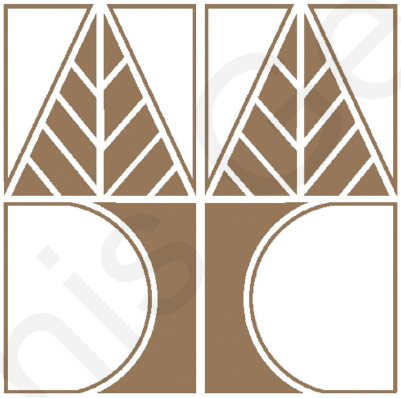
DYNAMIC WORKFLOWS IN THE HOME

eHEALTHCARE PROVISION



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2010

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Computer Supported Collaborated Work-related (CSCW) applications are becoming a trend for most business and organizations. A big challenge is to deploy an efficient CSCW system where the communication media is wireless, users are mobile and uses mobile devices with limited capabilities. A sector that utilizes such CSCW systems is the healthcare domain. Due to the sensitive area of healthcare provision, additional features are needed in a CSCW system like virtual teams, appropriate computational model for the eHealth domain, dynamic creation of collaboration workflows, proactive diaries and automatic triggered events upon time expiration. This thesis presents such a CSCW system that supports these features not only within an organization but across organizations as well. It also provides evaluation and feedback from its application in a real world environment, thus demonstrating its applicability and effectiveness.

DYNAMIC WORKFLOWS IN THE HOME eHEALTHCARE PROVISION

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This thesis is dedicated to my newborn baby girl, Rodothea.

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LIST OF ACRONYMS

3G	Third Generation
AAL	Ambient Assisted Living
ASP	Application Service Provider
BAN	Body Area Network
CSCW	Computer Supported Collaborated Work
CVD	Cardio-vascular diseases
DBMS	Database Management Systems
ECG	Electrocardiogram
EEG	Electroencephalogram
FDL	FlowMark Definition Language
GP	General Practitioner
GPRS	General Packet Radio Service
GSM	Global System for Mobile communications
GUI	Graphical User Interface
HC	HealthCare
HCP	Healthcare Professional
HIS	Health Information System
ICT	Information Communication Technologies
ICU	Intensive Care Unit
ID	Identification/Identity/Identifier
IP	Integrated Project
IrDA	Infrared Data Association
IT	Information Technologies
LAN	Local Area Network
LD	Long Distance
MHS	Message Handling System
MMI	Man-Machine Interface
MVT	Medical Virtual Team
OCR	Optical Character Recognition
OLE	Object Linking and Embedding
PDA	Personal Digital Assistant
PHR	Personal Health Record
PPH	Primary Pulmonary Hypertension
RTCAL	Real Time CALender
SD	Short Distance
SMS	Short Message Service
SOA	Service-Oriented Architecture
SQL	Structured Query Language
UML	Unified Modeling Language
UMTS	Universal Mobile Telecommunications System
VAR	Value-Added Reseller
VD	Variable Distance
VSM	Vital Signal Monitoring
VT	Virtual Team
WAN	Wide Area Network
WFM	Workflow Management
WFMC	Workflow Management Coalition
WFMS	Workflow Management System
WSA	World Summit Award

Chapter 1

Introduction

1.1. Background

The term workflow is used in computer programming to capture and develop human to machine interaction. So far, workflows are mainly used in the business sector, by depicting the sequence of operation in order to speed up procedures, enabling better handling of resources and reorganizing energy and information flows. Workflows applications mainly aim to provide end users with an easier way to orchestrate or describe complex processing of data. Nowadays, with the current evolution of mobile devices, users are constantly on the move using applications and accessing data with their notebooks, Personal Digital Assistants (PDAs) and mobile phones through a variety of wireless networks. This trend, where the context of the working environment is constantly changing, spawned the need for dynamic workflows. The benefits of using dynamic workflows are numerous, including dynamic business process restructuring, dynamic share of information and dynamic collaboration schemas.

During the last years, there has been a major reconstruction on the healthcare sector due to the diversification of user needs, demands and expectations, within the structure of a modern society. Workflows have been recently become an important aspect, because of

the necessity for provision of care services in different and remote locations and the constant environmental changes.

eHealth is a discipline that took over in the last years in the health sector, establishing the need for providing dynamic working environments of different actors (medical professionals) promoting effective collaboration among the actors, including the patient, at anytime, and any context (place). Our study focus on the needs for collaboration and dynamic workflows in the health care sector and more specific in the virtual health care teams[1].

1.2. Problem Context

Given the complexity and diversity of the provision of healthcare, in association with critical factors such as quality of care, adaptability, availability, flexibility, confidentiality, security (due to the medical record singularity[2]), expandability and ease of information sharing, made the eHealth a solid solution for the provision of effective and efficient healthcare, within a more distributed and technically related context (e.g. wireless networks and mobile collaboration).

Mobile devices usually are small with inefficient input methods, small screen, limited battery life and prone to damage and spoilage. These problems should be handled efficiently during the development of a system in the eHealth sector. In addition, specialists require efficient help from an eHealth system without the need for re-analyzing and restructuring their way of working with the system. After a more thorough examination of these problems, the need for virtual teams, dynamic workflows and the need for time driven events came to the surface.

[1] Virtual healthcare teams are teams that consist of healthcare professionals who collaborate and share information on patients through digital equipment.
[2] Medical records are intensely personal documents and there are many ethical and legal issues surrounding them such as the degree of third-party access and appropriate storage and disposal.

Combining the complexity of eHealth, along with the well-known problems faced in mobile computing (e.g. wireless environment/medium constrains and mobile devices capabilities such as battery, screen, etc), result in a working environment that had not been appropriately addressed till now. All these problems are denoted in more detail in the following chapters and a proposed solution is presented.

1.3. Thesis Main Aim

The main aim of this work is to present a complete system that address the need for effective health care provision through eHealth advanced technologies enhanced with the use of dynamic workflows that may be used within a wireless solution at anytime and environment. Through this work, I developed an innovative eHealth system focusing on efficient and effective collaboration of medical practitioners utilizing the concept of Virtual Medical Teams, Computer Supported Collaborated Work (CSCW) and the Dynamic Workflow Management. This system considers all the challenges discussed previously and introduces a new paradigm in collaboration application development and usage.

In the following chapters I present the system model, the architecture, the development of the pilot system and finally the evaluation of the proposed system. For the evaluation of the system, I developed evaluation metrics and applied them on real test-bed environment, developed for this work, in order to demonstrate the added value and the cost effectiveness of the system.

1.4. Design and Implementation Assumptions

Our system as a complete solution includes a security mechanism. However, security, auditing and logging issues are beyond the scope of this thesis project. Hence, it is assumed that the system will not be compromised by other systems. Furthermore, it is

assumed that the system do not carry any Trojan horse and/or virus, nor have any intention that poses any security threat to other systems.

1.5. Thesis Organization

This dissertation is organized as follows. Chapters 2 and 3 present the notions of collaboration and workflows. Definitions, standards and related work are also presented. Chapter 4 outlines existing eHealth applications along with their main features summarizing them in a comparison table. Chapter 5 identifies the extended features of an eHealth application that are utilized in the proposed model, along with the introduction of the terminology that I use, the notion of virtual teams, responsibilities, medical diaries, pro-activeness, timeouts and triggers. Chapter 6 analyzes the architecture, design and implementation of our system. Chapter 7 demonstrates the applicability of our model through the DITIS system. Using DITIS system, I showed how our model provides dynamic perspective in a collaboration system and demonstrate the interaction between users. Additionally, I analyzed and evaluated the prototype system. Finally, chapter 8 concludes this dissertation and present future work.

Chapter 2

Computer Supported Collaborative Work (CSCW)

2.1. Introduction

Collaboration is a structured, recursive process where two or more people work together towards a common goal - typically an intellectual endeavor that is creative in nature [106] - by sharing knowledge, learning and building consensus.

The term *"Computer-Supported Cooperative Work"* (CSCW) was first used by Irene Greif and Paul Cashman back in 1984. It used to describe the topic of an interdisciplinary workshop they were organizing on how to support people in their work arrangements with computers [70].

CSCW is a generic term, which combines the understanding of the nature of group working with the enabling technologies of computer networking, systems support and applications. CSCW has emerged as an identifiable research area which focuses on the role of the computer in group work.

An essential precursor to the study of collaborative systems is the definition of a mechanism for classifying these systems. Figure 1 clearly shows two principal characteristics which are common to all cooperative systems [110]:

1. **The form of interaction (synchronous versus asynchronous)**

   Some creative problems require group members to collaborate in a synchronous manner since the creative input of each group member is required to generate a strategy for solving a task. In contrast, prescriptive tasks have a previously formulated solution strategy where group members take on particular roles and work in an asynchronous manner often without the presence of other group members. Cooperative systems are therefore either synchronous or asynchronous systems.

2. **The geographical nature of the users (remote versus co-located)**

   Cooperative systems are either remote or co-located. This division is as much logical as physical and is concerned with the accessibility of users to each other rather than their absolute physical proximity. The term co-located is used to emphasize this logical division and to avoid confusion with the distinction between remote and local communication systems.

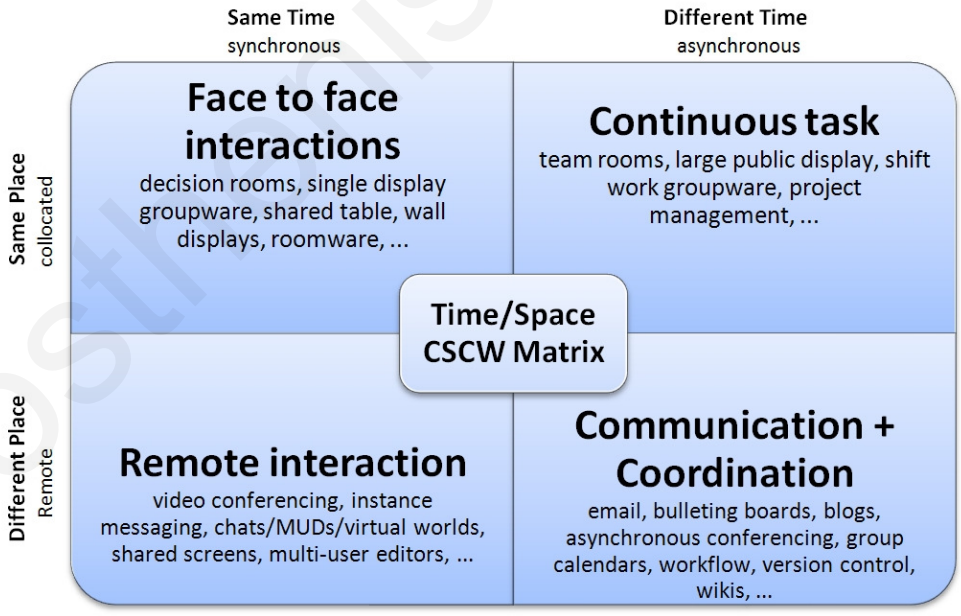


Figure 1: Common used Collaboration Model

During my work, a third characteristic was spawned that it is never mentioned so far and it's one of the innovative contributions of this thesis to this area. The third

characteristic involves the working organization of the users. Collaboration may extent outside the boundaries of an organization, involving users from various expertises. I will elaborate more on this in section 5.2.4.

Four classes of cooperative system have emerged over the last years. These classes are the "Message systems", "Computer conferencing", "Meeting rooms" and "Co-Authoring and argumentation systems". In more detail:

Message systems

Over the years, message systems have evolved from electronic mail programs which allow a user to send textual messages to other users on the same machine to any user, anyplace and anytime. As wide area networks designed to support computer communication became more widespread [112], electronic mail systems increased in complexity and functionality to support more communication schemes and media (e.g. audio, image and video).

This evolution resulted in the creation of a number of different standards for electronic message systems. Such system is the Message Handling System (MHS) model described in the CCITT X400 series of standards documents [111]. Message standards describe the message format used to transfer information in message systems. Structured message systems are based on the principle of extending the available amount of machines processing semantic information by adding syntactic structure to the existing message structures [110].

Computer conferencing

Computer conferencing systems are related to electronic mail programs. However, in such systems, the principles in terms of how messages are grouped are different. A

typical computer conferencing system consists of a number of groups (called conferences), where each of them has a set of members and a sequence of messages. These conferences are often arranged so that they address a single topic and users subscribe to conferences of interest. Usually, the system stores information about the progress of every member in each conference. The required information is usually stored as conference messages within a central database rather than the individual mailbox approach used in messaging systems. Reliable high-speed communications has lead to the emergence of new real-time conferencing systems that conference members can communicate in real-time. As computers become more powerful their capability to handle wider classes of data increased. This has led to multi-media systems that integrate audio, text and video [110]. The most common and simple form of computer conferencing systems are the well-known forums with their topics representing the conferences of interests (forums use only some key features. e.g. does not support registration to topics).

Meeting rooms

Meeting rooms usually consists of a conference room enhanced with a large screen video projector, a computer (or network of computers), video terminals, a number of individual input terminals, and a control terminal. These systems often make use of multi-user software based on some form of analytical decision technique [110] to support decision-making functionality.

Co-Authoring and Argumentation Systems

Co-Authoring and argumentation systems are systems that aim to support and represent the negotiation and argumentation involved in-group working. The collaborative

authoring of documents is an example of this class of cooperation where the final generation of the document represents the product of the process of negotiation between authors [110]. This class is lacking the functionality needed for the eHealth domain, as I will show later in this dissertation.

2.2. Existing Systems

Numerous systems were developed under these four classes of cooperative attributes. In this section, I will describe some classes' characteristics, along with some of the characteristic projects/systems for each one of the classes.

2.2.1. Message Systems

These systems are often termed structured or active message systems and use an asynchronous and remote mode of collaboration. An assumption that is made is that members of a group cooperate by exchanging messages. Structured message systems are based on concepts identified in electronic mail systems and a standard message interchange format is often assumed. Some popular message system research projects are: Coordinator [113], Information Lens [114], Chaos [115], Domino [116], Cosmos [117], Amigo [118] and Strudel [119].

2.2.2. Conferencing Systems

The oldest form of conferencing systems provided only asynchronous sharing of textual information. Many of these conferencing systems are still in use today. High bandwidth local area networks resulted in the development of Real-Time Conferencing Systems that support real-time concurrent access to the shared information space and Multimedia Desktop Conferencing Systems.

In computer conferencing systems users interact through a shared information space accessed by each of the users as shown in Figure 2 [110]. This model of interaction through a shared information space is often augmented by the use of direct user-to-user communication.

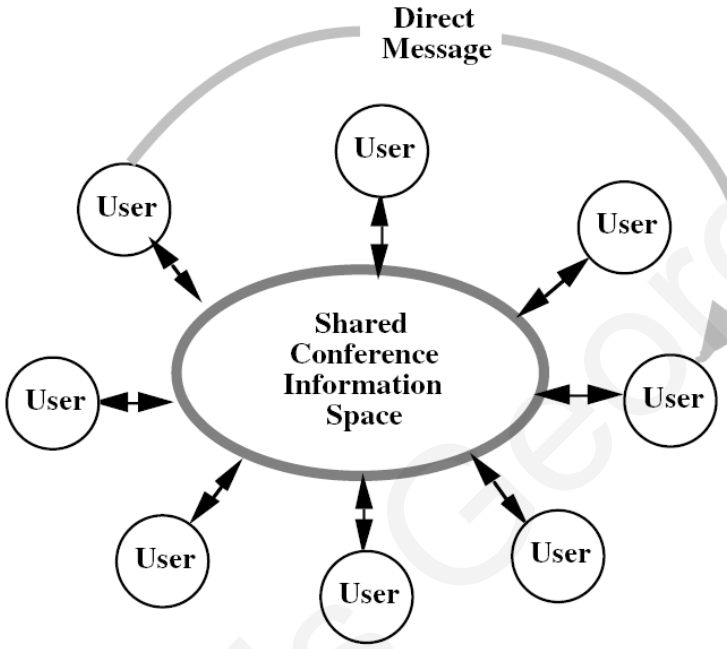


Figure 2: Interaction in Conferencing Systems

During the following paragraphs, I will present the three types or the conferencing systems.

2.2.2.1 Traditional Conferencing Systems

Traditional computer-conferencing systems are an extension of bulletin boards that have developed from early electronic mail systems. Bulletin board systems offer a fixed set of adjustable topics, by the system administrators. Also, new comments are simply appended to the end of the topic, with no facility to link related comments [110].

Conferencing systems create easily new conferences and organize comments within a conference. The system can learn about conferences, allowing people to interact with others who have common interests and experiences. Users can monitor changes to

conferences and search conference comments according to criteria such as date, author, and keyword [110].

A large number of conferencing systems exist each with different properties and peculiarities:

- EIES, Descended from Murray Turroff's earlier EMISARI System. One of the first conferencing systems.
- PARTI, PARTIcipate conferencing system developed and marked by Participation Systems Inc. One of the leading conferencing systems in the USA.
- NOTEPAD, Developed in 1979 by InfoMEDIA Corp; NOTEPAD has been used as (among other applications) the basis for an electronic journal system [120].
- COM, Developed at the Swedish National Defense Research Institute in 1977. COM is in regular use in Europe and has even spun off a "portable" system called PortaCOM. Its instantiation as Eurokom serves as the principal mail and conferencing system for Esprit projects.
- EFORUM, Developed by Network Technologies International (NETI) EForum is one of the more recent conferencing systems and provides a modern workstation interface.
- CONFER, A conferencing system developed at the University of Michigan. One of the latest generation of conferencing systems offering increased flexibility over its predecessors.

The most considerable influences on computer conferencing were of human or environmental nature. The main factor for the success of an individual conference was the activity level of that conference's leader. Other factors that influence a conference’s for a success or failure are:

- Appropriateness of Discussion Topics. Choosing conference's topics represents a considerable problem. Topics need to be sufficiently restrictive to prevent a conference wandering, but sufficiently general to include all users comments and interests. [110]
- Overload and Pruning. Over the time, user community produces a lot of text. As a result a new conference participant could easily spend days reading the text of some conferences. The conference systems administrators are forced to adopt harsh pruning measures (with a subsequent loss of information) in order to avoid discouraging new participants. [110]

2.2.2.2 Real-Time Conferencing Systems

Traditionally, computer conferencing systems provide asynchronous interaction among users. However there are numeral areas, such as crisis management, where synchronous communication is needed. Current conferencing systems, such as PARTIcipate and EForum, either already provide basic real time support, or are being extended to provide support for real time communication.

MIT developed a prototype real-time conferencing system that highlights the principles of real time conferencing. The prototype, RTCAL (Real Time CALender) supports meeting scheduling among a group of users. RTCAL, provides computer support for the scheduling of meetings by implementing a shared workspace of information from participants' on-line calendars. The shared workspace is displayed to the users combining their own personal calendar. While RTCAL provides users with information and tools for decision support, it does not automate the selection of a meeting time [110].

RTCAL demonstrates some general principles of real-time conferencing systems and supports only a specific application activity. The development of workstation technology combined with high bandwidth communications has led to the emergence of a particular class of real-time conferencing system called shared screen systems.

Other real time conferencing systems are the shared screen systems that allow the screen contents and windows to be displayed and manipulated by more than one workstation. The concepts underlying shared screen systems have developed from the work of the CoLab [122] project at Xerox PARC.

2.2.2.3 Multi-media and Desktop Conferencing systems

Merging workstation technology and real-time computer conferencing have had a significant impact on Computer Supported Collaborated Work (CSCW) systems. This merging has been termed desktop conferencing and an integral part of desktop conferencing is the use of multi-user interfaces. There are two approaches for the development of multi-user interfaces.

The first approach suggested is the development of special purpose applications that are collaboration aware. CoLab [122] is an example of a system employing collaboration aware applications.

The second approach is to provide facilities that allow existing single-user applications to be shared between users in a collaboration-transparent manner. These systems may support multi-media capabilities. Examples of work that use this approach include Vconf [124], Rapport [125], SharedX [126], Conference Toolkit [127], and MMConf [128].

An interesting development in computer conferencing is the emergence of systems that aim to support synchronous cooperative working in a manner, which unifies both

remote and co-located users. These systems combine the shared screen facilities provided within real-time conferencing systems with video and audio in a unified manner. In these systems, a stricter synchronous model concerning the communication paradigm is applied.

2.2.3. Meeting Room Systems

Face to face cooperation support, represents the most recent and distinct research development in cooperative working. A typical approach to this form of computer support is to develop a meeting room furnished with a large screen video projector and a number of computer workstation/terminals, often these systems include a control terminal. A typical meeting room arrangement is shown in Figure 3 [110].

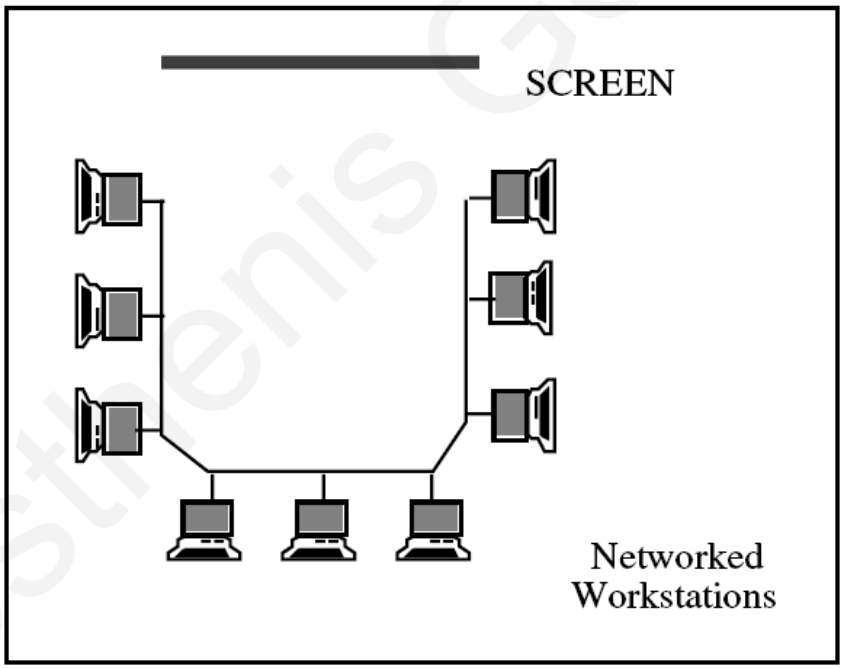


Figure 3: A typical Meeting Room Arrangement

Most systems that employ meeting rooms to support cooperation among local groups belong to a class of systems known as decision conferences. Decision conferences are related to earlier Decision Support Systems [129] but focus on improving decision making by groups rather than individuals. Decision conferences emphasize on the use of

structured decision processes, mainly involving statistical computer models but also utilizing models increasingly that embody collaborative notions such as the Delphi method.

Numerous decision conferences have been developed both in industry and university research centers. In industry, systems include the GROUP DECISION AID of Perceptronics Inc [130] and the Decision Conference of Decision and Designs Inc [131]. In universities, decision conferences include the Planning Laboratory at the University of Arizona [132] and the Decision Room [133]. A fundamental principle of the MIS laboratory like all decision laboratories is the emphasis on both statistical and analytic decision models.

The software elements that are identified as being important to the construction of decision conferences are the following:

- Decision Analysis Software
- Modeling Software
- Voting Tally
- Display Software

Examples of meeting room systems are the CoLab system developed at Xerox Parc, and Project NICK [135] at the MCC. The CoLab project is interesting because it represents a move away from the reliance on quantitative models exhibited by other meeting room systems. Project NICK represents a significant development in meeting support systems because of its long-term goal to develop models to formalize the meeting process and to build tools supporting these models.

2.2.4. Co-Authoring and Argumentation Systems

Almost all documents result from the work of more than one author. The aim of co-authoring systems is to support the cooperation necessary between these co-authors in document production.

The model that is adopted by these systems is that of asynchronous co-operation with each user working independently on a portion of the document. Reviews and comments are added to the document by annotating sections of the document.

While the mode of interaction in co-authoring systems is asynchronous, co-authoring systems are not distinguished by the location of users and used when the participants are collocated.

Co-authoring systems often use hypertext technology. The term hypertext describes any system employing non linear structuring of text, graphics, and other media. Hypertext systems [136] normally form linked network structures with data (usually text or graphics) in the nodes and occasionally typing information on the links. Hypertext documents resemble nets of connected nodes with each link between nodes denoting an association between the information held in the nodes.

2.3. Weaknesses of existing systems within the eHealth domain

The common collaboration model presented in Figure 1 supports users taking into account the form of interaction (synchronous or asynchronous) and the geographical nature of the collaboration (remote or co-located). During a thorough investigation of the abovementioned systems and in combination with the peculiarity of the eHealth sector, I identified a third characteristic in cooperative systems. This characteristic is the cross organization axis.

More specifically, under the eHealth sector, users that are collaborating for a common goal are specialists with different areas of expertise and in most occasions they work under different healthcare providers. Users from various organizations are now collaborating having a common goal and scope. This new characteristic, along with the updated model is presented in Chapter 6.

Furthermore, the existing models do not take into consideration the limitations that exist in the wireless environment. Such limitations are the bandwidth, frequent disconnections, mobile device characteristics (e.g. small screens, battery, easily subjected to damage, input methods) and coverage.

In addition, the existing models are patient centric and domain specific. The proposed model that will be presented in chapter 6 tackles all these issues, taking into account the restrictions of the eHealth domain having the focus on the patient for a more effective and efficient service provision.

Chapter 3

Workflow Management Systems

3.1. Introduction

During the past years, workflow management has become a popular active research field with numerous products and research groups. Workflow Management Systems (WFMSs) combine technologies, principles and methodologies from numerous fields of computer science. The landscape is being transformed significantly due to the absorption of emerging technologies like the World Wide Web, and due to mergers and partnerships involving numerous companies which produce complementary products. With the appearance of support for workflow management in process modeling and application development tools, WFMSs are becoming a little easier to use. Workflow management has a very significant role to play in disparate organizations' drive to improve their efficiency and customer service [137]. In this chapter, I will present the notion of workflows management, along with the market trends, business considerations, standards, technical trends and some research projects. Finally, I will refer to the limitations of the existing systems within the eHealth domain.

3.2. Workflow Management Systems

Various definitions have been proposed for concepts relating to Workflow Management (WFM). For example, Giga Group [138] once gave the following definition: "*we call the operational aspects of a business process - the sequence of tasks and who performs them, the information flow to support the tasks, and the tracking and reporting mechanisms that measure and control them - the workflow*". It should be noted that the aim of WFM is not to automate necessarily all the tasks of a workflow process. Some tasks (also called activities) might continue to involve humans and even for automated tasks the decision of when to initiate them and/or determining whether such automated tasks have successfully completed might be left to humans. The emphasis lies much more on automating the tracking of the states of the tasks of a workflow, and allowing specification of preconditions to decide when tasks are ready to be executed (intertask dependencies) and of information flow between tasks.

Giga also defined the associated management software as follows: "*workflow software is designed to improve business processes by providing the technology enabler for automating these aspects of the workflow: routing work in the proper sequence, providing access to the data and documents required by the individual work performers, and tracking all aspects of the process execution*". One of the main goals of WFM is to separate process logic from task logic that is embedded in individual user applications. This separation allows the two to be independently modified and the same task logic to be reused in different processes, thereby promoting software reuse, and the integration of heterogeneous and isolated applications. This is similar to the distinctions, which have been made in the software engineering community between programming in the large versus programming in the small [137].

In the last few years, the focus on business process reengineering by enterprises as a cost saving and service improvement has contributed significantly to the WFMSs' popularity. WFMSs have been widely deployed in the following types of businesses/organizations: banking, accounting, manufacturing, brokerage, insurance, healthcare, government departments, telecommunications, university administration and customer service. Some of the novel applications being considered for WFMSs are: system monitoring and exception handling and systems administration. A point to note is that WFM is not intended to deal with only business processes. Some organizations have found the high-level process definition capabilities of WFMS products to be a useful functionality by itself [137].

WFMSs and workflow applications have been divided into four broad categories: production, administrative, collaborative and ad hoc. While this is not a very strict categorization, it helps to distinguish the design points of different products somewhat reasonably [137]. **Unfortunately, to our knowledge, none of these categories characterize exactly the needs of the eHealth domain.**

3.3. Market Trends and Business Considerations

WFMSs engage a longer sales cycle, since their adoption requires executive approval and end user commitment. Adopting a WFMS necessitates a cultural change in the way an organization does its business, as it requires group consensus and retraining. Typically, implementing a workflow solution involves the hiring of consultants for advice [137]. VARs (Value-Added Resellers), tool vendors and consultants stand to benefit economically from the complexities involved in implementing WFM applications. Considering the difficulties that users face in customizing a general-purpose WFMS product for specific applications, InConcert [144] has recently decided

to concentrate on producing vertical market-specific (e.g., engineering, manufacturing and telecommunications) products.

WFM market has been undergoing a great deal of consolidation in the last couple of years. There have been many mergers and partnerships involving companies that produce workflow and related products (document management, imaging, text search, e-mail, forms management and groupware). Some of the significant events were: purchase of Lotus (developer of the groupware product Notes/Domino) by IBM (producer of the workflow product FlowMark and imaging/document management product ImagePlus VisualInfo); acquisition of Odesta Systems (LiveLink workflow product) by the text search company OpenText [145]; acquisition of the imaging product company WaterMark and document management company Saros, and a partnership with Novell by FileNet; purchase of the imaging/workflow company Sigma by Wang and the subsequent sale of Wang Software to Kodak (resulting in the formation of Eastman Software); Eastman Software's partnership with text search technology company Verity [146]; partnership between workflow vendor Action Technology [147] and document management company PC DOCS [148]; purchase of Delrina by Jet-Form [149]; acquisition of workflow vendor CSE Systems [150] by document and filing systems vendor Louis Leitz Enterprises; formation of Mosaix from the merger of ViewStar with Digital Systems International [137].

3.4. Workflow Standards

The Workflow Management Coalition (WFMC) [164] is the main organization that is involved in workflow management standardization efforts. It was formed in 1993 and it currently has about 200 members (vendors, users, analysts, systems integrators, universities, etc). WFMC defined a reference model for a WFMS's architecture. Version

1.1 of the document (WFMC-TC-1003) describing the model was published in November 1994. This model has 5 application program interfaces (APIs) that are intended to be standardized. The interfaces/APIs are: (i) Process definition model and interchange APIs, (ii) Client APIs, (iii) Application invocation interface, (iv) Workflow interoperability, and (v) Administration and monitoring.

While users find it very convenient to define process models using graphical tools, different products provide different graphical support. As a result, WFMC decided that it would be too difficult to establish a graphical standard for process definitions. Consequently, a language-based standard is a work in progress for this purpose. Products like FlowMark already support such a language (FlowMark Definition Language, FDL) to allow the convenient export and import of process definitions between different workflow installations [137].

3.5. Technical Trends

WFM is very interesting since it brings together principles, methodologies and technologies from various areas of computer science and management science: database management, client server computing, programming languages, heterogeneous distributed computing, mobile computing, graphical user interfaces, application (new and legacy) and subsystem (e.g., CICS and MQSeries) integration, messaging, document management, simulation, and business practices and reengineering. Integrating different concepts from these areas poses many challenges. Factors like scalability, high availability, manageability, usability and security also further aggravate the demands on the designs of WFMSs [137].

Functionality Evolution. Initially, many of the WFMS products were intended as imaging-based applications. Thus, imaging is being made an optional component of WFMSs, as a result, broadening the utility of such systems for a wider set of applications. Consequently, more and more information were digitally captured via online data entry rather than such information having to be extracted from paper documents via imaging technologies like optical character recognition (OCR) [137].

Embedded Workflow. Many general purpose business application packages have been developed for managing human resources, manufacturing, sales, accounting, etc. by companies like Baan, Oracle, PeopleSoft and SAP. The market for such products has grown tremendously as customer organizations try to avoid producing homegrown solutions. Vendors' generic application packages can be tailored to take into account the special needs of a particular enterprise. Developers of such packages, like SAP [166] and PeopleSoft [167], have incorporated workflow functionality into their products. This allows different functionalities of those products to be conveniently invoked in a well-defined order to implement some specific application requirements. Baan V [168], released in 1Q 1998, also included workflow functionality.

Web-based Workflow. With the widespread and rapid popularity of the worldwide web, many WFMS products have been rapidly adapted to work in the context of the web. The level of sophistication of web support varies from product to product. Some products permit workflows to be initiated or controlled from a browser. Worklist handling via the web is another form of support that is provided by a few products. In summary, it is the client side WFMS functionality that has been made available through a web browser. The advantage of web support is that no specialized WFMS-specific client software needs to be installed to invoke workflow functionality at a workflow server. Some of the products with basic web support are: Action Technology's

ActionWorks Metro 3.0, JetForm's InTempo [169], Mosaix's ViewStar Process@Work [170], CSE Systems' CSE/WorkFlow NoLimits, Open Text's Livelink Intranet, SAP Business Workflow 3.1, Staffware's Staffware Global [171], and Ultimus's Ultimus CyberFlow [172]. Process@Work requires the web server Microsoft Internet Information Services Server. Due to the nature of the eHealth domain and the wireless medium restrictions, in our case, I follow this technical trend. The web support provides the necessary functionality for anywhere and anytime healthcare service provision.

Distributed Workflows. WFMS architectures have evolved from supporting mostly single workgroup type environments to providing enterprise-wide functionality. With such enhancements, a single workflow is allowed to span amongst servers and clients across wide area networks. This provides additional scalability, availability and manageability since more servers can be involved in a single workflow and the impact of server failures can be minimized. Eastman Software's OPEN/workflow 3.1 [173] and IBM's FlowMark 2.3 [174] provide support for distributed workflows involving multiple servers.

Ad Hoc Workflows. WFMSs are being enhanced to provide support for ad hoc workflows with different levels of flexibility. Also, new products which are specifically intended for ad hoc workflows have been introduced recently. Novell released Groupwise Workflow [175] that is based on messaging. It uses as its core workflow engine FileNet's Ensemble [176]. Several e-mail based WFMS products have been developed recently on top of Microsoft's Exchange messaging product. Products in this category include Staffware for Microsoft Exchange, Keyfile's Keyflow 2.0 [177], JetForm's FormFlow [178], Reach Software's WorkMan 2.1 [179] and Ultimus [172]. Some systems like InConcert 3.6 [180] and TeamWARE Flow [181] allow executing workflow instances to be dynamically modified. This functionality permits a workflow

process to be instantiated without the entire process being completely defined at first and the process design to be inferred by tracking the dynamic modifications that are performed. Once the process is completely defined based on the observance of how the former evolved, a generated template can be used for instantiating future process instances of that kind.

Process Modeling. Business process and data modeling companies like HOLOSOFX [182] and IDS-Scheer [183] are enhancing their respective products Workflow-BPR and ARIS Toolset to generate workflow schema definitions. This is analogous to, in the relational DBMS world, 4GLs being used to generate SQL programs rather than forcing users to hand code SQL. HOLOSOFX's Workflow-BPR and FileNet's VisualWorkFlo [184] have been integrated so that the former's output (e.g., process definitions) can be fed into the latter. Also, feedback information from the latter can be fed to the former to refine assumptions made during process analysis. IBM's Business Process Modeler [185] can also produce input for FlowMark in the form of FDL schema definitions. Users have been demanding tools for enterprise modelling, analysis and simulation of workflows. In-Concert has been integrated with CACI Product Company's SIMPROCESS [186]. Adaptive Information Systems' Work Modeler [187] supports simulation of workflows. It is part of the company's AdaptFile/VisiFLOW software suite.

Metamodel. The metamodel support by the WFMS products is similar to the one found in parallel programming languages. Such as: block structuring, iteration, recursion, conditional and unconditional branching, and parallel branches. Some systems like Flow-Mark distinguish the types of connections between activities: data and control. Dataflow may be modeled with input and output data containers being associated with activities or via the descriptions of documents that flow through activities. Conditions

may be associated with the control flow connections to decide under what conditions control will flow through those connections.

Groupware. The groupware product Lotus Notes has been around for many years. The Notes server has been renamed to be Domino and the name Notes is now associated with the client. Domino provides some basic workflow functionality and permits building workflow applications with both database-based and mail-based architectures. Recent releases of Domino provide support for advanced concepts such as agents, field-level replication, integrated web access, web serving, etc. Domino has been ported to run even on the IBM mainframe operating system Posix-compliant OS/390. Other vendors have built products which provide high-level process definition capabilities on top of Domino/Notes. Some of these products are Action Technology's Action Workflow, Pavone's GroupFlow [188] and ONEstone Information Technologies' ProZessware [189].

OO Architecture. Some of the WFMSs are built using an object-oriented language like C++. Not all such systems expose the object-oriented architecture of the system for users to tailor the system's functionality. InConcert is an exception in this regard. Objects representing workflow processes and tasks are manifested externally via APIs.

WFMS State Repository. Many WFMSs' servers use a relational DBMS as the repository for keeping track of workflow process definitions, organization structure, runtime information on process and activity instances, workflow data, etc. The usage characteristic of a DBMS by a WFMS is very different from the usual assumptions made about most database accesses being read-only. As a matter of fact, most accesses made by a workflow server to its repository will be in the form of update transactions. This is because most of the time the server accesses the repository to perform state transitions in the workflow process graph at the time of activity/process instance

completions/initiations. Such actions have to be recorded persistently. High availability features in the repository DBMS are crucial since any failure of the DBMS would make the WFMS's operations come to a standstill since the workflow server needs access to it to do its process navigation on an activity completion.

Transaction Concepts. None of the current WFMS products supports the transaction concept in any explicit fashion. Typically, the products do not even guarantee that if an activity's execution is an ACID transaction that the execution of that activity and the recording of that activity's completion in the workflow server's repository will be done atomically. The consequence is that the activity may complete successfully but the client node where the activity executed may crash before the activity completion notification is sent to the server and then the server will continue to think that the activity is still in progress. Human intervention will be needed to resolve this situation. This scenario becomes especially difficult to handle where the activity program is a legacy application, which was written without its usage in a workflow context in mind.

Worklist Handling. Once a user finishes executing an activity, how the next activity to be performed by the user is chosen varies from system to system. In push systems; the user is given the specific next activity to perform. That is, the user is not given a choice and the system decides on work scheduling. Typically, this approach is adopted in production (clerical worker) environments. In pull systems, the user looks at the worklist, which contains a list of ready activities and chooses which one to process next. That is, the user does self-scheduling. Typically, this approach is adopted in knowledge worker environments.

Telephony Integration. ViewStar 5.0 integrates workflow management with telephony, thereby allowing companies to manage phone calls and the actions they trigger as part of a coherent business process. The intent is to integrate front-office

(customer care, help desk, etc) and back-office (under-writing, inventory control, loan applications, billing, accounts payable and receivable, etc) processing.

Application Development. A number of vendors have added support for Microsoft's Object Linking and Embedding (OLE) technology. This allows OLE-enabled applications to be very easily invoked by a WFMS as a consequence of starting executions of activities. Activity implementations become much easier to code since passing of data from the workflow engine to the invoked applications is automated. Support for OMG's CORBA has not been forthcoming as much as for OLE in WFMS products.

Document Handling. Different WFMSs provide different degrees of support for handling documents. Some WFMSs have built-in document management. Examples of such systems are Eastman Software's OPEN/workflow 3.1 and Keyfile's Keyfile. Certain WFMSs have tight coupling with external document management products. Products built on top of Lotus Notes/Domino, for example, belong to this category. Some products (like FlowMark) have a loose coupling with a document management system (e.g., ImagePlus VisualInfo [190]).

Intercomponent Communication. Some products currently use their own homegrown messaging mechanisms for communication between their components. In the case of FlowMark, work is in progress to replace the special purpose-messaging scheme with IBM's MQSeries [191], which provides persistent messages and transaction support across a wide variety of platforms. WFMS products based on Lotus Notes/Domino use that groupware product's native support for messaging.

3.6. Research Projects

To our knowledge, the workflow research community has not had enough impact on workflow products. An exception is the Action Technology's Action Workflow originated from research done at Stanford University. InConcert grew out of office automation research performed at the Computer Corporation of America. Pavone's GroupFlow came out of research work carried out at the University of Paderborn in Germany. Some of the ideas from the Intelligent Control Nets project at Xerox PARC were commercialized in the now-defunct FlowPath product of Bull, which was sold to Wang.

Much of the research work on workflow management has concentrated on workflow specification (e.g., intertask dependencies) and verification, transactional workflows (e.g., advanced transaction models) and extensions of ideas from active database management to workflow management. There are only a few workflow research groups, which are engaged in seriously prototyping their research results using either homegrown WFMSs or commercially available WFMS products. At least some of the prototypes replicate functionality that is already widely available in one or more products [137].

A number of issues derived from the research on this field such as: modeling of external events, exception handling (combining production and ad hoc workflows), interoperability, process schema inference, supporting object-oriented views of workflow definitions (e.g., inheritance), fault tolerance, benchmarks and load balancing [137]. Some of the systems-oriented workflow projects are:

Exotica [192] was a research project that was in existence for a few years (until early 1997) at the IBM Almaden Research Center in San Jose, USA. That project explored issues like scalability, availability, distributed workflows via transactional messaging,

disconnected workflow client operations, mapping advanced transaction models on top of WFMSs, alternate workflow repositories, OLE support, and ad hoc workflows. This work was done in the context of IBM's workflow product FlowMark, groupware product Lotus Notes and messaging product MQSeries. Prototyping work was done to support disconnected/mobile clients in FlowMark. Unfortunately, no specific work has been done towards the eHealth domain and therefore lacking the tools and ability of tackling the demanding eHealth requirements.

MENTOR [193] was a joint research project of the Union Bank of Switzerland and the University of Saarland at Saarbrucken, Germany. This project concentrated on the specification, verification and distributed execution of workflows based on state and activity charts.

METEOR [194] is a research project at the University of Georgia at Athens, USA. Their ORBWork prototype exploits CORBA for intercomponent communications. It is a fully distributed implementation of the workflow server functionality. It is realized using Iona Technologies' Orbix object request broker and associated products. Some of the METEOR work was done in the context of healthcare applications but not taking into consideration the wireless environment [226]. In more detail, METEOR components were used to provide services for collaborative consulting and collaboration technologies by integrating videoconferencing, application/data sharing, patient records and parallel access of multiple heterogeneous (healthcare) repositories [225].

METUFlow [195] is a research project at the Middle East Technical University in Ankara, Turkey. The METUFlow prototype also uses CORBA as its communication infrastructure, thereby resulting in a totally distributed implementation of the workflow server functionality.

MOBILE [196] is a research project at the University of Erlangen, Germany. The project advocates the idea of building a WFMS in a modular fashion so that the resulting system is easy to extend. The main goal of this project is to investigate the foundations of workflow management. One major characteristics of the Mobile approach is its comprehensiveness. They foster that the core issues of workflow management can only be addressed if the concept is investigated in a comprehensive manner. Thus, the research not only focuses on selected, isolated technical aspects of workflow management but also takes into account organizational matters.

OpenPM [197] is a research project at Hewlett-Packard Laboratories in Palo Alto, USA. The OpenPM prototype formed the basis for the HP product AdminFlow [198]. OpenPM uses CORBA-based communications infrastructure and supports OpenView-based systems management environment. It also allows specification of compensation scopes and actions.

Panta Rhei [199] is a research project at the University of Klagenfurt, Austria. Their prototype explores support for the internet and advanced transaction concepts. Its architecture is based on web technologies. It is implemented in Java.

WASA [200] is a research project at the University of Muenster, Germany. It concentrates on scientific applications such as geoprocessing, molecular biology or laboratory environments where the requirement to dynamically modify running workflows is considered to be higher than in more traditional workflow applications. A prototype has been implemented in Java with Oracle being used as the repository.

WIDE [201] is an European Esprit project involving Politechnic of Milan (Italy), Sema Group (Spain), ING Bank, Manresa Hospital and University of Twente (Holland). The goal of the project is to extend distributed and active database technologies to the

workflow arena. The results of WIDE will be implemented in Sema's WFMS product FORO.

3.7. Limitations on the existing systems within eHealth Domain

In this chapter I presented the notion of workflow management, along with the market trends, business considerations, standards, technical trends and some research projects. The integration of the abovementioned concepts within the eHealth context reported the deficiency on dynamic workflows on providing workflow management for the healthcare provision under the wireless environment.

eHealth applications demands features like medical virtual teams, dynamic questionnaires, actions, responsibilities, timeouts, triggers, medical diaries and pro-activeness (presented in more detail in later chapter). In addition these features needs to be embedded, controlled and work harmonically in workflows.

Furthermore, in eHealth sector the need of reorganizing the clinical procedure for the care provision is commonly identified. Nowadays, each time we need to reorganize the clinical procedure, developers have to analyze, implement and develop a new subsystem to tackle this new requirement. An ideal approach is to provide to the system administrator the ability to dynamically insert new workflows supporting the users. In chapter 6, I will present in more detail the proposed model that handles the provision of dynamic workflows and figures as one of the main innovations of this thesis.

Chapter 4

eHealth Applications

4.1. Introduction

It is true that nowadays many eHealth approaches focus on supporting patient/doctor communication, incorporating web-based technologies, and employing a particular theoretical collaboration model (see Figure 1) with main influential elements ranging for face to face interactions, continuous task, remote interaction and communication and coordination [34]. In this context, a large number of eHealth applications were investigated and analyzed with regards to their scope and functionality. Main limitations observed in these approaches, as well as to the theoretical model employed for these approaches, were the lack of communication provision, structured or not, among hospital specialists and general practitioners, or among different health provider environments, and the absence of the organization/working environment. Later, in chapter 6, I will present an extended model that overcomes these limitations.

This chapter presents eHealth projects/systems categorizing them into 5 classes based on their general scope. At a later stage I will present the limitations and weaknesses that were identified.

4.2. A Comprehensive Review of eHealth Systems

In this section an extensive analysis of eHealth applications is presented grouped based on their general scope. This classification is divided into systems that (i) Support of Users (healthcare specialists and patients), (ii) eHealth Services (how to develop and utilize), (iii) Monitoring (via sensors and ICT technologies), (iv) Information Processing (communication aid and support, techniques, algorithms, etc) and (v) Process Management. Below, I present a thorough analysis on each of the abovementioned classifications.

(i) Support of Users

The systems in this category focus on services that aim to support the work of the healthcare providers and also utilize the active participation of the patients providing a more efficient and effective continuity of care. Such approaches are:

C-CARE [202] develops tools for support of continuity of care by collecting and storing essential, relevant and up-to-date patient health-related information accessible to authorised users, patients included, any time/anywhere, e.g., from the patient's home, from a vehicle on the road or from a hospital emergency department. C-CARE gives access to information through both standard Internet technology and traditional voice telephony, bridging the technological gap between different categories of potential users. The main goal of the project is to meet an urgent request of healthcare professionals, using information technology in their daily practice, to share selected parts of a patient's record with authorised persons, whenever and wherever they may need it, in a secure, controlled but also automated way.

HealthMate [203] is a technology innovation project to provide market-oriented wireless solutions to a variety of health problems: care of chronic patients; support of

acute patients, including high-risk; and tele-assistance applications. The objectives are to develop a portable personal systems for health Tele-care and Tele-consultation based on new generation of wireless communication networks; integrating advanced, innovative wireless technologies to configure a secure information exchange media between the personal systems and the health service providers and to assure service continuity at any time and place.

The **HUMAN** [204] Project aims at improving the quality and continuity of patient-prisoner care by designing, developing and validating in two different European sites an umbrella of health telemedicine and demotic services, tailored on the inmates needs, as well as on the requirements of the health professionals operating in the detention centers. HUMAN addresses the needs of caring of EU inmates by applying new technologies to the area of delivery of health care in the prison environment, in order to increase the heath care quality and efficiency, and improve the working conditions of the medical and paramedical staff. HUMAN developed a web based platform for supporting the provision of remote consulting from specialists, as well as second opinions from clinicians operating outside the prison environment, thus allowing all of the domain actors to exchange information (including complex medical images) in a safe and secure environment.

COCOON [205] is an Integrated Project (IP) aimed at supporting health care professional in reducing risk management in their daily practices by building knowledge driven & dynamically adaptive networked communities within European health care systems. The risk management for a health care professional is completely related to its responsibilities assumption in mainly patient diagnosis and treatment processes. The growth of patient judgment autonomy and level of information together with the assessment of cost/benefit before deciding on intervention actions are three important

factors that force the health care professional to pay much more attention in providing the right answer to the patient problem. The main objective of COCOON project is to support knowledge driven collaborative practices in Networks of Healthcare Professionals in order to minimise medical errors in diagnosis and treatment through support publishing, organising and 'smart' searching of medical guidelines, papers and other relevant knowledge sources.

The **NOESIS** [206] system assists health professionals for effective decision making for prevention, diagnosis and treatment in the complex domain of cardiovascular diseases, allowing a smooth transition from established medical knowledge to personal judgment through an enhanced site seer for medical sciences and a decision support framework capable of producing a preliminary diagnosis. The enhanced site seer is based on a semantic integration platform associating medical concepts with information items, on a knowledge model for classification of extracted knowledge components and on interactive multimodal and attentive interfaces. The semantic integration will assist intelligent agents to automatically reason about the information in the information retrieval process. The NOESIS project aims at the development of a web-based personalised system with enhanced intelligence that will support health professionals in taking the best possible decision for prevention, diagnosis, and treatment.

PIPS [207] is an e-Health Integrated project (IP) that aims to create novel healthcare delivery models by building an environment for Health and Knowledge Service support. The PIPS Project main goal is to create a new Health and Life Knowledge and Services Support Environment for protecting the health of the Individual. This will improve current HealthCare (HC) delivery models while creating possibilities for HC professionals to access relevant updated medical knowledge and for European citizens to choose healthier lifestyles. PIPS will provide a set of services for supporting the HC

professional to promptly make the best possible decisions regarding prevention, diagnosis and treatment that are tailored to the Citizen's personal context, which consider his/her health status and personal preferences. PIPS will support Citizens in making informed decisions about therapy and nutrition, and assist them in determining their health status in a timely manner. PIPS Citizen centered model means that prevention and treatment must have the alliance and complicity of patients in the management of their own health. PIPS will support patients and citizens to be actively involved in the prevention and treatment process, throughout their life, anytime and anywhere.

In Summary:

As mentioned above, this category of projects/applications focuses on services that aim to support the work of the healthcare providers. Among others, my proposed system focuses on collaboration and dynamic workflow management. None of the above projects handles these features. C-CARE project collects and store essential patient health-related information and by sharing it between users, it emulates a very simple form of collaboration. Similarly, HealthMate, HUMAN, NOESIS and PIPS share patient's health-related information in various ways providing decision-making mechanisms and again an inadequate form of collaboration. On the other hand, COCCON project emulates collaboration by supporting a knowledge driven collaborative practices in Networks of Healthcare Professionals in order to minimise medical errors in diagnosis and treatment through support publishing, organising and 'smart' searching of medical guidelines, papers and other relevant knowledge sources.

(ii) eHealth Services

Within this category are applications that focus on providing or developing health services to the users through walkthroughs and toolchains. These services can be incorporated in an existing system in order to provide more functionality needed by the users. Some key projects are:

CHS [208] aims in the development of personal health services that can be used from home and communicates with the rest of the information infrastructure. CHS will develop a new generation telemedicine services for home care that will improve quality of health care and create a large new IT market by involving every single home and every single health care provider. Development of user acceptable Man-Machine Interfaces (MMIs) and Graphical User Interfaces (GUIs) for easy and error free data fusion, browsing, education, new generation decision support systems for artefact rejection and finally integration techniques for developing a complete health system for home care are CHS's IT related objectives.

The objective of the **ARTEMIS** [209] project is to develop a semantic Web-services-based interoperability framework for the health care domain. They focus on processes in terms of Web services rather than recording and documentation of electronic health records. In other words, their approach allows a standard way of accessing the data since there are very many standards that need to work together. The interoperability problems of medical information systems are twofold: First there are multiple, incompatible, proprietary approaches to connecting disparate applications. Secondly, there are more than one standard to represent the same information, which in turn creates an interoperability problem. ARTEMIS will enable medical practitioners to access patient records securely, seamlessly through a low-cost peer-to-peer infrastructure, regardless of where their patients or their records might be.

M-Power [210] is a user driven research and development project to create a middleware platform supporting rapid development and deployment of services for cognitive disabled and elderly. The platform is defined within an iterative process including end-user requirements, design, platform development, development of proof-of-concept applications and end-user trials. The project provides a clear toolchain for developing new healthcare services and a platform with basic services. Integration details on how to incorporate these basic services with an existing system are also available with the platform.

Wrapping up:

The projects in this category focus on the provision and development of guidelines for the developers on creating and applying robust, efficient and effective health care services. The collaboration services that were identified (m-Power project) were simple messaging system without the forwarding and multiple recipient features. No dynamic workflow support was identified.

(iii) Monitoring

Applications under this category aim to provide monitoring services through the use of vital signal sensors and ICT technologies in general. Some basic research applications are:

MobiHealth [211] aims at developing and trialling new mobile value-added services in the area of healthcare, thus bringing healthcare to the patient. The MobiHealth system allows patients to be fully mobile whilst undergoing health monitoring. The patient wears a lightweight monitoring system – the MobiHealth BAN (Body Area Network) – which is customized to their individual health needs. Physical measurements such as

blood pressure or ECG are measured by the MobiHealth BAN and transmitted wirelessly from the BAN to their doctor, the hospital or their health call centre. Therefore, a patient who requires monitoring for short or long periods of time doesn't have to stay in hospital for monitoring but with their MobiHealth BAN can be free to pursue daily life activities.

The **TOPCARE** [212] platform was in particular designed for therapy monitoring for home ventilation, for oral coagulation therapies and for PPH (Primary Pulmonary Hypertension) patients with infusion therapies, but it is also applicable for therapy monitoring in many chronic diseases. The overall objective of TOPCARE is to develop technical devices and telecommunication structures and to lay the organizational groundwork for bringing co-operative health care services into the home of patients. A telematic homecare platform will be established and evaluated in European cooperative health care environments for following scenarios: home monitoring and treatment of patients needing 1) infusion therapies, 2) controlled ventilatory support and 3) monitored medication adjustment and adherence control when treated with anti-coagulants.

AUBADE [213] project provides an innovative tool that will lead professionals to a deep study, analysis, understanding, and comprehension of neurological diseases and human emotions. The project has developed an intelligent, multisensor and wearable system for the assessment of the emotional state of humans under special conditions. The project has involved the utilization of technologies such as the recognition of the emotions after the processing of the following biomedical signals: EMG, obtained from the face of the users, ECG, skin conductivity and respiration rate. AUBADE results in a modular and multifunctional system to be applicable in different areas. Initially it is utilized in the health sector, primarily in the neurology and psychology areas, and also

in the car-racing sector. AUBADE platform incorporates a wearable system that obtains signals from multiple appropriate biosensors mainly placed on the face of the user (EMG, ECG, skin conductivity and respiration rate). The system is being used in a variety of healthcare applications mainly in the neurology and psychology field. Additionally, there are other areas of application, as the racing car sector. AUBADE has been designed to be highly modular and can be easily adapted or break-up in standalone modules, in order to accommodate a wide variety of neurological and psychological conditions.

The **CLINICIP** [214] system is a low-risk monitoring and control system for metabolic control in critically ill patients. The core of the system is a computer algorithm implemented into an ICU infusion system, which calculates insulin dosage from metabolic parameters to provide decision support for tight glycaemic control. A glucose sensor and a body interface have been integrated to allow for closed-loop insulin infusion. In a first step, a decision support system for tight glycaemic control was developed combining automated insulin delivery with an intelligent algorithm. The algorithm combines automatically recorded data about carbohydrate intake and current glucose levels measured by the nursing staff to calculate how much insulin is needed. The second step was designed to establish a complete glycaemic control system, "closing the loop" between glucose monitoring and insulin delivery. Research work within the CLINICIP project also included the integration of data management and physiology research on the applicability of glucose monitoring from subcutaneous adipose tissue.

INTREPID [215] project aims at developing a multi-sensor wearable system for the treatment of phobias and situational anxiety. INTREPID project actively contributes to the treatment of phobias in an unobtrusive, personalized and intelligent manner.

INTREPID will serve to empower Community citizens in the management of their individual health, to provide health care professionals and facilities with a reliable phobias treatment and decision support tool and to create new opportunities for the medical wearable device industry. INTREPID will build upon the well documented increasing demand for "healthy lifestyle" products and services on the consumer side and offer potentially significant returns for those who chose to invest in the project outcome.

MyHeart [216] system is suitable for supporting citizens to fight major Cardio-vascular diseases (CVD) risk factors and help to avoid heart attack, other acute events by personalized guidelines and giving feedback. It provides the necessary motivation the new life styles. The key challenges for lowering the mortality rate in CVD and their related costs are by successful guiding, informing and motivating the citizen to adapt to a permanently healthier life style and the early diagnosis of acute events. It is the aim of the MyHeart project to develop innovative, personalised, easy-to-use solutions and tools, which help the citizen to adopt permanent healthier lifestyle.

HealthService24 [217] have developed an innovative mobile healthcare system that supports patients' and health professionals' mobility aiming to increase patients' quality of life and reduce healthcare costs. HealthService24 aims to offer a viable mobile health care service permitting healthcare professionals to remotely assess, diagnose and treat patients whilst the patients are free to continue with daily life activities. The HealthService24 allows patients and non-patients to monitor their physical condition and obtain advice and information at any place and moment. Hence the service will enable patients to be fully mobile. An initial version of the proposed system, system was integrated successfully in this system providing an effective collaboration between the system users.

Wrapping up:

Projects under this category, aim to provide monitoring services via vital sensors and ICT technologies. TOPCARE platform provide secure and confidential patient data communication and will support co-operative caregiver networks. Ones more, the project does not focus on collaboration or dynamic workflows. On the other hand, as mentioned above, HealthService24 project successfully adopted an initial version of my system for the collaboration services among system users.

(iv) Information Processing

This category includes applications that utilize algorithms, techniques and processes that handle medical data. In addition, in this category fit applications that process medical information in order to enhance communication between users and systems. Some projects are:

Mobi-Dev [218] is a European effort which addresses the long standing and increasingly demanding need of health professionals to effectively, accurately, securely, from anywhere, anytime and in user-friendly way communicate with patients' databases located within hospitals, private offices, laboratories or pharmacies. An Internet based system will be set up to exchange clinical data between the Mobi-Dev portable devices and various kind of relevant information databases (Health Information System (HIS), GPs personal databases, clinical laboratories and pharmacy databases). Web interfaces with HIS will be realised using standard database interfaces products. The palm PC with microphone will be integrated with a smart card reader, a Bluetooth transceiver and an UMTS connectivity. Central servers will manage the mobile devices and perform the time/memory consuming tasks, as the language understanding. Bluetooth connection

will permit the use of Mobi-Dev inside the hospitals in conformity with the most restrictive and security requirements.

WIDENET [219] aims to continue building a network of national centres following the model of the already successful PROREC Belgium centre (www.prorec.be), to deal, among others, with the exploitation problem, and also to establish an international European-led organisation to co-ordinate the network on the European scale and strengthen successful suppliers. The project represents a response to the European Parliament's call for high-quality healthcare to be available to every citizen regardless of where he is, and to the Commission's related aims to raise the quality of life. Communication of data between health care institutions and professionals is an essential component of modern healthcare delivery. Better communication between the different healthcare providers is critical for achieving the level of quality and continuity that European citizens increasingly expect. Efficient exchange of information is the key element for managing resources, evaluating quality, and raising cost-effectiveness. It is commonly recognised that IT is essential to providing such data, and the use of standards-based record elements is crucial for interoperation. WIDENET's mission is therefore to promote the adoption and extended use of Standardised Electronic Health Care Records and the required infrastructure.

BIOPATTERN [220] aims to develop a pan-European, coherent and intelligent analysis of a citizen’s bioprofile; to make the analysis of this bioprofile remotely accessible to patients and clinicians; and to exploit bioprofile to combat major diseases such as cancer and brain diseases. A biopattern is the basic information (pattern) that provides clues about underlying clinical evidence for diagnosis and treatment of diseases. Typically, it is derived from specific data types, e.g. genomics information and vital biosignals such as the EEG. A bioprofile is a personal ‘fingerprint’ that fuses

together a person's current and past medical history, biopatterns and prognosis. It combines data, analysis and predications of possible susceptibility to diseases. BIOPATTERN proposes to provide novel computational intelligent techniques for biopattern analysis and a pan-European integrated, intelligent analysis of an individual's bioprofile. Information from distributed databases will be made available, securely, over the Internet to provide on-line algorithms, libraries and processing facilities for such analysis.

DICOEMS [221] aims to deliver an eHealth platform that acquires and transfers critical information from the place where a medical emergency occurs to remotely located health specialists for immediate assistance. The system instantiates a portable collaboration environment that brings together the on-the-spot care provider and a network of experts, thus enabling more effective decision support and risk management in primary diagnosis, pre-transfer arrangements and treatment of critical situations. The project has developed a wireless technology platform enabling doctors in hospital emergency rooms to remotely manage treatment of accident and other emergency victims. With specially equipped handheld computers or smart phones, paramedics and other emergency personnel first on the scene can send images and critical patient information, including vital data such as pulse, respiration, and ECG, to specialists at hospital emergency departments. Doctors can monitor the patient's condition via streaming video from the ambulance, make a diagnosis and provide detailed medical procedures for paramedics to follow.

SemanticMining's [222] main concern has been semantic interoperability in communication between health care information systems. The long-term goal of SemanticMining has been the development of generic methods and tools supporting the critical tasks of the field: data mining, knowledge discovery, knowledge representation,

abstraction and indexing of information, semantic-based information retrieval in a complex and high-dimensional information space.

Wrapping up:

Projects under this category enhance communication between users making the collaboration more efficient. Mobi-Dev project communicate with patient's databases located within hospitals, private offices and laboratories or pharmacies. WIDENET builds a network of national centers in European level (initially in Belgium). DICOEMS project, send images of incident sites and patients condition to hospital trauma specialists and to Central emergencies switchboards. The experts participate in a collaboration session providing their advice during the DICOEMS session. DICOEMS hosts a collaboration session between the involved peers, transparent sharing human or material resources and knowledge, with the use of PDA/smart phone devices. Similarly, the other projects in this category acquire and transfer critical medical data in order to enhance collaboration between system users not providing sophisticated tools that the eHealth domain requires.

(v) Process Management

This category deals with applications that focus on the management of the clinical process. Some key projects are:

IDEAS's [223] project objectives are the integration, evaluation and demonstration of a Universal Multi-media Distributed and Interactive Architect which supports a large set of application and systems for Tele-health, Tele-radiology and high level Tele-Homecare services, oriented to general medical assistance, to promotion and prevention of health, to render social care to vulnerable groups such as elderly and disabled people. The project will implement the ASP Business Model (Application Service Provider) in

the Health care domain, developing an optimised framework through the integration of standard components, and reducing the development costs and time-to-market of Telehealth applications.

HEARTFAID [224] aims to make more effective and efficient all the processes related to diagnosis, prognosis and treatment of the Heart Failure within elderly population. This general goal will be achieved by developing and providing an innovative technological platform that integrate biomedical data within electronic health record systems, for easy and ubiquitous access to heterogeneous patients data; provide services for healthcare professionals, including patient telemonitoring, signal and image processing, alert and alarm system; support clinical decision in the heart failure domain, based on pattern recognition in historical data, knowledge discovery analysis and inferences on patients' clinical data.

Wrapping up:

These projects focus on making more effective and efficient all the clinical processes (diagnosis, prognosis, treatment, etc). Implicitly, this approach enhances the collaboration process since all these notions are highly correlated.

4.3. Weaknesses and limitation identified

As Table 1 indicates, there is not much research effort on collaboration and workflow support in the existing eHealth applications although some of them claim to do so. Collaboration and Workflow is a more sophisticated notion to be accepted with ease.

The collaboration schemas in many of these projects utilize gimmicks in order to simulate collaboration. Such gimmicks can be the exploitation of common/shared EHR and simple messaging techniques. There are no projects that are using a more sophisticated solution which includes virtual teams, and this is the main reason why in

the Table 1 are marked with "No" under the "Collaboration Support". I consider that collaboration should include more sophisticated methods like the use of virtual teams as identified and described in the next chapter. Worth mentioning is the case of the HealthService24 project that had adopted an early version of the proposed collaboration schema of our system. The initial results were successful as the project scored high marks during the final evaluation.

Similarly, the "Workflow Support" is also marked with "No" due to the fact that there is no effort from the presented projects side on creating a workflow support focusing on the specific needs of the healthcare domain as described in the next chapter. The only case that adopted workflow support is the TOPCARE project. Even so, this workflow support lucks on dynamicity having all the business processes static and pre-defined. In our system, I propose a dynamic workflow support, were new workflows are created and applied anytime and from anywhere, without the need of redistributing any new patch or update. Furthermore this dynamicity provides flexibility on the outcome of the task according to the environment.

Table 1: eHealth Projects' Comparison

Project	Area	Collaboration Support	Workflow Support	Mobility	Dynamic Workflows
C-Care	EHR Access through voice	No	No	Yes	No
CHS	Home monitoring	No	No	Yes	No
HEALTHMATE	Tele-care & Tele-consultation	No	No	Yes	No
HUMAN	Telemedicine	No	No	Yes	No
IDEAS	Universal Multi-media Distributed and Interactive Architect	No	No	Yes	No
MOBIDEV	Integration of eHealth Databases	No	No	Yes	No
MOBIHEALTH	Telemedicine	No	No	Yes	No
TOPCARE	Telecommunication	Through co-	Pre-	Yes	No

		operative healthcare services	Defined		
WIDENET	EHR Interconnectivity	No	No	Yes	No
ARTEMIS	Semantic Web Services	No	No	Yes	No
AUBADE	Analysis of neurological diseases & human emotions	No	No	Yes	No
BIOPATTERN	Citizen's Bioprofile	No	No	Yes	No
CLINICIP	Automatic Insulin Injection	No	No	Yes	No
COCOON	Risk Management	Knowledge Driven Collaborative Practices	No	Yes	No
DICOEMS	Cooperation for Critical Situation	Portable collaboration environment	No	Yes	No
INTREPID	Intelligent Patient Treatment with wearable sensors	No	No	Yes	No
MYHEART	Heart Failures Prevention	No	No	Yes	No
NOESIS	Tools for prevention, diagnosis & treatment support	No	No	Yes	No
SEMANTICMINING	Data Mining of Medical Information	No	No	Yes	No
PIPS	Generic Medical Database	No	No	Yes	No
HEARTFAID	Diagnose, Prognoses & Treatment of Heart Failure	No	No	Yes	No
MPOWER	Middleware Platform for Rapid Development of Services	No	No	Yes	No
HEALTHSERVICE24	Mobile Healthcare System	Early Pilot of the System	No	Yes	No

In the next chapters I will present in more detail the proposed extended model that encapsulates new features like mobile virtual teams, dynamic questionnaires, actions, responsibilities, timeouts, triggers, medical diaries and pro-activeness that supports an advanced collaboration and dynamic workflow provision.

Chapter 5

Extended Requirements

5.1. Introduction

In chapters 2, 3 and 4 I presented the concept of computer supported collaborated work, workflow management systems and existing eHealth systems. Due to the peculiarity of the eHealth domain, these concepts are illustrating singular constrains and requirements. Consequently, in this chapter, I will embrace these notions in the eHealth context, presenting the extended requirements for eHealth applications.

As mentioned before, eHealth applications are very peculiar with special needs and specifications. Furthermore, the Computer Supported Collaborative Work (CSCW) system that will support medical teams must be formulated to cover all these needs. Such CSCW system should adhere:

- **Availability Awareness.** The CSCW system must be aware of the user status (availability), in order to manage better any critical situations.
- **Expandability.** A CSCW system has to be able to expand easily with new workflows and collaboration schemas.
- **Easy information sharing.** Users must be able to share the information they want (and nothing more) with other users, with minimum effort.

- **Flexible messaging methods.** Healthcare specialists are not always computer literate and the system has to adapt to their communication skills. Some specialists prefer the use of emails and others prefer the use of SMS text messages. The system has to provide all means of communication.
- **Availability.** A CSCW system has to be available 24/7 from anyplace and by any means. This brings in the wireless requirement as mandatory.
- **Confidentiality.** Collaboration messages must be confidential and only available to the intended recipients.
- **Security.** All collaboration messages must be secured (at least at a level acceptable to the eHealth domain).

After an extensive analysis of Medical Teams I came to the conclusion that such systems should utilize features such as:

- **Web-based.** Been a web-based application is a new trend that offers many advantages. Some of them are the ability of accessibility (anytime, anywhere and by any means) and always updated.
- **Ad-hoc (Dynamic).** Workflows supporting Medical Virtual Teams have to be dynamic in order to support the ongoing rapid changes that occur in medical situations. Team members' availability and patients' condition constantly changes providing a dynamic context, thus only dynamic workflows can cope with.
- **Recursive.** Workflows must be able to interact with other workflows and the latter ones invoke other workflows till a solution to the problem is found. Even recursive workflows can be formulated.

- **Event driven.** Workflows must be able to be initiated (triggered) by events. Such events can be the change of patient's condition, a message dispatch or even triggered directly by a medical virtual team member.
- **Time triggered.** Furthermore, workflows must be able to be initiated on time expirations (time triggered). For example, a backup workflow is initiated in case no action is taken for a specific event on predetermined time expiration.

All the above, synthesize a set of primal specifications of the workflows for Medical Virtual Teams.

5.2. Collaboration Concepts for Medical Virtual Teams

Collaboration and virtual teams refer to the notion that a team of professionals decides to collaborate over the internet and thus create a virtual team that eliminates the need of physical presence. In general, the proposed collaboration requirements are based on identified scenarios of collaboration analyzed using UML [53]. These scenarios identify the communication and collaborative requirements a computational model must support in an integrated fashion. Creating virtual collaborative teams for the healthcare environment can further introduce new and more specialized requirements.

5.2.1. Understanding Virtual Teams

The traditional image of a working group in a company contains meetings, encounters in the hallway, getting together for lunch and dropping into one another's offices. However, nowadays there are people that work together and do not meet physically one another especially when they are located in different places or spread out around the world or even housed in different parts of the same city. Many teams today never meet

face-to-face, but work together in an online manner. Face-to-face interactions among people from the same organization are the typical old model of teamwork [31].

A virtual team can be closely defined as a *group of people who work interdependently with a shared purpose across space, time, and organization boundaries using technology (ICT)*. The main benefit is that in a virtual team you can do what you can't do alone. The challenge of our time is to learn to work in virtual teams and networks while retaining the benefits of earlier forms. In time, virtual teams will become the natural way to work. Since many virtual teams do occasionally meet physically on predefined time intervals, they find themselves in the conventional face-to-face setting. It is generally agreed that a good virtual team is, in a way, a good team.

Four words capture the essence of virtual teams: *people, purpose, links, and time*. *People* populate and lead small groups and teams of every kind at every level, from the executive suite to the subcommittees of the local school's parent association. *Purpose* holds groups together, which for teams mean a focus on tasks that makes work progressing from goals to results. *Links* are the channels, interactions, and relationships. The greatest difference between in-the-same-place teams and virtual ones lies in the nature and variety of their links. *Time* is a dimension common to schedules, milestones, calendars, processes, and life cycles [31].

It is a fact that sometimes virtual teams fail. One major reason why many virtual teams fail is because they overlook the implications of the obvious differences in their working environments. People do not make accommodation for how different it really is when they and their colleagues no longer work face-to-face. Teams fail when they do not adjust to this new reality by closing the virtual gap. So why put up with the trouble of working across boundaries? Because, when the virtual team is effective and efficient, the business performance is improved dramatically. In brief, the cost can be reduced by

cutting travel costs and time, the cycle time can be shorten by moving from serial to parallel processes and establishing better communications, the innovation can be increased by permitting more diverse participation, stimulating product and process creativity, and encouraging new business development synergies. Finally it can leverage learning by capturing knowledge in the natural course of doing the work, gaining wider access to expertise, and sharing best practices [31].

5.2.2. Definition of Virtual Teams

Even though interactivity is usually presented as a key characteristic of a computer-mediated communication system, the emphasis is often given on the computer-human interaction rather than on human-to-human computer-mediated interaction [30]. The latter is particularly important since virtual teams are effective not only because of the technological advancements but also and most importantly because individuals are able to interact and thus constructively engage in knowledge sharing and creation in the increasingly emergent virtual work environments.

During the last few years there has been an increasing volume of literature on virtual organizations and virtual teams. This body of research generally agrees that virtual teams consist of a collection of geographically dispersed individuals who work on a joint project or common tasks and communicate electronically. For example, Lipnack and Stamps [31] define a virtual team as "*a group of people who interact through inter-dependent tasks guided by a common purpose*" that "*works across space, time and organizational boundaries with links strengthened by webs of communication technologies*". Indeed, virtual teams have been presented in the research literature as a communication intensive and a computer-mediated linked type of group. Electronic data interchange, computer-supported cooperative work, group support systems, as well as

email, videoconferencing and teleconferencing facilities, to name but a few, enable people based in different locations to communicate and coordinate their actions with great speed and effectiveness.

At this point, we are interested in understanding and identifying the refined requirements that define the computational model for supporting such teams, and more specifically medical virtual teams, in the wireless environment.

5.2.3. Medical Virtual Teams

Medical Virtual Teams (MVTs) focus on medical objectives and they consist of medical specialists (e.g. doctors, nurses, physiotherapists, and psychologists). Medical Virtual Teams can be categorized into three major categories based on the physical distance between the team members, also allowing for different organizations. It is interesting to note that the physical distance among team members define the urgency of the collaboration and the need for dynamicity [227].

5.2.3.1 Short Distance Medical Virtual Teams (Hospital MVTs)

The Short Distance Medical Virtual Teams (SDs) are a type of MVTs that are limited into the boundaries of a building (e.g. a hospital). In Figure 4 we can see the SDs as the number 1 virtual team type. In this case all the team members are collaborating mostly wirelessly (via a wireless LAN). In case of an emergency, the MVT is created. After the team members are alerted for the emergency, they physically meet for the best settlement of the problem. This type of MVT requires a less synchronous model and because of that, the team members are unknown before any action is taken (shift based teams[3]).

[3] Teams that are created according to who is working at that specific shift.

5.2.3.2 Long Distance Medical Virtual Teams (Home Care MVTs)

The Long Distance Medical Virtual Teams (LDs) are a type of MVTs where their team members works mostly separated and their lifetime is a bit extended. In Figure 4 we can see the LDs as the number 2 virtual team type. In this case all the team members are collaborating wirelessly (via a wireless WAN). Due to the limitations of the wireless link this MVT model requires an asynchronous model, which in essence guarantees the continuous running of the team. For that reason the team members are well known before any homecare visit (subject based teams). If a team member is unavailable, the system will record the request and when the team member will be available, the request will be served. In case of extreme emergency a backup member is usually assigned. A good example of a LD is a home care medical virtual team such as in the case of DITIS [35] (our case study). DITIS, supports the activities of PASYKAF (Cypriot Association of Cancer Patients and Friends), who run a national home-based healthcare service for cancer patients living all over Cyprus.

5.2.3.3 Variable Distance Medical Virtual Teams (Emergency MVTs)

Variable Distance Medical Virtual Teams (VDs) are MVTs that can change between SDs and LDs depending on the situation they occur. In Figure 4 the VDs can vary between the number 1 & 2 virtual team types. In this case all the team members are collaborating wirelessly apart from few exceptions. An example of a VD is a MVT that handles Emergency medical occurrences. MVT model requires a high synchronous model. As the first model, the team members are unknown before any action is taken (shift based teams). The main problem in all types of MVTs is that all the properties can change dynamically. Every system must be tolerant in every change that may occur.

5.2.4. Formalizing Virtual Teams

Given the analysis of the eHealth projects, presented in chapter 4, and the requirements indentified, I hereafter propose an extended collaboration model enhancing the existing one with vital modules that could support multi/cross organization collaboration. Users collaborating from hospitals, social worker office, nurses from various organizations, etc for a certain common goal. A clear classification of the various types and forms of medical teams based on the dimensions of time, place and organization was spawned, identifying eight types of collaboration is presented in Figure 4.

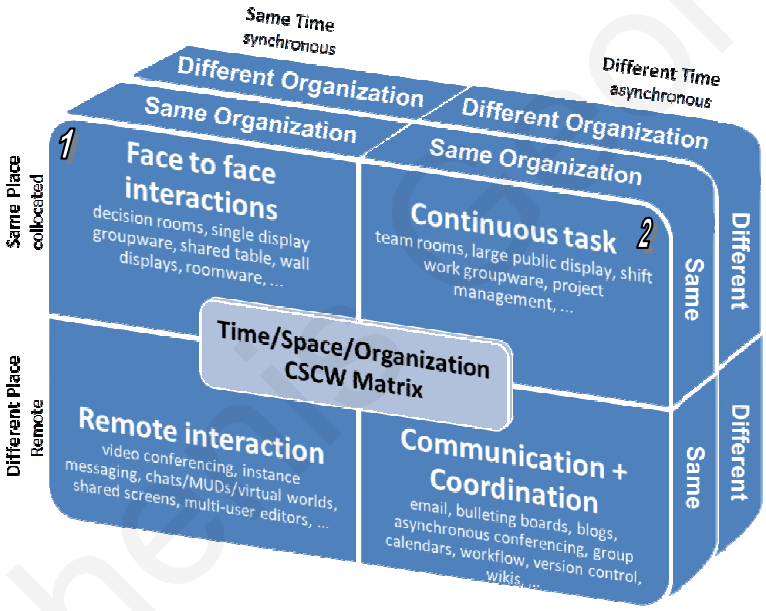


Figure 4: Types of Collaboration

Figure 4 presents a clear classification of the various types and forms of virtual teams based on the dimensions of time, place and organization. Eight cases are identified, in four cases, the members of virtual team, belong in the same organization, in other four cases the members are in the same labor space and in other four, the members work simultaneously [34].

5.2.5. Discussion and Technical Requirements

In the previous section, I mentioned in brief the preferences that categorize the Medical Virtual Teams (MVTs). These preferences that make these categorizations are (i) the collaboration model, (ii) the identity of the team members, (iii) the type of the network that the MVT will be active on, (iv) the distance between the team members and finally (v) the devices that the member will use.

Before the creation of the MVT, we need to clarify the need of collaboration between the team members. This analysis, will determine if the MVT will use a synchronous or asynchronous collaboration model. For instance if we conduct an analysis that will show that the system requires rapid requests and responses then we will definitely use a synchronous collaboration model. Otherwise we prefer the asynchronous collaboration model, like in the case of DITIS [68].

Our next concern should be the type of the network and the type of Medical Devices we will use. These two preferences will determine the application model that we will use. As we saw above, all the types of the MVTs are using wireless networks as the communication medium. Therefore, it would be better to use an application model that supports an agent to the fixed network that will maintain the user's instance all the time. There are two models for this functionality; the Client/Agent/Server and the Client/Intercept/Server Model [28]. Considering the capabilities of the mobile devices that will be used, we choose between the two application models (Client/Agent/Server and Client/Intercept Model). Nowadays, most of the Medical Mobile Devices are small in resources and size. This reason makes the Client/Intercept Model inappropriate.

Another characteristic is the boundaries that the MVTs will act. This is very important characteristic, because as we noted previously the MVTs types are categorized mainly by the distance between the team members. The distance, between others, determines

many things like the cost of supporting the MVT (which is vital to the MVT's existence) and the need for synchronous or asynchronous model.

Summarizing the above, we can compare the three models of MVTs with the following table (Table 2).

Table 2: Mobile Medical Teams Properties

	SD	**LD**	**VD**
Collaboration Model	Synchronous	Asynchronous	Synchronous
Medical Mobile Devices	Small-Mid Devices	Small Devices	Med-High Devices
Team Member Identity	Shift Based	Subject Based (e.g. Patient)	Shift Based
Boundaries	Within a Building	None	Vary
Network	Wireless (wifi)	Wireless (3G/GPRS)	Wireless (wifi/3G/GPRS)
Application Model	Client/Agent/Server	Client/Agent/Server	Client/Agent/Server

In conclusion, **Short Distance MVTs** are synchronous, shift-based within building boundaries teams, **Long Distance MVTs** are asynchronous, subject-based teams and **Variable Distance MVTs** are synchronous, shift-based teams. The continuous presence of the collaboration even during disconnections members is a must in all the types of virtual teams.

5.3. The Computational Model for Wireless Medical Virtual Teams

In such unpredictable environment, like the wireless one, it is inevitable that we want systems that will be persistent and fault tolerant, even when disconnections occur. The question that rises is: "which is the best combination of technologies for creating collaborative virtual medical teams?" To better answer the above question we split the problem into different layers. The first one is the technological layer, in which we examine the technologies that we'll use for the wireless networking and the types of the devices that the team members will use. The second layer is the application architecture layer. In this layer we examine the proper application model that we'll use, depending

on the decisions that we'll make in the first layer. Finally, there is a third layer in which we examine the way that the collaborative virtual team will be implemented. This layer is related with the other two layers. Thus, these three layers are dependent on each other, so the procedures of the analysis and deployment start together for all three of the layers (Figure 5) [34].

The technological layer must be examined after the analysis of the third layer, because we have to first identify the nature of the virtual teams. We can easily exclude the technologies that they depend on being in direct line of sight or technologies that work within few meters (e.g. IrDA, Bluetooth), because when we talk about virtual teams, we assume that a respective distance between the team members exists. Two of the things that we have to determine are the immediateness of the communication and the real distance between the team members. The distance between the team members reflects on the type of the wireless network that we will choose. If the virtual team moves within the boundaries of a hospital a WLAN may be suitable. If the team members work in locations spread all over the country, we could use a cellular network type of network (e.g. GSM/GPRS/UMTS). The immediateness of the communication determines the type of the connection that we'll use. For example if we want to send information to the team members all the time we'll choose a connection that the users will be always online (e.g. GPRS or UMTS) [34].

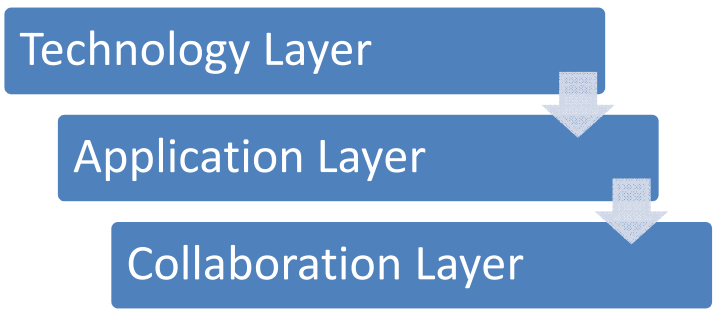


Figure 5: Identifying the appropriate Computational Model

In the application architecture layer, appropriate models are the Client/Agent/Server and the Client/Intercept/Server, depending on the resources that the mobile devices have. If the team members possess mobile devices with many resources, then we can use a Client-side Agent for handling disconnections that may occur. What is obvious is the necessity of a Server-side Agent. This agent will not only exist for sustaining the user's existence in the network, but also for sustaining the user's existence in the virtual medical team [34].

In the final third layer, we have to guarantee that every team member will be equal to the other team members in the virtual team anytime. Thus, we can use an agent for each user, representing him in every action. The agent will be always online and connected with the other members of his virtual team. Users can communicate with each other through their agents. The agent receives the message from the senders' agent and forwards it to his user for advising. If the user isn't connected, the agent waits for the user to connect or responds by himself depending on his responsibilities [34].

A system that successfully applies the technologies that are mentioned above is our case study, DITIS (Collaborative Virtual Medical team for home healthcare of cancer patients) [35]. In DITIS the Client/Agent/Server application model is used. Every user is represented by a mobile agent. Thus the virtual medical team exists anytime even after a disconnection. During DITIS deployment, serious stability and steadiness problems were observed due the use of the mobile agent technology. Mobile agent technologies were research platforms running under Java virtual machines, slowing down the process of data and having late responses in data requests due to technology heterogeneity. In order to overcome this problem, I adopted web services and SOA model. All issues that were handled by agents were also managed as well as with web services. The only advantage of the mobile agents was the ability to move between

computers, but due to the limited processing of the mobile devices, this feature was disabled. SOA architecture was proven to be more stable and suitable for this type of applications.

5.4. Extended Features for eHealth Applications

During the user requirements analysis for the development of our system, a set of features was also identified. These features provide the new dimension of our extended model and a more effective and efficient way of collaborating within the eHealth context. These include: Healthcare Virtual Teams, Dynamic Workflows, Events, Actions, Timeouts, Triggers, Responsibilities, Questionnaires, Medical Diaries and Pro-activeness. In the following section I present these features in a formal way.

5.4.1. Healthcare Virtual Teams

The key elements of our collaboration system are the users, the roles and the virtual teams. By Users I denote the set *U* of the users that are participating in the system.

$$U = \{u_1, u_2, ..., u_n\}$$

By Roles I denote the set *R* of all the available roles that a user can participate in the system.

$$R = \{r_1, r_2, ..., r_m\}$$

Additionally, users have a default role upon their establishment in the collaboration system. This default role is accessed by the function:

$$dr(u_i)=r_j$$

The notion of a virtual team *Ti* is denoted by a subset of Cartesian product of the sets *U* and *R*. In other words, we have:

$$T_i \subseteq UxR \Rightarrow T_i \subseteq \{(u,r) : u \in U, r \in R\} \neq \varnothing, i \in N$$

Through this definition, we can see that the users can participate in a virtual team having a role different than their default one. Furthermore, users can participate in a virtual team having multiple roles and many users participate in a team with the same specific role. The set of all virtual teams *VT* is defined as:

$$VT = \bigcup_{i=1}^{n} T_i$$

Consequently, the number of all possible virtual team is: $|VT|=|UxR|$. We can see a graphical representation of the model in Figure 6.

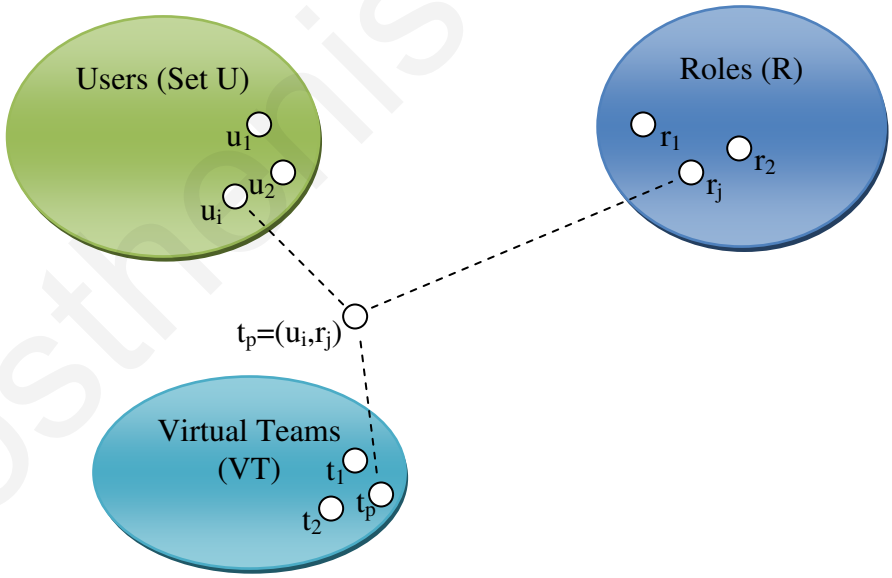


Figure 6: Virtual Teams Model

5.4.2. Dynamic Surveys

Another key feature of our system is the surveys. Surveys can be described as a collection of questions. Surveys can be sent to individuals in order to be completed. The results are sent back to the sender and gathered in one place, so we can review the results one by one or just have an overall result (voting). This service allows us to create, view, modify, delete and complete surveys.

In order to give a proper definition of what is a survey, we have to define first all the sub components of a survey. These sub components are the questions and the answers. Similarly to the above we have a set of answers.

$$AN = \{an_1, an_2, ..., an_z\}$$

A question q_i is defined as a set of answers. In other words:

$$Q = \{q_1, q_2, ..., q_z\} \text{ where } q_i = \{an : an \in AN\}$$

Finally, a survey qu_i is a set of questions.

$$QU = \{qu_1, qu_2, ..., qu_z\} \text{ where } qu_i = \{q : q \in Q\}$$

In Figure 7 we see the graphical representation of the model.

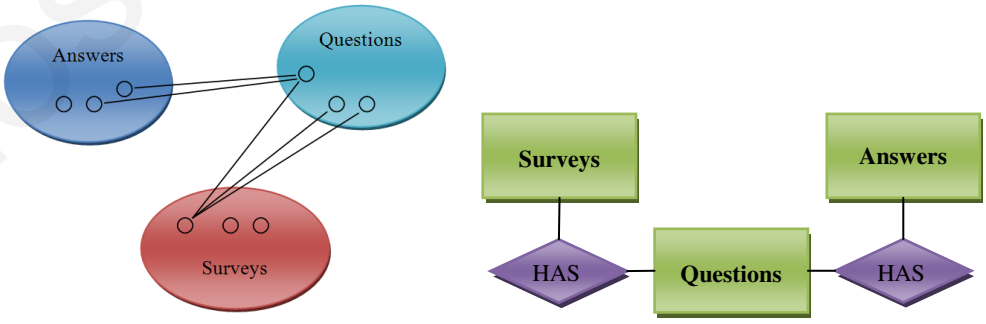


Figure 7: Surveys Model and ER

In this scenario, I demonstrate the dispatch of survey and the collection of the answers. Head Nurse (Athena) creates a survey and sends it to the members of a virtual team. The 4 members of the team, receives the surveys and answer the questions. The answers are send back to the Head Nurse (Athena) and she reviews them (Figure 8).

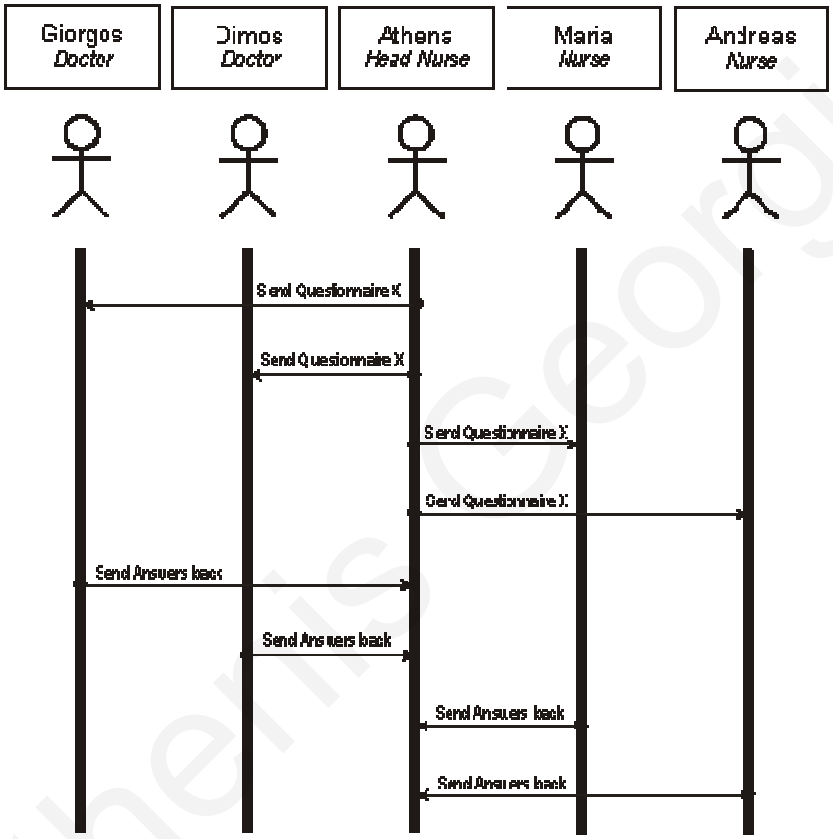


Figure 8: Surveys Scenario

5.4.3. Actions

An action is what a person can do. It could be just sending a message or a more complicated action. These messages are predefined and created by the system administrator. Usually *actions* are the actions and activities of the users or other specific roles. A more complicated action is calling a stored procedure. This action can encapsulate information that the administrator and/or the users pass. Additionally, an

action can call an existing workflow by sending an interactive message (presented in section 5.4.6). A mathematical representation of all actions is:

$$A = \{a_1, a_2, ..., a_z\}$$

5.4.4. Responsibilities

Some actions are requested to be performed by only one user of a certain role. We can notify all users of this role and send them the action to be performed. The first user that will get the action can take the responsibility of completing this task. All other users will be notified that this task is handled by another person. This way we avoid duplication of work. For instance, we can have the scenario that one nurse is asking for a drug prescription from any doctor in the organization. We don't want to have more than one doctor to prescribe the same drug. The Responsibility feature can mathematically represented as:

$$Rs = \{(u, r, a) : u \in U, r \in R, a \in A\}$$

Needless to say that a protocol needs to be defined to solve a potential deadlock. The solution to this problem introduced the timeouts and the triggers that are presented in more detail in the next section.

5.4.5. Timeouts & Triggers

Under the scope of the medical virtual teams, we have assignments of roles to patients. There are times though that certain tasks are of vital significance (urgent tasks) and thus the need for the dimension of time is spawned. We can set a timeout on such crucial action. When the timeout expires, another action or workflow is trigged. For example, we can have a nurse asking for a doctor's help. Nurse will initially ask help from the doctor of the patient's virtual team. After the timeout occurs, another action will be

triggered. The new action for example could be to ask help from any doctor of the system. A variant of such protocol were identified and implemented. The system provides the capability to set the exact timeout configuration and plan the actions during execution phase.

In this scenario, Head Nurse (Athena) sends the workflow (ChangeMedication(sameVT)) to the virtual team of a patient (members: Giorgos, Athena, Maria). The workflow automatically sends an action (NewMedication) to the doctors of the team (in this case only to Giorgos). In this workflow there is a 5 minutes timeout on the action. In case of timeout, a new workflow will be triggered (ChangeMedication(all)). It has the same action (NewMedication) but this time it will be send to all doctors of the organization (Giorgos, Dimos). Next, doctor Dimos takes the responsibility for the action, so an automatic message goes to the other doctors (Giorgos) that doctor Dimos will complete the action. Finally, doctor Dimos send a message to the Head Nurse (Athena) that she has the authority to change the medication of the patient (Figure 9).

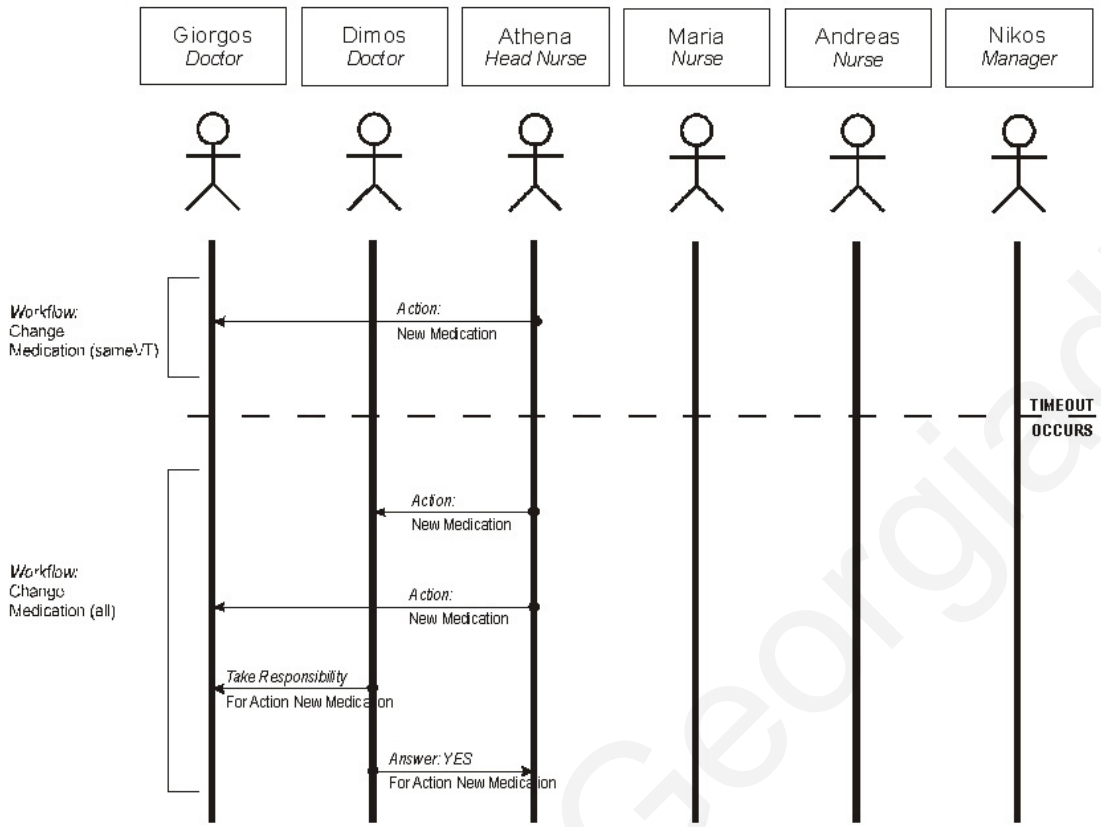


Figure 9: Timeout & Responsibility Scenario

5.4.6. Workflows (Interactive Message)

One of the scenarios depicts a head nurse that triggers a workflow that requests for a change of medication. An automated message from the workflows is dispatched to the doctor that belongs to the virtual team of the certain patient asking him for an approval, since the nurse isn't authorized to do so. The doctor responds to the message and the workflow updates the medication and in addition alerts all the corresponding medical team for this important change (Figure 10). Through this workflow, we notice that the head nurse didn't have to know who is the doctor of the patient and the doctor didn't have to know the medical team and alert each one of them saving precious time.

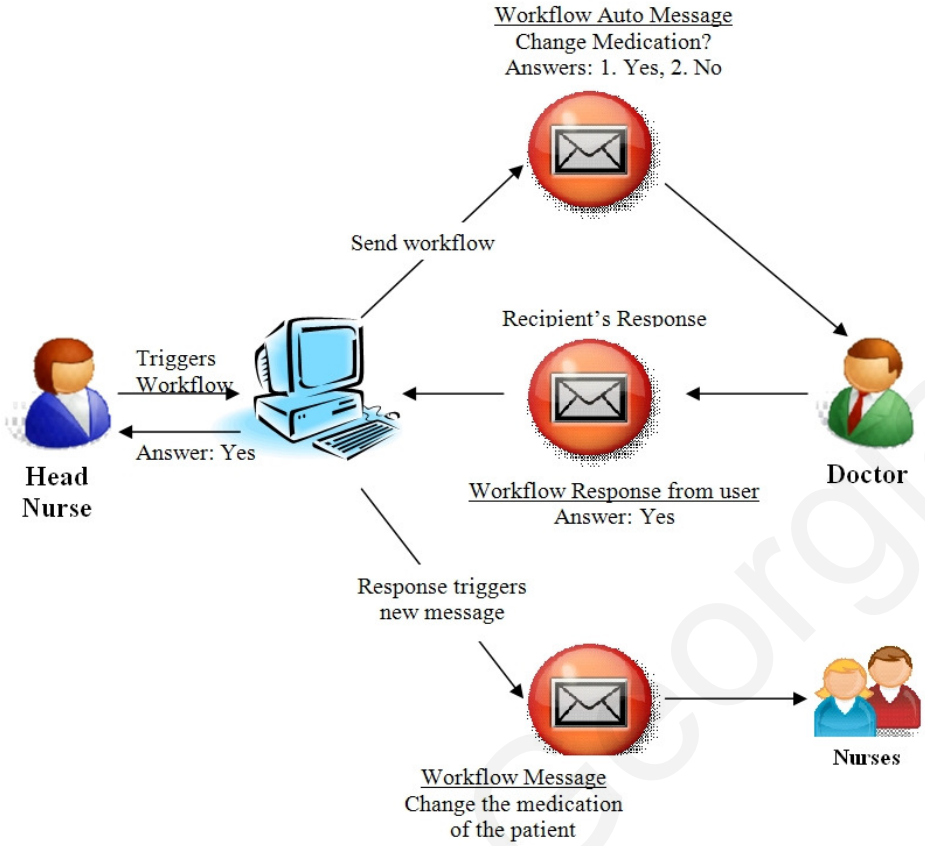


Figure 10: Workflow Example

Workflows are sets of actions that are initiated by sending a predefined message to another user. These messages are special messages that trigger actions and thus they make the users to interact with each other.

Workflows are defined as a set of actions connected with users or roles or virtual teams or virtual teams and roles together and with another workflow. For example, we can have the action "Visit Patient" and send it to one user of the system or to every doctor of the system or to the virtual team of the patient or to the doctors of the virtual team.

So, if A is the set of all actions of the system ($A = \{a_1, a_2, ..., a_z\}$), then:

$$W = \{(x, y) : x \in A, y \in U \cup R \cup T \cup RxT \cup W\}$$

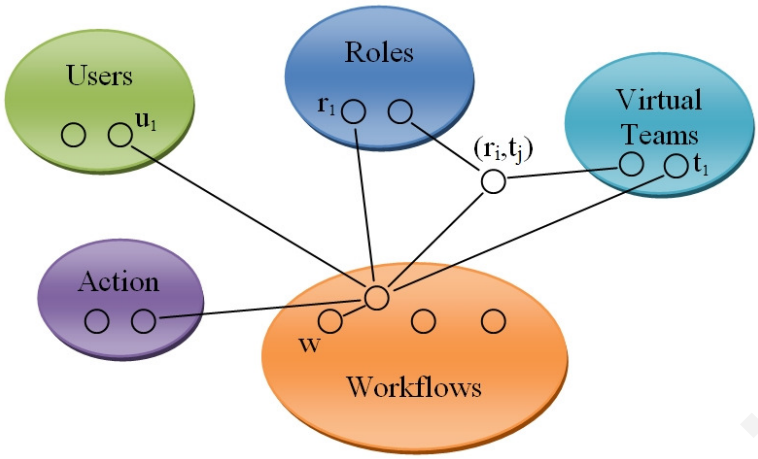


Figure 11: Workflow Model

Under the notion of the pre-mentioned timeouts and triggers, the idea of the events is spawned. Events are the elements e of the set E that triggers a workflow. Such events are the decision making of a user (complete an action) or it can be a timeout (predefined time expiration of a task). In other words, actions can trigger an event and events can trigger a workflow. So, if the mathematical representation of events is:

$$E = \{e_1, e_2, ..., e_m\},$$

then there is a function *g* that given an action *a*, it returns the generated event.

$$g(a) = \begin{cases} e & \text{if } a \text{ triggers a new event } e \\ NULL & \text{otherwise} \end{cases}$$

Similarly, we have a function *f* that given an event *e*, it returns the workflow *w* that it triggers:

$$f(e) = w \Leftrightarrow f(g(\alpha)) = w$$

In other words, the workflow system is a set of ordered pairs of events *e* and workflows *w (e,w).*

$$\text{Workflows} = \{(e, w) : e \in E, w \in W\}$$

5.4.7. Medical Diaries

Medical diaries are an easy self-monitoring method, used by patients from any mobile device. During this procedure, patients maintain a daily record of their symptoms (e.g. pain control ranking the symptom on a scale). It's a very simple procedure that uses only a few clicks and predefined text answers due to the mobile devices limitations. Medical Virtual Team can review anytime these diaries and suggest or take actions or initiate a workflow. Additionally, I introduced the notion of the threshold. Threshold is a limit on a diary entry that can be set to trigger a workflow or alert the team. For instance, a patient marks a pain of grade 10 in his pain diary. Then, a message can be send to his Medical virtual team, notifying them about this event.

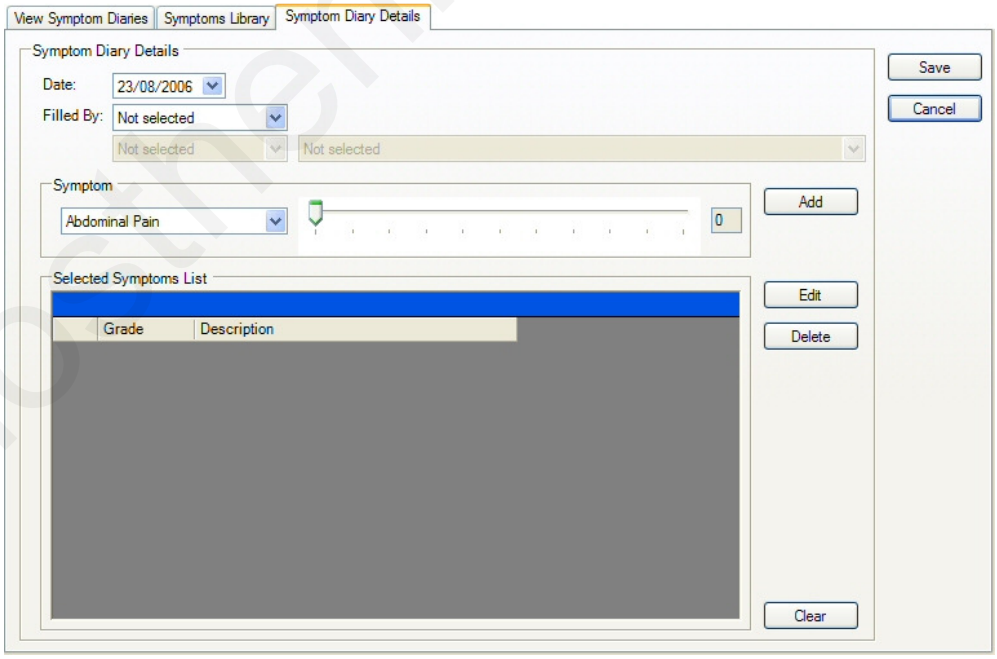


Figure 12: Medical Diaries

5.5. The Extended Features through a Scenario

In order to demonstrate these features in a more comprehensive manner, I will provide a scenario that describes these features and their functionality. In Figure 13 I present a simple scenario that includes the majority of the pre-mentioned features (in red color I denote the involving features). In this simple scenario, Patient Anna fills her Pain Diary. A value of high pain is triggering the workflow: "I feel pain". This workflow alerts all users of role "Doctor" and belongs in Anna's virtual team. Because of the importance of this event, the workflow was designed with a timeout. The timeout triggers another workflow that involves users with the role of Doctor, but not only the ones of this virtual team. This time, Doctor George responds to this task and takes the responsibility of answering the question on the medication change. This prevents other doctors to execute the same task.

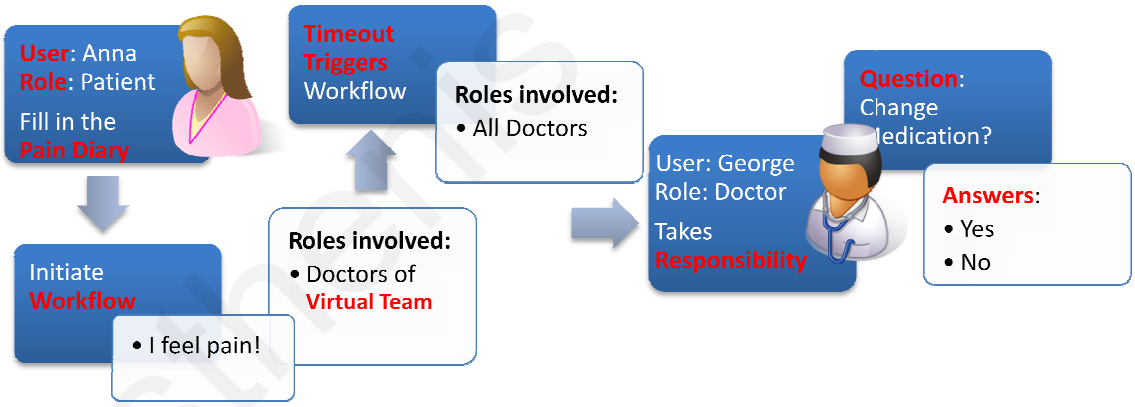


Figure 13: Workflow Scenario

5.6. Conclusion

In this chapter, I identified and modeled the key features that constitute the extended model that I will thoroughly present in the next chapter. These features were denoted through an analysis of the theoretical considerations, the collaboration concepts and the formalization of virtual teams, all under the eHealth Context. Furthermore, I took into consideration the wireless environment and thus put forward an appropriate

computational model for wireless MVTs. MVTs are modeled as Short, Long and Variable Distance according to their users' location. Furthermore, I proposed an appropriate computational model for each one of these teams. Finally, I defined the extended features of the proposed system that I will present in more detail in the next chapter, such as: Healthcare Virtual Teams, Dynamic Surveys, Actions, Dynamic Workflows, Responsibilities, Timeouts, Triggers and Medical Diaries.

Chapter 6:

Extended Model, Architecture, Design & Implementation of the system

6.1. Introduction

In this chapter, I will present the extended architectural model supporting the functionality presented in Chapter 5 and the overall Architecture of the system through the presentation of various collaboration cases showing the system functionality, cohesiveness and consistency. Furthermore, I will present the design of each component such as medical virtual teams, dynamic workflows, actions, workflows, responsibilities, timeouts, triggers and medical diaries. Finally, I will present some representative screenshots on the implementation of the system.

6.2. Model

During the phase of the analysis, a set of features was identified (Figure 14). These features provide the new innovative dimension of our extended model and a more effective and efficient way of collaborating within the eHealth context. These features form modules grouped as: **(i) Medical Virtual Teams, (ii) Dynamic Workflows, (iii) Events, (iv) Actions, (v) Timeouts, (vi) Triggers, (vii) Responsibilities, (viii)**

Questionnaires, (ix) Medical Diaries and (x) Pro-activeness, always within the peculiarities of the wireless medium. In the following section I present these modules in more detail.

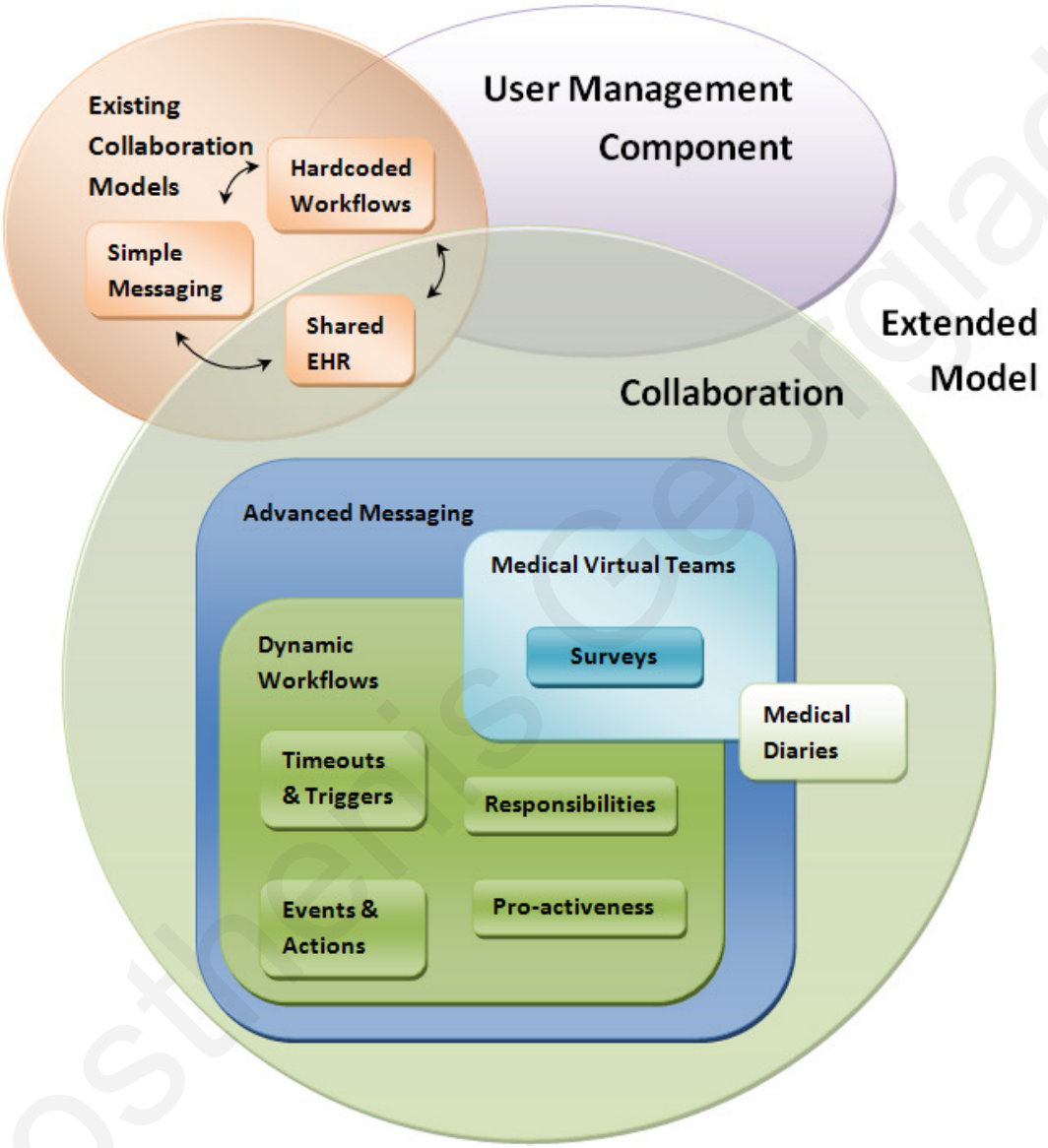


Figure 14: Extended System Model

6.3. Architecture

The system architecture is basically divided into 4 layers. These layers are the Application/User, the Workflows, the Services, the Sensors and the Database both on the same layer as parallel (Figure 15).

The Application/Users layer is the layer that hosts our GUI that provides all the necessary functionality for a flexible, efficient and effective collaboration, covering all the pre-mentioned requirements (e.g. events, actions, workflows, etc…). This layer can be altered according to the hosting organization's needs maximizing the added value of the system.

The Workflows layer is the layer that hosts the dynamic workflows as described earlier. It resembles the business processes layer in the SOA architecture, having an orchestration and coordination of the basic system services, but in a more dynamic and ad-hoc manner.

The services layer hosts the basic services that provide all the functionality of the system such as security, messaging, database access, sensors data access, etc. These services can be called directly from the application or from a workflow, and even more from another service.

Finally, the last two layers are the Sensor that hosts all the available sensors of the system (such as: temperature, sound, light, vital signals, etc) and the Database layer that hosts the DBMS of the system. The Sensor Layer is an optional one that sends readings to the DBMS from the sensors for future use by the application. The DBMS store also all the data for the user management, collaboration features, virtual teams, dynamic workflows, actions, questionnaires, etc.

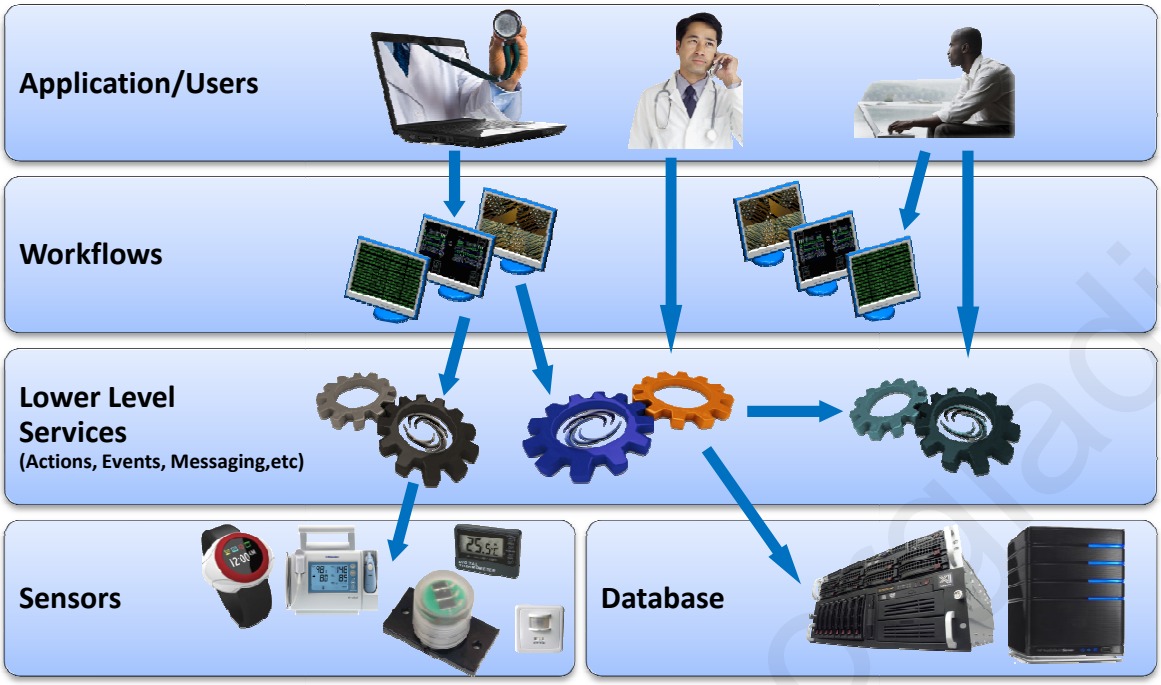


Figure 15: System Architecture

6.4. System Modules

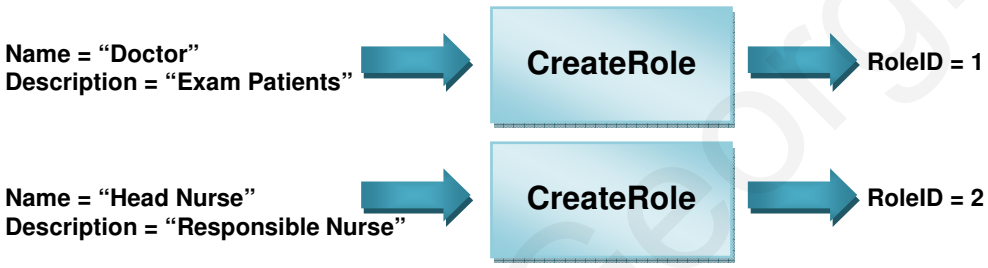
In this section, I will present various cases that helped us in identifying the requirements and system modules, showing the data flow management needs. These cases were used in the implementation phase of our system.

The main scenario that is analyzed was the creation of the medical virtual teams. This scenario prompted the notion of users and roles. In Case 1 I present the creation of roles and in Case 2 the creation of users. Later, in Case 3 I create the virtual team and in Case 4 populate the teams with users. The messaging module is presented in Cases 5, 6 and 7. In Cases 8, 9, 10 and 11 I present the Survey Module. Finally, I present the Workflow module through the Cases 12,13, 14 and 15.

Medical Virtual Teams Module

Case 1: Creation of user roles

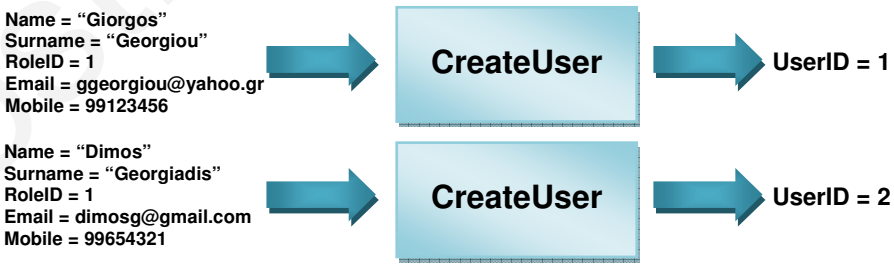
During the creation of the medical virtual teams, the users entries have to exist already in the system, thus the creation of users comes first. Furthermore, in order to create a user, we must define the roles. Consequently, in this case I illustrate the creation of basic roles (such as Doctor, Head Nurse, Nurse, etc…) calling the CreateRole method with the proper variables.



Case 1: Creation of user roles

Case 2: Creation of Users

As mentioned above, in order to create a virtual team, initially we have to create the roles of the persons in the member team, and then the users. In case 2 I present the creation of users Giorgos and Dimos as Doctors by calling the CreateUser method with the proper variables.

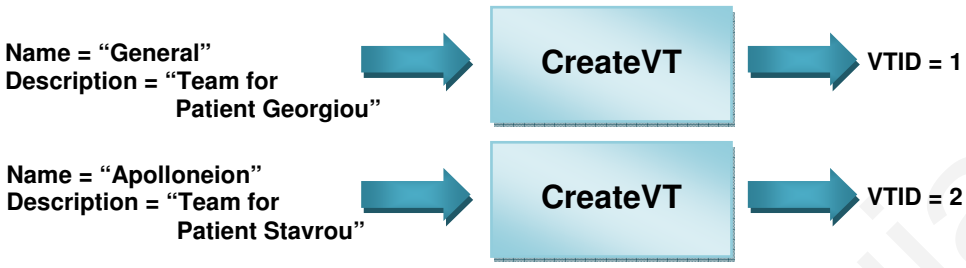


Case 2: Creation of Users

Case 3: Creation of virtual teams

Having in hand the roles and the users of the system, we can proceed with the creation of the medical virtual teams. During this phase, the assignment of the users is not

possible since there are no virtual teams. In this case we have the creation of virtual teams calling the CreateVT method with the proper variables. The following example creates virtual teams for patients Georgiou and Stavrou.

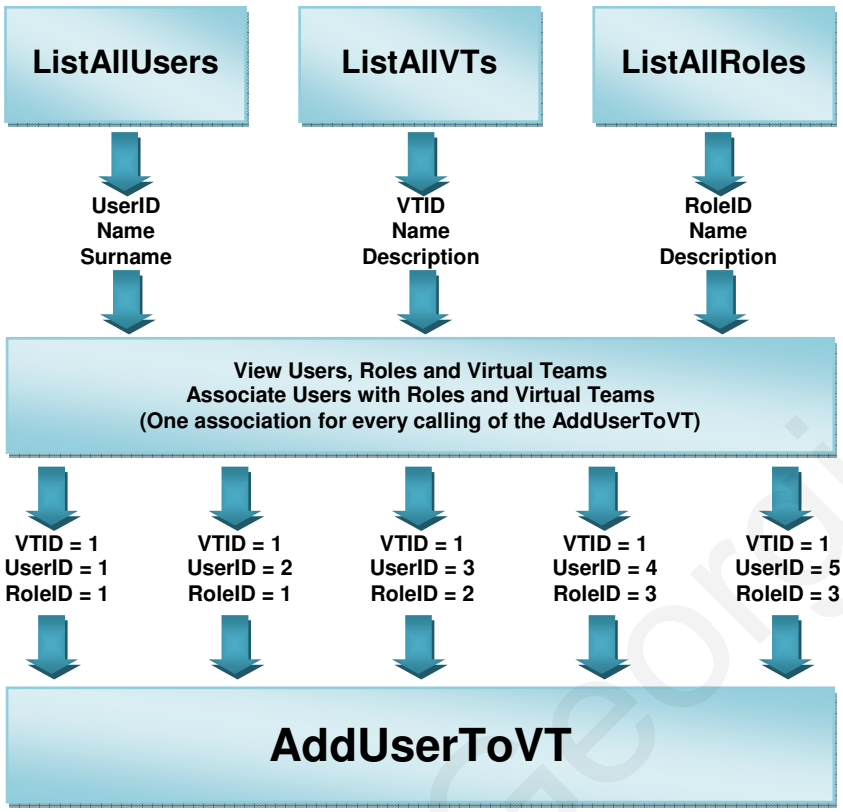


Case 3: Creation of virtual teams

Case 4: Assigning users to roles of a Virtual Team

Finally, the next logical step is to assign users to a virtual team having a certain role. In case 4 we associate 5 users (Giorgos, Dimos, Athena, Maria and Andreas) based on the role that each one should have.

Initially, we list all Users (ListAllUsers method) to view all the users of the system, next the list of all Virtual teams (ListAllVTs method) to view all the virtual teams and finally the list of all Roles (ListAllRoles method) to view the available roles of the system. The purpose of all this is to associate a user to a virtual team with the proper role. Calling the AddUserToVT giving the right parameters we apply this association. In order to complete this case, we have to repeat these steps for each user (5 times).

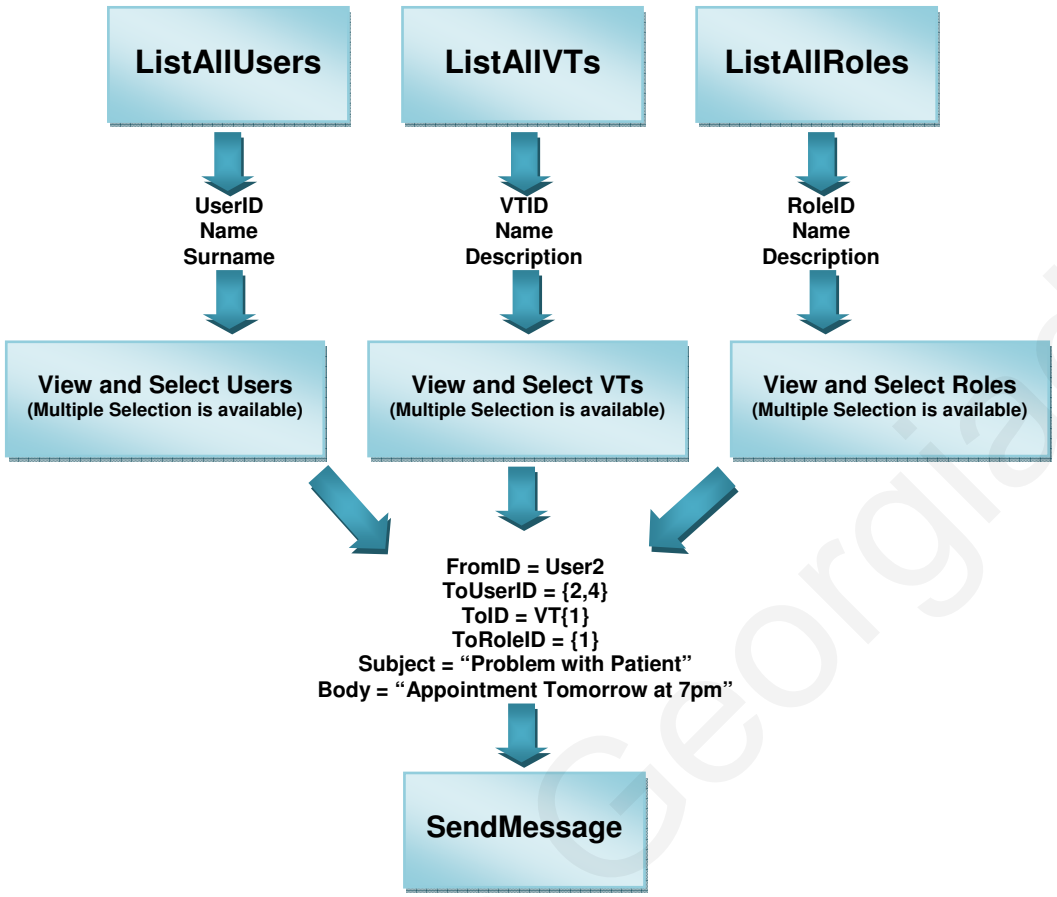


Case 4: Assigning users to roles of a Virtual Team

Messaging Module

Case 5: Sending Messages

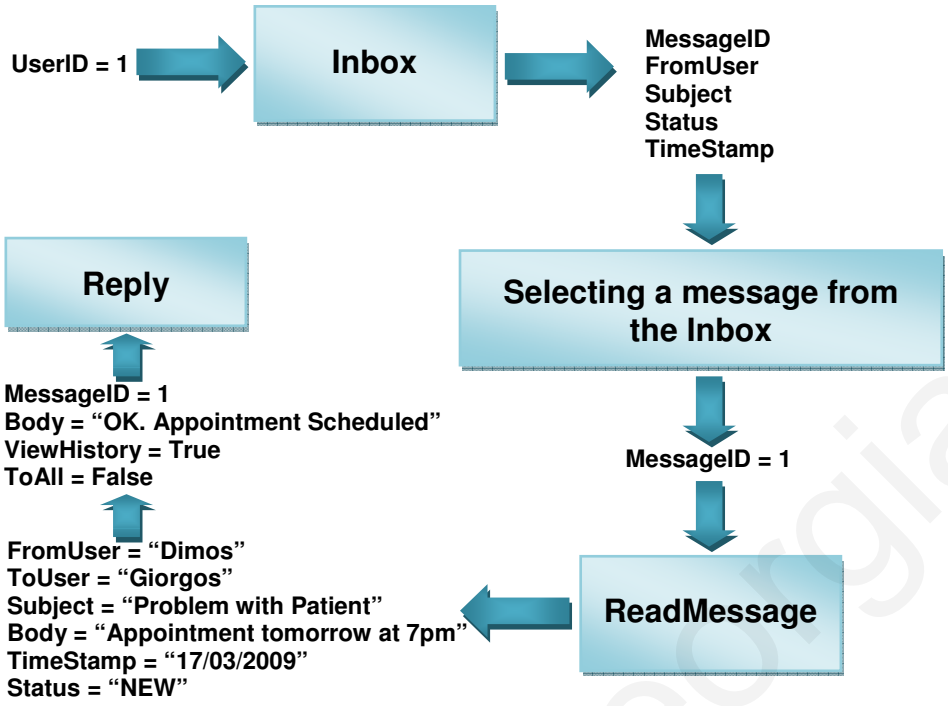
Through our analysis, a basic service in order to have a functional collaboration is the Messaging Service. Users must enable users to send messages to other users, roles or even virtual teams. In case 5 I present the procedure of dispatching a message to a virtual team, 2 users and 1 role. In the first step we list all Users, all Roles and all Virtual teams (ListAllUsers, ListAllRoles and ListAllVTs) in order to review the users, the roles and the virtual teams of the system. Following we select the recipients of the message and complete the additional information of the message like Subject and Body. By passing this information to the SendMessage method, the message is dispatched.



Case 5: Sending Messages

Case 6: Reply to a message

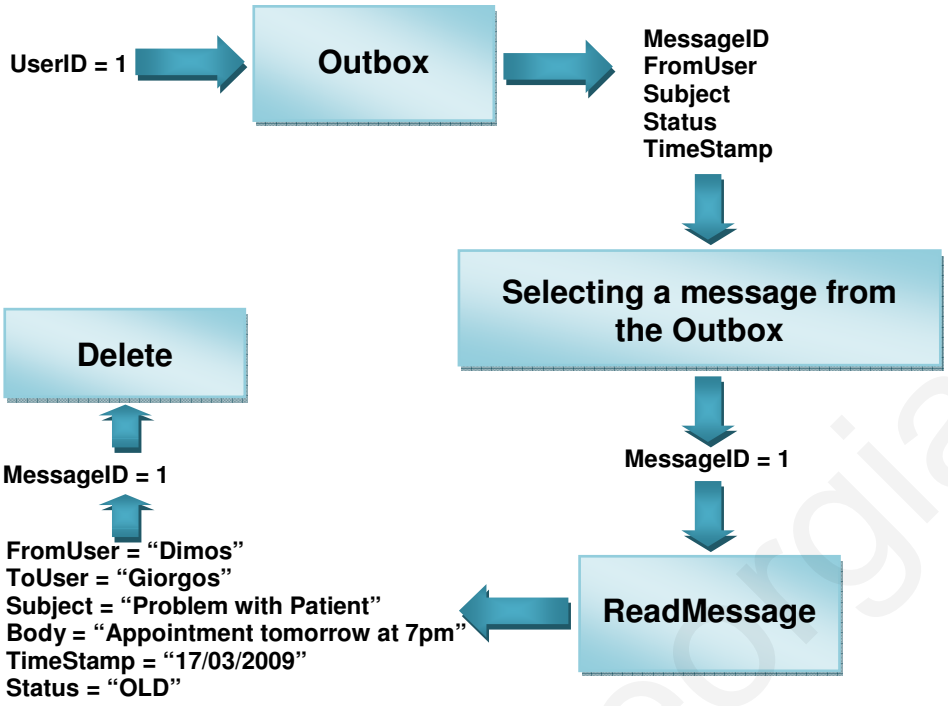
Under the same messaging module is the capability of viewing and replying to a message. In this case we view the messages that were send to our Inbox calling the Inbox giving the user ID. The method Inbox returns the titles of all incoming messages. By selecting a message, the module returns the message details (the ReadMessage method is called with the Message ID as parameter). Similarly, the users can reply to a message using the Reply method with the use of the Message ID and writing the body of the reply message. Additionally, users can select to include the body of the original message to the reply and select more recipients of the reply message.



Case 6: Reply to a message

Case 7: Delete a message

The next logical step is to delete old unwanted messages. First of all we have to select a message and view it. To view the messages that are stored for example in the Outbox folder, we call the Outbox method giving the ID of the user. The Outbox method returns the titles of the messages and their ID. Then, we select a message, (ReadMessage method) and the details of the message are returned. Users can delete the message by calling the Delete method with the message ID as parameter.

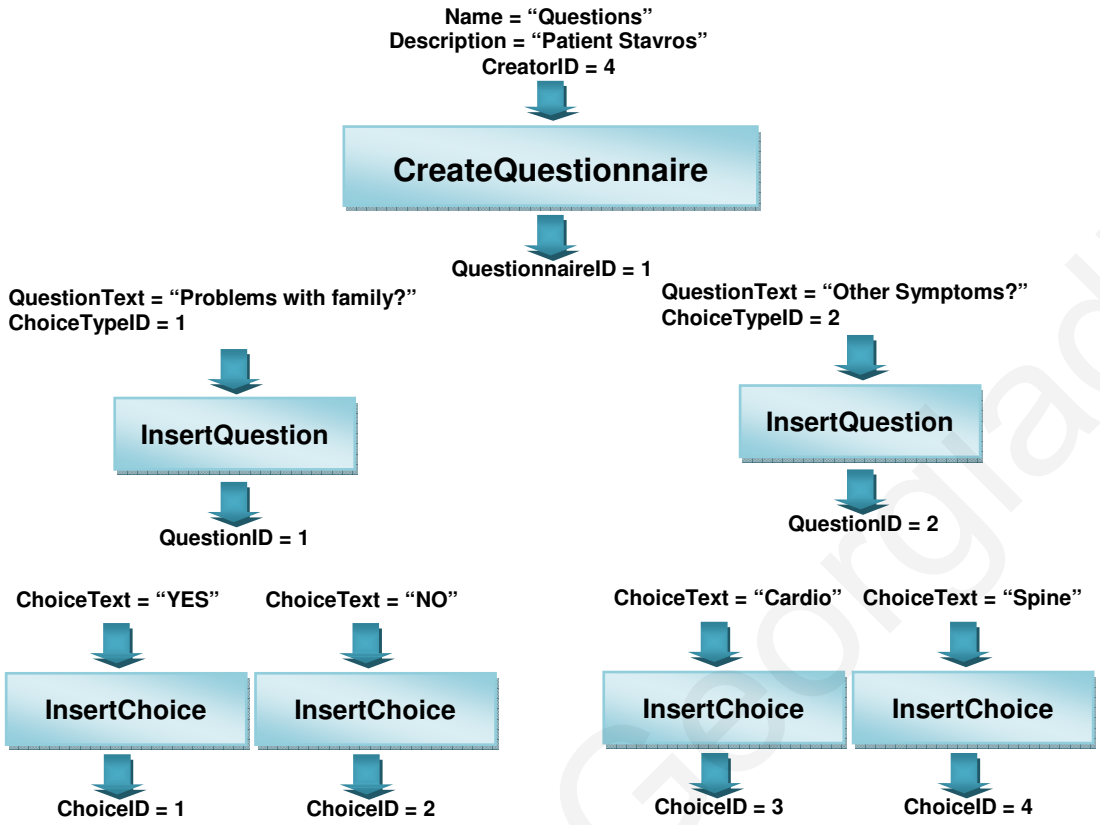


Case 7: Delete a message

Surveys Module

Case 8: Creation of a Survey

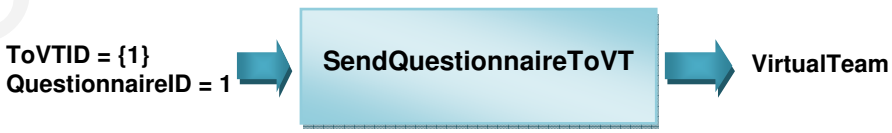
A more complex collaboration example is the dynamic surveys. Users can create surveys at runtime assigning questions and possible answers (therefore I also call them questionnaires). In case 8 we have a survey (questionnaire) that contains 2 questions with 2 selections each. Initially, we create the questionnaire (with the use of the CreateQuestionnaire method) giving the proper information (description, etc). Following, with the use of the Questionnaire ID to create a question (the InsertQuestion method is used). Then we add selections to a question with the Question ID as a parameter (through the method InsertChoice).



Case 8: Creation of a Survey

Case 9: Publishing a Survey

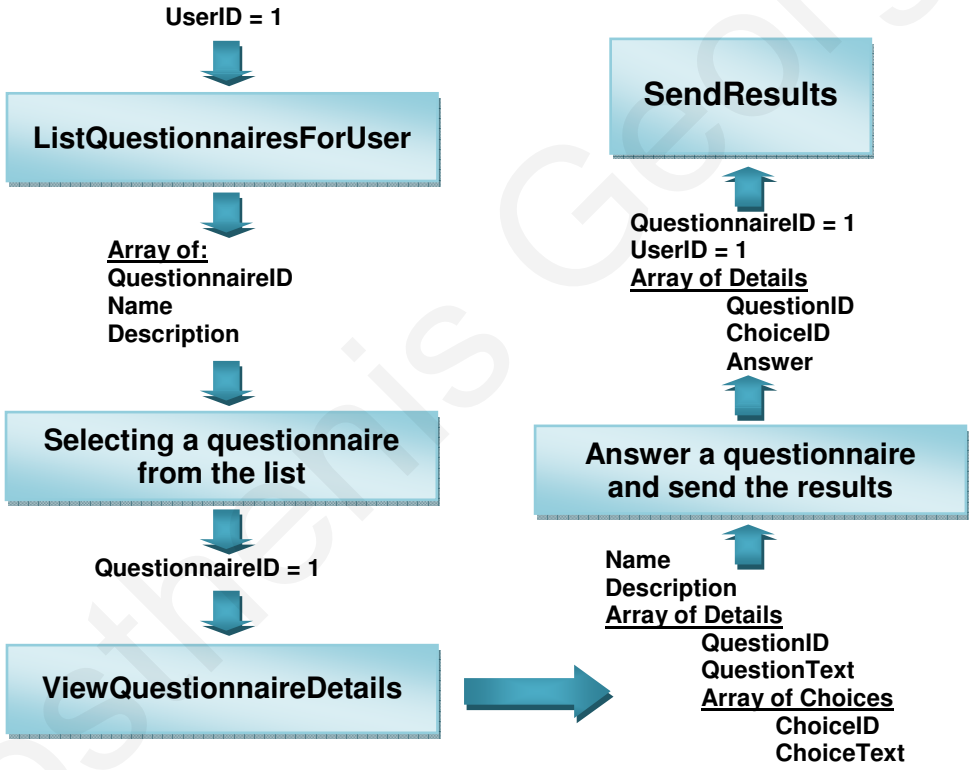
In order for the users to collaborate using the surveys, we have to be able to publish (send) surveys to other users or virtual teams. In this case I will demonstrate how to send a survey to a virtual team. In order to do that, we publish the survey by giving the Questionnaire ID and the Virtual Team ID as parameters to the proper service (the service that is called is the SendQuestionnaireToVT).



Case 9: Publishing a Survey

Case 10: View and answer a Survey

After receiving a survey, users must be able to view and answer it. In order to do so, we list all surveys assigned to the user (ListQuestionnairesForUser method). Through this method, we retrieve the surveys (questionnaires) that were send to a user. User selects a survey and reviews the details be clicking on the survey (ViewQuestionnaireDetails method). After answering the questions, he submits the results to the system (SendResults method).

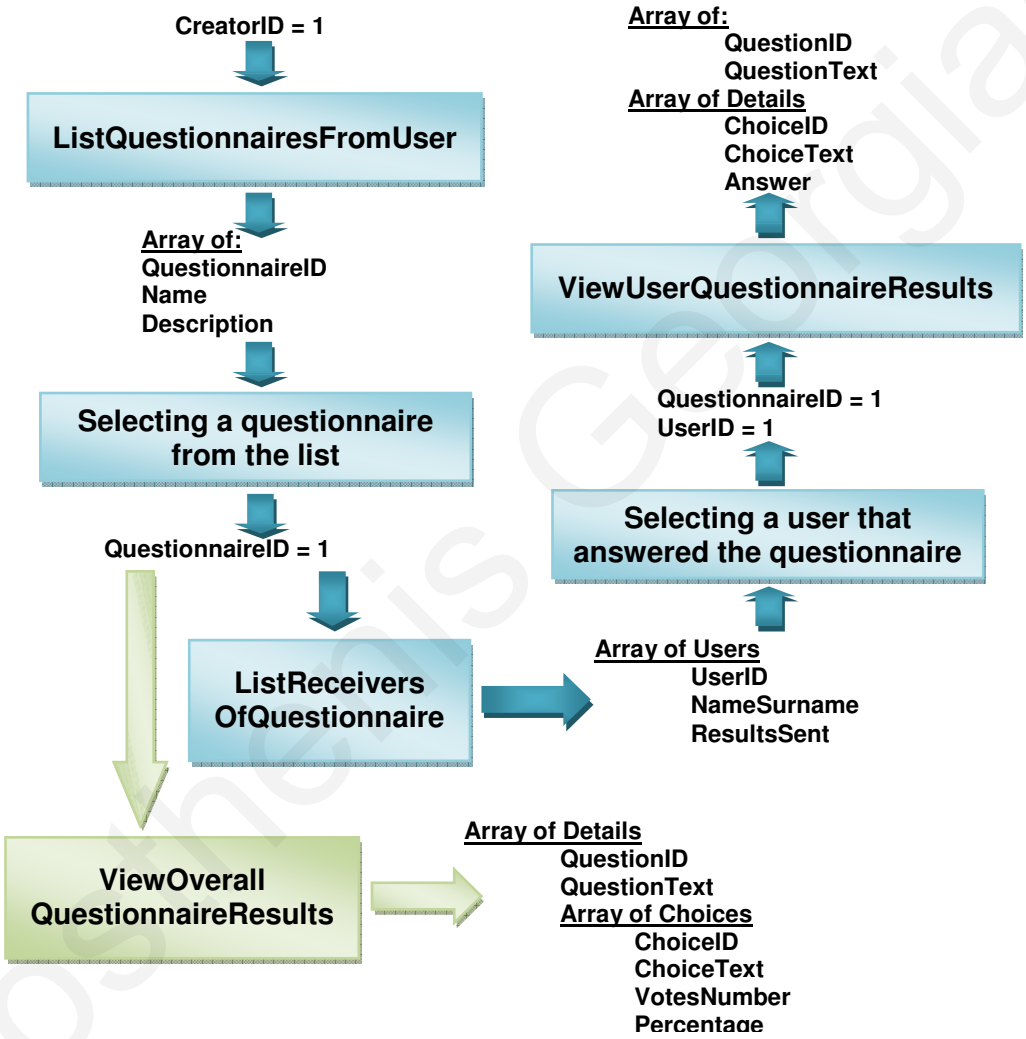


Case 10: View and answer a Survey

Case 11: View the results of a Survey

Subsequent to the previous case is the ability of the sender to be able to review the results of the posted surveys. In this case, the user receives a list (calls the ListQuestionnairesFromUser method) with all his questionnaires. After selecting a questionnaire, the list of users that the questionnaire was send and answered is shown

(through the ListReceiversQuestionnaire method). By selecting a user we can review his answers with the help of the ViewUserQuestionnaireResults method. Users can also view the overall results of the questionnaire with the ViewOverallQuestionnaireResults method.



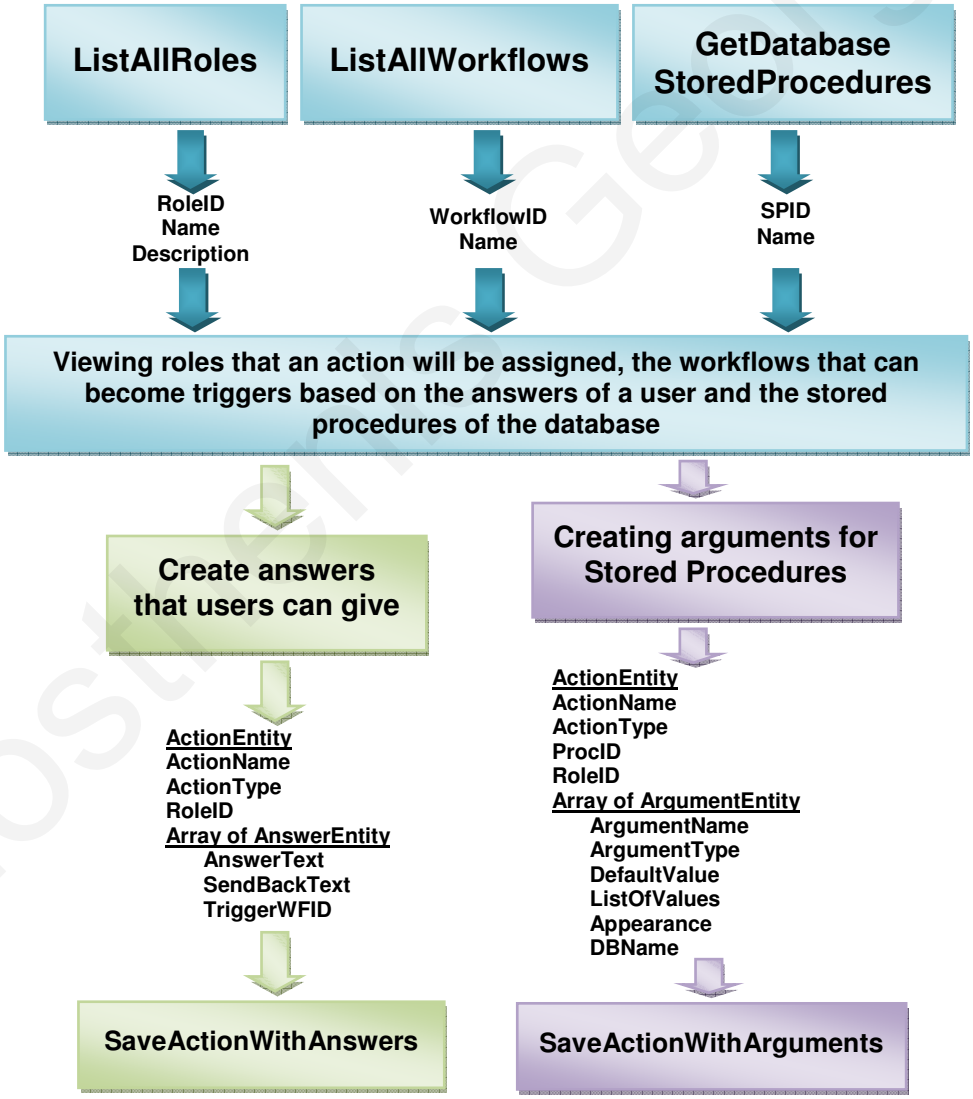
Case 11: View the results of a Survey

Workflow Module

Case 12: Creation of a workflow action with answers and parameters

The main feature of our system is the dynamic creation of workflows. By the term dynamic I mean that the users create new workflows at runtime. Workflows is consisted

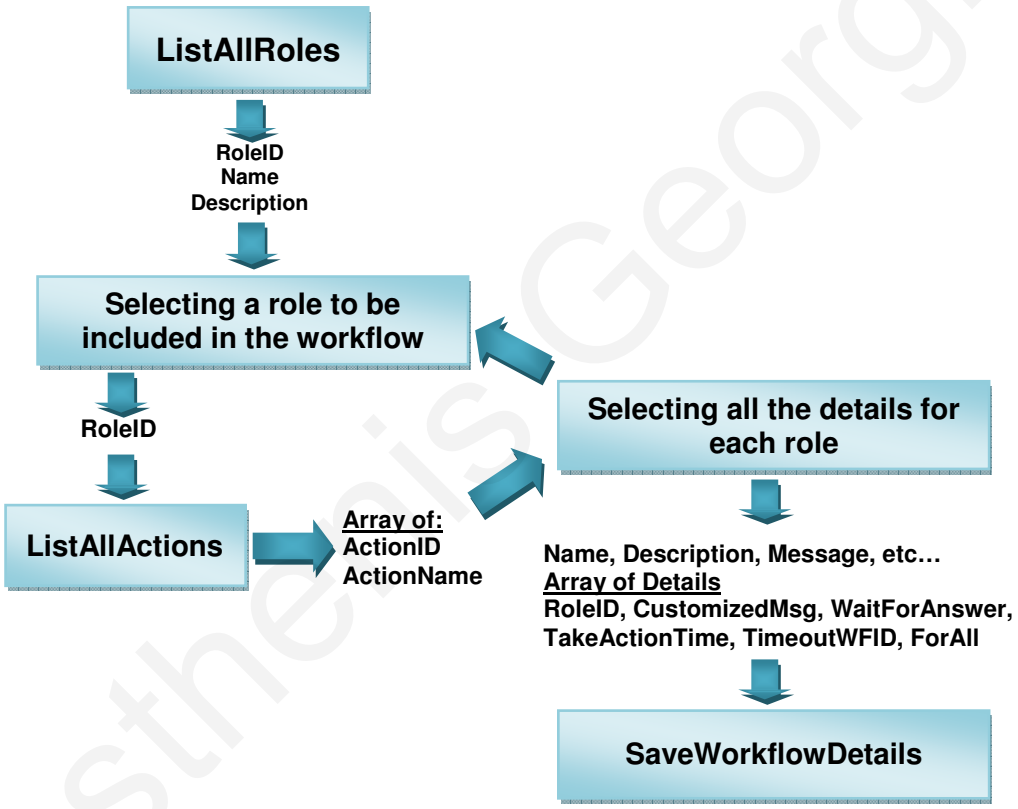
of actions. In more detail, Workflows can include questions or call stored procedures/SQL commands and can be bounded with actions at runtime. In this case we retrieve all roles (ListAllRoles method) and the all workflows of the system that can be used as triggers in user answers (ListAllWorkflows method). After that, results of an action (e.g. an answer) can be bind with other actions (with the call of the SaveActionWithAnswers method). In case of a workflow with arguments we need to view all system database Stored Procedures (GetDatabaseStoredProcedures method). Finally, we have to save the new action (SaveActionWithArguments method).



Case 12: Creation of a workflow action with answers and parameters

Case 13: Creation of a Workflow

Having all actions from the previous Case, we can create a workflow by populating it. In order to populate the workflow with more actions, we select roles that will be involved. Initially, we select the roles that we want to be included in the workflow and the actions linked with each role (ListAllRoles and ListActionsForRole methods). We repeat this step in order to add more actions in the workflow. Finally, we add the new workflow to the system (SaveWorkflowDetails method).

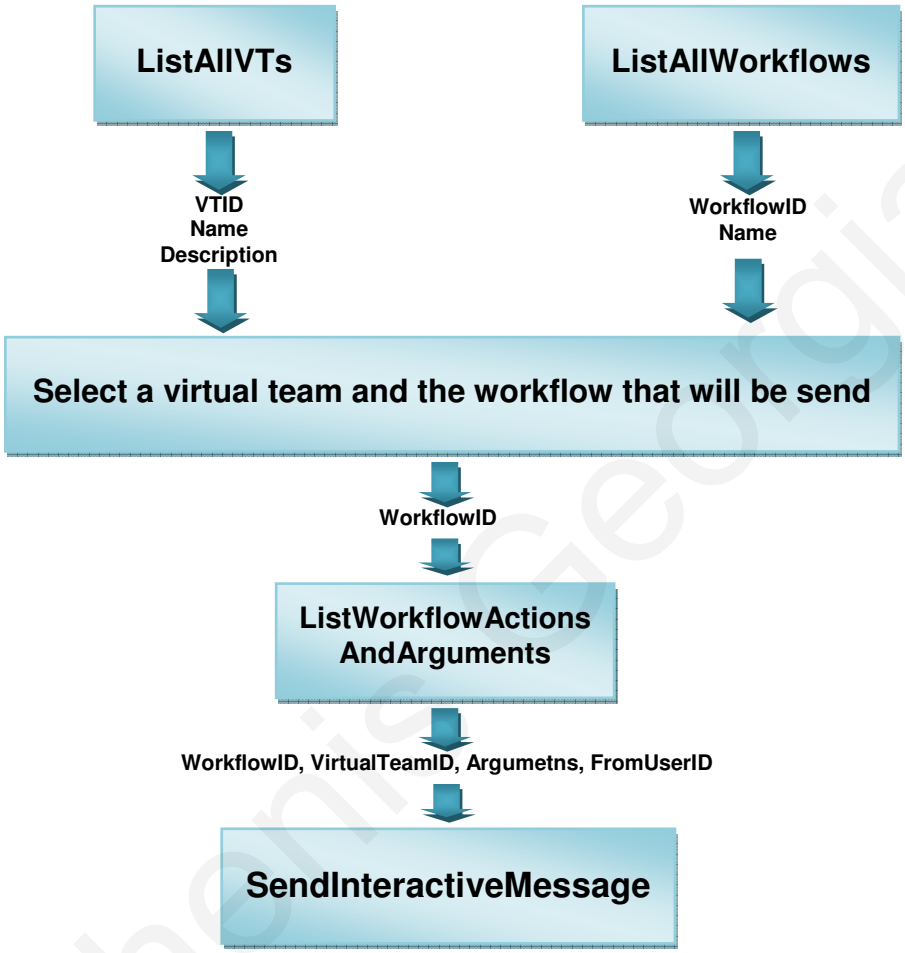


Case 13: Creation of a Workflow

Case 14: Assigning a Workflow

In case we want to assign (send) the workflow to a group of users (e.g. Virtual Teams), the user must select the virtual team that he/she wants to dispatch it. The participant receives a message that initiates the workflow. In more detail, the user retrieves the lists of all workflows and Virtual teams (ListAllWorkflows and ListAllVTs methods) that

exist in the system. Next, we need to setup any parameters that exist in the workflow (ListWorkflowActionsAndArguments method). Finally, we call the SendInteractiveMessage method to dispatch the workflow.

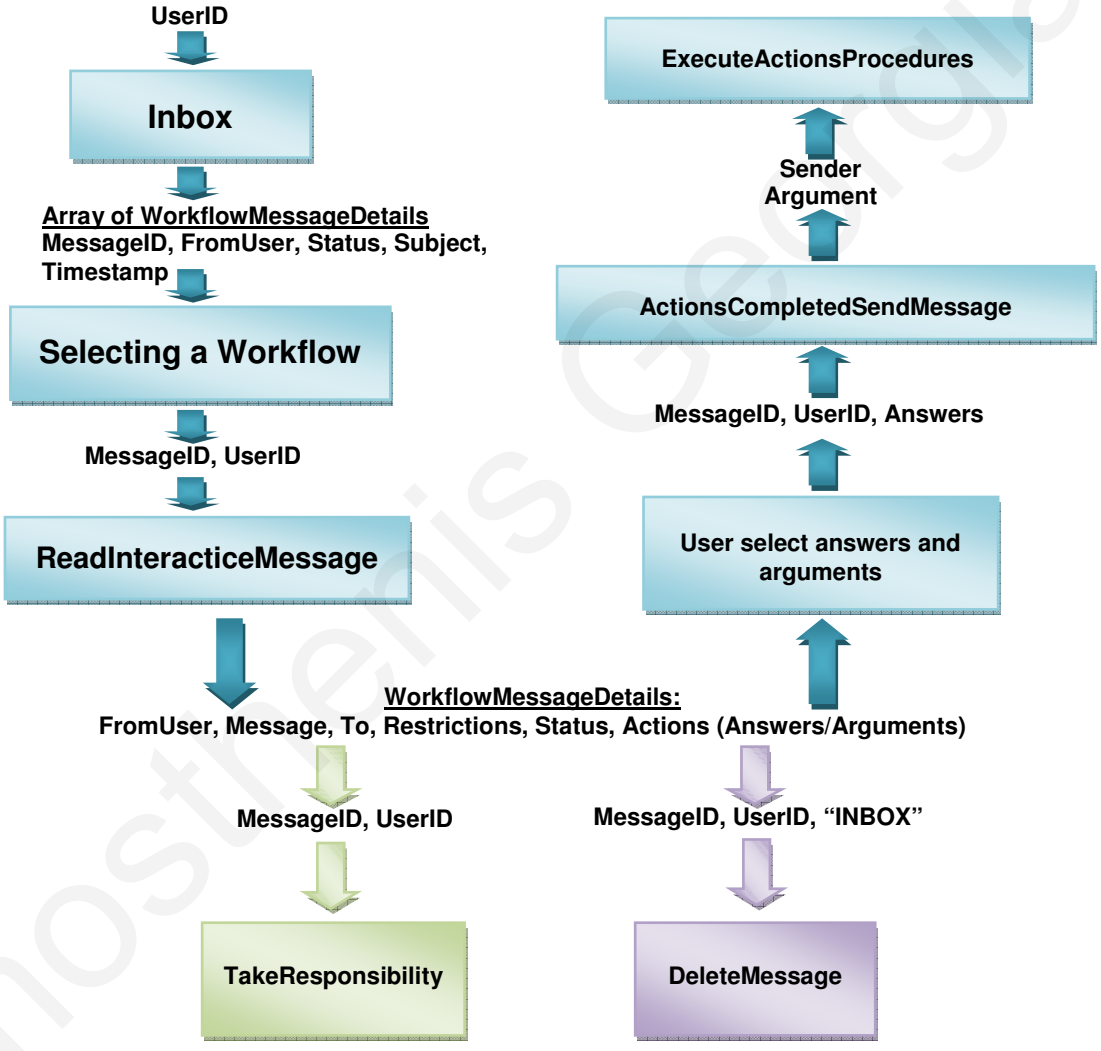


Case 14: Assigning a Workflow

Case 15: Various functionalities of a Workflow

To view the workflows that we have in our inbox we call the Inbox method with the proper ID (User ID). The Inbox method will return all the titles of the workflows and we can also review their details (ReadInteractiveMessage method). Next, users can select answers and send them back to the sender (ActionsCompletedSendMessage method). If there are actions that have parameters we execute the stored procedures based on these parameters (ExecuteActionsProcedures method). Users can also delete a

workflow with the DeleteMessage method. Finally, in case the workflow have actions that must be performed by only one user (the first one that will review the workflow), we notify the other recipients that the workflow is handled by another user (TakeResponsibility method). Thus, we save time by avoiding duplicate work by the users.



Case 15: Various functionalities of a Workflow

6.5. Dynamicity in Workflows

Existing eHealth applications that support workflows have their rules and processes hardcoded and predefined. In case users have new requirements or the organization change rules, the whole workflow process have to be analyzed, coded, recompiled, redistributed and finally retrain the end-users if needed. In other words we notice a lack of dynamicity, syntactic and contextual.

By syntactic dynamicity (i.e configurable), we mean the ability of the workflow to change on demand during a task's execution (according to new requirements and with the assistance of the administrator), without the whole software application development process to take place, as mentioned above.

A simple scenario that illustrates a syntactic change on a workflow it would be to alter the involving actions in a workflow. Instead of alerting the doctor and presents only the two options (Yes and No), we add an extra option of the one that doubles the dose (Figure 16 – Green Circle). This change could be realized by the system administrator through our interface without the need of any programming skills.

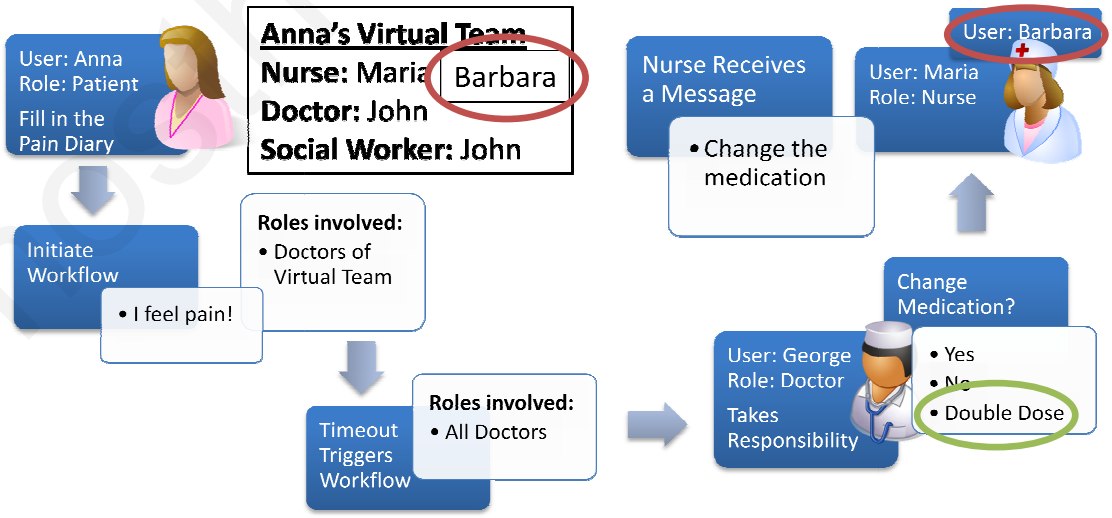


Figure 16: Dynamic Workflow Example

Contextual dynamicity (i.e self-adapting) is the ability of the workflow to detect and adjust on environmental changes like the medical virtual team members. For example, given the previous case (Figure 16 – Red Circle), the nurse of patient "Anna" changes from "Maria" to "Barbara". The new execution of the same workflow, results on alerting the newly assigned nurse Barbara. This dynamicity provides users with a high level of awareness. In addition, the error avoidance is increased due to the fact that users do not need to know all possible changes that may occur, consequently enhancing the transparency level.

6.6. Design

In this section I present the design of the components of the system. The system is divided into 4 main components, the **User** (Virtual Teams), the **Message**, the **Survey** and the **Workflow** components. Within the following sections, I will describe thoroughly each component's functionality and present some collaboration examples of the components and the procedures that are involved. Finally, I will show some scenarios of the services that are provided. A more detailed developer's "hands-on presentation" of each database diagram of the four components is presented in Annex 1.

6.6.1. User Component

This component is responsible for all the actions that are related to the users. By users, I don't necessarily mean only the user management, but also the role and virtual team's management. It consists by several web services that process all the above, providing the needed view, edit and delete functionality. The tables that are used in the User Component are presented in the database diagram in Figure 17.

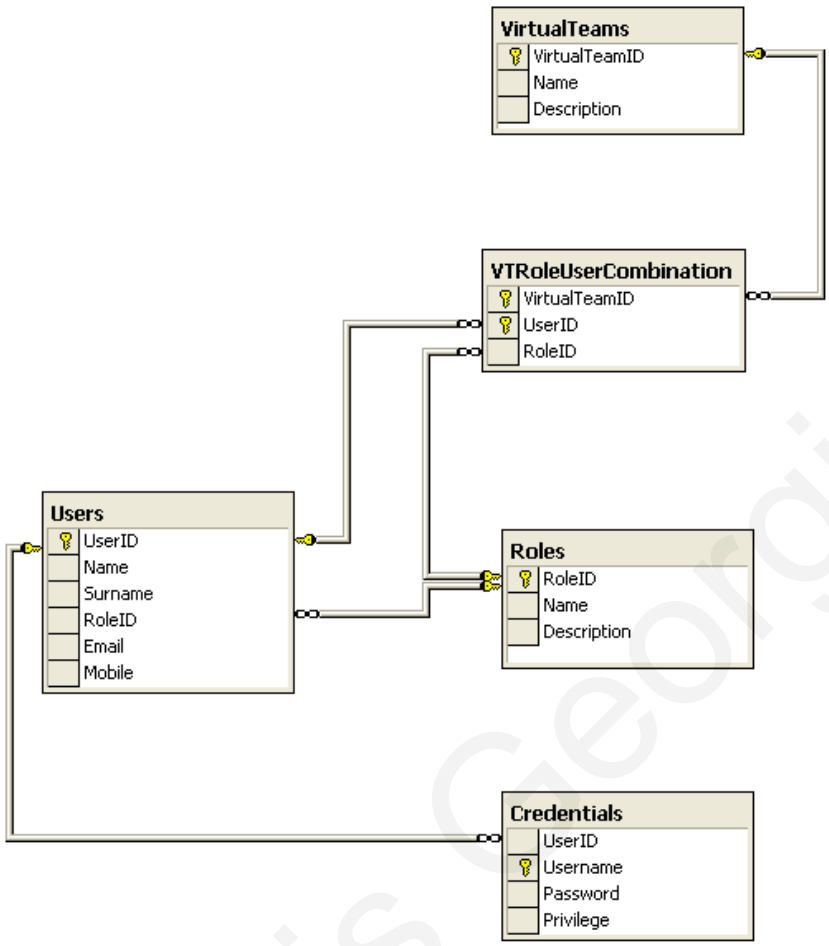


Figure 17: Database Diagram of *User Component*

The web methods that are used in User Component, can divided into 3 groups. Those that are related in the creation (insert), modification (update), deletion (delete) and viewing (select) of the system **Users**, the **Roles** and the **Virtual Teams**.

6.6.2. Message Component

This component is responsible for all the message functionality. This functionality includes the creation, deletion, modification, viewing and sending of messages. Additionally, there are methods for archiving the messages (inbox and outbox), forward and reply. The tables that are used in the Message Component are presented in the database diagram in Figure 18.

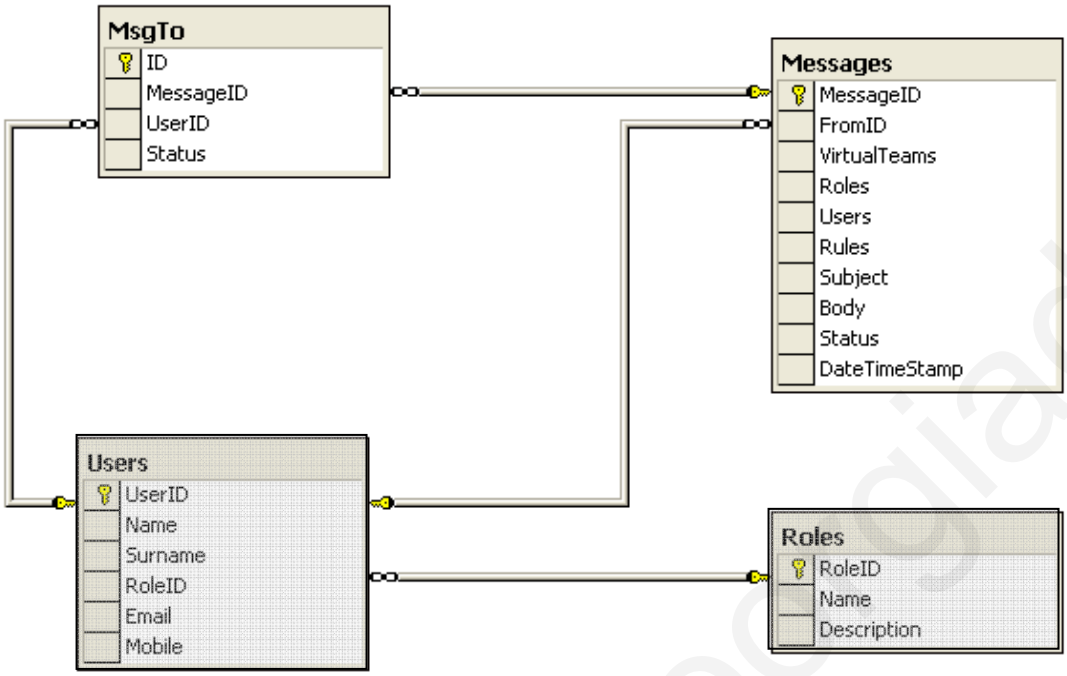


Figure 18: Database Diagram of *Message Component*

The web methods of the Message Component can be categorized into 2 groups. Those that are responsible for arching the messages (Inbox, Outbox and Deleted) and those that are responsible for processing the messages like: SendMessage, ReadMessage, MarkAsUnread, MarkAsRead, DeleteMessage, RestoreMessage, ForwardMessage and Reply.

6.6.3. Survey Component

This component is responsible for the creation, modification, deletion and sending of a survey. Additionally, there are methods for collecting and processing of the survey results. The tables that are used in the Survey Component are presented in the database diagram in Figure 19.

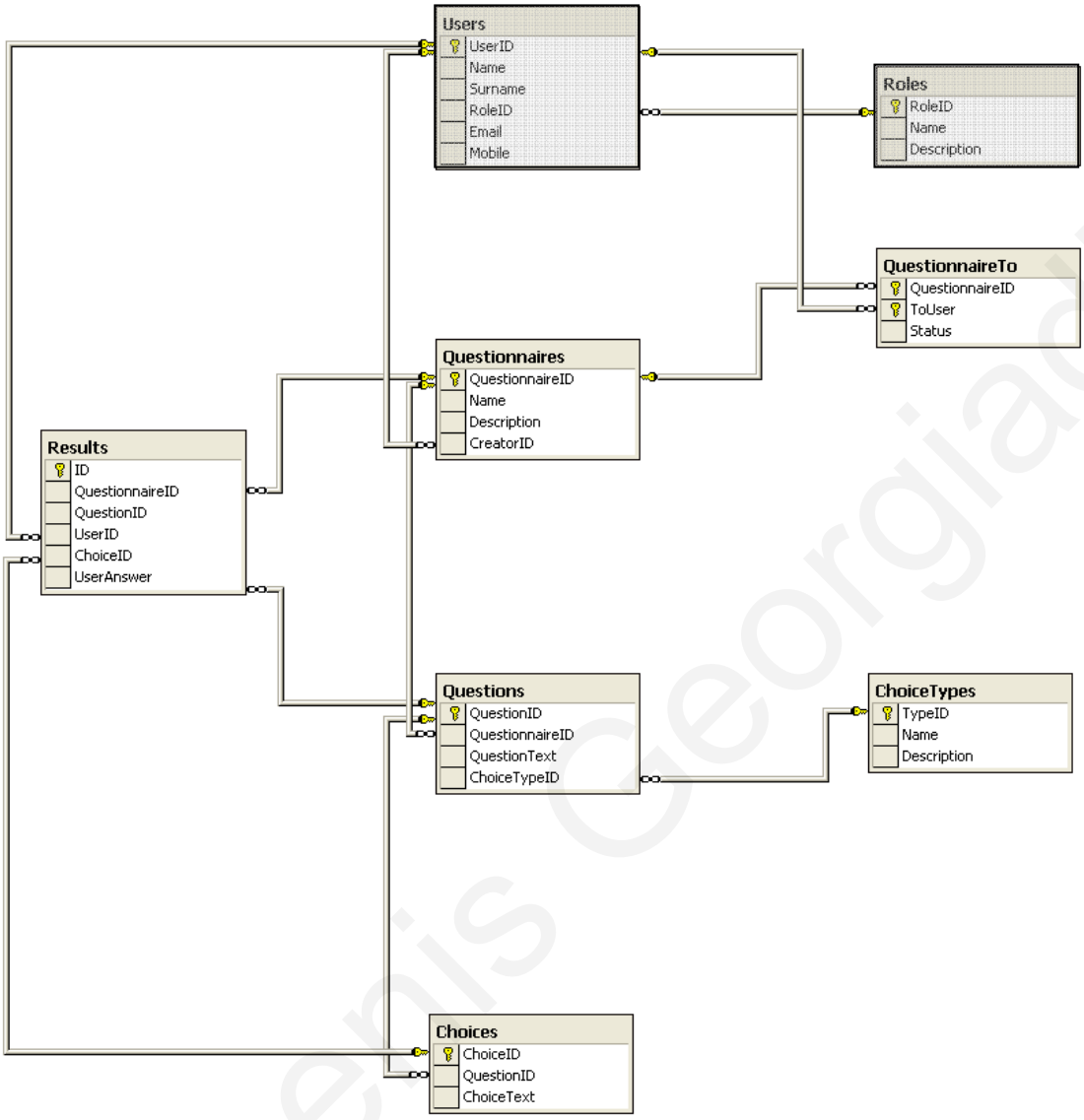


Figure 19: Database Diagram of Survey Component

The web methods of the Survey Component can be categorized into 5 groups. (i) Those that are responsible for the creation, modification, deletion and viewing of the surveys, (ii) those that are responsible for the creation, modification, deletion and viewing of questions, (iii) those that are responsible for the creation, modification, deletion and viewing results, (iv) those that are responsible for sending the surveys and (v) those that are responsible for the creation, modification, deletion and viewing of the completed surveys.

6.6.4. Workflow Component (Interactive Messages)

This component is responsible for the needed functionality of the workflows and the interactive messages. Is consisted with methods for creation, modification, deletion and viewing workflows and interactive methods, along with methods for their delivery to the users. Additionally, there are methods that are responsible for archiving (Inbox, Outbox etc.), methods for timeout resolving and taking responsibility of a task. The tables that are used in the Questionnaire Component are presented in the database diagram in Figure 20.

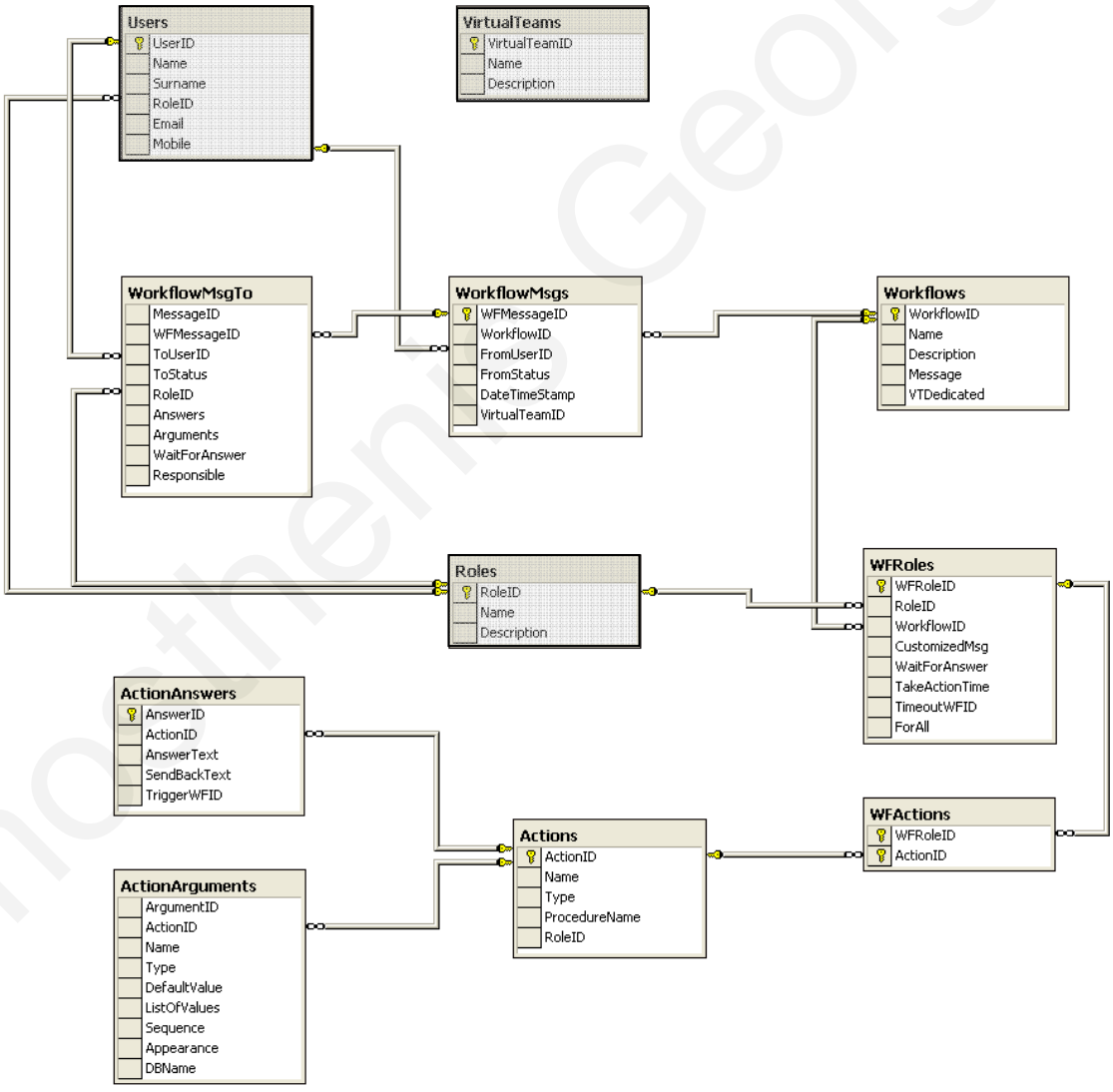


Figure 20: Database Diagram of *Workflow Component*

The web methods of the Workflow Component can also be categorized into 4 groups. (i) Those for archiving the workflows, (ii) those that send, delete and view the workflows, (iii) those that manage the actions and (iv) those that manage the workflows.

6.7. Interoperability

The development of our system is based on the HL7, ICD-0 and ICD-10 standards, with a view toward an open Healthcare Information Infrastructure. It is designed to be open to other services, in order to retrieve information from any organization such as hospitals. HL7 is tightly bound to UML, because it uses its methodology to help design messages, from use-cases to message definition. The HL7 has many concerns about respecting privacy in the storage and transmission of medical data. Another standard that was used was the ICD-10. This stands for International Classification of Diseases. This allows exchange of messages either in electronic health records (EHR) or in HL7, to clearly identify diseases using standard codes. Our system mainly used its subpart called ICD-0, which deals with Cancer-related diseases, however there are plans to migrate to ICD-10, as the Oncology Centre it is collaborating is migrating to ICD-10. Note that continuous monitoring of international standards is necessary. In particular we monitor, as a high priority electronic records, messaging, e-prescriptions, and protecting personal information (PKI and health cards). The use of the following standards is reviewed: the electronic patient record, e.g. CEN standard EN 13606, ISO PKI Technical Specification, multipart ISO standard on health cards, CEN standard for electronic prescriptions, and for messaging HL7 Version 3 and use of XML.

6.8. Implementation

During the following pages, I will present the implementation of the system. For this implementation, I used all the notions and components that are mentioned and presented

in the previous chapters. The system was implemented into two different applications. The windows-based application, that it's used from the administrator, in order to setup the collaboration rules and the web-based application that is customized to work on every mobile device and give the ability to the users of using the system 24/7 everywhere and by any means.

6.8.1. Intelligent User Interface

To get the right information at the right time and the right place in an easy and comprehensive manner isn't so easy for eHealth application's users. The system must support an active involvement of the users, giving them the control over the information through their ways of understanding. Furthermore, the system must provide easy means for navigation and orientation of the information taking into account the limitation of the accessing device (mobile phone, PDA, laptop, etc) and the connectivity medium (wireless network, GSM, GPRS, etc) in order to support alternative interaction methods. Having in mind the abovementioned, I adopted fully customizable screens according to the accessing device handled by the server. The server inquires the device's profile/capabilities (screen size, media capability, supported input methods, etc) and restructures the screens in order to meet these capabilities and serves the result. In addition, I minimized the "clicks" for getting the right information.

6.8.2. Windows-based Application (Administration)

As mentioned before, this application is designed to be used by the administrator to coordinate the whole system. Following I will present the screens that are implemented in this application.

In Figure 21 I demonstrate the administrators' main menu. The administrator can choose from creating new Action, Workflows, Users, Roles and Virtual Teams, or manage the existing ones.

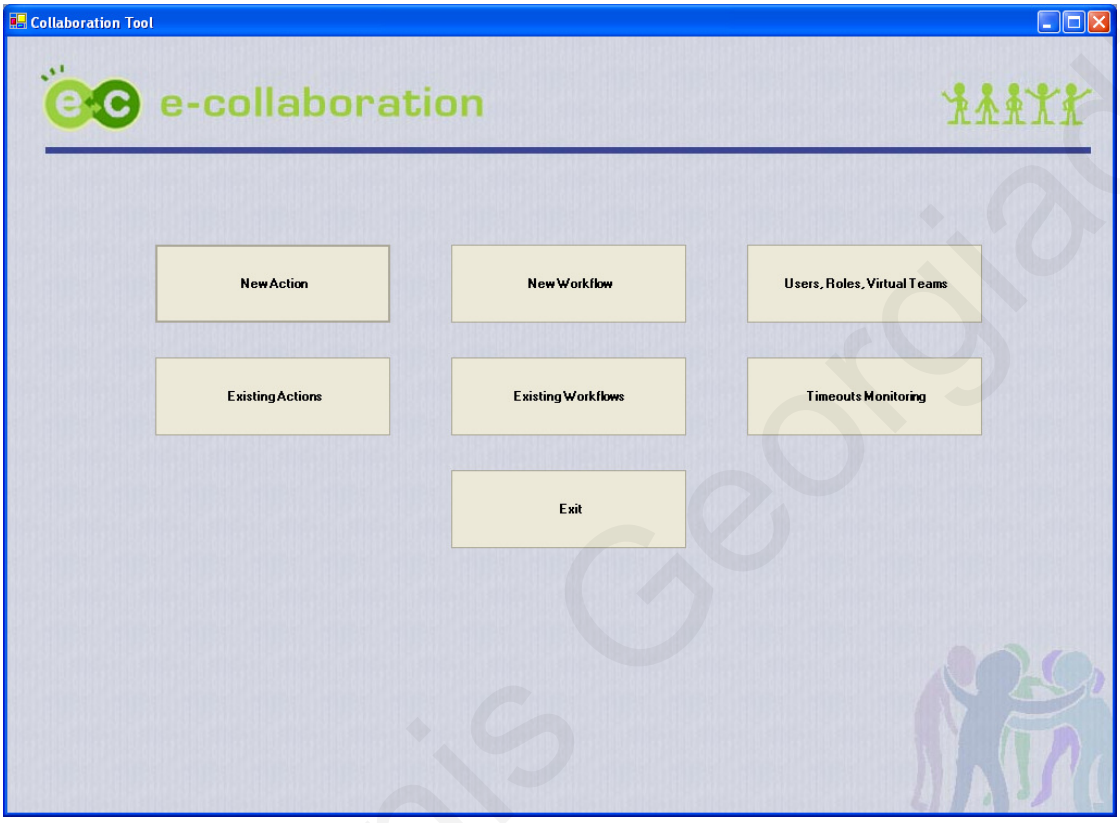


Figure 21: Administrator's Main Menu

Finally, the administrator can manage the workflow timeouts. Through this menu option, administrator can view the status of all timeouts and manage always at runtime.

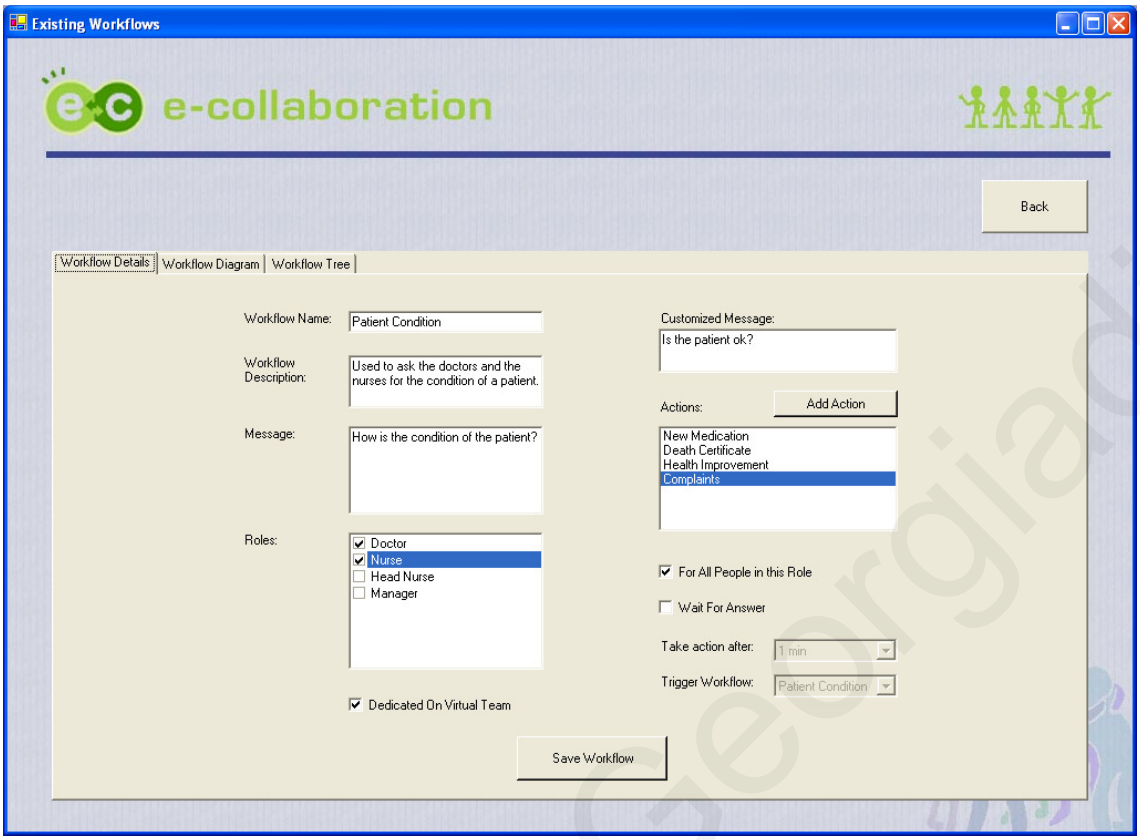


Figure 22: Create a new Workflow

In Figure 22, the administrator can create a new workflow. The administrator gives the name of the new workflow ("Workflow Name"), the "Workflow Description", the "Message" that will be send, select the Roles in case the workflow is virtual team oriented. When selecting a role, we can create a custom message that will be send instead of the default one (default is the "Message" that mentioned above) and select the actions that will performed for each role. We can also select if the action will be performed by one or all role members. In case we select the action to be performed by any member of the role only (the "For All People in this Role" field is unchecked) the first member that review the action, takes responsibility of it by clicking on the option "Take Responsibility". Additionally, we can set the timeout (tick the "Wait For Answer" field) and set the time and the workflow that will be activated in case the

selected time elapse. Finally, we press the "Save Workflow" button to save the workflow and exit.

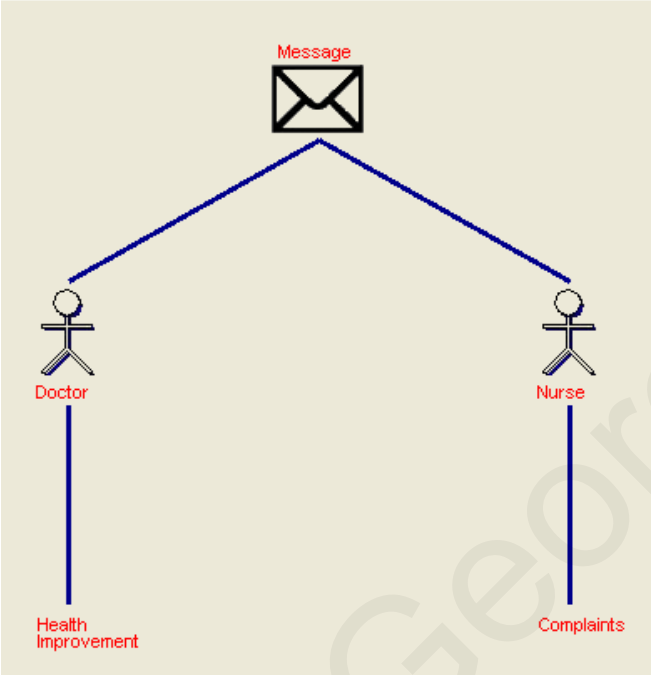


Figure 23: Workflow Diagram

By selecting the "Workflow Diagram" tab (Figure 23), we can review the workflow in a more friendly and understandable representation. This graphical representation shows only the first level of the workflow.

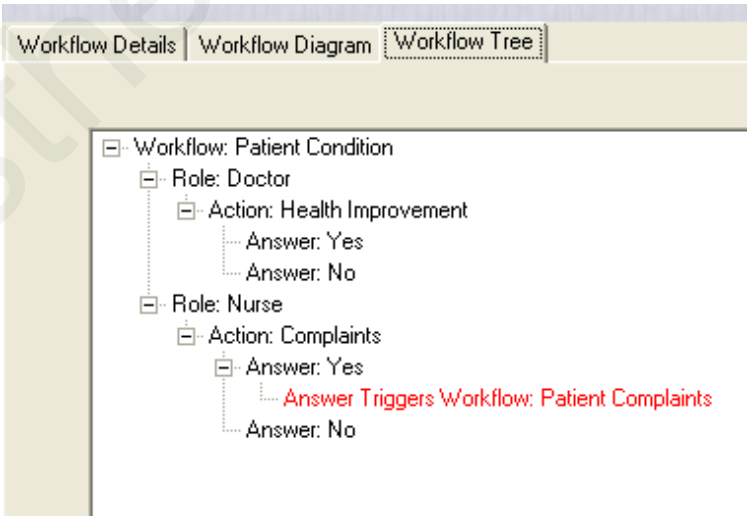
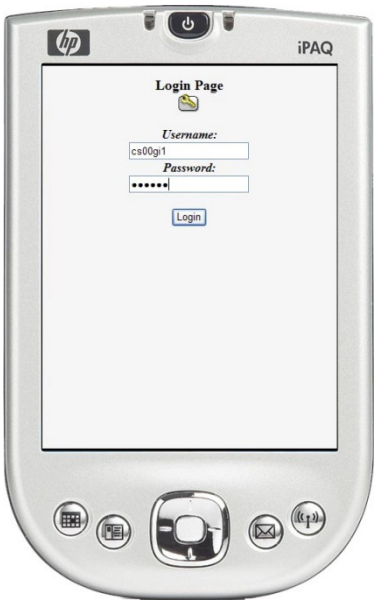


Figure 24: Workflow Tree View

In order to review all the levels of the workflow, we have to select the "Workflow Tree" tab (Figure 24). The red tree nodes, denotes that this answer of the action or the timeout triggers a workflow and that it can be expanded more (going to the next level of the workflow).

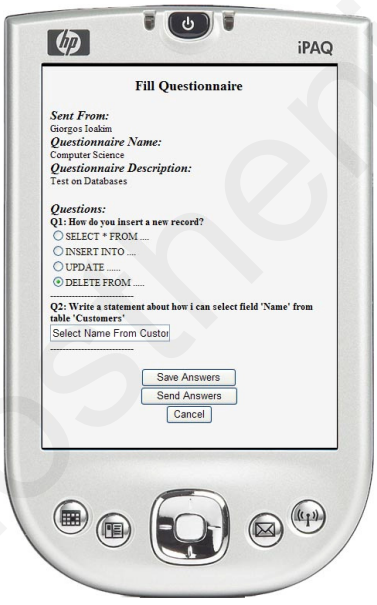
6.8.3. Web-based Application (Users)

As mentioned above, this application is used by users in a 24/7 basis through any device. Users have access in their data, and can collaborate in innovative ways, using dynamic interactive messages (workflows), questionnaires and virtual teams. In this section I present a part of the functionality of the web-based application through the use of a PDA.

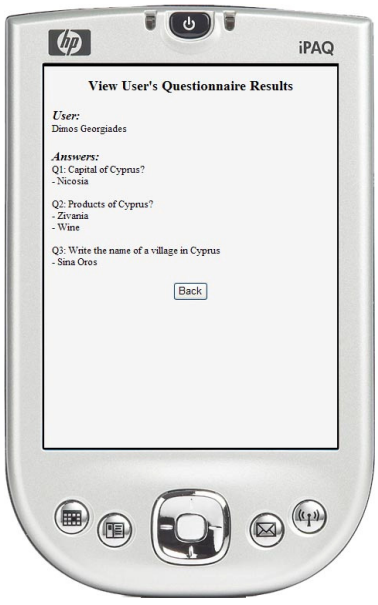


Through this login screen, users enters their credentials (username/password) to access the system.

Through the main menu, users can access the workflows, their messages, their questionnaires, the administration menu, where they can change their password and logout.



This is a sample screen for completing a questionnaire. We can save the answers (so we can continue some other time) or send them directly to the sender.



If we select to view the results b user, we will see the results like this screen.

Chapter 7

Case Study - System Evaluation – Results

7.1. Introduction

In order to test the proposed system, we needed a proof-of-concept application. This application is DITIS [68]. DITIS is an ongoing system that now support dynamic collaborative virtual healthcare teams, providing better homecare support, among many other benefits. Among others, the new collaboration and workflow extended model were integrated and the application tested with remarkable results. These results are denoted in section 7.4. During the next section I present our case study on the DITIS system. The ideas presented in this chapter are incorporated in the DITIS system in order to create a new version of the system, coined DITISv2 which supports dynamic workflows, triggers, timeouts, responsibilities, etc.

7.2. DITIS

By maintaining a dynamic collaborative virtual healthcare team and incorporating the findings of this thesis, DITIS [68] achieves the delivery of better home-care, as well as secure, easy, and timely access, to the unified Electronic Healthcare Record 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 maximizing the effectiveness and efficiency of the healthcare provision/treatment.

The demanding field of complex and chronic illnesses demands the use of specialist treatment protocols. According to these:

- The patient care is provided by a team of Healthcare Professionals (HCPs), as for example cardio specialists, nurses, physiotherapists, social workers, 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'*
- Specialist nurses and other mobile HCPs visit patients regularly at home, offer care, which must be provided in co-operation, and often under the direction of the treating doctors of a hospital (e.g. oncologist, cardiologist).

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 Electronic Medical Information database for the continuous home-treatment of patients. The virtual healthcare team is created explicitly to satisfy the needs of each particular patient at a point in time. Access to information is provided by fixed and mobile devices at any point in time and from anywhere.

- To provide the presence of the (virtual) team by the patient at any given time, irrespective of locality, or cross country movement.
- To improve communication within the dynamic (virtual) home care team and between the home care team and the hospital (locally, or cross country), thus providing enhanced quality of care.

- To provide flexible and secure access and management of healthcare records at any time and from anywhere, to improve continuity of care.
- To improve the collection of statistical data for further audit and research within the home care setting, enhancing knowledge and offering the possibility of evidence-based care.
- Provide continuation of care for chronic illness via Virtual Collaborative Medical Teams, finally leading to a Pan-European scale (for visiting or retiring in a foreign country).
- To aid in making the dependant role of the home-care nurse legally binding (for example, in the home setting when interacting with a hospital doctor for the prescription of a pain drug in the home).

Given the above are satisfied, the quality of life of chronic and severe patients will improve. I will now present an illustrative scenario that fully describes the modeling process in DITIS platform.

7.3. Advanced Collaboration Scenario in DITIS

Within DITIS I faced more complex collaboration scenarios than spotted within our initial investigation. Dynamic workflows driven by user actions and time intervals were handled in order to support these scenarios.

In Figure 25 I present an advanced scenario from DITIS that demonstrate best the added value of the new features of the system.

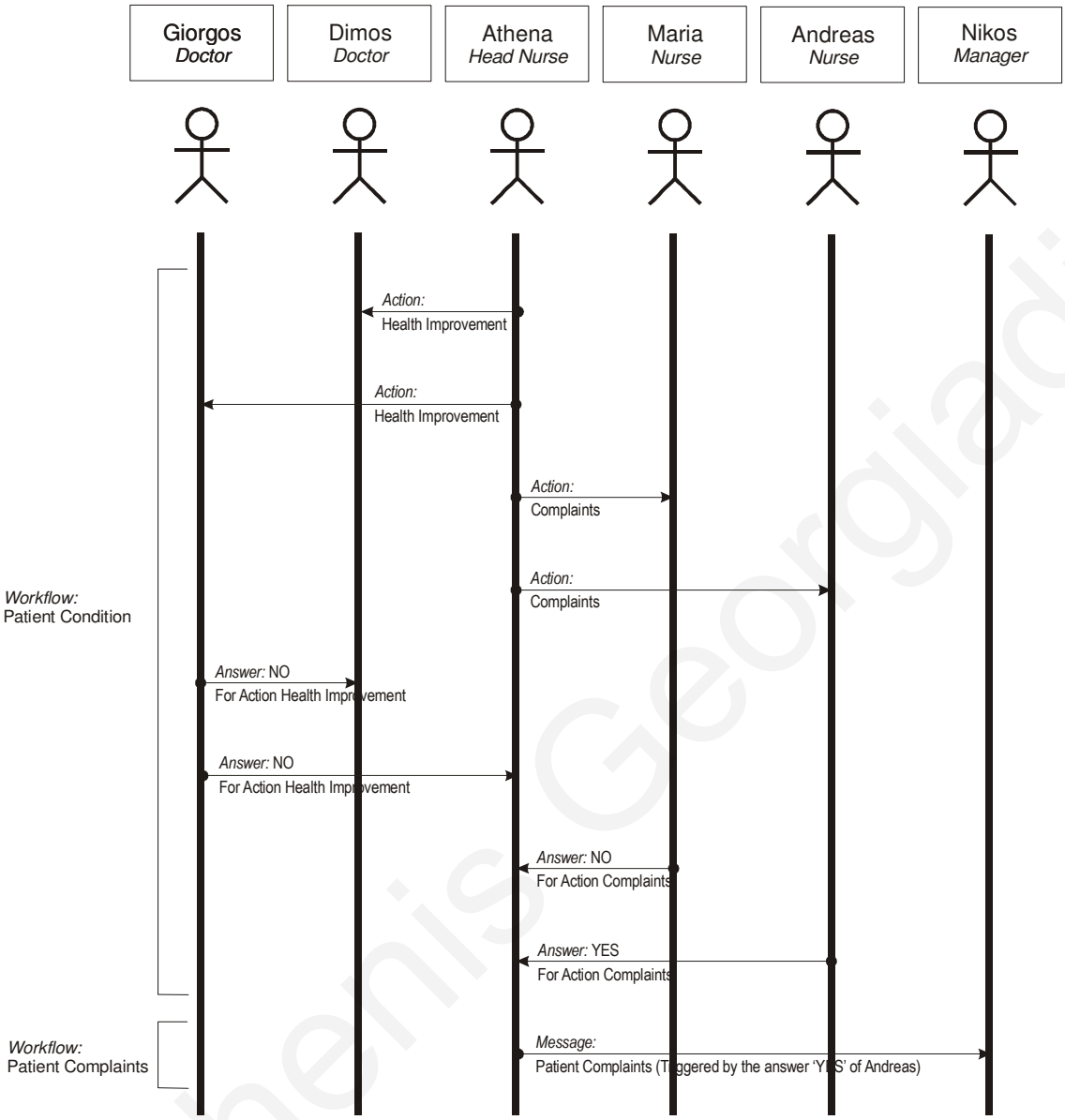


Figure 25: Advanced Collaboration Scenario

In this scenario, the Head Nurse (Athena) sends a workflow (PatientCondition) to the virtual team of a patient (members: Giorgos, Dimos, Athena, Maria, Andreas). The workflow PatientCondition automatically sends an action (HealthImprovment) to the doctors (Giorgos, Dimos) and an action (Complaints) to Nurses (Maria, Andreas) of the medical virtual team. Both doctors (Giorgos, Dimos) answers back to the head nurse (Athena) that there is no improvement to the patient's condition (Answer: NO). Both

nurses answer to the action (Complaints) that they received. Maria answers 'NO' and Andreas answers 'YES'. The answer 'YES' from the nurse Andreas trigger a new workflow (PatientComplaints) that notifies the Hospital Manager (Nikos).

7.4. Evaluation

7.4.1. Evaluation Methodology

Our research pilot site is PASYKAF, a cancer support care organization in Cyprus. PASYKAF was founded in 1986 to provide support to cancer patients and their families during their period of rehabilitation and is manned with highly qualified medical, paramedical and nursing staff. In 1992 it has started a home care service for cancer patients. Specially trained palliative care nurses in close co-operation with doctors (general practitioners and oncologists), physiotherapists and psychologists, attend and care for patients at home, focusing on maintaining the best possible quality of life, including medical care and psychological support.

The fieldwork has taken place in various district sites of PASYKAF. Each site is served by palliative care nurses who visit regularly patients at their house offering health care. Data on DITIS implementation were collected on different stages of the implementation process as follows:

Phase 1:

The preliminary part of the research has studied the use of mobile telephones by a group of palliative care nurses during the period August to September 2000. Interviews with three nurses and one doctor in the Larnaca site have enabled the study of nurses-to-nurses interactions and nurses and doctors/other specialists interactions via the use of

mobile telephones whilst also contributed to gathering information on their level of awareness about DITIS and its potential use in palliative care.

Phase 2:

This part of the study took place in May 2001 and involved the use of a structured questionnaire that was sent to DITIS developers and potential users. It aimed to explore stakeholders' expectations regarding DITIS.

Phase 3:

The final phase of data collection took place in April 2003. By this time DITIS (an early version) has been implemented in four district sites. During this phase, current users of the system in three district offices of PASYKAF (Larnaca, Limassol and Paphos) were interviewed: 1 psychologist and 3 nurses. The main issues explored during interviews in phase 3 of the study included the following:

- Participants' actual use of DITIS.
- Participants' own explanation of why they use DITIS the way they do.
- Participants' understanding of what users' and others stakeholders' role should be for achieving effective DITIS use.

The initial comments and overall potential of DITIS were encouraging.

"*Pasykaf will be able to extract more information and statistics about cancer symptoms. Information about cancers and their occurrence by region will help to detect possible reasons that may be responsible about cancer (e.g. factories in the areas, etc)*" (Developer, Phase 2).

"*...Life will be so much easier with DITIS to fill in the gaps from unknown to known*" (Limassol Nurse).

7.4.2. Evaluation Results

A recent study was carried out at PASYKAF for evaluating several aspects of DITIS. The findings are reported in [72], [71]. The study reveals that DITIS offers innumerable opportunities for palliative care nurses and other cancer-care practitioners. Nurses, psychologists and doctors acknowledge that DITIS has numerous advantages and that they are willing to incorporate it in their work activities. DITIS can improve communication, coordination and collaboration among members. Due to the huge amount of data regarding new and old patient records that need to be handled on a daily basis, DITIS enables users to access data quickly either from their office or remotely. Furthermore, it can be used as a statistical tool, for producing internal reports for the district offices and the head office as well as external reports required by the Ministry of Health and other government departments.

The paper in [71] presents a longitudinal study on DITIS. The study has found that users' support has gradually improved over the last years as they have been increasingly exposed to the system capabilities and have recognized the advantages of the system in their day to day work for both administrative and consultation purposes. Another reason for this is that the nurses have gained participation in the project team with periodical meetings with the project manager and developers. The study in [73] had adopted the stakeholders' analysis. It found that there are different relationship characteristics among the key stakeholders showing diversity in interests, expectations and level of involvement in the implementation of the system. DITIS has appeared to act as a useful fuel for improving patient-records and promoting an integrated approach that has a direct impact on the quality of treatment and health care support to home-based cancer patients.

DITIS is at present phase (DITISv2) it was also deployed, for its healthcare collaboration and patient management aspects, in the context of two EU funded e-TEN market validation projects (HealthService24 and LinkCare), involving trials for cardiac patient monitoring. On the Clinical side the following objectives were addressed by DITIS:

- The presence of the (Virtual) Collaborative Medical Team by the patient at any given time, irrespective of locality or movement. Continuity of care is supported.
- Improved communication within home care team and between home-care team and hospital, thus providing capability to consult within a team of experts (e.g. home nurse with treating doctor or oncologist), without need to move patient from his home to each one of them. This results in reduction of number of visits to health professionals and reduces burden not only on patient but also his relatives, and makes better use of the scarce and expensive medical professionals and scarce hospital beds.
- Improved and secure, timely access to patient information, in accordance with their authorization levels, through unified information space centered around the patient. As an added benefit, the patient need not provide the same history to multiple professionals.
- Improved and flexible collection of statistical data for further audit and research within the home care setting.
- Improved evaluation through the capability to offer audit and research.
- Improved cost effectiveness through improved communications and better planning of services.

- Improved health practices (shift toward evidence-based) and reduction of bureaucratic overhead.
- Assists in promoting the dependant role of the home-nurse legally binding (for example, in the home setting when interacting with a hospital doctor for the prescription of drugs in the home).

As a consequence of meeting the above clinical objectives the *system improves the provision of health care to Cardiac patients*, thereby achieving better quality of life, in the warmth of their own home.

7.4.3. Cost Benefits

In Cyprus, the estimated cost per nurse per month is shown in Table 3. Practically providing the nurse's salary (including the overheads for the organization) and the work-hours per month, we can calculate the cost of having a nurse per minute (Table 3).

Cost of home care nurse per month (including overheads for the organization)	3440
hours per month	152
minutes per month	9120

Table 3: Estimated cost (in EUROS) for 1 month per typical nurse

We can also estimate the cost per service. The services that a nurse provides are telephone calls, on call weekdays and weekends and regular visits. In Table 4 we can see the costs that typical nurses have within the period of a month.

Type of service:	duration (minutes)	Number of patient visits within a month	total time (min)	cost
telephone call (no visit required)	5	15	75	27.52
regular visits	40	110	4400	1659.80
on call weekdays	45	4	180	67.08
on call weekends / public holidays	20	12	240	91.16
Total	**110**	**141**	**4895**	**1845.56**

Table 4: Cost (in EUROS) of services per typical nurse

In order for the nurses to provide the above services, preparatory work had to be done. In Table 5 I present the figures for preparatory tasks, for the same number of patients.

Task	duration (minutes)	Number of patient visits per month	cost
office, discussion on patient issues, read patient notes, communication book entry	5	141	266.60
phone call to patient or his family	2	141	106.64
phone calls to other health professionals	2	141	106.64
organize equipment / prescriptions etc	2	141	106.64
other activities	2	141	106.64
office work including updating patient notes, briefing team, communication book etc	5	141	266.60
Total	**18**	**846**	**959.76**

Table 5: Cost (in EUROS) of preparatory work prior or after visit

Finally, we have to calculate all other costs like traveling between patients' homes, to office and back home, travel time, telephone costs, equipment, etc. (see Table 6). The cost for traveling is estimated near to 0.344 EUROS.

Task	Distance	Number of visits per month	Total	cost
to patient house from previous patient or from base	10 Km	130	1300	447.20
to office and back home	30 Km	20	600	206.40
travel time (minutes)	20 mins	130	2600	980.40
Telephone costs				68.80
Equipment costs (gauzes, needles, syringes, etc…)				34.40
Equipment (loaned to patient, e.g. bath seats, wheelchairs, etc…)				34.40
Total				**1771.60**

Table 6: Cost (in EUROS) of traveling to patient's home and other

In order to estimate the cost effectiveness of healthcare, we have also to measure the cost of hospitalization. In Table 7 I estimate the costs for a patient per month for a typical hospital. The cost is calculated as:

(cost of travel (km*0.344) + cost for relatives + cost for patient) * Services

Task	Services	cost for patient	cost for relatives	travel (km)	Cost
Hospitalization (nights for a month per nurse load of 25 patients)	25	172	34.40	30	5418
Hospice care (nights for a month per nurse load of 25 patients)	50	206.40	34.40	110	13932
Outpatient treatment (number of visits for a month per nurse load of 25 patients)	40	51.60	8.60	30	2820.80
Nursing treatment at hospital (number of visits for a month per nurse load of 25 patients)	75	17.20	8.60	30	2709
Oncologist or specialist (number of visits for a month per nurse load of 25 patients)	15	68.80	34.40	110	2115.60
Total	**205**	**516**	**120.40**	**310**	**26995.40**
Total per Patient (25 Patients)					**1080**

Table 7: Cost (in EUROS) of Hospitalization

In Table 8 I denote the total costs for homecare for 210 patients. The number of patients was not selected randomly, but patients that were monitored for 6 months from PASYKAF (the homecare service provider for cancer patients). We can easily notice that the cost benefit is enormous reaching up to 422% more as compared to the case without the homecare.

With Homecare	**number of patients**	**average duration (months)**	**cost per month**	**Total**
	210	6	153.08	**192174**
	number of visits		**cost per visit**	
	4000		32.68	**129803**
Without Homecare	**number of patients**	**average duration (months)**	**cost per month**	**Total**
	210	6	1080	**1360568** (+422%)

Table 8: Cost (in EUROS) comparison with and without homecare

Finally, I have to estimate the cost effectiveness of using our system. There were reductions in costs like avoiding travel to patients home, while he was emergently entered in a hospital and nobody had the time to notify the nurse. The users didn't need to communicate so often by phone to get updates on patient's status and among others, nurses saved time by reporting back to the office (see Table 9).

Savings by using the system	savings/day (minutes)	frequency (number of days)	total minutes per month	total saving per month	total savings per year
drive to patient house from previous patient or from base	30	30	900	309.60	3715.20
travel time (minutes)	30	10	300	113.52	1362.24
time to handover patients and history taking on admission	40	20	800	301	3612
team collaboration	20	20	400	151.36	1816.32
reporting and management (by nurses)	20	20	400	151.36	1816.32
NET Savings per Nurse per Year					**12322.08**

Table 9: Cost (in EUROS) savings with our system

In Table 10 I also present the cost of sustaining such system (running cost). Running costs are the server hosting, internet and telecom subscriptions.

Potential savings	• time and travelling costs saved • admin & management costs, including reporting • other indirect benefits (access to management data at any time, and in any form, benefit to patient care)	
Total savings		**12322.08**
Cost of service	yearly subscription (per user, based on 30 users) - including maintenance costs	1136.92
	IT equipment	344
	Telecom costs (subscription and data costs)	206.40
	Total costs	**1687.32**

NET MONEYTARY BENEFIT BY USING THE SYSTEM (per nurse)	10627.88
SERVICE BENEFITS PER YEAR	
NET MONEYTARY BENEFIT BY USING THE SYSTEM (for 30 nurses)	**318839.84**

Table 10: Potential Savings (in EUROS)

In Table 11 we can see the estimation of cost savings of using the system in national level. 1000 patients is a representative national level for a country as big as Cyprus. The average duration of care per person is 6 months and the cost varies depending on the type of care (homecare or hospitalization).

With Homecare (Per Year)	**number of patients**	**average duration (months)**	**cost per month (€)**	**Total Euros**
	1000	6	≈130	**779760**
	number of visits		**cost per visit (€)**	**Total Euros**
	20000		≈27	**547200**
Without Homecare (Per Year)	**number of patients**	**average duration (months)**	**cost per month (€)**	**Total Euros**
	1000	6	≈1074	**6443280**

Table 11: Cost comparison with and without homecare with our system

The cost for each home visit is about 27€ making the total cost for estimated 20.000 visits (1000 patient for a year) nearly 547.200€. Each patient although saves the cost for hospitalization, still has to buy his medication. This cost is about 130€ per month. Summing up, the total for services with homecare is around 1.326.960€. On the other hand, hospitalization is costing around 1074€ per month per patient bringing up the total amount to 6.443.280€.

7.5. Work in Parallel

The time saving on travelling was significant but it could be improved by introducing the location awareness of the nurses. On many occasions, nurses had to transfer their appointments to other nurses due to personal reasons (e.g. sickness). The idea behind this is for the system to select automatically the appropriate nurse to transfer the pending appointment. This selection was not a simple task, since it was requiring GPS location of each one patients' home and all nurses appointment schedules (from the schedules we can extract information on what is the location of all other nurses at the projected time of the cancelled appointment). Top-K queries were implemented in order to solve this problem. In his bachelor degree thesis, Mr. Andreas Pitsillides, a co-worker on DITIS system, created a prototype system to support this feature (Figure 26). This feature, although it is not yet being evaluated, it is clear that is able to reduce further the time savings of the system.

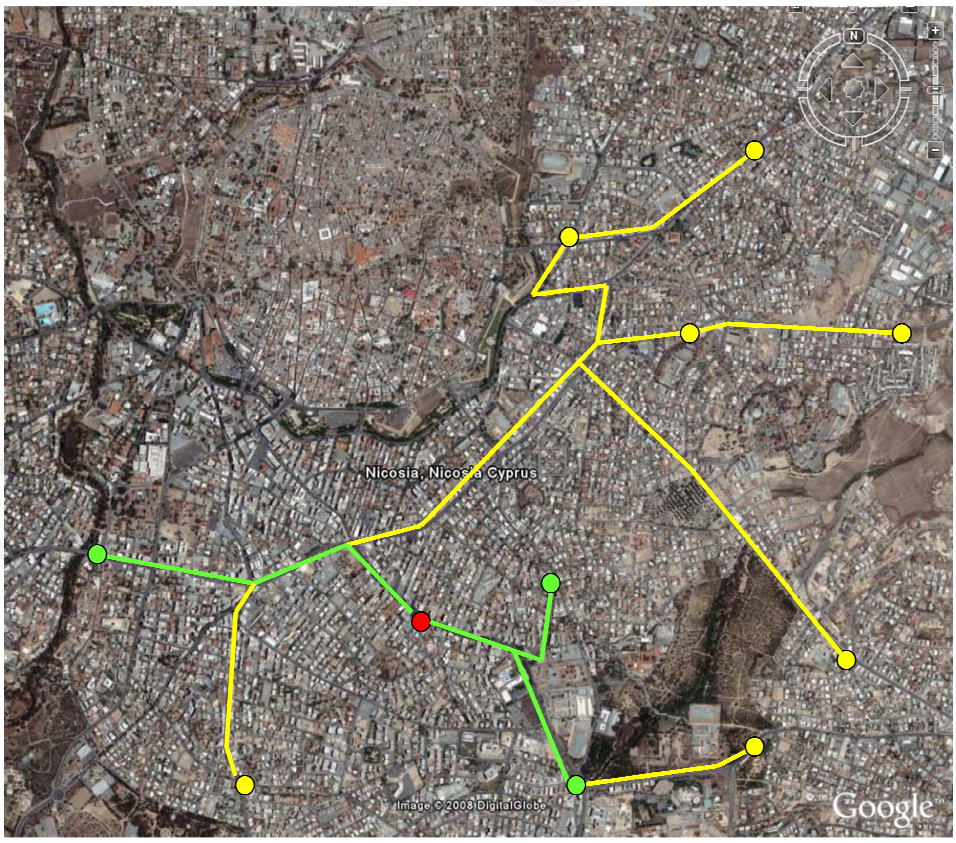


Figure 26: Top-K Queries on Appointment Transfer

7.6. Conclusions

DITIS is an ongoing system that hosted the fundamental elements of our design such as workflows, virtual team collaboration, etc. During the early stages of the system, the advantages were obvious and measured as presented in this chapter. By calculating the cost savings of a typical running month, with and without homecare, **I showed the possibility of tremendous savings up to ≈76%**. Additionally, **I demonstrated cost savings by the use of our system to more than 300.000€ per year, for a typical setting of 30 nurses.** Finally, I demonstrated the cost benefit with and without homecare using our system. The setting was a representing sample for Cyprus of 1000 patients. The **amounts were scaled up to ≈5.000.000€ savings signifying the importance and effectiveness of our research results of our system.**

The economical benefits are encouraging and the numbers are getting even bigger when the demographics scales up. In larger countries the numbers are expected to be more overwhelming. In addition to the economical benefits, better efficiency and effectiveness of the provided services was reported during the early stages of the deployment and is expected to carry through with full scale implementation.

Chapter 8

Conclusions

In this work we have presented dynamic workflows in the home eHealthcare provision. We have studied the requirements of eHealth services and more specifically mobile eHealth services related to homecare provision and we have identified the main limitations of current solutions. Our study revealed that current solutions feature limited collaboration messaging methods, inadequate support for communication under a wireless medium and do not support dynamic content adaptation based on the "environment" of the patient. To address these problems we present an extended collaboration model which enables cross-organizational communication, advanced messaging system and dynamic workflows.

In order to support cross-organizational communication we introduce the concept of Medical Virtual Teams (MVTs). MVTs are formed using a set of users with predefined roles that collaborate in order to achieve a specific goal. This collaboration is accomplished seamlessly by the advanced messaging system provided by our solution. The advanced messaging system employs a number of procedures (i.e., workflows) for automating the collaboration communication efforts (e.g., informing the appropriate homecare professionals in case of an emergency) thus speeding-up the overall process

and minimizing human errors. Our solution allows administrative users to dynamically create and maintain workflows without requiring redeployment of the system. The workflows provided by our solution are dynamic both with regards to syntax (i.e., workflows can be modified on the fly by adding new rules) and context (i.e., changes to the MVT are transparently propagated to the involved workflows). The proposed MVT model is quite generic able to support not only eHealthcare environments but any type of environment benefiting from virtual collaboration.

In order to assess the efficacy of our proposed approach, we have implemented the ideas presented in this work in a prototype homecare system, coined DITIS. We evaluated DITIS in a real setting involving a non-profit organization that provides palliative care to cancer patients. Our experimental series evaluate the proposed system both from the organization as well as the patient perspective using a number of quality metrics. We have shown that DITIS presents significant time and cost savings to the organization as well as increases the quality of life of the patient. Particularly, DITIS showed 52% reduction in time and 17% in cost saving, calculated on travelling, briefing, collaboration and reporting procedures.

8.1. Successful Exploitation in other Domains

In DITIS we adopted an EHR that was suitable for the PASYKAF's needs (cancer patients) following the HL7 (Health Level Seven)[4] standard. Collaboration involved information sharing of this EHR between users. During the needs of another EU project (HealthService24), the proposed system was installed, changing the current EHR to a related one for cardio patients. The adaptation of our system was performed easily by

[4] HL7 is an international community of healthcare subject matter experts and information scientists collaborating to create standards for the exchange, management and integration of electronic healthcare information.

only changing one component; the EHR. This was succeeded by the modularity and openness of our proposed system. In Figure 27 we can see a screenshot of the HealthService24 integration.

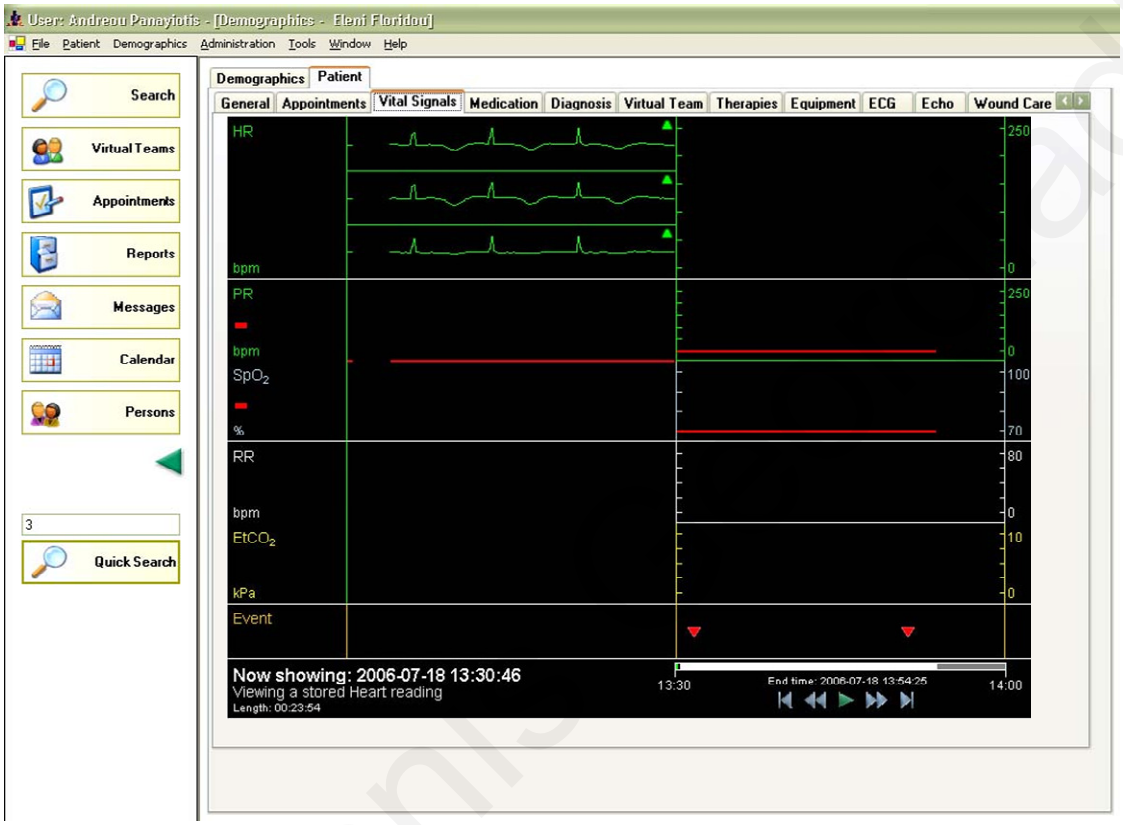


Figure 27: HealthService24 EU Project

Our proposed system demonstrated that it could easily serve also other medical domain (other than cancer) with minor changes, providing advanced collaboration support to the users.

Our system is open and modular to the extent that can be adapted in any system that requires collaboration between users, other than the eHealth domain. One of these domains is the AAL (Agile Assisted Lining) which is focusing in the encasement of the quality of life of elderly people. Our system easily changed in order to support AAL requirements under the running project MELCO (Figure 28). In MELCO the notion of

sub-virtual teams were introduced covering the aspect of social teams like family, friends, etc (Figure 29).

Figure 28: MELCO Project

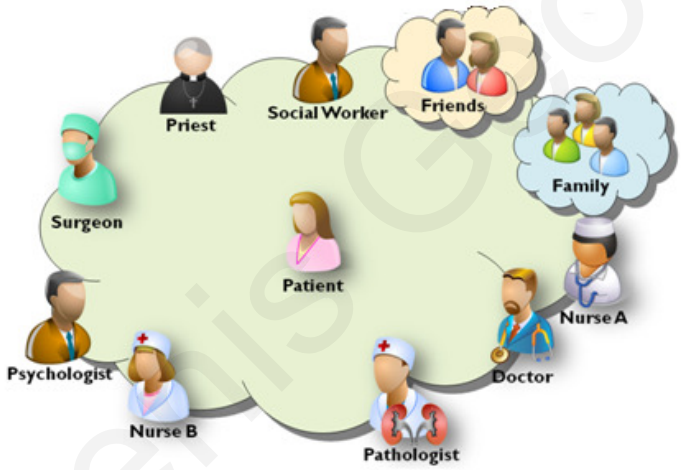


Figure 29: Sub-Virtual Teams – Social Aspect

The case of MELCO project supports once more the advanced collaboration through dynamic workflows, etc provided by the proposed system, in a domain other than the eHealth. In general, various interfaces have been provided making the adaptation and incorporation of the various modules in other systems trivial.

In Figure 30 I demonstrate the modularity of our system. We clearly see that in the center of our system, is the EHR. In case we want to use the proposed system in another domain X, we only need to change the center module from EHR to X. The proposed system is so open that it can be also operated without any topic of interest (e.g.

Healthcare provision), as long as we have users that want to collaborate for any reason, although it does not make any sense having users working/collaborating on no subject.

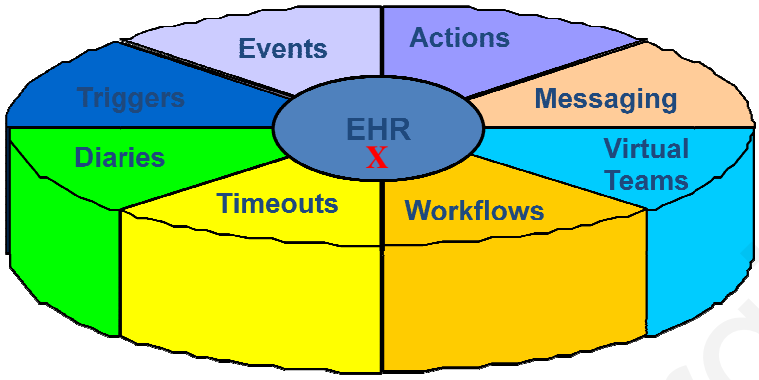


Figure 30: Modularity of the system

The steps that a system administrator would have to perform for integrating our system in his organizational needs would be:

i) Create the roles of the system,

ii) Create the users,

iii) Create Virtual Teams according to the organizational needs,

iv) Populate the VTs with users and roles and finally,

v) Create any workflow that may the organization wants.

8.2. Research Summary

In this dissertation I presented the current situation in collaboration and workflow management and more specifically in the eHealth sector. **After an extensive research on existing systems and trends, I identified the extended requirements and proposed an innovative extended model for collaboration and dynamic workflow management system within the demanding eHealth context.** Additionally, I took under consideration issues like the technical requirements and the most appropriate

computational model for this type of application since they are developed to work under wireless environments where many disconnections occur (m-Health).

The need for new features like medical virtual teams, questionnaires, actions, dynamic workflows, responsibilities, triggers & timeouts, medical diaries and pro-activeness is noted and they were analyzed, modeled, implemented and evaluated within our system.

The system architecture along with the proposed layers were presented and described. End-users can access the system anywhere and anytime through any mobile device as long as there is a support of an internet browser and an internet connection. This dynamic interface was purposely kept simple by minimizing the need for adding text and minimizing the "clicks", since the users in the eHealth domain aren't so computer and internet cultured.

Eventually, I presented the evaluation of the system, using a real test bed facility (an organization that provides homecare to cancer patients called PASYKAF). The methodology used for this evaluation consists of 3 steps and provids the overall evaluation results. The results found, among others, that users' support has gradually improved over the last years and the cost effectiveness for the organization was even greater (savings up to ≈76% and more than 300.000€ per year were estimated).

8.3. Research Contributions

This research featured numerous publications in well-established conferences in this area. Furthermore, in October 2003, project DITIS - Network for Medical Collaboration – that is using the proposed model, was submitted to the 2003 Ministerial Conference

on eHealth competition in ACM Europe and ranked as a finalist (a total of 28 projects were invited in Brussels on a two-day exhibition, selected among over 180 applicants Europe-wide). DITIS was submitted to the World Summit Award (WSA) competition as the best e-content and creativity example in the Category of e-Health from Cyprus. The World Summit Award (WSA) is a three year global project, held within the framework and in cooperation with the WSIS. It aims to go beyond the general issues of infrastructure development or network access and to recognize, select and promote the world's best e-content and innovative applications. It is worth mentioning that DITIS was competing with other high budget EU projects, unlike DITIS which was a local low budget project (funded by the national research promotion foundation and own time of the researchers, academic of University of Cyprus and PASYKAF).

Related publications include:

- D. Georgiadis, P. Germanakos, C. Mourlas, G. Samaras, & E. Christodoulou, "Dynamic Business Processes and Virtual Communities in Wireless eHealth Environments", A chapter to appear in: Ubiquitous Health and Medical Informatics: the Ubiquity 2.0 Trend and Beyond, S. Mohammed & J. Fiaidhi (Eds.), IGI Global, Hershey, USA. (ISBN: 978-1-61520-777-0), 2009

- D. Georgiadis, P. Germanakos, G. Samaras, C. Mourlas, & E. Christodoulou, "An Intelligent Web-based Healthcare System: The Case of DYMOS", A chapter to appear in: Web-based Applications in Health Care and Biomedicine of the Annals of Information Systems Series (AoIS). A. Lazakidou (Ed.), Springer-Verlag Berlin Heidelberg. (ISBN: 978-1-4419-1273-2), 2009

- D. Georgiadis, P. Germanakos, P. Andreou, & G. Samaras, “Evaluation Metrics for eHealth Services and Applications within Smart Houses Context”, Proceedings of the 7th International Conference on Smart Homes and Health Telematics (ICOST 2009), Tours, France, July 1-3, 2009, LNCS, Springer-Verlag Berlin Heidelberg, pp. 245-248.

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- A. Pitsillides, B. Pitsillides, G. Samaras, M. Dikaiakos, E. Christodoulou, P. Andreou, and D. Georgiades, A Collaborative Virtual Medical Team for Home Healthcare of Cancer Patients, Book Chapter, M-Health: Emerging Mobile Health

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- Georgiadis T. Dimosthenis, "Dynamic Creation of Collaborating System and Database Management, Using Mobile Agents.", Master thesis supervised by George Samaras, Computer Science Department, University of Cyprus, June 2002
- Georgiadis T. Dimosthenis, "Mobile Agents in the Service of Telemedicine.", Undergraduate thesis supervised by George Samaras, Computer Science Department, University of Cyprus, June 2000.

8.4. Future Work

Future research directions within the eHealth context are focusing in social based VTs, motivation and socialization of the patients. In general, it's a marriage of Ambient Assisted Living (aka AAL) and mobile healthcare. Within this context, systems will have to support an innovative social community model encouraging and supporting active participation, communication, socialization, mutual assistance and self-organization of the elderly, promoting seamless integration and interaction of different people (family members, caretakers, medical professionals, friends etc.) from all ages at any time and any place and providing daily activity monitoring. The model places the patient in the centre of the services, making him both a consumer and producer of assistance.

The use of innovative validated systems will intrinsically have a high positive impact in improving the quality of life of the patient, but also of their families and care personnel, by prolonging the time the person can live independently in a socially integrated community manner thereby reducing the demand for care and the associated care cost.

Furthermore, research has to be done on the effective and efficient integration of Vital Signal Monitoring (VSM) devices and sensors networks. Research will have to be conducted on new algorithms that will be integrated with the VSM devices and sensors for prevention and prediction of possible medical incidents. Due to the criticality and importance of the information in eHealth, the margin for errors must be zero. You have to bear in mind that a mistake here may result in the loss of a human's life and this is not acceptable by anyone, especially by the medical personnel.

With the emergence of the Web 2.0, the use of the Internet for health has become a mass phenomenon and not just limited to small projects and a small percentage of the population. Apart from having more health related information and services available, the health consumers can create their own content and communities by using available platforms on the Internet. Users can publish their own content in blogs, v-logs (video logs) or in comments posted in other patient's sites. In addition, new web-based health applications are becoming popular, such as Personal Health Records (PHRs) for the management of the patient's health records. As well as in the rest of the Web 2.0, there is an increasing usage of open APIs and standards that are making possible the integration of different services to provide new ones. For example, with the actual web PHRs it is possible to create new services adapted to the user based on the PHRs data accessible from an open API. The use of Web 2.0 services and platforms has also created new complex situations that could lead into ethical challenges, e.g. related with the sharing of genetic information. We can utilize Web 2.0 techniques in our work empowering patients to participate more actively concerning their own healthcare.

Finally, the European Committee is focusing on activity motivation services. The activity motivation services include services that will motivate and encourage persons

with chronic conditions to undertake physical and mental exercises and activities, change life style, socialize etc. Daily tasks assistance will provide the patients with direction indications, explanations on how to perform some tasks, or even instructions on how to call for human assistance for example through the use of the socialization services. Additionally, the system can assist patients by providing them with a type of memory help (reminders, directions indications to a place, memory assistance etc). New implicit workflows will manage the activities of patients making them more personal and thus more effective.

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Annex 1

1. User Component

Tables that are used in by the User Component

Table Name: **Users**

Field	Type	Description
USERID	INTEGER	Primary key
NAME	STRING	
SURNAME	STRING	
ROLEID	INTEGER	Foreign key (Roles table)
EMAIL	STRING	
MOBILE	STRING	

Table Name: **Roles**

Field	Type	Description
ROLEID	AUTONUMBER	Primary key
NAME	STRING	
DESCRIPTION	STRING	

Table Name: **VirtualTeams**

Field	Type	Description
VIRTUALTEAMID	AUTONUMBER	Primary key
NAME	STRING	
DESCRIPTION	STRING	

Table Name: **VTRoleUserCombination**

Field	Type	Description
VIRTUALTEAMID	INTEGER	Foreign key (VirtualTeams table)
USERID	INTEGER	Foreign key (Users table)
ROLEID	INTEGER	Foreign key (Roles table)

Table Name: **Credentials**

Field	Type	Description
USERID	INTEGER	Primary key Foreign key (Users table)
USERNAME	STRING	
PASSWORD	STRING	
PRIVILEGE	INTEGER	0 – Administrator 1 – Normal User

Web methods that are used for User Component

Method Name	**CreateUser**	
Description	This web method is for creating a new User	
Input Data	**Name**	**Type**
	UserEntity	
	Name	String
	Surname	String
	RoleID	Integer
	Email	String
	Mobile	String

Output Data	**Name**	**Type**
	UserID	Integer

Method Name	**EditUser**	
Description	This web method is for modifying a User.	
Input Data	**Name**	**Type**
	UserEntity	
	UserID	Integer
	Name	String
	Surname	String
	RoleID	Integer
	Email	String
	Mobile	String
Output Data	**Name**	**Type**

Method Name	**DeleteUser**	
Description	This web method is for deleting a User.	
Input Data	**Name**	**Type**
	UserID	Integer
Output Data	**Name**	**Type**

Method Name	**ViewUser**	
Description	This web method is for viewing a User.	
Input Data	**Name**	**Type**
	UserID	Integer
Output Data	**Name**	**Type**
	UserEntity Name Surname RoleName RoleID Email Mobile	 String String String Integer String String

Method Name	**ListAllUsers**		
Description	This web method is for viewing all the system users.		
Input Data	**Name**	**Type**	
Output Data	**Name**	**Type**	
	UserEntity UserID Name	Array of	 Integer String

	Surname		String

Method Name	**CreateVT**	
Description	This web method is for creating a Virtual Team.	
Input Data	**Name**	**Type**
	VirtualTeamEntity	
	Name	String
	Description	String
Output Data	**Name**	**Type**
	VTID	Integer

Method Name	**EditVT**	
Description	This web method is for editing a Virtual Team.	
Input Data	**Name**	**Type**
	VirtualTeamEntity	
	VTID	Integer
	Name	String
	Description	String
Output Data	**Name**	**Type**

Method Name	**DeleteVT**	
Description	This web method is for deleting a Virtual Team.	
Input Data	**Name**	**Type**
	VTID	Integer
Output Data	**Name**	**Type**

Method Name	**ViewVT**	
Description	This web method is for viewing a Virtual Team.	
Input Data	**Name**	**Type**
	VTID	Integer
Output Data	**Name**	**Type**
	VirtualTeamEntity Name Description CreatorID	 String String Integer

Method Name	**ListAllVTs**	
Description	This web method is for viewing all Virtual Teams of the system.	
Input Data	**Name**	**Type**

	Name	**Type**	
Output Data	*VirtualTeamEntity* Name Description VTID	 Array of	 String String Integer

Method Name	**CreateRole**	
Description	This web method is for creating a Role.	
Input Data	**Name**	**Type**
	RoleEntity Name Description	 String String
Output Data	**Name**	**Type**
	RoleID	Integer

Method Name	**EditRole**	
Description	This web method is for modifying a Role.	
Input Data	**Name**	**Type**
	RoleEntity RoleID Name Description	 Integer String String

Output Data	Name	Type

Method Name	DeleteRole	
Description	This web method is for deleting a Role.	
Input Data	Name	Type
	RoleID	Integer
Output Data	Name	Type

Method Name	ViewRole	
Description	This web method is for viewing a Role.	
Input Data	Name	Type
	RoleID	Integer
Output Data	Name	Type
	RoleEntity	
	Name	String
	Description	String

Method Name	ListAllRoles
Description	This web method is for viewing all the Roles of the system.

Input Data	**Name**	**Type**	
Output Data	**Name**	**Type**	
	RoleEntity RoleID Name Description	Array of	 Integer String String

Method Name	**GetRoleUsers**		
Description	This web method is for viewing all Users with a spesific Role.		
Input Data	**Name**	**Type**	
	RoleID	Integer	
Output Data	**Name**	**Type**	
	RoleEntity UserID Name Surname	Array of	 Integer String String

Method Name	**AddUserToVT**	
Description	This web method is for adding a user to a Virtual Team.	
Input Data	**Name**	**Type**
	VTID	Integer

	UserID RoleID	Integer Integer
Output Data	**Name**	**Type**

Method Name	**RemoveUserFromVT**	
Description	This web method is for deleting a user from a Virtual Team.	
Input Data	**Name**	**Type**
	VTID UserID	Integer Integer
Output Data	**Name**	**Type**

Method Name	**GetVTUsers**		
Description	This web method is for viewing the users of a Virtual Team.		
Input Data	**Name**	**Type**	
	VTID	Integer	
Output Data	**Name**	**Type**	
	UserEntity UserId Name Surname	Array of	 Integer String String

	RoleName RoleID		String Integer

Method Name	**GetVTRoleUsers**		
Description	This web method is for viewing the Users of a Virtual Team with a specific role.		
Input Data	**Name**	**Type**	
	VTID RoleID	Integer Integer	
Output Data	**Name**	**Type**	
	UserEntity UserId Name Surname	Array of	 Integer String String

Method Name	**InsertCredentials**	
Description	This web method is for adding credentials (username, password) to a user.	
Input Data	**Name**	**Type**
	CredentialEntity UserID Username	 Integer String

	Password Privilege	String Enumeration (Administrator/ NormalUser)
Output Data	**Name**	**Type**
	Inserted	Boolean

Method Name	**EditCredentials**	
Description	This web method is for modifying the credentials (username, password) of a User.	
Input Data	**Name**	**Type**
	CredentialEntity UserID Username Password Privilege	 Integer String String Enumeration (Administrator/ NormalUser)
Output Data	**Name**	**Type**
	Edited	Boolean

Method Name	**ViewCredentials**
Description	This web method is for viewing the credentials (username, password) of a User.

Input Data	**Name**	**Type**
	UserID	Integer
Output Data	**Name**	**Type**
	Username Password Privilege	String String Enumeration (Administrator/ NormalUser)

Method Name	**ListAllCredentials**		
Description	This web method is for viewing all the credentials (username, password) of the system users.		
Input Data	**Name**	**Type**	
Output Data	**Name**	**Type**	
	CredentialEntity UserID Username Password Privilege	Array of	 Integer String String Enumeration (Administrator/ NormalUser)

Method Name	**CheckCredentials**	
Description	This web method is for checking the credentials (username, password) of a User. If correct, it returns the User information.	
Input Data	**Name**	**Type**
	Username Password	String String
Output Data	**Name**	**Type**
	CredentialEntity UserID Username Password Privilege	 Integer String String Enumeration (Administrator/ NormalUser)

2. Message Component

Tables that are used in by the Message Component

Table Name: **Messages**

Field	Type	Description
MESSAGEID	AUTONUMBER	Primary key
FROMID	INTEGER	Foreign key (Users table)
VIRTUALTEAMS	STRING	The IDs of the Virtual Teams are

		separated with |
ROLES	STRING	The IDs of the Roles are separated with |
USERS	STRING	The IDs of the Users are separated with |
SUBJECT	STRING	
BODY	STRING	
STATUS	STRING	(SENT, DELETED)
DATETIMESTAMP	DATETIME	

Table Name: **MsgTo**

Field	Type	Description
ID	AUTONUMBER	Primary key
MESSAGEID	INTEGER	Foreign key (Messages table)
USERID	INTEGER	Foreign key (Users table)
STATUS	STRING	(NEW, OLD, DELETED)

Web methods that are used for Message Component

Method Name	**Inbox**		
Description	This web method is for viewing the Inbox messages.		
Input Data	**Name**	**Type**	
	UserID	Integer	
Output Data	**Name**	**Type**	
	MessageDetails MessageID	Array of	Integer

	FromUser (Name+Surname) Subject Status TimeStamp		String String String DateTime

Method Name	**Outbox (Sent)**		
Description	This web method is for viewing the Outbox messages.		
Input Data	**Name**	**Type**	
	UserID	Integer	
Output Data	**Name**	**Type**	
	MessageDetails MessageID Subject Status	Array of	 Integer String DateTime

Method Name	**Deleted**		
Description	This web method is for viewing the trash bin of the user.		
Input Data	**Name**	**Type**	
	UserID	Integer	
Output Data	**Name**	**Type**	
	MessageDetails MessageID	Array of	 Integer

	FromUser (Name+Surname) Subject Status TimeStamp		String String String DateTime

Method Name	**SendMessage**	
Description	This web method is for sending messages to users, roles and virtual teams.	
Input Data	**Name**	**Type**
	SendMessageDetails FromUserID ToUserID ToVTID ToRoleID Subject Body	 Integer Array of Integers Array of Integers Array of Integers String String
Output Data	**Name**	**Type**
	MessageID	Integer

Method Name	**ReadMessage**	
Description	This web method is for viewing a message.	
Input Data	**Name**	**Type**

	MessageID	Integer
	UserID	Integer
Output Data	**Name**	**Type**
	ReadMessageDetails	
	FromUser (Name+Surname)	String
	ToUser (Name+Surname)	Array of Strings
	ToVT	Array of Strings
	ToRole	Array of Strings
	Subject	String
	Body	String
	TimeStamp	DateTime
	Status	String

Method Name	**MarkAsRead**	
Description	This web method is for marking a message as read (Old).	
Input Data	**Name**	**Type**
	MessageID	Integer
	UserID	Integer
Output Data	**Name**	**Type**

Method Name	**MarkAsUnread**

Description	This web method is for marking a message as unread (New).	
Input Data	**Name**	**Type**
	MessageID UserID	Integer Integer
Output Data	**Name**	**Type**

Method Name	**DeleteMessage**	
Description	This web method is for deleting a message.	
Input Data	**Name**	**Type**
	MessageID UserID Place	Integer Integer String (INBOX, OUTBOX, DELETED)
Output Data	**Name**	**Type**

Method Name	**RestoreMessage**	
Description	This web method is for restoring a message (change the Status from DELETED to OLD).	
Input Data	**Name**	**Type**
	MessageID	Integer

	UserID	Integer
Output Data	**Name**	**Type**

Method Name	**ForwardMessage**	
Description	This web method is for forwarding a message to a user, role or virtual team.	
Input Data	**Name**	**Type**
	FwdMessageDetails MessageID ToUserID ToVTID ToRoleID	 Integer Array of Integers Array of Integers Array of Integers
Output Data	**Name**	**Type**

Method Name	**Reply**	
Description	This web method is for replying to a message.	
Input Data	**Name**	**Type**
	MessageID Body WithHistory	Integer String Boolean

	ToAll	Boolean
Output Data	**Name**	**Type**

3. Questionnaire Component

Tables that are used in by the Questionnaire Component

Table Name: **Questionnaires**

Field	Type	Description
QUESTIONNAIREID	AUTONUMBER	Primary key
NAME	STRING	
DESCRIPTION	STRING	
CREATORID	INTEGER	Foreign key (Users table)

Table Name: **QuestionnairesTo**

Field	Type	Description
QUESTIONNAIREID	INTEGER	Primary key Foreign key (Questionnaires table)
TOUSER	INTEGER	Primary key Foreign key (Users table)
STATUS	STRING	(NEW, ANSWERED, SAVED)

Table Name: **Questions**

Field	Type	Description
QUESTIONID	AUTONUMBER	Primary key

QUESTIONNAIREID	INTEGER	Foreign key (Questionnaire table)
QUESTIONTEXT	STRING	
CHOICETYPEID	INTEGER	Foreign key (ChoiceTypes table)

Table Name: **Choices**

Field	Type	Description
CHOICEID	AUTONUMBER	Primary key
QUESTIONID	INTEGER	Foreign key (Questions table)
CHOICETEXT	STRING	

Table Name: **ChoiceTypes**

Field	Type	Description
TYPEID	AUTONUMBER	Primary key
NAME	STRING	
DESCRIPTION	STRING	

Table Name: **Results**

Field	Type	Description
ID	AUTONUMBER	Primary key
QUESTIONNAIREID	INTEGER	Foreign key (Questionnaires table)
QUESTIONID	INTEGER	Foreign key (Questions table)
USERID	INTEGER	Foreign key (Users table)
CHOICEID	INTEGER	Foreign key (Choices table)
USERANSWER	STRING	

Web methods that are used for Questionnaire Component

Method Name	**CreateQuestionnaire**	
Description	This web method is for creating a questionnaire.	
Input Data	**Name**	**Type**
	QuestionnaireEntity	
	Name	String
	Description	String
	CreatorID	Integer
Output Data	**Name**	**Type**
	QuestionnaireID	Integer

Method Name	**EditQuestionnaire**	
Description	This web method is for modifying a questionnaire.	
Input Data	**Name**	**Type**
	QuestionnaireEntity	
	QuestionnaireID	Integer
	Name	String
	Description	String
Output Data	**Name**	**Type**

Method Name	**DeleteQuestionnaire**
Description	This web method is for deleting a questionnaire.

Input Data	**Name**	**Type**
	QuestionnaireID	Integer
Output Data	**Name**	**Type**

Method Name	**ViewQuestionnaire**	
Description	This web method is for viewing a questionnaire.	
Input Data	**Name**	**Type**
	QuestionnaireID	Integer
Output Data	**Name**	**Type**
	QuestionnaireEntity Name Description CreatorID	 String String Integer

Method Name	**ListQuestionnaires**	
Description	This web method is for viewing all the questionnaires of the system.	
Input Data	**Name**	**Type**
Output Data	**Name**	**Type**
	QuestionnaireEntity	Array of

	QuestionnaireID Name Description		Integer String String

Method Name	**ListQuestionnairesFromUser**		
Description	This web method is for viewing all questionnaires tha are created from a specific user.		
Input Data	**Name**	**Type**	
	CreatorID	Integer	
Output Data	**Name**	**Type**	
	QuestionnaireEntity QuestionnaireID Name Description	Array of	 Integer String String

Method Name	**InsertQuestion**	
Description	This web method is for creating a new question.	
Input Data	**Name**	**Type**
	QuestionEntity QuestionnaireID QuestionText ChoiceTypeID	 Integer String Integer
Output Data	**Name**	**Type**

	QuestionID	Integer

Method Name	**EditQuestion**	
Description	This web method is for modifying a question.	
Input Data	**Name**	**Type**
	QuestionEntity	
	QuestionID	Integer
	QuestionText	String
	ChoiceTypeID	Integer
Output Data	**Name**	**Type**

Method Name	**DeleteQuestion**	
Description	This web method is for deleting a question.	
Input Data	**Name**	**Type**
	QuestionID	Integer
Output Data	**Name**	**Type**

Method Name	**ViewQuestion**
Description	This web method is for viewing a question.

Input Data	**Name**	**Type**
	QuestionID	Integer
Output Data	**Name**	**Type**
	QuestionEntity	
	QuestionText	String
	ChoiceTypeID	Integer
	ChoiceTypeName	String

Method Name	**ListQuestions**		
Description	This web method is for viewing all questions for a questionnaire.		
Input Data	**Name**	**Type**	
	QuestionnaireID		
Output Data	**Name**	**Type**	
	QuestionEntity		
	QuestionID	Array of	Integer
	QuestionText		String
	ChoiceTypeID		Integer
	ChoiceTypeName		String

Method Name	**InsertChoice**	
Description	This web method is for creating a new choice.	
Input Data	**Name**	**Type**

	ChoiceEntity QuestionID ChoiceText	 Integer String
Output Data	**Name**	**Type**
	ChoiceID	Integer

Method Name	**EditChoice**	
Description	This web method is for modifying a choice.	
Input Data	**Name**	**Type**
	ChoiceEntity ChoiceID ChoiceText	 Integer String
Output Data	**Name**	**Type**

Method Name	**DeleteChoice**	
Description	This web method is for deleting a choice.	
Input Data	**Name**	**Type**
	ChoiceID	Integer
Output Data	**Name**	**Type**

Method Name	**ViewChoice**	
Description	This web method is for viewing a choice.	
Input Data	**Name**	**Type**
	ChoiceID	Integer
Output Data	**Name**	**Type**
	ChoiceEntity ChoiceText	 String

Method Name	**ListChoices**		
Description	This web method is for viewing all the choices of a question.		
Input Data	**Name**	**Type**	
	QuestionID	Integer	
Output Data	**Name**	**Type**	
	ChoiceEntity ChoiceID ChoiceText	Array of	Integer String

Method Name	**ViewQuestionnaireDetails**	
Description	This web method is for viewing all the details of a questionnaire (including all the questons and their choices).	
Input Data	**Name**	**Type**

	QuestionnaireID		Integer
Output Data	**Name**		**Type**
	QuestionnaireDetails QuestionnaireName QuestionnaireDescription QuestionDetails		 String String Array of *QuestionDetails*
	QuestionDetails	QuestionID QuestionText ChoiceTypeID ChoiceTypeName ChoiceDetails	Integer String Integer String Array of *ChoiceDetails*
	ChoiceDetails	ChoiceID ChoiceText	Integer String

Method Name	**ViewQuestionDetails**		
Description	This web method is for viewing a question details including their choices.		
Input Data	**Name**	**Type**	
	QuestionID		
Output Data	**Name**	**Type**	
	QuestionDetails QuestionText ChoiceTypeID	Array of	 String Integer

	ChoiceTypeName ChoiceDetails			String Array of *ChoiceDetails*
	ChoiceDetails	ChoiceID ChoiceText	Integer String	

Method Name	**ListChoiceTypes**	
Description	This web method is for viewing all the available types in the system.	
Input Data	**Name**	**Type**
Output Data	**Name**	**Type**
	ChoiceTypeEntity ChoiceTypeID Name Description	 Integer String String

Method Name	**ListQuestionnairesForUser**	
Description	This web method is for viewing all unanswered questionnaires that are send to a specific user.	
Input Data	**Name**	**Type**
	UserID	Integer
Output Data	**Name**	**Type**

	QuestionnaireEntity QuestionnaireID Name	Array of	Integer String

Method Name	**SendQuestionnaireToUser**	
Description	This web method is for sending a questionnaire to a user.	
Input Data	**Name**	**Type**
	ToUsersID QuestionnaireID	Array of Integers Integer
Output Data	**Name**	**Type**

Method Name	**SendQuestionnaireToVT**	
Description	This web method is for sending a questionnaire to a virtual team.	
Input Data	**Name**	**Type**
	ToVTsID QuestionnaireID	Array of Integers Integer
Output Data	**Name**	**Type**

Method Name	**SendQuestionnaireToRole**	
Description	This web method is for sending a questionnaire to a role.	
Input Data	**Name**	**Type**
	ToRolesID QuestionnaireID	Array of Integers Integer
Output Data	**Name**	**Type**

Method Name	**SendQuestionnaireToVTRole**	
Description	This web method is for sending a questionnaire to users of a specific role and specific virtual team.	
Input Data	**Name**	**Type**
	ToRolesID ToVTsID QuestionnaireID	Array of Integers Array of Integers Integer
Output Data	**Name**	**Type**

Method Name	**DeleteSavedUserAnswers**	
Description	This web method is for deleting all the results of a specific questionnaire and user.	
Input Data	**Name**	**Type**
	QuestionnaireID	Integer

	UserID	Integer
Output Data	**Name**	**Type**

Method Name	**SaveResults**		
Description	This web method is for saving the results/answers of a specific user and questionnaire.		
Input Data	**Name**		**Type**
	QuestionnaireAnswers QuestionnaireID UserID QuestionDetails		 Integer Integer Array of *QuestionDetails*
	QuestionDetails	QuestionID ChoiceID Answer	Integer Integer String
Output Data	**Name**		**Type**

Method Name	**SendResults**	
Description	This web method is for sending the results/answers of a user for a questionnaire..	
Input Data	**Name**	**Type**

	QuestionnaireAnswers QuestionnaireID UserID QuestionDetails		 Integer Integer Array of *QuestionDetails*
	QuestionDetails	QuestionID ChoiceID Answer	Integer Integer String
Output Data	**Name**		**Type**

Method Name	**ListReceiversOfQuestionnaire**		
Description	This web method is for viewing all users that a specific questionnaire is send.		
Input Data	**Name**	**Type**	
	QuestionnaireID	Integer	
Output Data	**Name**	**Type**	
	ReceiversEntity UserID NameSurname ResultsSent	Array of	 Integer String Boolean

Method	**ViewUserQuestionnaireResults**

Name				
Description	This web method is for viewing results/answers that a user gave to a questionnaire.			
Input Data	**Name**		**Type**	
	QuestionnaireID UserID		Integer Integer	
Output Data	**Name**		**Type**	
	UserQuestionnaireResults QuestionText QuestionID Answers		Array of	String Integer Array of *UserQuestionResults*
	UserQuestionResults	ChoiceText ChoiceID Answer	String Integer String	

Method Name	**ViewOverallQuestionnaireResults**		
Description	This web method is for viewing the overall results of a questionnaire (only for Boolean type questions).		
Input Data	**Name**	**Type**	
	QuestionnaireID	Integer	
Output Data	**Name**	**Type**	
	OverallQuestionnaireResults	Array	

	QuestionText QuestionID		of	String Integer Array of *Overall* *QuestionResults*
	OverallQuestionResults	ChoiceText ChoiceID VotesNumber Percentage	String Integer Integer Float	

Method Name	**ViewUserQuestionResult**		
Description	This web method is for viewing the answer of a user to a question.		
Input Data	**Name**	**Type**	
	QuestionID UserID	Integer Integer	
Output Data	**Name**	**Type**	
	UserQuestionResults ChoiceText ChoiceID Answer	Array of	String Integer String

Method Name	**ViewOverallQuestionResults**		
Description	This web method is for viewing the overall answers to a question.		
Input Data	**Name**	**Type**	
	QuestionID		
Output Data	**Name**	**Type**	
	OverallQuestionResults User (Name+Surname) UserID ChoiceText ChoiceID Answer	Array of	String Integer String Integer String

4. Workflow Component (Interactive Messages)

Tables that are used in by the Workflow Component

Table Name: **Workflows**

Field	Type	Description
WORKFLOWID	AUTONUMBER	Primary key
NAME	STRING	
DESCRIPTION	STRING	
MESSAGE	STRING	
VTDEDICATED	BOOLEAN	Specify if the workflow is linked with a

		Virtual Team of not.

Table Name: **WorkflowMsgs**

Field	Type	Description
WFMESSAGEID	AUTONUMBER	Primary key
WORKFLOWID	INTEGER	Foreign key (Workflows table)
FROMUSERID	INTEGER	Foreign key (Users table)
FROMSTATUS	STRING	(SENT, DELETED)
DATETIMESTAMP	DATETIME	
VIRTUALTEAMID	INTEGER	Foreign key (VirtualTeams table)

Table Name: **WorkflowMsgTo**

Field	Type	Description
MESSAGEID	AUTONUMBER	Primary key
WFMESSAGEID	INTEGER	Foreign key (WorkflowMsgs table)
TOUSERID	INTEGER	Foreign key (Users table)
TOSTATUS	STRING	(NEW, OLD, ASWERED, DELETED)
ROLEID	INTEGER	Foreign key (Roles table)
ANSWERS	STRING	
ARGUMENTS	STRING	
WAITFORANSWER	BOOLEAN	
RESPONSIBLE	INTEGER	Valid Values: 0, 1, 2

Table Name: **WFRoles**

Field	Type	Description
WFROLEID	AUTONUMBER	Primary key
ROLEID	INTEGER	Foreign key (Roles table)
WORKFLOWID	INTEGER	Foreign key (Workflows table)

CUSTOMIZEDMSG	STRING	
WAITFORANSWER	BOOLEAN	
TAKEACTIONTIME	INTEGER	
TIMEOUTWFID	INTEGER	Foreign key (Workflows table)
FORALL	BOOLEAN	

Table Name: **WFActions**

Field	Type	Description
WFROLEID	INTEGER	Foreign key (WFRoles table)
ACTIONID	INTEGER	Foreign key (Actions table)

Table Name: **Actions**

Field	Type	Description
ACTIONID	AUTONUMBER	Primary key
NAME	STRING	
TYPE	STRING	ANSWER, ARGUMENT
PROCEDURENAME	STRING	
ROLEID	INTEGER	Foreign key (Roles table)

Table Name: **ActionAnswers**

Field	Type	Description
ANSWERID	AUTONUMBER	Primary key
ACTIONID	INTEGER	Foreign key (Actions table)
ANSWERTEXT	STRING	
SENDBACKTEXT	STRING	
TRIGGERWFID	INTEGER	Foreign key (Workflows table)

Table Name: **ActionArguments**

Field	Type	Description
ARGUMENTID	AUTONUMBER	Primary key
ACTIONID	INTEGER	Foreign key (Actions table)
NAME	STRING	
TYPE	STRING	
DEFAULTVALUE	STRING	
LISTOFVALUES	STRING	If it's a query, it must begin with @ If it's a list of values, they must by separated with |
SEQUENCE	INTEGER	
APPEARANCE	STRING	SENDER, RECEIVER
DBNAME	STRING	Must begin with @

Web methods that are used for Workflow Component

Method Name	**Inbox**		
Description	This web method is for viewing the incoming interactive messages (workflows).		
Input Data	**Name**	**Type**	
	UserID	Integer	
Output Data	**Name**	**Type**	
	WorkflowMessageDetails MessageID FromUser (Name+Surname) Status	Array of	Integer String String

	Subject TimeStamp		String DateTime

Method Name	**Outbox (Sent)**		
Description	This web method is for viewing the outgoing interactive messages (workflows).		
Input Data	**Name**	**Type**	
	UserID	Integer	
Output Data	**Name**	**Type**	
	WorkflowMessageDetails MessageID Subject TimeStamp	Array of	 Integer String DateTime

Method Name	**Deleted**		
Description	This web method is for viewing the deleted interactive messages (workflows).		
Input Data	**Name**	**Type**	
	UserID	Integer	
Output Data	**Name**	**Type**	
	WorkflowMessageDetails MessageID	Array of	 Integer

	FromUser (Name+Surname) Subject TimeStamp		String String DateTime

Method Name	**SendInteractiveMessage**	
Description	This web method is for sending an interactive message. PassingArgs is for passing arguments with the message.	
Input Data	**Name**	**Type**
	WorkflowID VirtualTeamID FromUserID PassingArgs	Integer Integer Integer String
Output Data	**Name**	**Type**
	WFMessageID	Integer

Method Name	**ReadInteractiveMessage**	
Description	This web method is for viewing the information/details of an interactive message (workflow).	
Input Data	**Name**	**Type**
	MessageID UserID	Integer Integer

	Name		**Type**
Output Data	*WorkflowMessageDetails*		
	FromUser (Name+Surname)		String
	Body		String
	TimeStamp		DateTime
	Status		String
	Responsible		Integer
	Restrictions		String
	ToUsers		Array of Strings
	Actions		Array of *ActionEntity*
	ActionEntity	ActionID	Integer
		ActionName	String
		ActionType	String
		ProcedureName	String
		Answers	Array of *AnswerEntity*
		Arguments	Array of *ArgumentEntity*
	AnswerEntity	AnswerText	String
		SendBackText	String
		AnswerID	Integer
		TriggerWFID	Integer
		SelectedAnswer	Boolean
	ArgumentEntity	ArgumentName	String
		ArgumentType	String
		ListOfValues	String

		LovArray() DefaultValue Appearance ExistingValue DBName	Array of *Entity* String String String String
	Entity	Name Value	String String

Method Name	**DeleteMessage**	
Description	This web method is for deleting interactive messages.	
Input Data	**Name**	**Type**
	MessageID UserID Place	Integer Integer String (INBOX, OUTBOX, DELETED)
Output Data	**Name**	**Type**

Method Name	**RestoreMessage**	
Description	This web method is for restoring an interctive message (change the Status from DELETED to OLD).	
Input Data	**Name**	**Type**

	MessageID UserID	Integer Integer
Output Data	**Name**	**Type**

Method Name	**MarkAsRead**	
Description	This web method is for marking an interactive message as Read.	
Input Data	**Name**	**Type**
	MessageID UserID	Integer Integer
Output Data	**Name**	**Type**

Method Name	**GetDatabaseStoredProcedures**		
Description	This web method is for returning all the stored procedures that exists in the database.		
Input Data	**Name**	**Type**	
Output Data	**Name**	**Type**	
	ProcedureNames	Array of	String

Method Name	**SaveActionWithAnswers**		
Description	This web method is for saving actions that are consisted of answers.		
Input Data	**Name**		**Type**
	Action Type		*ActionEntity* String (NEW, EXISTING)
	ActionEntity	ActionID ActionName ActionType RoleID Answers	Integer String String Integer Array of *AnswerEntity*
	AnswerEntity	AnswerText SendBackText TriggerWFID	String String Integer
Output Data	**Name**		**Type**

Method Name	**SaveActionWithArguments**	
Description	This web method is for saving actions that are consisted of arguments.	
Input Data	**Name**	**Type**
	Action Type	*ActionEntity* String (NEW, EXISTING)

	ActionEntity	ActionID ActionName ActionType ProcedureName RoleID Arguments	Integer String String String Integer Array of *ArgumentEntity*
	ArgumentEntity	ArgumentName ArgumentType ListOfValues DefaultValue Appearance DBName	String String String String String String
Output Data	**Name**		**Type**

Method Name	**GetActionDetails**	
Description	This web method is for viewing the details of an action.	
Input Data	**Name**	**Type**
	ActionID	Integer
Output Data	**Name**	**Type**
	ActionEntity ActionID ActionName	 Integer String

	ActionType		String
	ProcedureName		String
	RoleID		Integer
	Answers		Array of *AnswerEntity*
	Arguments		Array of *ArgumentEntity*
	AnswerEntity	AnswerID	Integer
		AnswerText	String
		SendBackText	String
		TriggerWFID	Integer
	ArgumentEntity	ArgumentID	Integer
		ArgumentName	String
		ArgumentType	String
		ListOfValues	String
		DefaultValue	String
		Appearance	String
		DBName	String

Method Name	**ListAllActions**		
Description	This web method is for viewing all actions of the system.		
Input Data	**Name**	**Type**	
Output Data	**Name**	**Type**	
	ActionEntity	Array of	

	ActionID ActionName		Integer String

Method Name	**ListWorkflowActionsAndArguments**			
Description	This web method is for viewing all actions of a workflow that contains arguments fro Sender or Receiver.			
Input Data	**Name**		**Type**	
	WorkflowID sAppear		Integer String (SENDER, RECEIVER)	
Output Data	**Name**		**Type**	
	ActionEntity ActionID ActionName ActionType Arguments		Array of	Integer String String Array of *ArgumentEntity*
	AnswerEntity	AnswerID AnswerText SendBackText TriggerWFID	Integer String String Integer	
	ArgumentEntity	ArgumentID ArgumentName	Integer String	

		ArgumentType ListOfValues DefaultValue DBName LovArray	String String String String Array of *Entity*
	Entity	Name Value	String String

Method Name	**ListActionsForRole**		
Description	This web method is for viewing all actions for a specific role.		
Input Data	**Name**	**Type**	
	RoleID All	Integer Boolean	
Output Data	**Name**	**Type**	
	ActionEntity ActionID ActionName	Array of	 Integer String

Method Name	**DeleteAction**	
Description	This web method is for deleting an action.	
Input Data	**Name**	**Type**
	ActionID	Integer
Output Data	**Name**	**Type**

Method Name	**ActionsCompletedSendMessage**	
Description	This web method is for sending back to the sender a message with the answers. It also checks if an answer is triggering another interactive message.	
Input Data	**Name**	**Type**
	WFMessageID AnswerID AnswerText UserID	Integer Integer String Integer
Output Data	**Name**	**Type**

Method Name	**ExecuteActionsProcedures**	
Description	This web method is for executing the procedures that are linked with the answers of the user.	
Input Data	**Name**	**Type**
	WFMessageID AnswerID AnswerText	Integer Integer String

	UserID		Integer
Output Data	**Name**		**Type**
	WorkflowMessageDetails Actions		 Array of *ActionEntity*
	ActionEntity	ProcedureName Arguments	String Array of *ArgumentEntity*
	ArgumentEntity	ExistingValue DBName	String String

Method Name	**SendWorkflowDetails**		
Description	This web method is for saving all the information of a workflow (interactive message).		
Input Data	**Name**		**Type**
	WorkflowEntity WorkflowID Name Description Message VTDedicated Roles		 Integer String String String Boolean Array of *WFRoleEntity*
	WFRoleEntity	RoleID CustomizedMessage WaitForAnswer	Integer String Boolean

		TakeActionTime TimeoutWorkflowID ForAll Actions	String Integer Boolean Array of *Entity*
	Entity	Name Value	String String
Output Data	**Name**		**Type**

Method Name	**ViewWorkflow**	
Description	This web method is for viewing basic information of a workflow.	
Input Data	**Name**	**Type**
	WorkflowID	Integer
Output Data	**Name**	**Type**
	WorkflowEntity WorkflowID Name Description VTDedicated Message	 Integer String String Boolean String

Method Name	**GetWorkflowDetails**

Description	This web method is for viewing all information of a workflow.		
Input Data	**Name**		**Type**
	WorkflowID		Integer
Output Data	**Name**		**Type**
	WorkflowEntity WorkflowID Name Description Message VTDedicated Roles		 Integer String String String Boolean Array of *WFRoleEntity*
	WFRoleEntity	RoleID RoleName Enabled CustomizedMessage WaitForAnswer TakeActionTime TimeoutWorkflowID ForAll Actions	Integer String Boolean String Boolean String Integer Boolean Array of *Entity*
	Entity	Name Value	String String

Method Name	**ListAllWorkflows**		
Description	This web method is for viewing basic information of all workflows.		
Input Data	**Name**	**Type**	
Output Data	**Name**	**Type**	
	WorkflowEntity WorkflowID Name Description	Array of	 Integer String String

Method Name	**DeleteWorkflow**	
Description	This web method is for deleting a workflow.	
Input Data	**Name**	**Type**
	WorkflowID	Integer
Output Data	**Name**	**Type**

Method Name	**FindWorkflowRecipients**	
Description	This web method is for viewing the recipients of a workflow based on the virtual team that they are part of.	
Input Data	**Name**	**Type**
	WorkflowID	Integer

	VirtualTeamID	Integer	
Output Data	**Name**	**Type**	
	Entity Name Value	Array of	String String

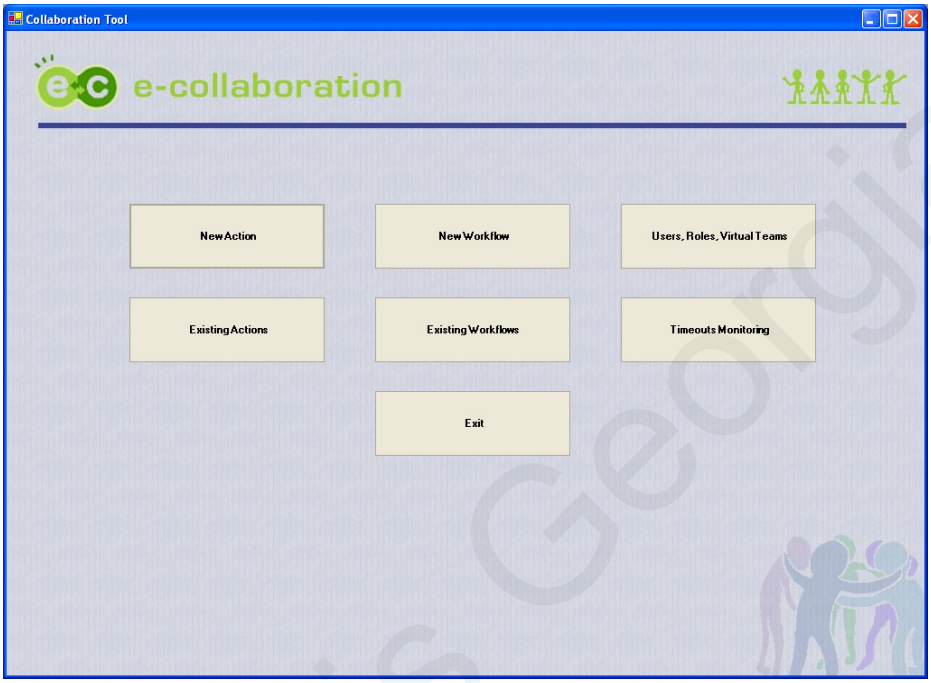
Method Name	**FindWorkflowNonRecipients**		
Description	This web method is for viewing the users that will not receive a workflow that is send into their virtual team.		
Input Data	**Name**	**Type**	
	WorkflowID VirtualTeamID	Integer Integer	
Output Data	**Name**	**Type**	
	Entity Name Value	Array of	String String

Method Name	**TakeResponsibility**	
Description	This web method is for giving the responsibility of an action to a specific user.	
Input Data	**Name**	**Type**
	MessageID UserID	Integer Integer
Output Data	**Name**	**Type**

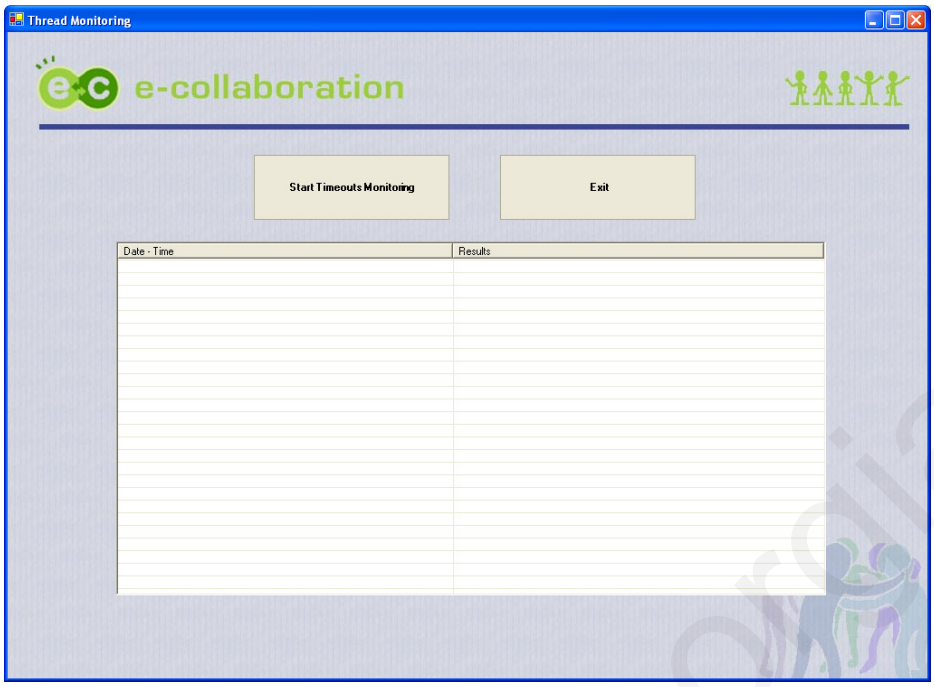
Method Name	**FindAndResolveTimeouts**	
Description	This web method is for tracking the timeouts. It also triggers new interactive messages if a timeout occurs.	
Input Data	**Name**	**Type**
Output Data	**Name**	**Type**
	TimeoutCount	Integer

Annex 2

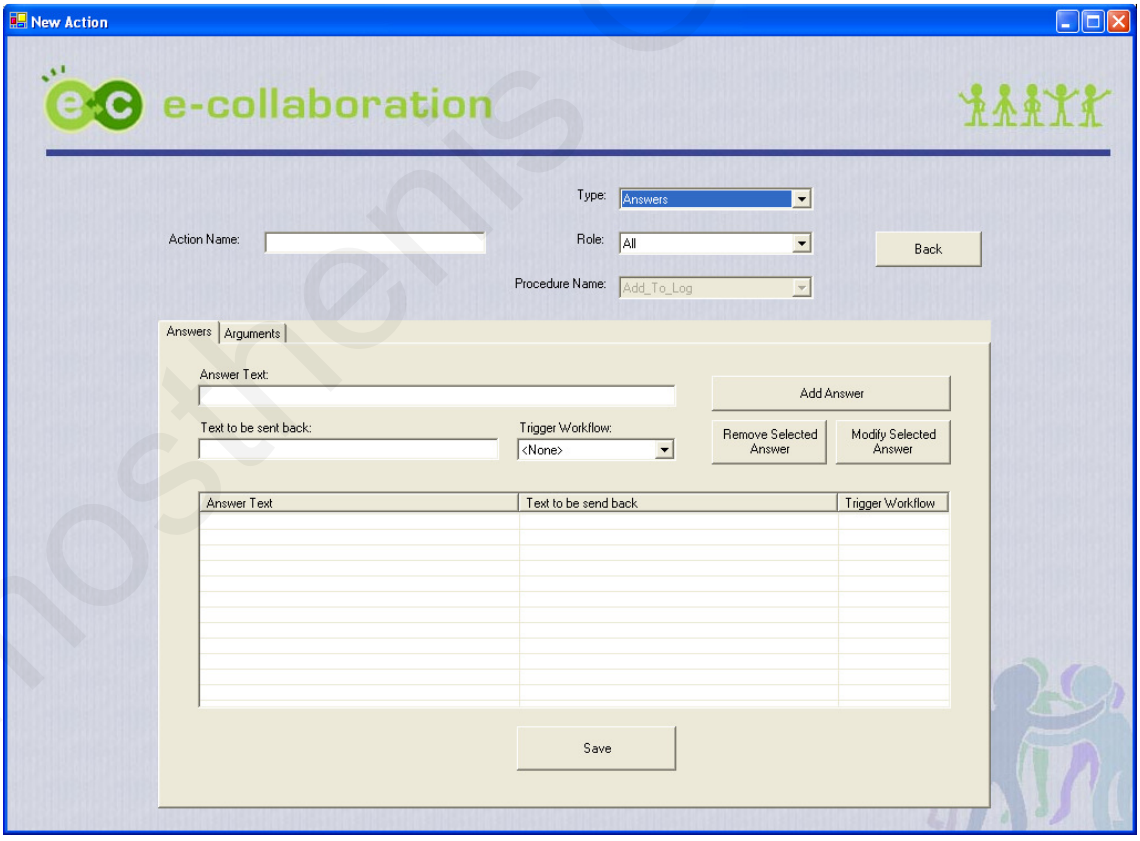
1. Administrator's System Screenshots



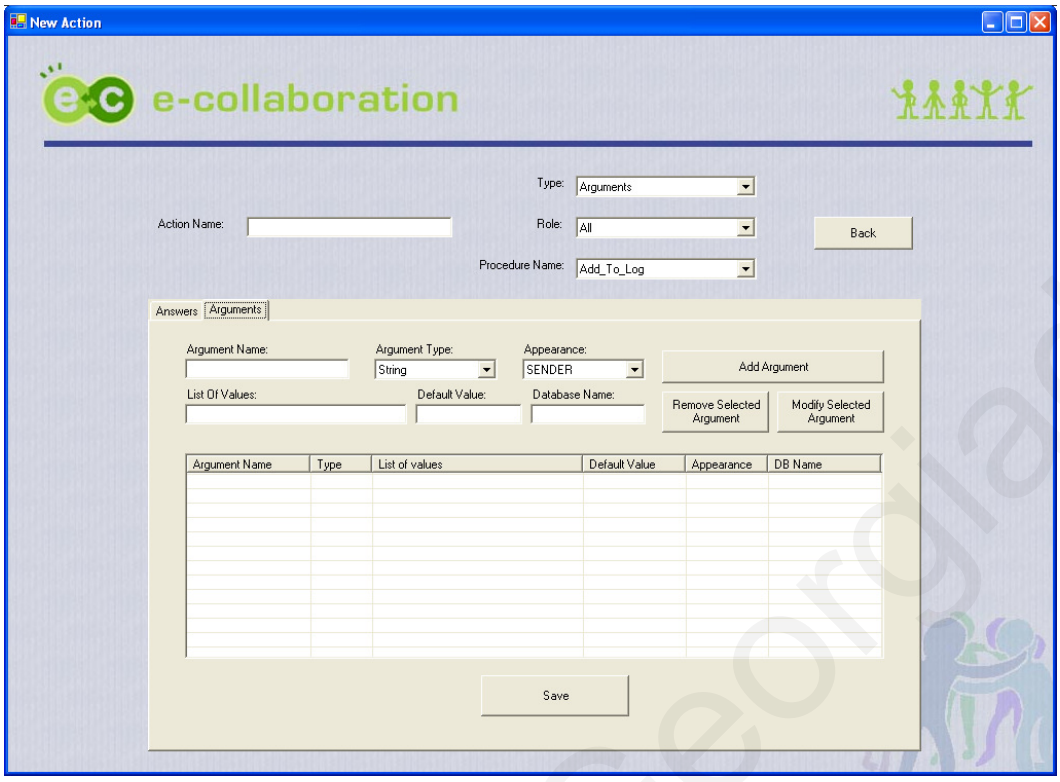
Administrator's Main Menu



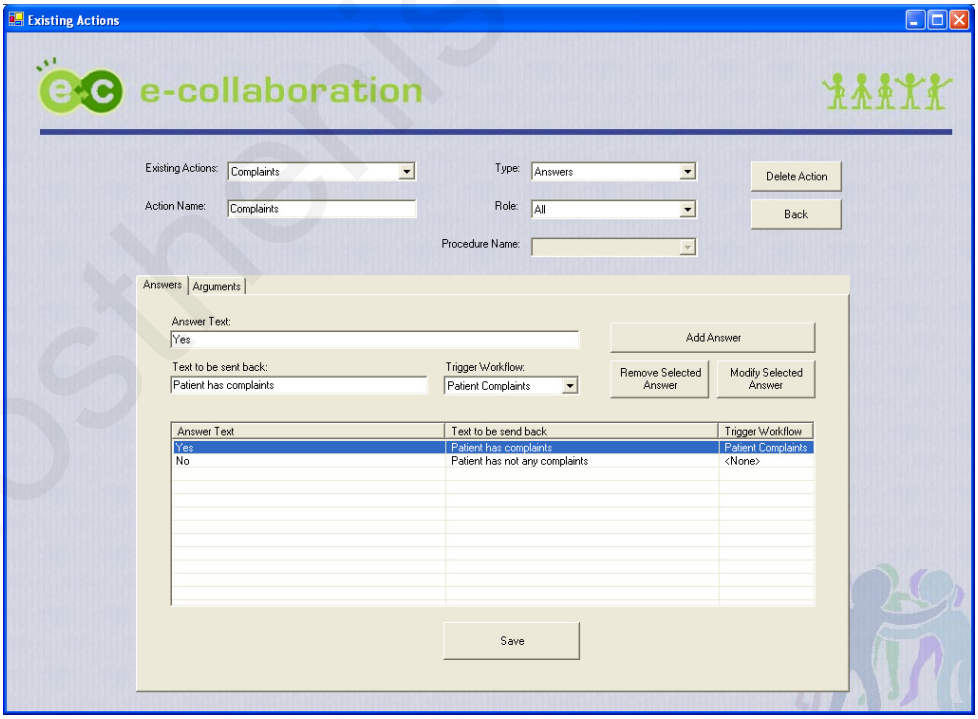
Timeouts Monitoring



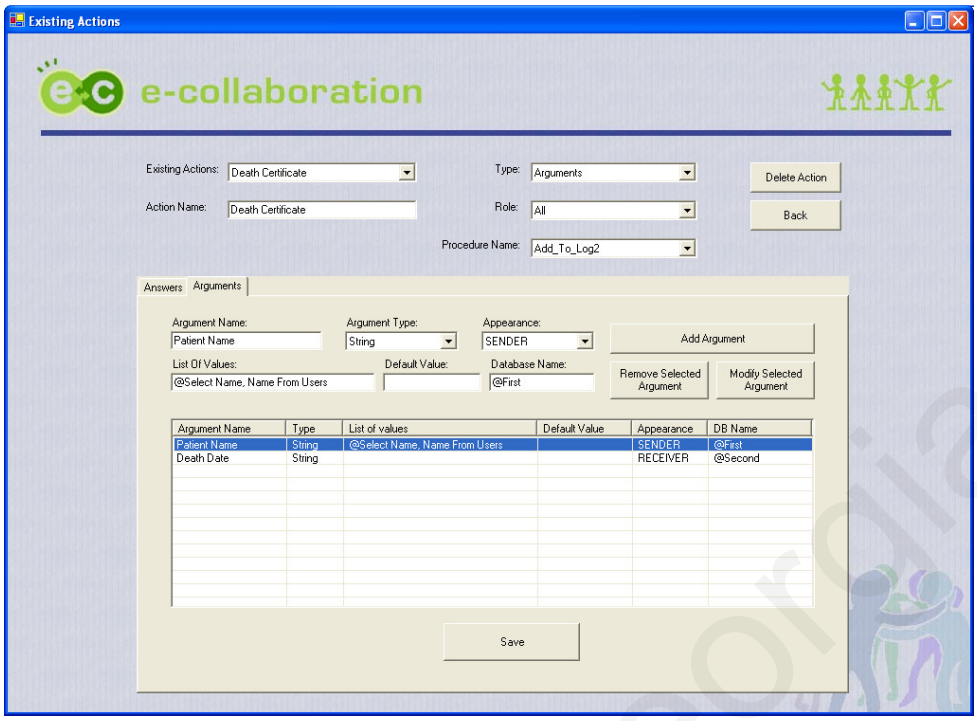
Create a new Action with Answers



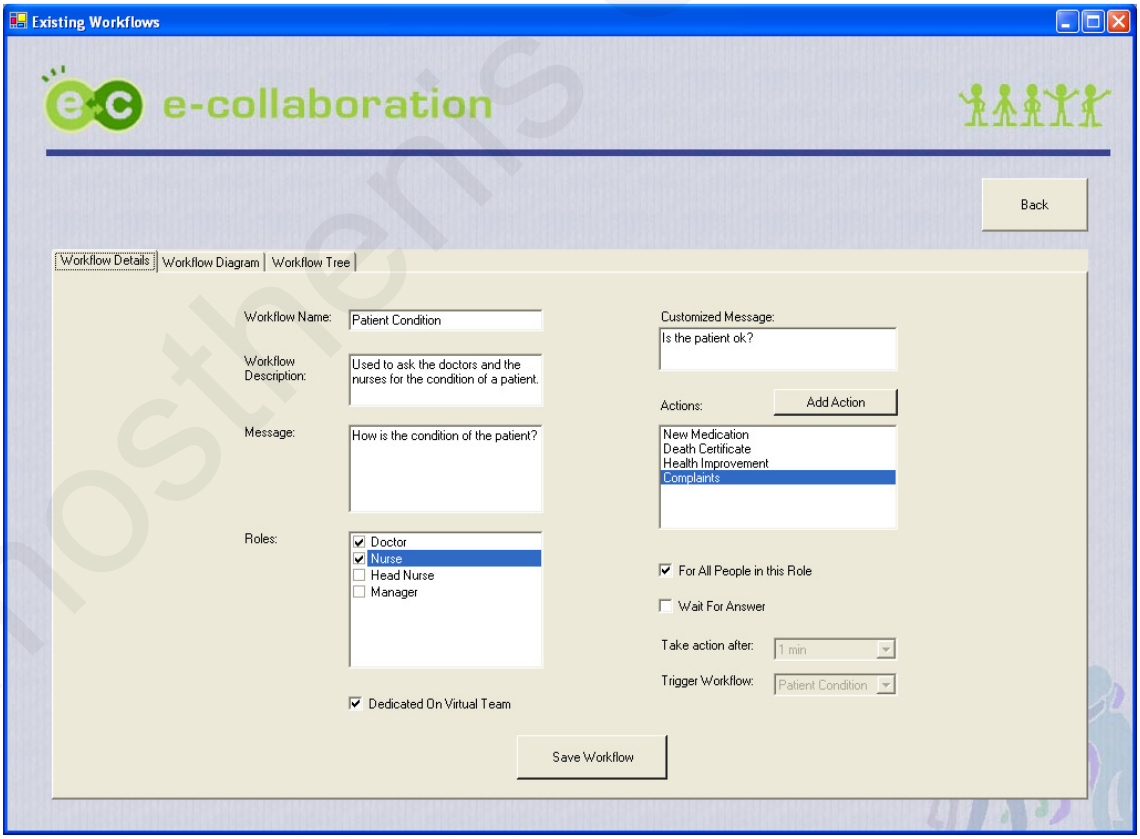
Create a new Action with Arguments



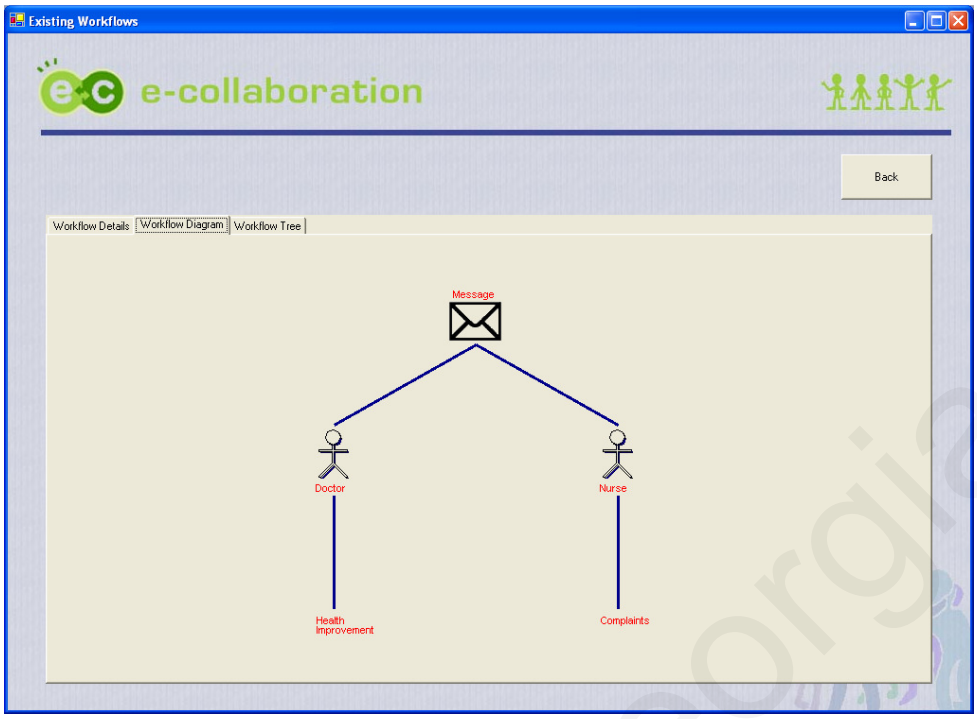
Manage Action with Answers



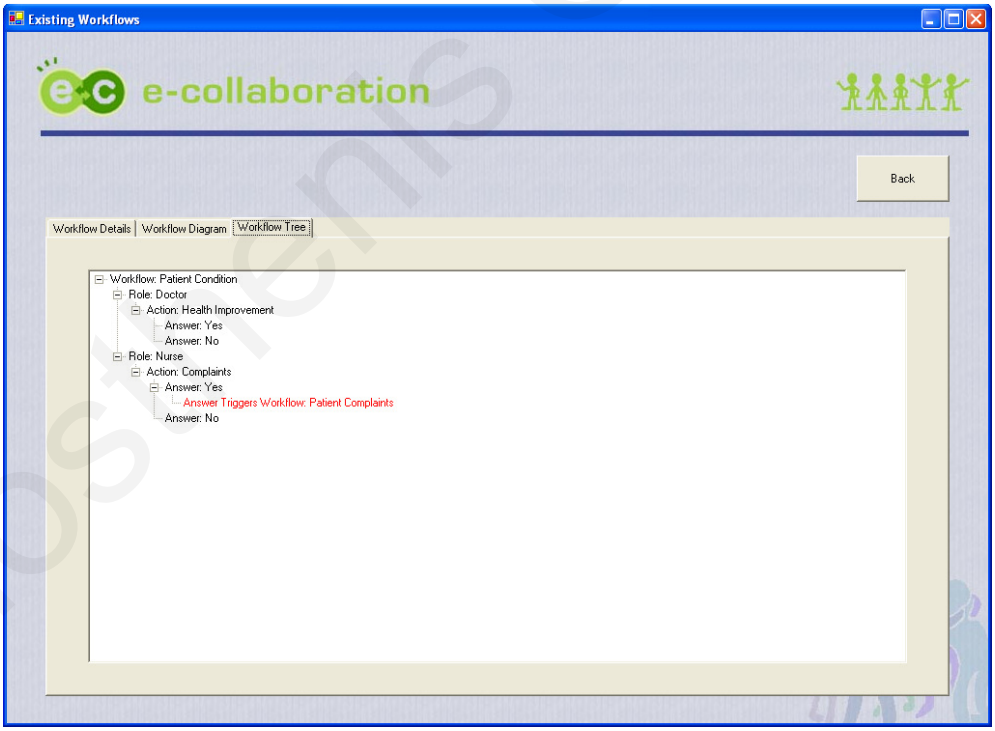
Manage Action with Arguments



Create a new Workflow

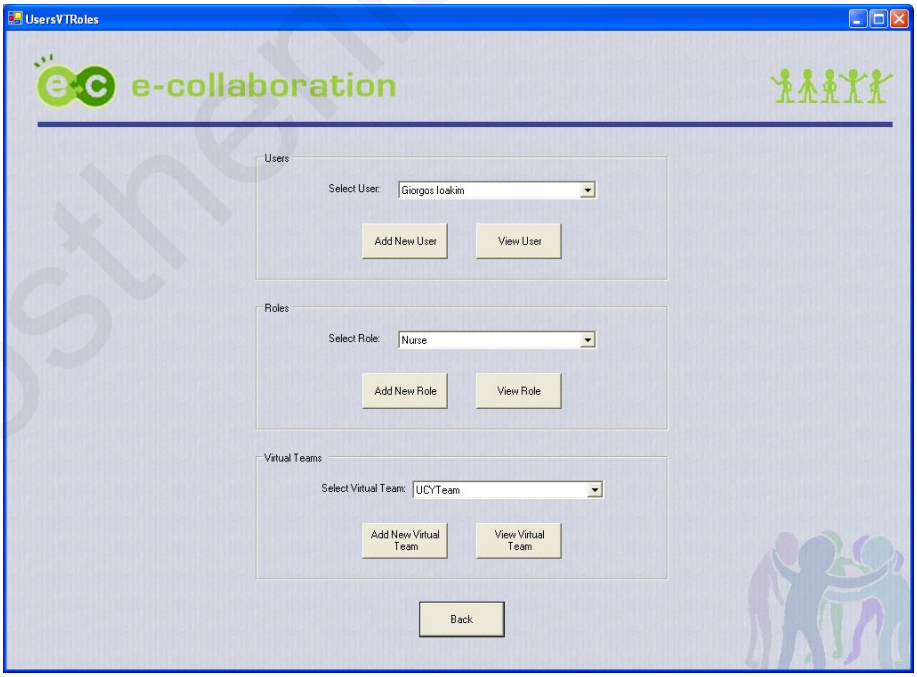


Workflow Diagram



Workflow Tree View

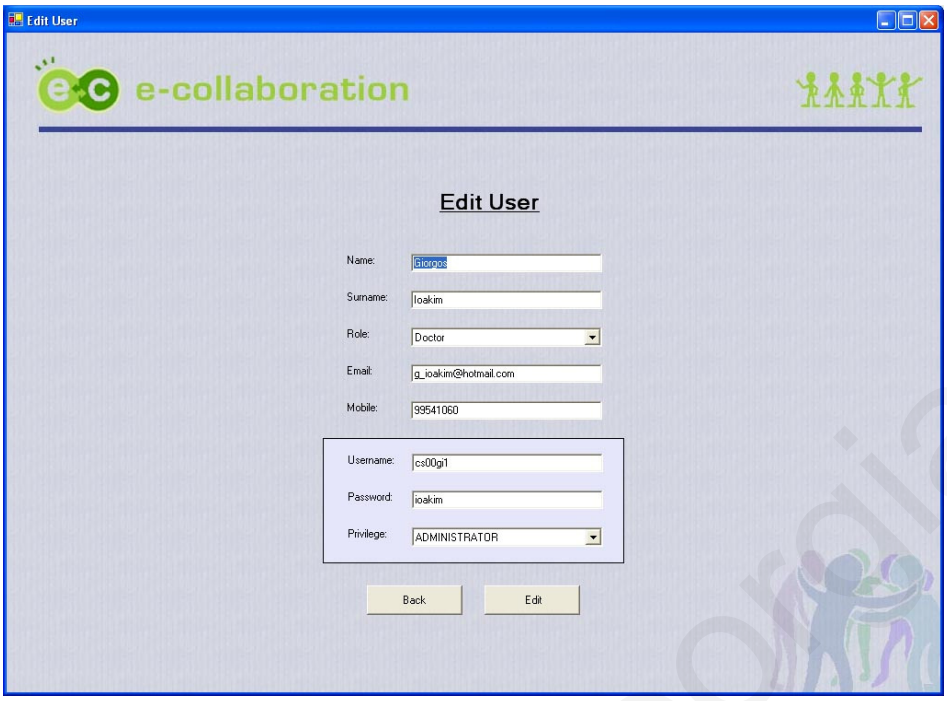
Managing Workflows



User Component Management Console

Add New User to the System

View the Users of the system

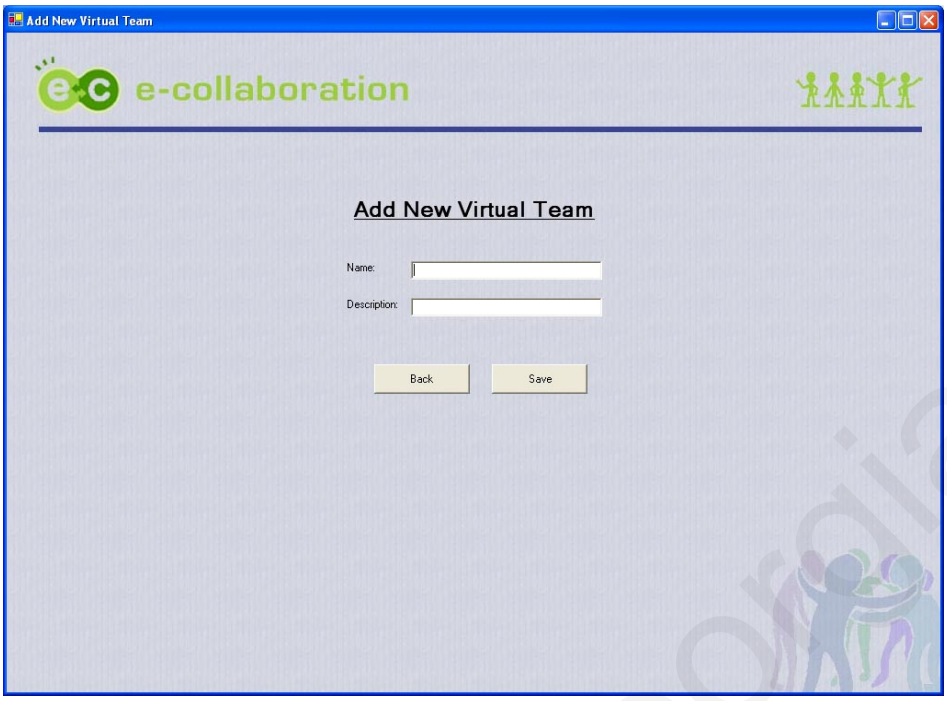


Edit the Users of the system

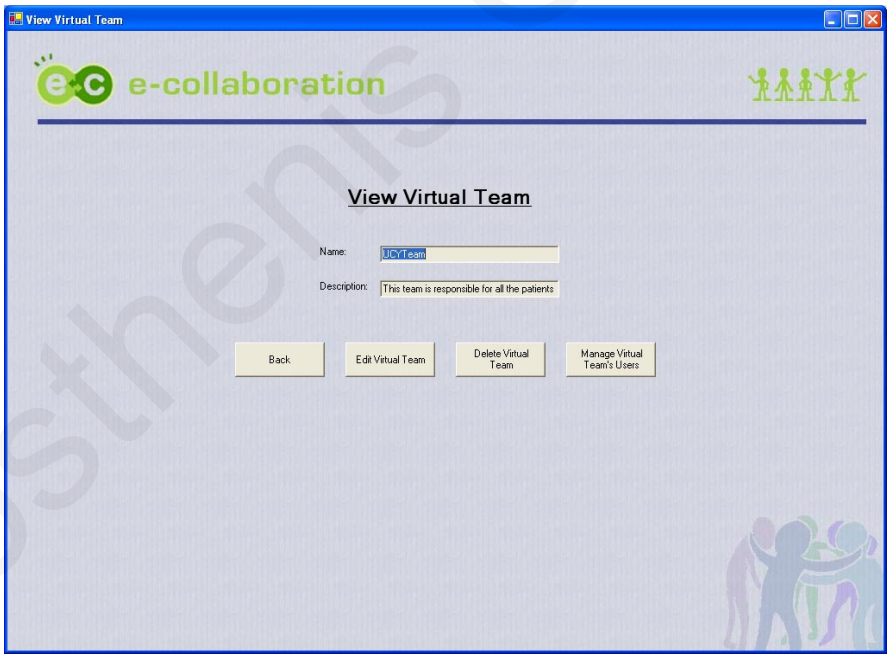
Create a Role

View an existing Role

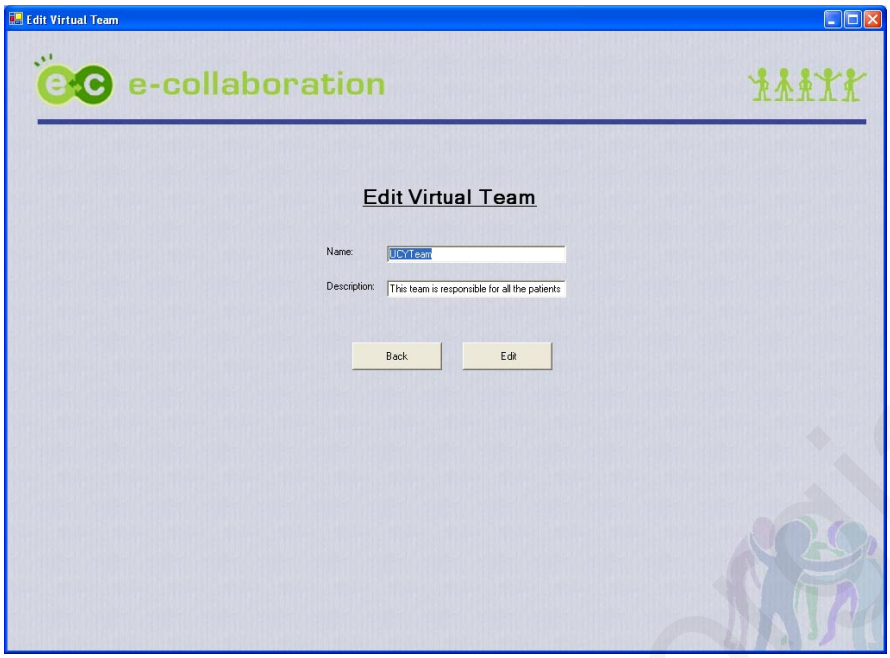
Edit an existing Role



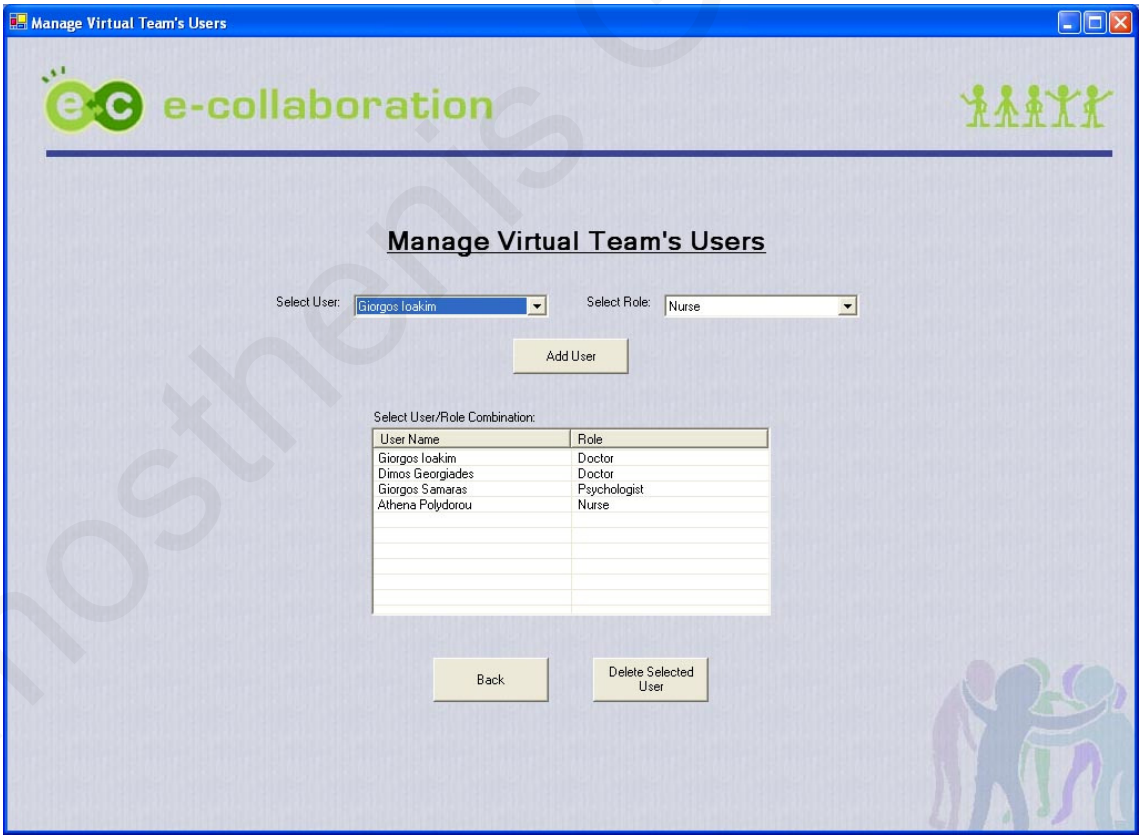
Add new Virtual Team



View an existing Virtual Team

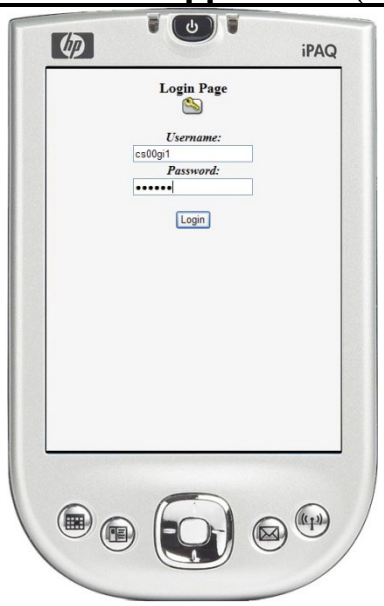


Edit an existing Virtual Team



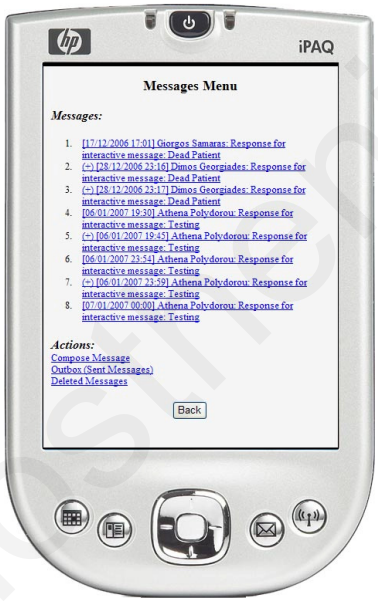
Manage Virtual Team's Users

2. Web-based Application (Users) Screenshots

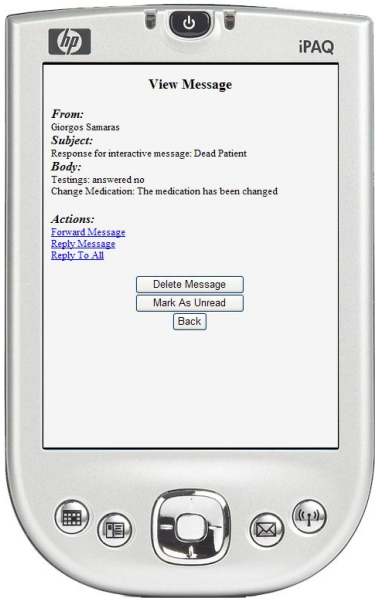


Through this login screen, users enters their credentials (username/password) to access the system.

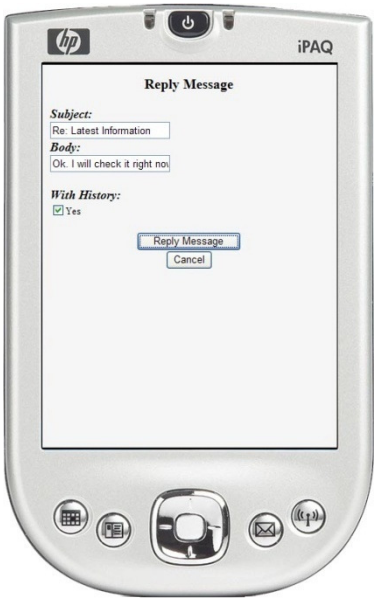
Through the main menu, users can access the workflows, their messages, their questionnaires, the administration menu, where they can change their password and logout.



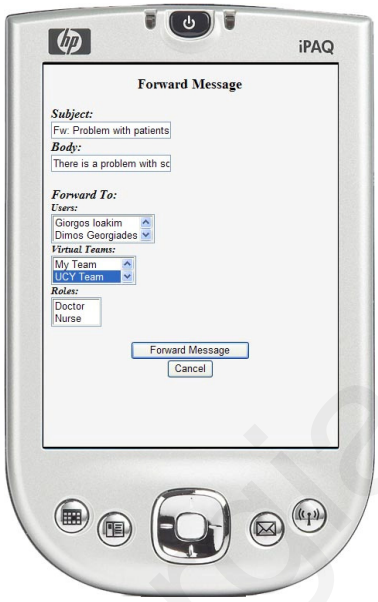
By selecting the Message menu, users can view their messages. Inbox, Outbox and Deleted Message. By selecting a message, he can view more details.



While viewing a message, users can forward, reply, reply to all or delete a message. He can also mark the message as unread.



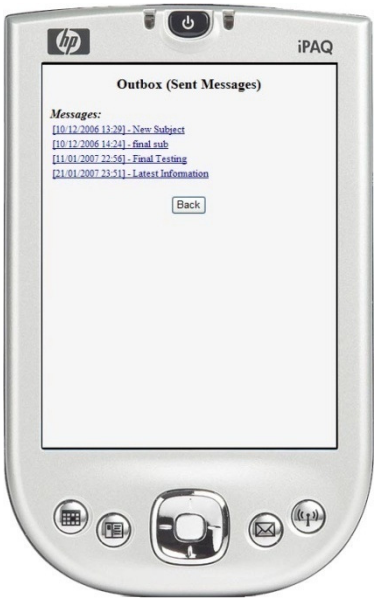
During replying, the user must enter the subject and body and then send it to the sender. He can also choose to add in the message the body of the original one.



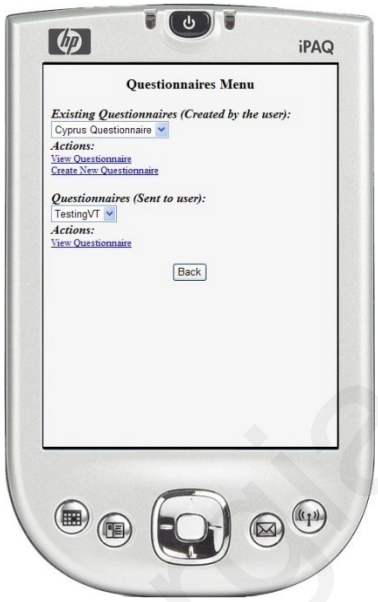
During forwarding a message, the user can select to send the message to other users, virtual team or roles.

From this screen, users can compose a new message and send it to many users, virtual teams or roles. The Subject and Body fields must be filled.

This screen shows the Deleted Messages folder. Users can review one of these messages and even recover it (Undelete).

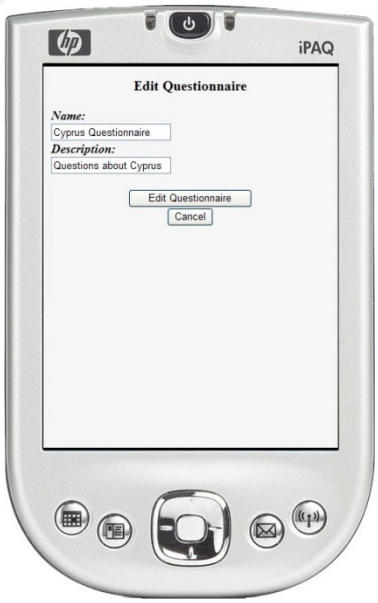


Users can also review the messages that they send in the past (Outbox).

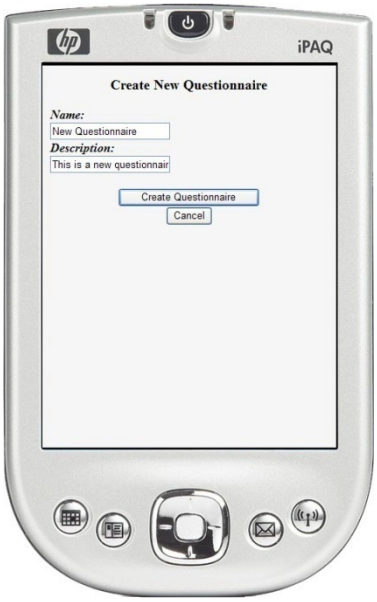


Users can also review the questionnaires that they created and the questionnaires that they have to answer. From this screen the users can create new questionnaires or review an old one.

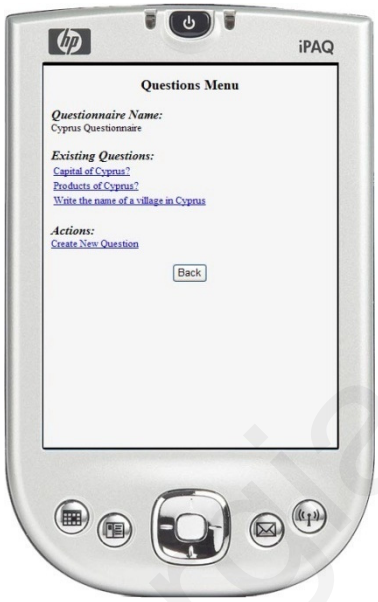
By selecting an existing questionnaire, we view the basic information about it. Users can edit it, send it to other users or review the results.



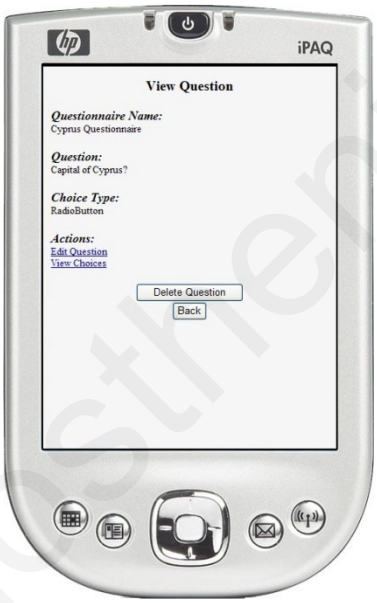
Through this screen, users can change the questionnaires basic details.



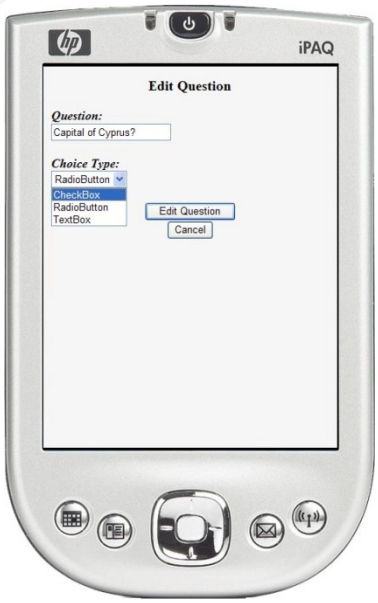
Users can create a new questionnaire by giving the name and the description of the questionnaire.



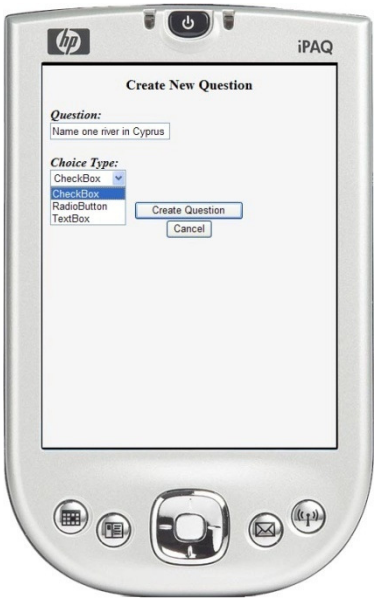
Later we add questions to the questionnaire. We have a list of the existing questions and we add new ones by clicking on the "Create New Question" link.



By clicking a question, users can view the details of the question and view the choices, edit and delete the question.



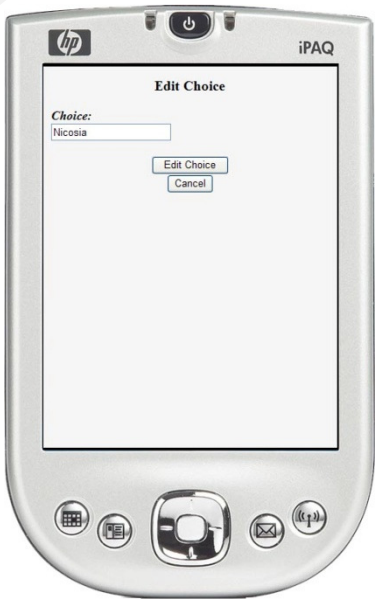
By editing the question, users can change the Question and the type (CheckBox, RadioButton and TextBox)



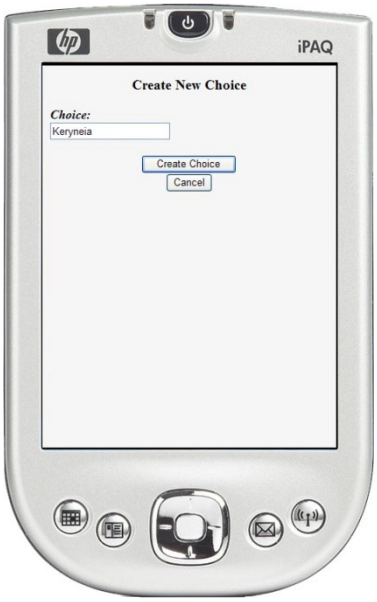
Similar screen is used when we are creating a new question. We enter the Question and the type.

When we are viewing a question, we see the existing choices. We have the option also to create a new one.

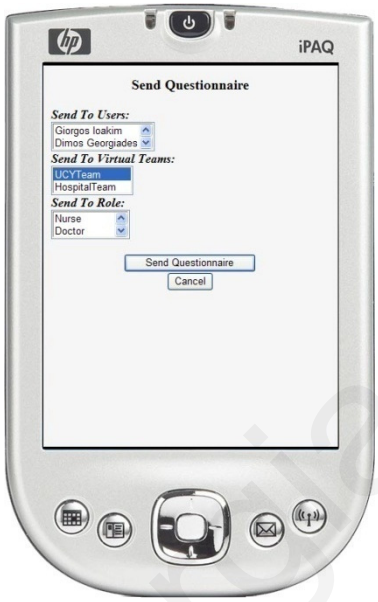
In this screen we review a choice of a question. We can edit it, or delete it.



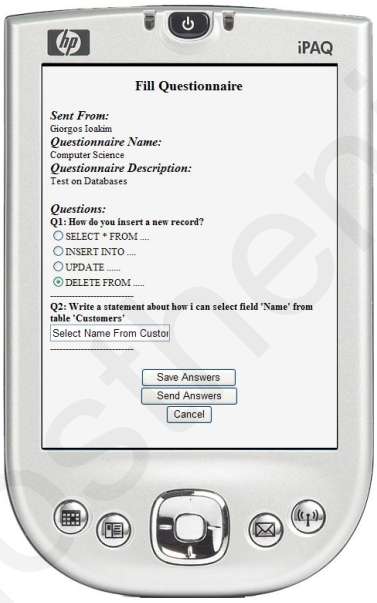
While editing the choice, we can only change the Choice Name.



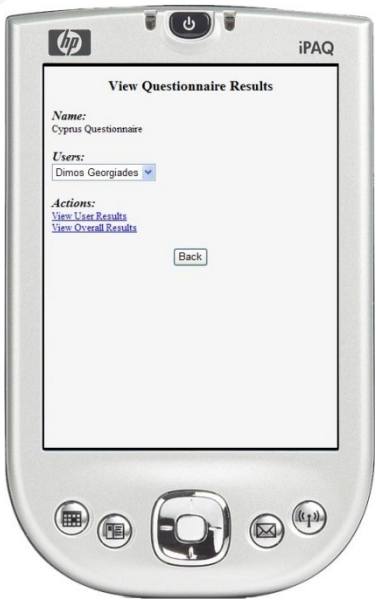
Similar screen is used to add a new Choice. We only have to add the Name.



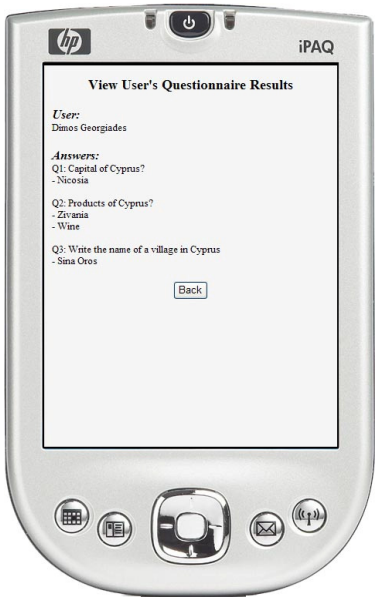
When we have to send the questionnaire, we just select users, virtual teams or roles. Then we press the "Send Questionnaire" Button.



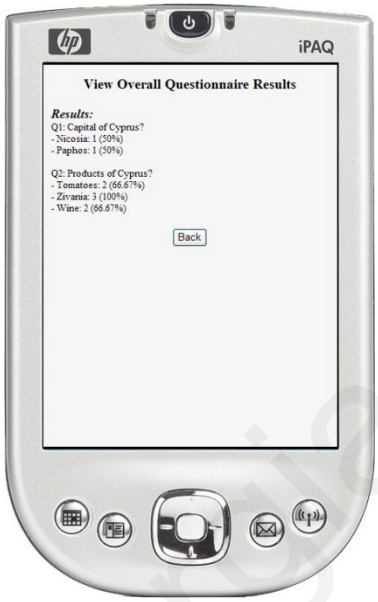
This is a sample screen for completing a questionnaire. We can save the answers (so we can continue some other time) or send them directly to the sender.



Users can review the results of the questionnaires. The results can by shown by user or overall.

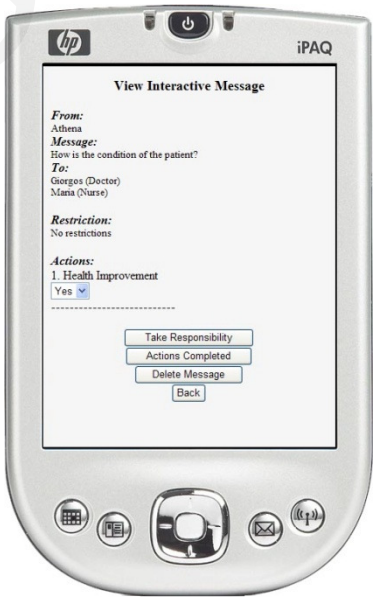


If we select to view the results b user, we will see the results like this screen.

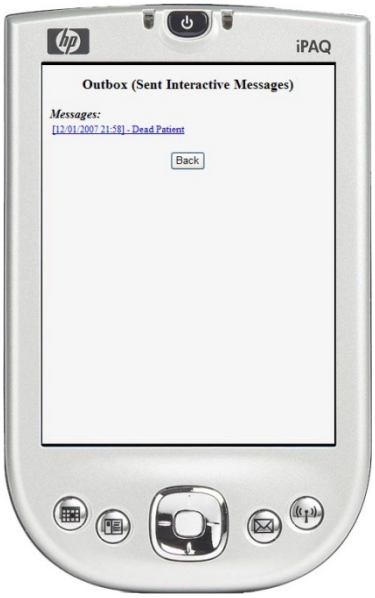


With the overall view of the results, we see a screen like this one.

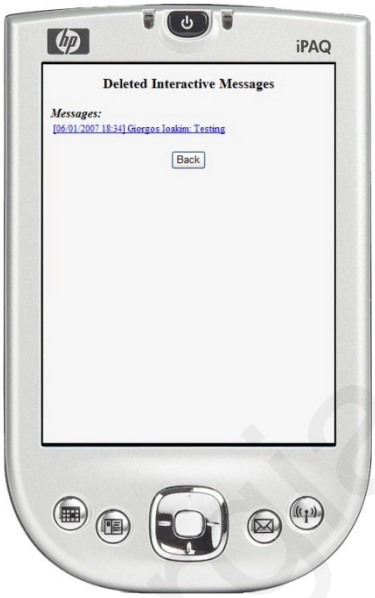
Users can also review their workflows, create a new interactive message, view the ones that he send view the deleted ones (Inbox, Outbox and Deleted).



By clicking on an interactive message we see the details. User can take responsibility of the action, send the result (Actions Completed) or delete the interactive message.

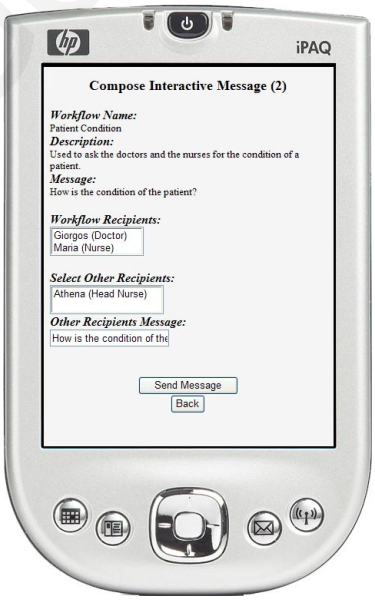


In the Outbox, users can review the interactive messages that they send.

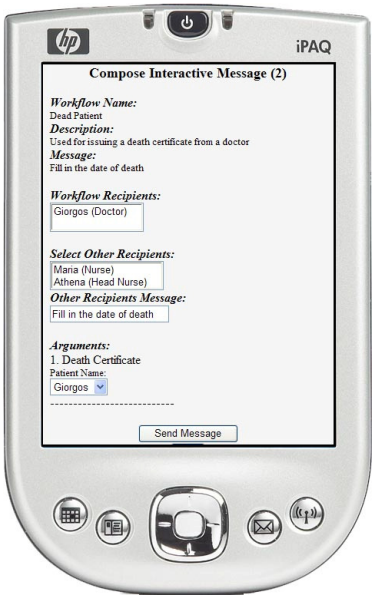


Similarly, users can see the messages that they deleted.

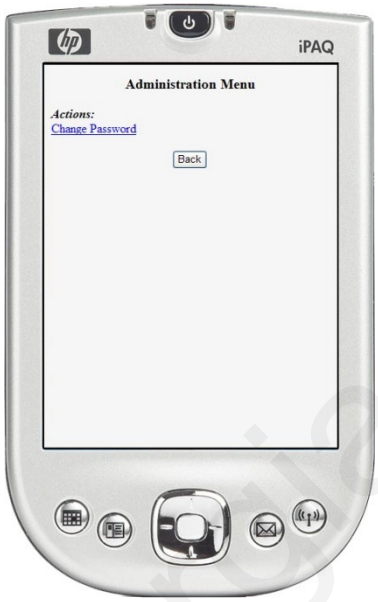
In order to create a new interactive message, users select the workflow of the system and the virtual team that he is referring to.



The next step is to review the workflow and choose more recipients that they may not be included in the default list of the workflow. We also add the message that these recipients will get.

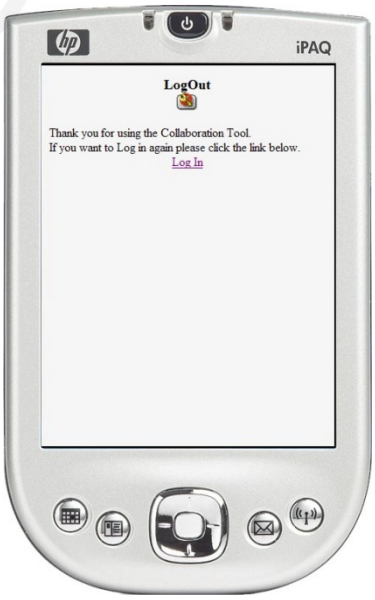


This is a creating of a interactive message that had arguments for the sender. As you can see, it asks the sender a question before sending to the recipients the interactive message.



Within the Administration Menu, users can change their password.

In order to do so, users enter the old password, and 2 times the new one, in order to avoid any typing mistakes.



Finally, users logout of the system. In the logout screen there is a link allowing to the user to reenter the system by reentering his credential