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Designing and Implementinga Telemedicine System

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Hachemi Atroune2, Abderrazak Sebaa1, KoceilaChefai2 , Lydia Abbas2, Nesrine Hammouche2, Yamina Khiati2
1 LIMED Laboratory, Faculty of Exact Sciences, University of Bejaia,Algeria
2 Department of Computer Science, University of Bejaia, Algeria

Abstract
Background: A modern Teleconsultation System (TCS) improves patients' monitoring and favors remote assistance in terms of facilitating the daily life to the patients. This work investigates how to design and implement a modern remote consultation system.
Methods: To achieve this work, we identify the actors who interact with the system to be developed and the use cases relating to each actor. A class model is designed to derive the relational model and the corresponding database. During implementation, we have used PHP language and MySQL database system.
Results: A tele-consultation framework is implemented. The users (patients and doctors) must register then authenticate in order to use the system. The latter allows them audio and video conversation between them.
Conclusion: We have given in this study how to design and implement a telemedicine system, which will improve health care, ensure continuity and quality of homecare while inhibiting intercurrences or complications, which will limit hospital admissions and limit medical travel.
Keywords: Telemedicine, Tele-consultation, Healthcare, Medical remote system.

Corresponding author: AbderrazakSebaa,Department of Computer Science, University of Bejaia, Algeria Email: balzak.sebaa@gmail.com
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1. Introduction

1.1. Background and the problem specification

Developing countries are severely lacking healthcare infrastructure and staff. Indeed, these countries suffer from understaffed hospitals and community services, especially the specialist medical doctors. This situation spawned health inequalities between different regions and population [1].

When talking about the qualifications and distribution of health personnel, the WHO (World Health Organization) considers it unlikely that countries with fewer than 23 health professionals (counting only the doctors, the nurses, and midwives) per 10,000 population obtain appropriate coverage rates for essential interventions in primary healthcare that are prioritized by the development intentions for the millennium[2].

Thus, considering the vastness of the Algerian territory, the number of the health personnel and based on the recommendations of WHO, the medical coverage is not fully ensured especially in the remote zones of the country. Telemedicine can solve partially this problem. Teleconsultation (TC), in particular, become a necessity or even an obligation for greater equity in the availability of healthcare specialists throughout the country. By telemedicine, it is meant a form of remote therapeutic practice linking a patient and one or more healthcare specialists via Information and Communication Technologies (ICTs). Different categories of telemedicine, includingtele-expertise, tele-monitoring, tele-assistance, and finally,teleconsultation.

1.2. Objectives

This work focuses on achieving a telemedicine system. The proposed Teleconsultation System (TCS) will connect patients, caretakers, and health staff.

It will allow consultation and diagnosis of patients remotely fulfilling the following objectives:

- To ensure the quality as well as the continuity of homecare;
- To prevent complications and thus limit hospitalizations;
- Limit travel and facilitate access to care in remote areas;
- To shorten waiting times; and
- To increase the medical coverage of users of the healthcare system and to follow-up patients with chronic illnesses or incapacities [3].

2. Materials and Methods

Referring to the 2TUP (Tow Tracks Unified Process) approachcovering all steps involving the analysis phase to the system design, it represents two essential stages of our conception process. The initial functional structure comprises class models and use cases for the different actors: the physician, governmental agencies, the administrator, the caretaker and the patient. The proposed architecture entails a 3-tier architecture style that relates the client applications and the database server. The next subsections describe materials and methods.

2.1 Materials

In order to properly design our tele-consultation system, we designed the use cases diagram and the class model of our framework.Noting that the last one is used to obtain the relational model (required in our application) using passing rules to be used in our application. The implementation of the system was made by PHP language, the querying and databases were implemented with MySQL, which is compatible with PHP.

2.2 Methods

Realizing a telemedicine system is a complex task, which consists of several phases: designing phase, which includes requirements identification, actors' identification, and UML modeling.Then, the implementation phase that consists of databases, interfaces, and communication tools implementation.

The project requirements are twofold. Functional requirements for the TCS must allow a trustworthy and confidential communication among all the actors. Non-functional requirements which mean to ensure a secure communication, processing speed, and performance.

2.2.1 Uses cases

This use case diagram involves the information system general modeling where there is the root actor "user" that has as only case of use "registration" and it is inherited by three other actors "administrator", "doctor" and "patient". The administrator has a single use case "User Management" to manage physicians and patients and that directly includes an authentication.

The doctor has four use cases: "Patient Management" to manage patients, "Prescription Management" for giving and writing of medical prescriptions, and two other use cases shared with the actor "Patient." These shared cases are, respectively, "Appointment Management" for making appointments, and "Conversation Management" to manage conversations among patients, caretakers and doctors. The latter actor "Patient" has two specific use cases, namely, "Medical samples" and "Prescription consulting". In all these use cases, an actor must receive authentication first.

The next step is the data model elaboration, which must specify the system to accept expansions to accommodate present and forthcoming requirements.

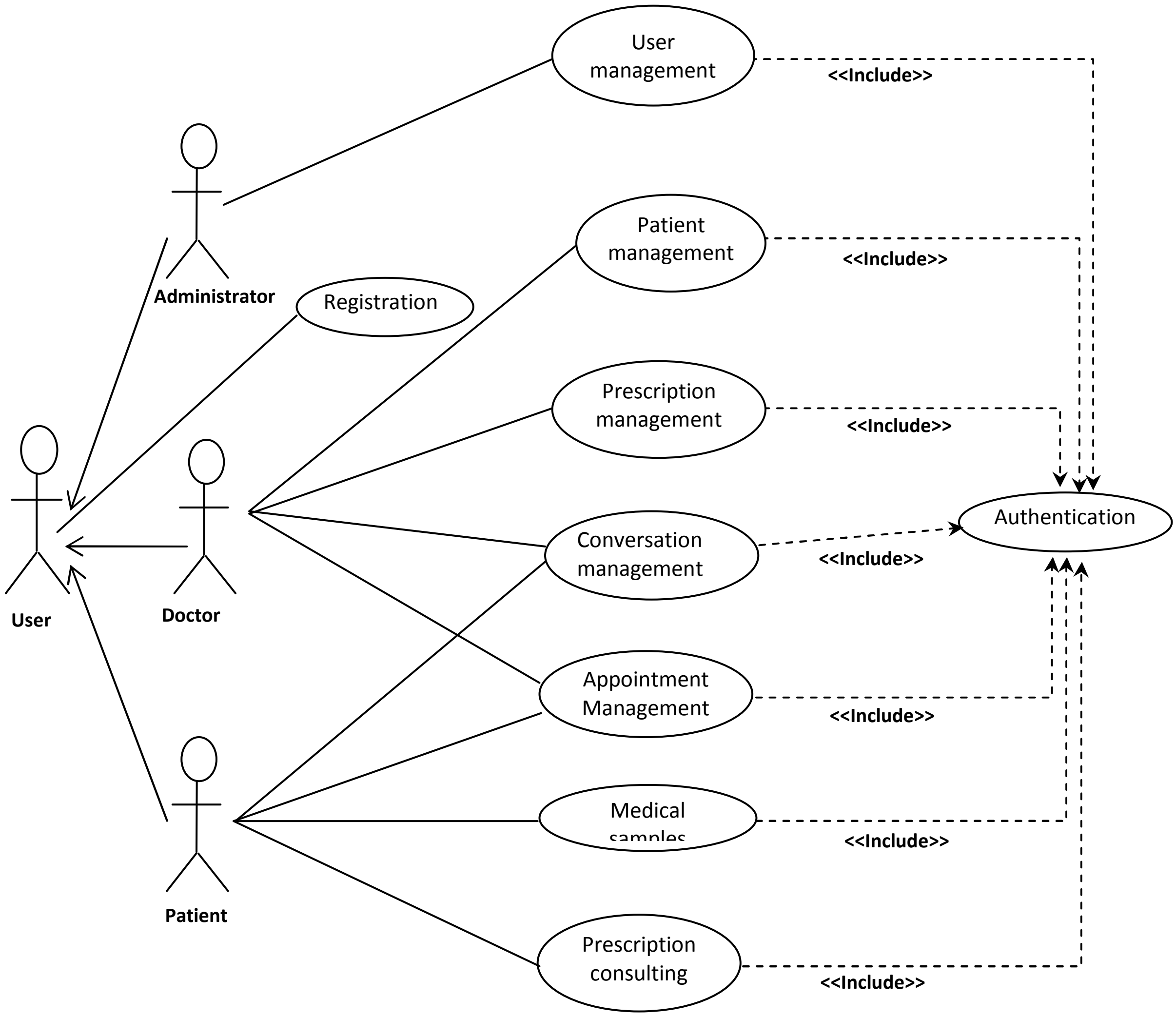

Figure 1: Uses cases of the TCS.

2.2.2 Data modeling

The simplest UML diagram is the class diagram. The static system view is shown through this diagram, comprising classes, their interrelations including generalization, specialization, relationship, aggregation, composition, operations and attributes [4]. Thus, this diagram contains the attributes to implement all the classes exposed in Figure 2 are necessary for the application modeling. Starting with the class "user," which is inherited by the pair of classes: "doctor" and "patient". Then, the class "Appointment" is requested by the patient and validated by the doctor. Right after two association classes appear: "Message," which classifies it for the conversations, and "consultation," which is related to the classes "Therapy" " and "Report" by the relations <father rt" <father-son>. Coming back to the "patient" that has a <father father-son> relationship with the class "additional information" which gives the inheritance to the last three classes "Glycemia", "Weight" and "blood pressure".

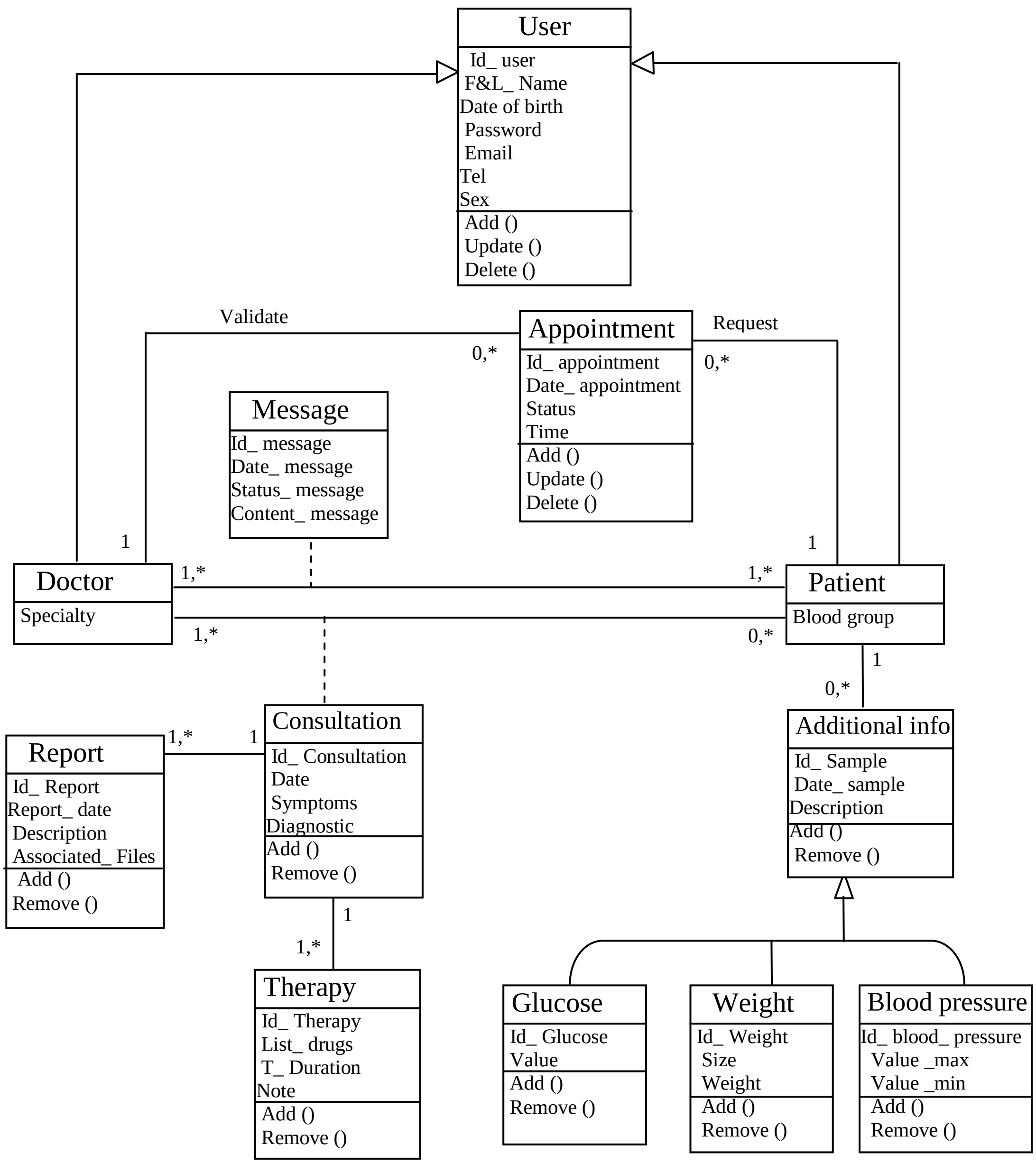

Figure 2: Class diagram of the tele-consultation system.

2.2.3 Tele-consultation system implementation

Some software packages for the implementation of Web-based applications have been investigated relying on several parameters, e.g., administration tools, deployment and maintenance strategies, data confidentiality, information integrity, concurrency regulation, data backup and restore existing procedures and software learning curves. As far as software goes the teleconsultation application system uses a MySQL database.

2.3 Ethical aspects

Protection and confidentiality about patients' personal information: Patients' particular data like first name, last name, native land, and date of birth demand system protection. This can be accomplished by the identifier and the patient's age. Only those directly involved with the TCS development, healthcare provision and the medical administration have access to medical information items.

3. Results

The subsequent aspects of the designed TCS will be investigated:

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(a) Inscription;
(b) Authentication;
(c) Doctor's appointments list;
(d) Patient interface;
(e) Doctors and Patients management; and
(f) Creation of the medical staff accounts relation.

(a) Inscription *(b) Authentication*
(c) Doctor appointments list *(d) Patient interface*
(e) Doctors and Patients management *(f) Creation of the medical staff accounts*

Figure 3: Main TCS interfaces.

The recommended TCS allows accessing physician remotely. The user (patient) remotely begins with the homepage by first authenticating his credentials (Figure 3.a). If an account associated to his name is not found, then he must register (Figure 3.b). If the doctor is available, (Figure 3.c), the patient will access to the appointments' list for the sake of perusal and to contact the patient through messages and a video call. When the consultation ends, he can prescribe tact medications through an electronic prescription. If the operator tries to enter a

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patient account, (Figure 3.d), then he can choose a doctor to treat and make an available appointment and see the previous messages with his chosen doctor as he can contact ointment him. The administrator of the application can make modifications, deletions of doctors and patients (Figure 3.e) and create medical staff accounts (Figure 3.f). The subsequent diagram (Figure 4) illustrates the interaction between a physician and a patient via tele-consultation. So, the TCS will give assistance and medical diagnostic to patients remotely.

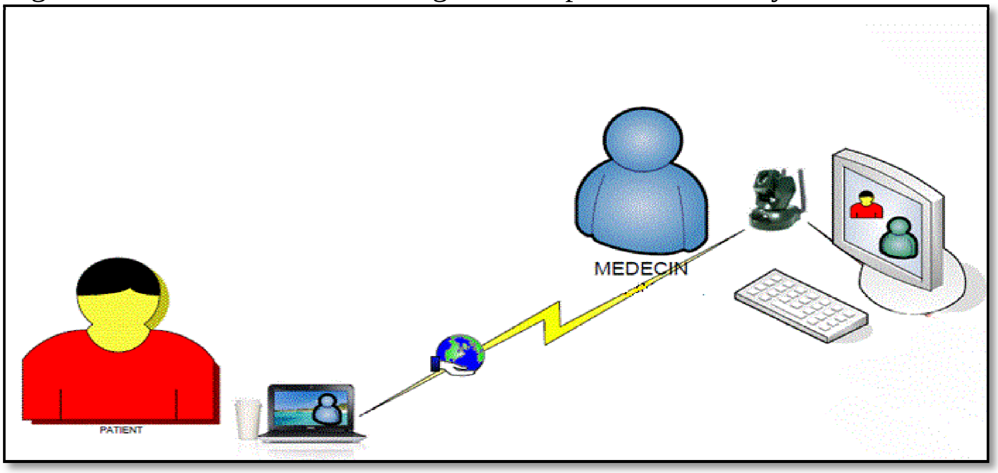

Figure 4. Remote interaction between a physician and patient.

4. Discussion

Numerous studies [4, 5, 6] have recommended telemedicine to improve healthcare quality of patients. Several telemedicine applications examples have been developed by Kvedar et al. [7], and these many examples show the potential of telemedicine system for healthcare access improving quality, and efficiency in healthcare and telemedicine.

However, little efforts have addressed telemedicine systems in Algeria. To begin with, the slow adoption of telecommunication technology in Algeria has introduced some challenges, and secondly that the direction and effort of the country are directed towards the ensuring of enough number of doctors. Only the Algerian Advanced Technology Development Center he (CDTA) has developed the only Algerian telemedicine platform for some Algerian hospitals [8]. Nevertheless, many Algerian other hotels, health centers and private medical professionals still do not have this solution or are not apt to use the telemedicine systems. The proposed TCS solution simplifies communications between patients and doctors, and it allows managing diverse patient' information. However, it is better to enrich it with other features. Furthermore, privacy policies regarding patients' data due to the delicate nature of medical/healthcare information are paramount for telemedicine.

Future developments will analyze solutions from other places and how they can be translated to Algeria [9, 10, 11, 12]. Moreover, provisions for intelligent information retrieval and database handling must be thought [13, 14].

5. Conclusions

Telemedicine is a promising alternative solution to provide healthcare to distant to reach or underdeveloped areas. Several novel medical technologies and research projects are currently being considered for the sake of easy deployment and implementation. This manuscript has examined the design of a telemedicine system for medical tele-consultation relying on a Web application. This medical remote structure reduces distances and facilitates collaboration between healthcare organizations, healthcare professionals, patients, and caretakers by using communication technology and data transmission techniques. Our solution provides an interesting resolution for issues of many levels, namely economical, medical, social, and technical. Nevertheless, enriching this solution with other features will give superior results. Furthermore, since medical data is extremely sensitive and involve privacy, it is important to enforce and deploy robust privacy policies of patients' data.

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6. Conflict of interest statement

Authors declare no conflicts of interest.

7. Authorsbiography

HachemiAtrouneis a Master Student in the Department of Computer science of Exact SciencesFaculty at Mira AbderahmaneUniversity, Bejaia, Algeria.

AbderrazakSebaais currently Associate Professor with the Department of Computer science and searcher at LIMED laboratory, at Mira Abderahmane University, Bejaia, Algeria. He received his Ph.D. degree in computer science from the same university.

KoceilaChefaiis a Master Student in the Department of Computer science of Exact SciencesFaculty at Mira AbderahmaneUniversity, Bejaia, Algeria.

Lydia Abbasis a Master Student in the Department of Computer science of Exact SciencesFaculty at Mira AbderahmaneUniversity, Bejaia, Algeria.

NesrineHammoucheis a Master Student in the Department of Computer science of Exact SciencesFaculty at Mira AbderahmaneUniversity, Bejaia, Algeria.

YaminaKhiatiis a Master Student in the Department of Computer science of Exact SciencesFaculty at Mira AbderahmaneUniversity, Bejaia, Algeria.

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