ADDIS ABABA UNIVERSITY
SCHOOL OF GRADUATE STUDIES


# MOBILE BASED TELEDERMATOLOGY SYSTEM

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# ABSTRACT

Skin diseases currently pose a threat on the general population in the global arena. Both in developing and developed countries, controlling the prevalence of skin problems is a current public health challenge. Teledermatology studies the use of information communication technologies to deliver dermatology care from a remote distance. This project designs and implements a secure, efficient and reliable mobile based teledermatology system for situations where the mobile phone's internet connection is slow and intermittent.

In order to achieve efficient data transmission over limited-bandwidth connections the system keeps the data transmitted over the network to a minimum. The application requests and responses were formatted as binary messages. And in situations where the connection fails in the middle of sending an image only the unsent part of the image is transmitted to the server when connection is reestablished. Thereby, achieving in efficient bandwidth usage. Security while transmitting data is achieved by using secure Hyper Text Transfer Protocol (HTTP) connections.

The project addresses intermittent connectivity, by making use of the mobile device's storage to store the data temporarily. When a connection is reestablished the data is automatically sent to the server.

The system was tested for connection failures by programmatically closing the connection in the middle of data transmission at random points. An emulator was used to simulate the mobile application. The system successfully recovered from all the failures.

This project demonstrated the use of mobile applications to deliver teledermatology services in situations where the network is slow and unreliable.

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# 1. INTRODUCTION

## 1.1. Background

Skin diseases currently pose a threat on the general population in the global arena. Both in developing and developed countries, controlling the prevalence of skin problems is a current public health challenge [1]. Compared to other parts of the world, sub-Saharan African countries have trouble in providing dermatology care for the general public [2]. According to [3], skin diseases were associated with mortality of 20,000 in Sub-Saharan Africa in 2001. In many sub-Saharan African countries, there is an acute shortage of specialists [5]. Thus, large areas of sub-Saharan Africa suffer from a substantial lack of skin care [2], resulting in higher prevalence of skin diseases than any part of the globe. A report on Health and Health Related Indicators published by the FDRE Ministry of Health shows that in 2008 there were only 168 specialists in Ethiopia serving the whole country of more than 79 million people. Another problem in sub-Saharan countries is that the available dermatologists are concentrated in cities [5] whereas, the majority of population lives in rural areas.

Teledermatology, a special field of telemedicine, has emerged as a solution to address problems with shortage and maldistibution of specialists. Teledermatology is the use of information communication technology to deliver dermatologic care from a remote site [7]. Due to the visual nature of skin problems teledermatology has been proved to produce appropriate diagnosis and treatment from a distance.

Effective teledermatology systems have been successfully implemented in developed counties [4] [16]. In recent years there have been attempts to incorporate teledermatology into the health care system of developing countries to increase health care coverage for the underserved [17] [18].

Telemedicine is very different in the developing countries compared to that of the developed world. In Africa, many clinics and hospitals in many areas do not have regular access to internet connection [5]. Therefore, the sophisticated mechanisms used in the systems implemented in developed countries don’t seem to be something that sub-Saharan countries can afford [5].

Fortunately, in recent years, modern telecommunications technology has rapidly advanced resulting in mobile telephones capable of capturing and transmitting high-resolution dermatologic images to

remote specialists [13]. In sub-Saharan countries, this could create an opportunity that enables access to dermatologic expertise in previously unreachable areas.

## 1.2. Statement of the problem

In Ethiopia, there is only one specialized hospital, All Africa Leprosy Tuberculosis Rehabilitation Research Training Center (ALERT) located at the capital Addis Ababa, specializing in dermatologic care. Due to shortage of specialists, majority of the Ethiopian population gets treatment from non-specialists. This may result in inaccurate diagnosis and treatment.

A far better quality of dermatologic care could be achieved if expert dermatologic consultation services are provided by specialists to other health professionals. This consultation service can be provided using teledermatology.

In order to decrease the cost of teledermatology equipments, mobile teledermatology can be used. In countries like Ethiopia, where the mobile internet connection is very slow and intermittent, sending data to and from the mobile device is difficult. Therefore, for a successful mobile based teledermatology, the system designed should consider very slow and intermittent connections.

## 1.3. Objective

This project aims at increasing access to expert dermatological care for underserved patients of skin diseases through a mobile based teledermatology system. The major objective of this project is to design and implement a reliable mobile based teledermatology system for situations in which the mobile phones internet connection is slow and intermittent. Since medical information is very sensitive, it should be encrypted to protect it from eavesdropping. Therefore, the project also addresses the issue of security.

### Specific objectives of the project

- ✓ Design and implement a mobile application that can access the built-in camera and send pictures along with important patient history to a specialist.
- ✓ Design a web-interface that allows expert dermatologists to view patient's information and perform consultation.
- ✓ Testing the performance and reliability of the system.

### 1.4. Scope

The scope of the project when defined in terms of the tasks that the system accomplishes is:

- Allow general practitioners, health extension workers and health officers to request consultations and get the specialist's recommendations.
- Allows the specialist to recommend diagnosis and treatment for the request.
- Allow the specialist ask questions for further examination.
- Allow the specialist order confirmatory laboratory tests if the data cannot lead to definitive diagnosis.
- Manage announcements.
- Managing user accounts.
- The system archives all the cases in a repository for further use as reference, thus providing an archive which can be helpful for further research, and education.

**Constraint**

- The process of requesting a consultation involves taking a picture using the mobile phone's built in camera. This is accomplished using Mobile Media API (MMAPI) of Mobile Information Device Profile (MIDP). MMAPI is found in devices supporting Java Mobile Information Device Profile (MIDP) 2.0 and above. Therefore, the mobile device must support Mobile Information Device Profile 2.0 (MIDP 2.0).
- As [13] stated, small skin lesions might result in images of poor quality, therefore, decreasing the effectiveness of the diagnosis.
- The testing was under taken using a Java MIDP emulator rather than an actual device. This is because the web application could not be accessed through a mobile phone unless it runs on a registered domain name.

## 1.5. Document organization

The document is organized into eight chapters. The first chapter discusses the background, the problem statement, the objective the project and its scope. The second chapter revises literatures that are found to be relevant to the topic investigated. In the third chapter the related works are presented, while the fourth chapter describes the requirement analysis. The system design is presented in the fifth chapter followed by the system's prototype which is presented in chapter six. Chapter seven and eight present the conclusion and future works respectively.

# 2. Literature Review

## 2.1. Overview of teledermatology

Teledermatology can be offered using two modalities; Live- interactive patient care, and store and forward [7].

Live-interactive teledermatology uses videoconferencing technology consisting of audio and visual communication to connect the specialist and the patient [7]. The two parties interact with one another in real time. Typically the teledermatology service is requested by the patient or the clinician treating the patient.

Store-and-forward type uses digital images of the skin lesion along with the patient's historical data to represent a case [7]. Store and forward consults are requested and reviewed at different times. Generally, the request is generated by a healthcare professional. After receiving the request for teledermatology consultation, the dermatologist generates a report that is sent back to the requester. This would include a diagnosis, treatment, and a management plan that is implemented by the referring clinician. Table 2.1 shows the advantages and disadvantages of using live-interactive, and store and forward technologies.

**Table 2.1:** Summary of pros and cons of the different teledermatology modalities.

| **Modality** | **Advantage** | **Disadvantage** |
|---|---|---|
| **Live – Interactive** | Dermatologist - patient interaction using audio and video | Requires agreement on a scheduled time between the two parties. |
| | Referring clinician can get an education from the consult. | High bandwidth requirement |
| **Store and Forward** | Diagnosis require less time to perform | Adequate training may be required to ensure that imaging is done correctly |
| | Dermatologists can complete consults at times and locations that are most convenient for them | |
| | Low bandwidth requirement | |

## 2.2. Services offered by a teledermatology System

Live-interactive, and store and forward systems can be used to deliver telecare, teleconsultation, teleteirage, and teldereferral [7].

Telecare is when teledermatology care is sought by the patient and directly provided for the patient over a distance [7].

Teletriage is the delivery of triage over a distance. It is used to prioritize patients and route their healthcare management depending on the triage evaluation [7]. No diagnosis or management is performed but the evaluation is used to prioritize patient healthcare needs, determine how quickly the patient should be seen, and by whom/what clinic.

Telereferral is a process by which a patient is referred by a health care professional, but teledermatologist takes over the management limited to the skin condition after the referral [7].

In Teleconsultation a patient is referred by a health care professional, and teledermatologist makes the diagnosis and recommends treatment to the referring provider [7]. Treatment is not initiated by the teledermatologist in this model and the care of the patient is not assumed by the teledermatologist.

**Table 2.2:** Advantages and disadvantages of services that can be provided with a teledermatology system.

| | **Advantage** | **Disadvantage** |
|---|---|---|
| *Telecare* | Early intervention will lead to faster a more accurate diagnosis. | Uniform standards for images acquired and cameras used are not available |
| | | Imaging protocol and training for an individual patient at home is too cumbersome |
| *Teletriage* | Ensures that those most in need of care would receive it | |
| *Telereferral* | Dermatologist is able to directly interact with the patient | Referring provider would miss the opportunity to learn |
| *Teleconsultation* | No need to talk to the dermatologist | Requester may not be familiar with the mediations and diagnosis provided by a dermatologist |

## 2.3. Mobile Wireless Technologies To Support Teledermatology

Mobile networking promises teledermatology the ability to provide teledermatology services using mobile phones. Even though all the teledermatology services mentioned in section 2.2 can be provided using mobile phones, with wireless connectivity, mobile phones are mainly used to provide teleconsultaion services.

The following section discusses mobile wireless services, and mobile messaging services that have a potential to be used to implement mobile teledermatology.

### 2.3.1. Wireless Networking Technologies

Wireless networks can be broadly classified into four according to the geographical area that the networks cover; Satellite networks, Wireless Wide Area networks (WWAN), Wireless Local Area Networks (WLAN), and Wireless Personal Area networks (WPAN) [14].

WPAN and WLAN networks are confined to a limited area. WPANs are used to create a network where mobile devices within close proximity to one another need to communicate, a typical example is Bluetooth. WLAN networks cover a bit bigger area, such as buildings, or school campuses. This technology includes standards such as 802.11a, 802.11b, 802.11g, and 802.11n. WWANs span large areas such as a metropolitan area, a state or province, or an entire country. Satellite networks are used when global coverage is needed.

In the context of providing teledermatology services using mobile phones WWANs are appropriate choices, since most teledermatology services are implemented in a country level. Therefore, the next section briefly discusses the WWAN technologies that are currently available.

Second-and-a-Half-Generation Networks (2.5G) enabled packet switched networking. These networks introduced, packet data, a feature that enables mobile users successfully use mobile internet. Packet switched networks allow high-speed data transfer at rates up to 144 Kbps (the actual throughput is much less figure). Two leading 2.5G network protocols are in use: General Packet Radio Services (GPRS) and Code Division Multiple Access 2000 1x (CDMA2000 1x).

Third-generation (3G) networks provide higher data rates ranging from 144 Kbps to 2 Mbps. There are three branches of 3G; Wideband CDMA (WCDMA), CDMA2000, and Enhanced Data Rates for Global Evolution (EDGE).

### 2.3.2. Wireless Messaging Services

Apart from wireless networks mentioned above, mobile devices can use messaging services to realize teledermatology. These services live within wireless networks [15].

The most widely used messaging service in mobile devices is Short Messaging Service (SMS). It is the delivery of alphanumeric messages to mobile phones over wireless networks. The Enhanced Short Messaging Service (EMS) adds functionalities to SMS which enable the mobile device send content such as images. The Multimedia Messaging Service (MMS) provides an even mature multimedia content communication such as audio and videos.

# 3. Related works

This section discusses the works related to this project. It also points out the limitations that make them not appropriate for slow and intermittent network connections.

For mobile teledermatology to produce the reliable results, the images captured using the mobile phones' integrated camera should produce images of certain quality. Ralph *et al* tried to study whether newer-generation mobile phones can be used for wound treatment consultation and result in a reliable diagnosis. The research tried to access the reliability of diagnosis made based on an image captured using mobile device. The study showed that mobile phones provide feasible solution in teledermatology to amplify access to expert teledermatologic care where there may not be otherwise. The research evaluated the quality of the images taken by the mobile phone. The built-in camera provides images with a resolution of 640 X 480 pixels. Only 5% if the images were said to be of poor quality, and the dermatologist felt satisfied performing teledermatology in 82% of the cases. The images taken by mobile phones were sent to dermatologist using email.

In mobile clients that use a micro browser installed on the mobile device, for example using email as the case of [13], the entire request/response process happens while the user is connected to a wireless network [14]. Though these architectures have the advantage of alleviating the need of special software installed on the mobile client for the purpose of communication, they have major drawbacks that make them not suited for situations where there is a very slow and intermittent connection. Some of these drawbacks are:

- ✓ Since browser based client cannot access the on-device storage, if the network connection is temporarily unavailable while transmitting data, the user must reenter the data and send data again.
- ✓ Another disadvantage of browser based clients is that they download both application data and user interface every time the interface changes, which adds more overhead to the network.
- ✓ Browser based clients cannot leverage device extensions such as the built-in camera, therefore, the user needs to take a picture, open the web site, attach and send the image. This reduces the usability of the system.

ClickDiagnostics [10] offers a telemedicine service which enables medical consultation to be provided by remote doctors via mobile camera-phones. The system uses Mobile Multimedia Service to send clinical images and patient history to a specialist doctor.

Similarly, [11] tried to solve the problem with the current paper based health data collection system in Ethiopia using MMS. The system supports attaching and sending an image of the skin lesion, along with text, and audio data as a report to a central server.

The problem associated with using MMS for teledermatology is twofold. First, the included content is medical information, that should be sent over a network securely, but data sent via MMS would not be encrypted. Therefore, data transmission via MMS was not suitable [12]. Second, MMS service is provided by 3G networks [11]. However, due to high construction costs, 3G networks are not widely available yet in developing countries.

# 4. Requirement Analysis

The following section describes the interactions between the proposed system and its environment.

## 4.1. Functional Requirement

The system allows general practitioners, health extension workers and health officers to do the following tasks using their mobile phones.

- Request consultation for cases that they want a specialist's advice. The clinician can also update, or withdraw a previously submitted request.
- Receive the recommendations made by a specialist for the request.
- Provide answer to questions asked by the specialist.
- Perform tests recommended by a specialist and send back the results if the tests are available.

The system allows specialists to do the following tasks using a web interface.

- Ask questions concerning a certain case if the available data cannot lead to definitive diagnosis.
- Recommend confirmatory tests for suspected diseases.
- Ask for another picture of the skin lesion.

The system allows the coordinator to do the following tasks using a web interface.

- Manage announcements.
- Assign a specialist to handle a case.

The system allows the system administrator to do the following tasks using a web interface.

- Managing user accounts.

## 4.2. Non-functional Requirement

This section discusses the non-functional requirements of the system.

### 4.2.1. Reliability

If a connection failure occurs while submitting a request for consultation, the system must save the data and retry sending when connection is reestablished.

### 4.2.2. Performance

If a connection failure occurs while sending an image, which is likely since the size can be big, the system should not try to resend the whole image when connection is available. Instead the system must resume sending the image from where it left off. The system should also keep transmit as minimal data as possible.

### 4.2.3. Availability

The system will be available to the clinician requesting consultation through a wireless internet connection using GPRS or CDMA networks.

### 4.2.4. User Interface

The system is designed to have easy navigation which enhances users' efficacy of usage. Software installed on the mobile device guides the clinician through the data acquisition process, including taking a picture.

### 4.2.5. Security

The system ensures that only authorized users can gain access to the system, which guarantees protection from illicit access into the system. Also communication from the mobile phone to the server is also done via Hyper Text Transfer Protocol over Secured Socket Layer (HTTPS).

### 4.2.6. Miscellaneous

The system is designed to be platform independent. As long as the mobile devices support CLDC configuration and MIDP profile 2.0 the mobile application can be installed on the mobile.

## 4.3. System Models

System model is used to describe the different facets of the system.

### 4.3.1. Use Case Model

**Actor Description**

Clinician is a licensed physician who does not specialize in dermatology but trained in a medical discipline; a Health officer, a health extension worker, or a non-specialist medical doctor. A clinician uses this system to get consultation from a specialist dermatologist on cases that he or she has difficulty dealing with.

Specialist is a licensed physician specializing in dermatology. The specialist provides consultation to a clinician when assigned by the coordinator to handle a consultation request.

Coordinator is a specialist who manages requests for consultations in the application. A coordinator has all the capabilities of a specialist with the added responsibility of assigning a specialist to handle a consultation request.

System Administrator is a person who is responsible for the smooth operation of the system; managing Network connection, web deployment and database problems. The webmaster is also responsible for adding, removing and editing user information.

**Use Case Diagram**

Use case diagrams are used to depict the functional requirements of the system.

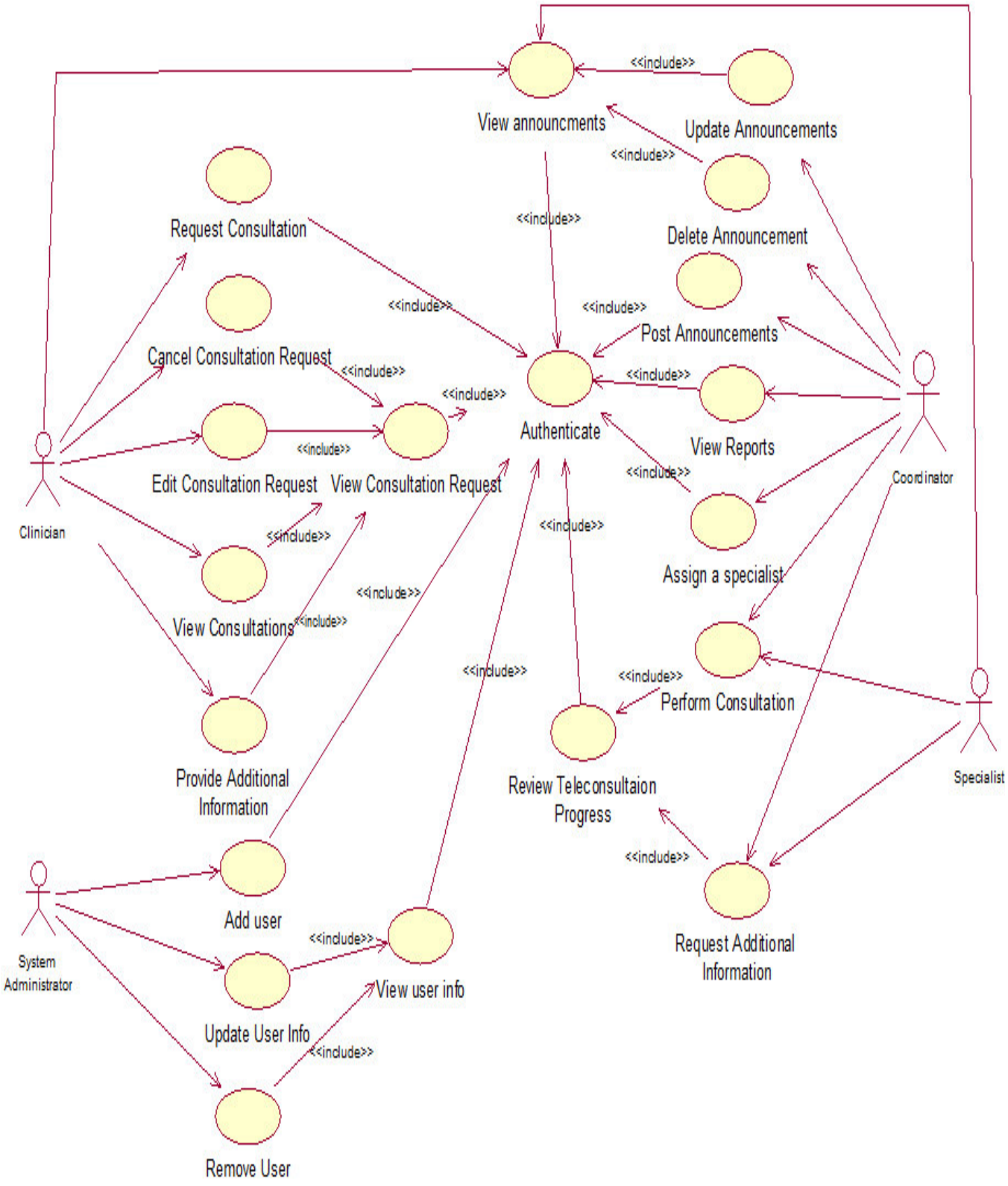



**Figure 4.1:** Use case diagram

**Use Case Description**

**Table 4.1:** Request Consultation use case description.

| | |
|---|---|
| *Use case name* | Request consultation |
| *Actor* | Clinician |
| *Description* | Allows the clinician to request specialist's consultation about a specific case. |
| *Preconditions* | The clinician is authenticated and identified as a clinician with privileges to make a request for consultation. |
| *Flow of events* | 1. The clinician wants to create a new consultation request.<br>2. The clinician navigates to the main menu through the mobile application and selects "Add consultation request".<br>3. The mobile application prompts the clinician the details of the request including tentative, and differential diagnosis made by the clinician patient information, address of the patient, and image of the skin lesion of the patient. The clinician will have access to the mobile's integrated camera to take pictures of the affected area.<br>4. The clinician provides the desired information, and takes a picture of the affected skin area.<br>5. When all the information is entered, the clinician submits the request.<br>6. The system checks if the information is complete and valid.<br>7. The system shows a progress bar while it sends the consultation request to the server.<br>8. The system displays a confirmation message notifying the clinician that the request is successfully stored, and the clinician is returned to the main menu.<br>9. The consultation request is placed in a state of pending response.<br>10. This use case ends. |
| *Alternate course A* | A.6. If the submitted information is incomplete or does not pass validation, the form is redisplayed, with the errors highlighted. |

| | |
|---|---|
| | A.7. The clinician fills out the form again.<br>A.8. The use case continues at step 6 of the basic flow of events. |
| *Alternate course B* | B.7 The system cannot send the request to the server.<br>B.8 The system notifies the clinician that it was unable to send the request to the server.<br>B.9 The system stores the teleconsultation request in the mobile device's local storage.<br>B.10. The system sends the data when connection is reestablished. |
| *Post Condition* | A new request for consultation is added to the system. |

**Table 4.2:** Cancel consultation request use case description

| | |
|---|---|
| *Use case name* | Cancel Consultation Request |
| *Actor* | Clinician |
| *Description* | Allows the clinician to cancel a request for consultation. |
| *Preconditions* | The clinician is authenticated and has made a consultation request, and that request's state is not closed. |
| *Flow of events* | 1. The clinician wants to cancel an outstanding request for consultation.<br>2. The clinician views the details of request for consultation using View Consultation Request use case.<br>3. The clinician selects "Cancel consultation request" item.<br>4. The system prompts the clinician to confirm the request to withdraw the previously submitted request for consultation.<br>5. The clinician confirms the desire to cancel the request.<br>6. The request for consultation is removed from the system, a confirmation is displayed to the clinician and the clinician is returned to application's main menu.<br>7. If the consultation request is already assigned to a specialist, the request is removed from the specialist's list of consultation requests |

| | |
|---|---|
| | that (s)he handles.<br>8. The system updates the request state to withdrawn.<br>9. This use case ends. |
| *Alternate course A* | A.8. The system finds out that the consultation request has not yet been assigned to a specialist<br>A.5 The system removes the request from the administrators list of cases pending approval.<br>A.10. The use case continues at step 10 of the basic flow of events. |
| *Alternate course B* | B.5. The client decides not to remove the consultation request when prompted.<br>B.6. The client is returned to the form containing the details of request for consultation.<br>B.7. This use case ends |
| *Post Condition* | A consultation request made by a clinician is removed from the system. |

**Table 4.3:** Edit consultation request use case description.

| | |
|---|---|
| *Use case name* | Edit Consultation Request |
| *Actor* | Clinician |
| *Description* | Allows the clinician to update the information or change the picture of a consultation request (s)he previously made. |
| *Preconditions* | The clinician is authenticated and has previously submitted a consultation request. |
| *Flow of events* | 1. The clinician wants to edit an outstanding request for consultation.<br>2. The clinician views his consultation request using View Consultation Request use case.<br>3. The clinician selects “Edit Consultation request” item.<br>4. The system displays an editable view of the request. The clinician is allowed to change the information contained in the request, patient, |

| | |
|---|---|
| | or patient's address, and image of the skin lesion of the patient.<br>5. The clinician makes the appropriate changes to the request information and submits the changes to the system.<br>6. The system checks if the information is complete and valid.<br>7. The system updates the consultation request, a confirmation is displayed, and the clinician is returned to application's menu.<br>8. This use case ends. |
| *Alternate course A* | A.6. If the submitted information is incomplete or does not pass validation, the form is redisplayed, with the errors highlighted.<br>A.7. The clinician fills out the form again.<br>A.8. The use case continues at step 6 of the basic flow of events |
| *Alternate course B* | B.8. If the case has not yet been assigned to a specialist (if it is in pending state), an e-mail/notification is immediately sent to the administrator notifying that the consultation request has been updated.<br>B.9. This use case ends |
| *Post Condition* | A consultation request is updated. |

**Table 4.4:** View Consultation Request use case description.

| | |
|---|---|
| *Use case name* | View Consultation Request |
| *Actor* | Clinician |
| *Description* | Allows the clinician to see the details of a consultation request he /she previously submitted. |
| *Preconditions* | The clinician is authenticated and has submitted a consultation request. |
| *Flow of events* | 1. The clinician wants to view the details of a previously submitted request for consultation.<br>2. The clinician navigates to the main menu through the mobile application and selects "View consultation request" item. |

| | |
|---|---|
| | 3. The application displays a form containing a list of previously submitted request for consultations, along with the current status of the requests.<br>4. The clinician navigates to and selects the request he is seeking.<br>5. The system displays a non editable view of the request.<br>6. This use case ends |
| *Post Condition* | Details of a consultation request are displayed. |

**Table 4.5:** View Consultation use case description

| | |
|---|---|
| *Use Case Name* | View consultation |
| *Actor* | Clinician |
| *Description* | Allows the clinician to view a recommendation made by a specialist to a consultation request. |
| *Preconditions* | The clinician is authenticated, has previously made a consultation request |
| *Flow of events* | 1. The clinician wants to view a request for consultation.<br>2. The clinician views his consultation request using View Consultation Request use case.<br>3. The clinician selects the “View Consultation” item.<br>4. The system displays a non editable view of the consultation.<br>5. This use case ends. |
| *Alternative Flow* | A.4. The system detects that specialist didn’t conduct a consultation yet.<br>A.5 The system notifies the user that his request was not processed.<br>A.5 The use case ends. |
| *Post Condition* | Details of a consultation are displayed. |

**Table 4.6:** Provide additional information use case description.

| | |
|---|---|
| *Use Case Name* | Provide additional information |
| *Actor* | Clinician |
| *Description* | Allows the clinician to answer question(s) asked by a specialist about a certain consultation request. |
| *Preconditions* | The clinician is authenticated, has made a consultation request, and the specialist has asked a question about a consultation request. |
| *Flow of Events* | 1. The clinician wants answer questions asked by the specialist concerning a consultation request.<br>2. The clinician views his consultation request using View Consultation Request use case.<br>3. The clinician selects the "View Question" item.<br>4. The system displays the question(s) asked by the specialist. The question(s) can be three types; a multiple choice question that the clinician can select only one, multiple choice question that the clinician can select many choices from the list, or a free textual answer. In each of the cases the system displays the question(s) one question per screen and gives the clinician the ability to answer. The clinician can also specify that the answer to the question is not available.<br>5. The clinician provides answer(s) and submits the answer(s) to the system.<br>6. The system checks if the information is complete and valid.<br>7. The system assigns the answer to the question.<br>8. This use case ends. |
| *Alternate course A* | A.6. If the submitted information is incomplete or does not pass validation, the form is redisplayed, with the errors highlighted.<br>A.7. The clinician answers the question again. |

| | |
|---|---|
| | A.8. The use case continues at step 6 of the basic flow of event. |
| *Post Condition* | An answer is given for a specialist's question. |

**Table 4.7:** Assign a specialist to handle a request use case description.

| | |
|---|---|
| *Use Case Name* | Assign a specialist to handle a request |
| *Actor* | Coordinator |
| *Description* | Allows the coordinator to assign a specialist to handle a consultation request. |
| *Precondition* | The coordinator has successfully logged into the system and there is at least one pending consultation request. |
| *Flow of events* | 1. The coordinator wants to assign a specialist to conduct consultation for a request.<br>2. The coordinator selects "View pending requests" from his home page.<br>3. The system displays a page that lists requests pending specialist assignment. The administrator selects each of these one at a time to individually assign a specialist.<br>4. When the administrator selects a request, the system displays the details of the consultation request and a list containing summary of specialists available. The administrator selects a specialist and assigns him/her to handle the request.<br>5. Once the administrator assigns a specialist, the internal state of the request is changed to Assigned.<br>6. An e-mail notification is immediately sent to the requesting clinician and the assigned specialist.<br>7. The system displays a confirmation message. |
| *Post condition* | A specialist is assigned to handle a consultation request. |

**Table 4.8:** Perform Consultation use case description.

| | |
|---|---|
| *Use case name* | Perform Consultation |
| *Actor* | User (Specialist, Coordinator) |

| | |
|---|---|
| *Description* | Allows the user to perform a consultation for a consultation request. |
| *Preconditions* | The user is authenticated and identified as a specialist or a coordinator with privileges to make a consultation. |
| *Flow of events* | 1. The user wants to perform a new consultation.<br>2. The system prompts the user for the diagnosis (tentative, or definitive), treatment, supportive therapy, and preventive measurements.<br>3. When all the information is entered, the user submits the consultation.<br>4. The system checks if the information is complete and valid.<br>5. The system adds the recommendation to the consultation request, a confirmation is displayed, and the user is returned to his/her home page.<br>6. The consultation request is placed in a state of closed. |
| *Alternate course A* | A.4. If the submitted information is incomplete or does not pass validation, the form is redisplayed, with the errors highlighted.<br>A.5. The specialist fills out the form again.<br>A.6. The use case continues at step 5 of the basic flow of events |
| *Post Condition* | A consultation is performed for a consultation request. |

**Table 4.9:** Request additional information use case description.

| | |
|---|---|
| *Use case name* | Request additional information |
| *Actor* | User (Specialist, Coordinator) |
| *Description* | Allows the user to request additional information for further examination of the case. |
| *Preconditions* | The user is authenticated and identified as a specialist or a coordinator with privileges to make a consultation. |
| *Flow of Events* | 1. The clinician wants to request additional information needed to |

conduct a consultation for a request.

2. The specialist selects “Request additional information” functionality.
3. The system prompts the specialist for the type of question he/she has. The question(s) can be three types; a multiple choice question from which the clinician can select only one, a multiple choice question from which the clinician can select many choices from the list, or a question answered textually.
4. If the user selects one of the first two types of questions, the system displays page that allows the specialist provide the question, and list of possible choices. Using this kind of functionality the user can easily ask questions like does the patient feel touch on his hands and legs? For example, the previous question is important to identify if the patient is suffering from leprosy.
5. When all the information is entered, the user submits the request for additional information.
6. The system checks if the information is complete and valid.
7. The system adds the questions to the consultation request, a confirmation is displayed, and the specialist is returned to his/her home page.
8. An e-mail/notification is immediately sent to the clinician notifying that a new request for additional information has been requested.

*Alternate course A*

A.4. If the user selects the third type of question, the system displays page that allows the specialist provide the question. Using this kind of functionality the specialist can recommend tests to be performed and results reported, for example, the white blood cell count of the patient.

A.5. The use case continues at step 5 of the basic flow of events.

*Alternate course B*

B.6. If the submitted information is incomplete or does not pass validation, the form is redisplayed, with the errors highlighted.

B.7. The specialist fills out the form again.

| | |
|---|---|
| | B.8. The use case continues at step 5 of the basic flow of events |
| *Post Condition* | A consultation is performed for a consultation request. |

**Table 4.10:** View Reports use case description.

| | |
|---|---|
| *Use Case Name* | View Reports |
| *Actor* | Coordinator |
| *Description* | Allows the coordinator to view reports. |
| *Preconditions* | The coordinator is authenticated. |
| *Flow Of Events* | 1. The coordinator wants to generate a report for consultation.<br>2. The coordinator selects "View report" item.<br>3. The system displays a form containing a list of all the reports that can be generated.<br>4. The coordinator selects one of the reports in the list.<br>5. The system prompts the coordinator for various parameters needed to generate the report.<br>6. The system displays a printable report in the form of a table, a chart, or a diagram. |
| *Post Condition* | Report is generated |

**Table 4.11:** Create User account use case description.

| | |
|---|---|
| *Name* | Create user account |
| *Actor* | System Administrator |
| *Description* | Allows the System Administrator to register a new user account into the system. |
| *Precondition* | The System Administrator has successfully logged into the system. |
| *Flow of Events* | 1. The System Administrator wants to create an user account |

| | |
|---|---|
| | 2. The System Administrator clicks the “create user account” link<br>3. The system prompts the administrator to provide the username, password. It also allows the administrator to select the type of the user from a list that contains “Administrator”, “Coordinator”, “Specialist”, and “Clinician”.<br>4. The System Administrator fills out the form and clicks the “create” button.<br>5. The system checks if the form is filled out correctly<br>6. The system creates the user account and displays a confirmation message to the System Administrator.<br>**7.** The use case ends. |
| *Alternate course A* | A.5. The system identifies that the form is not filled out correctly<br>A.6. The system informs the System Administrator that the form has not been filled out properly<br>A.7. The System Administrator fills out the form again<br>A.8. The use case continues at step 5 of the basic flow of events |
| *Post Condition* | A new user account is added to the system |

**Table 4.12:** Remove user account use case description.

| | |
|---|---|
| *Name* | Remove user account |
| *Actor* | System Administrator |
| *Description* | Allows the system administrator to remove a user account from the system. |
| *Precondition* | The System Administrator has successfully logged into the system |
| *Flow of events* | 1. The System Administrator wants to remove a user account from the system.<br>2. The System Administrator clicks on the “Manage user account” link on his home page. |

| | |
|---|---|
| | 3. The system displays the list of user accounts with their respective “delete” button.<br>4. The System Administrator clicks the “delete” button of a specific user account.<br>5. The system asks the System Administrator if he/she is sure to delete the user account<br>6. The System Administrator confirms by clicking the “yes” button<br>7. The system deletes the user account and displays a confirmation message<br>**8.** The use case ends |
| *Alternate Course A* | A.6. The System Administrator clicks the “No” button<br>A.7. The System Administrator case continues at step 3 of the basic flow of events |
| *Post condition* | A user account is deleted |

**Table 4.13:** Update User Information use case description.

| | |
|---|---|
| *Name* | Update User Information |
| *Actor* | System Administrator |
| *Description* | Allows the System Administrator to modify user information. |
| *Precondition* | The System Administrator has successfully logged into the system. |

| | |
|---|---|
| *Flow of events* | 1. The System Administrator wants to update a user account<br>2. The System Administrator clicks the “Manage user account” link<br>3. The system displays the list of user accounts with their respective “update” link<br>4. The System Administrator clicks the “update” link of a specific user account<br>5. The system displays the “update user account” form with the current content of the user account<br>6. System Administrator modifies the content of the user account and clicks the “update” button.<br>7. The system checks if the user account is modified correctly.<br>8. The system updates the content of the updated user account and displays a confirmation message<br>9. The use case ends |
| *Alternate Course A* | A.6. The system identifies that the user account is not modified correctly.<br>A.7. The system informs the System Administrator that the content has not been modified correctly.<br>A.10. The use case continues at step 5 of the basic flow of events. |
| *Alternate Course B* | A.5. The system finds out that there is no user account.<br>A.6. The system informs the System Administrator that there is no user account to be updated.<br>A.7. The use case ends. |
| *Post Condition* | A user’s user account information is updated. |

**Table 4.14:** Authenticate User use case description.

| | |
|---|---|
| *Name* | Authenticate User |
| *Actor* | User (Clinician, Specialist, Coordinator and System Administrator) |
| *Description* | Authenticates the user who tries to log into the system. |
| *Flow of events* | 1. The user wants to log into the system.<br>2. The user types the starts the application.<br>3. The system displays the "log in" page.<br>4. The user provides his username and password.<br>5. The system checks the validity of the username and password.<br>6. The system redirects the user to his/her homepage.<br>7. Use case ends |
| *Alternate course A* | A.5. The system identifies that the username and password is not valid<br>A.6. The system informs user that the username and password is not valid<br>A.7. The use case continues at step 3 of the basic flow of events |
| *Post condition* | Authorized user successfully logs into the system. |

**Table 4.15:** Post Announcement use case description.

| | |
|---|---|
| *Use case name* | Post Announcement |
| *Actor* | Coordinator |
| *Description* | Allows the Coordinator to post announcements onto the system. |
| *Precondition* | The Coordinator has successfully logged in into the system. |
| *Flow of Events* | 1. The Coordinator wants to post an announcement<br>2. The Coordinator clicks the "Post announcement" link<br>3. The system prompts the coordinator to provide a title, and content to the announcement. |

| | |
|---|---|
| | 4. The Coordinator fills out the form and clicks the “Post” button |
| | 5. The system checks if the form is filled out correctly. |
| | 6. The system posts the announcement and displays a confirmation message to the Coordinator |
| | 7. The use case ends |
| *Alternate Course A* | A.5. The system identifies that the form has not been filled out correctly |
| | A.5. The system informs the Coordinator that the form has not been filled out correctly |
| | A.7. The Coordinator fills out the form again |
| | A.8. The use case continues at step 5 of the basic flow of events |
| *Post condition* | A new announcement is posted |

**Table 4.16:** Update Announcement Use case description.

| | |
|---|---|
| *Name:* | Update Announcement |
| *Actor:* | Coordinator |
| *Description:* | Allows the coordinator to update an announcement he/she previously posted. |
| *Precondition:* | The coordinator has successfully logged into the system |
| *Flow of events* | 1. The coordinator wants to update an announcement |
| | 2. The coordinator clicks the “Manage announcements” link |
| | 3. The system displays list of announcements with their update link |
| | 4. The Coordinator clicks the “update” link of a specific announcement |
| | 5. The system displays the “update announcement” form with the current content of the announcement |
| | 6. The Coordinator modifies the content of the announcement and clicks the update button |

| | |
|---|---|
| | 7. The system checks if the announcement is modified correctly.<br>8. The system updates the content of the announcement and displays a confirmation message<br>9. The use case ends |
| *Alternate Course A* | A.7. The system identifies that the announcement is not modified correctly<br>A.8. The system informs the Coordinator that the content has not been modified correctly<br>A.9. The use case continues at step 5 of the basic flow of events |
| *Alternate Course B* | B.5. The system finds out that there is no announcement<br>B.6. The system informs the Coordinator that there is no announcement to be updated.<br>B.7. The use case ends |
| *Post condition* | An announcement is updated |

**Table 4.17:** View Announcement use case description.

| | |
|---|---|
| *Name* | View Announcement |
| *Actor* | User (Clinician, Specialist, Coordinator) |
| *Description* | Allows the user to view an announcement |
| *Precondition* | The user has successfully logged into the system. |
| *Flow of events* | 1. The user wants to view an announcement<br>2. The user clicks the “view announcement” link<br>3. The system displays list of announcements with a link to view the details<br>4. The user clicks the link to a specific announcement<br>5. The system displays the announcement<br>6. The use case ends |

| | |
|---|---|
| *Alternate Course A* | A.3. The system finds out that there is no announcement to be listed<br>A.4. The system informs the user that there is no announcement to be viewed<br>A.5. The use case ends |
| *Post condition* | An announcement is displayed to the user. |

**Table 4.18:** Delete Announcement use case description.

| | |
|---|---|
| *Use case name* | Delete Announcement |
| *Actor* | Coordinator |
| *Description* | Allows the Coordinator to delete an announcement that he/she previously posted. |
| *Preconditions* | The Coordinator has successfully logged into the system and he or she had already posted at least one announcement. |
| *Flow of events* | 1. The Coordinator wants to delete an announcement.<br>2. The Coordinator views his announcements using "View Announcements" use case.<br>3. The Coordinator selects the "delete announcement" item.<br>4. The system asks if the Coordinator is sure to delete the announcement.<br>5. The Coordinator confirms the desire to delete the announcement.<br>6. The system deletes the announcement and displays a confirmation message.<br>7. The use case ends. |
| *Alternate course A* | A.6. The Coordinator decides not to delete the announcement when prompted.<br>A.7. The use case continues at step 3 of the basic flow of events. |
| *Post Condition* | An announcement is successfully removed from the system. |

### 4.4. Class Diagram

Class diagram shows the classes of a system and the associations between them.

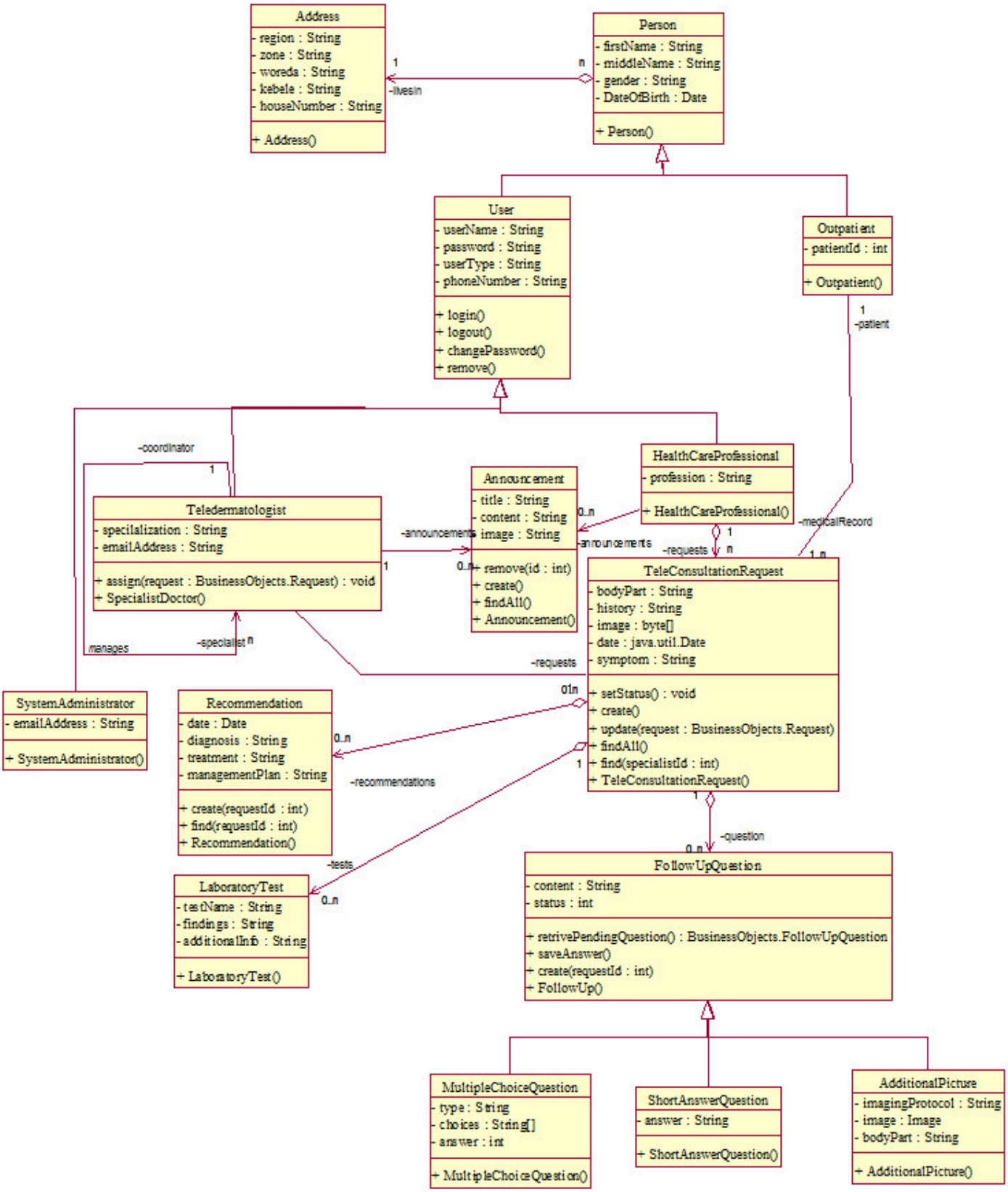



**Figure 4.2:** Class diagram

## 4.5. Sequence diagram

Sequence diagram models the sequential logic, in effect, and the time ordering of messages. It is very useful to refine the relationship between the objects represented in the class diagram presented in the previous section.

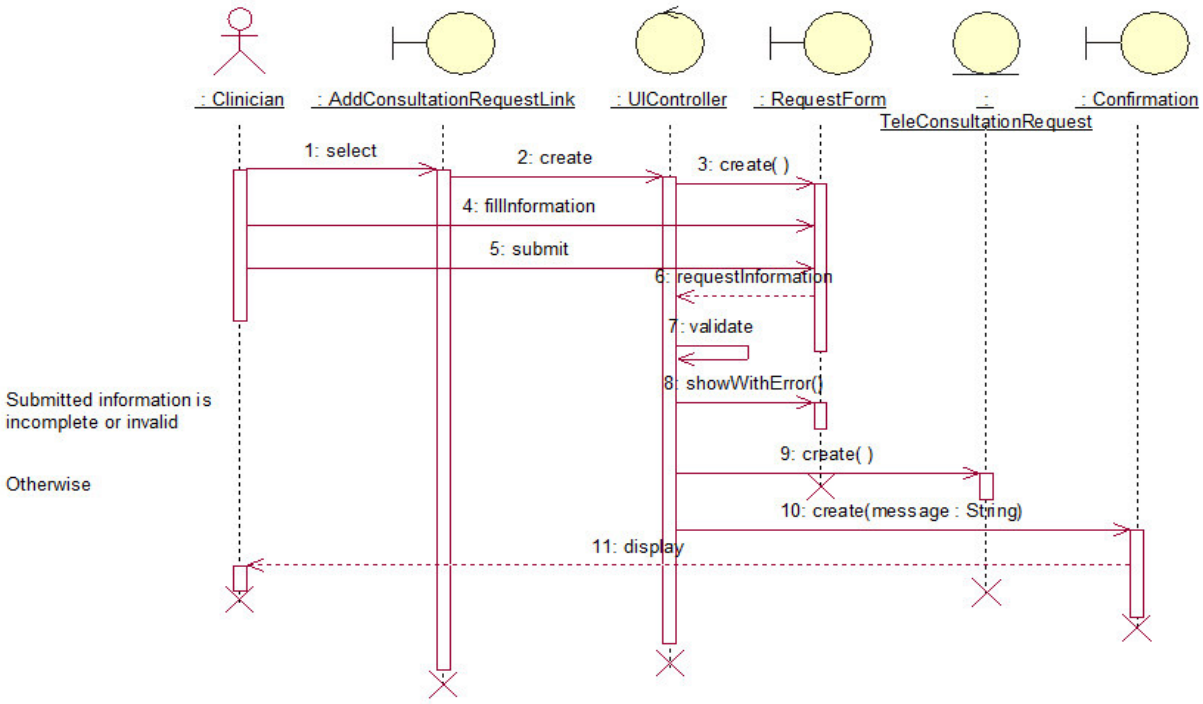



**Figure 4.3:** Request Consultation sequence diagram

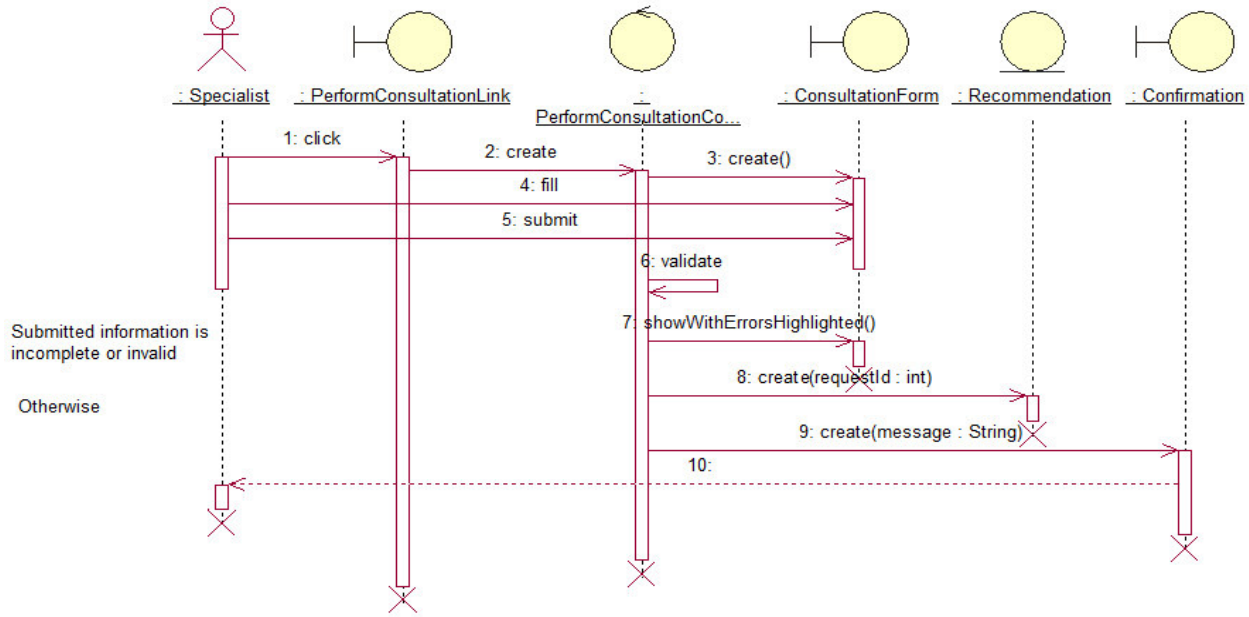



**Figure 4.4:** Perform consultation sequence diagram

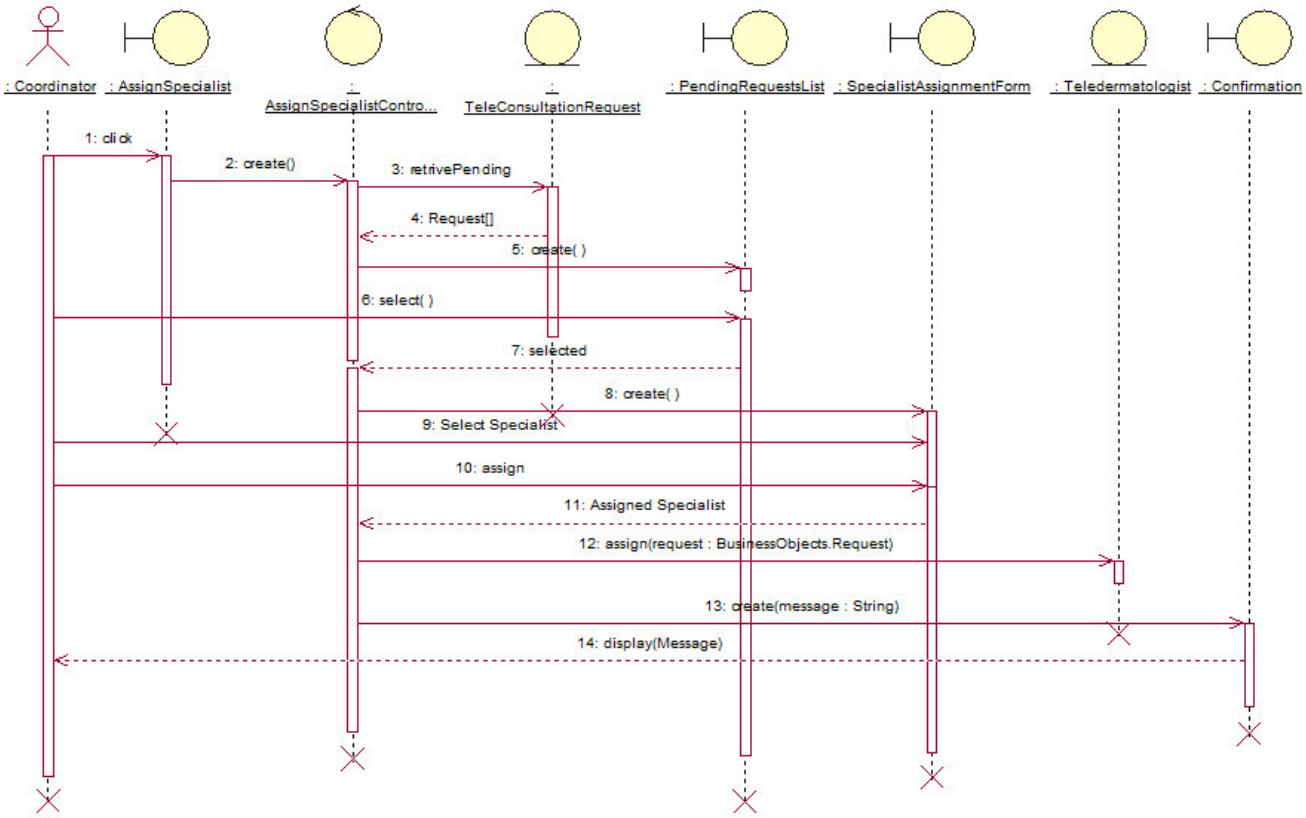



**Figure 4.5:** Assign Specialist sequence diagram

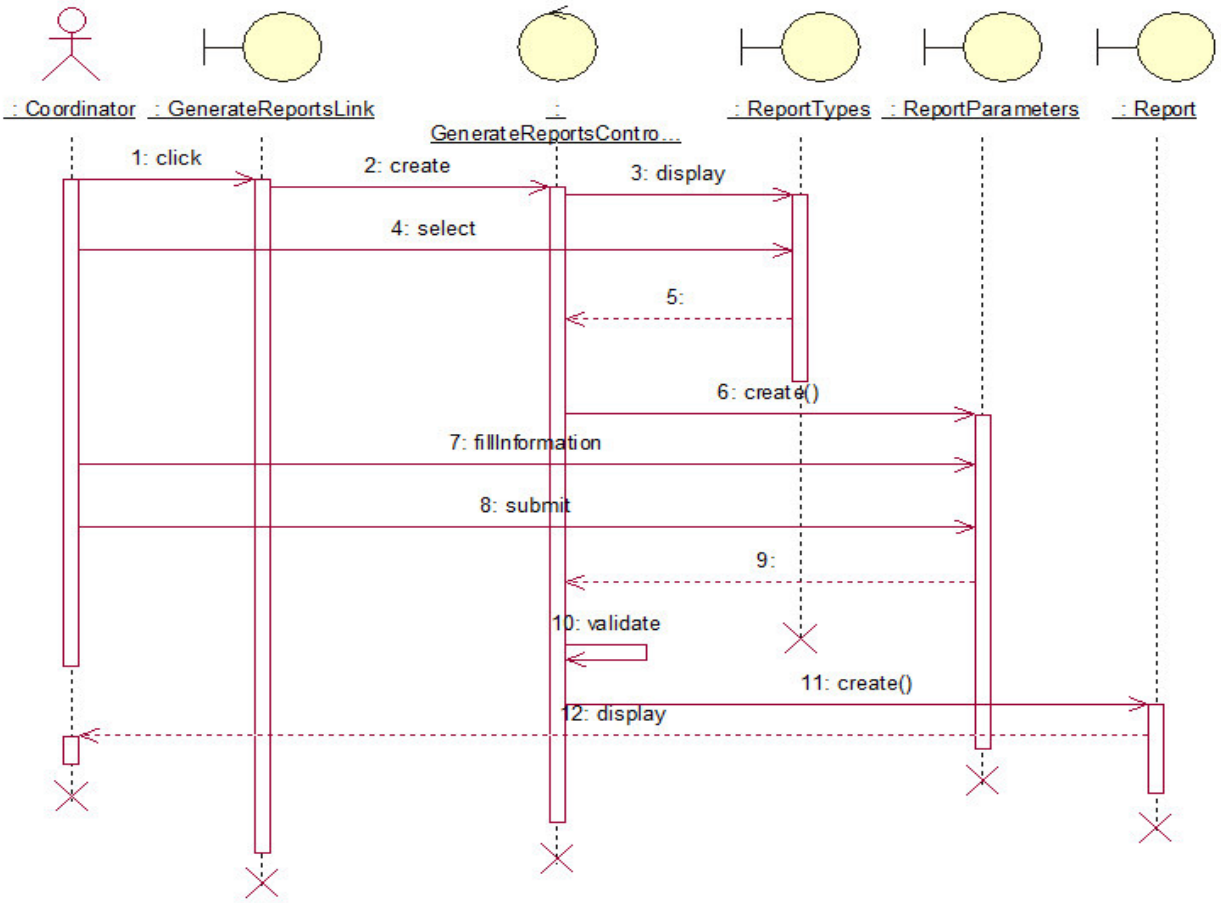



**Figure 4.6:** View Reports sequence diagram

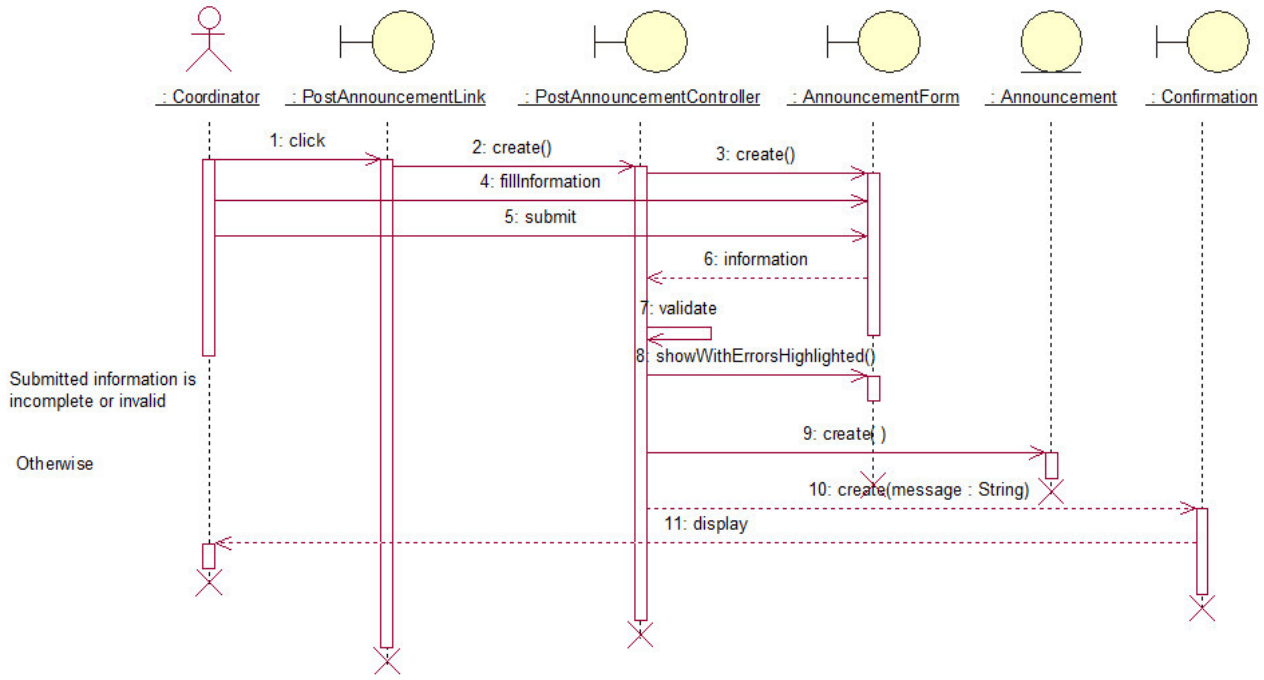



**Figure 4.7:** Post announcement sequence diagram

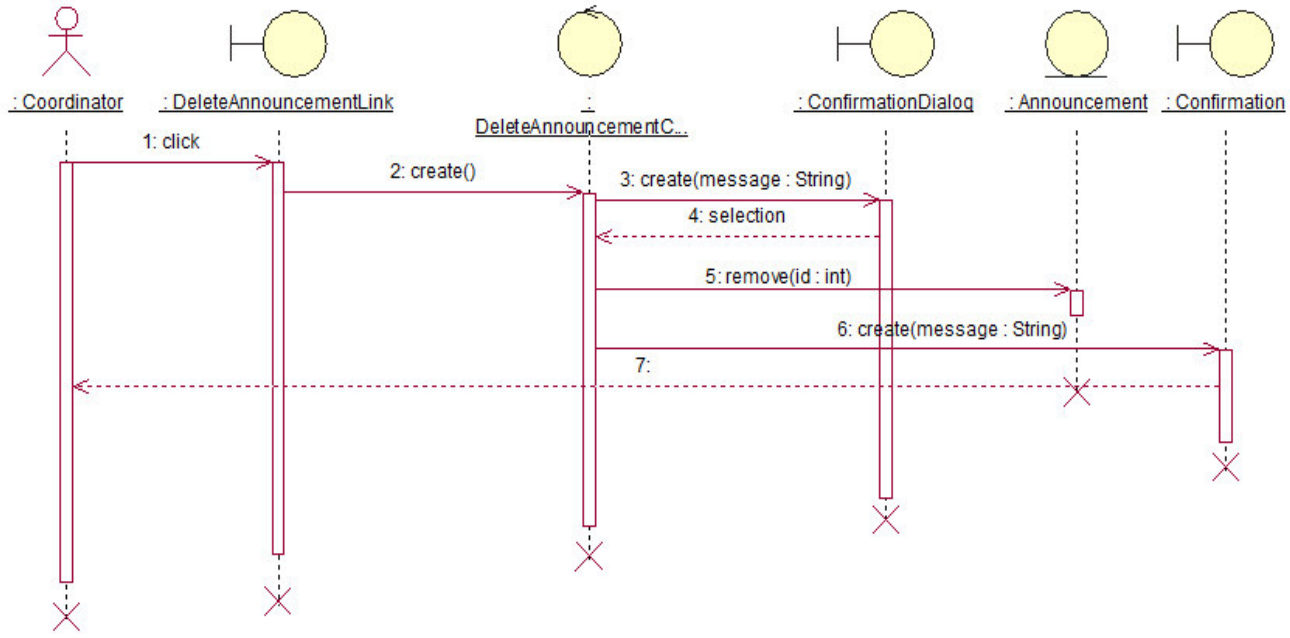



**Figure 4.8:** Delete announcement sequence diagram

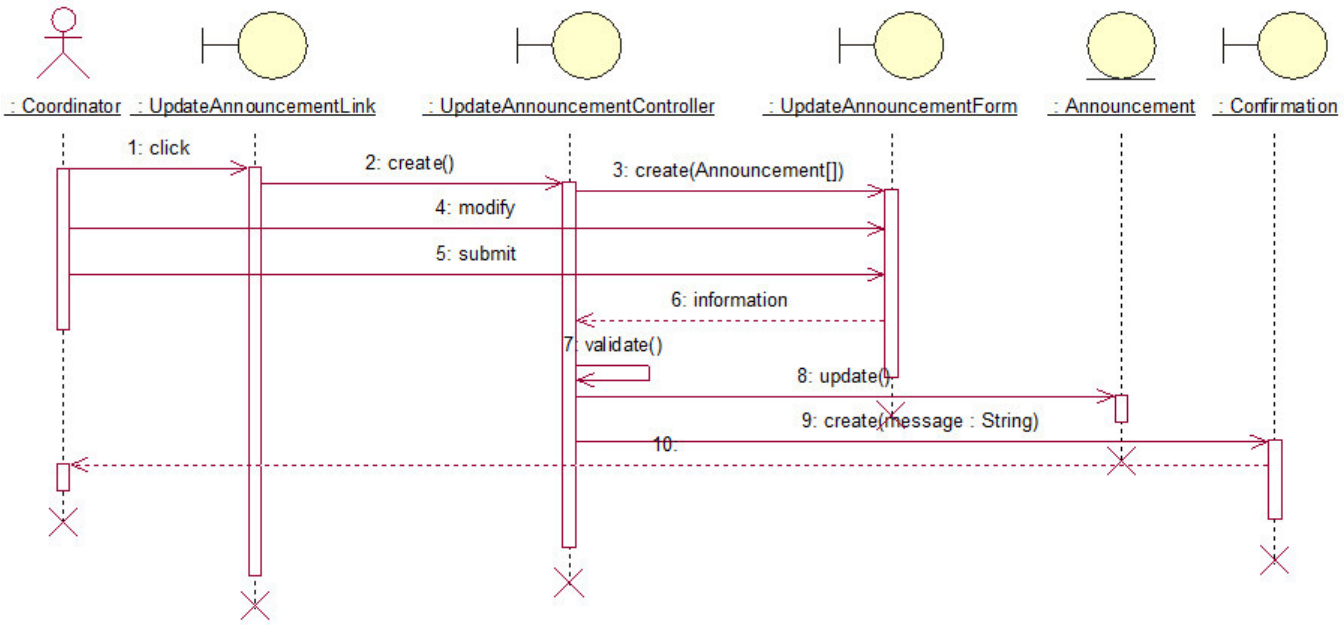



**Figure 4.9:** Update announcement sequence diagram

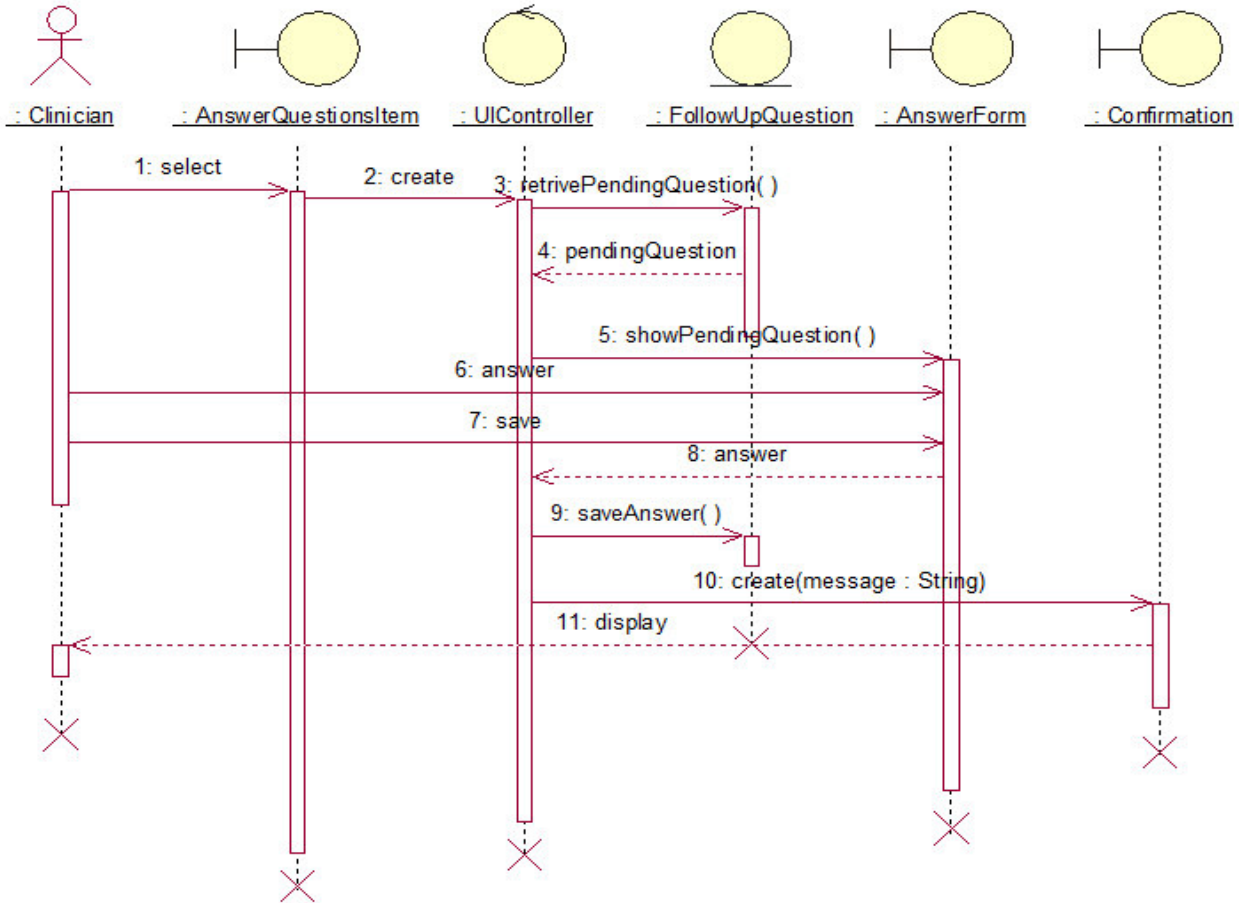



**Figure 4.10:** Provide additional information sequence diagram

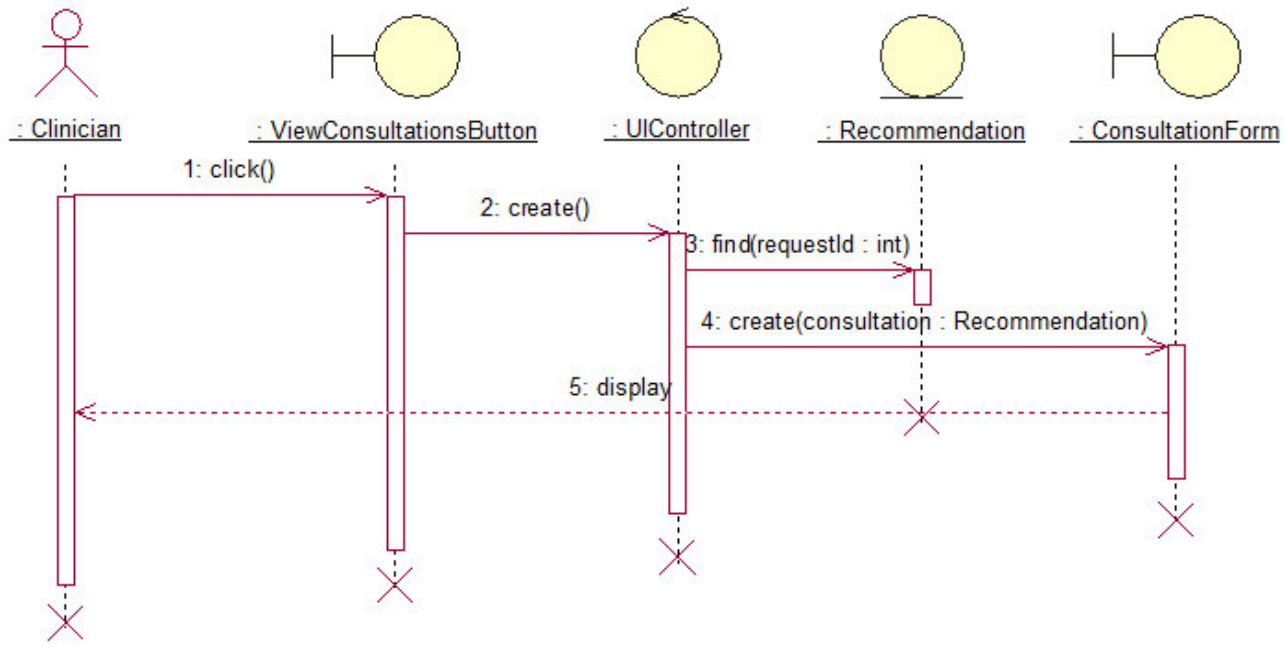



**Figure 4.11:** View consultation request sequence diagram

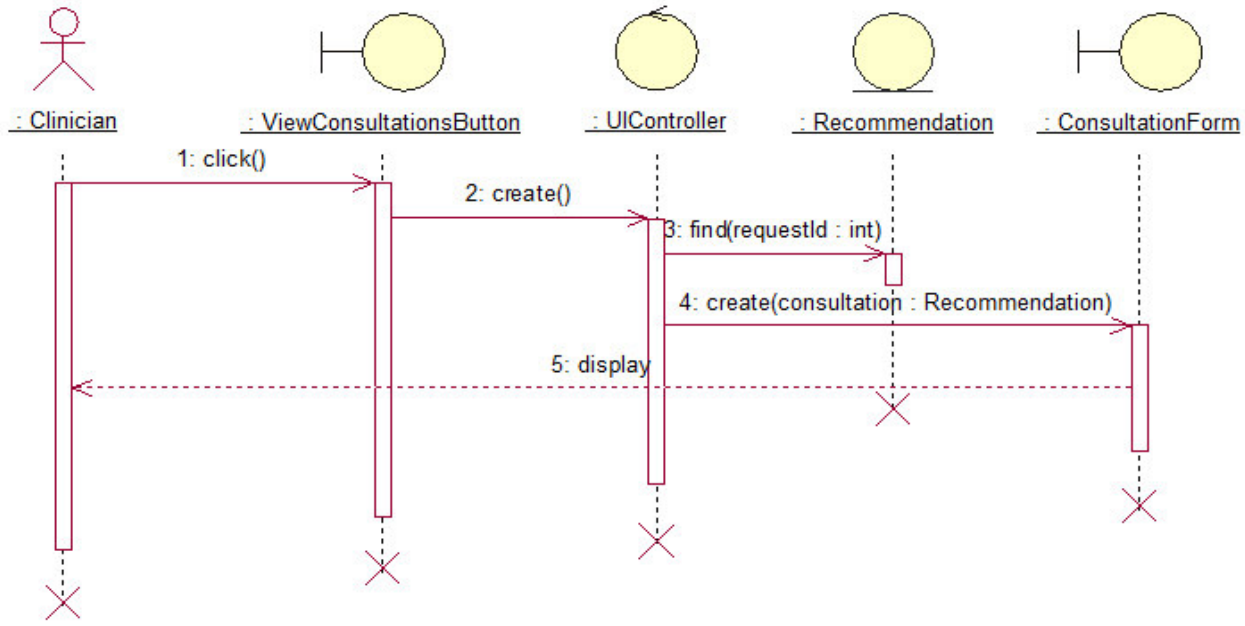



**Figure 4.12:** View consultation sequence diagram

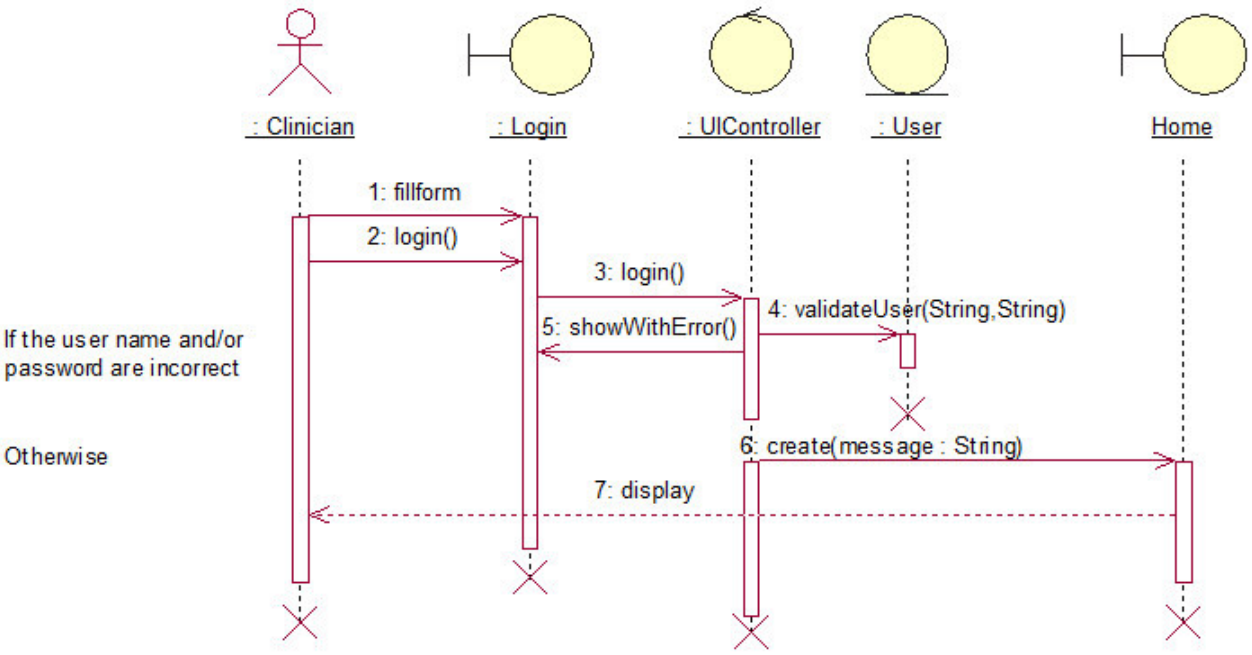



**Figure 4.13:** Authenticate User sequence diagram

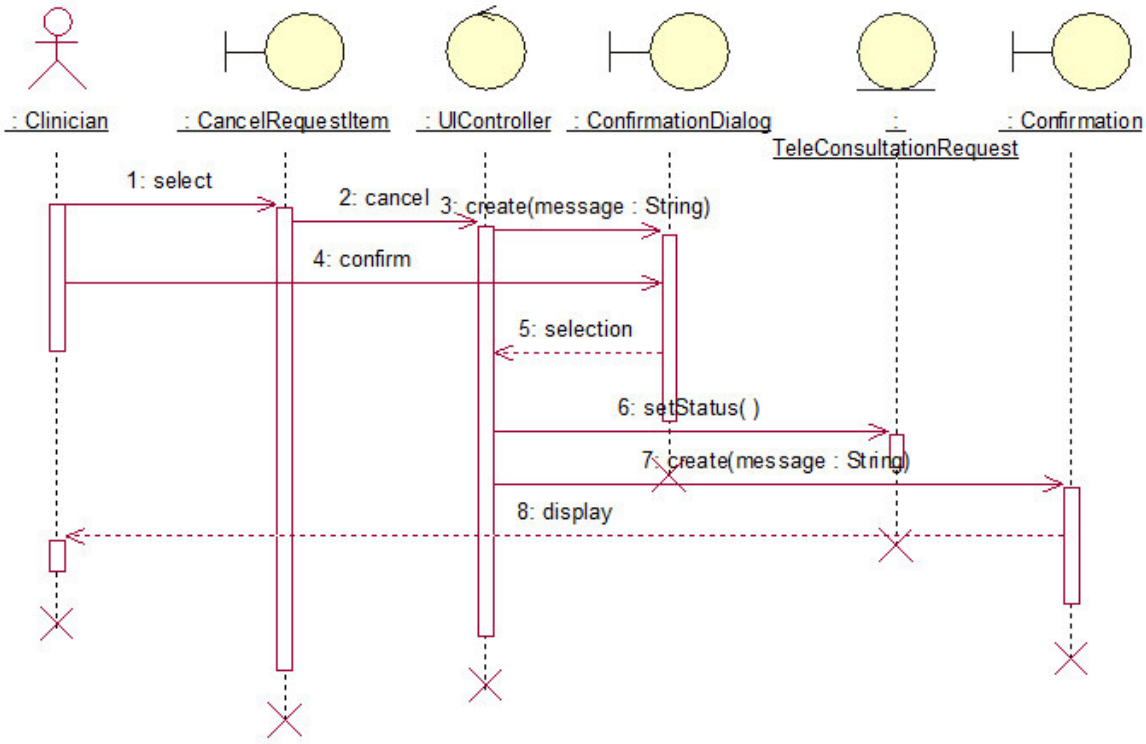



**Figure 4.14:** Cancel consultation request sequence diagram

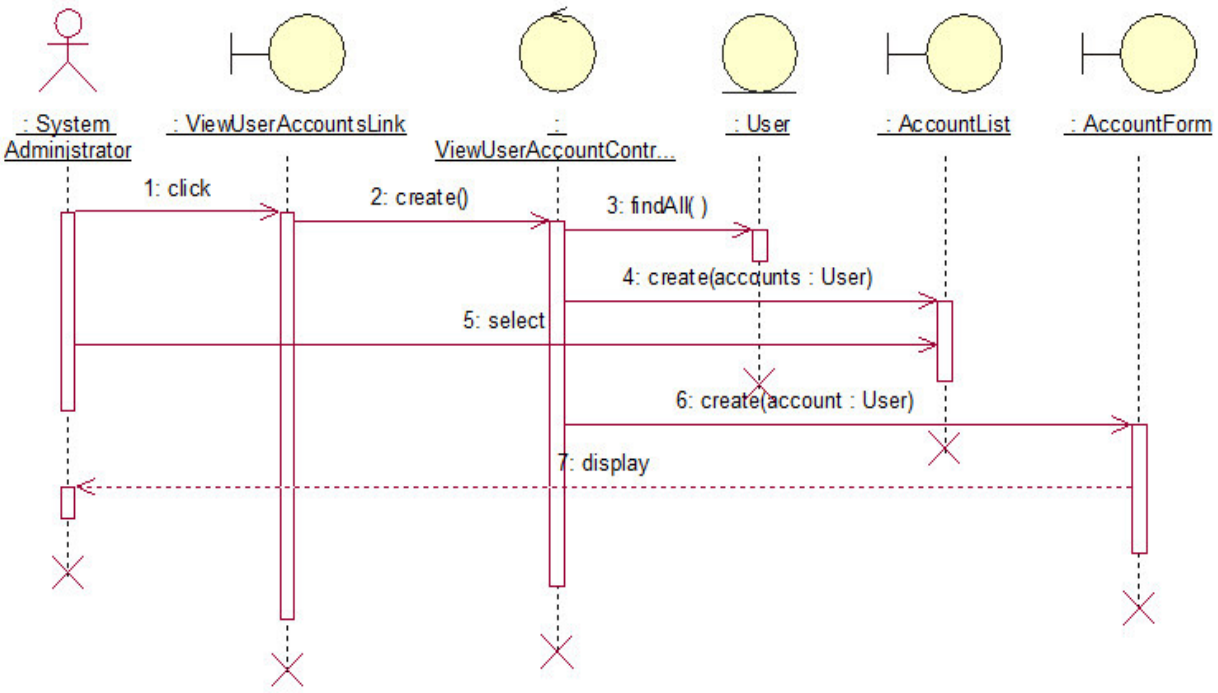



**Figure 4.15:** View user information sequence diagram

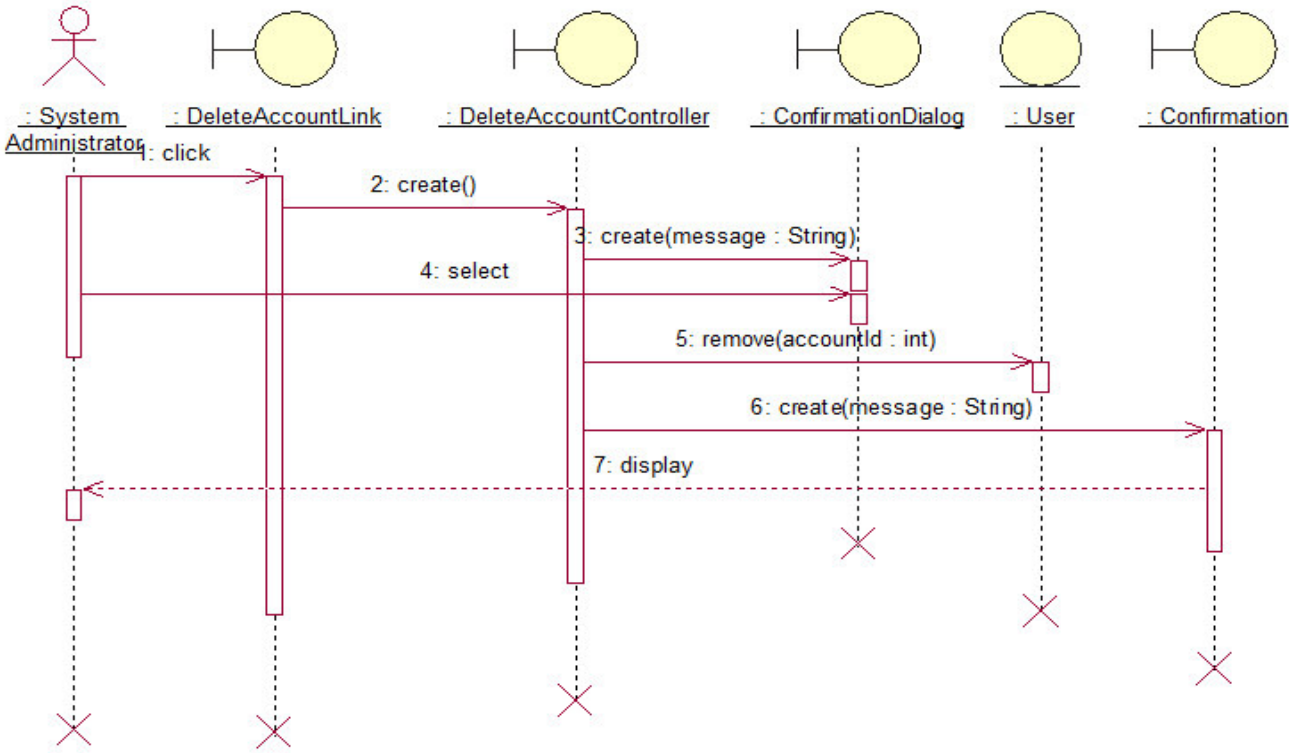



**Figure 4.16:** Remove user account sequence diagram

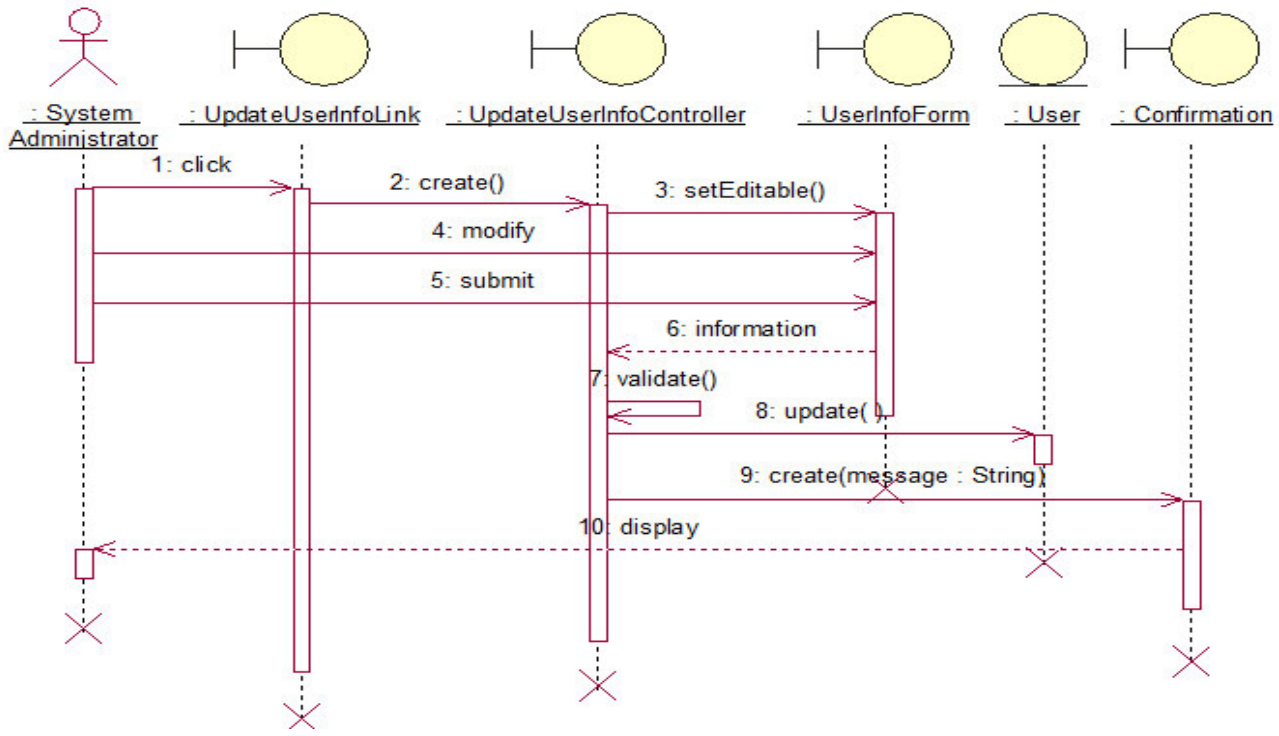



**Figure 4.17:** Update user info sequence diagram

# 5. System design

## 5.1. Introduction

This section will discuss the details that need to be defined in order to turn the requirements stated in the previous section to a final implementation in code. These include:

- Design goals.
- Subsystem decomposition – the process of breaking down the system into manageable pieces in an attempt to understand the complexity of the system.
- Hardware/software mapping showing which components are will to be deployed on which node.
- Persistent data model that describes the database structure.

## 5.2. Design goals

As stated on the statement of the problem, the main challenge associated with designing mobile applications that reap the benefits of teledermatology is the slow and intermittent connectivity. The main design consideration of the system is to achieve effective and reliable communication between the mobile client and the server.

### 5.2.1. Reliability

Since the mobile network in Ethiopia is intermittent, the mobile device should recover from a temporary connection failure and retry sending the data without requiring the user to input the data again.

The system stores the request locally in the occurrence of a connection failure, and retries to send the data when connection is established automatically.

### 5.2.2. Performance

Since the images of the skin problem can be very large, there is a higher probability that the connection will fail in the middle of sending the image. When a connection failure occurs at the middle of sending an image, the application should not send the data already sent to the server before the connection failure occurred.

Mobile applications can use different communication methods to communicate with the server via HTTP. But in a bandwidth constrained situations that data transferred should always be kept to a minimum.

Messaging format used to communicate with the server fall between the two extremes of a simple binary message format versus a complex Extensible Markup Language (XML) message format. Using binary messages results in efficient exchanges because the message payloads are compact. However, because they are also intended to save space, binary messages sacrifice self-descriptiveness. Consequently, both client and server must know the format of binary messages in advance, which means that client and server are tightly coupled.

Extensible Markup Language (XML) messages provide a loose coupling between the client and the sever but the messages transmitted are very large in size. Since the one of the most important issues this project considers is designing an application that uses the network bandwidth effectively, binary messages are used.

### 5.2.3. Security

Since information transmitted over the network contain personal medical information, the mobile client and the server should protect the transmitted content during communication, the server also needs to authenticate the client.

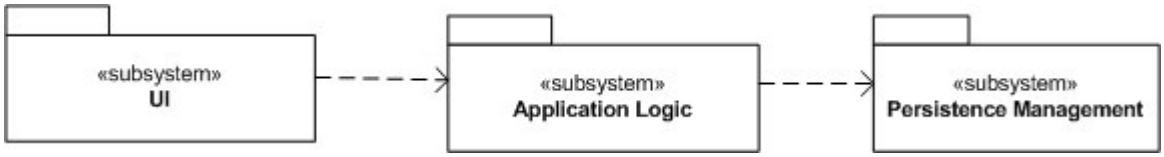
The Java 2 Micro Edition (J2ME) platform (see section 6.1) supports HTTPS for MIDP v2.0. Therefore, the project uses secure HTTP to send and receive encrypted messages.

## 5.3. Subsystem decomposition

System design decomposes the system into smaller components called subsystems. Decomposing the system into manageable smaller parts helps to understand the problem better.

The subsystems comprising the application are depicted in figure 5.1. The diagram also represents the relationships between the subsystems.

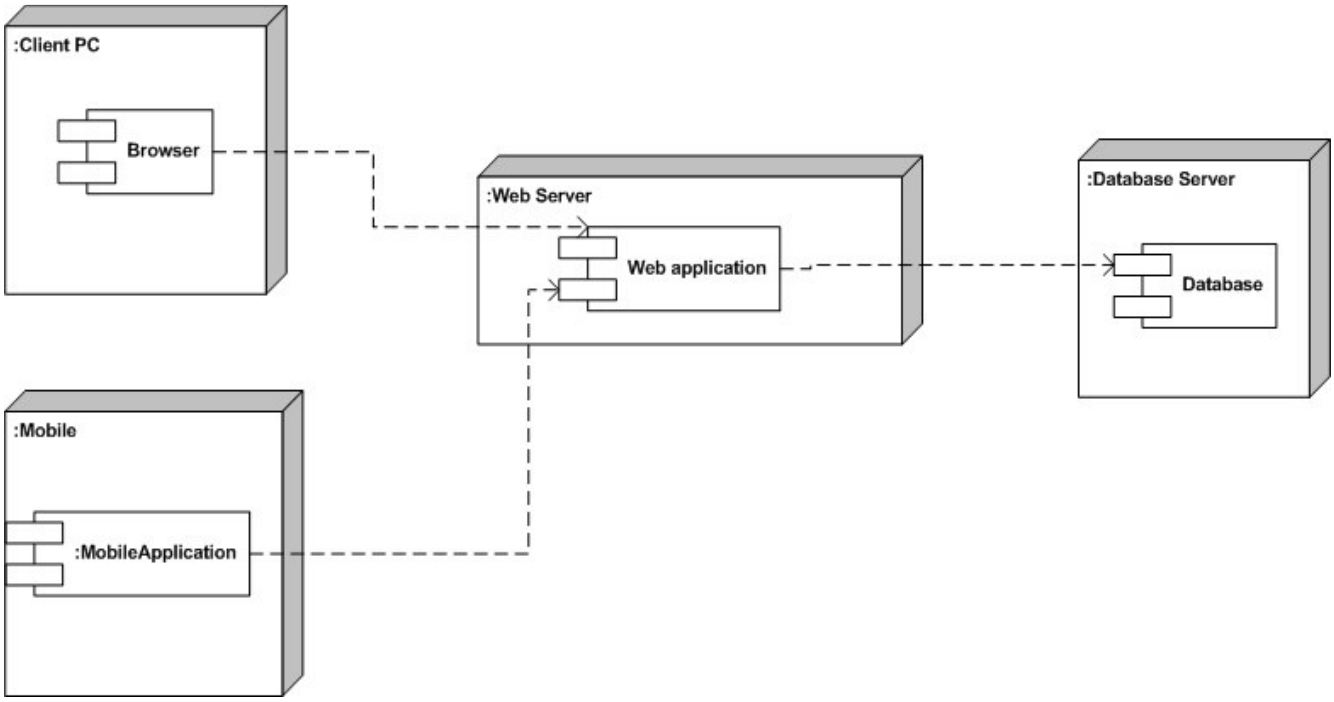
**Figure 5.1:** Subsystem decomposition




## 5.4. Hardware/Software Mapping

Hardware/software mapping describes how subsystems are assigned to hardware and off-the-shelf components.

**Figure 5.2:** Software/Hardware Mapping



**Hardware/Software Mapping Description**

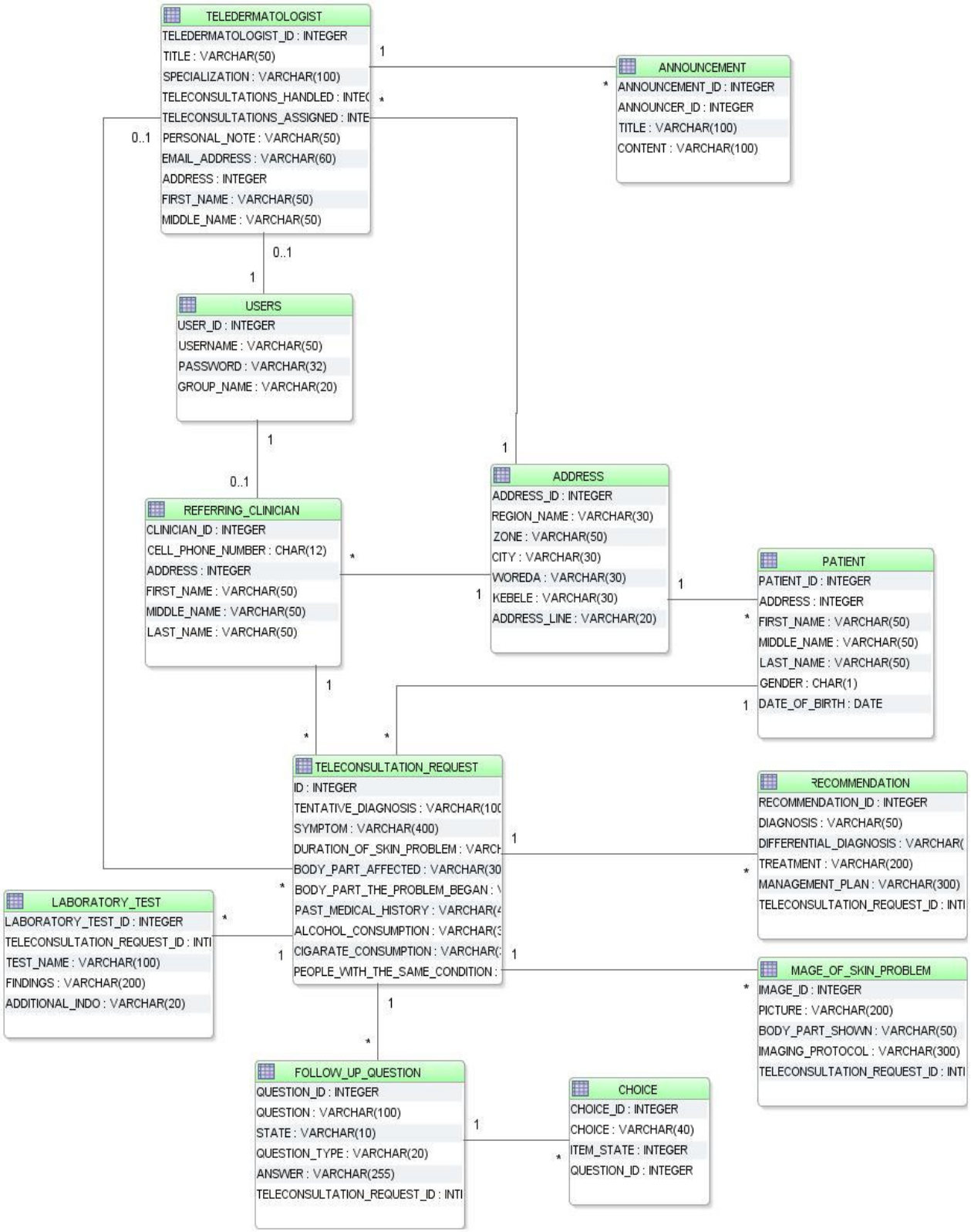
**Table 5.1:** Software/Hardware Description

| **Node** | **Description** |
|---|---|
| Client PC | Hosts a web browser on which the user interfaces of the system are loaded. |
| Mobile | Hosts the mobile application. |
| Glassfish Web Server | Hosts the web application. |
| JavaDB Database Server | Hosts the database of the system. |

## 5.5. Persistent Data Management

Relational databases are often used as a mechanism to store the applications objects persistently. The following diagram shows the database design of the system.

**Figure 5.3:** Database diagram


TELEDERMATOLOGIST
TELEDERMATOLOGIST_ID : INTEGER
TITLE : VARCHAR(50)
SPECIALIZATION : VARCHAR(100)
TELECONSULTATIONS_HANDLED : INTE
TELECONSULTATIONS_ASSIGNED : INTE
PERSONAL_NOTE : VARCHAR(50)
EMAIL_ADDRESS : VARCHAR(60)
ADDRESS : INTEGER
FIRST_NAME : VARCHAR(50)
MIDDLE_NAME : VARCHAR(50)
ANNOUNCEMENT
ANNOUNCEMENT_ID : INTEGER
ANNOUNCER_ID : INTEGER
TITLE : VARCHAR(100)
CONTENT : VARCHAR(100)
USERS
USER_ID : INTEGER
USERNAME : VARCHAR(50)
PASSWORD : VARCHAR(32)
GROUP_NAME : VARCHAR(20)
ADDRESS
ADDRESS_ID : INTEGER
REGION_NAME : VARCHAR(30)
ZONE : VARCHAR(50)
CITY : VARCHAR(30)
WOREDA : VARCHAR(30)
KEBELE : VARCHAR(30)
ADDRESS_LINE : VARCHAR(20)
REFERRING_CLINICIAN
CLINICIAN_ID : INTEGER
CELL_PHONE_NUMBER : CHAR(12)
ADDRESS : INTEGER
FIRST_NAME : VARCHAR(50)
MIDDLE_NAME : VARCHAR(50)
LAST_NAME : VARCHAR(50)
PATIENT
PATIENT_ID : INTEGER
ADDRESS : INTEGER
FIRST_NAME : VARCHAR(50)
MIDDLE_NAME : VARCHAR(50)
LAST_NAME : VARCHAR(50)
GENDER : CHAR(1)
DATE_OF_BIRTH : DATE
TELECONSULTATION_REQUEST
ID : INTEGER
TENTATIVE_DIAGNOSIS : VARCHAR(10
SYMPTOM : VARCHAR(400)
DURATION_OF_SKIN_PROBLEM : VARCH
BODY_PART_AFFECTED : VARCHAR(30
BODY_PART_THE_PROBLEM_BEGAN :
PAST_MEDICAL_HISTORY : VARCHAR(
ALCOHOL_CONSUMPTION : VARCHAR(
CIGARATE_CONSUMPTION : VARCHAR(
PEOPLE_WITH_THE_SAME_CONDITION :
RECOMMENDATION
RECOMMENDATION_ID : INTEGER
DIAGNOSIS : VARCHAR(50)
DIFFERENTIAL_DIAGNOSIS : VARCHAR(
TREATMENT : VARCHAR(200)
MANAGEMENT_PLAN : VARCHAR(300)
TELECONSULTATION_REQUEST_ID : INTI
LABORATORY_TEST
LABORATORY_TEST_ID : INTEGER
TELECONSULTATION_REQUEST_ID : INTI
TEST_NAME : VARCHAR(100)
FINDINGS : VARCHAR(200)
ADDITIONAL_INDO : VARCHAR(20)
MAGE_OF_SKIN_PROBLEM
IMAGE_ID : INTEGER
PICTURE : VARCHAR(200)
BODY_PART_SHOWN : VARCHAR(50)
IMAGING_PROTOCOL : VARCHAR(300)
TELECONSULTATION_REQUEST_ID : INTI
FOLLOW_UP_QUESTION
QUESTION_ID : INTEGER
QUESTION : VARCHAR(100)
STATE : VARCHAR(10)
QUESTION_TYPE : VARCHAR(20)
ANSWER : VARCHAR(255)
TELECONSULTATION_REQUEST_ID : INTI
CHOICE
CHOICE_ID : INTEGER
CHOICE : VARCHAR(40)
ITEM_STATE : INTEGER
QUESTION_ID : INTEGER

# 6. Prototype

## 6.1. Mobile client for the web application

There are five major cell phone platforms available today: Symbian, Windows CE, BREW, WAP and J2ME [14].

- Symbian is an operating system for Nokia smart phones. Developers can use the Symbian C++ native programming API to develop applications.

- Windows CE is a mobile operating system that allows development of mobile applications by providing access to the hardware such as input/output, and networking [15].

- Binary Run-time Environment for Wireless (BREW) is a C++ based framework that is mainly targeted for variations of CDMA sets. The applications are written specifically for a given hardware platform without the traditional notion of the operating system [15].
- Java 2 Micro Edition (J2ME) is a Java based platform for cell phones. It includes APIs to enable building Graphical User Interfaces (GUIs), and accessing the device's persistent data storage and network. J2ME introduces platform independence across mobile devices, and is currently supported by a majority of cell phones. In order to address the majority of cell phones on the market, J2ME is selected to implement the mobile application component of this project. This reason, and the authors experience with Java, led to the decision to use Java-based products in the overall architecture.

J2ME platform provides two configurations, depending on the memory constraint of the mobile device. The CLDC (Connected Limited Device Configuration) and the CDC (Connected Device Configuration). CLDC is targeted for devices with low memory. These types of devices include cell phones, and PDAs. CLDC addresses the needs of devices with 32 to 512 kB of memory [15]. CDC is the part of J2ME that addresses devices that have a total memory of 2 to 16 MB and can have a high bandwidth and continuous connection to the network [15].

Built up on the CLDC configuration, the most successful J2ME profile is Mobile Information Device Profile (MIDP). The MIDP targets the smallest devices, such as cell phones. MIDP provides APIs to

support timers, networking, mobile storage manipulation, and user interface design. The project uses the APIs provided by MIDP to implement its functionality.

Capturing an image of the skin problem directly from the application using the mobile's built in camera, is handled using Mobile Media API (MMAPI) that is found in devices supporting MIDP 2.0. The MMAPI is designed to support multiple media content types and data capturing mechanisms.

In terms of providing security, MIDP 2.0 supports HTTPS (Secured-Hyper Text Transfer Protocol). The mobile application uses this protocol to communicate securely with the server.

## 6.2. Web Application

In addition to the basic components of the Web - HTML, CSS, and JavaScript- the project uses the following components

Client tier: JavaScript enabled browser.

Presentation tier: Java Server Pages (JSP), Servlets, and Java Server Faces (JSF)

Business tier: Java Persistence API (JPA) 3.0 Container Managed Persistence beans for object relational mapping and stateless session beans for handling business logic such as adding and removing records.

Security: Java Authentication and Authorization Service (JAAS): JAAS is a set of APIs that enable services to authenticate and enforce access controls upon users.

## 6.3. Programming Tools used

Netbeans IDE 9.9.1 is used to program and the server side using J2EE platform.

Glassfish Application server is used to deploy the web application.

Sun Java Wireless Toolkit 2.5.2, a J2ME emulator platform, integrated into Netbeans Integrated Development Environment, was used to emulate the mobile device.

JavaDB database is used to keep the back end data.

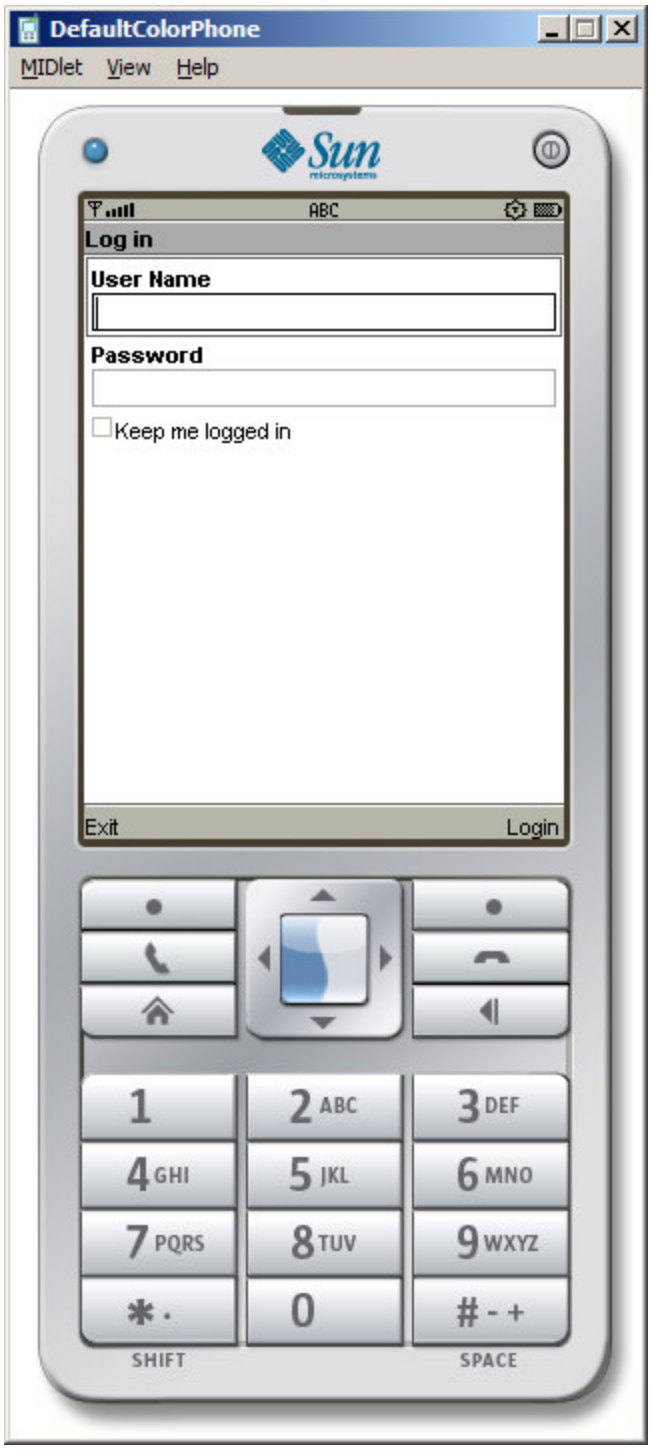
Rational rose 2002 and Microsoft Visio were used to design the UML diagrams.

### 6.4. Testing

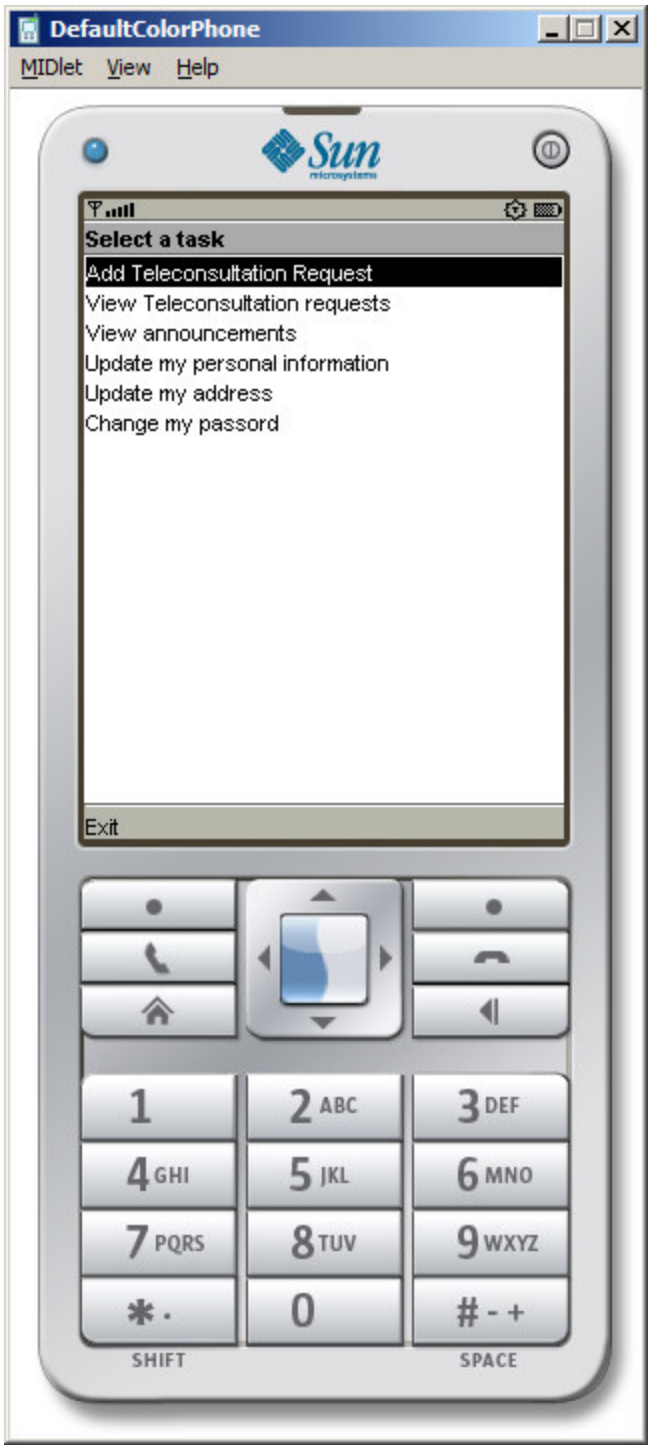
The system was tested for connection failures by programmatically closing the connection in the middle of data transmission at random points. An emulator was used to simulate the mobile application. The system successfully recovered from all the failures.

### 6.5. The mobile based teledermatology system

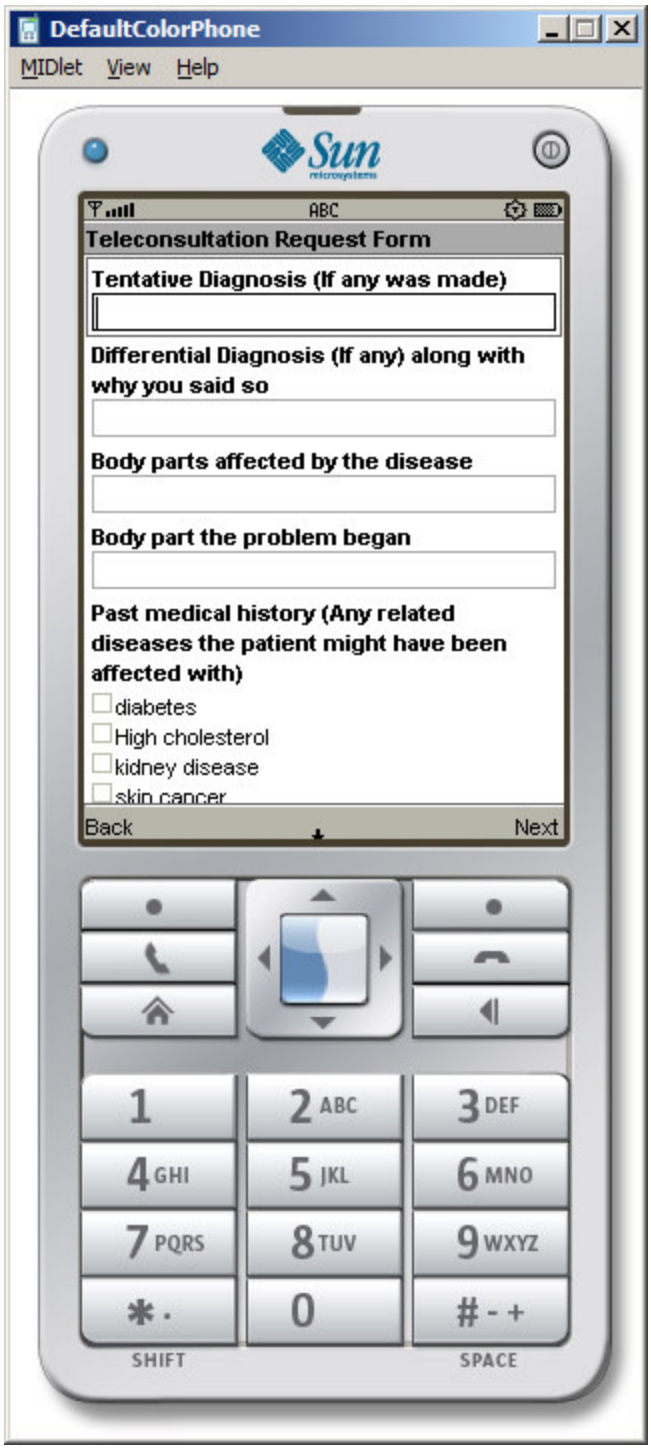
Based on the system design, the system's prototype was developed. When the clinician starts the application on his mobile phone, he/she is requested to provide his/her user name and password.




If the clinician provided a valid user name and password, the system displays the main menu. From here clinician can request a consultation by selecting Add Teleconsultaion Request.

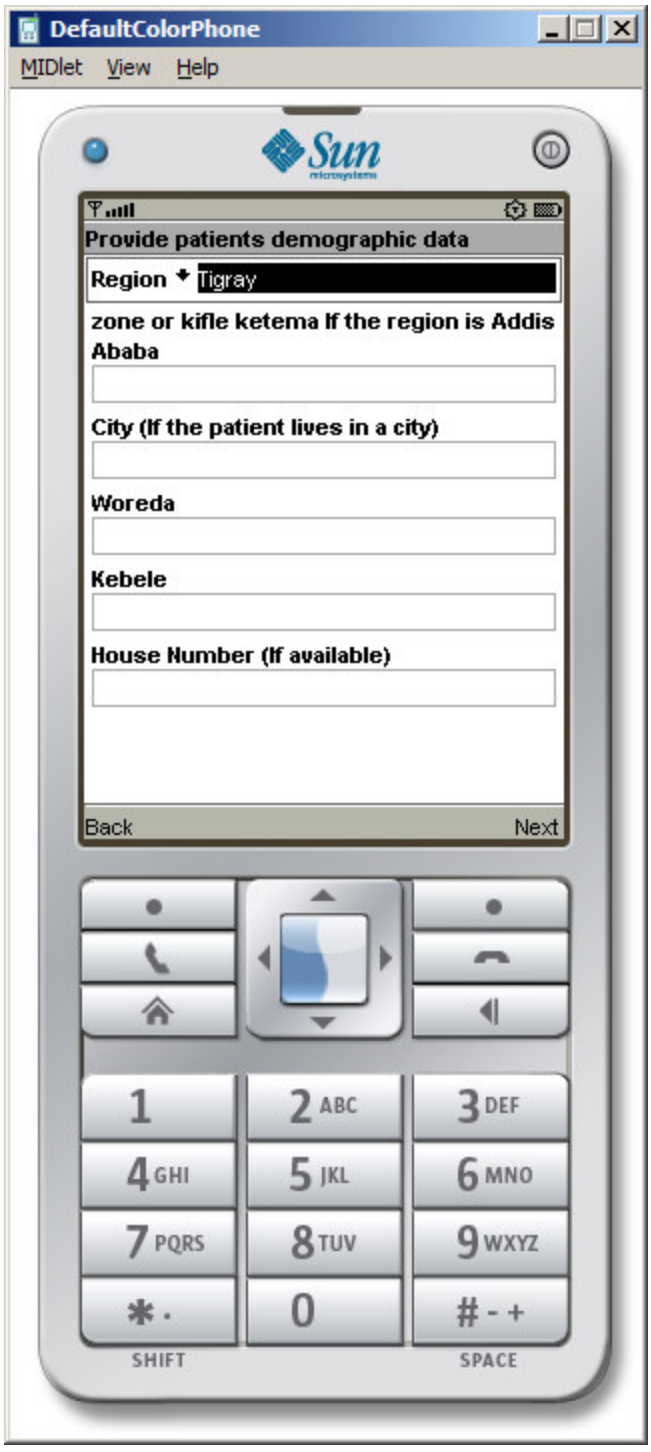



When the user selects the add teleconsultation request, the system prompts for details of the request. As shown in the screen shot.




After filling the details of the request the system asks the clinician to enter the patient's information.


After the clinician fills the form and clicks submit, the system asks the clinician for the geographic location of the patient. Since geographical information is used by the dermatologist while accessing a case.

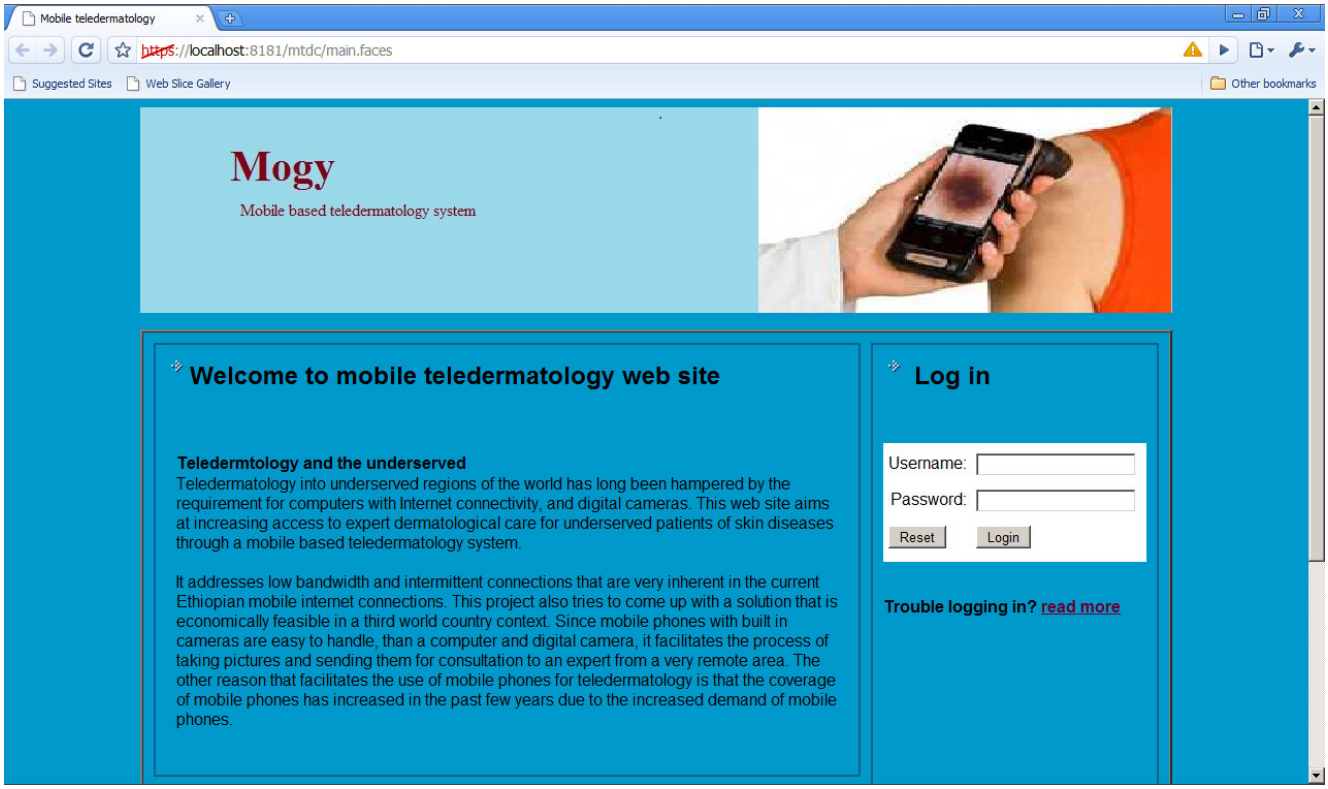



After entering the location information of the patient and selecting “Next”, the clinician is requested to take a picture of the skin problem, as shown in the following figure.

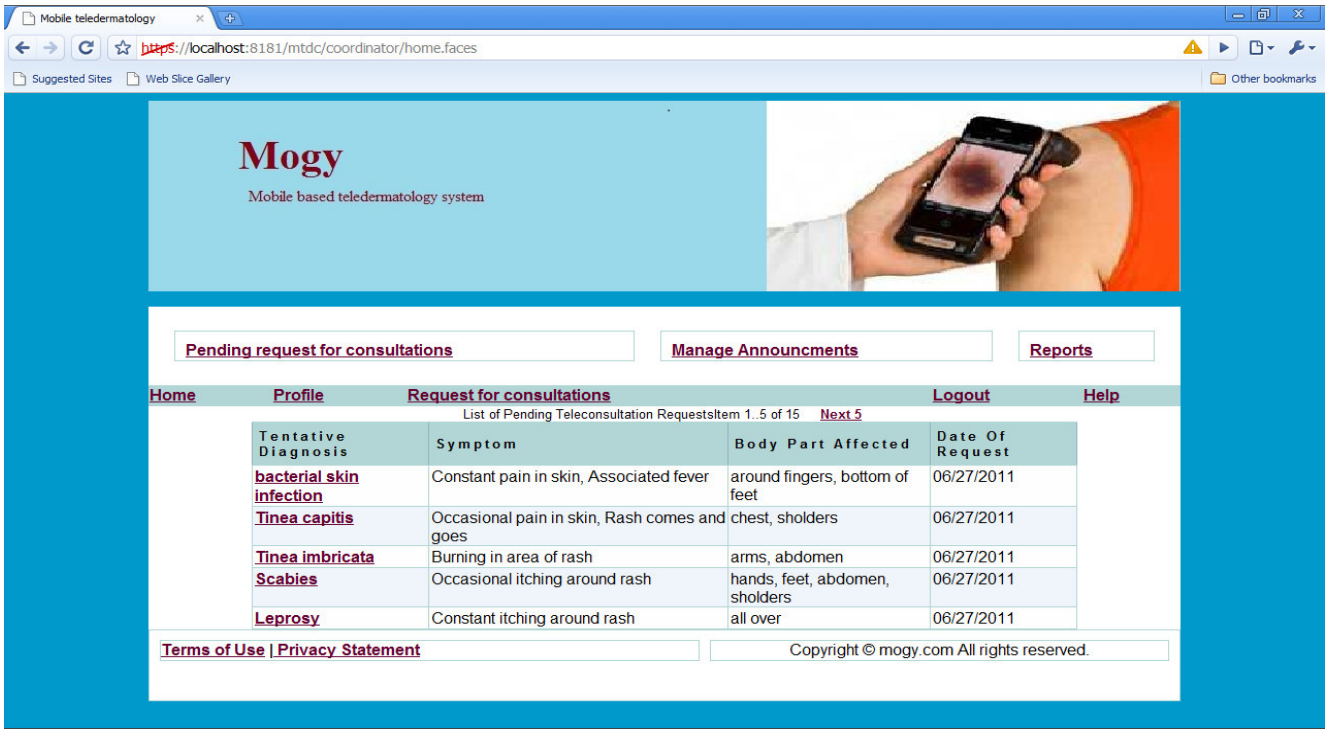

The clinician takes a picture by selecting the “Capture” Command. The system responds by displaying the captured image.


The consultation requester can decide to send the request for consultation, or to take another picture if he/she is not satisfied with the current picture.

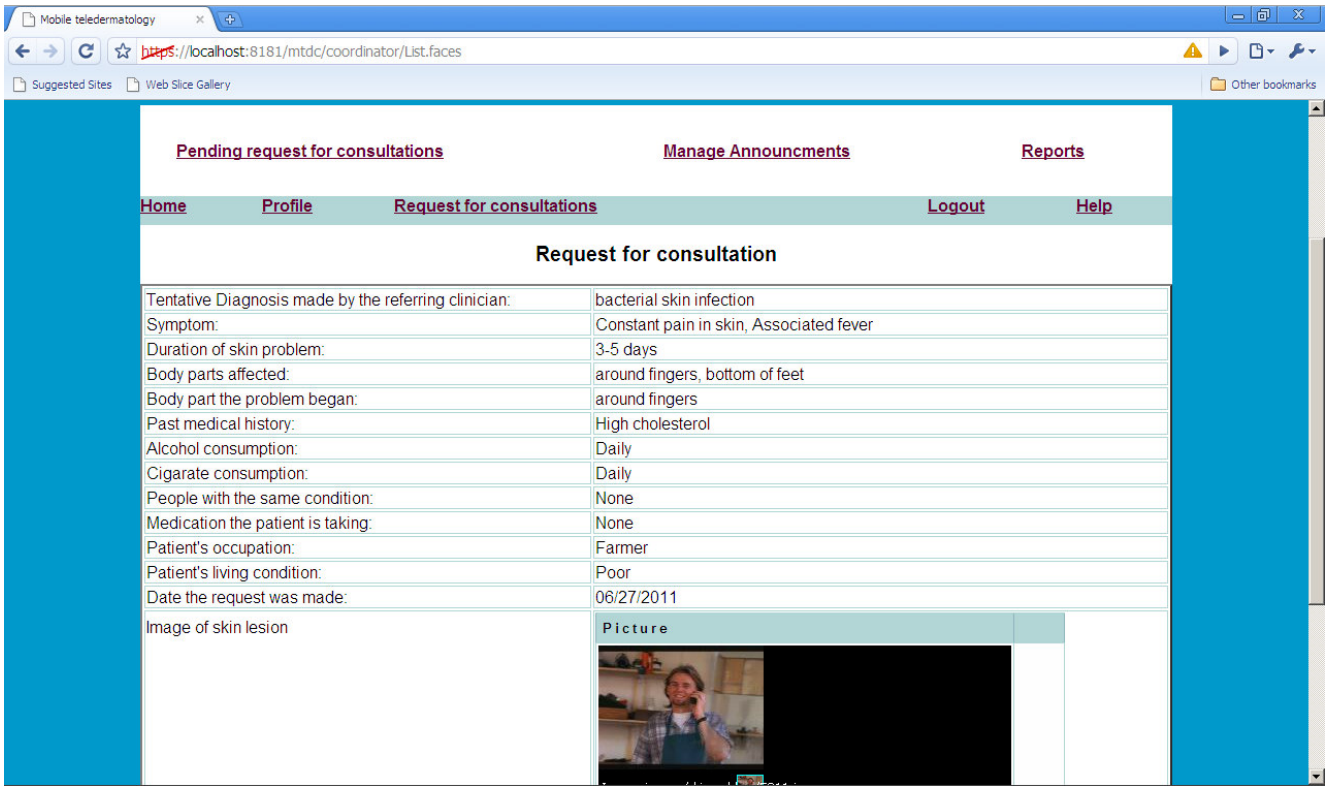
After the clinician submits a request for consultation, the request is placed in “Pending” state. Then the coordinator logs onto the system via HTTPS protocol. The logon form looks like the following.



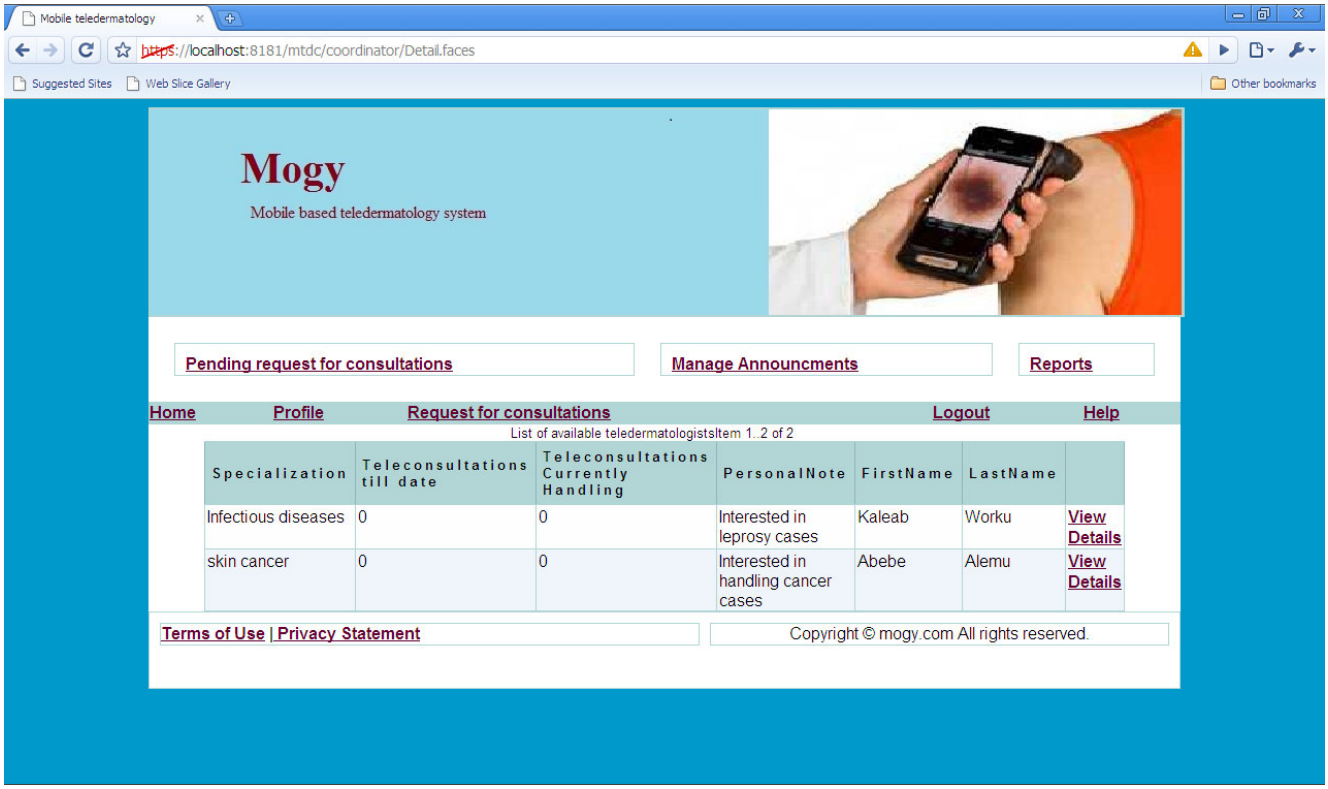

When the coordinator logs clicks “list of pending requests for consultation” link five the pending requests are displayed per page arranged in descending order according to their date of the request.



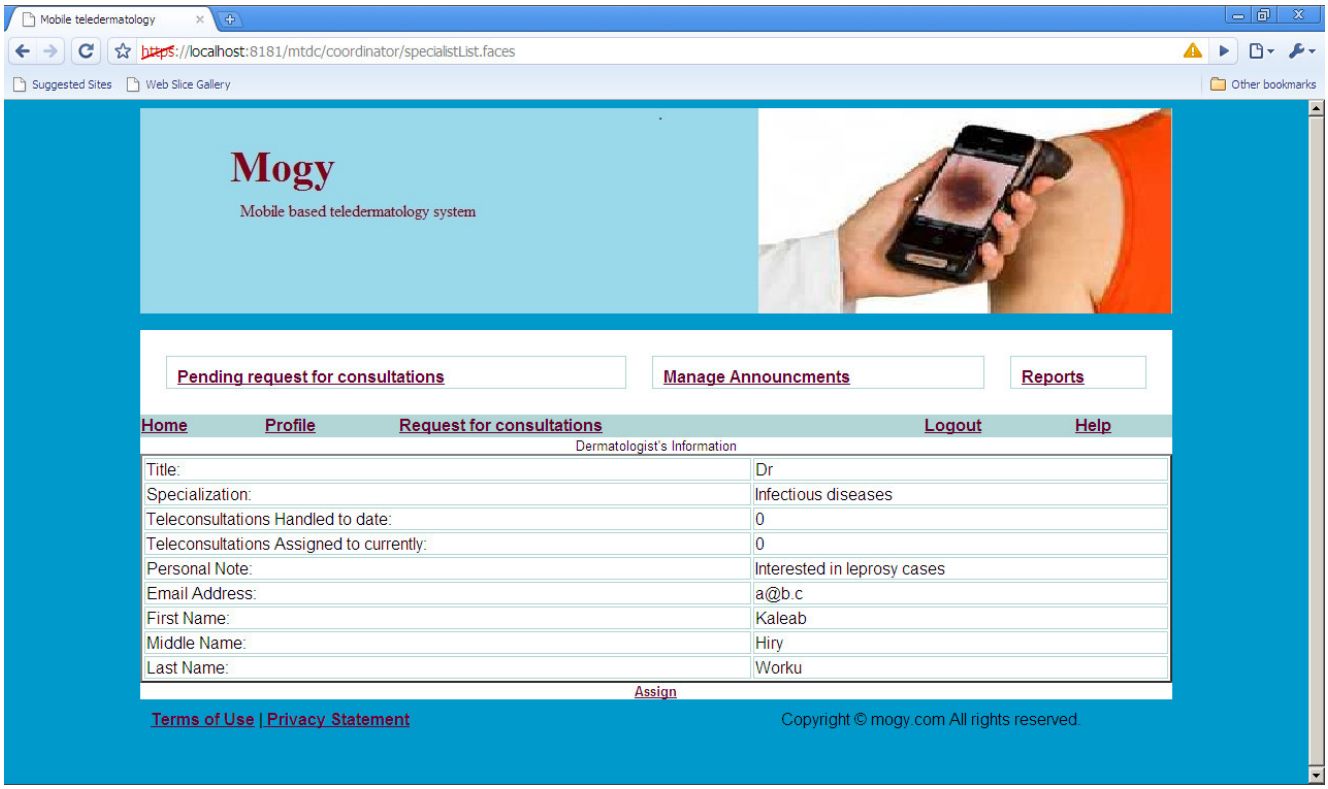
The coordinator clicks on the “tentative diagnosis” of a particular request for consultation to view the details of the request.




The coordinator clicks the “assign a specialist button” which displays the list of specialists available.



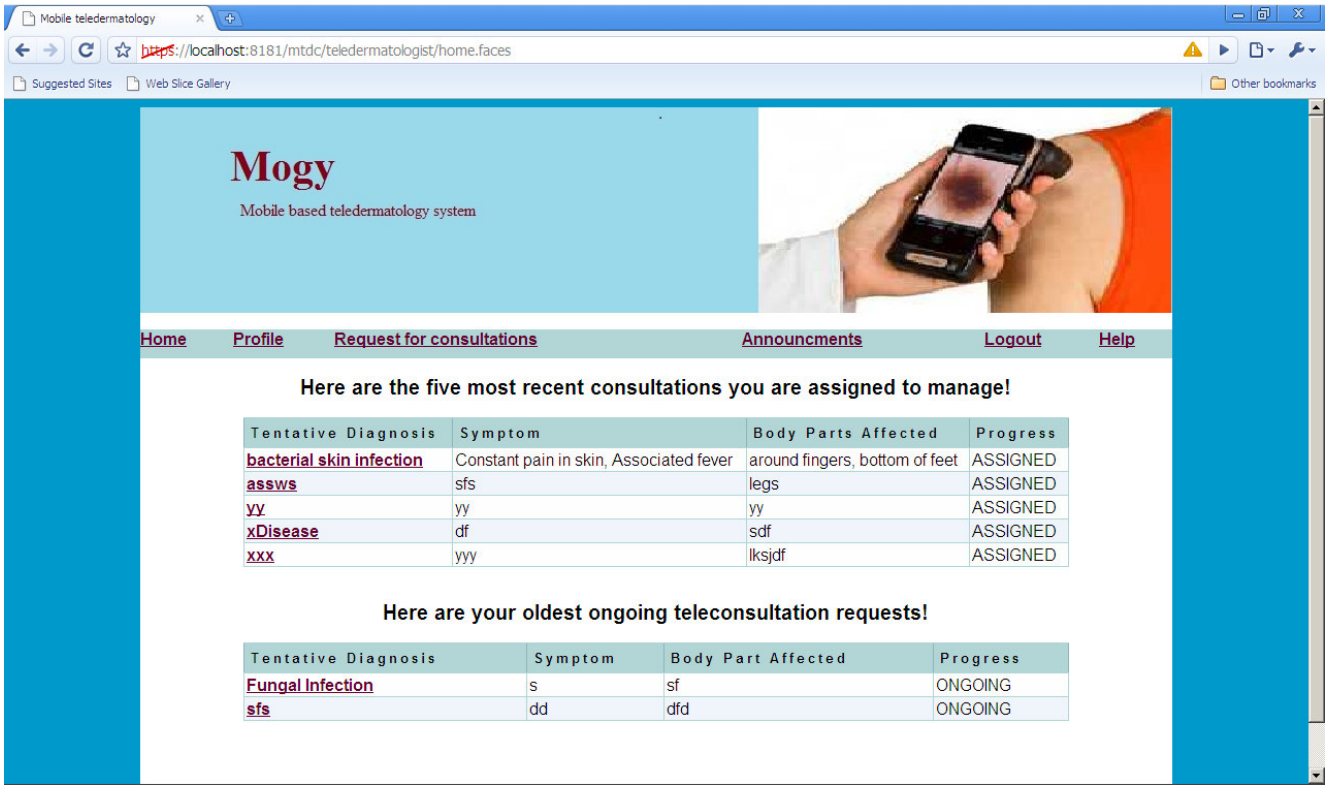

The coordinator then clicks on “View Details” to see detailed information about the specialist.



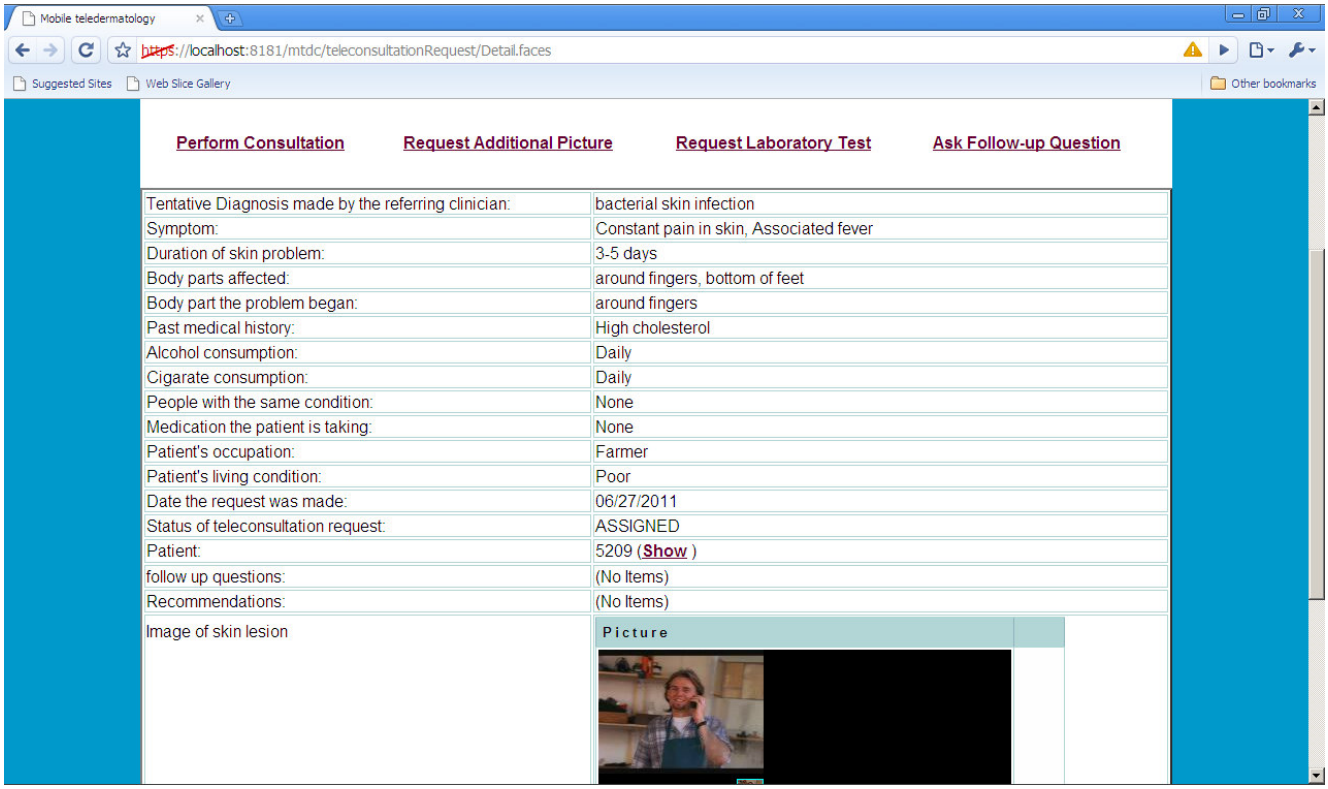
The coordinator finally selects “assign link” to assign a specialist to handle a certain request.

After being assigned to handle a case, the specialist logs on to the system by using the login page.

The specialist’s home page contains a list of the most recent five requests he has been assigned to handle, and also a list of five of the oldest requests are not yet closed.

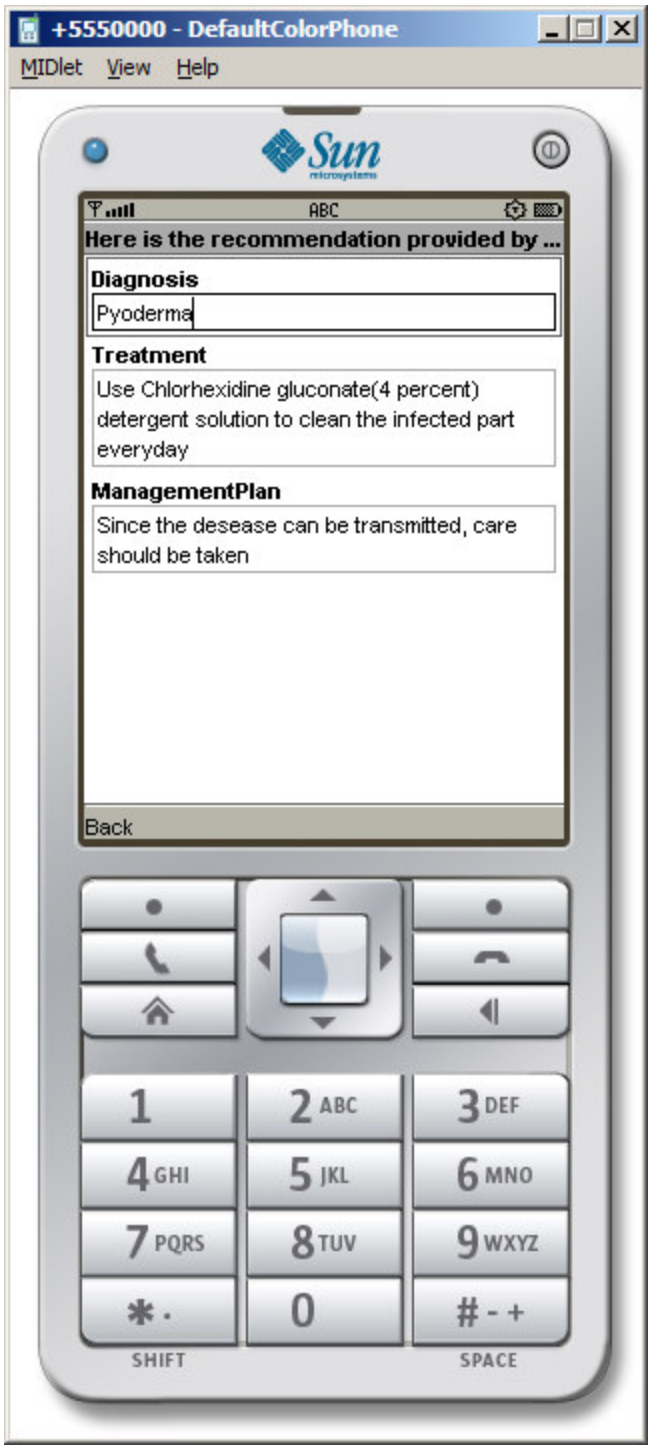



The specialist selects one of the requests (or clicks on “Request for consultations link” on his home page to see all the requests five requests per page).




From the above page specialist can ask a question, request another image of the lesion, recommend a laboratory test, or if he has all the information he needs perform diagnosis, and recommend treatment to the requester as shown in the following figure.


When the requester logs onto the system he/she can find the recommendation made by the specialist.


+5550000 - DefaultColorPhone
MIDlet View Help
Sun
ABC
Here is the recommendation provided by ...
Diagnosis
Pyoderma
Treatment
Use Chlorhexidine gluconate(4 percent) detergent solution to clean the infected part everyday
ManagementPlan
Since the desease can be transmitted, care should be taken
Back
1
2 ABC
3 DEF
4 GHI
5 JKL
6 MNO
7 PQRS
8 TUV
9 WXYZ
* .
0
# - +
SHIFT
SPACE

# 7. Conclusion

This project demonstrated the use of mobile applications to deliver teledermatology services in situations where the network is slow and unreliable. A mobile phone, and a web based applications were developed using Java MIDP, and J2EE technologies respectively. The developed system makes efficient use of the underlying network by keeping the data transmitted over the network to a minimum. It also works in unreliable network environments by making use of the mobile devices local storage as a temporary storage until the data can be successfully transmitted over the network.

This mechanism proposed is tested successfully addresses the challenge faced in implementing mobile based teledermatology services due to slow and unreliable mobile networks.

# 8. Future works

Image similarity checking algorithms can be designed to infer similarity between the image under examination and a knowledge store containing images and the associated diseases. These kinds of systems could be very helpful in providing recommendations to the dermatologist especially about features that are not evident for the naked eye.

# Reference


[1] Jung, C.R.; Scharcanski, J.; "Sharpening Dermatological Color Images in the Wavelet Domain," *Selected Topics in Signal Processing. Journal of IEEE,* 2009; vol.3, no.1, pp.4-13,

[2] Schmid-Grendelmeier P, Masenga EJ, Haeffner A, Burg G.; "Teledermatology as a New Tool in sub-Saharan Africa: an experience from Tanzania". *J Am Accad Dermatol.* 2000; 42: 833–5.

[3] . Colin D. M., Dejan L.; *Updated projections of global mortality and burden of disease, 2002-2030: data sources, methods and results,*2006.

[4] Association of Telehealth service providers. 2001 ATSP report on U.S. Telemedicine activity. Portland, OR, 2001.

[5] Schmid-Grendelmeier P., Doe P., Pakenham-Walsh N.; Teledermatology in sub-Saharan Africa. *Curr Probl Dermatol* 2003; 32: 233–46.

[6] FDRE Ministry of Health, 2008. *Health and Health Related Indicators*, January 2008, Addis Ababa Ethiopia.

[7] Han S. Pak, Karen E. Edison, John D. Whited; Teledermatology a user's guide.

[8] Tran, K., Ayad, M., Weinberg, J., Cherng, A., Chowdhury, M., Monir, S., El Hariri, M., Kovarik, C.; Mobile teledermatology in the developing world: Implications of a feasibility study on 30 Egyptian patients with common skin diseases. *J Am Acad Dermatol*. 2011; 64(2): 302-309

[9] Dejene, H., 2005. Medical Data Access With a PDA-based Client. MSc. Project report, School of Graduate Studies Department of Computer Science, Addis Ababa University, Ethiopia.

[10] Click diagnostic. http://www.clickdiagnostics.com/ourse_rvices.html#08 (visited on June 18, 2011)

[11] Andualem W., 2009. Design And Development Of Public Health Record Collection System Using MMS. MSc. Project, School of Graduate Studies Department of Computer Science, Addis Ababa University, Ethiopia.

[12] Günter S., Dieter H., Peter K., Silvia K., Wolfgang S., and Rainer H., 2008. A Mobile-Phone based Teledermatology System to support Self-Management of Patients suffering from Psoriasis: 30th Annual International IEEE EMBS Conference: Vancouver, British Columbia, Canada, August 20-24, 2008

[13] Ralph P.B., Jean L. V., Luc T., Christa P., Lars E.F., Aron J.G., Jean-Hilaire S., and Denis S., 2005. Telemedical Wound Care Using a New Generation of Mobile Telephones: A Feasibility Study. *Arch Dermatol., 141:254-258*

[14] Martyn M., 2003. Mobile and Wireless Design Essentials. Willey publishing, Inc., Indianapolis, Indiana.

[15] Reza B., 2005. Mobile computing principles: Designing and Developing Mobile Applications With UML and XML. Cambridge University Press, New York, USA.

[16] Cho, J.M.; Jung, J.Y.; Kim, S.W.; Soyer, R.H.; Dong, H.; Jang, H.S.; Cho, S.H.; , "TEIN-based Teledermatological Service System among Korea, China and Austria," *Engineering in Medicine and Biology Society, 2005. IEEE-EMBS 2005. 27th Annual International Conference of the* , vol., no., pp.2199-2202, 17-18 Jan. 2006

[17] Schmid-Grendelmeier P, Masenga EJ, Haeffner A, Burg G. Teledermatology as a new tool in sub-saharan Africa: an experience from Tanzania. *J Am Acad Dermatol* 2000; 42: 833–5.

[18] Schmid-Grendelmeier P, Doe P, Pakenham-Walsh N. Teledermatology in sub-Saharan Africa. *Curr Probl Dermatol* 2003; 32: 233–46

**Declaration**

This project is my original work. It has not been presented for a degree in any other university, and that all source of materials used for the project have been duly acknowledged.

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Signature:_____

Date:_____

**Confirmed by Advisor:**

Name: Dr. Fitsum Admasu

Signature:_____

Date:_____

Place and date of submission: Addis Ababa, June 2011