

School of Engineering & Design
Electronic & Computer Engineering

REHABILITATION TELEMONITORING SYSTEM

A Thesis submitted for the degree of Master in Science in Data
Communication Systems

BY

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Abstract

One of the top current NHS priorities is to address the issue of the increasing load placed on rehabilitation clinics across the country, large commuting times and costs of rehabilitation for both the government and patients. As the computer technology has advanced a great deal in the past few years, the development of a telemonitoring system, which can solve all problems mentioned above, is now a reality.

The current Thesis does a research on some available telemonitoring solutions and it presents a rehabilitation telemonitoring system which enables patients to conduct physiotherapy sessions from home, giving them the opportunity to enhance their quality of life and at the same time cut down hospitalization expenses. It describes the overall architecture of the prototype system, its various components, and the methodology that has been used.

The rehabilitation telemonitoring system is tested using four different scenarios in order to make the user comprehend the philosophy and usability of the system software and extract some useful conclusions.

Keywords: Rehabilitation, physiotherapy, Telemonitoring, Telemedicine, health-care, Java, MySQL, X3D, Xj3D, jogl, vlcj

1. Telemonitoring

1.1 Prototype System Overview

The prototype system enables the Therapist to send customised therapy sessions (exercises) to their patients at home and allow patients to send their completed therapy sessions back to their Therapist. Moreover, the remote monitoring of patients progress is possible and of course feedback exchange. There is no need for real-time communication between patient and therapist as this is a store-and-forward solution.

The main steps that describe the Rehabilitation Telemonitoring System are presented below:

Step 1

The Therapist logs into the Server, from his client tool and uploads the therapy session/exercise. This is then automatically sent to the patient' s client tool.

Step 2

The patient accesses the therapy session (at his/her own time) and after (s)he completes it, (s)he sends it to the Server.

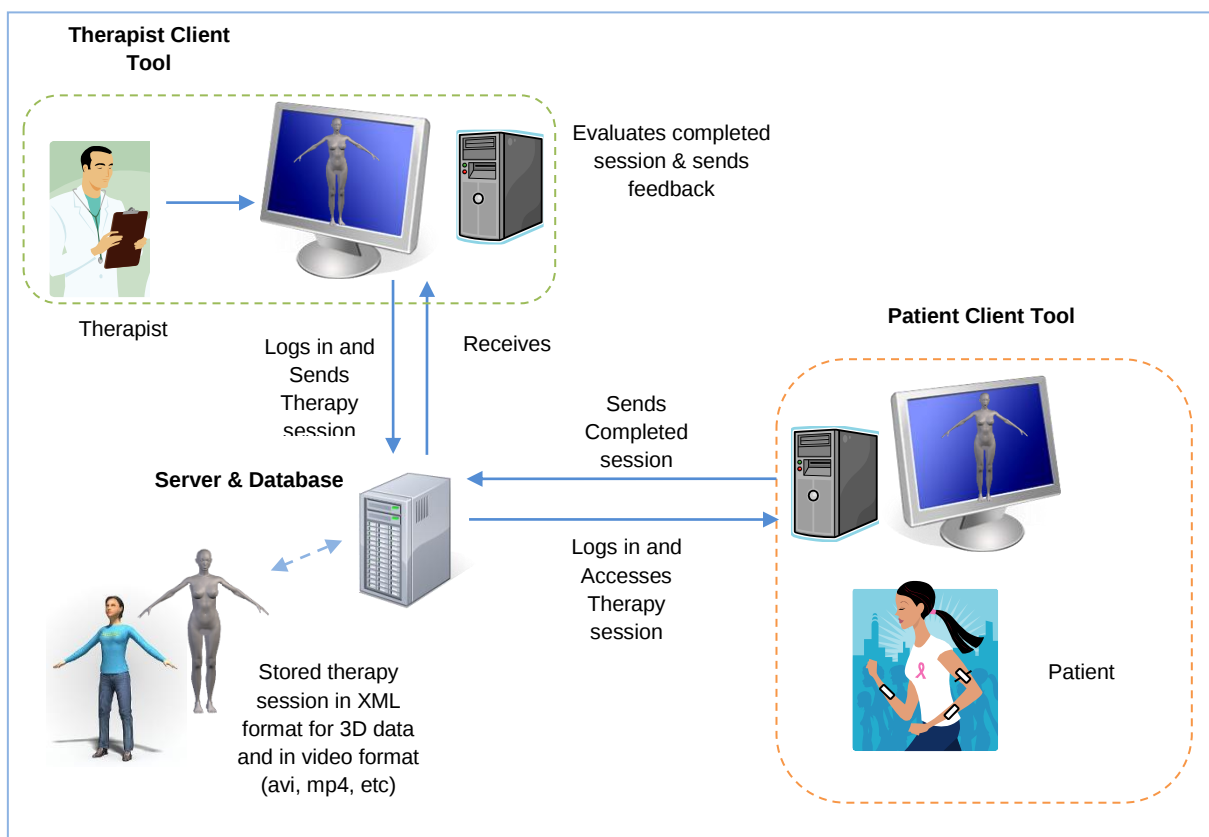
Step 3

The Server automatically notifies the therapist (to the client tool or/and email) that there is a completed therapy session waiting for him/her.

Step 4

After receiving the notification the therapist logs in again to the server at his/her own time and accesses the completed therapy session. (S)He then adds feedback to it (whether the exercise was done correctly as well as any suggestions for improving it) and sends it to the patient.

The following figure states the system overview.



Prototype System Overview

1.2 Architecture of the proposed Telemonitoring System

The philosophy is to create an intuitive, user friendly and easy-to-use interface for both the therapist and the patient as they would not be technically skilled and in most cases they are technology illiterate or technophobes.

The software, used by the prototype system, is a client-server type and it will be developed in Java using Netbeans. An SQL Server will be configured properly for that reason and it will contain the login information, therapy sessions, all patients' progress and therapist's feedback.

The therapy sessions are stored in a secure electronic location that both the therapist and patient can only access to review their progress. The therapy sessions can be in XML format for 3D data and in mpeg4 video format (*.avi, *.mp4, *.divx).

The progress of each patient will be stored also into the Server. Special sensors and accelerometers will collect all valuable information during treatment session and store them into the server.

When the treatment session is over, the therapist will be notified in order to evaluate patient's performance. As soon as (s)he reviews the patient's progress, (s)he adds feedback to it and sends it to patient through the Server using his/her own client tool. The feedback could be any comments about the exercise and whether it was performed correctly or not., as well as any suggestions for improving it.

2. CHAPTER 5 – SYSTEM EVALUATION

In this section some prospective users are chosen to test the prototype system. Different scenarios concerning patient and therapist interaction will be explored, extracting valuable information for the future development and correction. Official X3D files by Web3D consortium have been used as samples for system testing. (39)

The tests which were conducted have examined the system in the following categories:

- Video and X3D files upload.
- Video and X3D playback.
- Viewing Progress - Sending Feedback.
- Server' s response test.

The whole system has been tested on the same machine running all three programs (therapist' s, patient' s and server' s tool) using the localhost address: 127.0.0.1). In order to operate on a LAN or Internet, we simply have to change the localhost address with the real static Server' s IP Address.

It is assumed that the therapist, named Emmanuel, has three (3) patients under his supervision and that all patients' data is already inserted into the database. All programs were running on Windows 7 Pro OS with JRE 6 32bit. The data has been inserted into the MySQL database using the appropriate MySQL queries.

So, “st_p” , “sessions” , “kartella” and “feedback” tables were included the following data prior to running the tests, in order to cover all possible scenarios and perform a reliable test.

Patient Code	Patient Surname	Patient name	Join Date
0001	Patient1surname	Patient1name	13-01-2011 14:00
0002	Patient2surname	Patient2name	14-01-2011 15:45
0003	Patient3surname	Patient3name	14-01-2011 16:00

Table 1 – Example contents of SQL Table “st_p”

ID	Session Title	Session Type	Upload Date	Filename
1	Video Test	Video	26-01-2011 17:02	Low back rehab exercises.mp4
2	X3D Test	X3D	29-01-2011 18:30	NancyPrototypes.x3d
3	Video Test 2	Video	05-02-2011 10:30	Hip Operation.flv

Table 2 – Example contents of SQL Table “sessions”

Patient Code	Session ID	View Date	Status	Feedback code
0001	1	27-01-2011 12:20	Completed	0001-3
0001	2	03-02-2011 12:00	Completed	-
0002	1	28-01-2011 12:00	Completed	0002-1
0002	2	01-02-2011 12:00	Completed	0002-2
0002	3	-	Pending	-

Table 3 – Example contents of SQL Table “Kartella”

Feedback code	Type	Upload Date	Filename
0001-3	Audio File	29-01-2011 14:02	0001-1-fdb.mp3
0002-1	Written text	30-01-2011 14:36	0002-1-fdb.xml
0002-2	Written text	02-02-2011 13:22	0002-2-fdb.xml

Table 4 – Example contents of SQL Table “Feedback”

2.1 Scenario 1 – Video and X3D files upload

The therapist Emmanuel types his username and password to login. A warning message box appears, if the user doesn't provide the correct data or if the database connection cannot be accomplished.

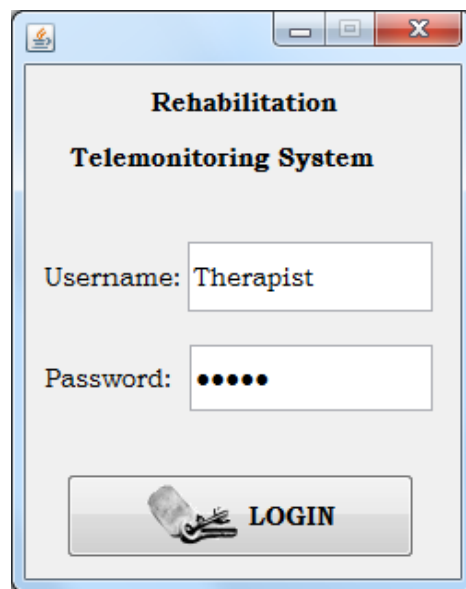


Figure 1: System Evaluation – Therapist Login

If the login has been successful, the program automatically shows all therapists' patients and prompts him to select one. When he selects the desired patient, the four following choices are enabled:

- i. "View progress"
- ii. "Send feedback"
- iii. "Upload Session"

In this scenario, Emmanuel chooses to upload a new session to patient 1. The program does not let him to proceed if he doesn't select a patient by clicking a row on the table. So, he selects patient 1 and click on the third option. Then, the upload form opens and shows the status of patient 1.

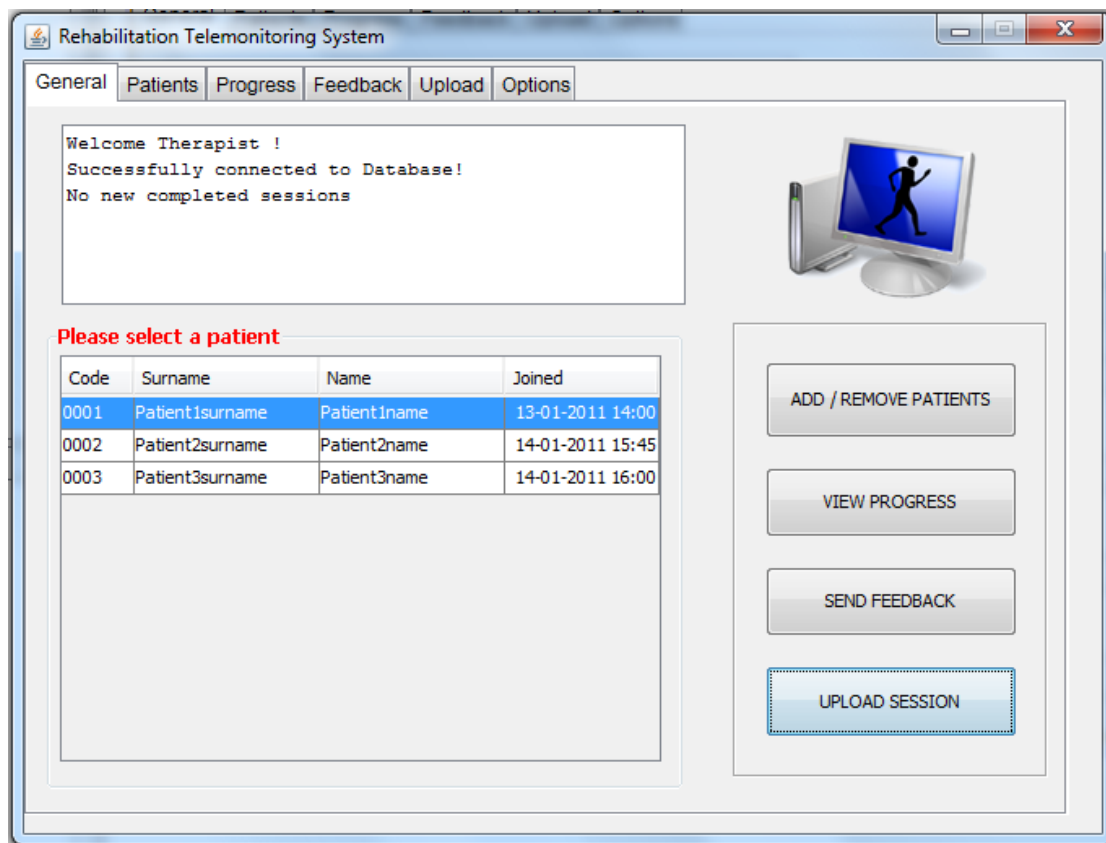


Figure 2: System Evaluation – Selecting a patient

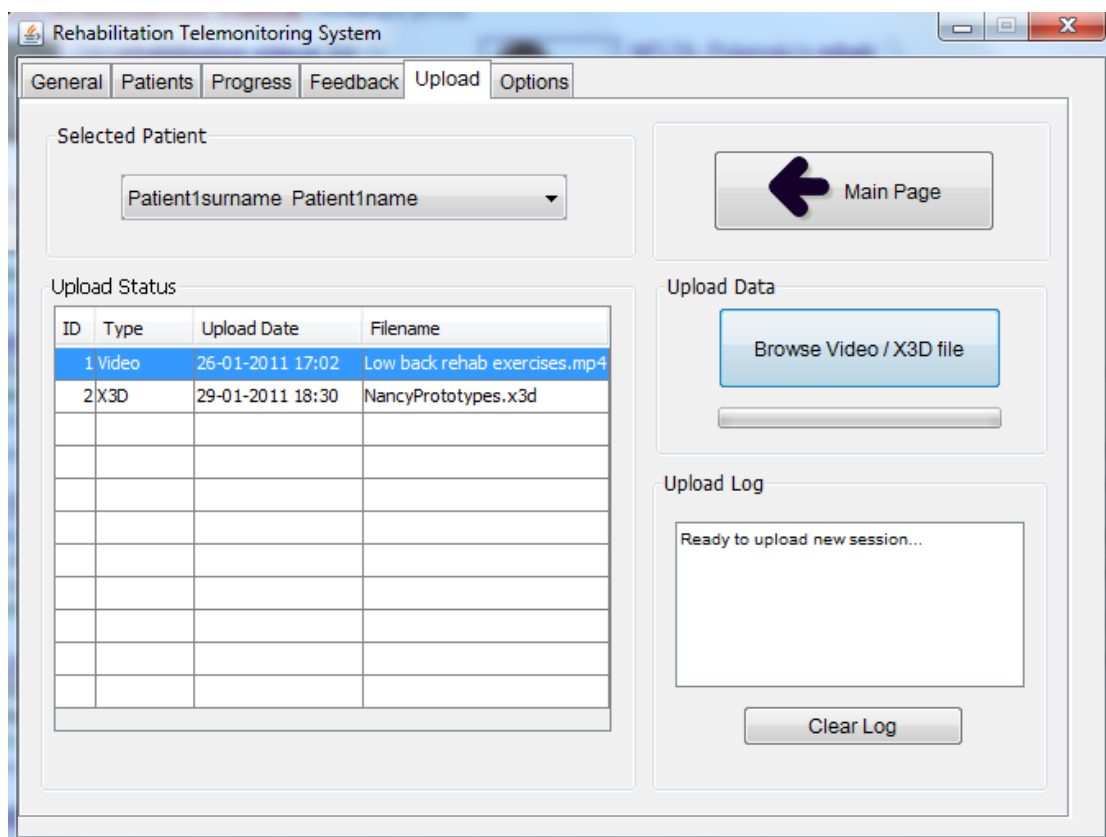


Figure 3: System Evaluation – Uploading a new session

The therapist can check the patient 1 status to see which sessions have been sent to him/her in the past. The above figure states that one video session having the name “Low back rehab exercises” and an X3D session named “NancyPrototypes” have already been uploaded to the server at the given dates and thus, sent to the patient.

The next step of the therapist should be to browse for a video or X3D file to upload to Server. The therapy sessions can be in XML format for 3D data (*.x3d, *.x3dv, *.x3db, *.wrl) or in any popular video format (*.mp4, *.avi, *.mkv, *.mpg, *.flv).

The following “file chooser” window opens when the therapist clicks on the “Browse Video / X3D file” button.

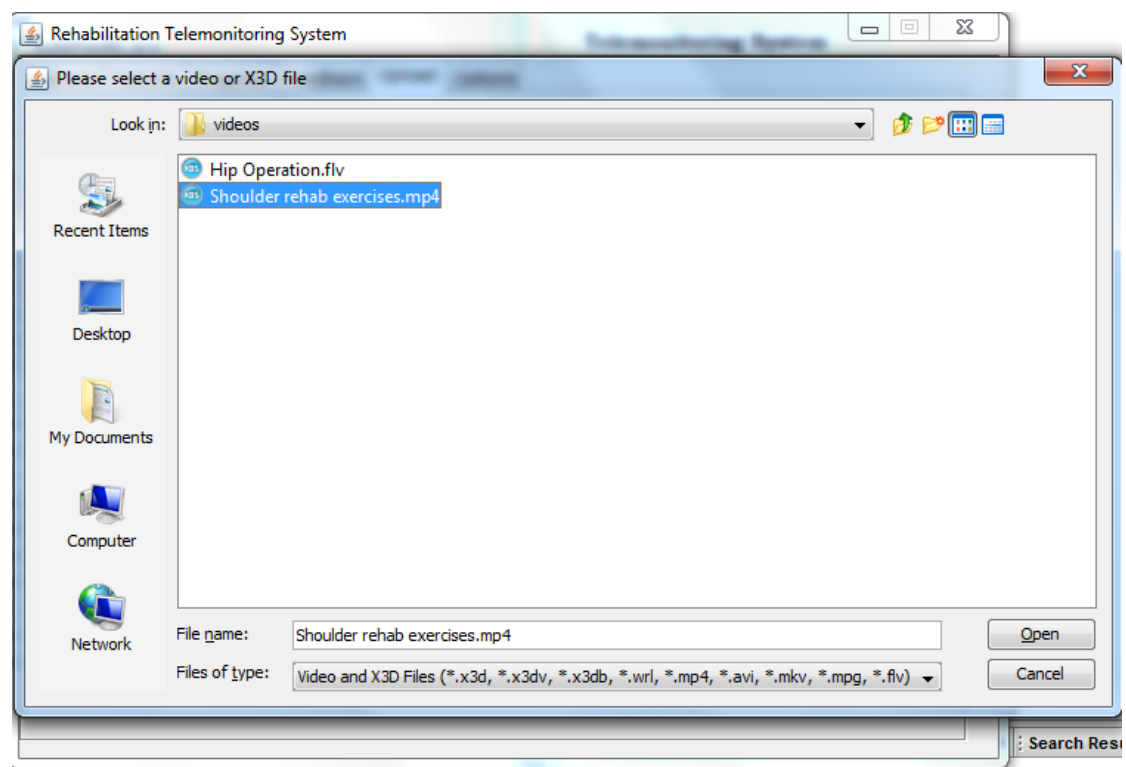


Figure 4: System Evaluation – Selecting a video or X3D file

As soon as he chooses to open the selected file, it is played back through the integrated video player. After a few seconds, a message box pops up and asks the therapist / user if the program can proceed uploading the file to the Server.

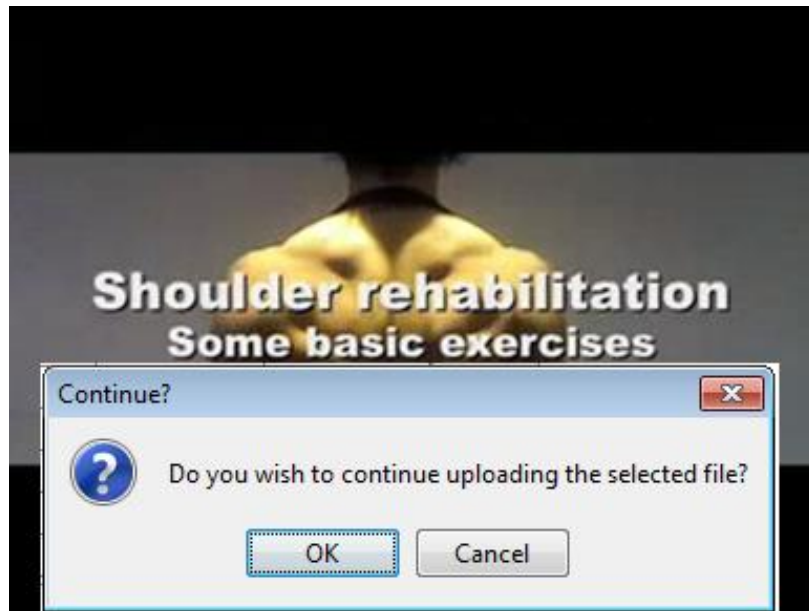


Figure 5: System Evaluation – Upload message

If the user selects to proceed the program detects whether this session exists or not by querying the database. If it exists, the video will not be uploaded to server and if it does not, like here, the video session will be uploaded using TCP sockets. When the upload is completed successfully, the server will store the file into the appropriate folder, depending on its type.

Afterwards, two changes occur: First, a new row is inserted into the table “session” and one into the table “kartella” to update the database. The patient’s program is configured to listen for database changes at a regular basis. In this way, the client program will be automatically notified that a new session is available. This scenario gets analyzed further down.

2.2 Scenario 2 – Video and X3D playback

Patient 1, let say Maria, run her client tool at her time and she is notified that a new therapy session is waiting for her. The list of patient' s downloaded sessions is shown by clicking the “View Sessions” button.

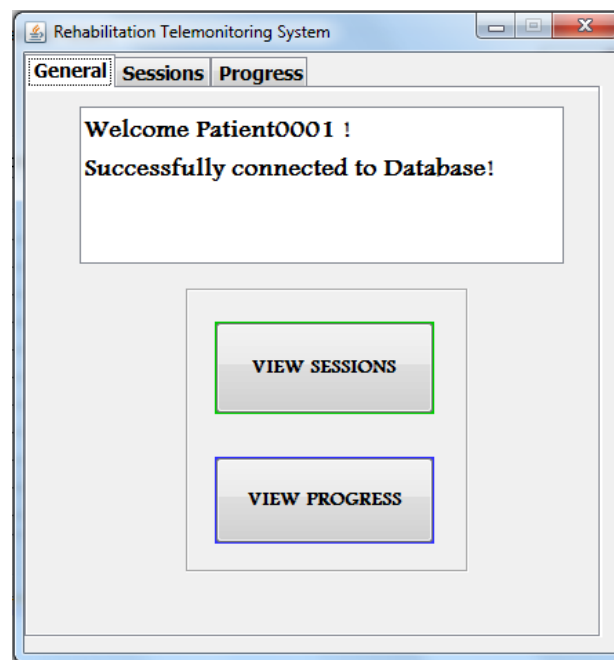


Figure 6: System Evaluation – Patient tool: Main window

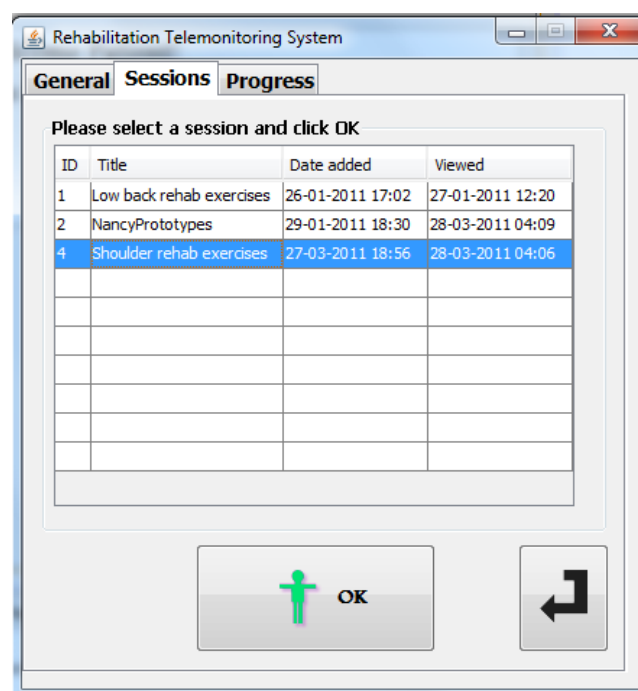


Figure 7: System Evaluation – Patient tool: Selecting a new session

Afterwards, Maria clicks on the new session and then on the “OK” button to watch the new video session “Shoulder rehab exercises” .

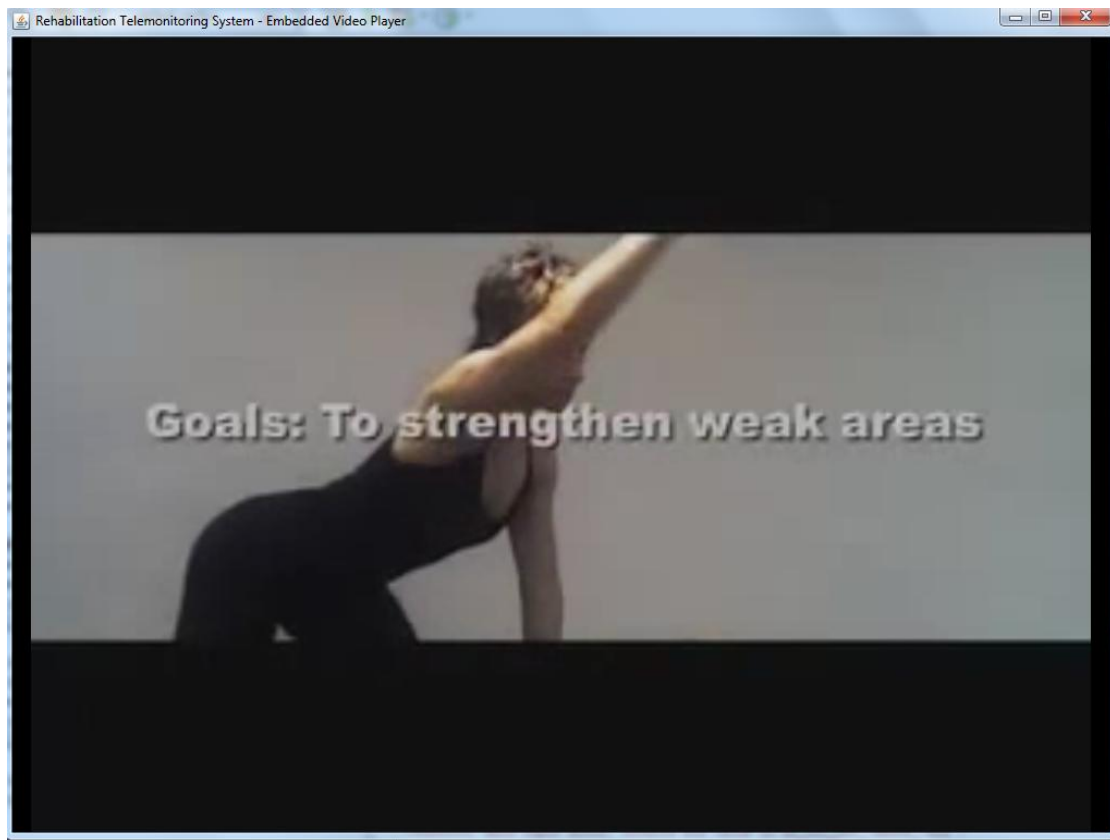


Figure 8: System Evaluation – Viewing a Video file

While Maria is performing the physiotherapy exercise, a video camera is recording her movements in order to create a video feedback for therapist.

As soon as Maria reviews the session, the “kartella” table of the database is updated to track that change. The column status is changed to “completed” and the current date-time is added. Then, the therapist is notified by the Server that Maria has completed her therapy session. The next step for the therapist is to review it and leave a feedback. That scenario is reported below.

Let say that Maria wants to review again the 3D XML data file named “NancyPrototypes” . When she clicks on it, a validation message informs the patient that she has already conducted the requested exercise. Maria clicks on “OK” button and then the X3D file is immediately opened.

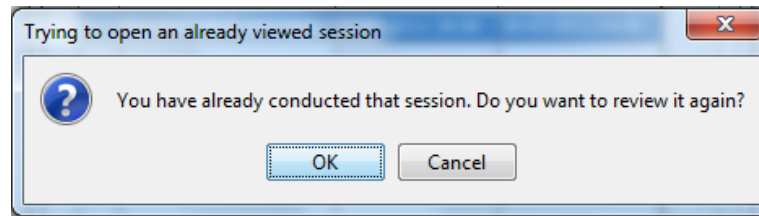


Figure 9: System Evaluation – Re-conducting exercise message



Figure 10: System Evaluation – Viewing an X3D file

A new video recording takes place to inform the patient that Maria has viewed again the particular session. So, the therapist must now leave feedback for this session too.

2.3 Scenario 3 – View Progress - Send Feedback

When the treatment session is over, the therapist is notified through his client tool and email to review patient' s performance in order to evaluate it. Using SQL queries and by searching for downloaded sessions under default download directories, the program automatically computes the number of new completed therapy sessions and appends this information to the main text area. According to the previous scenario, the therapist has to review two new completed sessions.

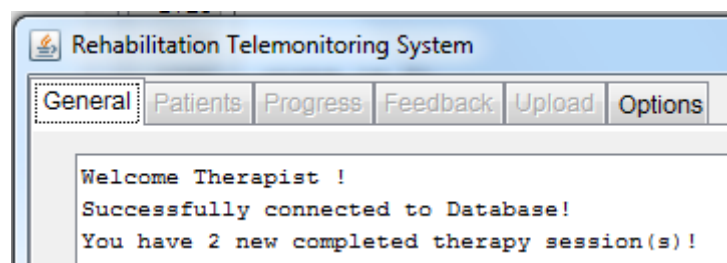


Figure 11: System Evaluation – Therapist tool: New message

The therapist clicks on "View progress" button to open the progress window and select a completed session to review it. In the progress window, the therapist can view the session ID, the title of the session, the date and time that the patient has conducted this session and the corresponding feedback which he has already sent.

The patient combo box is updated dynamically depending on how many patients are under therapist' s supervision. If the therapist changes his mind and wants to view another patient' s progress he can always click on the patient combo box and select another patient. In that case, the 'Patient Progress' table will be updated dynamically too.

Here also, the therapist can click on “Go back to Main Page” button.

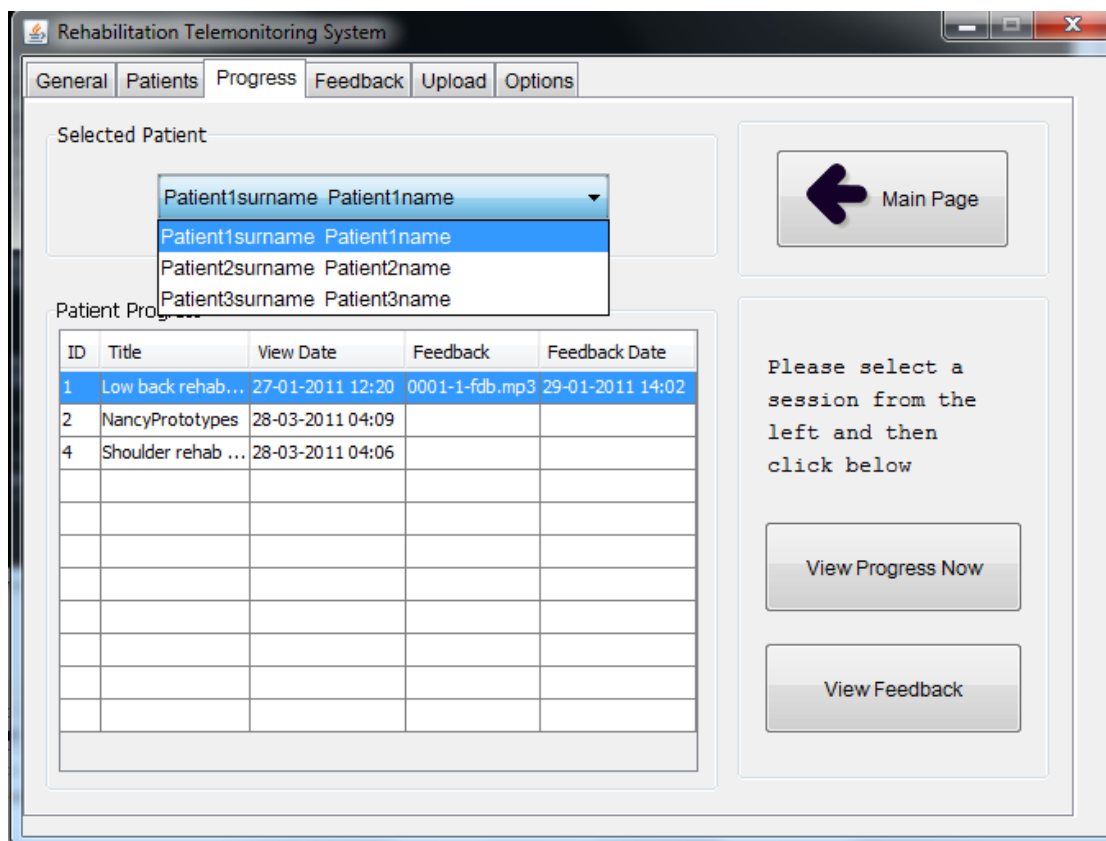


Figure 12: System Evaluation – View Patient Progress

By clicking on the “View Progress Now” button and depending on the completed session type, the embedded multimedia player or the X3D browser will open.

In this example, the therapist can click on the sessions which have ID equal to 2 or 4 because he has already reviewed and left feedback for the session which has ID equal to 1.

So, by clicking on Session 2 the completed X3D which has the name “0001-1-NancyPrototypes.x3d” is shown. It is not imperative to leave feedback right away. Let say, the therapist chooses to review the other session and don’ t leave a feedback for this one now.

So, the completed video session 4, corresponding to the session titled “Shoulder rehab exercises” is played back. As soon as he reviews the patient’s progress, the therapist can add feedback by using his client tool.

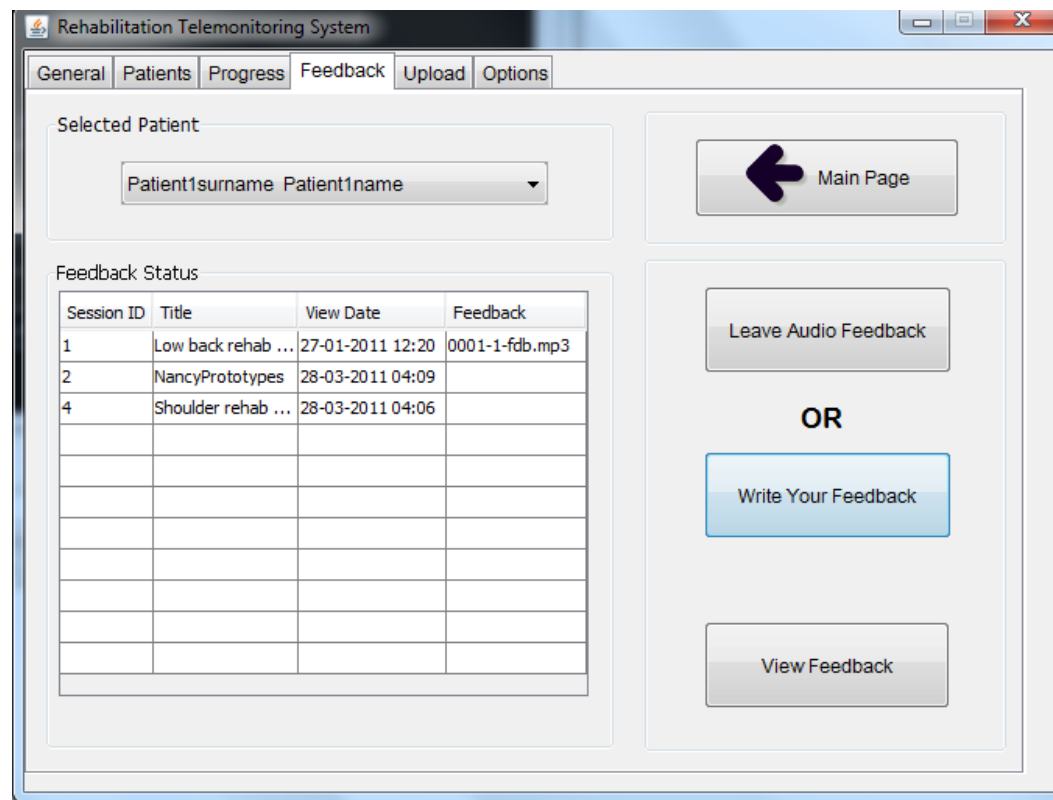


Figure 13: System Evaluation – Send Feedback to Patient

The feedback could be any comments about the exercise and whether it was performed correctly or not, as well as any suggestions for improving it. The therapist’s feedback can be in two formats:

- Audio (mp3) capture through his PC microphone
- Written text in XML format

If the therapist chooses to write his feedback, then a new frame opens including a simple text editor. When he finishes typing, he clicks on “Send & Exit” button and his client tool converts the written text into XML format and sends it to patient.

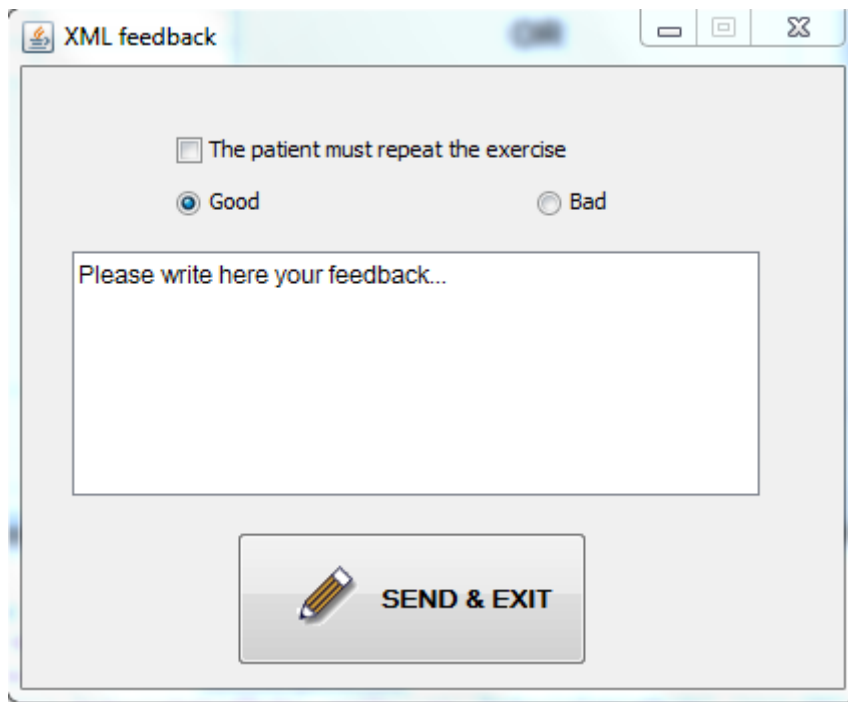


Figure 14: System Evaluation – Therapist Tool: XML Feedback

On the other hand, a new frame opens with a record button if the therapist chooses to record his feedback through his PC microphone. The therapist can listen to his feedback and re-record if he wants to.

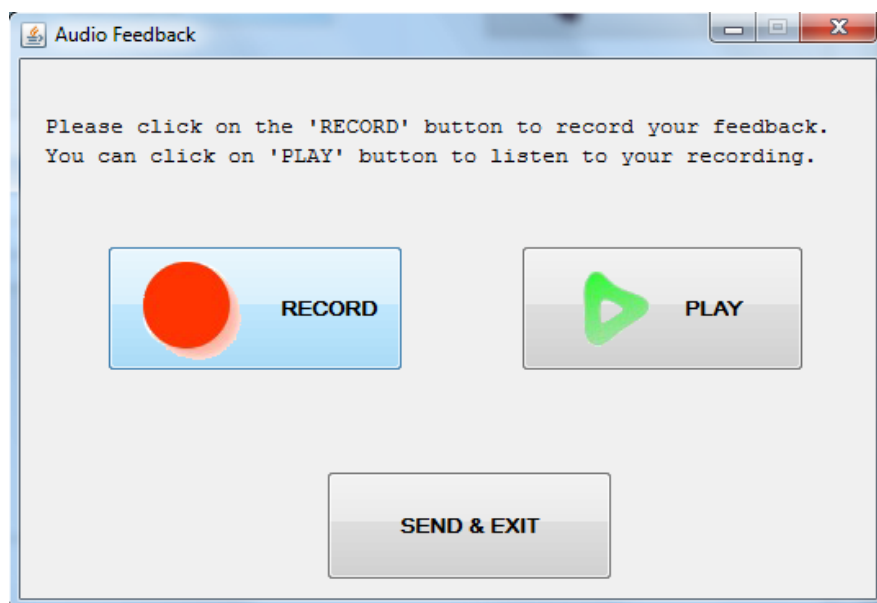


Figure 15: System Evaluation – Therapist Tool: Audio Feedback

The patient opens at his/her own time the client tool and (s) he is notified that a new feedback is waiting for him/her. The progress window displays prompt information about the session feedback.

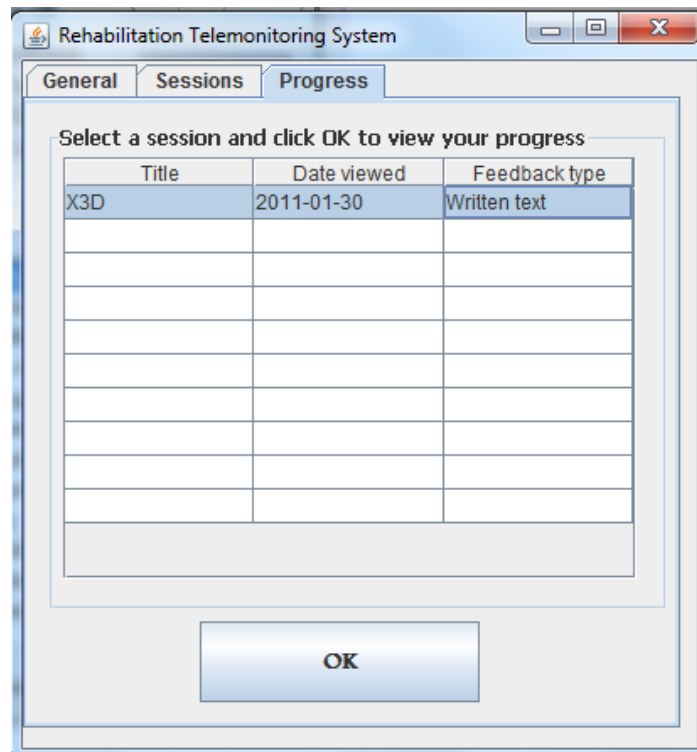


Figure 16: System Evaluation – Patient Tool: Viewing Progress

The appropriate feedback window opens when the patient clicks on OK.



Figure 17: System Evaluation – Patient Tool: Audio feedback

2.4 Scenario 4 – Server’s response test

A Server machine running SQL service and the developed Java server program has been set up for the purposes of this prototype system. The main window and the options of the java server tool are shown below:

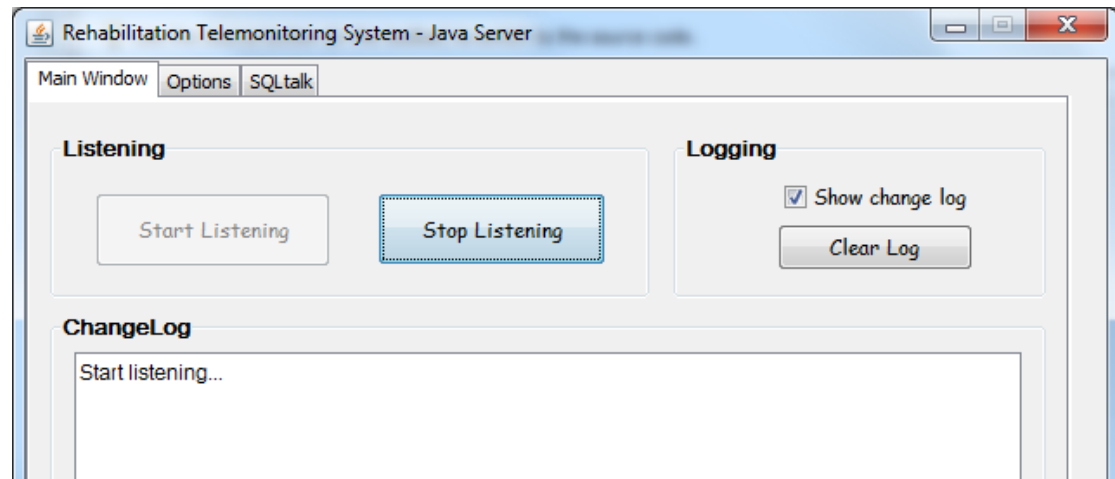


Figure 18: System Evaluation – Server Main Window

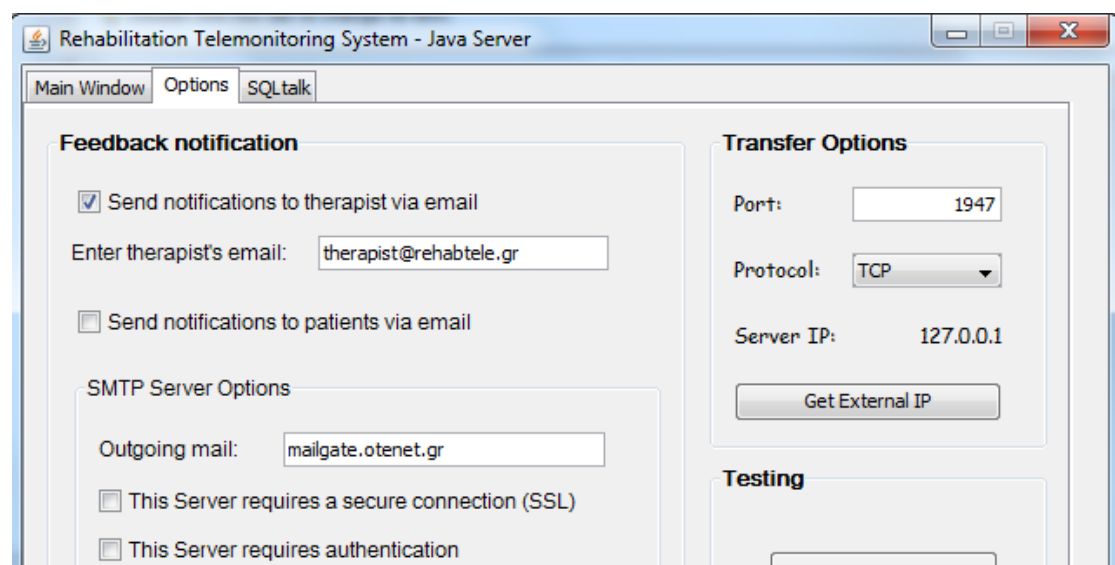


Figure 19: System Evaluation – Server Options

By clicking on the “Start Listening” button, the Server is listening on port 1947 for incoming messages and files. Moreover, it lists the changes happening in MySQL database. The log file provides this kind of information.

The Server stores the database which contains the login credentials, patients' information and feedback from both therapist and patients. Special sensors and accelerometers collect all valuable data during treatment session and store patient's data and progress into the server.

The figure below displays the viewable text when the file "Shoulder Rehab" of the previous scenario 1 is successfully transferred to the server. What is more, it states the change to the progress of patient 1 when (s) he watches the X3d file in scenario 2.

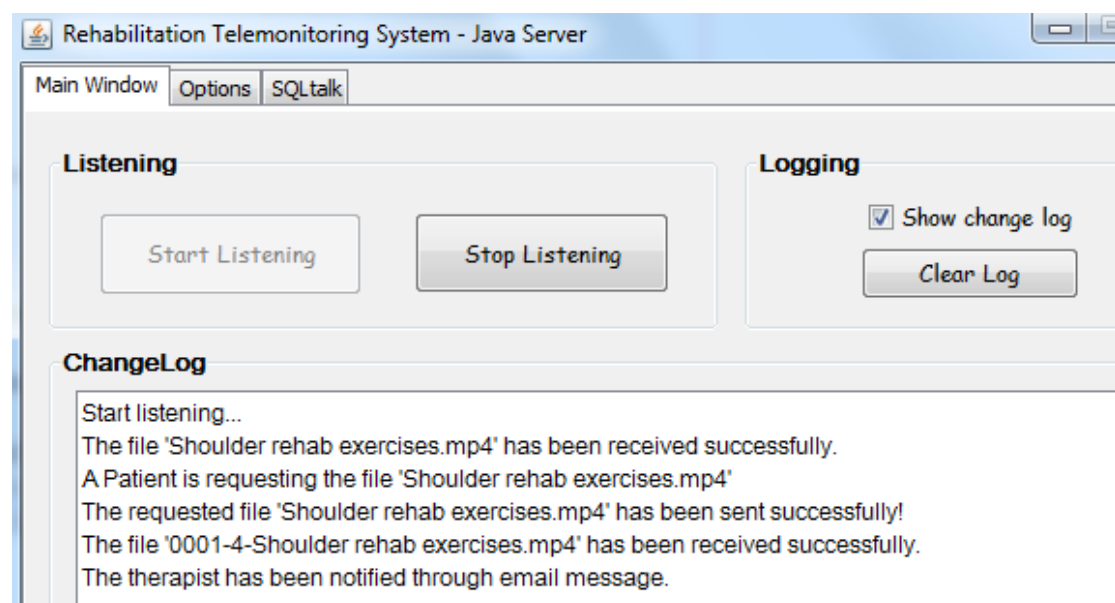


Figure 20: System Evaluation – Server Logging System

Using the Server tool, it can be specified the therapist's email address and also whether the therapist will be notified by email or not whenever there is a new completed therapy session.

You can view the videos of the first three scenarios by clicking below, in order to get a better and more holistic and visual understanding of the system:

[Scenario 1 video](#)

[Scenario 2 video](#)

[Scenario 3 video](#)