

DEVELOPMENT OF A SECURE WIRELESS SYSTEM FOR TELEPROCESSING OF MEDICAL IMAGES

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Abstract. *The aim of this study is to develop an information system, which will perform remote medical image processing (teleprocessing). A mobile unit is considered, which functions within the boundaries of a wireless network (e.g. in a hospital). This mobile unit, which plays the role of a client, communicates via a wireless network infrastructure with a server. The server contains medical data of patients. The main feature of the server is to perform remote image processing and data display on client demand. The result of the teleprocessing is the display of the processed images on a mobile unit.*

1 INTRODUCTION

Medical images are one of the basic parameters that physicians take into consideration in diagnosis. These images, that may need processing to enhance the accuracy of diagnosis, are stored in central storage devices within a hospital.

In the present study, network operations, such as retrieval and transmission of images from central points to remote clients, and remote image processing tasks, such as image enhancement, were implemented on the server side. This approach relieved the client from computationally intensive processes. Additionally, it promoted the wireless communication between client and server by transferring the workload to the server side.

Nowadays, Wireless Local Area Networks (WLANs) may be easily deployed and maintained within a hospital environment. Their main advantages comprise the roaming ability provided to users and the network scalability and flexibility, derived from the lack of necessity for rewiring in the case of potential network adjustments^[1].

In the proposed system, information exchanged between client and server is accomplished using Extensible Markup Language (XML). Moreover, the Secure Socket Layer (SSL) protocol, supported by Java for authentication and encryption^[2], was employed to enhance the security of wireless communications.

2 MATERIALS AND METHODS

The system comprised two software applications, the server-side and client-side applications, creating an information system based on the server-client model. These two applications were developed in Java. The server-side application, is a console application that generates the software object, which serves the client by a) accepting requests, b) performing the necessary processes, and c) replying to the client^[3]. The image processing is performed on the server-side. Every event that occurs on the server is recorded and displayed on its output console. The client-side application has a graphical user interface, which allows the user to perform his/her tasks and requests easily.

Both applications were developed on a typical desktop computer (Intel Pentium 4 / 3.06 GHz with 1GB RAM), running Microsoft Windows XP, using the Java Development Kit (JDK), and the Eclipse platform version 3.0^[4]

software packages. An IEEE 802.11g compliant wireless network infrastructure was employed for the client (laptop computer powered with Intel Pentium 3 / 866 MHz with 576MB RAM) – server connection.

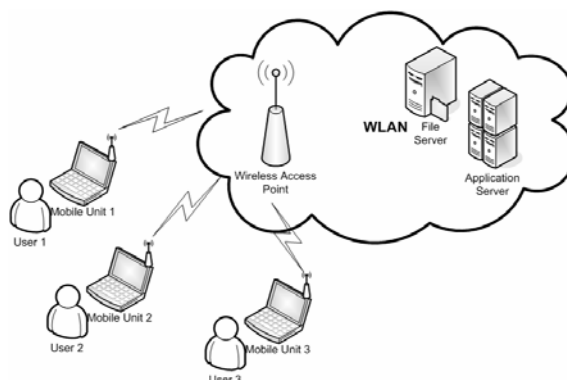


Figure 1. System's architecture

2.1 Information exchange

Once the server application initializes, several clients can connect to the server and request remote image processing. The server accepts the connection, creates a new server object that receives and identifies the client's requests. When the requested processes are completed on the server-side, the reply is sent to the client-side application that displays the processed image [Fig. 1]. All the exchanged information between the client and the server is encapsulated in XML-based messages. XML supports the interoperability of the system and the portability of the data exchanged, allowing the integration with other systems and various platforms^[5].

2.2 Image Processing

The image processing considered in the present study is based on neighborhood operations. Neighborhood operations, also called filters, combine the pixels of a small area according to a specific transformation. Filters are also mentioned as masks and are small arrays that their values describe, distinguish, and determine the kind of the processing that they perform, mostly by convolving the mask with the image locally. In the present study, the masks employed were: a) Laplacian mask, used for detecting the edges within an image, b) hi-emphasis mask, which is a composite Laplacian mask used for accentuating the edges displayed on an image, and c) smoothing mask, used to clean the noise introduced to an image^[6].

2.3 Security

The security of the system is promoted by employing the SSL protocol. Two certificates were created, using Java tools for both the server and client. One certificate is associated to the server and the other to the client. The applications become aware of these certificates during their initialization and they use this information in order to clarify the validity of the corresponding peer with mutual authentication. Thus, the client-side verifies that it connects to a valid server. Additionally, the server allows for the establishment of a connection only to authorized users. Once both sides are mutually authenticated, the SSL protocol provides an encrypted connection between them for secure message transmission^[2].

3 RESULTS

The advantages of WLANs (IEEE 802.11g) were exploited by transferring the execution of CPU-demanding processes from clients to the server. The latter allowed users to carry lightweight and portable devices, of limited computational power. The Graphical User Interface (GUI) of the client-side application was designed to be simple and user friendly even for users unfamiliar with similar applications [Fig. 2]

Transmission and processing times were proportional to image size and, in case of typical 512x512 greyscale images, were considered to be at an acceptable level. The overall processing time was diminished by employing computationally efficient servers. The processing times were also dependent on the current network state and number of simultaneously connected users. As the number of users expanded, the overall processing time increased, due to extended processing requests.

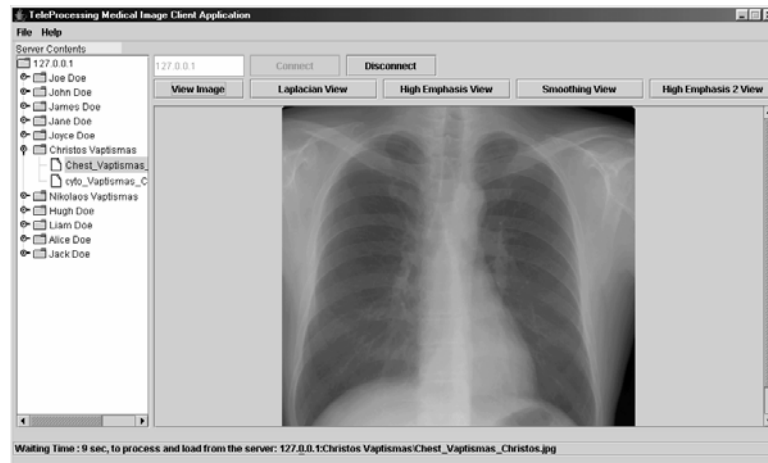


Figure 2. The client-side application

The implementation of the SSL protocol for the wireless communication between the client and the server enhanced the security of the information system by ensuring that only authorized users could connect to a valid server.

Finally, the use of Java in combination with XML promoted interoperability and rendered the system platform independent.

4 DISCUSSION

Regarding security, a further increase in the security level of the system, can be achieved by the use of more than one certificate per peer. The first certificate can be used for mutual authentication, when the client attempts to connect to the server. The second certificate can be used for the mutual authentication and the establishment of the encrypted channel between the new server thread, that will perform the image processing, and the client.

In order to decrease the overall processing time, more than one application servers can be deployed using the same file server. This achieves distribution of the workload, avoiding potential delays on the application server, caused by increased number of client requests.

Additionally, the system was designed in such a way that new computationally demanding algorithms can be easily integrated in the future.

5 CONCLUSION

By employing state of art technologies, a secure and reliable platform was designed, which enabled the remote monitoring and processing of patient image data. The system exploited the advantages of wireless networks and enhanced their security using the SSL protocol. Thus, it provided the capability of monitoring and processing images in powerful workstations in a secure way.

REFERENCES

- [1] Janice Reynolds (2003), Going Wi-Fi, A Practical Guide to Planning and Building an 802.11 Network, CMP Books, New York
- [2] Stephen Thomas (2000), SSL and TLS Essentials, John Wiley & Sons
- [3] Reilly David and Reilly Michael (2002) Java Network Programming and Distributed Computing, Addison Wesley
- [4] Holzner Steve (April 2004), Eclipse, O'Reilly, Sebastopol
- [5] McLaughlin Brett (2001), Java and XML, Second Edition, O'Reilly
- [6] Gonzalez C. Rafael and Woods E. Richard (2002), Digital Image Processing. New Jersey, Prentice Hall