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Role-Based Architecture for Secure Management of Telepathology Sessions

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Abstract. Digital pathology is the computer technology that allows the management of the information generated by the whole-slide scanners from a microscopic slide, encompassing the virtual microscopy. This paper proposes and describes the architecture of a secure collaborative platform that integrates a web pathology viewer with role-based access control. The proposed architecture is ensured by a shared medical repository that serves web pathology viewer with the medical images, using the DICOM standard. The system offers collaborative work session management tools as the managing of users, sessions, access control to sessions, and many others. Furthermore, the use cases related to telepathology and e-learning are presented.

Keywords. WSI, collaborative, digital pathology, PACS, DICOM, access control

1. Introduction

Digital pathology has gained popularity in the most recent years as a consequence of the proliferation of the Whole-slide Imaging (WSI) [1,2], replacing the traditional microscopes [3]. The digital era in the pathology field brought new features in the review process: the samples can be easily accessed from anywhere and anytime and at the same time as other users and then remotely reviewed and annotated. The improvements lie in the diagnostic accuracy and efficiency of the support systems. The handling of the samples becomes more secure as there is no deterioration in the image quality [4].

Digital pathology made available new methods to teach histology and pathology that was impossible until the digital revolution [5]. The digital replaces the old and expensive microscopes and simplifies the process in a way that all that is required is a device with internet access and a web browser for concurrent access to the same sample, either for teachers or students. Still, the regulation nowadays forces to protect the patient's data [6]. Therefore, the handling of these samples over the network requires strong access control and security protocols.

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teachers or students. Still, the regulation nowadays forces to protect the patient's data [6]. Therefore, the handling of these samples over the network requires strong access control and security protocols.

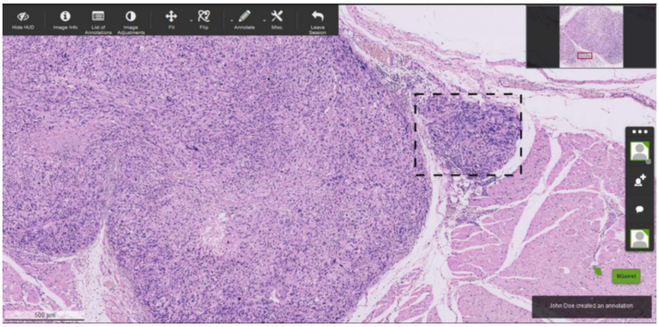

Figure 1. Screenshot of the platform during a work session.

This paper proposes and implements a secure architecture for the management of digital pathology remote working sessions[2]. The management platform provides means for a session creator to restrict and personalize permissions for the access and handling of medical images. The framework also integrates a pure web pathology viewer fully compliant with Digital Imaging and Communications and Medicine (DICOM) standard, the Dicoogle open-source project to support the WSI storage, and a web platform for the management of all the working sessions and their associated users. Furthermore, the introduction of a security layer [7] enables to control access policies in a non-secure environment, deploying an innovator multi-repository concept. The data management is assured by this accounting mechanism specially designed for medical imaging archives which creates the concept of virtual archives for each user.

2. Background

2.1. DICOM-PACS Universe

The evolution of the radiology regarding the digital paradigm let to the implementation of Picture Archiving and Communication Systems (PACS). PACS is an aggregation of hardware and software services that orchestrate acquisition, storage, and display of medical imaging data. All of the previous steps are integrated into digital networks supported by DICOM standard. PACS rely on DICOM, which is one of the most popular standards in the medical imaging field [8].

In 2010, microscopy was introduced in the DICOM, as a result of the rapid spread and adoption of the standard. The publication of the supplement 145 boosted the development of the automated whole-slide scanners [4]. However, the technology maturity level and initial vendor-lock positioning of scanners industry does not promote a fast adoption of DICOM-WSI in the first years.

Whole-Slide Images are specimen-centric, unlike the traditional DICOM information model, that are considered patient-centric where the specimen is not the

[2] Demo: http://demo.dicoogle.com/pathobox; Demo Video: https://youtu.be/Mmsb25edcOo

most relevant subject [9]. The most recent DICOM standard supplement dedicated to WSI specify the workflows regarding the preparation, acquisition, and storage of this kind of imaging objects [9].

2.2. Dicoogle

Dicoogle[3] is an open-source PACS [10]. Its applicability encompasses different contexts as clinical, research and academic. Dicoogle's architecture follows a modular approach, allowing the development of new features over time.

The Dicoogle Software Development Kit (SDK) allows the addition of new features by third parties without the need to change the software core. The Dicoogle SDK provides interfaces that the developers need to implement to build a plugin[4]. Dicoogle, during the startup, automatically loads the modules contained in this directory and all the operations related to storage, querying and indexation become immediately available via its API.

3. Architecture Overview

Figure 2 shows the general architecture of the proposed system. Four main components can be identified: the PACS archive, the management platform (MP), the web viewer and the access control module.

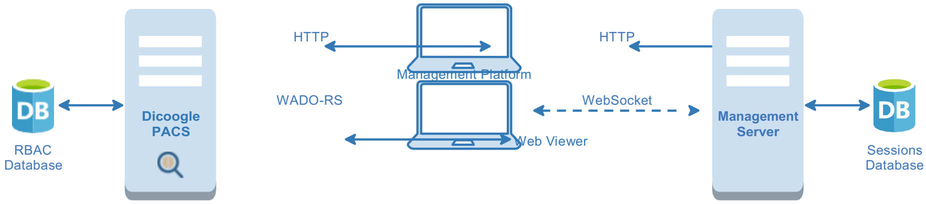

Figure 2. Collaborative platform general architecture.

In this context, a working session is a live persistent document, that maintains synchronization between all users. The MP is where all the data, regarding sessions, users and their permissions, is stored. This component is independent of the viewer, so with little effort, other viewers can be attached to the management platform to support the working sessions.

The purpose of the MP is to give the user the necessary tools to manage his sessions, with the possibility to create user groups (that speed up the process of inviting users), define user permissions in the working sessions, define access control configurations to each session, insert new case studies and create new sessions. The MP handles the access to the working sessions at two different levels: controlling the access to the working sessions through user-defined parameters, such as access dates, invited users and their permissions; controlling the access to the case studies that the sessions are based on.

The users can be invited via two ways: email, where a personal invitation link to the session is delivered, with preemptively defined permissions; or through a public share-

[3] Website: www.digoogle.com; GitHub: https://github.com/bioinformatics-ua/dicoogle

[4] https://bioinformatics-ua.github.io/dicoogle-learning-pack

able link, up to a defined limit, which will be given no permissions to edit the session. These permissions can be changed live in the session.

The permissions on the session define which actions the user can perform concerning the image and the study, such as moving around the image or create annotations, and regarding the collaborative tools, such as inviting or kicking users from the session.

The MP controls the users in the session, registering who and how many users are connected, preventing the simultaneous usage of the same invitation link and limiting the number of users connected through a public link.

Given that the platform works over medical repositories, including personal archives that constitute sensitive information and therefore need to be compliant with the General Data Protection Regulation (GDPR), the access to the case studies needs to be controlled. In this case, access to the case studies is role-based and controlled by an existing accounting mechanism developed by Lebre et al. [7]. This mechanism is role-based, preventing users from accessing archives they should not have access to. The permissions can be extended to third-party entities allowing to create multiple virtual archives and share them amongst other users and institutions.

Upon logging in into the MP, a role is given to the user, defining which case studies he/she has access to. The user can upload to the platform his cases or the system administrator can grant this user access to existing archives.

Within a working session, the viewer, using the web link, determines the visualization mode to be used, retrieving the user's permissions and session's details from the MP and the specific medical case from the PACS archive. It has three visualization modes, all sharing the same basic visualization tools: live mode, the representation of the working session; replay mode, allowing to review all the actions on the working session; archive mode, the study case can be viewed without any of the collaborative features.

4. Use Cases

A collaborative paradigm in pathology enables the interaction and discussion by several users simultaneously, each in their own device. The collaborative system was designed to satisfy two usage scenarios, clinical and educational.

In the clinical field, the leader of the study can create a group of users from his peers to an easier attribution of permissions. Alternatively, the leader may specify or change the permissions of each member when establishing the working session. The replay mode will allow the peers to review actions performed and be able to keep up with the research. In the educational field, the groups could be formed with students or can be given the public link, allowing these users to follow along with the class. By changing the permissions of one of the attendees, the educator can, for instance, evaluate the ability of a specific student to detect critical regions in the study. Moreover, tasks for students can be defined. For instance, annotation of a working case that will be saved as a session than can be reviewed later by the evaluator.

On both cases, the framework virtualizes the concept of PACS archive. I.e., the management platform creates virtual sessions where the users only have access to the DI- COM objects that the creator of the session has previously defined. However, all of the DICOM objects are stored in the same archive. The framework provides then, the capacity to share studies and instances among users belonging to distinct healthcare organizations or departments.

5. Conclusion

In the medical field, the imaging field represents a crucial tool in the quality of diagnosis. Sharing patient data between entities boosts the accuracy of decision making. In this line, collaborative work is a breaking-change in clinical decision-making. The collaborative paradigm addresses also educational purposes, allowing collaboration among professors and students.

This paper presents the architecture and use cases of a DICOM web digital pathology viewer with access control mechanisms integrated. The proposed framework creates the concept of collaborative sessions. However, the existence of such a framework requires a permission management system which led to the deployment of a management framework that promotes the resource sharing among users or institutions. The working sessions are virtual web viewers where an administrator can define which users can have access to which resources. These features turn the system institution-free and enhance telemedicine and remote diagnosis. Moreover, using pure web technologies, the system can be used anywhere, anytime, regardless of the operating system and without any prior installation.

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