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| Harvard EXTENSION SCHOOL |
| Health Data and Analytics for Radiology Information Systems |
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# Data and Analytics

## Overview

Radiologists are often perceived as some of the most technologically savvy physicians, in large part due to their daily usage of software. The field was perceived as the cutting edge of futuristic technology in the 70s with adoption of advanced imaging modalities in the form of MRI and CT scans. Later in the 90s, radiologists again revolutionized the industry with the replacement of imaging film with digital. However, the industry is currently facing issues in IT architecture. Lack of interoperability is one of the key technical issues, lagging the quality in care (Garriott, K.).

For example, currently separation in radiology reporting and image database software (PACS) prevents fluidity and seamless connectivity. Radiologists must manually edit data in order to sync information. Instead of just saying “rib” and having the right images displayed to the viewer and right section queued up, radiologists must manually find the right section of the report, scroll through multiple image slices, and adjust the window levels accordingly. Also, the reporting can be faulty as well. It is one-dimensional, plain text-only document that doesn’t support markups or automatic imports of measurements from an image (*The Status of Medical Errors Among Health IT Systems*). Radiologist-recommended follow-ups happen less than 40 percent of the time, resulting in thousands of preventable deaths each year (Hansra, S.).

Digital Imaging Adoption Model (DIAM) is the collaborative effort of imaging experts around the world to create an eight-stage maturity model offering industry-standard guidance and benchmarks for IT adoption of medical imaging best practices (*Digital Imaging Adoption Model*). This group is focused on improving the future by identifying technological gaps, creating a roadmap for improvements and validating proficiencies.

Their recommendation for future software design is to marry the patient’s clinical information and images with their corresponding electronic medical records. This isn’t the case, as they noted, finding patient images are still being acquired on unsecured mobile devices, ultrasounds stored on CDs or memory sticks, and patients being responsible for transporting hard copies of images between healthcare providers. I propose to solve this problem by designing an electronic image sharing software platform, called Advanced Radiology Information Systems (ARIS), that joins the patient network with their images and EHRs for enhanced interoperability for quicker and more efficient diagnoses.

The proposed, advanced revision to Radiology Information System (RIS) is presented to facilitate the procedure required for a patient to go through the imaging process in healthcare, along with technical storage and usage by healthcare workers. Digital Imaging Adoption Model (DIAM) recommends for future software design to marry the patient’s clinical information and images with their corresponding electronic medical records. I propose to solve this problem by revising an electronic image sharing software platform, called Radiology Information Systems (RIS), that joins the patient network with their images and EHRs, for enhanced interoperability for quicker and more efficient diagnoses. In this proposed system, many actors access it at different steps. In the previous project, functional requirements were stated involving all the actors and uses.

Advanced Radiology Information Systems (ARIS) will be a software platform that is integrated into patient portals and clinical settings as an installation, enhancing data flow of images with notes between an interconnected network. This would be a secure network operating on cloud storage in a Java workflow. Databases would be used in the use case diagrams on connectivity between the various actors in the system. Radiologic image compression would reduce the data volume using PACs. This lossy compression would use JPEG algorithms for the ability of patients to choose if they are reversible or not.

Diagram

Description automatically generated Caption: Workflow. The Referring Physician will contact the Hospital Admin to input new patient information and schedule appointments. Once the appointment is made, the technician will perform the imaging process and submit a tech report that will be sent to the radiologist. Once the radiologist reviews the imaging information, he will write a final review that will be accessible by the referring physician who will review the findings with the patient. After the review is complete, the billing will be reviewed and finalized by the administrative assistant and the final bill will be sent to the payer for processing.

A quick traceability run through of the key requirements includes:

1. Referring physician can access RIS and place order for procedure
2. RIS can display worklist
3. Actor can schedule appointment
4. RIS can acquire an image for a patient
5. Radiologist can respond to patient images
6. Store technician info
7. Store patient information
8. Radiologist can review image retrieved from database
9. Store procedure status
10. Store images
11. Require Electronic Signature (Security Purposes)
12. Create and Read Reports (Radiologist)
13. Automatically retrieve demographic information and RP information
14. RIS and PACS pull pictures, reports, and patient information properly
15. See previous exams

## Health Data System Requirements

The system will be implemented entirely in Java using the JDK 14. The System Architecture follows a modular microservice architecture. Each of the system components will be implemented as a microservice. To simplify the implementation, the same Java Virtual Machine (JVM) would be installed. This will allow direct Java level method access to the interfaces by the peer services and client applications. Security would be addressed via an authentication service which would identify the user through biometrics (face and/or voice recognition). Once identified, the authentication service is used to gain access to the platform. Users and permissions granted will be labeled to secure the platform based on requirements.

Technologies:

* Java SDK – Latest Version through IntelliJ
* XAMPP – Apache distribute for MySQL Database

Each service will:

* Define a Java interface that provides a list of operations supported by the service.
* Provide an implementation in Java of the service interface.
* Fully encapsulate the service implementation details.

## 1.3 Users & Responsibilities

1. **Technician (Tech) -** the tech is the actor in the process that is responsible for administering the picturing procedure. They can access the worklist to see the scheduled appointments and what modality is required. Once the procedure is complete, the tech is responsible for putting in a “tech entry” which covers an overview of the actual procedure, this will be attached to the pictures taken and sent to the radiologist for final review. The tech will also compile a list of equipment used that is sent to the admin assistant for billing purposes.
2. **Patient-** the patient is the actor in the process that is responsible for confirming and showing up to their appointment. All the interactions that the patient has with the actual system will be through other actors. The patient must talk with the scheduling employee before an appointment can be scheduled, check into the clinic through the admin assistant upon arrival and be present before a picture can be taken.
3. **Radiologist-** the radiologist is the actor in the system that is responsible for reviewing the pictures taken during a procedure. To do this, they will have access to the pictures, patient information, and tech entry. They will review this information and generate a report that will finish the procedure process.
4. **Admin Assistant (Front Desk) -** The admin assistant is the actor in the process that is responsible for checking in patients when they arrive at the clinic; this is also a time that the admin assistant can verify the patient information with the patient. Once the procedure is finished, the admin assistant will review the tech entry and verify billing details. She will then approve an invoice that will be sent to either the patient or the patient’s insurance company.
5. **Referring Physician-** The referring physician is the actor in the process that is responsible for inputting patient information. They will then have access to patient information throughout the entire process but only the patients they referred. Once the radiologist has finished the report review, the referring physician will have access to the report for a follow up appointment with the patient.
6. **Modality-** The modality is the actor in the process that is responsible for taking the pictures and saving them to PACS. The modality will also have a schedule that will be used by the scheduling employee to assure availability.
7. **Scheduling Employee-** The scheduling employee is the actor in the process that schedules the appointments. To do this, the scheduler must consider modality, technician, and patient availability. The scheduling employee cannot schedule an appointment without first contacting the patient and coordinating to the patient’s schedule.

**Permission List**

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| Referring Phys. | * [Patient Information] Access to only patients they have referred or are assigned. * [Report Review] Access to read reviews from Radiologist from selected patients and their procedures. |
| Admin. Asst. | * **[Appointment]** Can create, edit, and view all appointments. * **[PACs]** See information regarding selected patient and procedures *with an export for billing.* * **[Patient Information]** Can create, edit, and view all patients. * **[Billing]** Can create and send billing forms. * **[Files]** Has access to files of completed and finished reports in downloadable formats. |
| Technician | * **[Worklist]** Accesses patient appointment, patient’s conditions, and designated modality * **[Technician Entry]** Views list of appointed patients for their procedures and list of all appropriate resources |
| Front Desk | * **[Billing]** Can create and send billing forms. * **[Patient Information]** Can create, edit, and view all patients. * **[PACs]** See information regarding selected patient and procedures *with an export for billing.* * **[Appointment]** Can create, edit, and view all appointments. * **[Files]** Has access to files of completed and finished reports in downloadable formats. |
| Patient | * N/A |
| Radiologist | * **[Report Review]** Radiologist can read and write to a list of completed procedures. * **[Files]** Has access to files of completed and finished reports in downloadable formats. * **[Patient Information]** Access to all patient information and can update current / add new patients. * **[PACs]** Access to information regarding their selected patient and procedures in-progress/finished |

## Data Analytics Requirements

Procedures would be logged through an excel format, collecting data on patients, staff and EHR data. The data collected would contain the description of each table, its columns, type accepted and other descriptors for the database. At end of the relational schematic, a primary and foreign key would be logged for security enforcement along with general table relation for analytics.

Diagram, schematic

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Caption: Database Diagram

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|  | **Functional Requirements** | |
| R1 | Referring physician can access ARIS and place order for procedure | This requirement is met when the referring physician can add a patient and request a specific operation, using the ARIS. |
| R2 | ARIS can display worklist | This requirement is met when the technician, radiologist, and administrative assistant can all view a list that contains detailed appointment data. This data must include patient name, technician assigned, and status of the patient. |
| R3 | ARIS can acquire an image for a patient | This requirement is met when the technician can upload a picture taken from radiology modality during the imaging process. |
| R4 | Radiologist can respond to patient images | This requirement is met when the radiologist can view the image uploaded by the technician. |
| R5 | Store patient information | This requirement is met when the ARIS can intake, store, and display patient information. There must be a unique ID regarding each patient and the patient information must be able to be viewed by the technician, radiologist, and admin. |
| R6 | Require Electronic Signature | This requirement is met when the radiologist can provide his credentials during the report review process to verify identity and submit report. |
| R7 | Radiologist can review image retrieved from database | This requirement is met when a radiologist can access images associated with current and previous appointments. This must be searchable by patient in order to develop a patient history. |
| R8 | Store images | This requirement is met when the ARIS can store images taken during the imaging process. The images must be accessible and have a unique image ID. |
| R9 | CRUD Reports | This requirement is met when the radiologist can create a report based on the tech entry. The radiologist must also be able to update and delete a report. |
| R10 | Automatically retrieve demographic information and RP information | This requirement is met when the patient information displayed for each patient includes name, gender, vitals, and referring physician name. This must be readable each time the patient’s profile is accessed. |
| R11 | ARIS and PACS pull pictures, reports, and patient information properly | This requirement is met when the ARIS can access the pictures, reports, and patient information if the employee has access to the information. |
| R12 | See previous images and exams | This requirement is met when there is an archive of files including previous completed reports. The reports must include the tech entry, patient information, and radiologist report document. |

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|  | **Non-Functional Requirements** | |
| N1 | Coded in Java | This requirement is met when the main coding language used is Java. If any other languages are used, they must be compatible with Java language. |
| N2 | Database accepts SQL commands | This requirement is met when the database can be accessed and updated through SQL commands run from the Java models. |

## 1.5 Security and Privacy

It is important to identify weaknesses and risks when designing the platform. The traditional method of sending medical images is by burning them onto a CD and delivering them in person or through the mail. However, this method has several drawbacks risking HIPAA violation. Unless they are protected by a password or encrypted, the images aren’t secure. Another risk is the cost of training staff to ensure security and privacy. Electronic signatures would be required when signing in and out of system. The program would run on multiple programming languages including Java which has various security providers such as JMS, a native Oracle Cloud Infrastructure services that monitors customer data centers. HIPAA compliance would be essential when designing the system and encryption of data would be implemented.

Data sharing would be essential for an RIS system as images and information on patients is being sent back and forth as demonstrated in the diagrams. For additional security, an in-house analytics system would be recommended for using an enterprise data warehouse to log and report operational data. This would make the system more secure with permissions granted to users based on their listed roles and needed access. By doing this, data would also be better processed to provide useful analytics such as reported timestamps and logged speed for orders. Any delays or loss in data would be easier to trace in the reports along with reassuring privacy and security.

# Data Solution: Diagrams

## Architecture Diagrams

Diagram, engineering drawing

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Caption: Class Diagram displaying actors and intertwining of roles.

Diagram

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Caption: Flow Chart explaining database and PACS technical requirements.

## Use Case

Diagram

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Caption: UML Use Case Diagram with actors and their abilities.

## Use Case

Diagram

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Caption: UML Use Case Diagram with packages detailing system operability.

# Additional Diagrams

## 3.1 Sequence Diagrams

Diagram

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Diagram

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Diagram

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Diagram

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# Conclusion

The risk of inaction is too high when looking at reform to Radiology IT. Improving the software tools for radiologists and technicians can greatly improve the interoperability and efficiency of reporting. It is my intention to propose new IT innovation that is integrated throughout the entire medical industry for the benefit of patients, providers and insurers. As the world is moving towards more advanced technology, there is a need for hospitals and imaging centers to improve their workflow to facilitate patients for better diagnosis.

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