Integration and Implementation Strategies for AI Algorithm Development, Deployment and Enhancement using DICOM and Other Standards

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Disclosures

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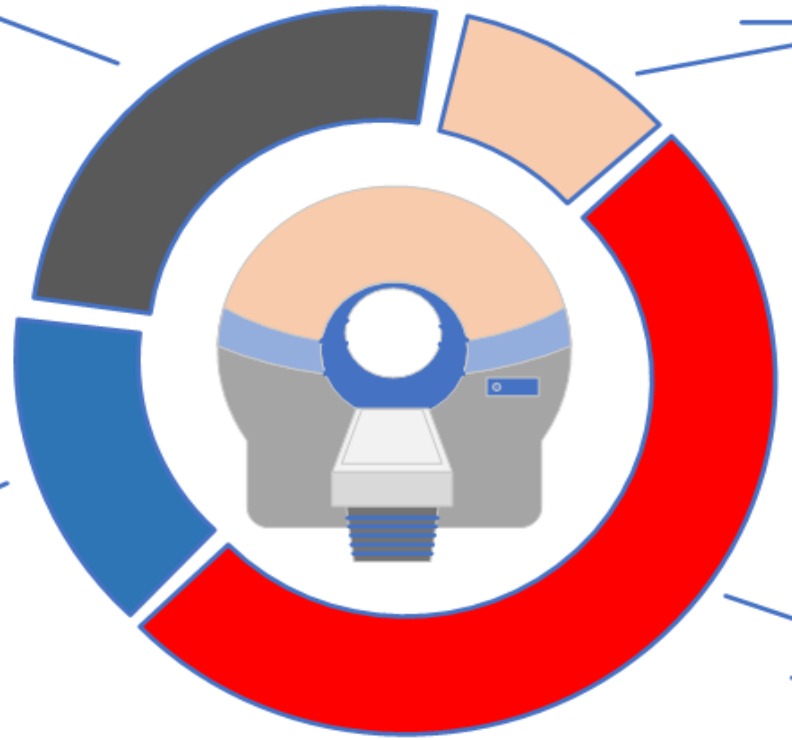
Master Research Agreement: Mayo Clinic - Siemens

Master Research Agreement: Mayo Clinic – NVidia

MONAI+

https://monai.io/

Deployment

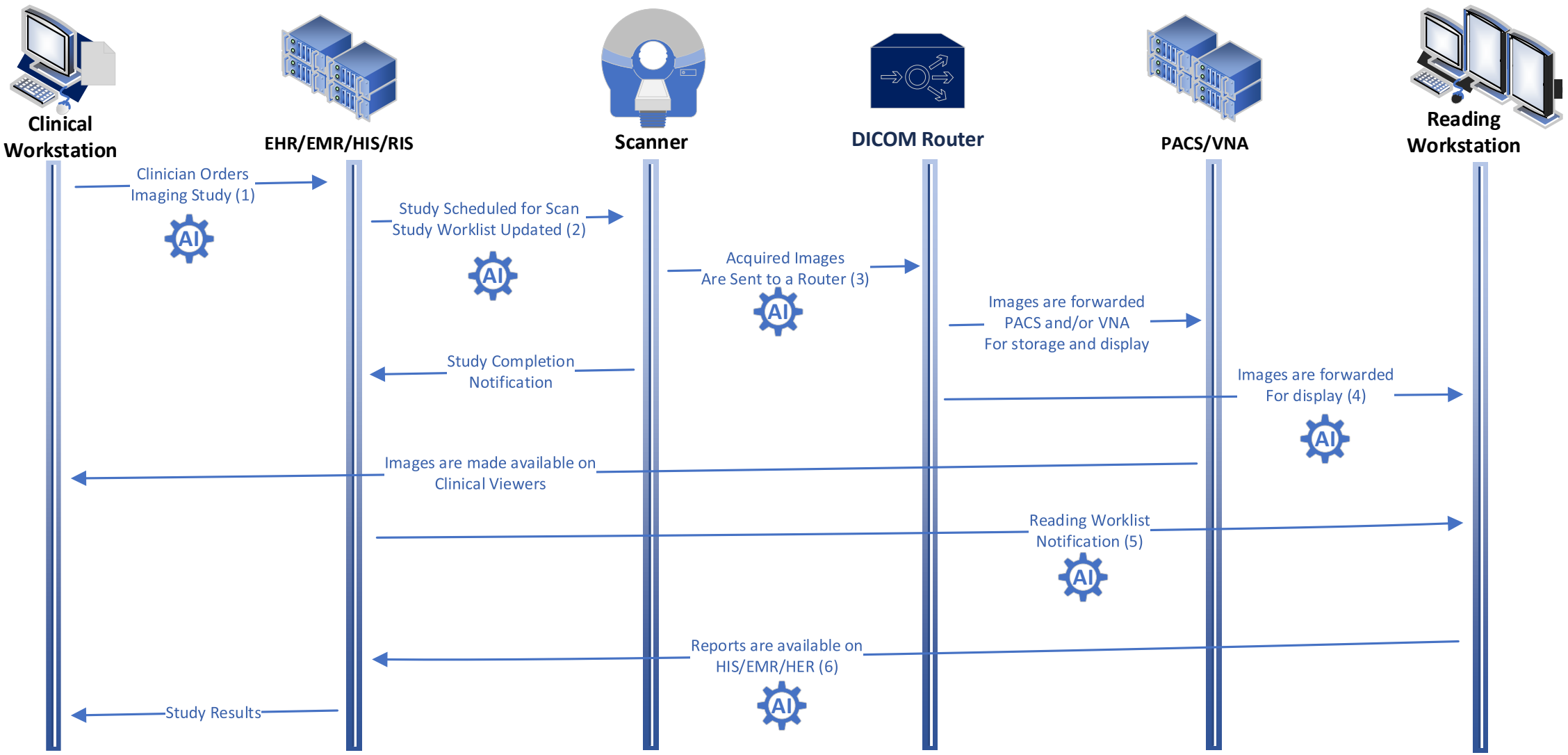


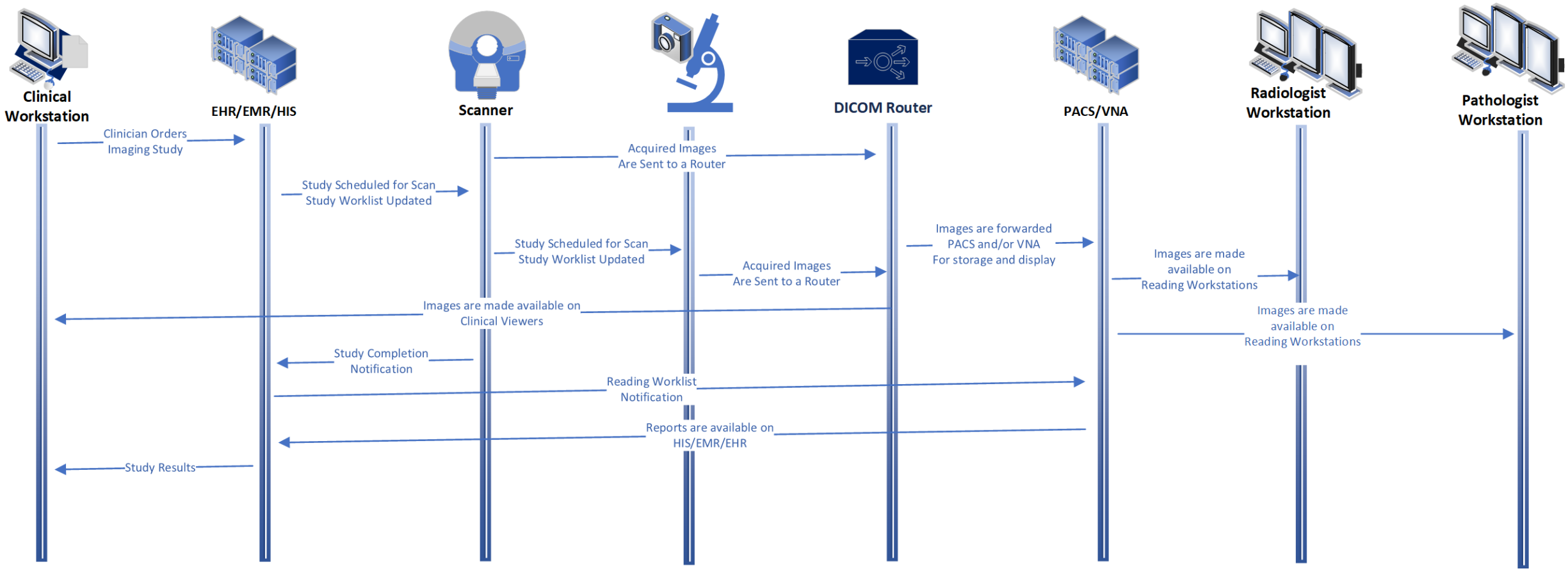
Integration
Testing
Operationalization
2.5-5 Months

Data Identification
Data Extraction
1- 2 Months

Algorithm Development
Model Training
Model Tuning
1.5-3 Months

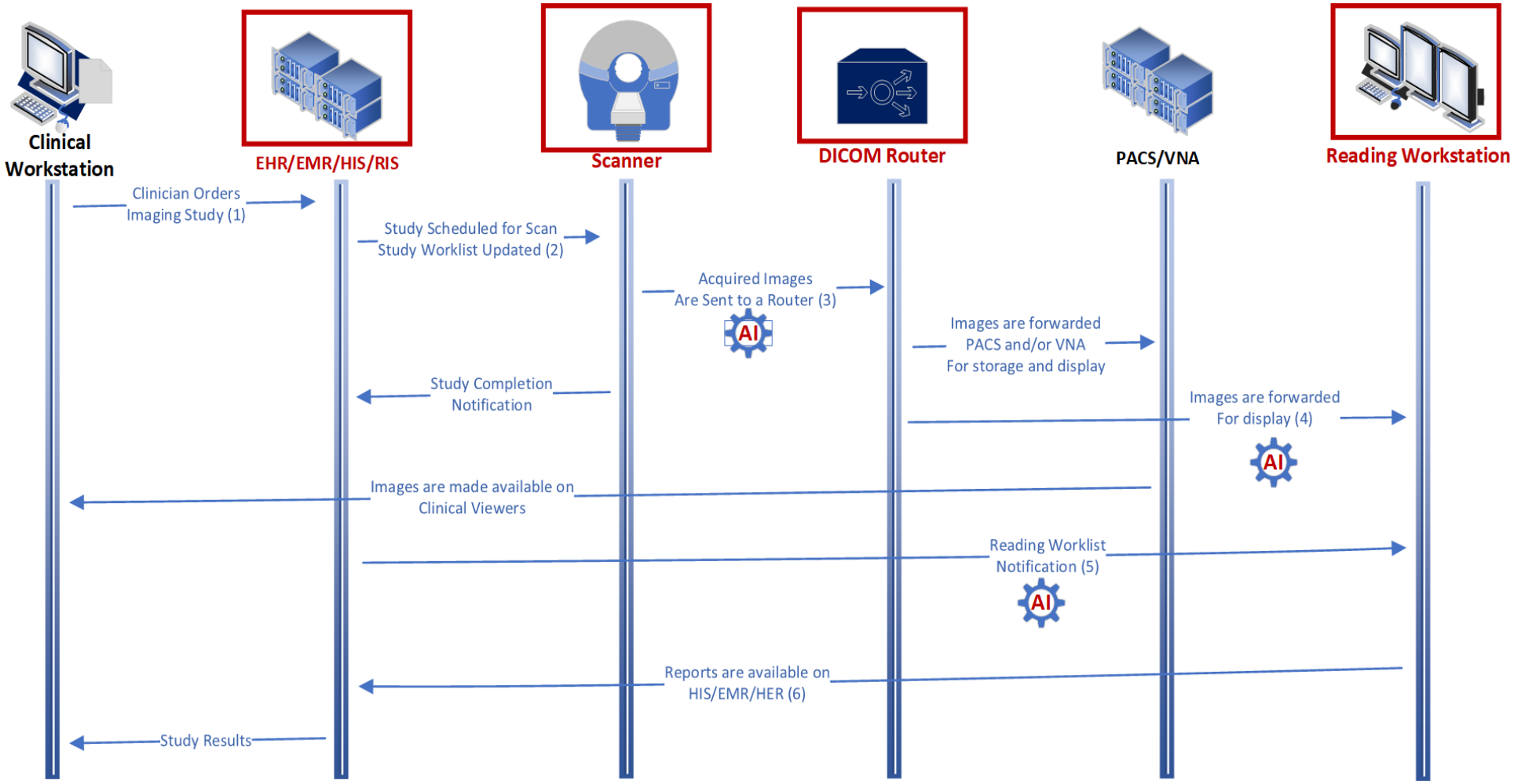
Data Cleansing,
Data Labeling
5-10 Months


Clinical Workstation
EHR/EMR/HIS/RIS
Scanner
DICOM Router
PACS/VNA
Reading Workstation
Clinician Orders Imaging Study (1)
AI
Study Scheduled for Scan Study Worklist Updated (2)
AI
Acquired Images Are Sent to a Router (3)
AI
Images are forwarded PACS and/or VNA For storage and display
Study Completion Notification
Images are forwarded For display (4)
AI
Images are made available on Clinical Viewers
Reading Worklist Notification (5)
AI
Reports are available on HIS/EMR/HER (6)
AI
Study Results

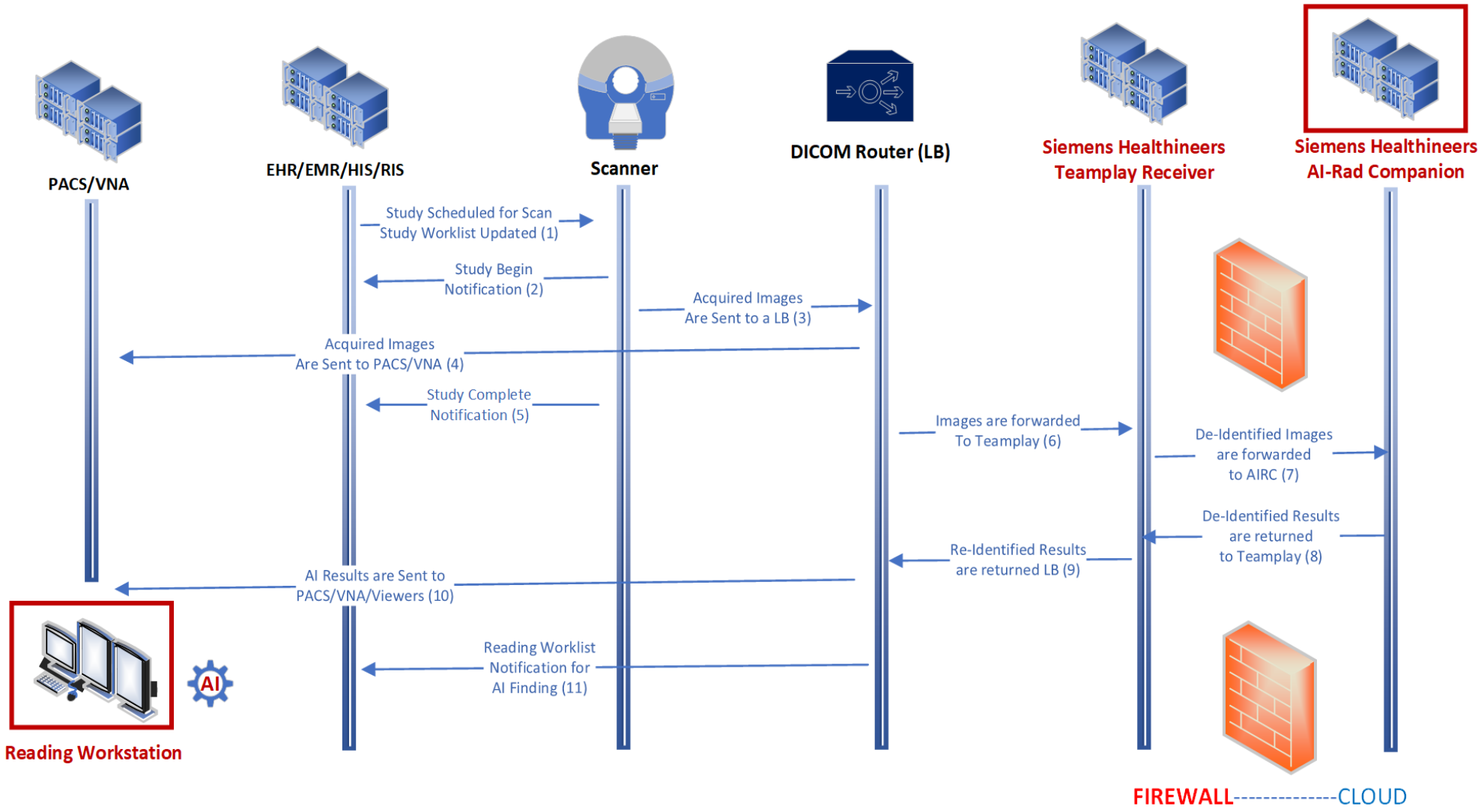

Clinical Workstation
EHR/EMR/HIS
Scanner
DICOM Router
PACS/VNA
Radiologist Workstation
Pathologist Workstation
Clinician Orders Imaging Study
Study Scheduled for Scan Study Worklist Updated
Acquired Images Are Sent to a Router
Study Scheduled for Scan Study Worklist Updated
Acquired Images Are Sent to a Router
Images are forwarded PACS and/or VNA For storage and display
Images are made available on Reading Workstations
Images are made available on Clinical Viewers
Images are made available on Reading Workstations
Study Completion Notification
Reading Worklist Notification
Reports are available on HIS/EMR/EHR
Study Results

Steps	Common Workflow Theme	AIW and AIR Described Boundaries
1	When a clinician orders an imaging examination in the HIS/RIS, they may be guided by a CDSS to ensure its appropriateness. Depending on the clinical setting, the order may contain a clinical-status priority code (e.g., "stat")	Make recommendations as to the types of procedures that should be ordered, based on the patient's condition and record.
2	Once the patient examination is scheduled for a date and location, an entry is created on the "study worklist" of the scanner (or another imaging device). In some instances, an entry is also created on a "protocoling worklist", where a radiologist determines the specific imaging techniques to be used (e.g., scanning details, contrast-agent type/amount/administration route) during the diagnostic imaging study or image-directed procedure.	Make recommendations on the type of protocol to be used on the scanner.
3	Once the examination is completed, images are reconstructed into a human-interpretable format and sent to a DICOM-router to be forwarded to the appropriate destinations, including a PACS and/or VNA for management or storage. Once the organized images (original and/or post-processed) are ready to be evaluated by the radiologist, the examination description appears on the radiologist's "reading worklist".	Post-process the image, identify QA issues prior to the patient leaving the department, and prepare classifications and segmentations in advance of the radiologist's evaluation.
4	Radiologists assess the examination images on their diagnostic viewer and dictate their interpretation (typically into a voice recognition system).	Include insights alongside the images in the radiologist's display.
5	The dictated report is sent to the HIS/RIS. If actionable critical and/or non-critical findings are identified, radiologists may invoke additional workflows to alert the ordering clinician and issue the final examination report.	Include emergent insights for consideration of the ordering physician.
6	Final examination reports become available in the HIS/EHR, along with the images in the PACS or clinical viewers.	Pre-populate the radiologist's report with draft insights to be considered by the radiologist.

In-house Development (within Firewall)



Vendor Integration (Cloud)



Vendor Integration (Cloud)

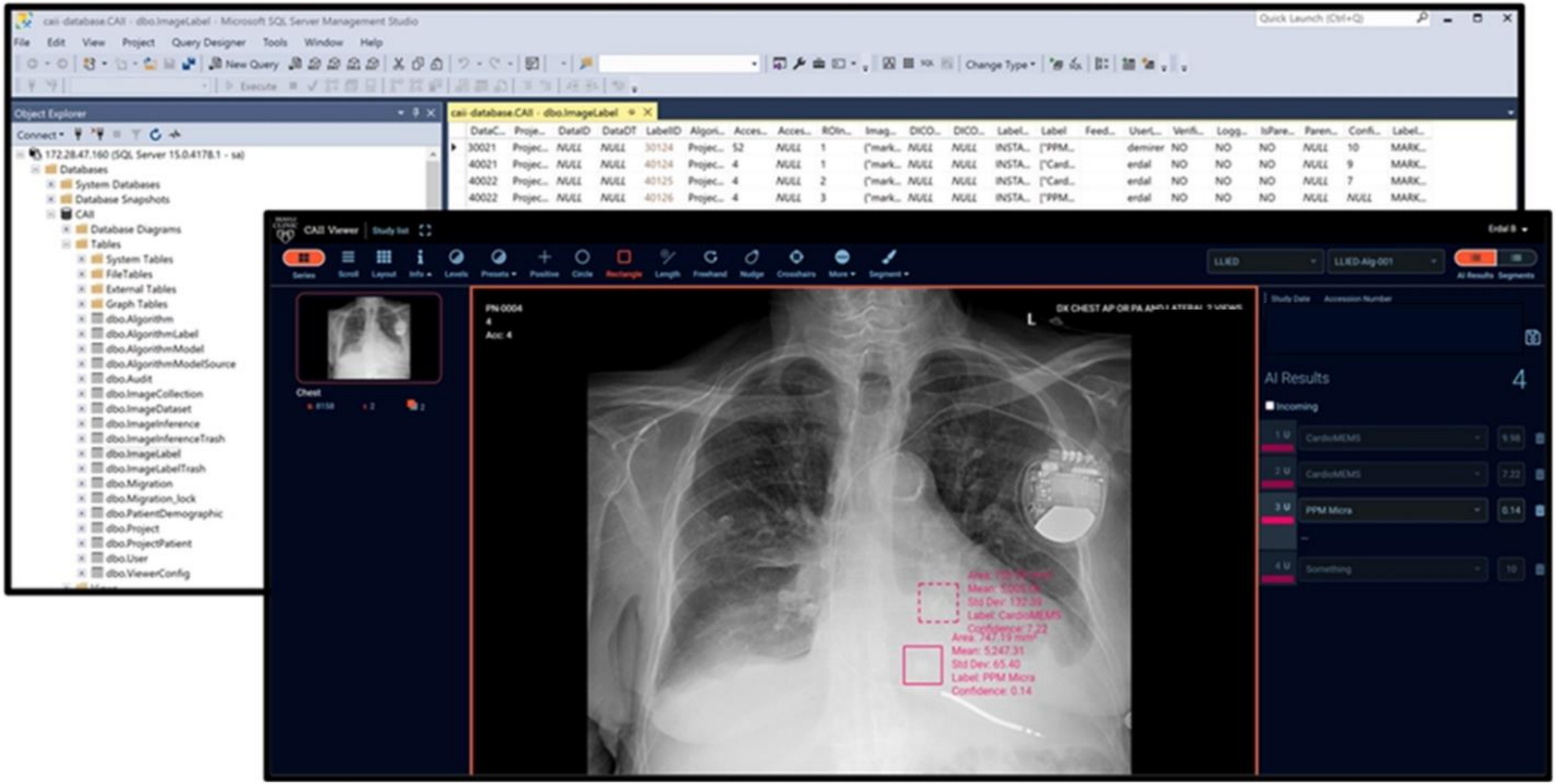
```
AI-Results-Handling (Image Studies)
        Check each exam for matching exam descriptions
        If (matching exam found) {
        /*LB and STP Running inside the institutional firewall*/
        LB to STP
        STP to De-identify the studies
        /*AIRC Running outside the institutional firewall*/
        STP to send studies to AIRC
        /*Results in the form of DICOM SC and DICOM SR*/
        AIRC to return results to STP
        STP to Re-identify the studies
        STP to Return Results to LB
        LB to Forward the DICOM SC and DICOM SR to Viewers
        /*Using Custom C# based DICOM SR parsing to produce an XML template to
        provide mapping during HL7 conversion by LB*/
        LB to Produce HL7 from DICOM SR
        LB to Send HL7 message to Interface Engine for HIS for Prioritization
```

Reading Worklist Prioritization

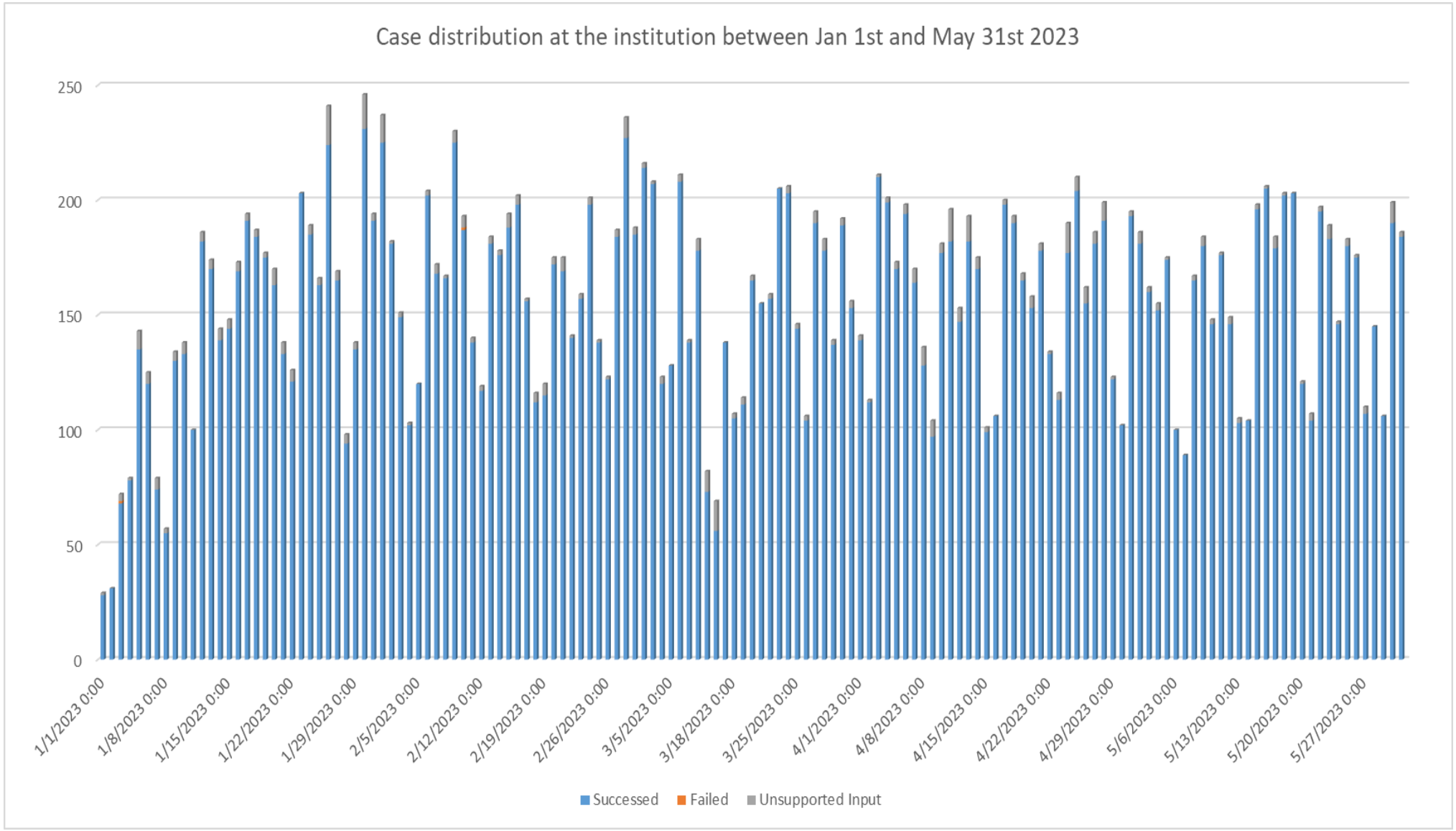
```
MSH|^~\&|AI Product Name{AIRC}|HIS{HIS_TEST}|||Timestamp||ORM^O01|GUID|T|2.5.1
PID|||patient ID^^^MC^MC||Patient last name^Patient first name||Patient DoB
ORC|XO|||||||Datetime of transaction
OBR|1||Accession number|Study code^Study description^IMAGEID^^Short study
description|||Study Date||||||||||||||Study Date
OBX|1|ST|AI_PRIORITY_type of evaluation{AI_PRIORITY_PTX}||priority level{HIGH}
OBX|2|ST|AI_DETECTION_type of evaluation{AI_DETECTION_PTX}||detection{POS}
```

P..	L...	R..	I...	P..	C..	S	E..	Appt Date	Appt Ti...	AI	Patient	MRN	Accession #	Procedure (Pref List Name)
4								4/11/23	1:10 pm		Ai, Ben	11-261-324	321137	DX Chest 1 View
4								4/11/23	1:10 pm		RSA-FLA, Tito X	11-261-700	321136	DX Chest 1 View
4								4/11/23	12:55 pm	⚠	RSA-FLA, Mercades X	11-261-696	321135	DX Chest 1 View
4								4/11/23	3:50 pm		FLA, Test	11-240-813	321147	US Chest

Performance



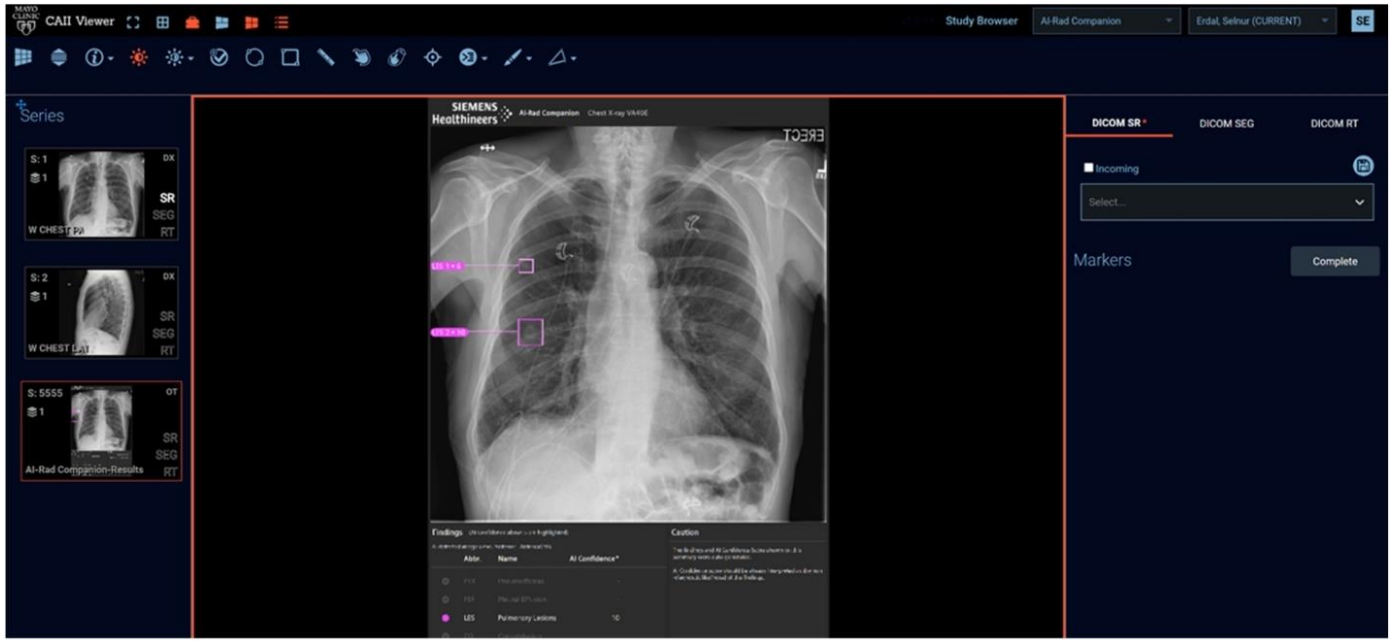
Daily Activity (Sample Period)

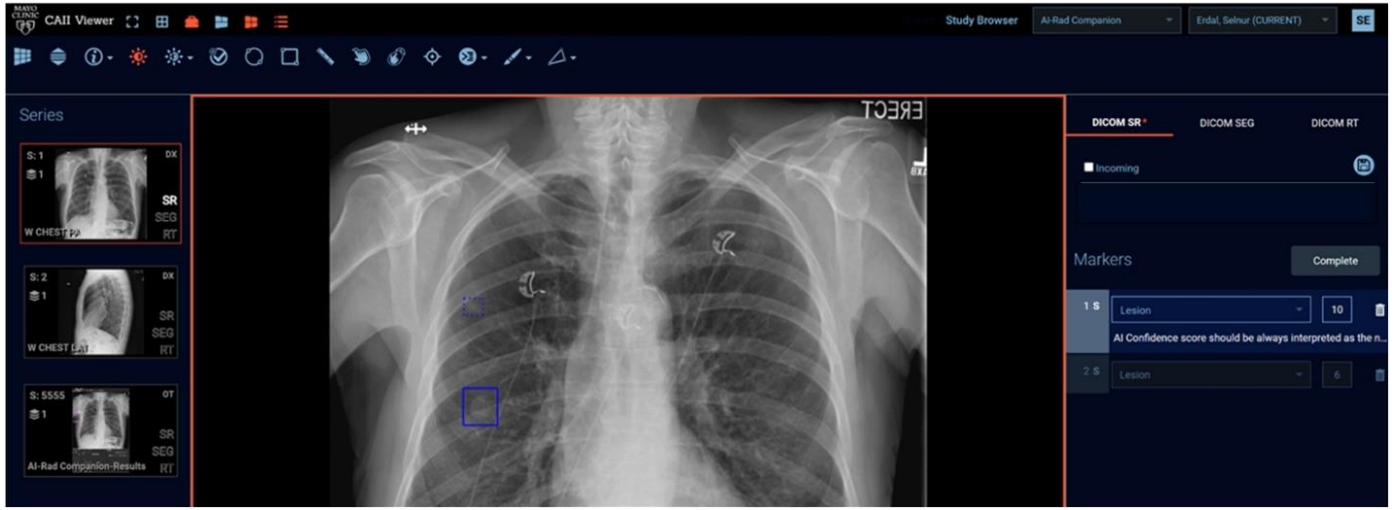


Performance

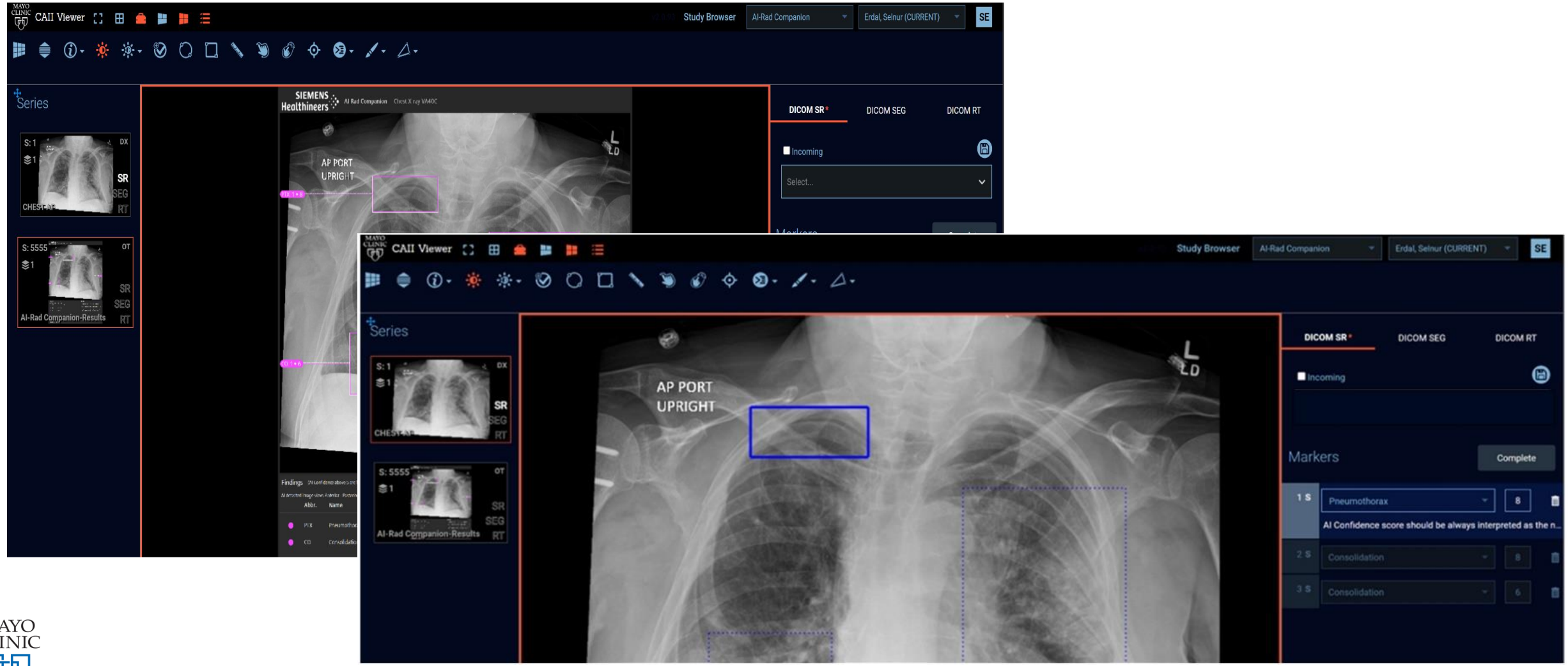
Result of Processing	Count	% of Total Images Received by AIRC	Average # Images Received per Day	Comments
Processed Successfully	22,382	97.80%	154/day	Results available within 3 minutes after image reception by TPR
Failed Processing (No Results Created)	2	0.01%	<<1/day	
Unsupported Input (No Results Created)	501	2.19%	3/day	Reasons include unsupported image types, patient demographics (age), other check on DICOM attributes
Total Number of Images Received by AIRC	22,885	100%	158/day	Corresponding to 113 individual exams/day

Editable Results



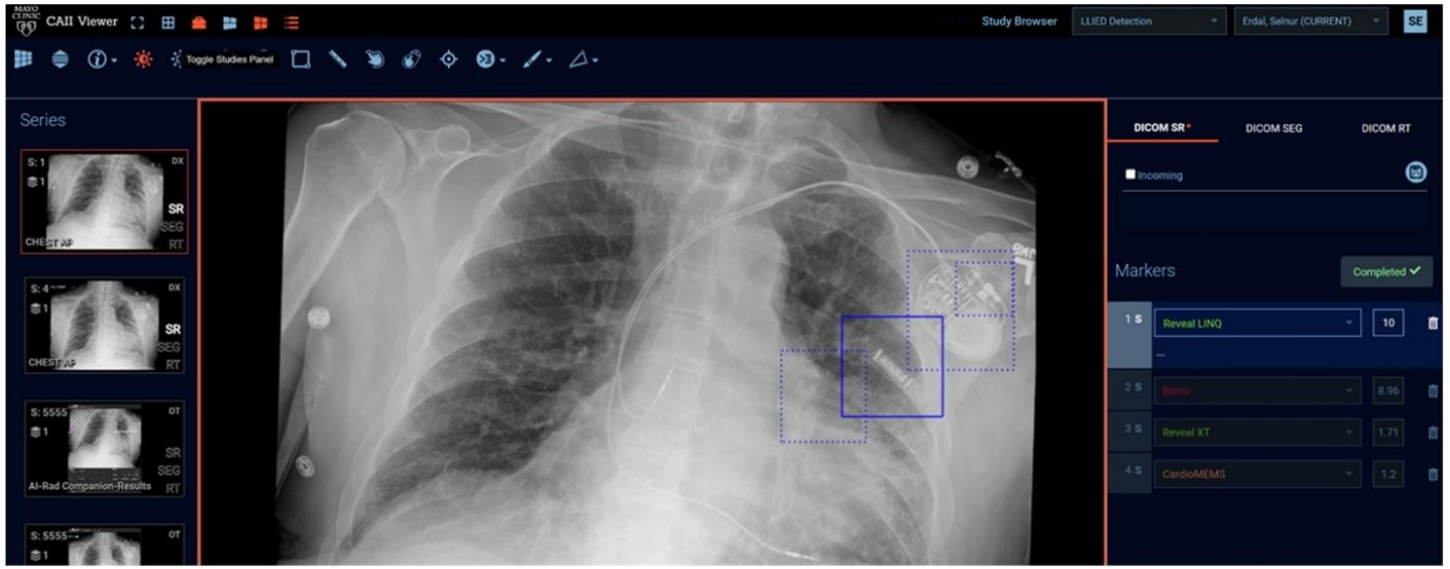


Editable Results Cont.

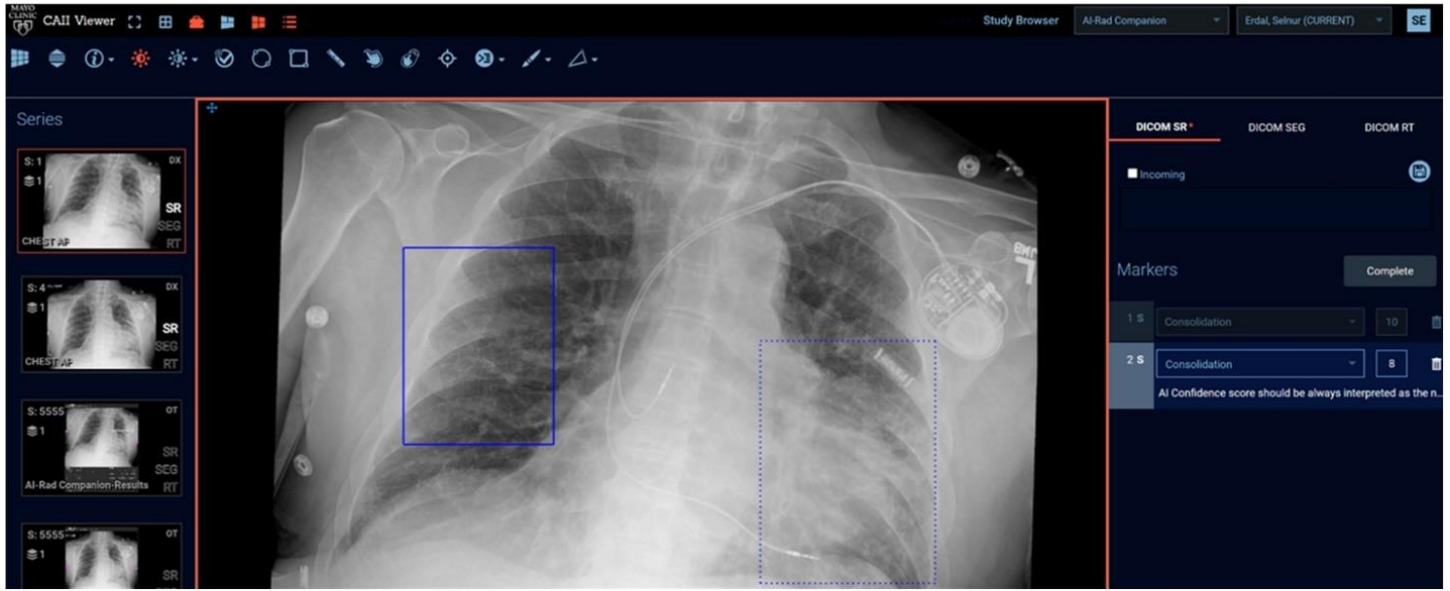


Multiple Algorithms

Local Development



Vendor Based



Conclusions

Standards-based inference result production (e.g., as IHE-compliant DICOM SR TID1500), as well as result consumption by downstream applications, is possible. These capabilities could enable medical institutions to:

1) Gain control over AI results with which they interact (e.g., by providing edit/delete functionalities in appropriate viewing environments, therefore enabling adjudication of AI results).
2) View and interact with AI results from different sources (e.g., vendor-provided or locally developed algorithms)
3) Influence their reading workflow, if products cleared for that purpose are used (e.g., to flag time-sensitive cases in their worklist to promote timely reading and reporting). This could happen either by using middleware (parsing information from standard formats to transmit data points to a HIS/RIS worklist into a specific message format), as shown in examples here, or by relying on existing functionalities of the HIS/RIS to ingest IHE-AIR-compliant datapoints.

Thank You!

Questions?

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