# **System Integration Document: ThakaaMed Dental IQ AI Integration**

**Prepared for: ThakaaMed Healthcare Solutions**

| **DATE** | **BY** | **REASON FOR CHANGE** |
| --- | --- | --- |
| 25 June 2025 | Eng Abdullah Selim | Initial HIS-RIS-PACS-AI Integration |

## **1. Introduction**

### **1.1. Document Purpose**

This document outlines the comprehensive integration between ThakaaMed's Dental IQ AI analysis platform (SAIF) and healthcare information systems including Hospital Information System (HIS), Radiology Information System (RIS), and Picture Archiving and Communication System (PACS). It covers the functional and technical interface specifications, as well as the data exchange workflows between all integrated systems.

### **1.2. System Overview**

The ThakaaMed Dental IQ AI Integration provides an end-to-end solution for dental imaging workflow automation, from initial order placement through AI-powered diagnostic analysis to final report delivery. The system leverages industry-standard HL7 v2.x messaging and DICOM protocols to ensure seamless interoperability.

## **2. Scope of Integration**

The primary goal of this integration project is to establish a robust multi-directional interface that facilitates seamless data exchange between HIS, RIS, PACS, and ThakaaMed's SAIF AI platform. This integration enhances diagnostic accuracy and workflow efficiency in dental imaging departments.

### **2.1. Key Components**

The key components involved in this HL7/DICOM integration include:

* **Order Management:**
  + HIS sends HL7 ORM^O01 messages to RIS for new imaging orders
  + Automatic patient demographic synchronization
* **Worklist Distribution:**
  + RIS provides DICOM Modality Worklist (MWL) to imaging devices
  + Real-time scheduling updates
* **Procedure Tracking:**
  + Modality sends DICOM MPPS messages for procedure status updates
  + Automatic workflow progression
* **Image Management:**
  + DICOM C-STORE from modality to PACS
  + Automatic triggering of AI analysis upon image arrival
* **AI Analysis Integration:**
  + RESTful API integration with ThakaaMed SAIF platform
  + Automatic analysis of dental images with confidence scoring
* **Results Distribution:**
  + AI results sent via HL7 ORU^R01 messages
  + Final reports delivered via HL7 MDM^T02 messages
* **Image Accessibility:**
  + Web-based viewer integration
  + Direct image access from HIS/RIS interfaces

## **3. HL7 Interface Specifications**

### **3.1. Overview**

The integration utilizes bi-directional HL7 interfaces where messages flow between HIS, RIS, PACS, and the AI platform following healthcare workflow standards.

### **3.2. Version and Protocol**

* **HL7 Version:** 2.5 (with backward compatibility to 2.3)
* **Communication Protocol:** TCP/IP with MLLP (Minimal Lower Layer Protocol)
* **Character Encoding:** UTF-8
* **Message Acknowledgment:** Application-level ACK/NACK

### **3.3. Supported Messages**

| **Message Type** | **Description** | **Direction** | **Source** | **Destination** |
| --- | --- | --- | --- | --- |
| ORM^O01 | New Imaging Order | Inbound | HIS | RIS |
| ORM^O01 | Order Status Update | Outbound | RIS | HIS |
| ORU^R01 | AI Analysis Results | Outbound | SAIF | RIS |
| MDM^T02 | Final Report | Outbound | RIS | HIS |
| ACK | Acknowledgment | Bi-directional | All | All |

### **3.4. Integration Points**

| **Integration Point** | **Protocol** | **Port** | **Description** |
| --- | --- | --- | --- |
| HIS → RIS | HL7/TCP | 6661 | Order placement |
| RIS → Modality | DICOM | 104 | Worklist query |
| Modality → PACS | DICOM | 11112 | Image storage |
| PACS → AI Gateway | REST/HTTPS | 8000 | Analysis trigger |
| AI → RIS | HL7/TCP | 8080 | Results delivery |
| RIS → HIS | HL7/TCP | 6663 | Report delivery |

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## **4. Message Specifications**

### **4.1. Order Placement Message (ORM^O01)**

**Purpose:** Transmit new dental imaging orders from HIS to RIS

**Example Message:**

MSH|^~\&|HIS|HOSPITAL|RIS|RADIOLOGY|20241215143000||ORM^O01|MSG001|P|2.5

PID|1||12345^^^HOSPITAL^MR||ALBADR^AHMED^MOHAMMAD||19850312|M|||123 MAIN ST^RIYADH^RIYADH^12345^SA||(011)555-0123

PV1||O|DENTAL||||||||||||||||VIS123|||||||||||||||||||||||||20241215143000

ORC|NW|ORD001|REQ001|GRP001|SC||||20241215143000|||DR.SMITH^JOHN^A|||||||DENTAL^Dental Department

OBR|1|ORD001|REQ001|PANO^Panoramic X-Ray^L|||20241215150000|||||||||DR.JONES^MARY^B||||||||F|||1^once^^20241215150000^^R

NTE|1||Clinical History: Routine dental examination

### **4.2. AI Analysis Results Message (ORU^R01)**

**Purpose:** Transmit AI analysis findings from SAIF platform to RIS

**Example Message:**

MSH|^~\&|SAIF|THAKAAMED|RIS|RADIOLOGY|20241215153000||ORU^R01|AI001|P|2.5

PID|1||12345^^^HOSPITAL^MR||ALBADR^AHMED^MOHAMMAD||19850312|M

PV1||O|DENTAL||||||||||||||||VIS123

ORC|RE||ORD001||||^^^20241215150000||20241215153000|AI\_SYSTEM

OBR|1|ORD001|REQ001|PANO^Panoramic X-Ray^L|||20241215150000|||||||||||F|||20241215153000||DEN|F

OBX|1|TX|AI\_FINDING^AI Analysis Finding^L||Caries detected in tooth #14||||||F|||20241215153000

OBX|2|NM|CONFIDENCE^Finding Confidence^L||95|%|||||F|||20241215153000

OBX|3|TX|AI\_FINDING^AI Analysis Finding^L||Bone loss indicated in mandibular region||||||F|||20241215153000

OBX|4|NM|CONFIDENCE^Finding Confidence^L||87|%|||||F|||20241215153000

OBX|5|NM|OVERALL\_CONFIDENCE^Overall Analysis Confidence^L||91|%|||||F|||20241215153000

OBX|6|RP|AI\_ANNOTATION^Image Annotation^L||http://thakaamed.com/viewer?study=ORD001&annotation=true||||||F

### **4.3. Final Report Message (MDM^T02)**

**Purpose:** Deliver finalized diagnostic reports from RIS to HIS

**Example Message:**

MSH|^~\&|RIS|RADIOLOGY|HIS|HOSPITAL|20241215154500||MDM^T02|MDM001|P|2.5

EVN|T02|20241215154500

PID|1||12345^^^HOSPITAL^MR||ALBADR^AHMED^MOHAMMAD||19850312|M

PV1||O|DENTAL

TXA|1|DI|TX|20241215154500||||||DOC001|||||AU||AV|||

OBX|1|ED|REPORT^Final Report^L||^TEXT^^Base64^JVBERi0xLjQKJeLjz9MKM...||||||F|||20241215154500

## **5. DICOM Integration**

### **5.1. Modality Worklist (MWL)**

**Purpose:** Provide scheduled procedure information to imaging modalities

**Query Parameters:**

* Scheduled Procedure Step Start Date (0040,0002)
* Modality (0008,0060)
* Scheduled Station AE Title (0040,0001)

**Response Fields:**

* Patient Name (0010,0010)
* Patient ID (0010,0020)
* Accession Number (0008,0050)
* Requested Procedure ID (0040,1001)
* Scheduled Procedure Step Description (0040,0007)

### **5.2. Modality Performed Procedure Step (MPPS)**

**N-CREATE Message Fields:**

* Performed Procedure Step Status: IN PROGRESS
* Performed Procedure Step Start Date/Time
* Modality
* Study Instance UID

**N-SET Message Fields:**

* Performed Procedure Step Status: COMPLETED
* Performed Procedure Step End Date/Time
* Performed Series Sequence
* Image Acquisition Results

### **5.3. DICOM Storage (C-STORE)**

**Supported SOP Classes:**

* Digital X-Ray Image Storage (1.2.840.10008.5.1.4.1.1.1.1)
* Digital Intra-Oral X-Ray Image Storage (1.2.840.10008.5.1.4.1.1.1.3)
* CT Image Storage (1.2.840.10008.5.1.4.1.1.2)
* Secondary Capture Image Storage (1.2.840.10008.5.1.4.1.1.7)

## **6. AI Integration Specifications**

### **6.1. SAIF API Endpoints**

**Base URL:** https://api.thakaamed.com/saif/v1

**Authentication:** Bearer Token (OAuth 2.0)

### **6.2. Analysis Request**

**Endpoint:** POST /analyze

**Request Body:**

json

{

"patient\_id": "12345",

"order\_id": "ORD001",

"study\_uid": "1.2.840.113619.2.55.3.20241215150000",

"modality": "PANO",

"analysis\_type": "dental\_comprehensive",

"priority": "normal",

"callback\_url": "https://ris.hospital.com/ai-callback"

}

**Response:**

json

{

"analysis\_id": "AI20241215001",

"status": "processing",

"estimated\_completion": "2024-12-15T15:30:30Z",

"tracking\_url": "https://api.thakaamed.com/saif/v1/status/AI20241215001"

}

### **6.3. Analysis Results Callback**

**Method:** POST to callback\_url

**Payload:**

json

{

"analysis\_id": "AI20241215001",

"order\_id": "ORD001",

"status": "completed",

"confidence\_score": 91,

"findings": [

{

"type": "caries",

"tooth\_number": 14,

"description": "Caries detected in tooth #14",

"confidence": 95,

"severity": "moderate",

"bbox": [120, 340, 180, 400]

},

{

"type": "bone\_loss",

"region": "mandibular",

"description": "Bone loss indicated in mandibular region",

"confidence": 87,

"severity": "mild"

}

],

"viewer\_url": "https://viewer.thakaamed.com/study/ORD001",

"report\_url": "https://api.thakaamed.com/reports/AI20241215001.pdf"

}

## **7. Workflow Diagram**

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│ HIS │ │ RIS │ │ Modality │ │ PACS │ │ SAIF │ │ Viewer │

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│ ORM^O01 │ │ │ │ │

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│ │ DICOM MWL │ │ │ │

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│ │ │ DICOM Store │ │ │

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│ │ │ │ REST API │ │

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│ │ │ │ │ AI Results │

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│ │ ORU^R01 │ │ │ │

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│ MDM^T02 │ │ │ │ │

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│ │ │ │ │ URL Access │

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## **8. Error Handling**

### **8.1. HL7 Error Responses**

**NACK Message Structure:**

MSH|^~\&|RIS|RADIOLOGY|HIS|HOSPITAL|20241215150000||ACK^O01|MSG002|P|2.5

MSA|AE|MSG001|Missing required field PID-3

ERR|PID^1^3^1|M|101|Missing required field|E

### **8.2. Error Codes**

| **Code** | **Description** | **Severity** | **Action** |
| --- | --- | --- | --- |
| 101 | Missing required field | Error | Reject message |
| 102 | Invalid field format | Error | Reject message |
| 201 | Patient not found | Warning | Create new patient |
| 301 | AI service unavailable | Error | Queue for retry |
| 302 | Image quality insufficient | Warning | Flag for manual review |

### **8.3. Retry Logic**

* **HL7 Messages:** 3 retries with exponential backoff (5s, 15s, 45s)
* **AI API Calls:** 5 retries with exponential backoff (10s, 30s, 90s, 270s, 810s)
* **Failed Message Queue:** Persistent storage for 7 days

## **9. Security Specifications**

### **9.1. Authentication & Authorization**

* **HL7 Interfaces:** IP whitelisting + TLS 1.2 minimum
* **REST APIs:** OAuth 2.0 with JWT tokens
* **DICOM:** AE Title verification + TLS encryption

### **9.2. Data Protection**

* **PHI Encryption:** AES-256 for data at rest
* **Transport Security:** TLS 1.2+ for all communications
* **Audit Logging:** All access and modifications logged

### **9.3. Compliance**

* **HIPAA:** Full compliance with technical safeguards
* **DICOM:** Conformant to DICOM PS3.15 Security Profiles
* **HL7:** Following HL7 Security and Privacy specifications

## **10. Implementation Requirements**

### **10.1. Infrastructure**

**Mirth Connect Server:**

* Version: 4.5.2 or higher
* CPU: 8 cores minimum
* RAM: 16GB minimum
* Storage: 500GB SSD

**Database Server:**

* PostgreSQL 14+
* CPU: 4 cores minimum
* RAM: 8GB minimum
* Storage: 1TB with automated backups

**AI Gateway Server:**

* Python 3.9+
* CPU: 4 cores minimum
* RAM: 8GB minimum
* GPU: Optional for local inference

### **10.2. Network Requirements**

* **Bandwidth:** 100 Mbps minimum
* **Latency:** < 50ms between components
* **Firewall Rules:** Documented port openings

### **10.3. High Availability**

* **Load Balancing:** HAProxy or similar for API endpoints
* **Failover:** Active-passive configuration for critical services
* **Backup:** Daily automated backups with 30-day retention

## **11. Testing & Validation**

### **11.1. Test Scenarios**

1. **End-to-End Order Flow**
   * Order creation in HIS
   * Worklist retrieval by modality
   * Image acquisition and storage
   * AI analysis trigger
   * Results delivery
   * Report generation
2. **Error Scenarios**
   * Network disconnection
   * Invalid message format
   * System downtime
   * Concurrent access
3. **Performance Testing**
   * 1000 messages/hour throughput
   * < 5 second AI processing time
   * < 200ms message processing

### **11.2. Validation Criteria**

* **Message Conformance:** 100% HL7 compliance
* **Data Integrity:** Zero data loss
* **System Availability:** 99.9% uptime
* **Response Time:** Meeting all SLAs

## **12. Deployment Plan**

### **12.1. Phase 1: Core Integration (Week 1-2)**

* Mirth Connect installation and configuration
* Basic HL7 message routing
* Database schema deployment

### **12.2. Phase 2: AI Integration (Week 3-4)**

* SAIF API gateway deployment
* AI processing pipeline setup
* Results delivery mechanism

### **12.3. Phase 3: Advanced Features (Week 5-6)**

* Web viewer integration
* Performance optimization
* Security hardening

### **12.4. Phase 4: Go-Live (Week 7-8)**

* User acceptance testing
* Production deployment
* Monitoring setup

## **13. Support & Maintenance**

### **13.1. Support Levels**

* **Level 1:** Help desk (business hours)
* **Level 2:** System administrators (24/7)
* **Level 3:** Development team (on-call)

### **13.2. Monitoring**

* **Uptime Monitoring:** Pingdom or similar
* **Application Monitoring:** ELK Stack
* **Performance Metrics:** Grafana dashboards

### **13.3. Maintenance Windows**

* **Scheduled:** Sundays 2:00 AM - 6:00 AM
* **Emergency:** As required with 2-hour notice

## **14. Appendices**

### **14.1. Glossary**

* **SAIF:** Scalable AI Framework (ThakaaMed's AI platform)
* **MPPS:** Modality Performed Procedure Step
* **MWL:** Modality Worklist
* **PHI:** Protected Health Information

### **14.2. References**

* HL7 Version 2.5 Specification
* DICOM PS3.4 Service Class Specifications
* IHE Radiology Technical Framework
* ThakaaMed SAIF API Documentation v1.0