

## Lecture 07 - Contents

An overview of the parts in the medical AI agents lecture.

### Part 1

Agent Fundamentals

### Part 2

Multi-Agent Systems

### Part 3

Clinical Workflows

### Hands-on

Agent Building Hands-on

This outline is for guidance. Navigate the slides with the left/right arrow keys.



Lecture 7:

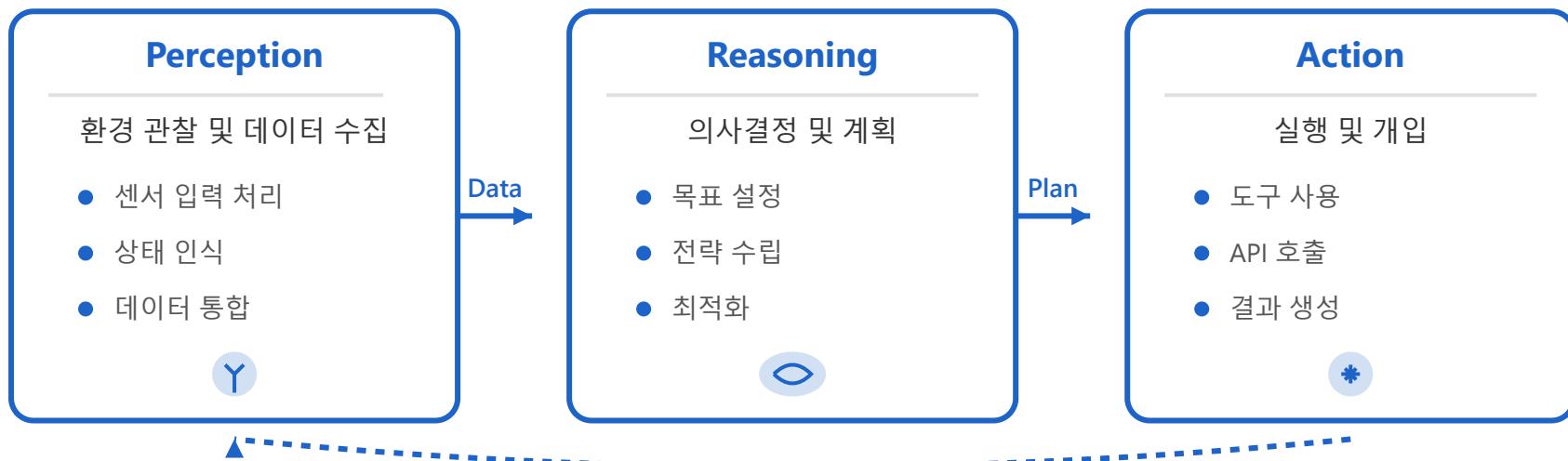
# **Agentic AI: Autonomous Medical Assistants**

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## Agent Architecture Overview



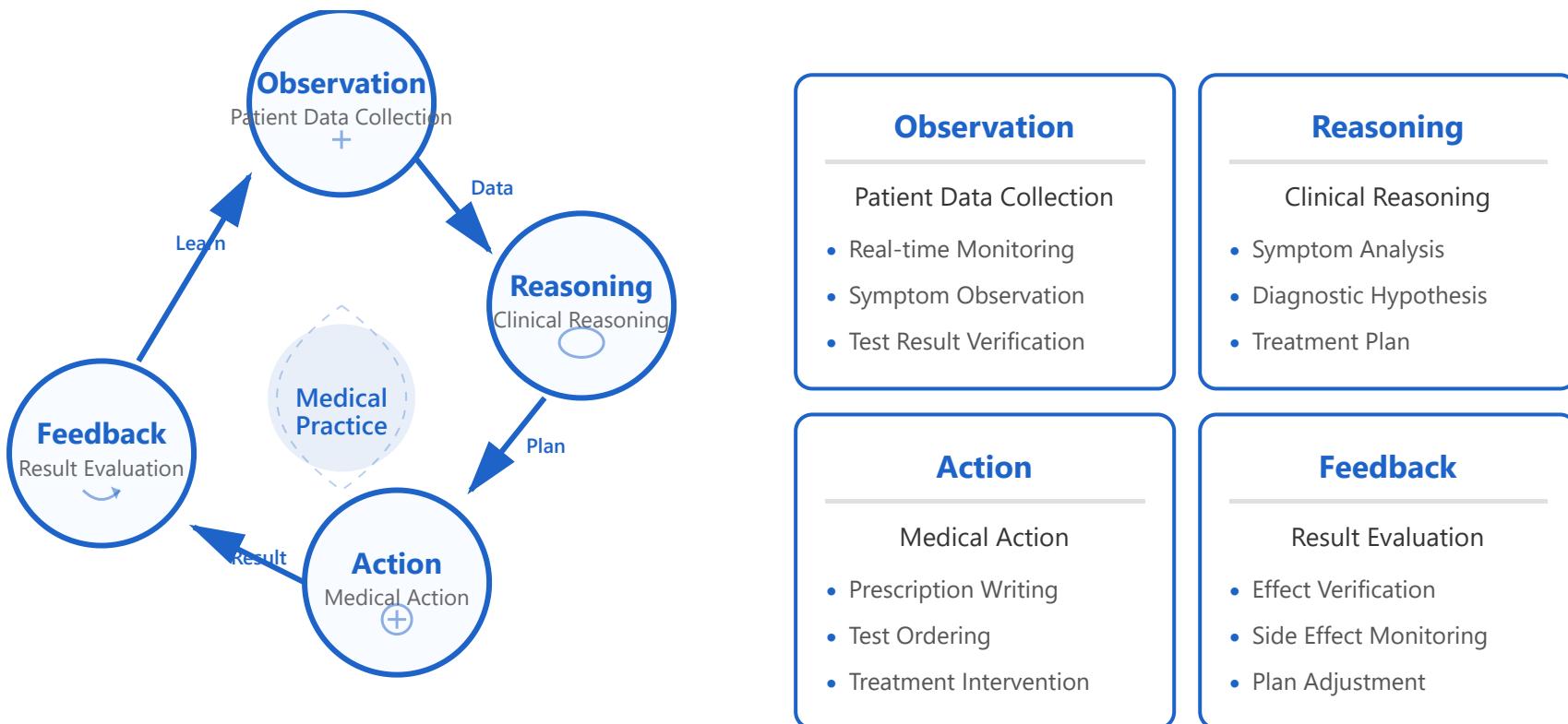
의료 환경에 특화된 자율 에이전트 시스템

**Part 1/3:**

# **Medical Agent Fundamentals**

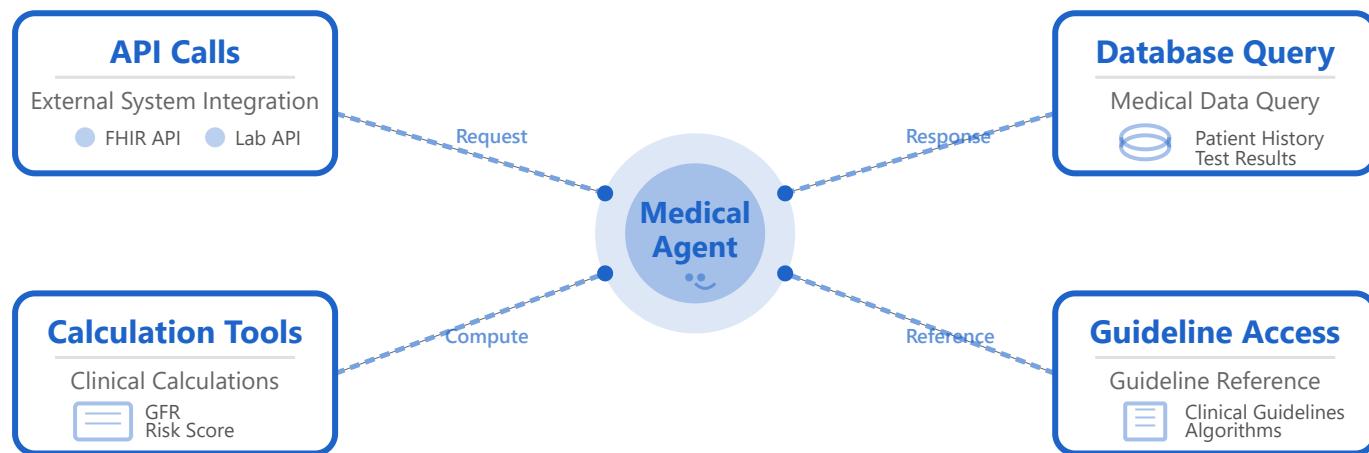
- 1.** Perception-Action Loops
- 2.** Medical Tool Use
- 3.** EHR API Integration
- 4.** Lab System Interfaces
- 5.** Drug Database Access
- 6.** Medical Calculator Tools
- 7.** Clinical Guideline Agents

## Perception-Action Loops



Continuous Learning Loop in Medical Practice

## Medical Tool Use



### API Calls

#### External System Integration

- FHIR API
- Lab System API
- Drug DB API

### Database Query

#### Medical Data Query

- Patient History
- Test Results
- Drug Information

### Calculation Tools

#### Clinical Calculations

### Guideline Access

#### Guideline Reference

- GFR Calculation
  - Risk Score
  - Drug Dosing
- Clinical Guidelines
  - Drug Interactions
  - Algorithms

## EHR API Integration

### FHIR API

Standard medical information exchange

- Patient Resource
- Observation Resource
- Medication Resource

### Read Access

Patient data retrieval

- Demographics
- Diagnosis history
- Medication records

### Write Access

Data creation/modification

- Medical records
- Prescription orders
- Test requests

Security & Authorization Required

## Lab System Interfaces

### LIS Connection

Laboratory System Integration

- Order Transmission
- Result Reception
- Status Check

### Test Ordering

Test Order Creation

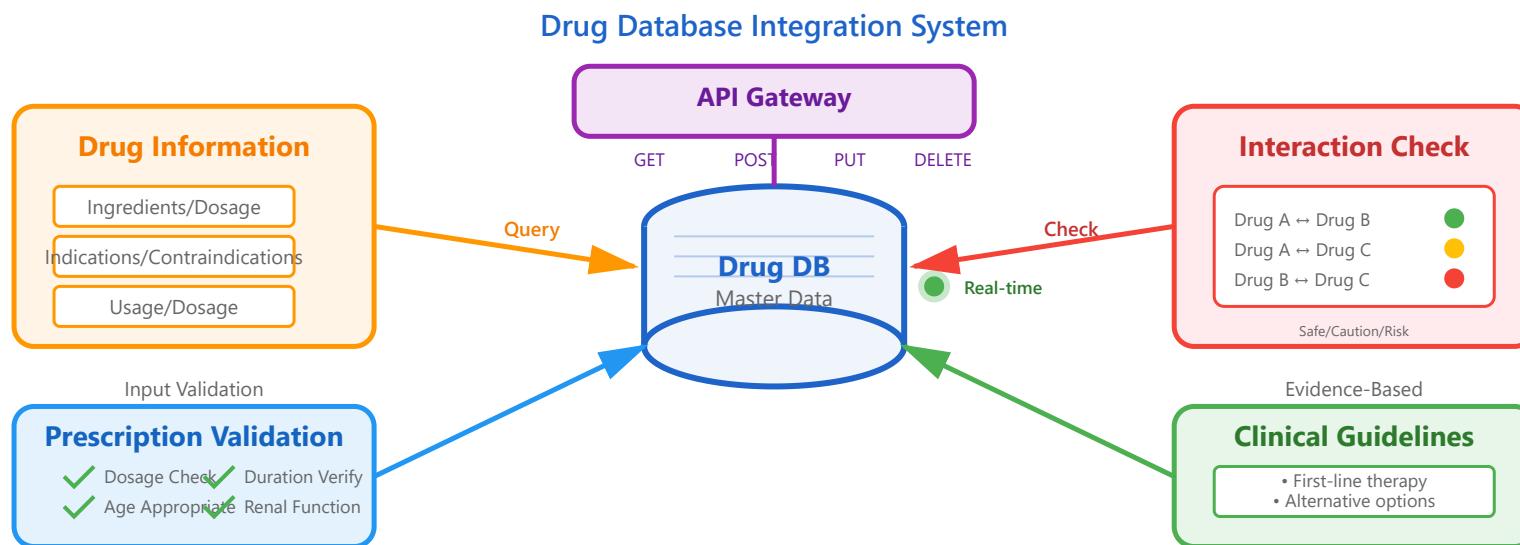
- Test Selection
- Priority Setting
- Specimen Information

### Result Retrieval

Result Viewing

- Automatic Reception
- Notification Processing
- Abnormal Value Detection

## Drug Database Access



### Drug Information

- Ingredients & Content
- Indications/Contraindications
- Usage/Dosage Guidelines
- Side Effect Information

### Interaction Check

- Drug-Drug Interactions
- Drug-Food Interactions
- Risk Assessment
- Alternative Drug Suggestions

### Prescription Validation

- Dosage Appropriateness
- Duration Verification
- Age-Based Adjustment
- Renal/Hepatic Considerations

## Medical Calculator Tools

### Renal Function

- eGFR
- CrCl (Cockcroft-Gault)
- MDRD

### Risk Scores

- CHADS2-VASc
- GRACE Score
- APACHE II

### Drug Dosing

- Weight-based
- Renal Adjustment
- Age-based

## Clinical Guideline Agents

### Guideline Retrieval

Latest guideline search

- Disease-specific guidelines
- Treatment algorithms
- Evidence levels

### Recommendation

Personalized recommendations

- Patient characteristics considered
- Preference consideration
- Alternative suggestions

### Update Monitoring

Guideline updates

- Change tracking
- Notification generation
- Reassessment

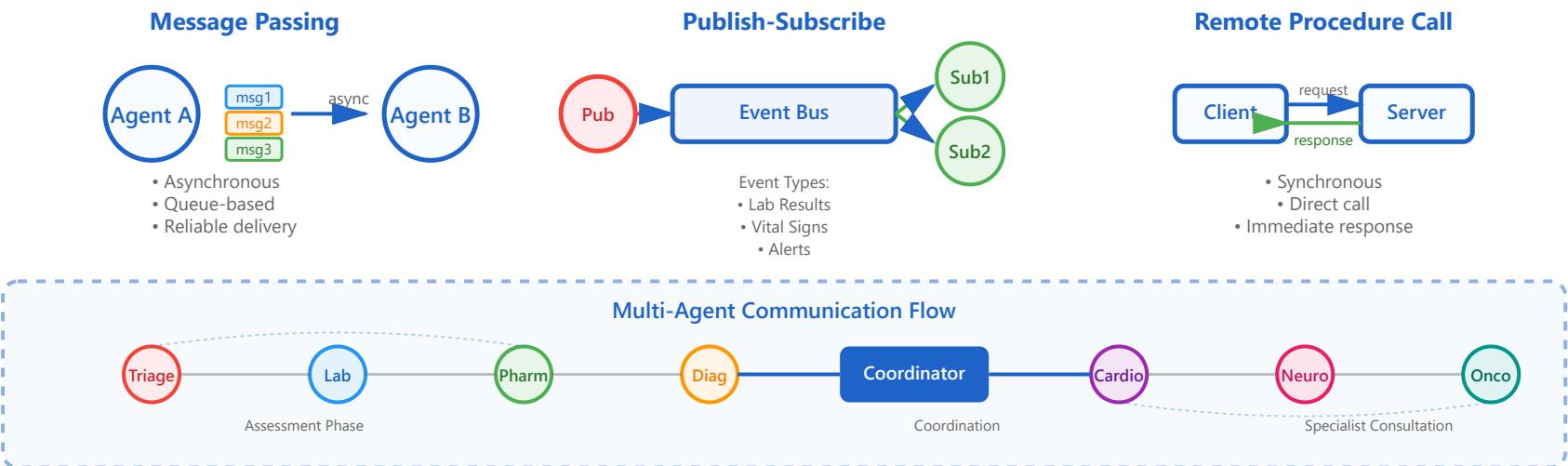
**Part 2/3:**

## **Part 2: Collaborative Multi-Agent Systems**

- 1.** Agent Communication Protocols
- 2.** Collaborative Diagnosis
- 3.** Specialist Agent Networks
- 4.** Consensus Mechanisms
- 5.** Task Delegation Strategies
- 6.** Workflow Orchestration

# Agent Communication Protocols

## Medical Agent Communication Architecture



### Message Passing

- Asynchronous message delivery
- Queue-based delivery
- Guaranteed ordering
- Error handling
- Retry mechanism

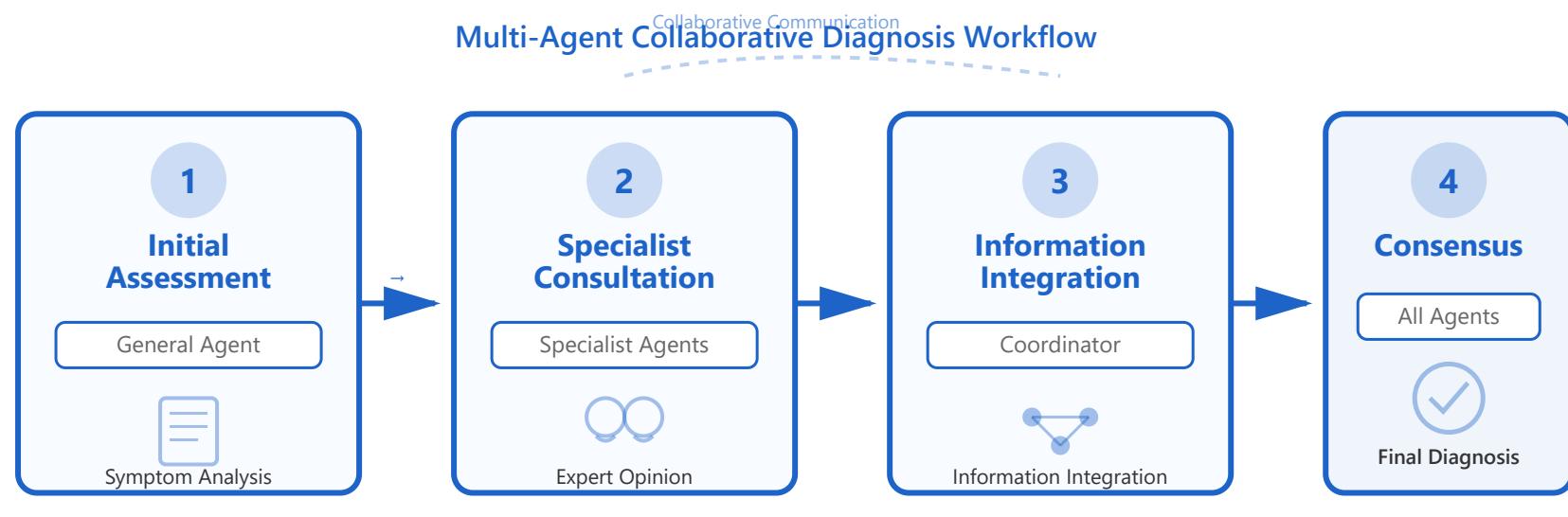
### Publish-Subscribe

- Event-driven communication
- Event broadcasting
- Multiple subscribers
- Topic filtering
- Loose coupling

### RPC

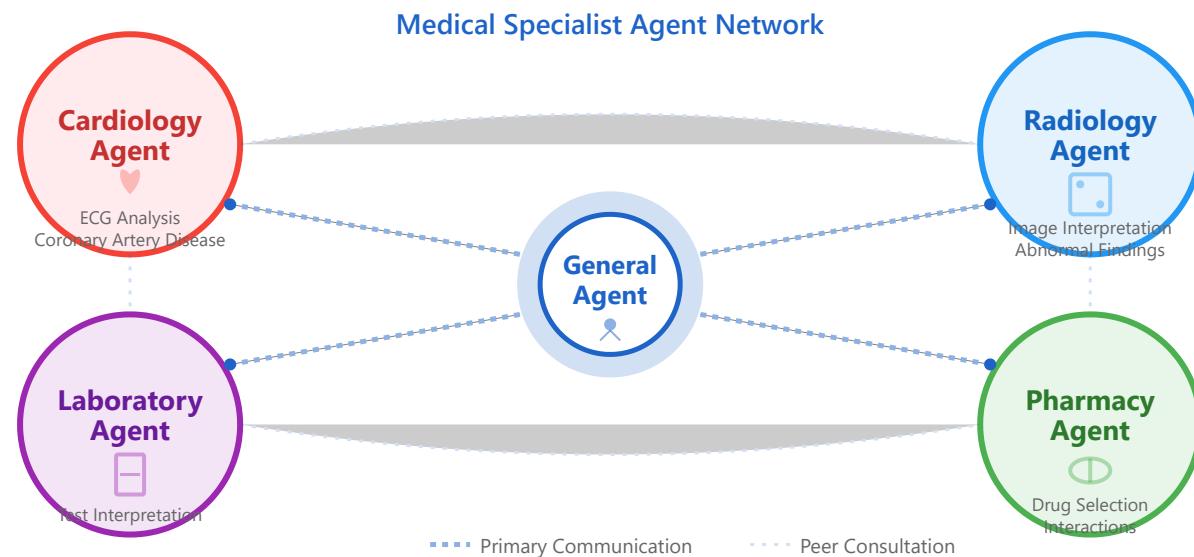
- Remote procedure call
- Synchronous calls
- Direct response
- Type safety
- Error propagation

## Collaborative Diagnosis



- 1 Initial Assessment**  
General Agent  
Symptom Analysis
- 2 Specialist Consultation**  
Specialist Agents  
Expert Opinion
- 3 Information Integration**  
Coordinator  
Information Integration
- 4 Consensus**  
All Agents  
Final Diagnosis

## Specialist Agent Networks



### Cardiology Agent

- ECG Analysis
- Coronary Artery Disease
- Arrhythmia

### Radiology Agent

- Image Interpretation
- Abnormal Findings
- Anatomical Assessment

### Laboratory Agent

- Test Interpretation
- Abnormal Value Analysis
- Trend Analysis

### Pharmacy Agent

- Drug Selection
- Interactions
- Dose Adjustment

## Task Delegation Strategies

### Capability-based

Allocation based on capability

- Expertise
- Availability
- Workload

### Priority Queue

Priority-based

- Urgency
- Importance
- Dependencies

### Load Balancing

Load distribution

- Workload
- Response time
- Resources

## Task Delegation Strategies

### Capability-based

Allocation based on capability

- Expertise
- Availability
- Workload

### Priority Queue

Priority-based

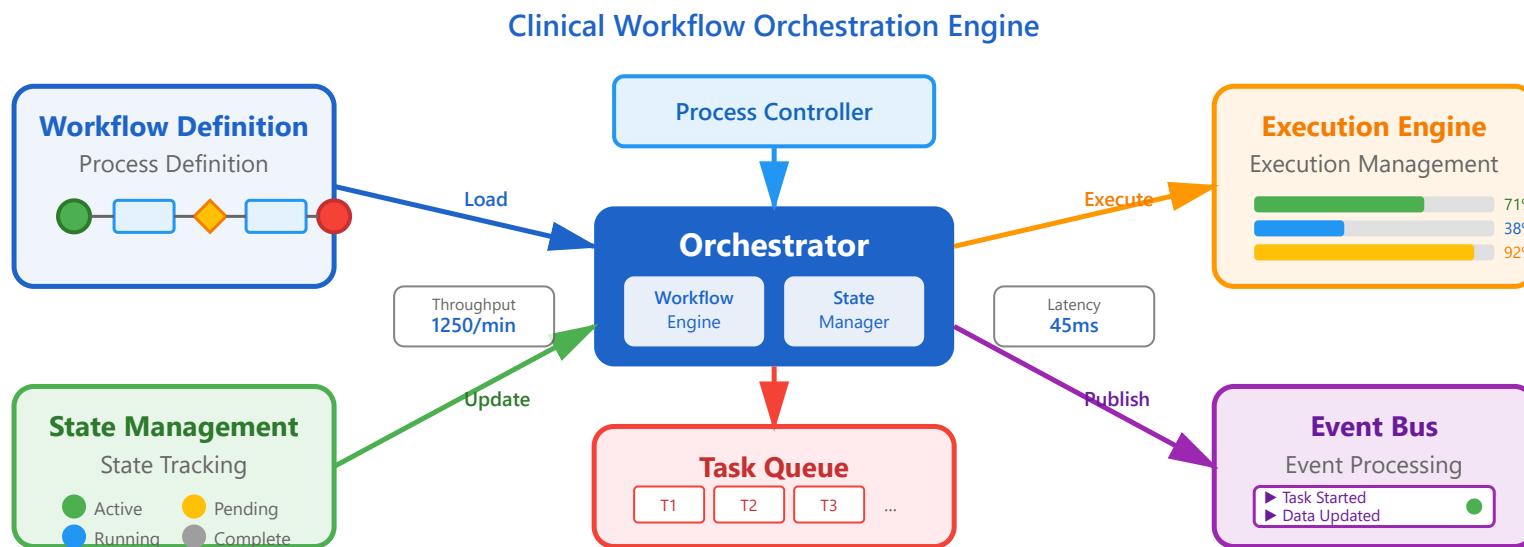
- Urgency
- Importance
- Dependency

### Load Balancing

Load distribution

- Workload
- Response time
- Resources

## Workflow Orchestration



### Workflow Definition

#### Process Definition

- BPMN Modeling
- Conditional Branching
- Parallel Processing
- Event Triggers

### Execution Engine

#### Execution Management

- Task Scheduling
- Resource Allocation
- Error Handling
- Retry Logic

### State Management

#### State Tracking

- Real-time Monitoring
- State Transitions
- Audit Logs
- Recovery Points

**Part 3/3:**

## **Part 3: Clinical Workflow Automation**

- 1.** Patient Intake Agents
- 2.** Clinical Pathway Automation
- 3.** Medication Management Agents
- 4.** Follow-Up Care Coordination
- 5.** Quality Assurance Agents
- 6.** Safety Monitoring Systems

## 환자 접수 에이전트

### 등록

- 신원 확인
- 보험 확인
- 동의서

### 주호소

- 주 증상
- 발생 시기
- 진행 경과

### 병력

- 과거력
- 가족력
- 약물 이력

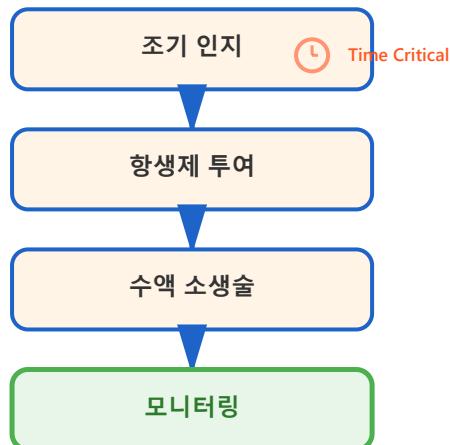
### 초기 평가

- 활력정후
- 초기 평가
- 긴급도 분류

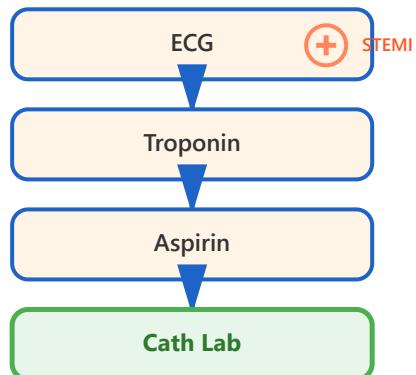
## Clinical Pathway Automation

### Automated Clinical Pathways

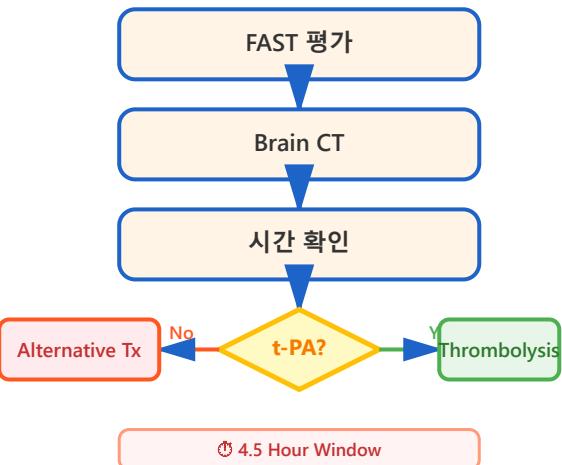
#### Sepsis Pathway



#### ACS Pathway



#### Stroke Pathway



#### Sepsis Pathway

조기 인지 → 항생제 투여 → 수액 소생술  
→ 모니터링

#### ACS Pathway

ECG → Troponin → Aspirin → Cath Lab

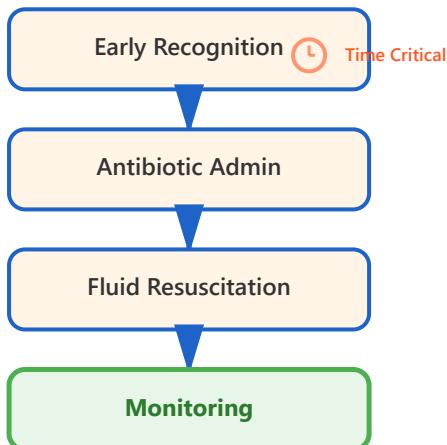
#### Stroke Pathway

FAST 평가 → Brain CT → 시간 확인 → t-PA 고려

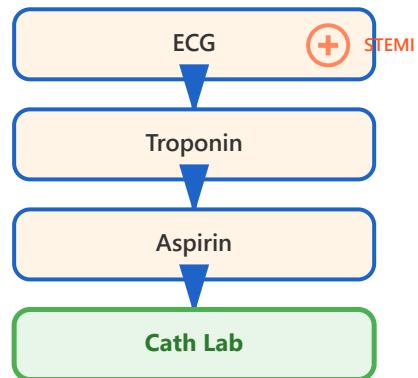
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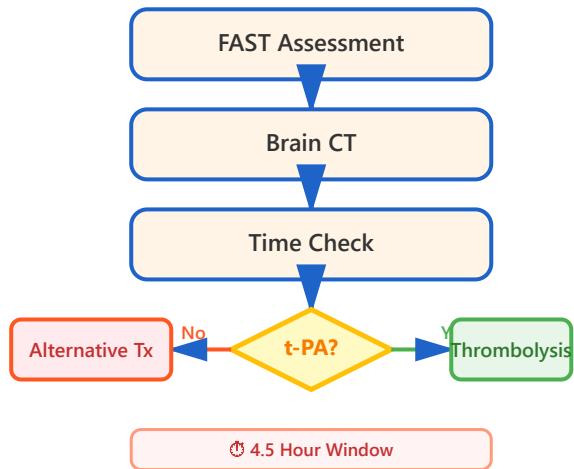
#### Sepsis Pathway



#### ACS Pathway



#### Stroke Pathway



#### Sepsis Pathway

Early Recognition → Antibiotic Administration → Fluid Resuscitation → Monitoring

#### ACS Pathway

ECG → Troponin → Aspirin → Cath Lab

#### Stroke Pathway

FAST Assessment → Brain CT → Time Check → t-PA Consideration

## Follow-Up Care Coordination

### Appointment Scheduling

- Follow-up Schedule
- Automatic Booking
- Reminders
- Notification Settings

Automatically manages follow-up appointment schedules according to patient treatment plans and prevents no-shows through appointment reminders.

### Test Follow-up

- Result Verification
- Additional Testing
- Abnormal Value Alerts
- Trend Analysis

Tracks test results, sends immediate alerts when abnormal values are detected, and analyzes long-term health trends.

### Care Transition

- Discharge Planning
- Referral Management
- Inter-department Coordination
- Continuity Maintenance

Ensures continuity of care after discharge and supports seamless information sharing and referral management with other departments or external healthcare facilities.

## Quality Assurance Agents

### Process Metrics

- 대기 시간
- 처리 시간
- 완료율
- 병목 지점

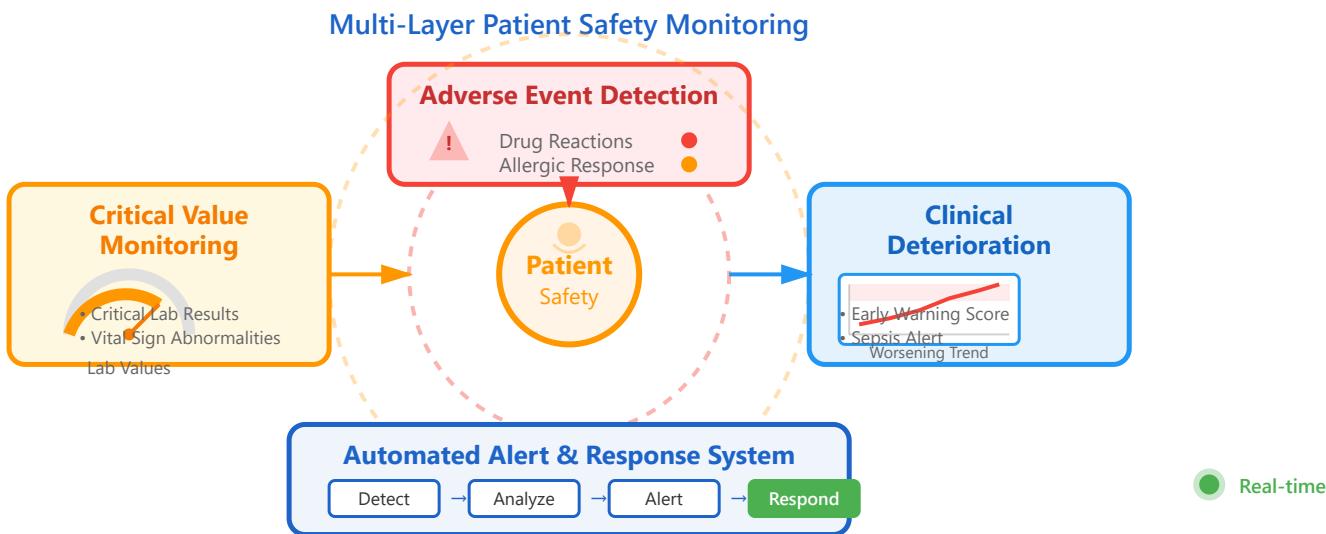
### Outcome Metrics

- 재입원율
- 합병증 발생
- 환자 만족도
- 치료 효과

### Compliance Metrics

- 가이드라인 준수
- 문서화 완성도
- 안전 점검
- 인증 기준

# Safety Monitoring Systems



## Adverse Event Detection

- Drug Adverse Event Detection
- Allergic Reactions
- Interaction Warnings
- Reporting System

## Critical Value Monitoring

- Critical Lab Results
- Vital Sign Abnormalities
- Critical Imaging Findings
- Immediate Notification

## Clinical Deterioration

- Early Warning Score
- Sepsis Alert
- RRT Criteria
- Rapid Response

## Agent Evaluation Metrics

### Performance

- Accuracy
- Precision
- Recall
- F1-Score

Measures how well the agent completes tasks correctly, including prediction accuracy, precision in identifying relevant information, recall in capturing all necessary elements, and balanced F1-score.

### Efficiency

- Response Time
- Throughput
- Resource Usage
- Latency

Evaluates operational speed and resource optimization, tracking response time, task throughput, computational resource consumption, and system latency for optimal performance.

### Reliability

- Uptime
- Error Rate
- Recovery Time
- Fault Tolerance

Assesses system stability and dependability through uptime monitoring, error frequency analysis, recovery speed after failures, and capacity to handle unexpected conditions.

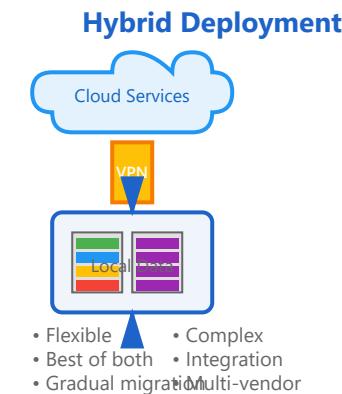
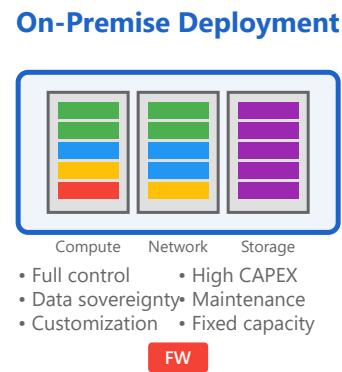
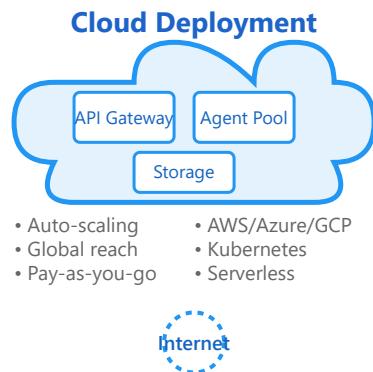
### Safety

- Error Detection
- False Alarm Rate
- Clinical Impact
- Patient Safety

Ensures safe operation in critical environments by monitoring error detection capabilities, minimizing false alarms, evaluating clinical outcomes, and prioritizing patient safety standards.

# Deployment Architectures

## Medical AI Agent Deployment Options



Metric	Cloud	On-Premise	Hybrid	Scalability:	Excellent	Limited	Good
Initial Cost:	Low	High	Medium				

### Cloud

- ✓ Rapid deployment
- ✓ Auto-scaling
- ✓ Low initial cost
- ✓ Simplified management
- ✗ Data security concerns
- ✗ Network dependency
- ✗ Regulatory constraints
- ✗ Cost predictability

### On-Premise

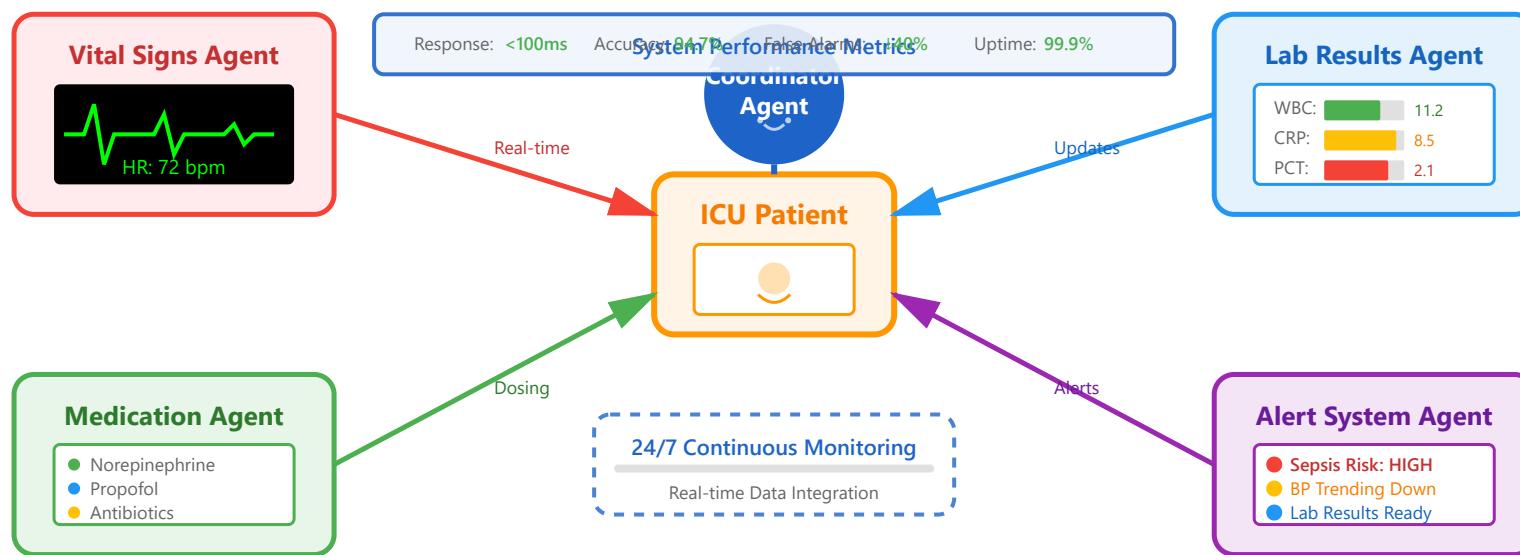
- ✓ Complete data control
- ✓ Enhanced security
- ✓ Customization
- ✓ Regulatory compliance
- ✗ High initial cost
- ✗ Maintenance burden
- ✗ Scalability limitations
- ✗ Infrastructure management

### Hybrid

- ✓ Flexible architecture
- ✓ Gradual migration
- ✓ Diversified backup
- ✓ Optimization
- ✗ Complex integration
- ✗ Dual management
- ✗ Security boundaries
- ✗ Consistency challenges

## Case Study: ICU Monitoring Agent

Multi-Agent ICU Monitoring System Architecture



### Problem

- Need for real-time ICU monitoring and early warning system
- Increased medical staff burden and alarm fatigue
- Difficulty in integrating and interpreting complex data

### Solution

- Multi-agent based integrated monitoring system development
- Real-time data analysis and pattern recognition
- Intelligent alarm filtering and prioritization

## Implementation

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- Real-time analysis integrating vital signs, lab results, and medication data
- Each specialized agent manages a specific domain
- Central coordinator performs comprehensive assessment and generates alerts

## Results

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- 30% improvement in early detection rate
- 40% reduction in false alarms
- Increased medical staff satisfaction and improved patient outcomes

## Hands-On: Agent Building

### LangChain

- Tool Integration
- Chain Composition
- Memory Management
- Prompt Templates

### AutoGen

- Multi-Agent Framework
- Conversation Patterns
- Code Execution
- Collaboration

### Custom Implementation

- Flexible Design
- Domain-Specific Logic
- Full Control
- Integration

### Example Project

- Simple Medical Agent with EHR Access

## Regulatory Considerations

### FDA Regulation

- SaMD Classification
- Clinical Trial Requirements
- Approval Pathway
- Post-market Surveillance

### Liability

- Clarification of Liability
- Medical Malpractice Insurance
- Scope of Indemnity
- Legal Review

### Audit & Validation

- Detailed Logging
- Complete Traceability
- Regular Validation
- Performance Monitoring

### Data Privacy

- HIPAA Compliance
- GDPR Compliance
- Personal Data Protection
- Data Encryption

# Thank you

## Lecture 7 Summary:

- Medical Agent Fundamentals
- Multi-Agent Collaboration
- Clinical Workflow Automation
- Deployment & Regulatory Compliance

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