

# Holonic Manufacturing Execution System

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# Outlines

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- ☺ Introduction
- ☺ Basic Foundations
- ☺ Development of Holonic Manufacturing Execution Systems
- ☺ Development of WIP Holons
- ☺ Implementation and System Integration
- ☺ Summary and Conclusions

# Outlines

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- ☑ Introduction

- ☺ Basic Foundations

- ☺ Development of Holonic Manufacturing Execution Systems

- ☺ Development of WIP Holons

- ☺ Implementation and System Integration

- ☺ Summary and Conclusions

# Introduction

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☑ Background

☑ Motivation and Purposes

# Introduction

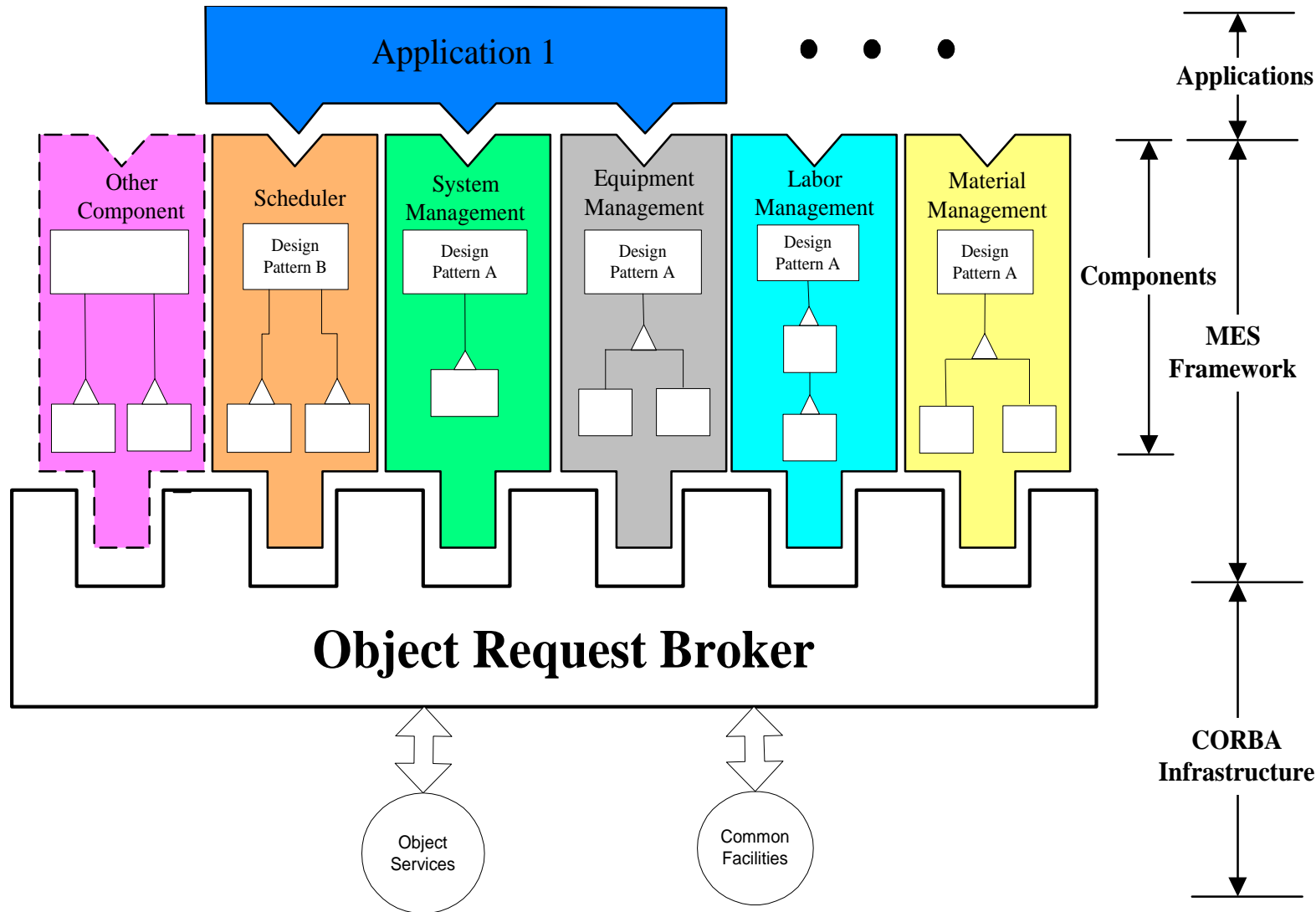
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## Manufacturing Objectives

- Cost Reduction
  - Cycle-Time Reduction
  - Yield Improvement
  - Empowerment
  - Agility
  - WIP Visibility
  - Asset Utilization
  - On-Time Delivery
-  Failure recovery
  -  Security certification

# Introduction

## Background - MES Framework



# Introduction

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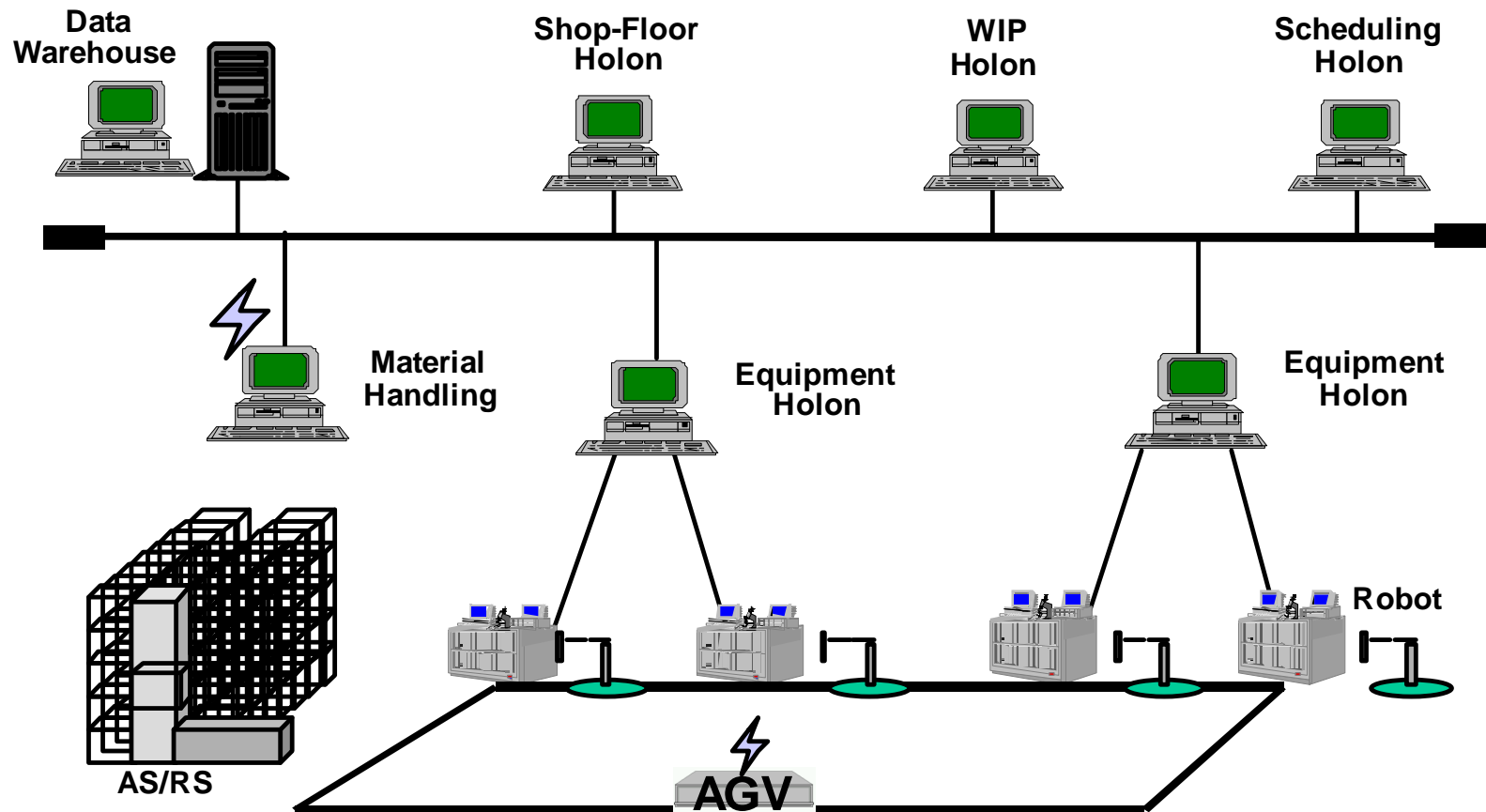
## Motivation and Purposes -

### Characteristics of Holonic Manufacturing Systems

- Intelligence
- Autonomy
- Cooperation
- Reconfigurability
- Extensibility

# Introduction

## Motivation and Purposes - Deployment Diagram for Holonic Manufacturing Execution Systems





# Outlines

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☺ Introduction

☑ **Basic Foundations**

☺ Development of Holonic Manufacturing Execution Systems

☺ Development of Scheduling Holons

☺ Development of WIP Holons

☺ Implementation and System Integration

☺ Summary and Conclusions

# Basic Foundations

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💧 Holon

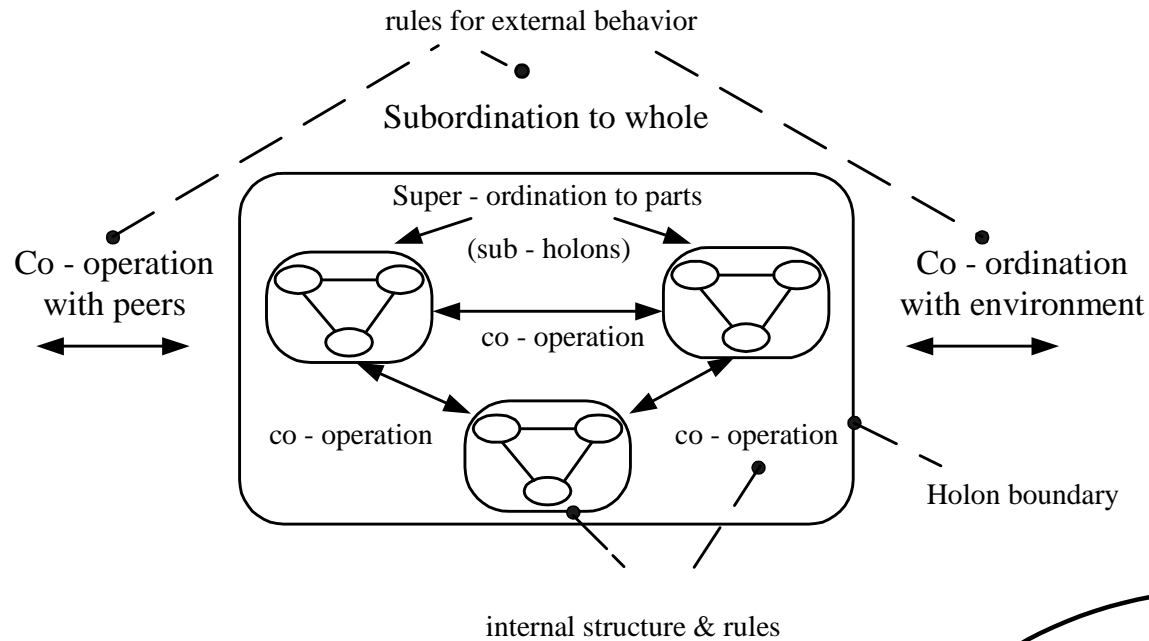
💧 UML

💧 CORBA

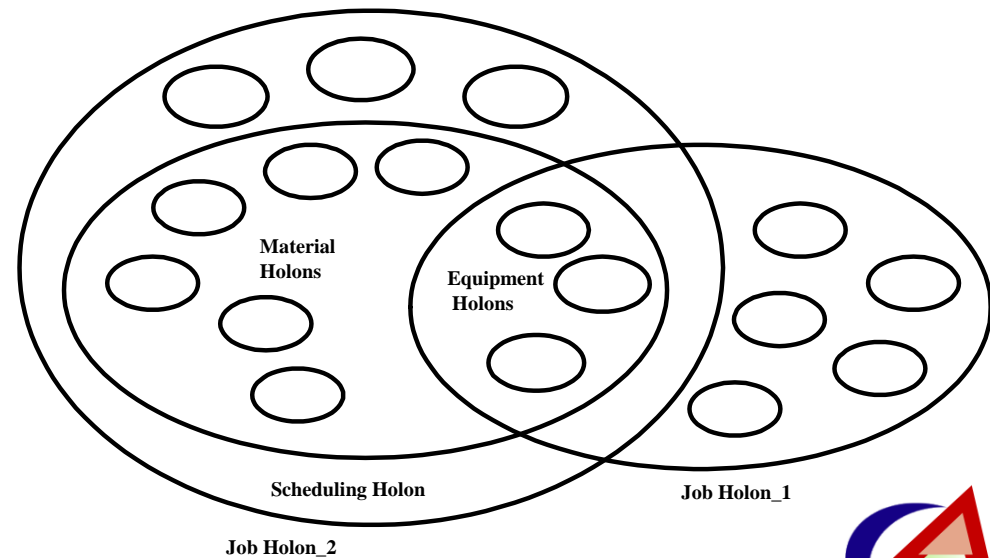
💧 MES Framework

💧 Development Procedure for OO Systems

# Basic Foundations



**Holon**



# Basic Foundations

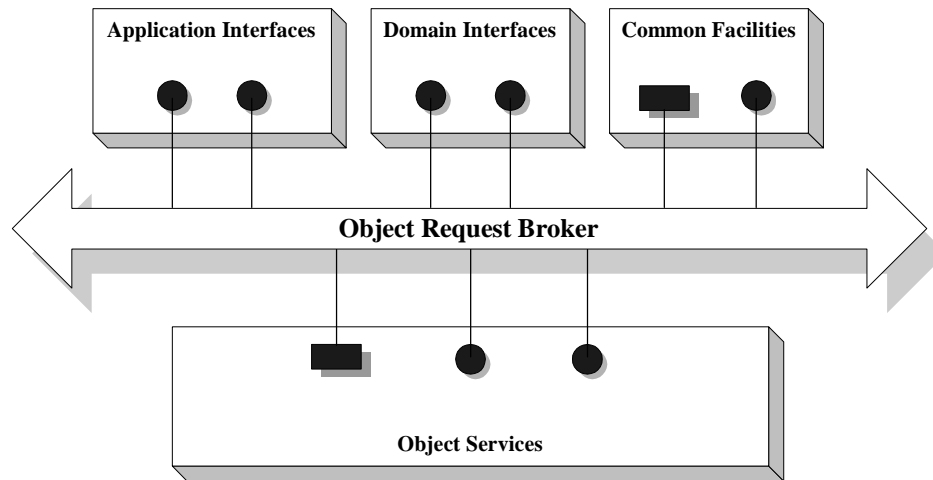
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## UML (Unified Modeling Language)

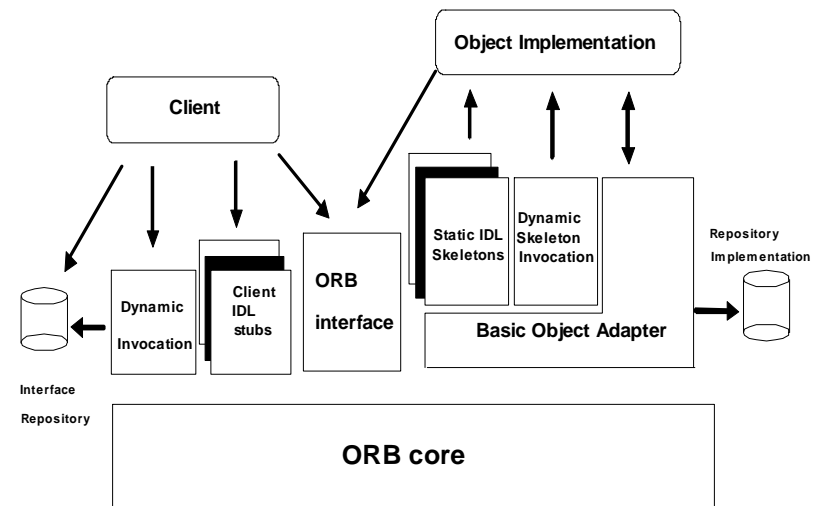
- ✿ Use Case Diagram
- ✿ Class Diagram
- ✿ State Diagram
- ✿ Sequence Diagram
- ✿ Collaboration Diagram

# Basic Foundations

## CORBA (Common Object Request Broker Architecture)



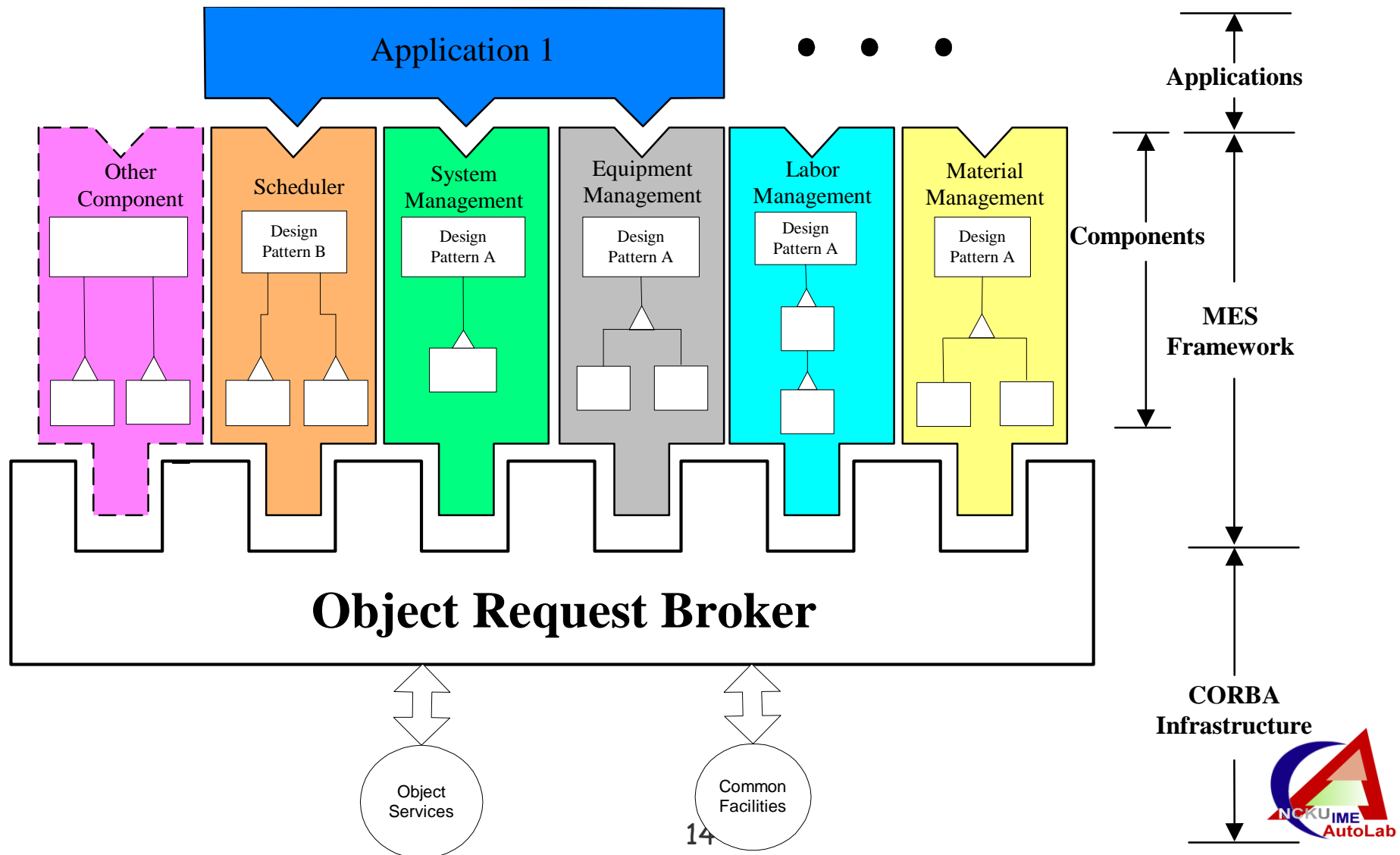
OMG Reference Model Architecture



The Structure of a CORBA ORB

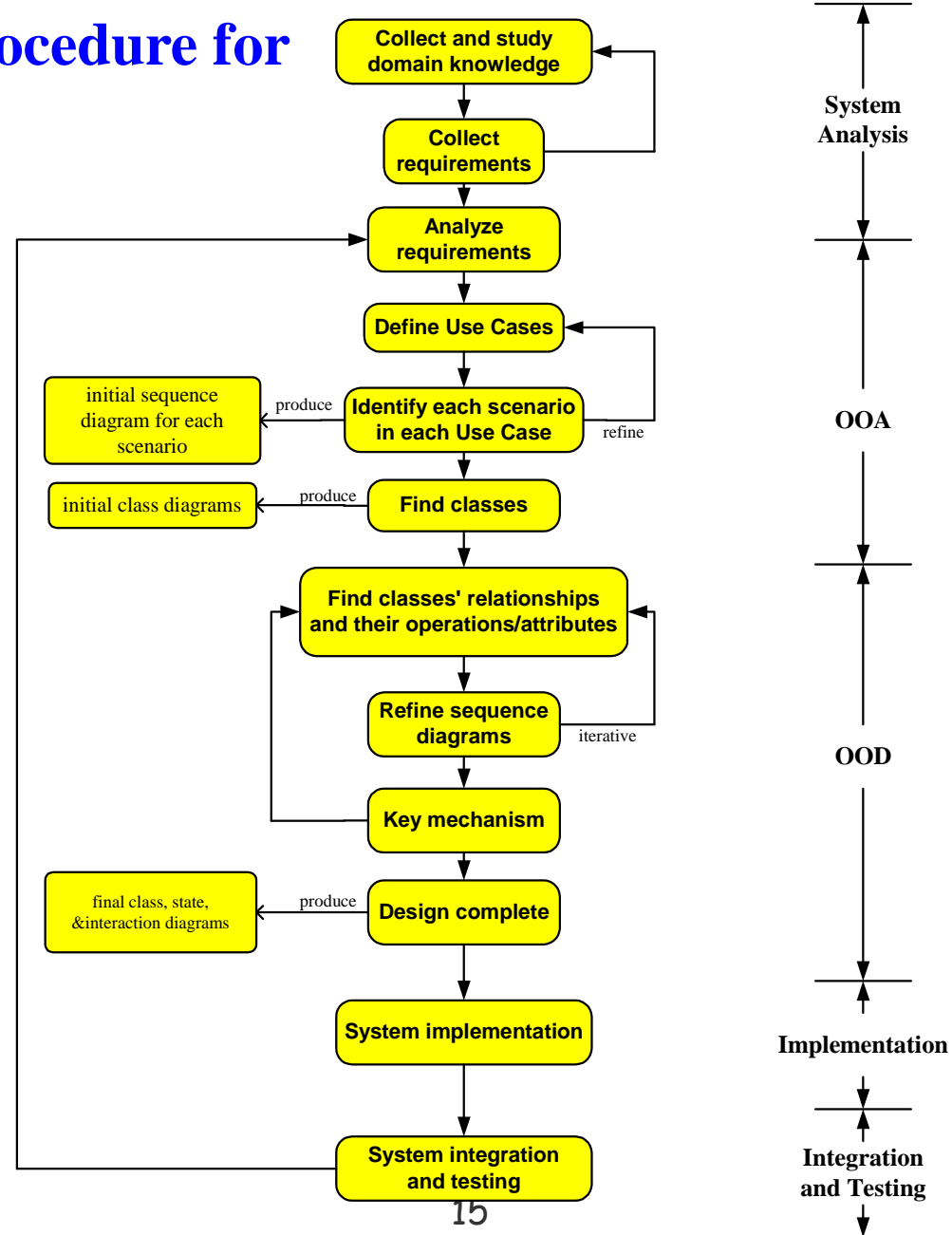
# Basic Foundations

## MES Framework Architecture



# Basic Foundations

## Development Procedure for OO Systems



# Outlines

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☺ Introduction

☺ Basic Foundations

☑ **Development of Holonic Manufacturing Execution Systems**

☺ Development of WIP Holons

☺ Implementation and System Integration

☺ Summary and Conclusions



# Development of Holonic Manufacturing Execution Systems

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## ◆ Development Procedure for HMES

## ◆ Collect Domain Requirements and Analyze Domain Knowledge

## ◆ Holarchy Design

- ◆ Construct Abstract Object Model

- ◆ Partition Application Domain into Components

- ◆ Identify Generic Functions

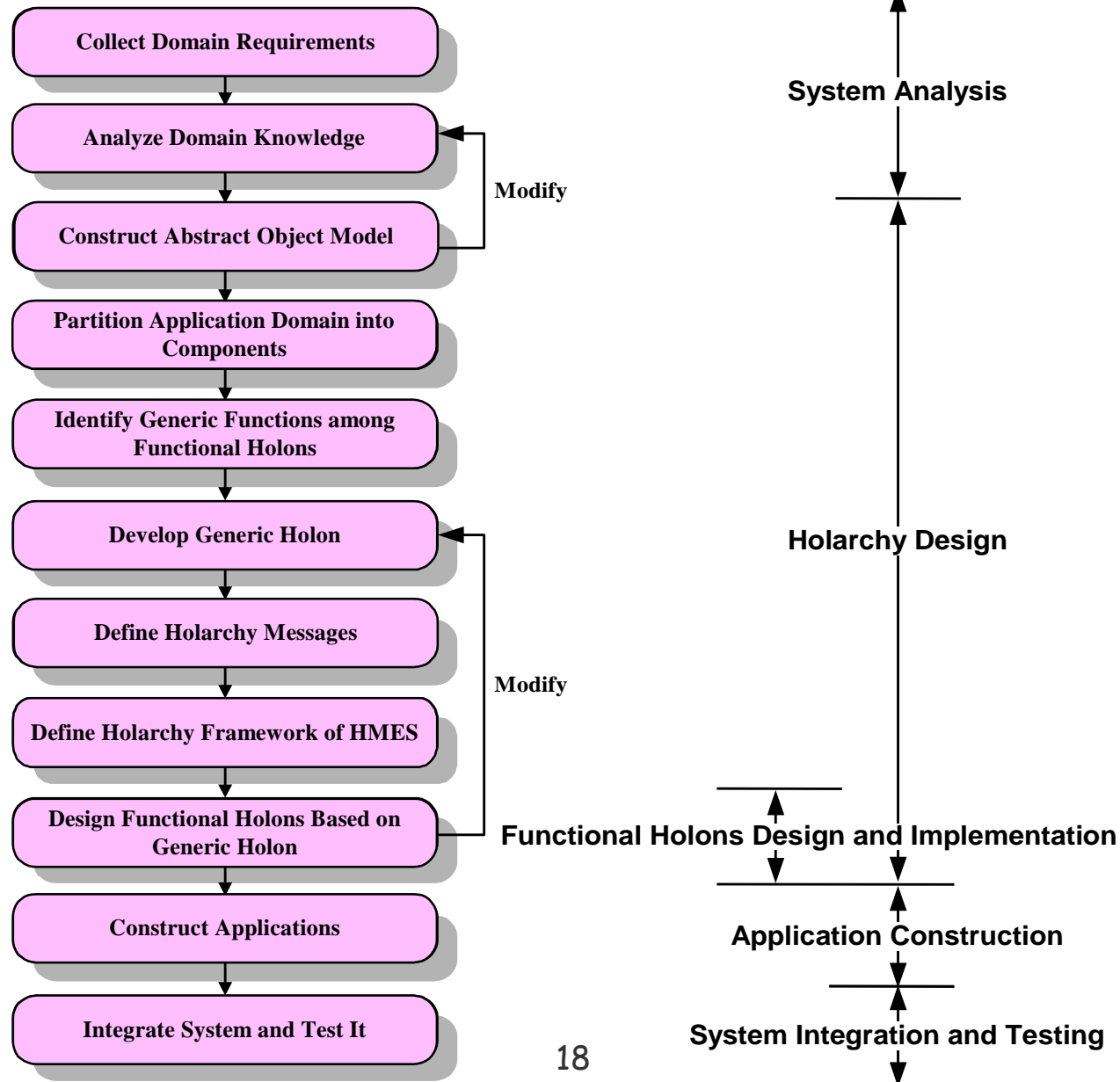
- ◆ Develop the Generic Holon

- ◆ Define Holarchy Messages

- ◆ Holarchy Framework of HMES

# Development of Holonic Manufacturing Execution Systems

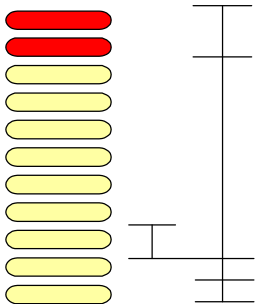
## Development Procedure for HMES



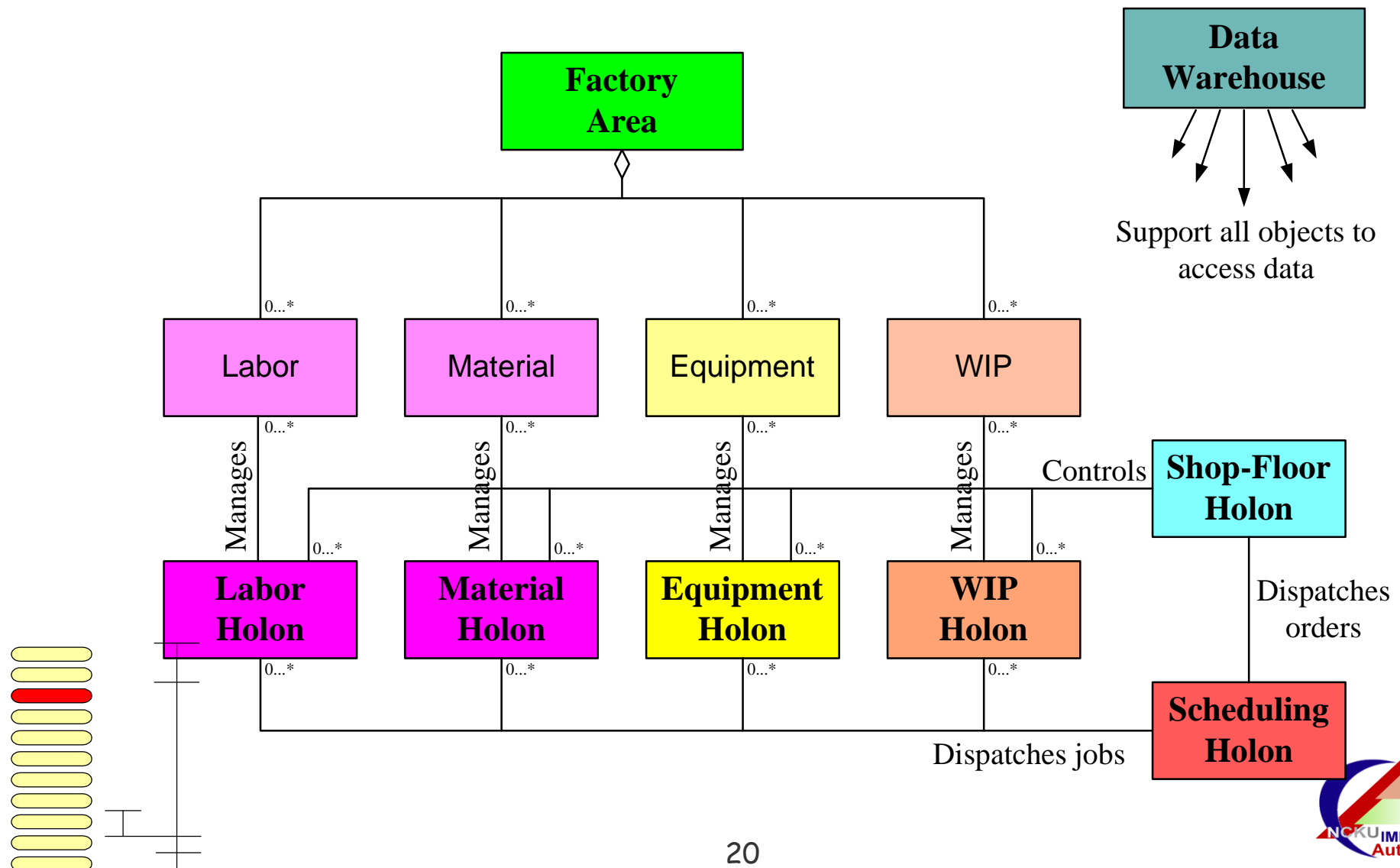
# System Analysis

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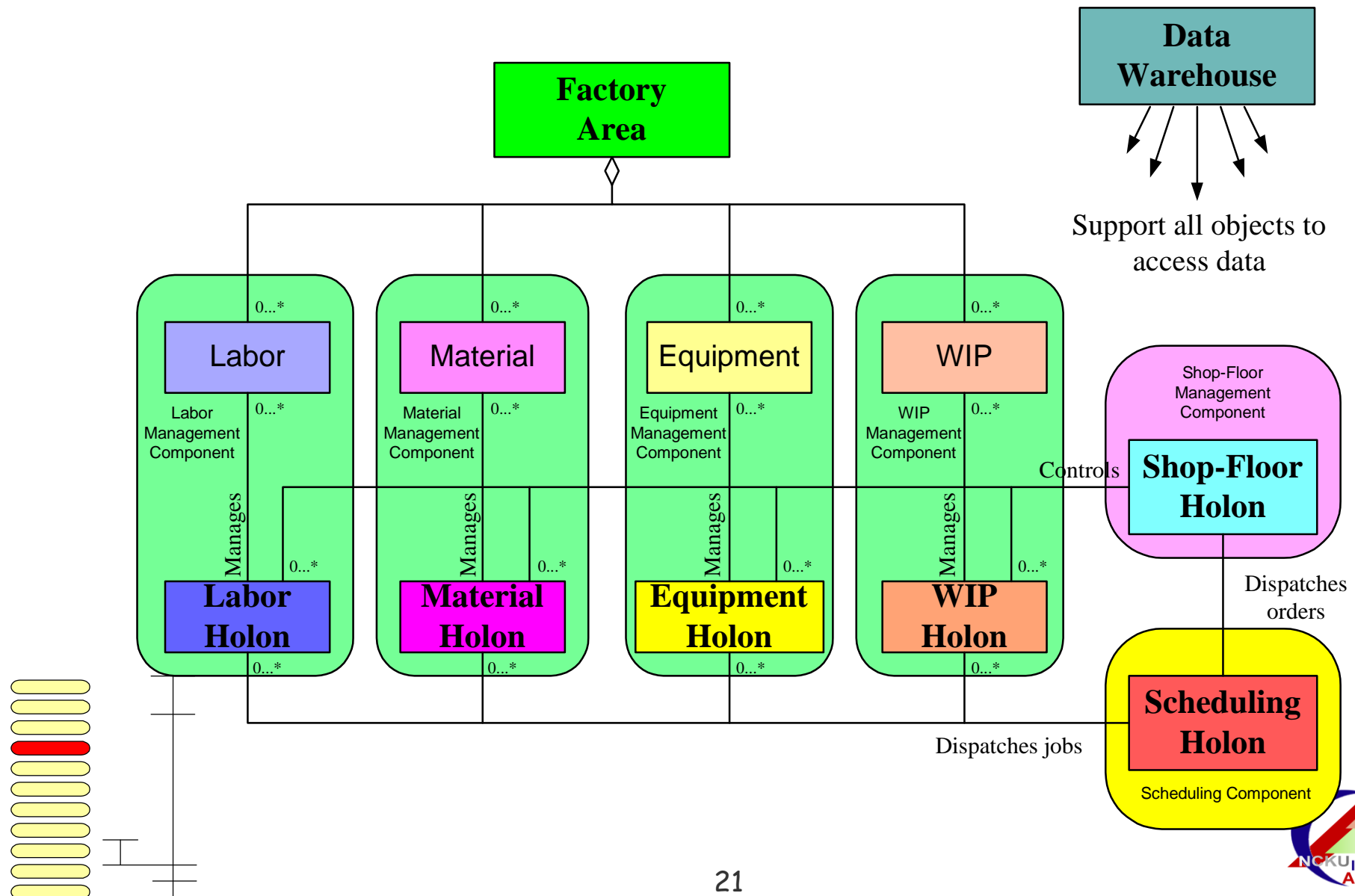
- Manufacturing Objectives shown in pp. 5.
- Open Interfaces
- Modularization
- Distribution
- Configurability
- Interoperability
- Maintainability
- ★ Security Certification
- ★ Failure Recovery



# Holarchy Design -- Construct Abstract Object Model



# Holarchy Design -- Partition Application Domain into Components



# Holarchy Design -- Identify Generic Functions among Functional Holons

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## Intelligence Mechanism

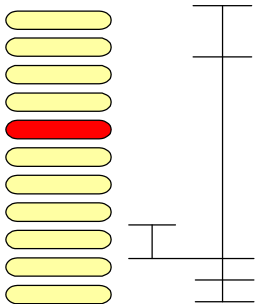
- Exception Detection
- Exception Diagnosis

## Search Mechanism

- Collaboration
- Reconfigurability

## Security Mechanism

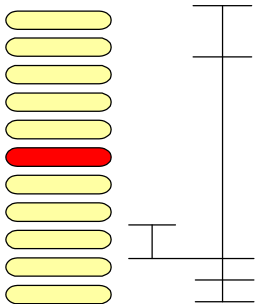
- Security Certification
- Data Encryption
- Data Decryption



# Holarchy Design -- Develop the Generic Holon

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- ☐ Requirements of GH
- ☐ Use Case Diagram for GH
- ☐ Sequence Diagram for Diagnosing Exceptions
- ☐ Class Diagram of Generic Holon
- ☐ Generic Holon Internal Architecture

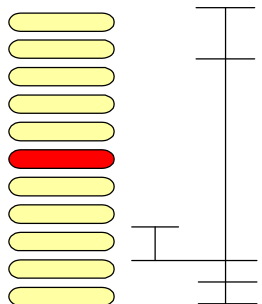


# Holarchy Design -- Develop the Generic Holon

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## Requirements of GH

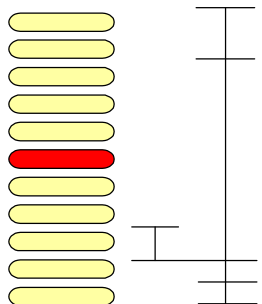
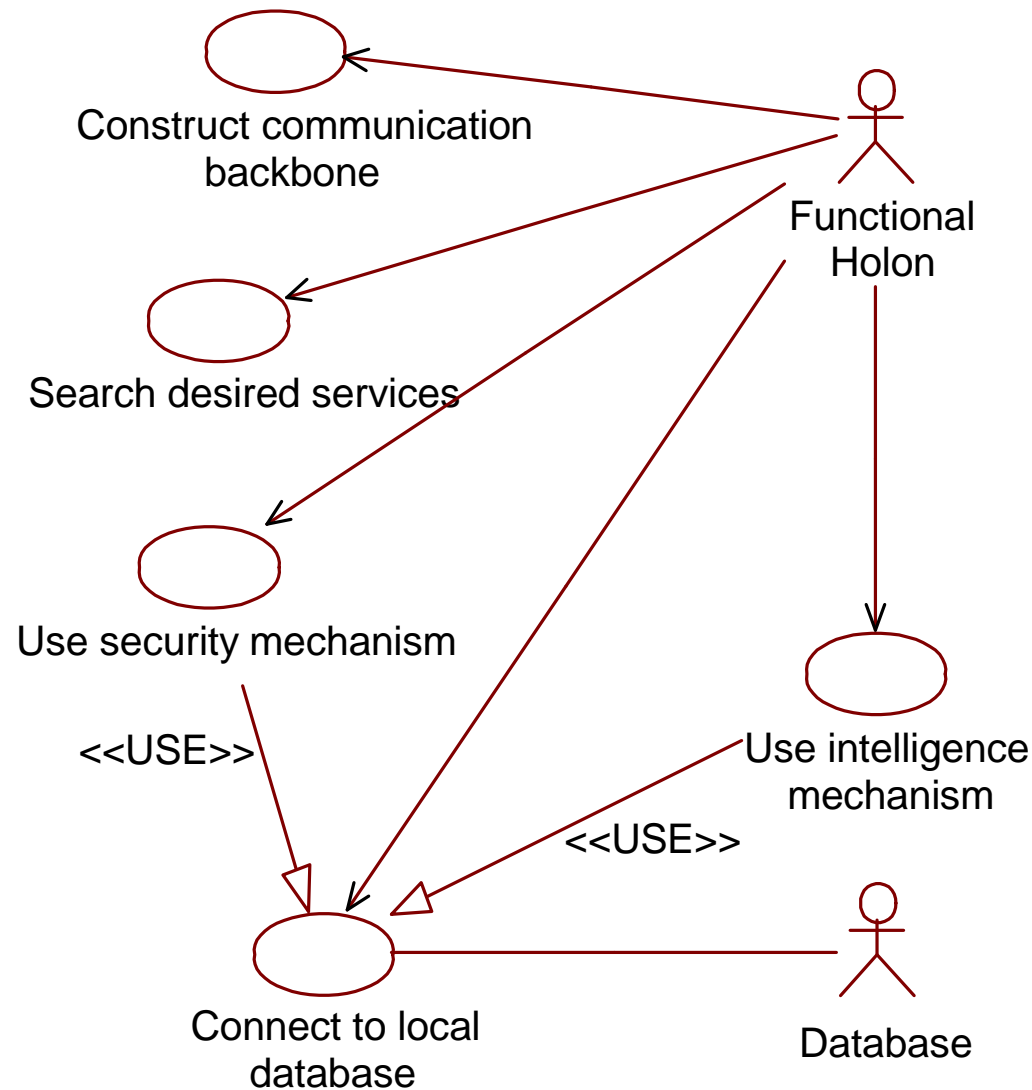
- ✧ It can construct the message backbone for cooperation and communication purposes.
- ✧ It provides the mechanism for security.
- ✧ It provides the ability of error diagnosis.
- ✧ It provides the ability of searching the desired services.
- ✧ It provides the ability of establishing a database service for information storage.





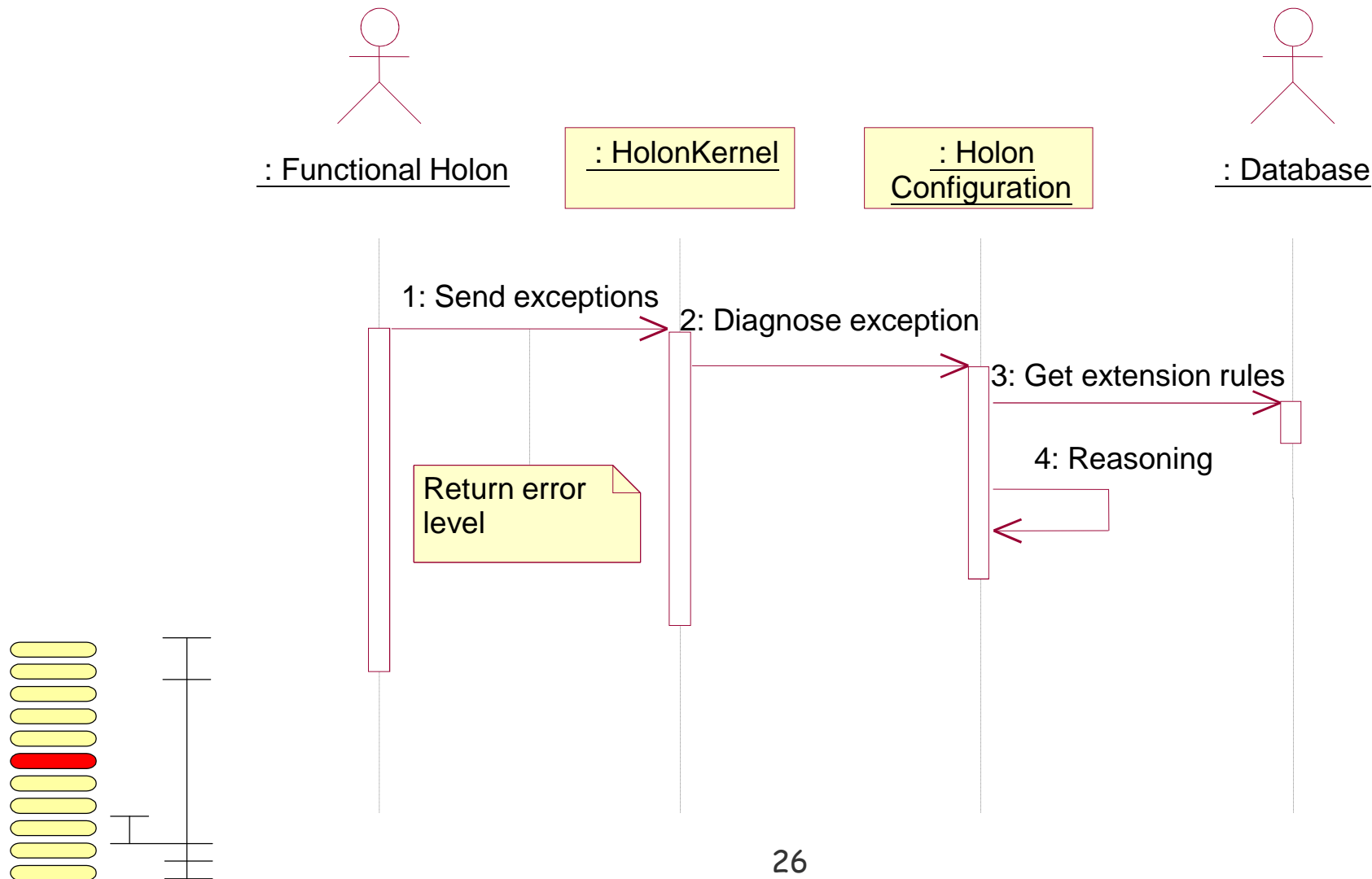
# Holarchy Design -- Develop the Generic Holon

## Use Case Diagram for GH



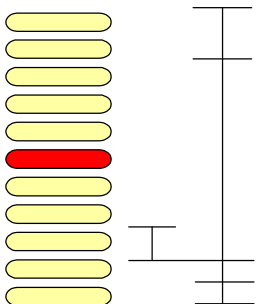
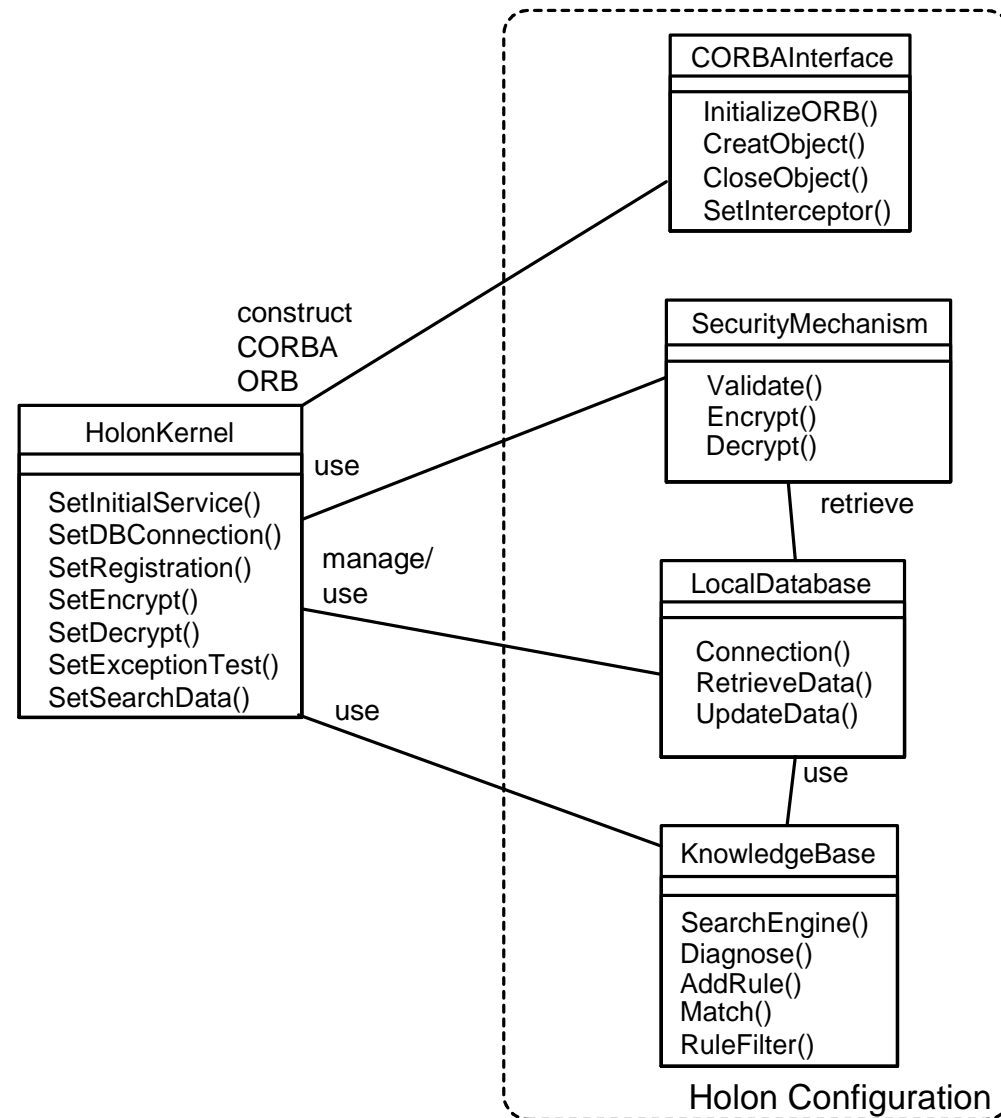
# Holarchy Design -- Develop the Generic Holon

## Sequence Diagram for Diagnosing Exceptions (OOA)



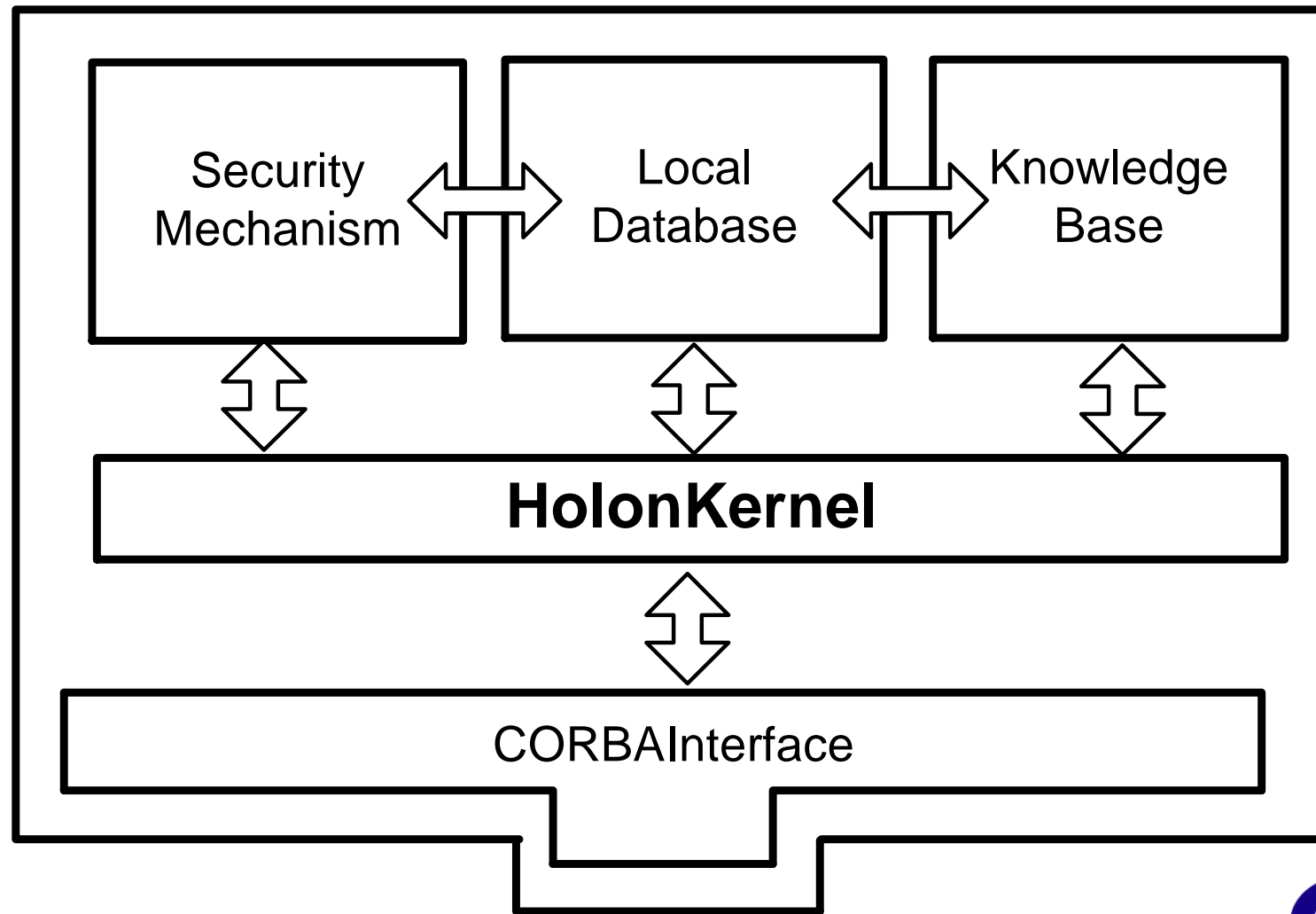
# Holarchy Design -- Develop the Generic Holon

## Class Diagram of Generic Holon (OOD)



# Holarchy Design -- Develop the Generic Holon

## Generic Holon Internal Architecture



# Holarchy Design -- Define Holarchy Messages

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- **Fully-Automated Holarchy Messages**

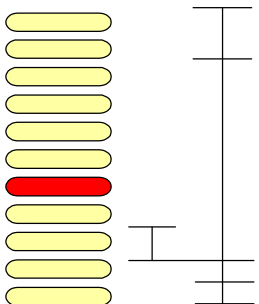
Sequence Diagram

Collaboration Diagram

- **Semi-Automated Holarchy Messages**

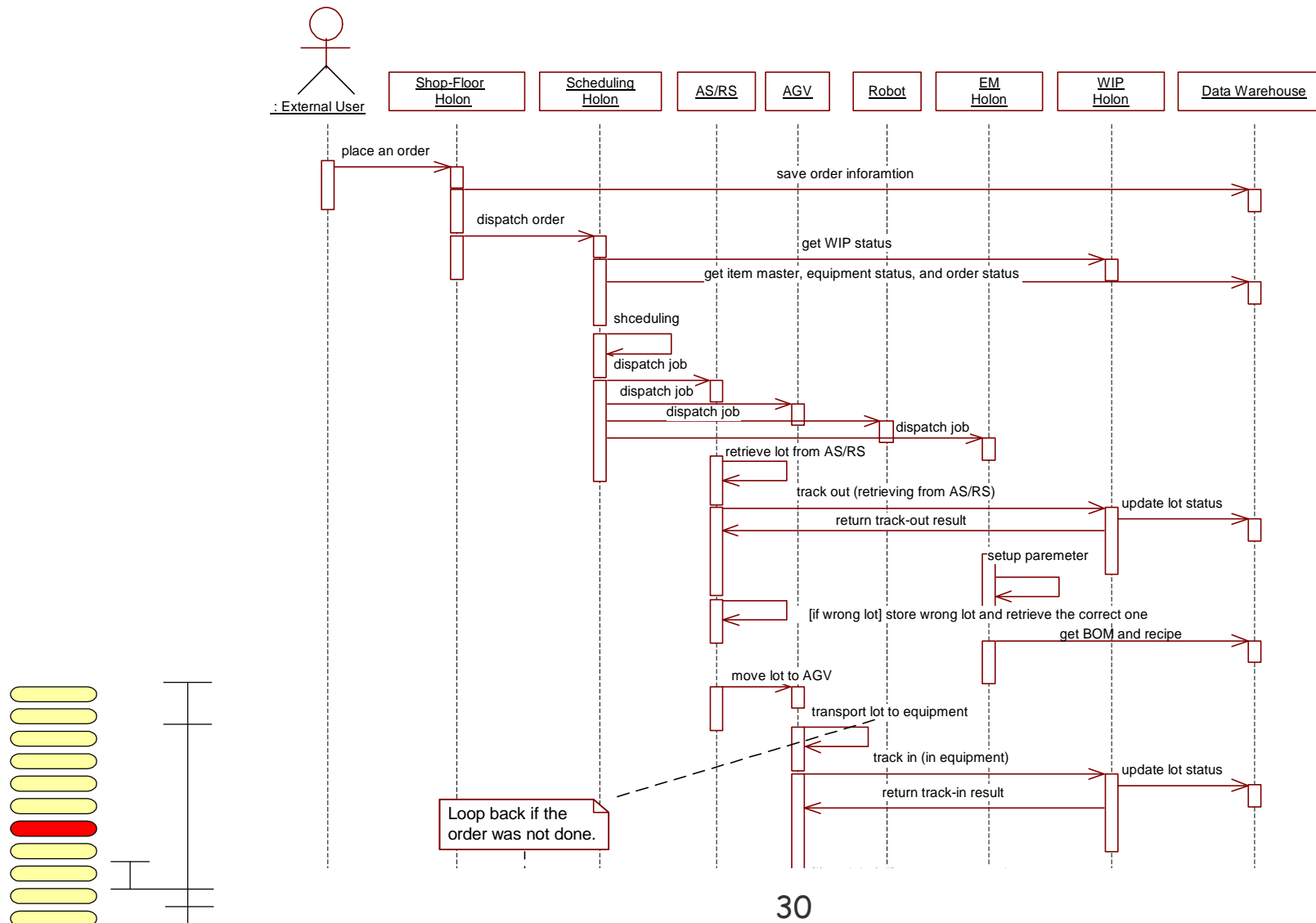
Sequence Diagram

Collaboration Diagram



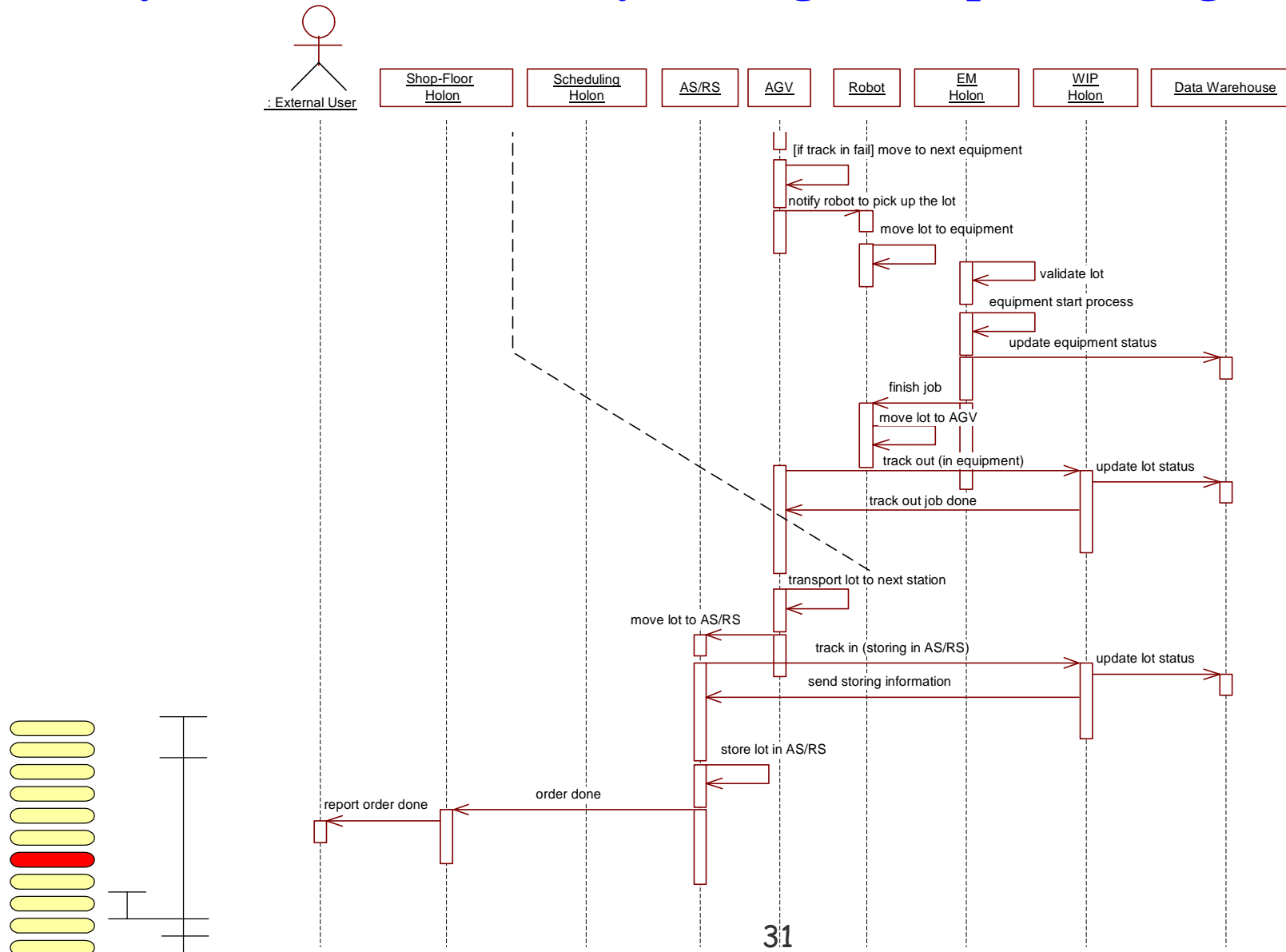
# Holarchy Design -- Define Holarchy Messages

## Fully-Automated Holarchy Messages - Sequence Diagram



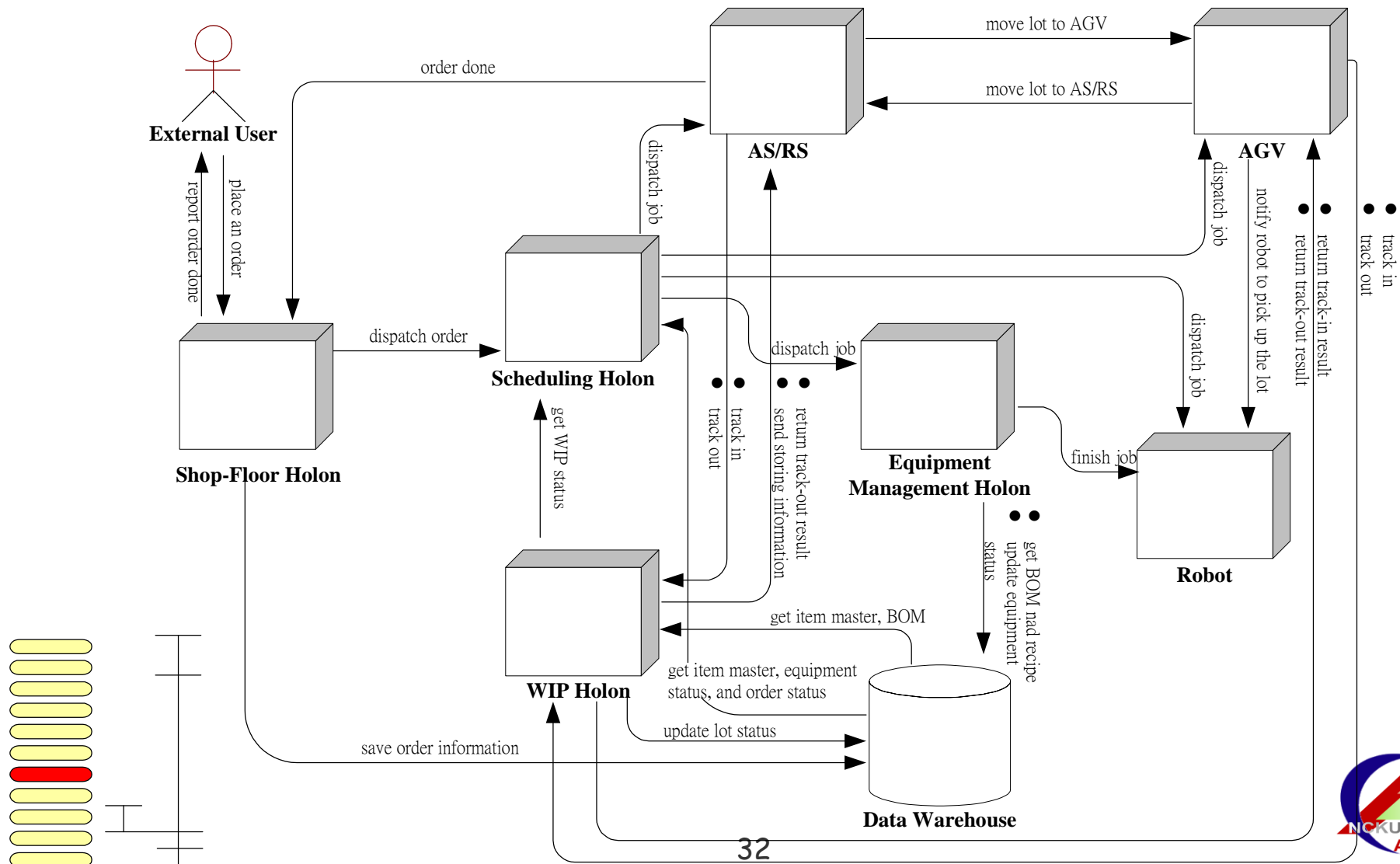
# Holarchy Design -- Define Holarchy Messages

## Fully-Automated Holarchy Messages - Sequence Diagram(Cont'd)

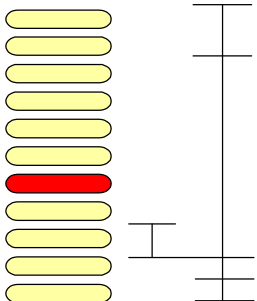


# Holarchy Design -- Define Holarchy Messages

## Fully-Automated Holarchy Messages - Collaboration Diagram

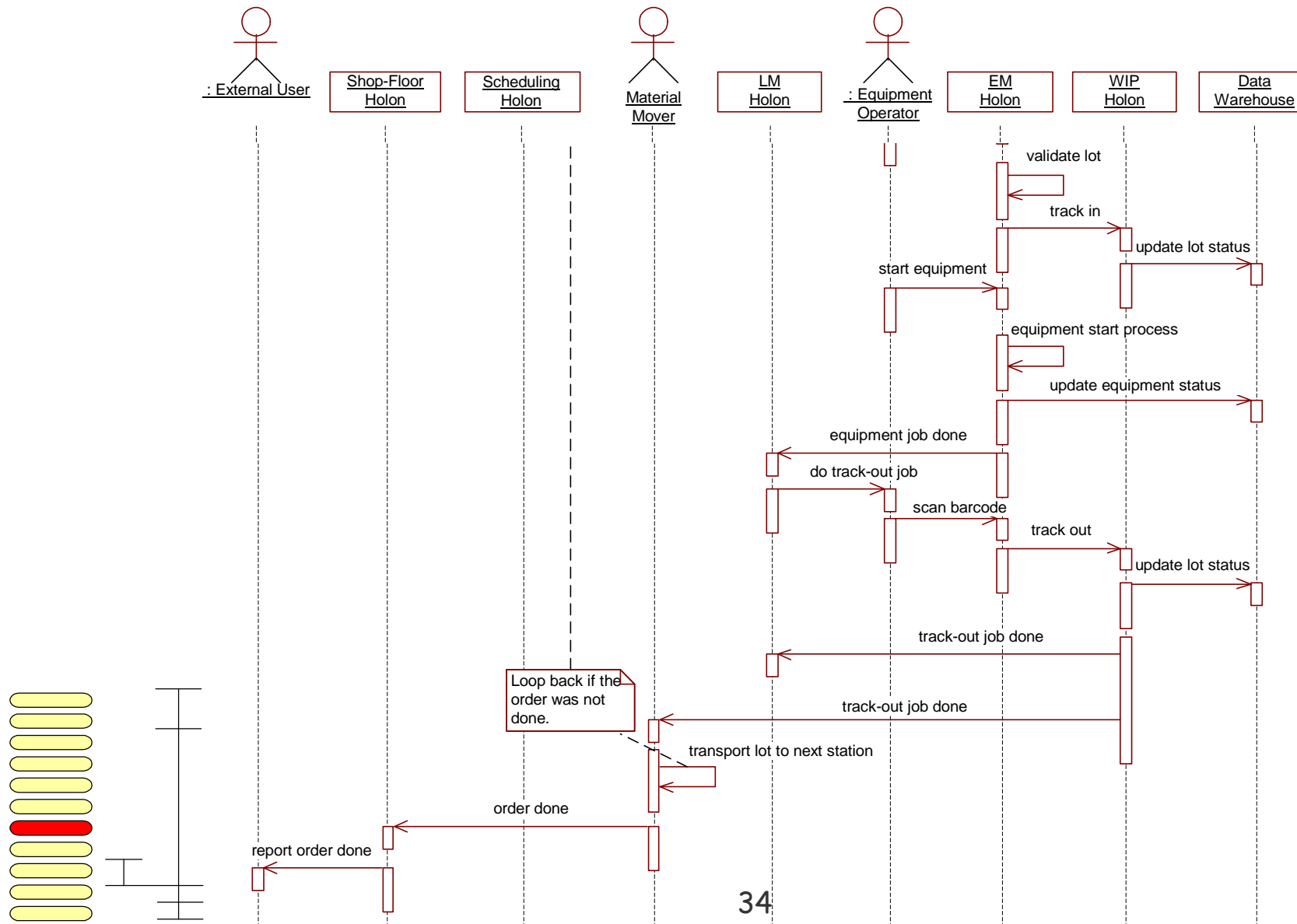






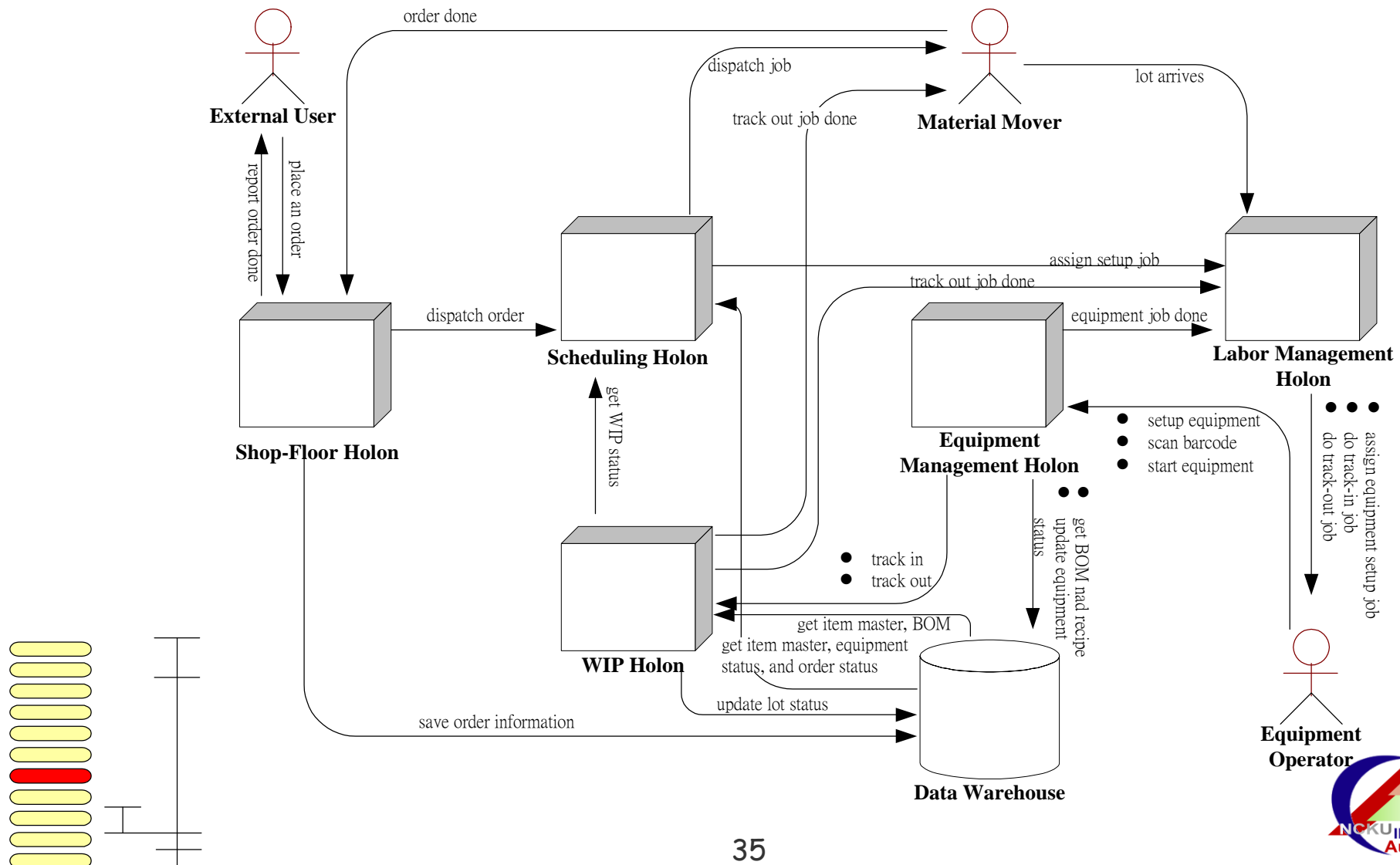
# Holarchy Design -- Define Holarchy Messages

## Semi-Automated Holarchy Messages - Sequence Diagram (Cont'd)

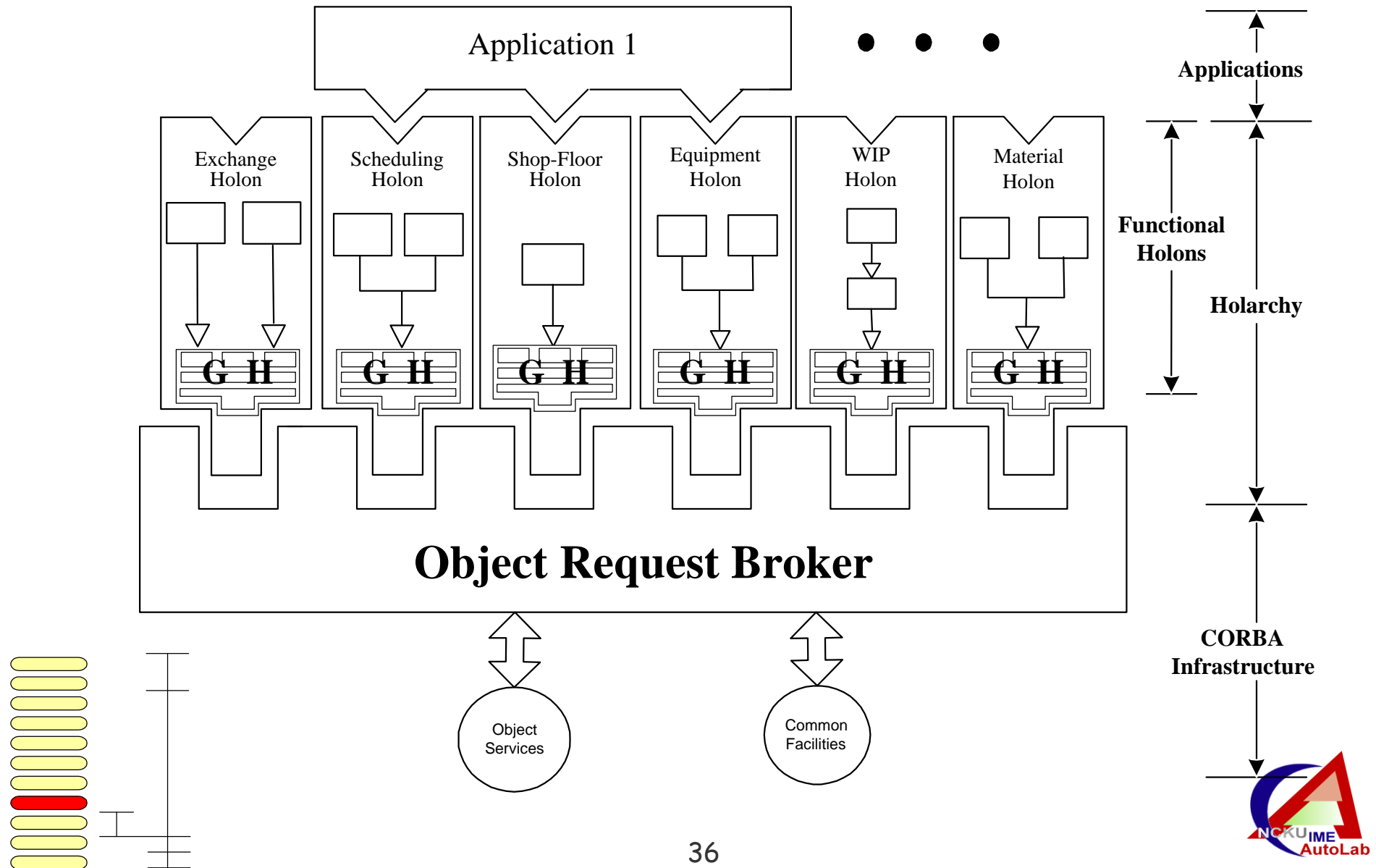


# Holarchy Design -- Define Holarchy Messages

## Semi-Automated Holarchy Messages - Collaboration Diagram



# Holarchy Design -- Holarchy Framework of HMES



# Outlines

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☺ Introduction

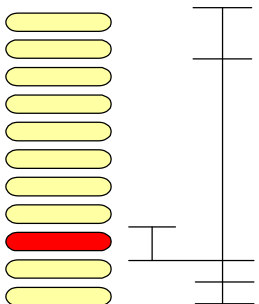
☺ Basic Foundations

☺ Development of Holonic Manufacturing Execution Systems

☑ Development of WIP Holons

☺ Implementation and System Integration

☺ Summary and Conclusions



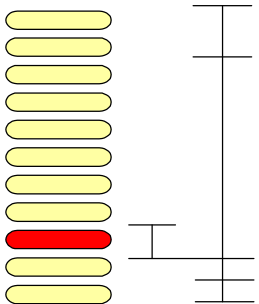
# Development of WIP Holons

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✧ Requirements for WIP Holons

✧ Object-Oriented Analysis

✧ Object-Oriented Design

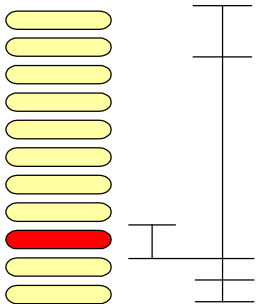


# Development of WIP Holons

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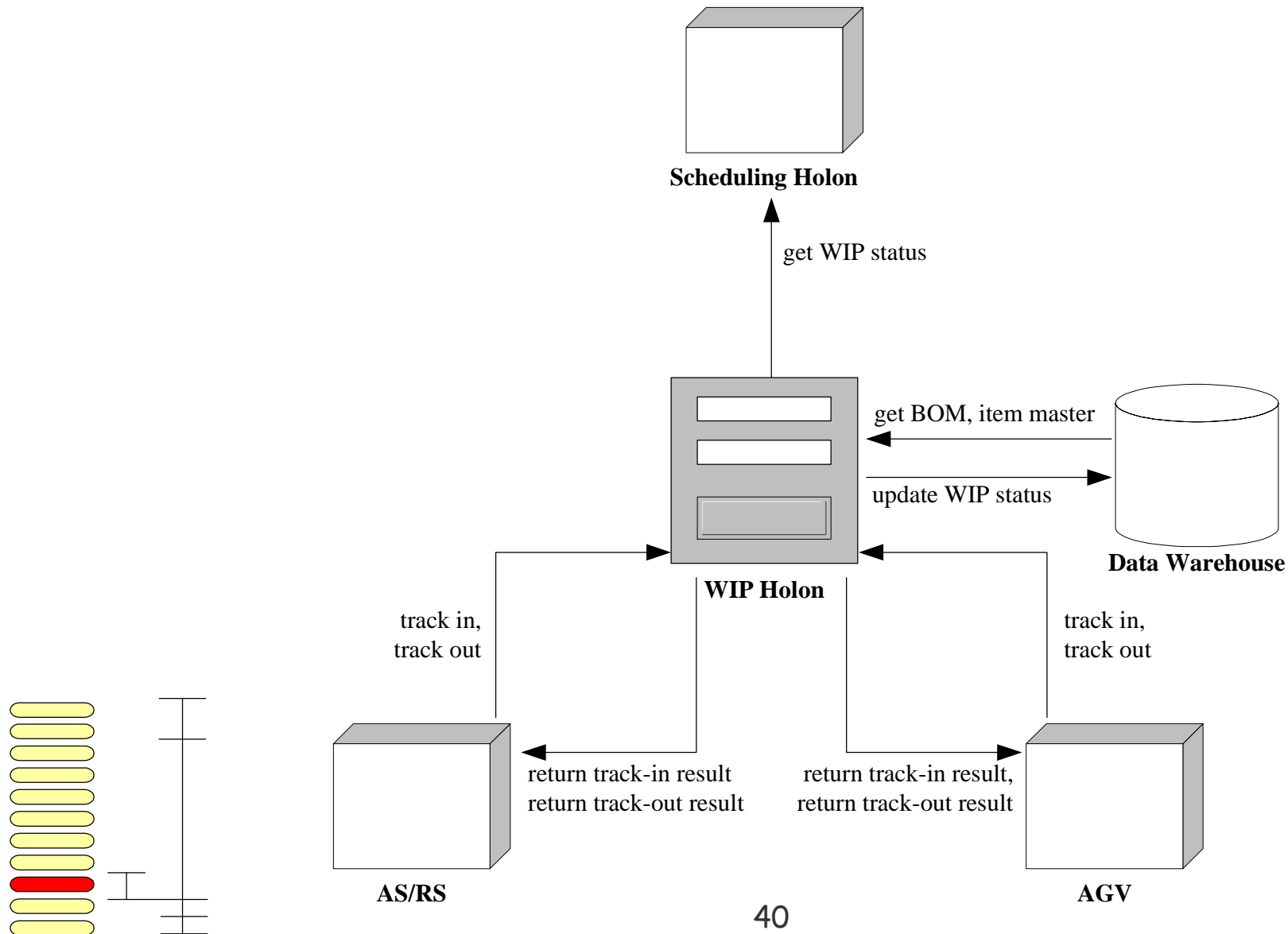
## Requirements for WIP Holon

- Real-Time Update WIP
- Track by Process of Lots
- Provide Information for Other Holons
- Provide Information for Users
- Ability of Accessing DBMS
- Open Interfaces
- Error Recovery
- Security Certification



# Development of WIP Holons

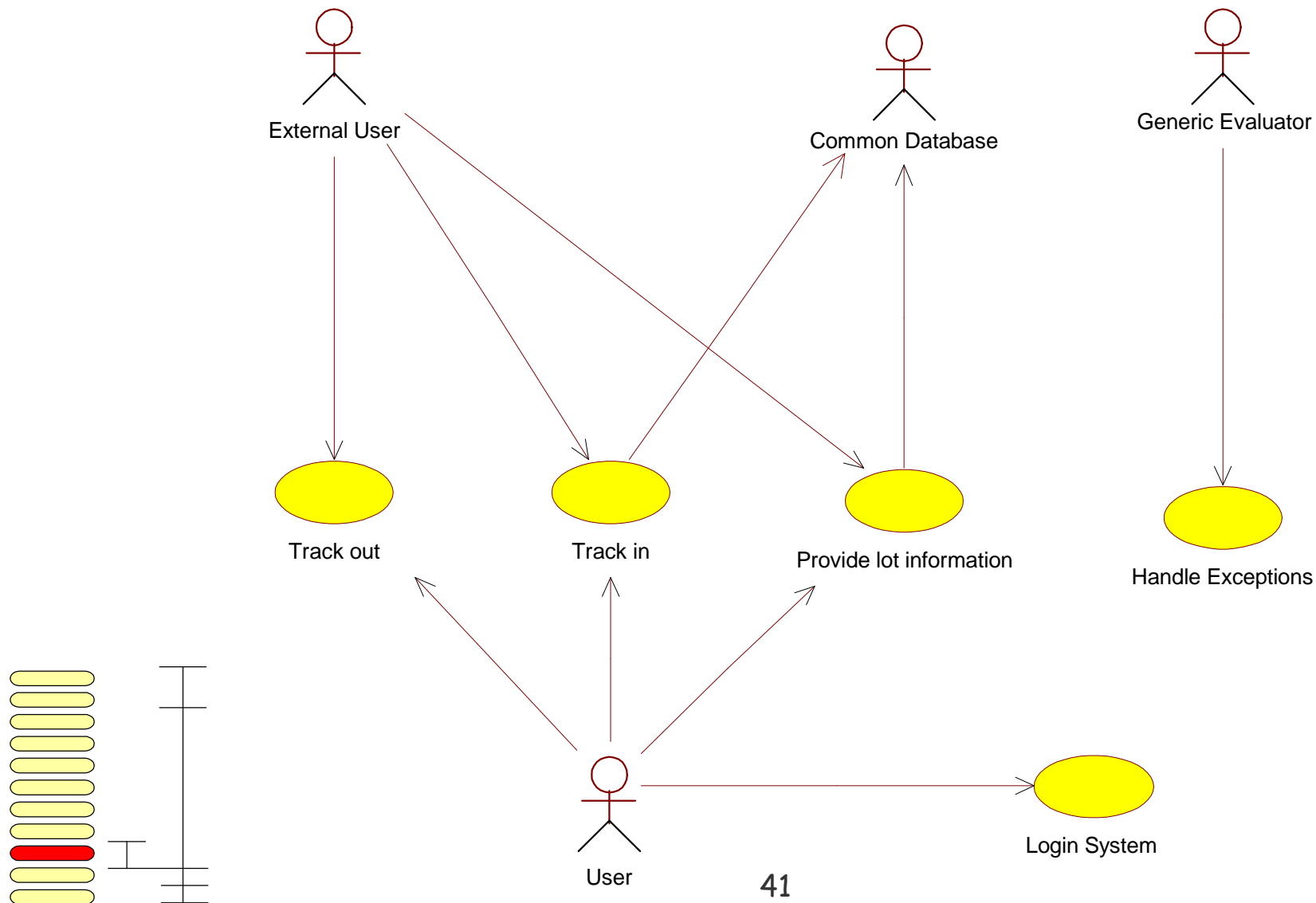
## Holarchy Messages of WIP Holon





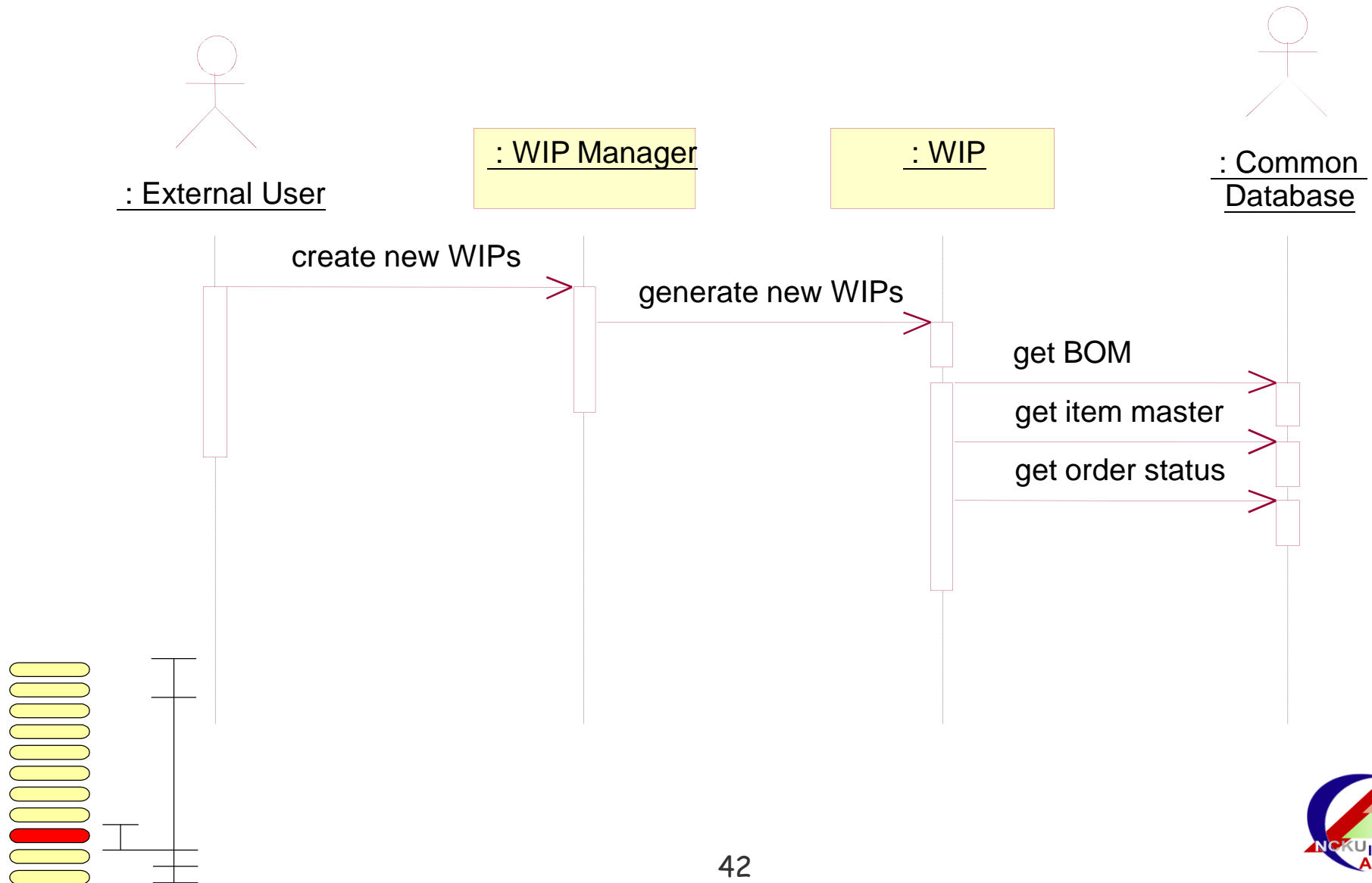
# Development of WIP Holons

## Use Case Diagram for WIP Holon



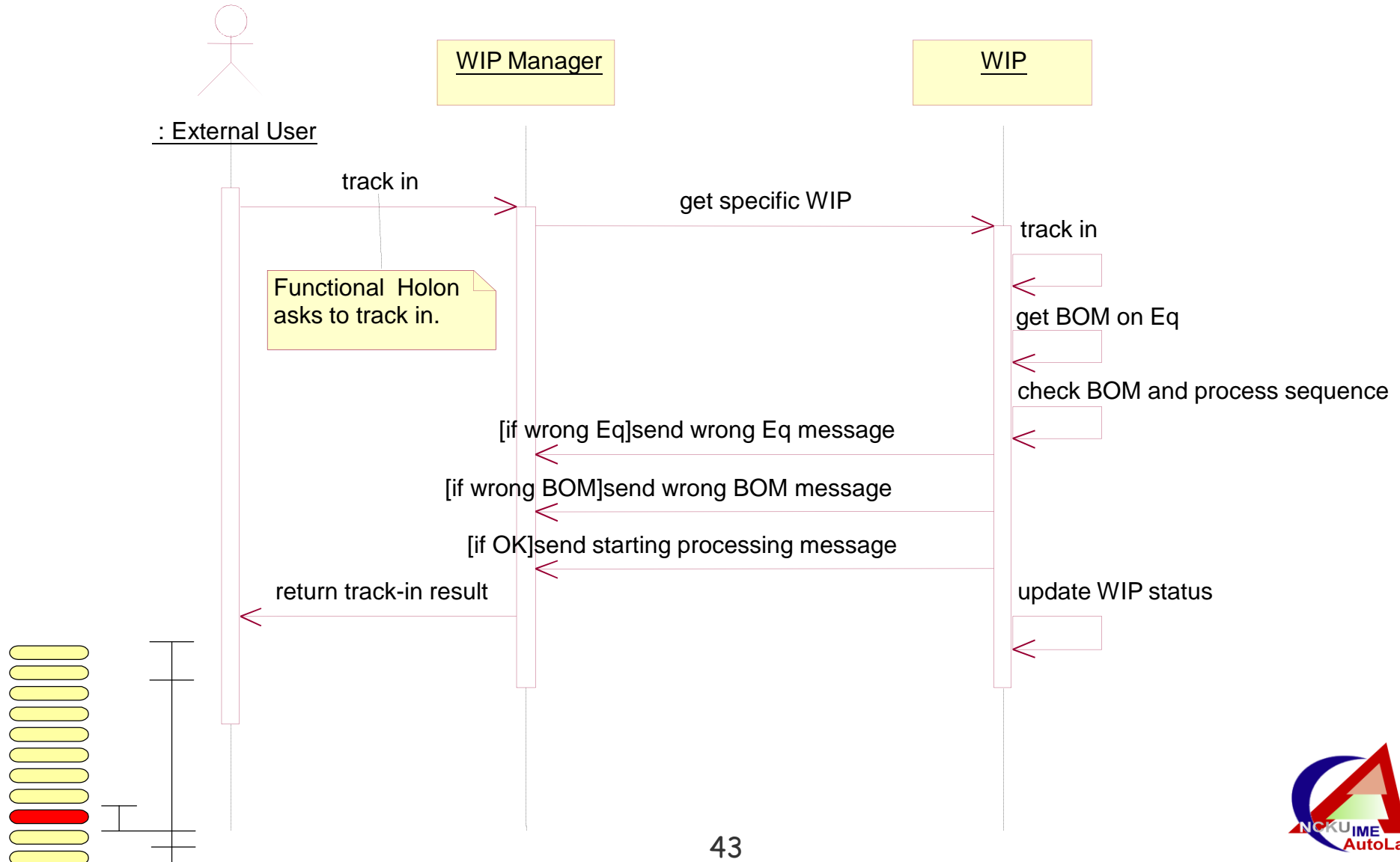
# Development of WIP Holons

## Creating New WIP Object (OOA)



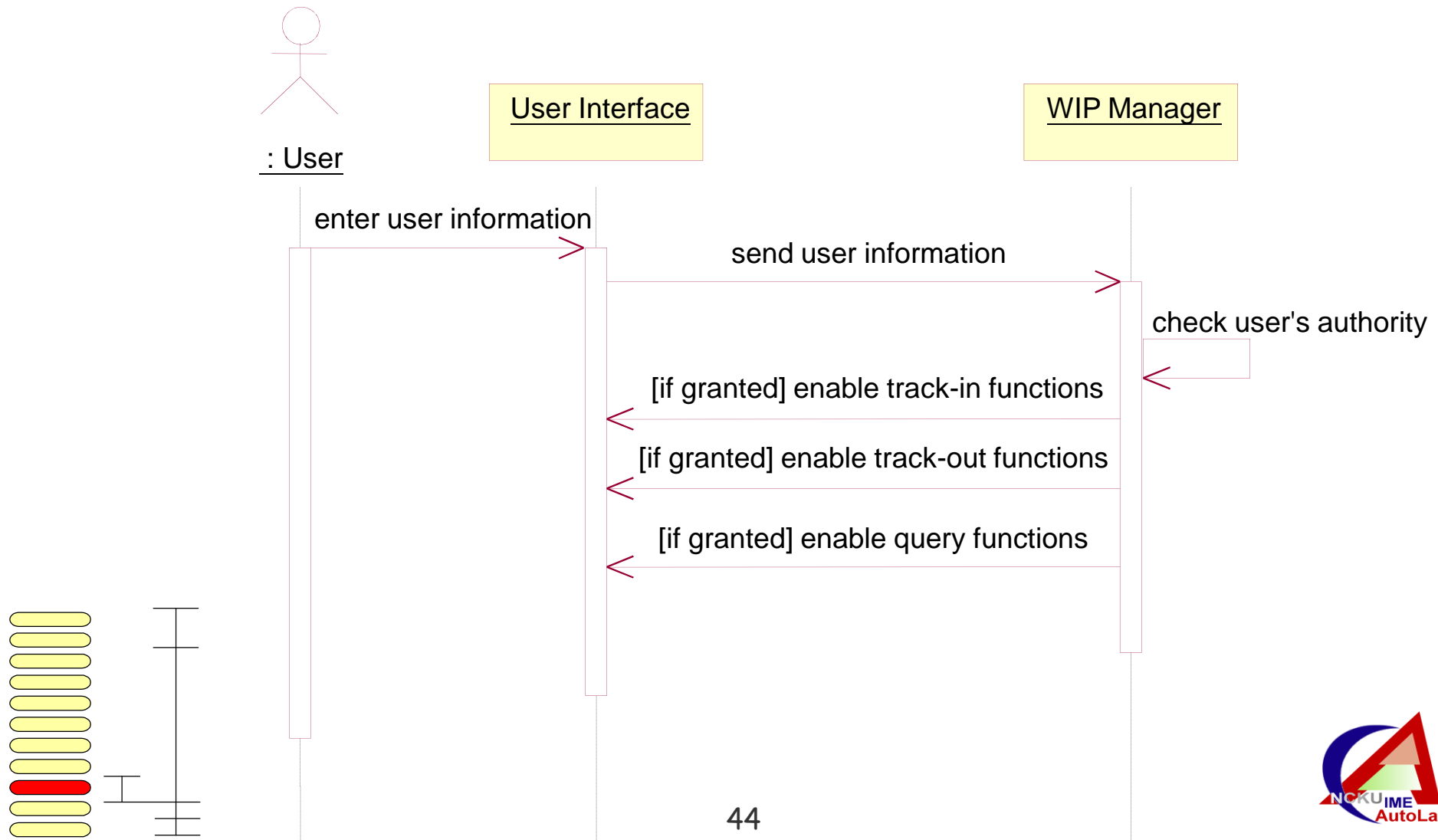
# Development of WIP Holons

## Regular Track in (OOA)



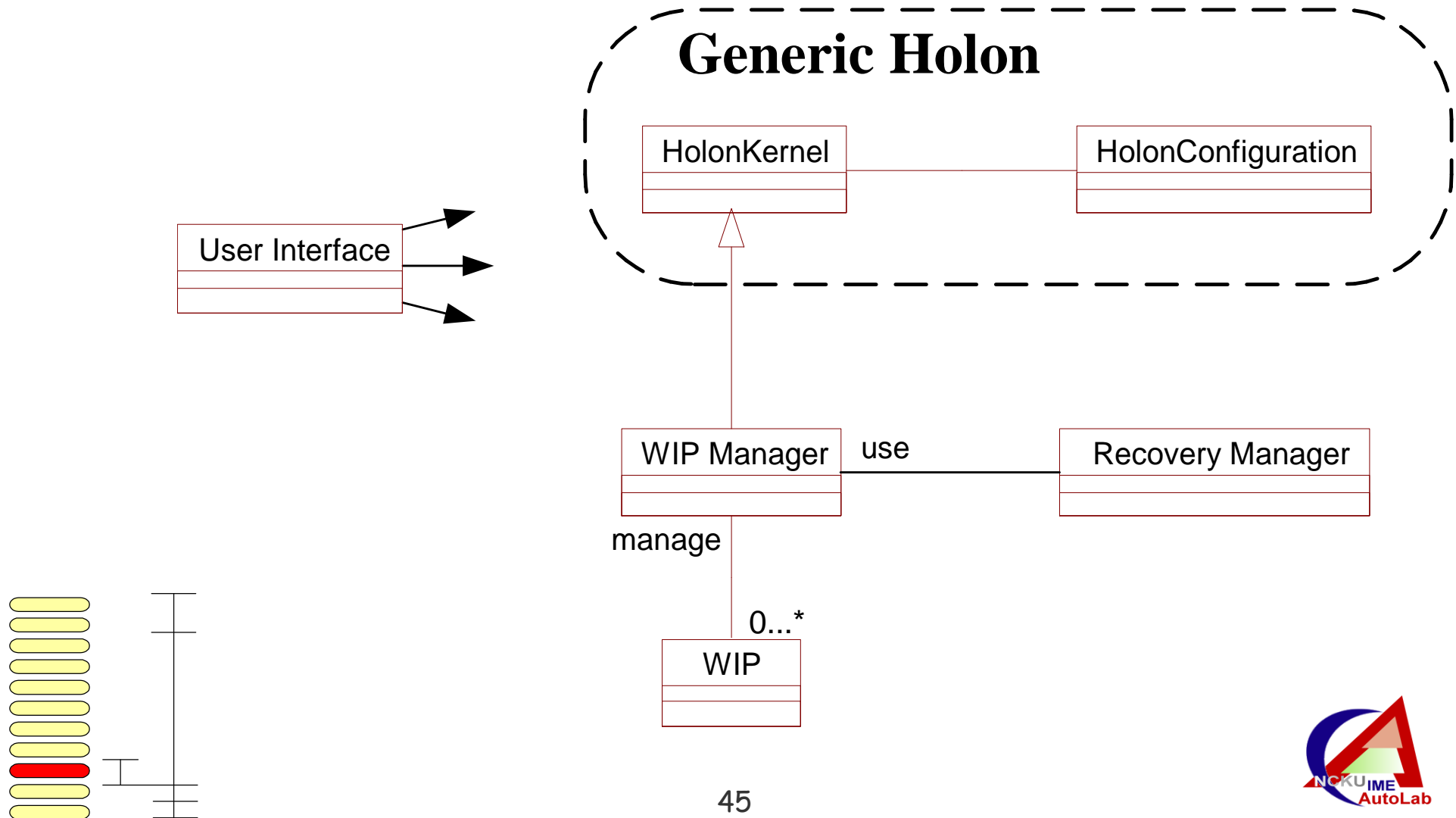
# Development of WIP Holons

## User Login System (OOA)



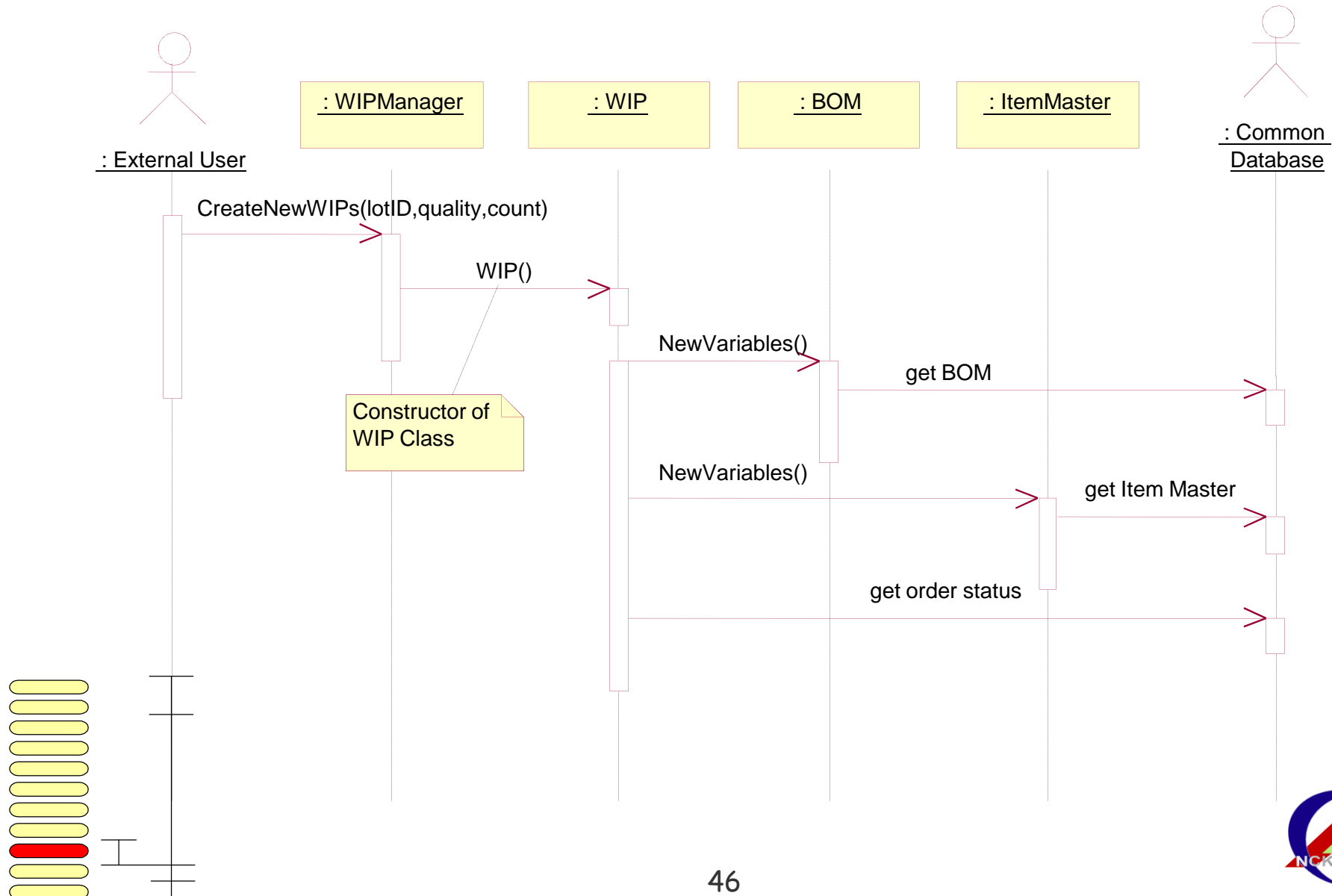
# Development of WIP Holons

## OOA-Stage Class Diagram



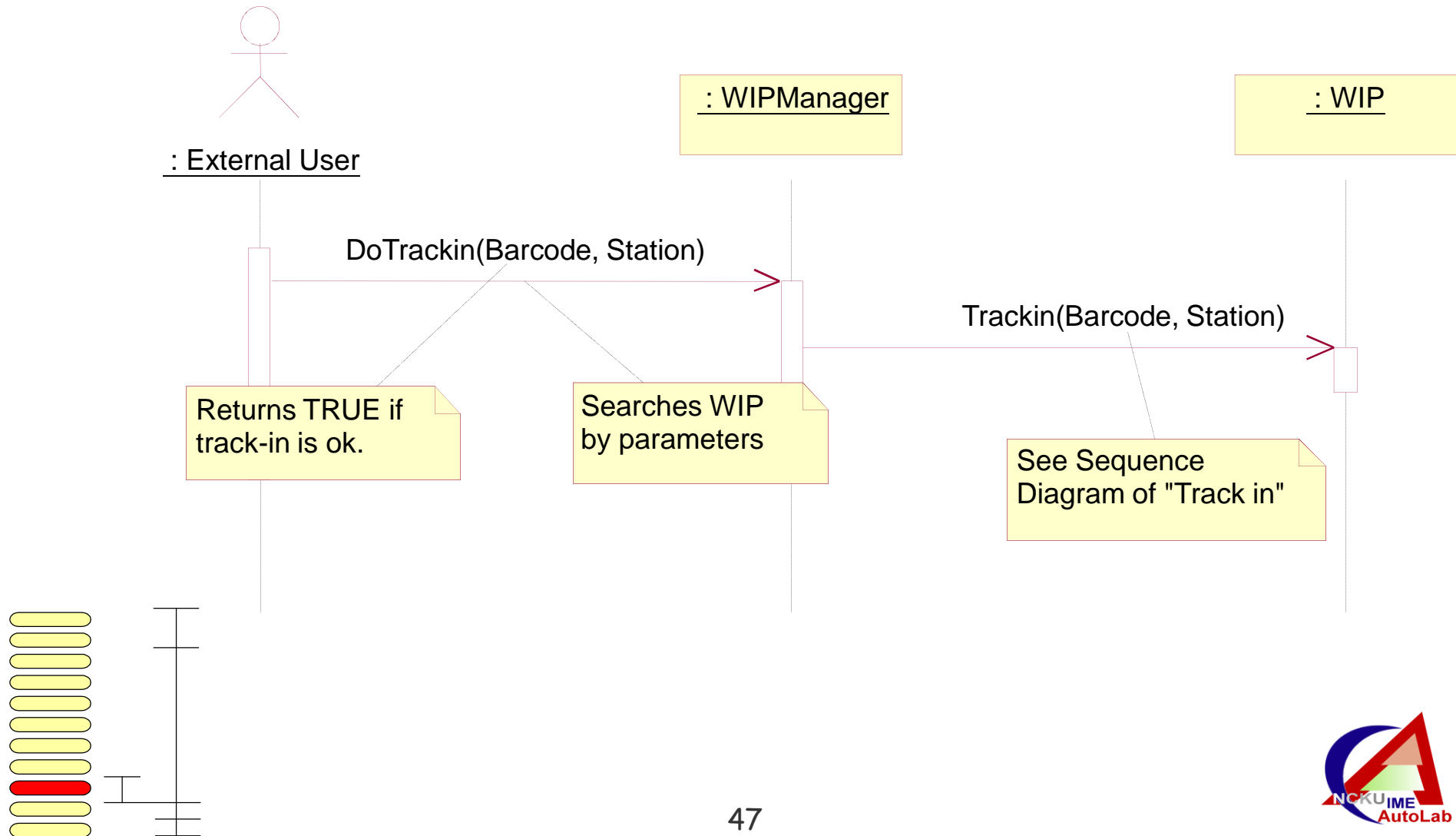
# Development of WIP Holons

## Creating New WIP Object (OOD)



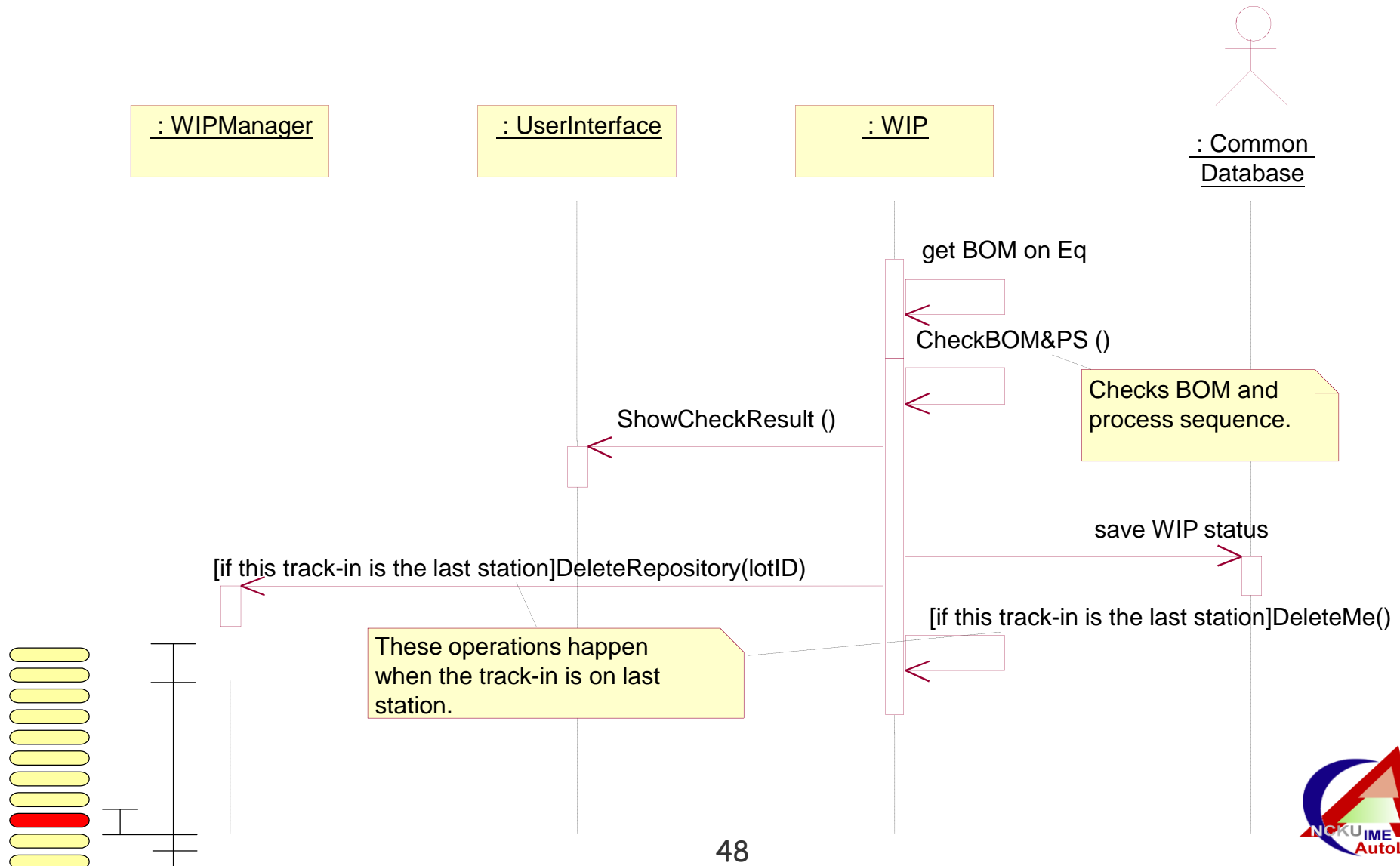
# Development of WIP Holons

## Regular Track in (OOD)



# Development of WIP Holons

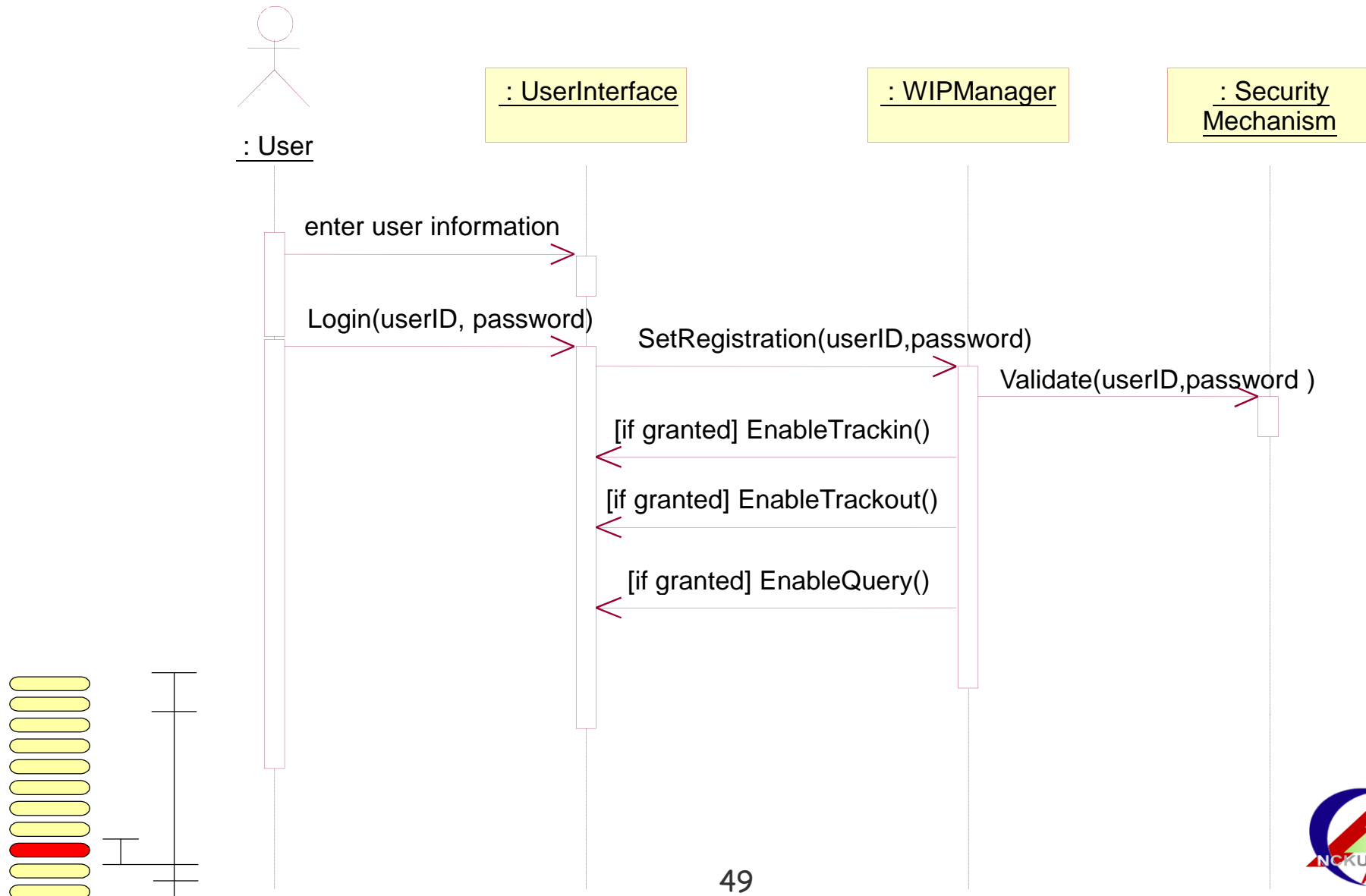
## “Track in” Operation (OOD)





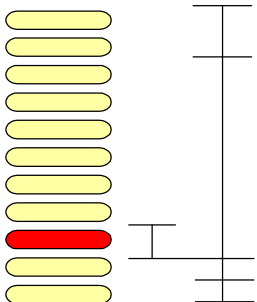
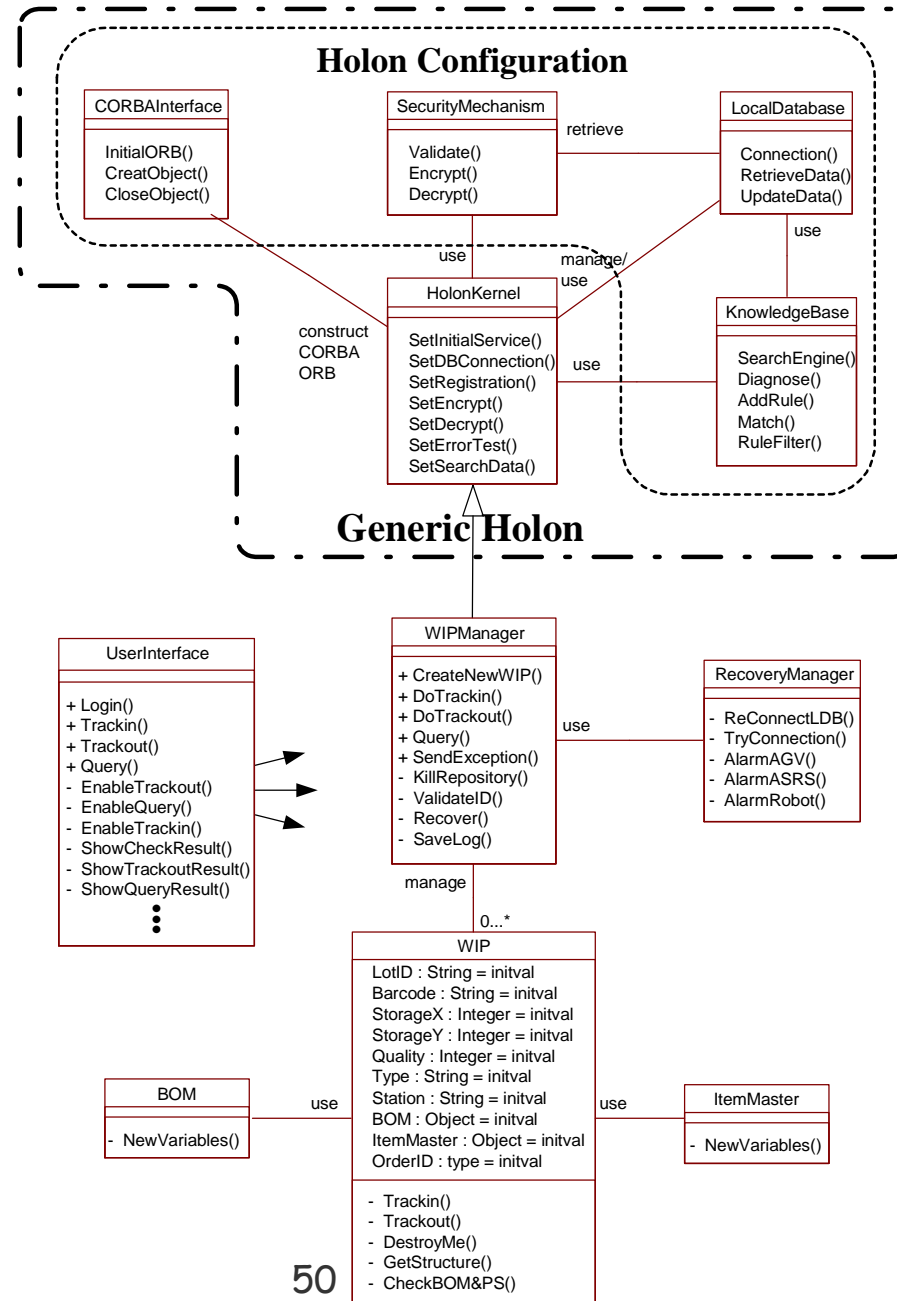
# Development of WIP Holons

## User Login System (OOD)



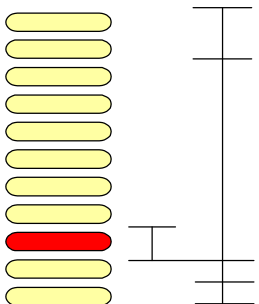
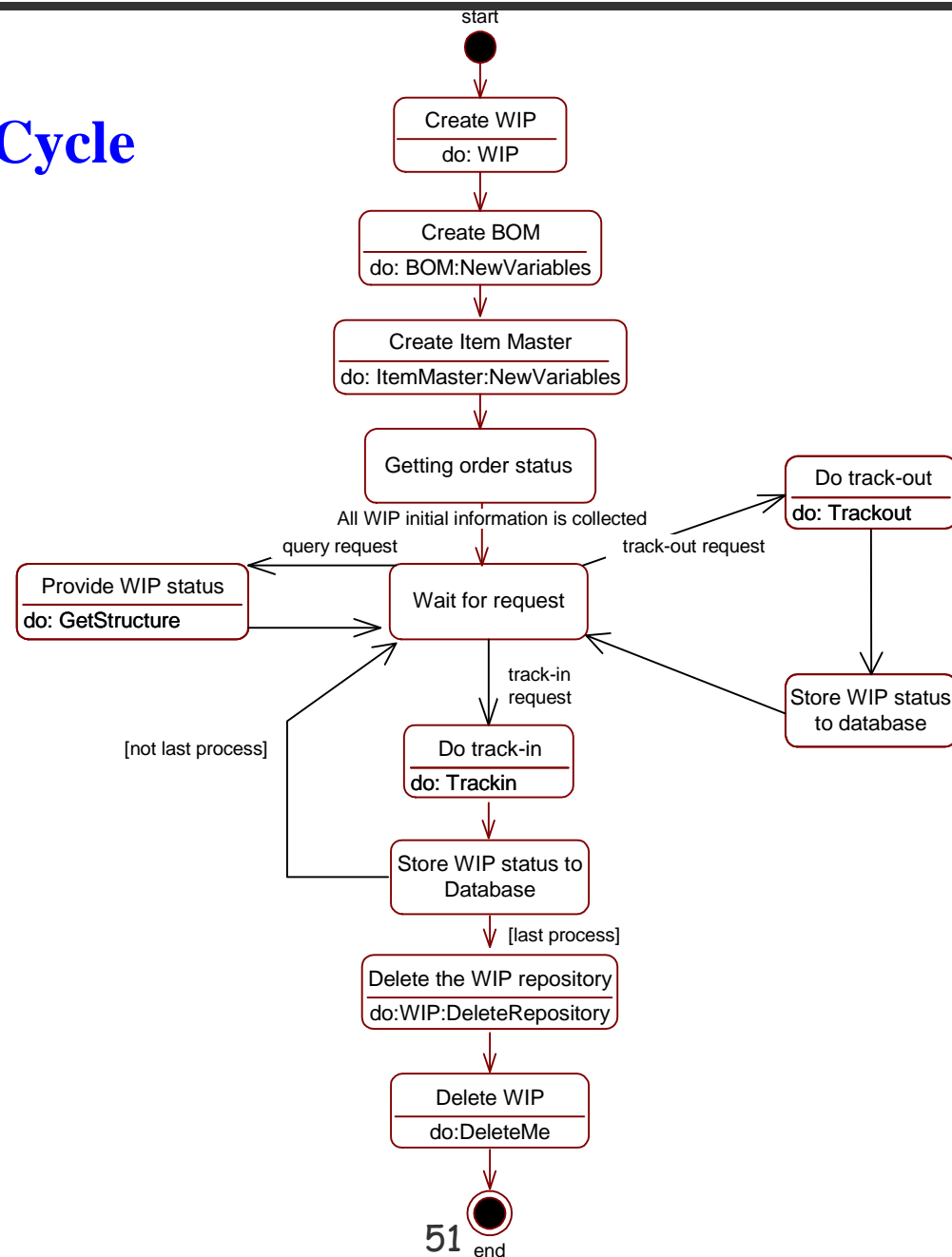
# Development of WIP Holons

## OOD-Stage Class Diagram



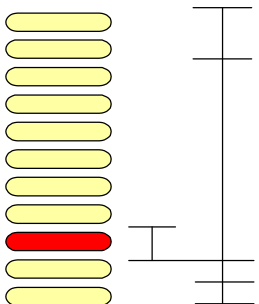
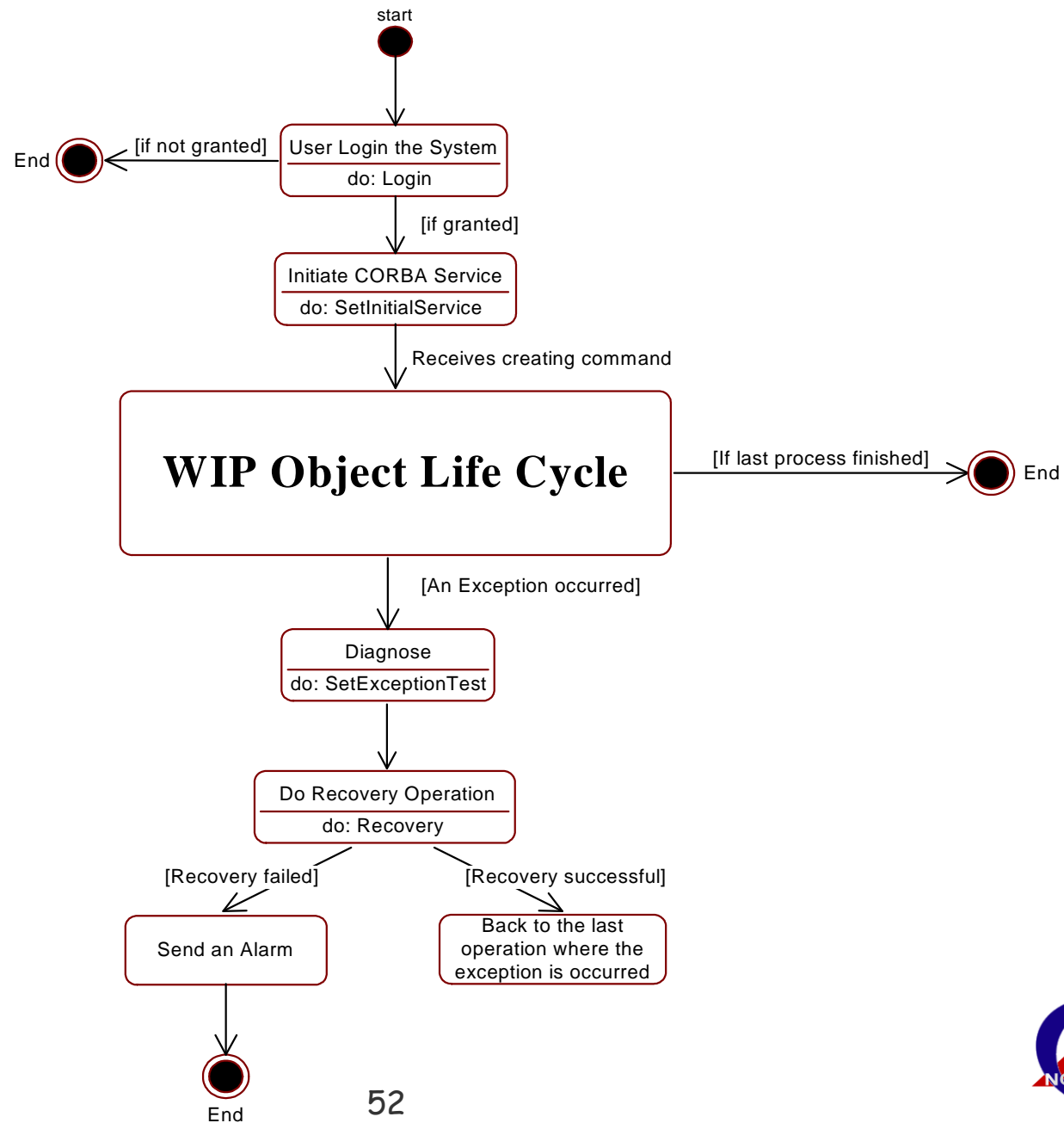
# Development of WIP Holons

## State Diagram of WIP Object Life Cycle



# Development of WIP Holons

## State Diagram of WIP Holon



# Outlines

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☺ Introduction

☺ Basic Foundations

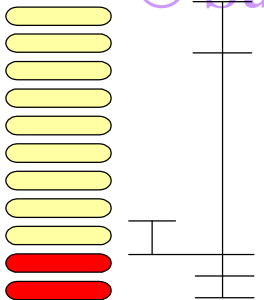
☺ Development of Holonic Manufacturing Execution Systems

☺ Development of Scheduling Holons

☺ Development of WIP Holons

☒ **Implementation and System Integration**

☺ Summary and Conclusions



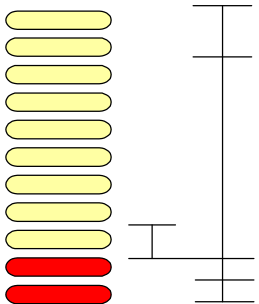
# Implementation and System Integration

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☆System Deployment Architecture

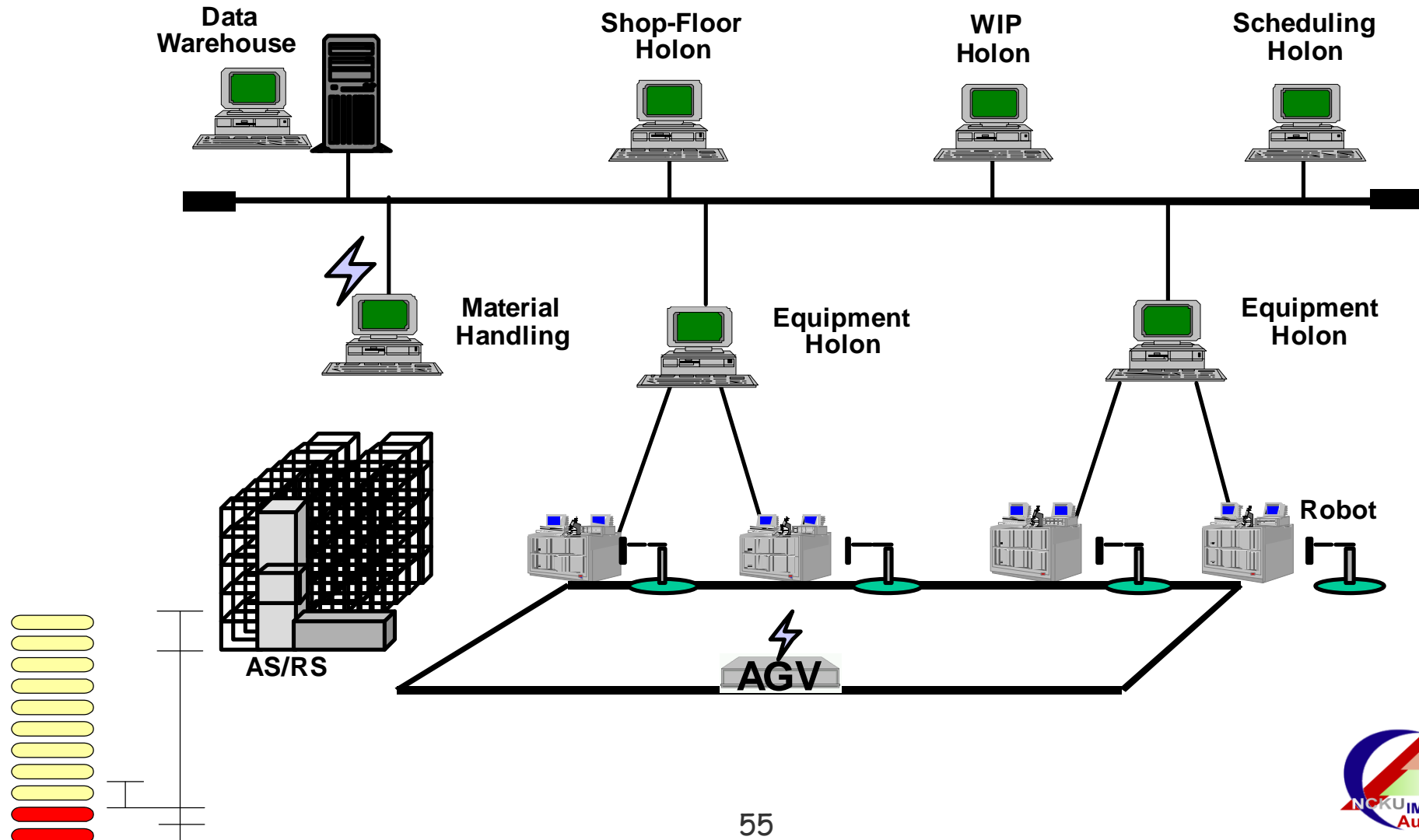
☆Functional Holons Implementation Procedure

☆Application Construction with System Integration



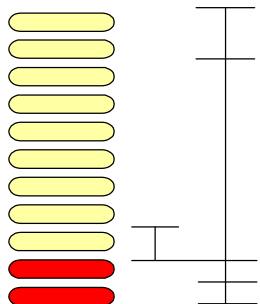
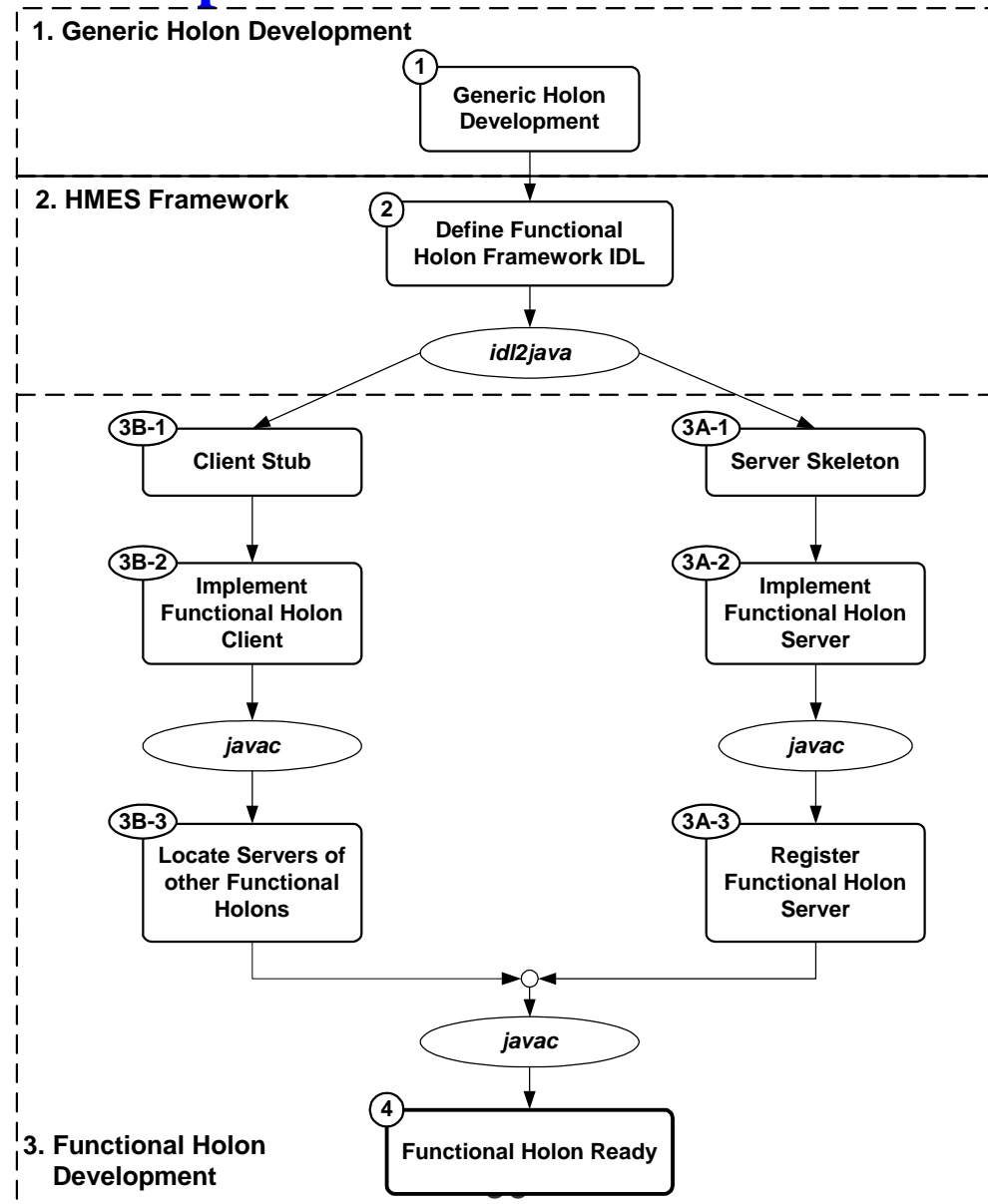
# Implementation and System Integration

## System Deployment Architecture



# Implementation and System Integration

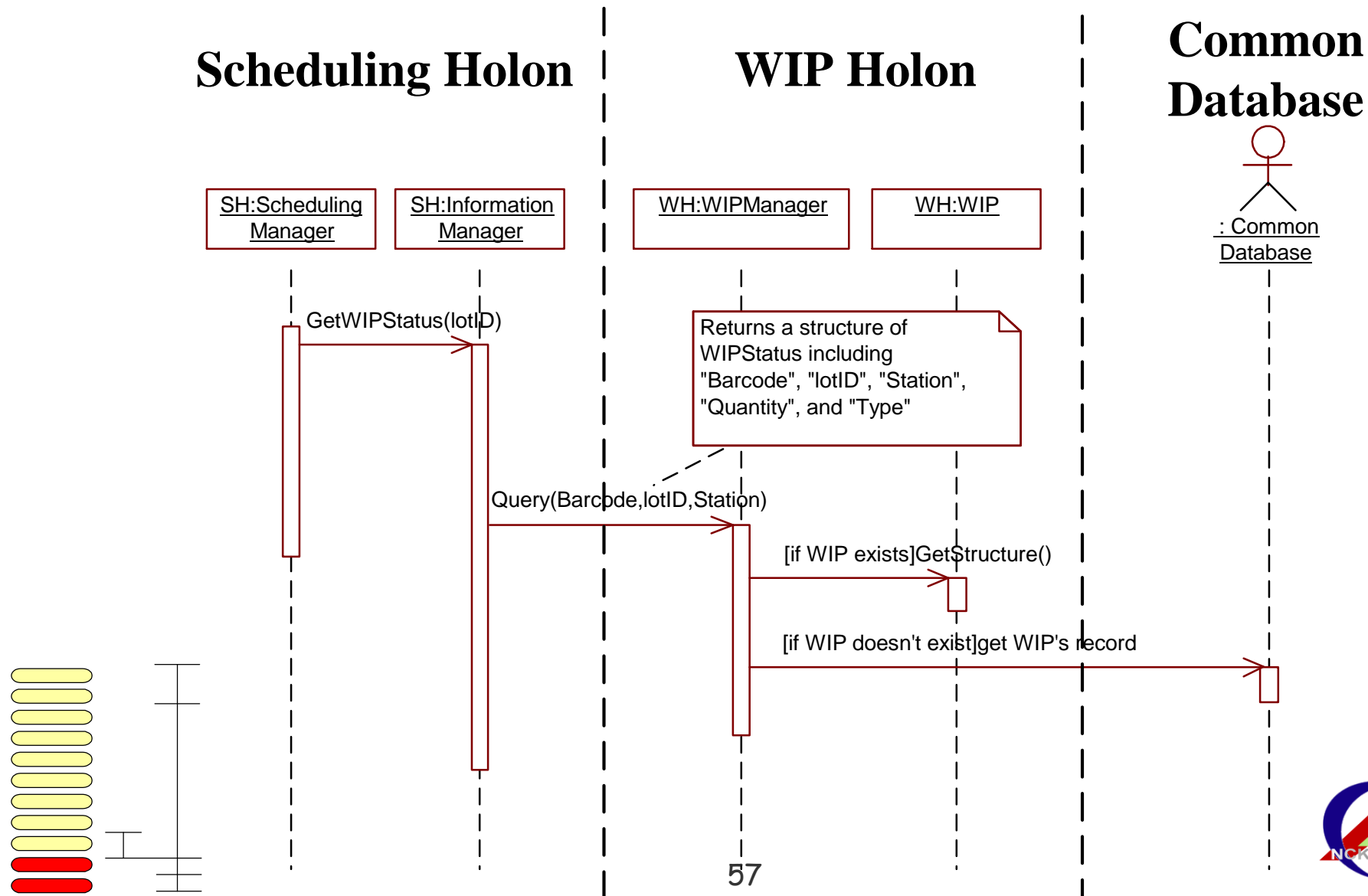
## Functional Holons Implementation Procedure





# Implementation and System Integration

## Application Example for Getting WIP Status



# Outlines

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☺ Introduction

☺ Basic Foundations

☺ Development of Holonic Manufacturing Execution Systems

☺ Development of Scheduling Holons

☺ Development of WIP Holons

☺ Implementation

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# Summary and Conclusions

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✧ Comparisons between MES and HMES

✧ Summary and Conclusion

# Summary and Conclusions

## Comparisons between MES and HMES

	<b>Legacy MES</b>	<b>MES Framework</b>	<b>HMES Framework</b>
<b>Architecture</b>	Centralization	Distributed OO	Holarchy
<b>Open Interfaces</b>	No	Yes	Yes
<b>Modularization</b>	Low	High	High
<b>Interoperability</b>	Low	High	High
<b>Configurability</b>	Low	High	High
<b>Cost</b>	High	Low	Low
<b>Maintainability</b>	Difficult	Easy	Easy
<b>Security Certification</b>	No	No	Yes
<b>Failure Recovery</b>	No	No	Yes

\*Legacy MES: Promis, WorkStream, etc.,  
Framework MES: SiView, FACTORYWorks, etc.,



# Summary and Conclusions

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- ©Present a new concept for developing next generation Manufacturing Execution Systems.
- ©Provide a systematic procedure to develop holonic manufacturing systems.
- ©Demonstrate the feasibility and capability of HMES by designing and implementing a WIP Holon.

# END

Thanks.....  
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