SWE 621:
Software Modeling and Architectural Design

Lecture Notes on Software Design

Lecture 8 – Architectural Design of Distributed Applications

Hassan Gomaa

Dept of Computer Science
George Mason University
Fairfax, VA

Overview

- Collaborative Object Modeling and architectural design mEThod (COMET)
  - Object Oriented Analysis and Design Method
  - Uses UML (Unified Modeling Language) notation
    - Standard approach for describing a software design
  - COMET = UML + Method
- Provides steps and guidelines for
  - Software Modeling and Design
  - From Use Case Models to Software Architecture
- H. Gomaa, *Software Modeling and Design: UML, Use Cases, Patterns, and Software Architectures*, Cambridge University Press, February 2011

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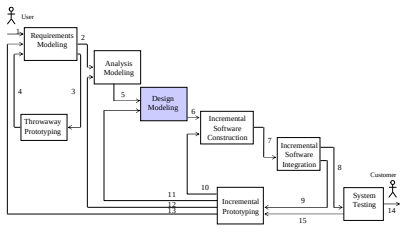
Reference: H. Gomaa, Chapters 12, 13, 15 - *Software Modeling and Design*, Cambridge University Press, February 2011

Steps in Using COMET/UML

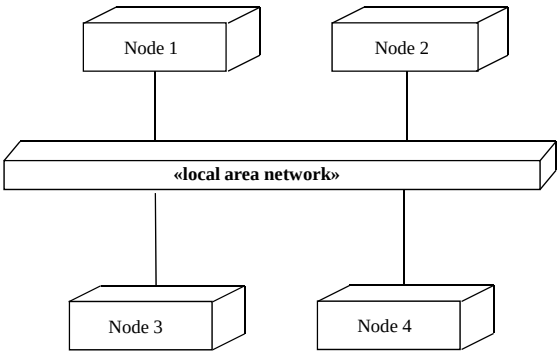
1 Develop Software Requirements Model
2 Develop Software Analysis Model
3 **Develop Software Design Model**
- Design Overall Software Architecture (Chapter 12, 13)
- **Design Distributed Applications (Chapter 12,13,15)**
- Structure Subsystems into Concurrent Tasks (Chapter 18)
- Design Information Hiding Classes (Chapter 14)
- Develop Detailed Software Design

Figure 6.1 COMET object-oriented software life cycle model



Architectural Design of Distributed Applications

- Distributed processing environment
  - Multiple computers communicating over network
- Typical applications
  - Distributed real-time data collection
  - Distributed real-time control
  - Client / server applications
- COMET/UML for Distributed Applications
  - Addresses structuring application into distributed subsystems



Distributed processing environment

Figure 15.1 Basic Client / Server configuration

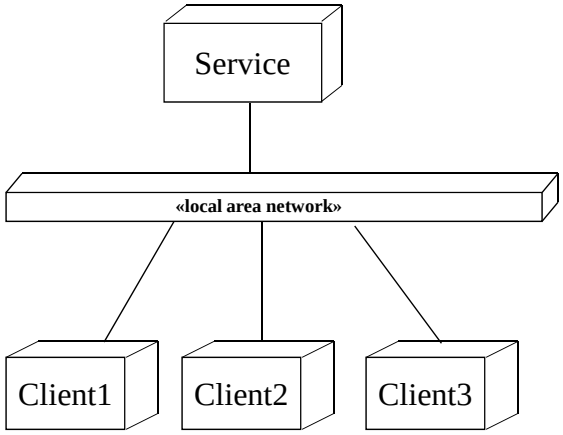
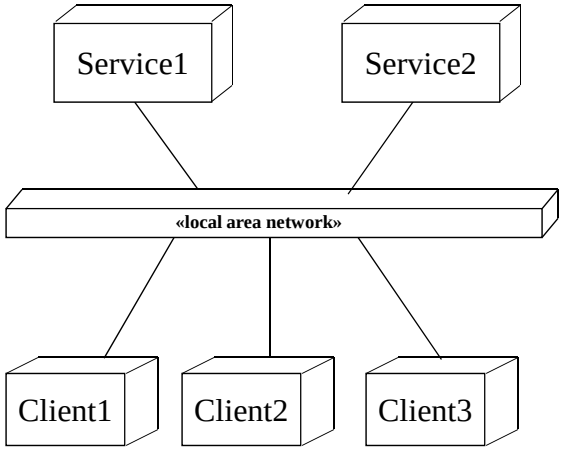
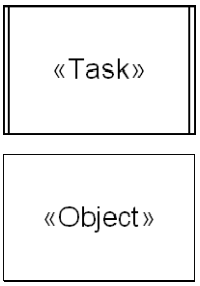


Figure 15.4 Distributed processing configuration

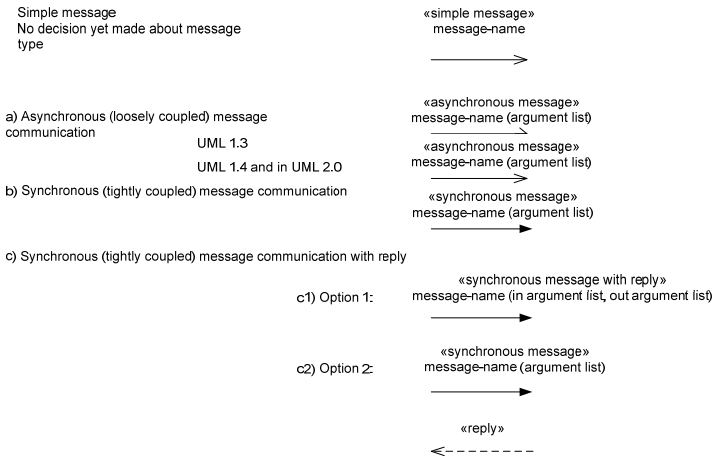


Active and Passive Objects

- Objects may be **active** or **passive**
- **Active object**
  - **Concurrent task or component**
  - Has thread of control
- **Passive object**
  - a.k.a. **Information Hiding Object**
  - Has no thread of control
  - Operations of passive object are executed by task



UML notation for messages



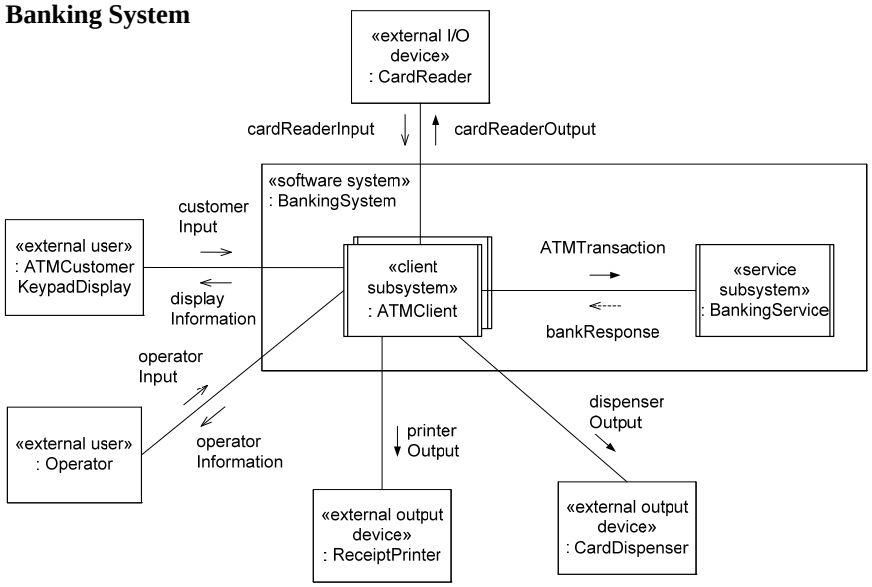
Characteristics of Distributed Applications

- Structure of component-based distributed application
  - Consists of one or more component-based subsystems
  - Each subsystem designed as a distributed component
  - Execute on multiple nodes in distributed configuration
- Structure of component-based subsystem
  - Consists of one or more objects
  - Objects all execute on same node
- Communication between component-based subsystems
  - Message communication

Steps in Designing Distributed Applications

- System Decomposition
  - Decompose system into distributed subsystems
    - Each subsystem designed as configurable component
    - Component
      - Active self-contained object with a well-defined interface, capable of being used in different applications from that for which it was originally defined
  - Define message communication interfaces
- Subsystem Decomposition
  - Structure subsystem into active objects (tasks) and passive objects
- System Configuration
  - Define component subsystem instances of target system
  - Map to hardware configuration

Figure 21.28 Design of Subsystem interfaces –high level communication diagram for Banking System



Define Subsystem Interfaces

- Message Communication between distributed subsystems
  - Loosely coupled (asynchronous) message communication
  - Multiple Client / Server message communication
    - Tightly coupled (synchronous) message communication
    - Remote Procedure Call
  - Group Message Communication
    - Broadcast message communication
    - Multicast message communication
  - Object Broker Architecture
  - Negotiation among Software Agents
  - Transaction Processing

Asynchronous Message Communication (Loosely Coupled)

- Producer sends message and continues
- Consumer receives message
  - Suspended if no message is present
  - Activated when message arrives
- Message queue may build up at Consumer

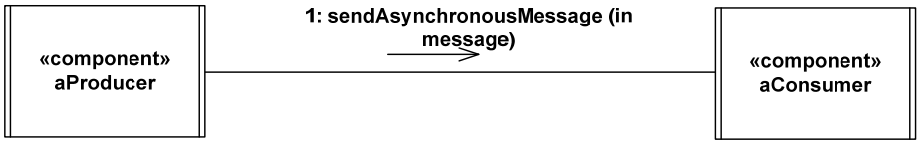


Figure 12.8 Asynchronous message communication

Synchronous Message Communication with Reply (Tightly Coupled)

- Service
  - Responds to message requests from several clients
- Client
  - Sends message to Service and Waits for response
- Remote Procedure Call
  - Client makes RPC to service on different node
  - Communication details hidden from client & service
- Remote method invocation (RMI)
  - Client object sends message to service object

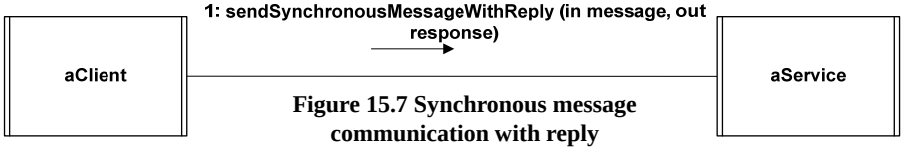
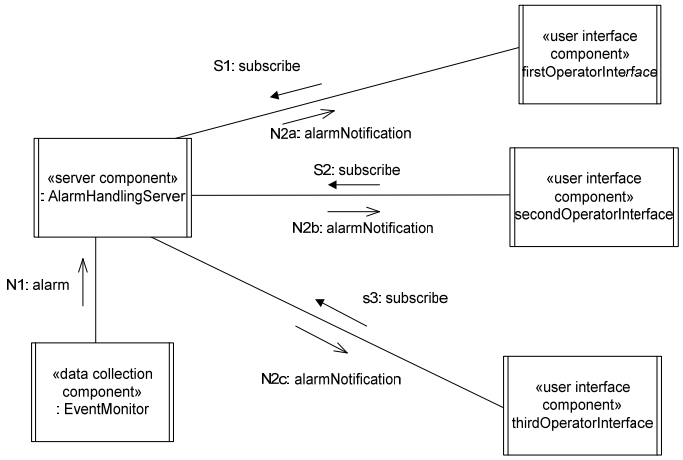


Figure 15.7 Synchronous message communication with reply

Group Message Communication

- One-to-many message communication
  - Same message sent to several recipients
- Broadcast message communication
  - Message sent to all recipients
- Multicast message communication
  - Same message sent to all members of group
- Subscription/Notification communication
  - Client subscribes to group
  - Receives messages sent to all members of group
  - Sender sends message to group
    - Does not need to know recipients

Figure 17.10 Example of subscription/notification (message multicast) communication



Distributed Objects and Object broker

- Clients and Servers designed as distributed objects
- Object Broker
  - Mediates interactions between clients and servers
  - Frees client from having to maintain information
    - Where particular service provided
    - How to obtain service
- Servers register Services & Location with Broker
- Clients request information from Broker about Servers
- Broker provides different services

Object Broker Architecture

- White pages
  - Client knows name of service but not location
  - Forwarding design
    - Broker forwards client request to Server
    - Broker forwards Server response to Client
  - Handle-driven design
    - Broker returns handle (remote reference) to Client
    - Client uses handle to communicate with Server

Figure 16.1 Service registration with Broker

- Services registers service information with Broker
  - Service name
  - Service interface
  - Service description
  - Location
- Service re-registers after moving to different location

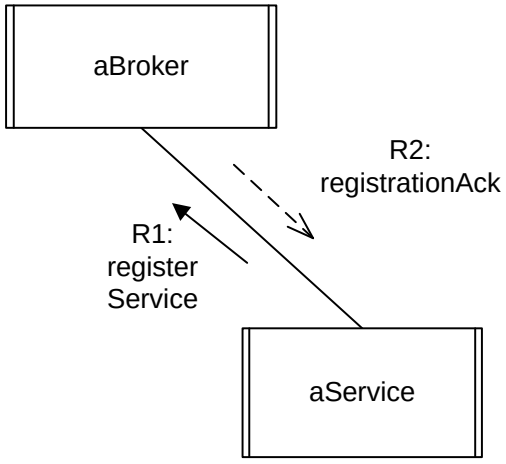


Figure 16.2: Broker Forwarding (White pages) pattern

• Broker Forwarding Pattern
  - Broker forwards client request to Service
  - Broker forwards Service response to Client

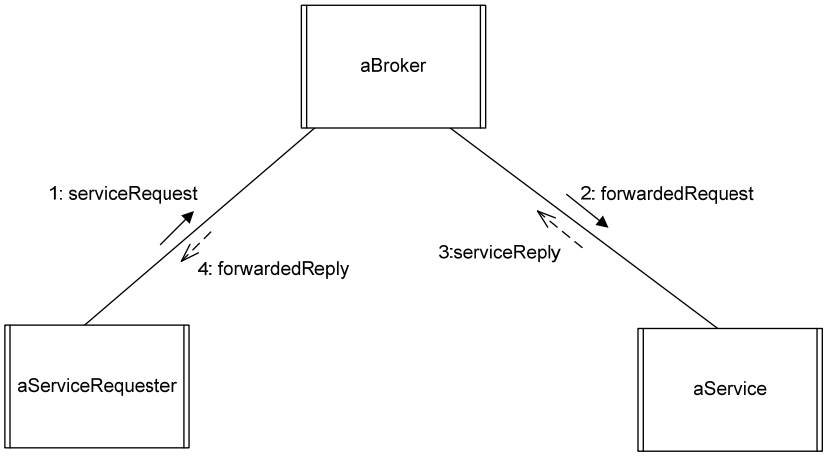
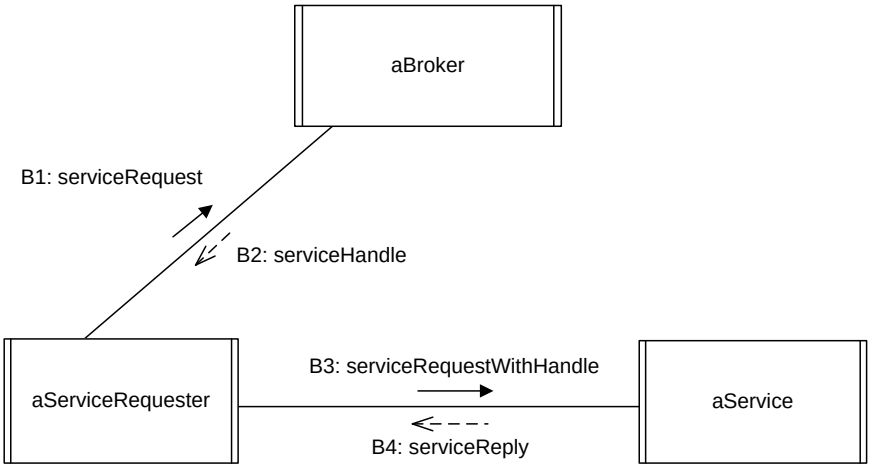


Figure 16.3: Broker Handle (White pages) pattern

• Broker Handle Pattern
  - Broker returns handle (remote reference) to Client
  - Client uses handle to communicate with Service



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