

Object-Oriented Middleware for Distributed Systems

Distributed Systems
Sistemi Distribuiti

Andrea Omicini
andrea.omicini@unibo.it

Dipartimento di Informatica – Scienza e Ingegneria (DISI)
ALMA MATER STUDIORUM – Università di Bologna a Cesena

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Outline

- 1 Middleware Overview
- 2 Object-Oriented Middleware
- 3 CORBA & OSGi

These Slides...

... are derived from a Presentation by Giovanni Rimassa, which we warmly thank

Slides were made kindly available by the author

- Every problem or mistake contained in these slides, however, should be attributed to the sole responsibility of the teacher of this course

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What is Middleware?

Traditional definition

- What is middleware?
 - The word suggests something belonging to the middle
 - But middle between what?
- The traditional middleware definition
 - The middleware lies in the middle between the Operating System and the applications
- The traditional definition stresses *vertical* layers
 - Applications on top of middleware on top of the OS
 - Middleware-to-application interfaces (*top interfaces*)
 - Middleware-to-OS interfaces (*bottom interfaces*)

Why Middleware?

Behind middleware

- Problems of today
 - Software development is *hard*
 - Experienced designers are *rare* (and *costly*)
 - Applications become more and more complex
- What can middleware help with?
 - Middleware is developed once for many applications
 - Higher quality designers can be afforded
 - Middleware can provide *services* to applications
 - Middleware abstracts away from the specific OS

Middleware and Models I

Middleware

- A key feature of middleware is *interoperability*
 - Applications using the same middleware can interoperate
 - This is true of any common platform (e.g. OS file system)
- But, many incompatible middleware systems exist
 - Applications on middleware *A* can work together
 - Applications on middleware *B* can work together, too
 - But, *A*-applications and *B*-applications cannot!
- The *Enterprise Application Integration* (EAI) task
 - Emphasis on *horizontal* communication
 - *Application-to-application* and *middleware-to-middleware*

Middleware and Models II

Conceptual integrity

- Software development does not happen *in vacuum*
 - Almost any software project must cope with past systems
 - There is never time nor resources to start *from scratch*
 - Legacy systems were built with their own approaches
- System integration is the only way out
 - Take what is already there and add features to it
 - Try to add without modifying existing subsystem
- First casualty: **Conceptual Integrity**
 - The property of a system of being understandable and explainable through a coherent, limited set of concepts

Middleware and Models III

Models from middleware to applications

- Real systems are heterogeneous
 - Piecemeal growth is a *very troublesome* path for software evolution
 - Still, it is very popular – being asymptotically the most cost effective when development time goes to zero
- Middleware technology is an *integration* technology
 - Adopting a given middleware should ease *both* new application development *and* legacy integration
 - To achieve integration while limiting conceptual drift, middleware tries to cast a *model* on heterogeneous applications.

Middleware and Models IV

Integration middleware

- Before: you have a total mess
 - A lot of systems, using different technologies
 - Ad-hoc interactions, irregular structure
 - Each piece must be described in its own reference frame
- Then: the Integration Middleware (IM) comes
 - A new, shiny model is supported by the IM
 - Existing systems are re-cast under the Model
 - New model-compliant software is developed
- After: you have the same total mess
 - But, no, now they are CORBA objects, or TuCSoN agents

Middleware Technologies

Abstract vs. concrete middleware

- Abstract middleware: a common *model*
- Concrete middleware: a common *infrastructure*
- Example: Distributed Objects
 - Abstractly, any middleware modeling distributed systems as a collection of network reachable objects has the same model: OMG CORBA, Java RMI, MS DCOM, OSGI Architecture. . .
 - Actually, even at the abstract level there are differences. . .
 - Concrete implementations, instead, aim at actual interoperability, so they must handle much finer details
 - Until CORBA 2.0, two CORBA implementations from different vendors were not interoperable
 - OSGI easily provides you with specifications—technology not so easy to find

Middleware Standards

The role of standards

- Dealing with infrastructure, a key-issue is the so-called *network effect*
 - The value of a technology grows with the number of its adopters
- Standardisation efforts become critical to build momentum around an infrastructure technology
 - Large standard consortia are built, which gather several industries together (OMG, W3C, FIPA, OSGi)
 - Big industry players try to push their technology as de facto standards, or set up more open processes for them (Microsoft, IBM, Sun)

Middleware Discussion Template

How to (re)present a middleware

- Presentation and analysis of the model underlying the middleware
 - What do they want your software to look like?
- Presentation and analysis of the infrastructure created by widespread use of the middleware
 - If they conquer the world, what kind of world will it be?
- Discussion of implementation issues at the platform and application level
 - What kind of code must I write to use this platform?
 - What kind of code must I write to build my own platform?

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Distributed Objects

From OO to Distributed OO

- Distributed systems need quality software, and they are a difficult system domain
- OOP is a current software best practice
- Questions are
 - Can we apply OOP to Distributed Systems programming?
 - What changes and what stays the same?
- Distributed Objects apply the OO paradigm to Distributed Systems
 - Examples: CORBA, DCOM, Java RMI, JINI, EJB, OSGi

Core of OOP I

What is the fundamental concept of OOP?

- From the very name of object-oriented programming, could it be

The **Object**

?

- Definitely not—and *you should know this!*
- The fundamental concept of object-oriented programming is

The **Class**

!

Core of OOP II

Class: A definition

- A class is an **abstract data type**, with an associated **module** that implements it
- Writing this as a conceptual equation *à la* Wirth,

$$\text{Type} + \text{Module} = \text{Class}$$

Modules vs. Types

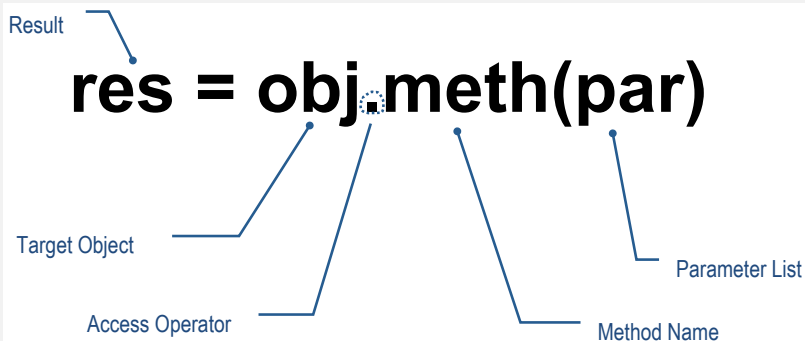
Modules & Types

- Modules and types look very different
 - Modules give structure to the implementation
 - Types specifies how each part can be used
- But they share the *interface* concept
 - In modules, the interface selects the *public* part
 - In types, the interface describes the allowed *operations* as well as their *properties*
- As a result, the interface is at the very core of the notion of class

OOP Mechanism

Method Call

The fundamental OOP computation mechanism



OOP Extensibility

Subclassing

Subclassing is the main OOP extension mechanism, and it is affected by the dual nature of classes

- Type + Module = Class
- Subtyping + Inheritance = **Subclassing**

Subtyping — a partial order on types

- A valid operation on a type is also valid on a subtype
- **Liskov Substitutability Principle**: If S is a subtype of T , then replacing objects of type T with objects of type S does not alter the properties of a program

Inheritance — a partial order on modules

- A module grants special access to its sub-modules
- **Open/Closed Principle**: An OO language must allow the creation of modules *closed* for use but *open* for extension

Distributing the Objects

How to?

- Q How can we extend OOP to a distributed system, preserving all its desirable properties?
- A Just pretend the system is not distributed, and then do business as usual!
- This is called *transparency*
 - As crazy as it may seem, it works!
 - Well, up to a point at least, but generally enough for a lot of applications
 - Problems arise from failure management
 - In reliable and fast networks, things run smooth...
 - Whenever a failure comes from what we abstracted away – e.g., a network failure –, we are just plain dead

Core of Distributed OOP

What is the fundamental concept of Distributed OOP?

- Could it be

The **Object**

or, again,

The **Class**

?

- Clearly not
- The fundamental concept of distributed OOP is

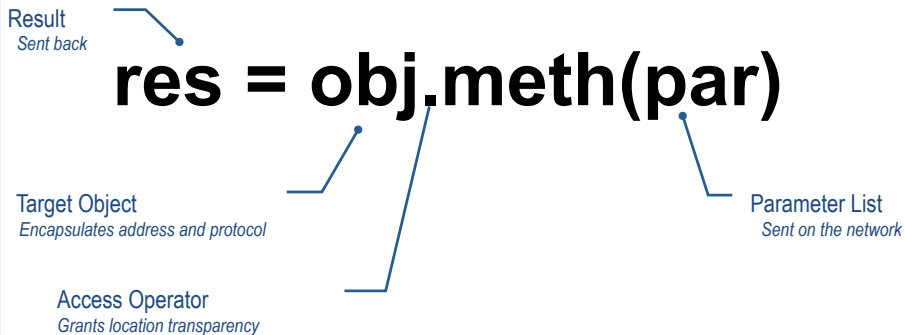
The **Remote Interface**

!

Distributed OOP Mechanism

Remote Method Call

The fundamental Distributed OOP computation mechanism



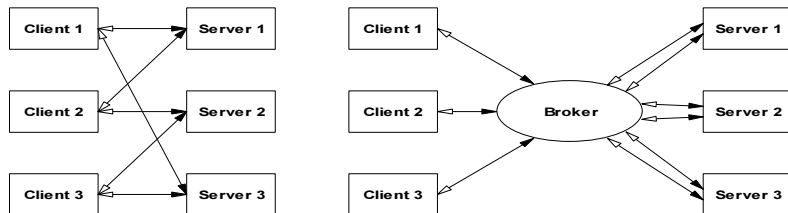
Distributed OOP: Communication Model

The Distributed Objects communication model...

- ... is *implicit*
 - Transmission is implicit, everything happens through *stubs*
 - The stub turns an ordinary call into an Inter-Process Communication (IPC) mechanism
 - As a result, both local and remote calls are handled homogeneously—*location transparency*
- ... is *object-oriented*
 - Only *objects* exist, invoking operations on each other
 - Interaction is client/server with respect to the individual call—micro C/S, not necessarily macro C/S
 - Each call is attached to a specific target object: the result can depend on the target object state
 - Callers refer to objects through an object reference

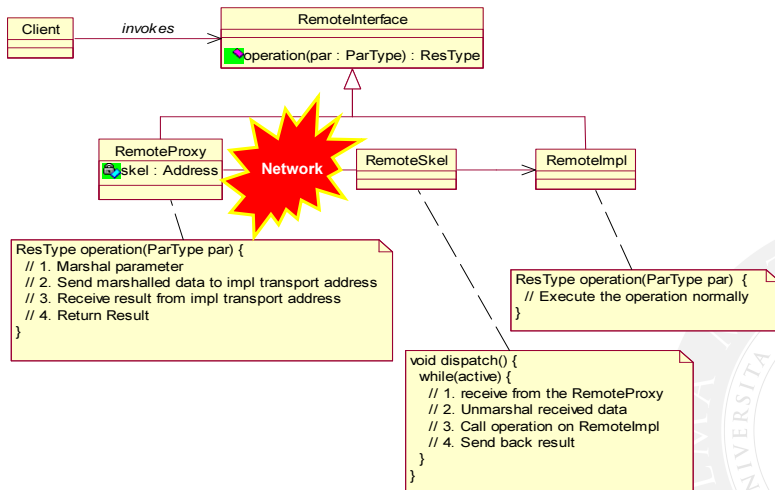
Broker Architecture

Broker architectural pattern [Buschmann et al., 1996]



- Stock market metaphor
- Publish/subscribe scheme
- Extensibility, portability, interoperability
- A broker reduces communication channels from $N_c \times N_s$ to $N_c + N_s$

Proxy and Impl, Stub and Skeleton



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CORBA

Many thanks...

... to Giovanni Rimassa for his slides

OSGi

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... to Marcel Offermans for his slides

Summing Up

Object-oriented Middleware...

- ... provides a coherent framework for Distributed OOP, both conceptually and technologically
- ... extends OOP to Distributed Systems
- ... hides the complexity of programming DS
- ... is supported by open standards—such as OMG CORBA and OSGi
- ... promotes integration across OSs, networks and languages
- ... counts on a lot of free implementations available

Does it solve everything?

- Of course not.
- That is why we have a course on Multi-agent Systems, then!

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