E CORBA Programming

E.1 Introduction

- Provide information on how to write CORBA applications
- Primary implementation language is Java
- C++ as an additional language – after all CORBA is cross-language
- No repetition of general CORBA concepts – see Lecture
- Focus on practical problems
- Some advanced topics to understand special features

1 CORBA

- Common Object Request Broker Architecture and Specification (CORBA) – The Core Spec
- Other specs based on CORBA with independent revisions
  - CORBAservices
  - (CORBAfacilities)
  - Domain Interfaces
  - CORBA Component Model
  - (Unified Modelling Language & Meta Object Facility)
- Numerous Task Forces and Special Interest Groups within the OMG
  - Addition of new concepts and extensions
  - Revision of existing standards

➜ All OMG specs are "moving targets"

2 CORBA Versions

- CORBA 1.x
  - CORBA object model and architecture
  - Interface Definition Language (IDL)
  - Language mappings for C, C++, and Smalltalk
- CORBA 2.0 (July 1996)
  - Interoperability through IIOP as a required protocol
- CORBA 2.1 (August 1997)
  - IDL extensions
  - New language mappings (Cobol, Ada)
- CORBA 2.2 (February 1998)
  - Portable Object Adaptor (POA) replaces Basic Object Adaptor (BOA)
  - New language mapping (Java)

2 CORBA Versions (2)

- CORBA 2.3/2.3.1 (June/October 1999)
  - ◆ Revised language mappings to adapt to POA spec
  - ◆ Valuetypes, object-by-value parameters
  - ◆ Separate documents for language mappings
- CORBA 2.4/2.4.1 (October/November 2000) – the current version
  - ◆ CORBA Messaging
  - ◆ Minimum CORBA
  - ◆ Real-time CORBA
- CORBA 3 (???) – probably the next official release
  - ◆ Huge hype
  - ◆ CORBA Component Model

3 Information on CORBA

- If you really want to know what CORBA is all about, you will ultimately have to read the specs!
- Specs are publically available
- OMG Web site
  - http://www.omg.org/
- Local mirror of interesting OMG documents
  - file:/proj/i4doc/CORBA/OMG/docs/index.html
  - Also available via the OODS Tutorial Web pages
- Lots of books of varying quality
  - List of selected titles on the OODS Tutorial WWW pages
- Beware of CORBA product documentation!
  - Often describes proprietary extensions

4 CORBA Products versus the CORBA Standard

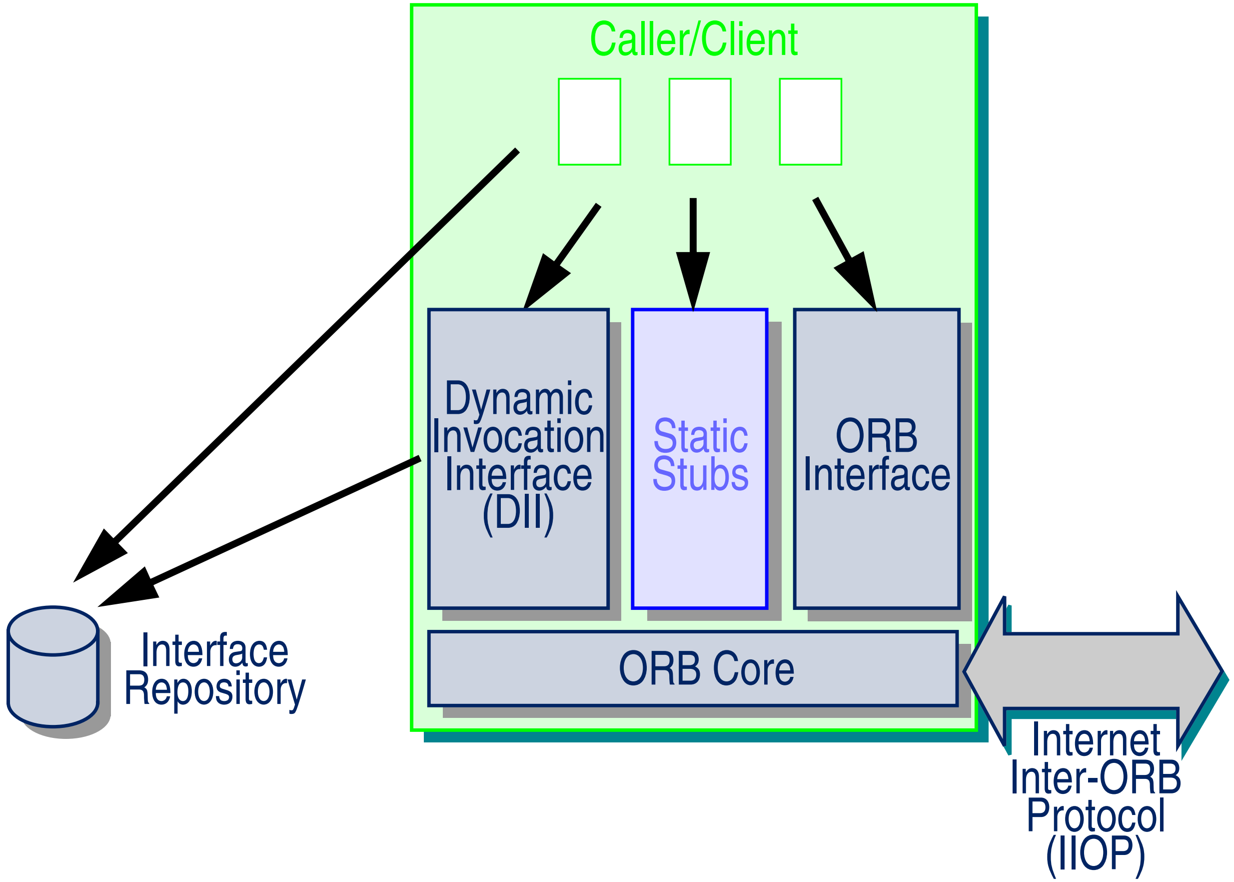
- No established CORBA branding yet
  - Anyone can claim to be CORBA version x.y compliant
  - Open Group recently started certification
- CORBA vendors introduce(d) proprietary extensions
  - Fine as long as you don't rely on them
  - In former times there was no way round, e.g. BOA
  - Nowadays there is a standard-compilant way of achieving almost anything
- Some features in products are not 100%-compliant with the specs
  - E.g. language mappings
  - Specs change, products change a little later

E.2 Using CORBA Objects

1 Caller's View of CORBA Objects

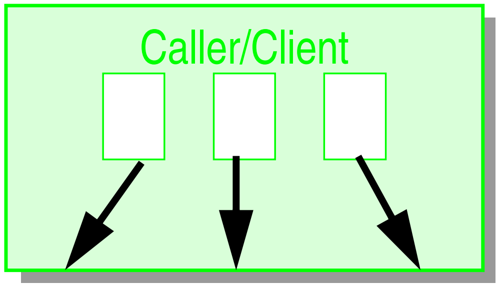
- CORBA objects have (exactly one) interface
  - ◆ Description of interface in the CORBA Interface Definition Language (IDL)
  - ◆ IDL interfaces are a contract between the CORBA object and its callers
- Callers of a CORBA object only have an opaque object reference
  - ◆ Invoke operations on the objects via reference
  - ◆ No need to know whether object is local or remote
  - ◆ Query objects interface
  - ◆ Create invocations at run-time (Dynamic Invocation)
- Object Request Broker (ORB) transmits invocations and replys
  - ◆ Only the ORB can interpret object references
- Caller/Client is a *role* for one invocation only, e.g. callbacks

2 Caller/Client Architecture



3 The Client

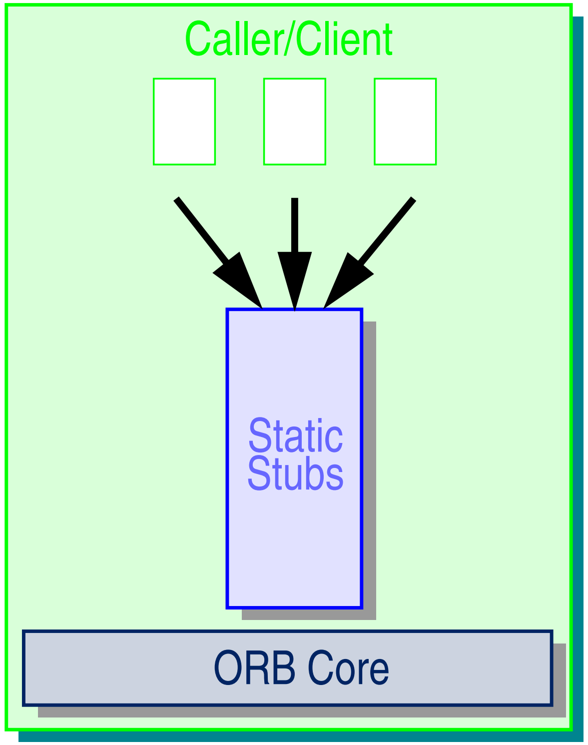
- Invokes operations on CORBA objects
- Doesn't have to be a (CORBA-) object itself



◆ Your first CORBA programs will only have a **`static main()`** method

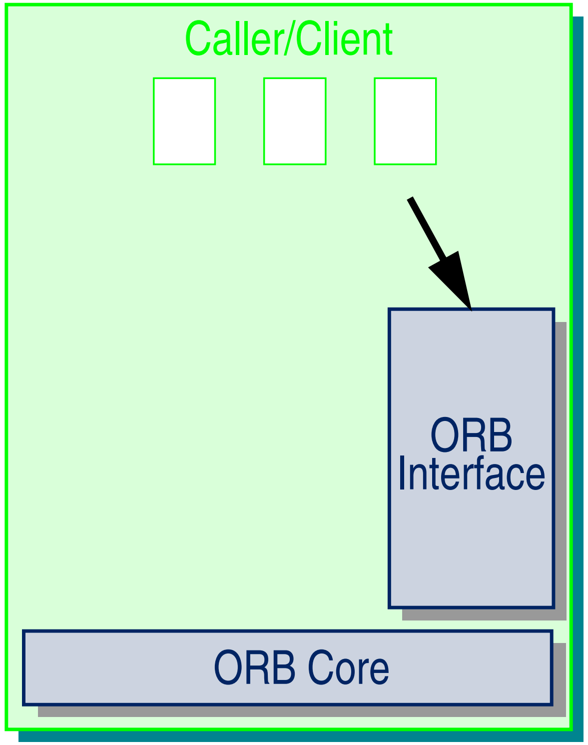
4 Static Stubs

- Can be automatically created from the IDL interface
- Marshalling of invocation parameters
- Demarshalling of return values or exceptions from the invocation



5 ORB Interface

- Export of initial object references (ORB, POA, Services, ...)
- Manipulation of object references (conversion into strings and back)

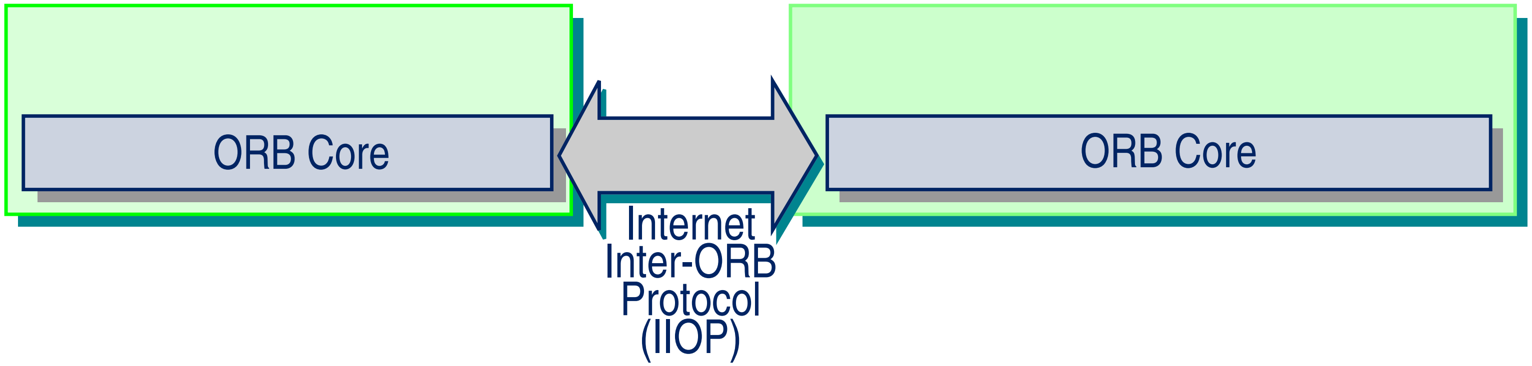


6 ORB Core

- Transmission of invocations using information in object references

7 General Inter-ORB Protocol (GIOP)

- Standard transmission protocol between ORBs
- Basis of interoperability
- GIOP over TCP connections is the Internet Inter-ORB Protocol (IIOP)
- Every CORBA 2.x ORB must implement IIOP



8 Caller/Client Summary

- Don't have to be CORBA objects themselves
- May invoke operations on CORBA objects
- Opaque object references
- ORB transmits invocation data

E.3 Interface Definition Language

- Identifiers
- Primitive types
- Constructed types
- Interfaces of CORBA objects
- Valuetypes
- Design issues

1 Basics

- IDL is for the description of data types and interfaces
- Independent of the implementation language(s)
- Syntax is strongly based on C++
  - Only description of data and interfaces (types, attributes, methods, ...)
  - No control statements (if, while, for, ...)
- Pre-processor like in C++
  - **`#include`** to include other IDL files
  - **`#define`** for macros
- Comments like in C++ and Java:

```
// This is a single-line comment
/*
 * This is a multi-line comment
 */
```

2 Identifiers

- Various reserved words
  - **`module`**, **`interface`**, **`struct`**, **`void`**, **`long`**, ...
- Any other combination of small and capital letters, numbers and underscores allowed
  - No numbers at the beginning of an identifier
- Once an identifier is used, any variation that has the same combination of letters but different capitalisation becomes illegal!
- Example:

```
module Example1 { ... };
module eXample1 { ... };      // illegal in IDL
```

- Rationale:
  - Allow mapping of IDL to languages that are not case-sensitive
  - Preserve identifiers for case-sensitive languages

3 Modules

- Name space (scope) for IDL declarations
- Syntax:

```
module name {
    Declarations
};
```

- Access to other scopes via `::` operator
- Example:

```
module Example1 {
    typedef long IDNumber;
};
module Example2 {
    typedef Example1::IDNumber MyID;      // typedef long MyID;
};
```

4 Type Declarations

- Alias for an existing type
- Syntax:

typedef *existing_type alias*;

- Example:

```
typedef long IDNumber;
```

5 Primitive Types

- Integer numbers
  - `short` — -2^{15} to $2^{15}-1$
  - `unsigned short` — 0 to $2^{16}-1$
  - `long` — -2^{31} to $2^{31}-1$
  - `unsigned long` — 0 to $2^{32}-1$
  - `long long` — -2^{63} to $2^{63}-1$
  - `unsigned long long` — 0 to $2^{64}-1$
- Floating point numbers (IEEE Standard for Binary Floating-Point Arithmetic, ANSI/IEEE Std 754-1985)
  - `float` — single precision
  - `double` — double precision
  - `long double` — extended precision (at least 15 bit exponent and 64 bit base)

5 Primitive Types (2)

- Characters
  - **`char`** ISO 8859-1 (Latin1) character
  - **`wchar`** multi-byte character (e.g. Unicode)
  - Length is dependent on implementations and programming languages
- **`boolean`**
  - The only values are TRUE and FALSE
- **`octet`**
  - 8 bit length
  - No conversion at all during transmission
- **`any`**
  - Can encapsulate any CORBA-defined type
- **`void`**

6 Structures

- Grouping of several types in a structure
- Syntax:

```
struct name {
      Declaration of structure elements
};
```

- Example:

```
struct AmountType {
    float value;
    char currency;
};
```

- Usage:

```
AmountType amount;
```

6 Nested Structures

- Structures can be defined within other structures
- Example:

```
struct AmountType {
    struct ValueType {
        long integerPart;
        short fractionPart;
    } amount;
    char currency;
};
```

- Structures create a name space (scope) of their own!
- Complete name of the above type:

```
AmountType::ValueType
```

7 Unions

- Union of different types that are distinguished by the value of a switch type
- Syntax:

```
union name switch( switch_type ) {
    case switch_constant:  Declaration
    ...
    default:  Declaration
};
```

- Possible switch types: integers, characters, **boolean**, enumerations
- Declarations have to be unique
- Example:

```
union Example switch( long ) {
    case 1:        long l;
    case 2:        float f;
};
```

8 Enumerations

- Enumerations with declared set of possible values
- Syntax:

```
enum name {
    value1, value2, ...
};
```

- Example:

```
enum Color {
    GREEN, RED, BLUE
};
```

- Caution: Enumerations do not create a scope of their own!
- Access to enumeration values:

```
GREEN
not Color::GREEN
```

9 Arrays

- Single or multi-dimensional arrays
  - Fixed size in each dimension
- Syntax:

```
typedef element_type name[positive_constant][positive_constant]...;
```

- Example:

```
typedef long Matrix[3][3];
```

- Caution:
  Array types have to be declared with **`typedef`** before they can be used!

10 Sequences

- Single dimension array
  - Variable size
  - Optional maximum size (bounded sequence)
- Syntax:

```
typedef sequence<element_type> name;                                  // unbounded
typedef sequence<element_type,positive_constant> Name;   // bounded
```

- Example:

```
typedef sequence<long> Longs;
typedef sequence< sequence<char> > Strings;
```

- Caution:
  Sequence types also have to be declared with **typedef** before they can be used!

11 Strings

- Character strings
  - Similar to **`sequence<char>`** and **`sequence <wchar>`**
  - Are special types for performance reasons
  - No need to declare strings with **`typedef`**

- Syntax:

```
typedef string name;                                    // unbounded
typedef string<positive_constant> name;                 // bounded
typedef wstring name;                                   // unbounded
typedef wstring<positive_constant> name;                // bounded
```

- Example:

```
typedef string<80> Name;
```

12 Fixed-Point Numbers

- Similar to integer numbers
  - At most 31 digits
  - Scaling factor for decimal point
- Syntax:

```
typedef fixed<positive_constant, scaling_constant> name;
```

- Example:

```
typedef fixed<10,2> Amount;
```

- Caution:
  Not yet implemented in most ORBs!

13 Constants

- Symbolic name for special values
- Syntax:

```
const type name = constant_expression;
```

- Constant expressions
  - Constant values
  - Operations with all constant values
  - Arithmetic operations
  - Logic operations
- Example:

```
const Color WARNING = RED;
```

14 Interfaces

- Visible interface of CORBA objects
- Contain:
  - Attributes
  - Operations
  - Local types, constants, and exceptions
- Syntax:

```
interface name {
    Declaration of attributes and operations (as well as types and exceptions)
};
```

- Interface also defines a scope of its own
- Names of attributes and operations must be unique
  - No overloading!

14 Interfaces – Attributes

- Public object variables
  - Write access can be prohibited (read-only attributes)
  - Not an instance variable
- Syntax:

```
attribute type name;                          // read & write
readonly attribute type name;                 // read-only
```

- Example:

```
interface Account {
    readonly attribute float balance;
};
```

14 Interfaces – Operations

- Methods of CORBA objects with:
  - Method name
  - Return value
  - Parameters
  - Exceptions
  - (Invocation context)

- Syntax:

```
return_type name( parameter_list ) raises( exception_list );
```

- Only method name is significant
  - No overloading by means of parameter types!

- Method invocation with best-effort semantics (no return values and no exceptions allowed)

```
oneway void name( parameter_list );
```

14 Interfaces – Parameter Transmission

- For each parameter a copy direction is required:
  - **`in`** from client to server only
  - **`out`** from server to client only
  - **`inout`** in both directions

- Syntax:

`(` *copy_direction1 type1 name1*`,` *copy_direction2 type2 name2*`,` *...* `)`

- Example:

```
interface Account {
    void makeDeposit( in float sum );
    void makeWithdrawal(  in float sum,
                          out float newBalance );
};
```

14 Interfaces – Inheritance

- Derivation of a new interface from existing ones
- Multiple inhertiance possible
- Syntax:

```
interface name : inherited_interface1, inherited_interface2, ... {
     Declaration of additional attributes and operations
};
```

- Names of inherited attributes and operations must be unique
  - Exception: Identifiers that are inherited via different paths but originate from the same base interface

14 Interfaces – Inheritance (2)

- Neither Overloading nor Overriding is allowed:

```
module Foo {
    interface A {
        void draw( in float num );
    };

    interface B {
        void print( in float num);
        void print( in string str); // Wrong: overloading
    };

    interface C: A, B {
        void draw( in float num);   // Wrong: Overriding
    };
};
```

14 Interfaces – Inheritance (3)

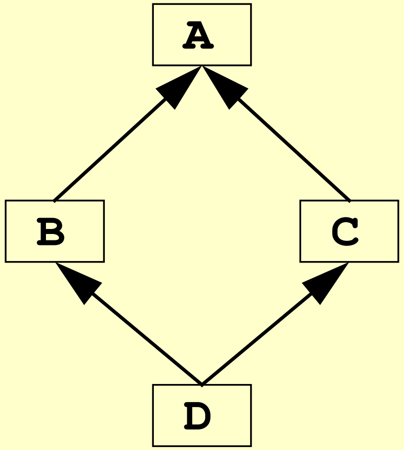
- Legal inheritance graph in CORBA:

```
module Foo {
    interface A {
        void draw( in float num );
    };

    interface B : A {
    };

    interface C : A {
    };

    interface D : B, C {
    };
};
```



15 Exceptions – User Exceptions

- User exceptions created in user code on the server side and propagated to the client
- Syntax:

```
exception name {
      Declaration of data elements
};
```

- Exceptions are special structs
  - ◆ Data elements only, no operations
  - ◆ No inheritance for exceptions!
- Example:

```
interface Account {
    exception Overdraft { float howMuch; };
    void makeWithdrawal( in float sum )
                raises( Overdraft );
};
```

15 Exceptions – System Exceptions

- System exceptions created by the ORB when invocation fails internally

```
module CORBA {
    enum completion_status { COMPLETED_YES, COMPLETED_NO,
                             COMPLETED_MAYBE};
    exception UNKNOWN {
        unsigned long     minor;
        completion_status completed;
    };
    exception BAD_PARAM {
        unsigned long     minor;
        completion_status completed;
    };
    exception NO_MEMORY  {
        unsigned long     minor;
        completion_status completed;
    };
    exception COMM_FAILURE  {
        unsigned long     minor;
        completion_status completed;
    };
    ...        // Many exceptions more
};
```

16 Forward Declarations

- Problem: Circular dependencies in declarations
  - Interface **A** has operation **op_b()** that returns object of type **B**
  - Interface **B** has operation **op_a()** that returns object of type **A**
- Solution: Forward declaration
  - Declare an identifier for a type but not the whole type
- Example:

```
interface B;        // Forward declaration
interface A {
    B op_b();
};
interface B {
    A op_a();
};
```

17 Value types

- Provide semantics that bridge between structs and interfaces
  - ◆ Support description of complex state (i.e., arbitrary graphs, with recursion and cycles)
  - ◆ Instances are always local to the context in which they are used (because they are always copied when passed as a parameter to a remote call)
  - ◆ Support both public and private (to the implementation) data members
- Value types support single inheritance (of valuetype) and can support an interface
- Example:

```
valuetype Person {
    public string name;    // A public state
    private long id;       // A private state

    void print();          // An operation
};
```

18 IDL Summary

- Description of data and interfaces of CORBA objects
- C++-like syntax
- Primitive types (**`short`**, **`long`**, **`boolean`**, **`char`**, ...)
- Constructed types (**`struct`**, **`union`**, **`enum`**)
- Arrays
- Template types (**`sequence`**, **`string`**, **`fixed`**)
- Object **`interface`** with attributes and operations
- Error reporting via exceptions
- Objects-by-value through **`valuetype`**s

19 Design Issues

- Problem: High-volume data objects

- Solution 1: Interface with attributes or access operations
  + Clean OO abstractions
  + All possibilites of distribution
  – High network traffic for data access
  – Scalability problems in some ORBs

- Solution 2: Struct with data members, local wrapping in objects
  + Local data access
  – Broken OO abstractions
  – Multiple unsynchronised copies

- Solution 3: Value type
  + Local data access and OO abstractions
  – Multiple unsynchronised copies