CORBA

Overview, Goals

Basic mechanisms for modularity, exchangeability, adaptation, transparency

Appendices:

CORBA Services and CORBA Facilities
CORBA, Web and Java
Evaluation of CORBA as a composition system

CORBA Component Model (after EJB)

[Szyperski, Chapter 13]

Background literature on CORBA

- F. Bolton: *Pure CORBA*. Sams Publishing, 2002. Java and C++ examples
- M. Aleksy, A. Korthaus, M. Schader: *Implementing Distributed Systems with Java and CORBA*. Springer, 2005.
- Special issue of *Communications of the ACM* **41**(10), Oct. 1998.
  All articles. Overview of CORBA 3.0.
- Tanenbaum, van Steen: *Distributed Systems*. Pearson, 2003.
  Principles and paradigms.
- OMG: *CORBA 2.2* and *CORBA 3.0 Specification*.
  http://www.omg.org
  See also further material from the OMG on the Web
- OMG: *CORBAfacilities: Common Object Facilities Specifications*.
  http://www.omg.org

CORBA

OMG OBJECT MANAGEMENT GROUP

CORBA™

- Common Object Request Broker Architecture®
- Founding year of the OMG (Object Management Group) 1989
- Goal: plug-and-play components everywhere

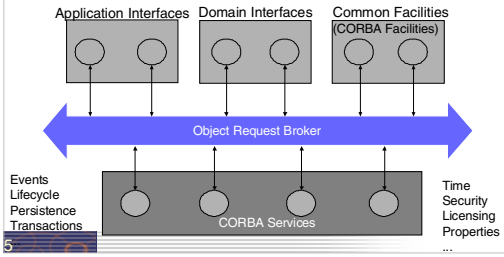
- CORBA 1.1 1991 (IDL, ORB, BOA)
- ODMG-93 (Standard for OO-databases)
- CORBA 2.0 1995.
  Version 2 is a separate line, 2.2 and 2.4 are status quo
- CORBA 3.0 1999 (POA).
  Current version (2005) is 3.0.3.

Ingredients of CORBA

- **Component Model**
  - Components == classes (and objects), i.e., similar to object-oriented software. CORBA components have more component secrets.
- **Basic interoperability**
  - Language interoperability by uniform interfaces description
  - Transparent distribution
  - Transparent network protocols
- **CORBA Services**
- **CORBA Facilities**
  - Horizontal (general-purpose) vs. vertical (domain-specific)
  - CORBA MOF

OMA (Object Management Architecture)

- **A software bus**

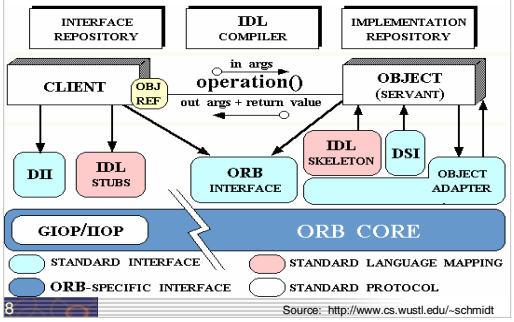


Corba's Hydrocephalus

- **Corba is large**
  - Object Request Broker – 2000 pages of specification
  - Object Services – 300 pages
  - Common Facilities – 150 pages
- **Technical reasons**
  - Clean detailed solution
  - Sometimes overkill
- **Sociologic reasons**
  - OMG is large (over 800 partners) and heterogeneous
  - Standard covers a wide range
- **Linguistic reasons**
  - Own language
  - Lots of unintuitive 3-capitals-names (OMG, ORB, IDL, …)
  - Appears larger than necessary

Corbas Mechanisms for Composition (Basic Interoperability)

CORBA interoperability mechanisms



Source: http://www.cs.wustl.edu/~schmidt

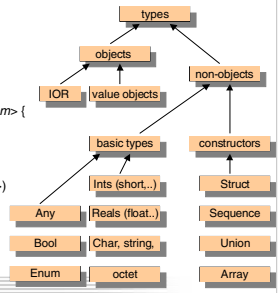
Language Transparency

- **Interface definition language – CORBA IDL**
  - CORBA Interface Definition Language describes interfaces
  - From that, glue code is generated
    (*glue code* is code that glues non-fitting components together)
    - Generate stub and skeletons for language adaptation
  - Powerful type system
  - Standardized (ISO 14750)
- **Language bindings for many languages**
  - Antique: COBOL
  - Classic: C
  - OO: C++, SmallTalk, Eiffel, Java
  - Scripting: Python

Concepts in the CORBA Interface Definition Language (IDL)

module *<identifier>* {
<type declarations>
<constant declarations>
<exception declarations>

// classes
interface *<identifier>* : *<inheriting-from>* {
<type declarations>
<constant declarations>
<exception declarations>
// methods
<optype> <identifier>(<parameters>)
....
}
}



IDL-to-Language Mapping

- **Bijective mapping**
  from Corba IDL types to programming language types
  - Maps basic types directly
  - Maps type constructors
- **Mapping makes transparent**
  - Byte order (big-endian / little-endian)
  - Word length
  - Memory layout
  - References
- **One standard for each programming language!**

IDL-to-C, Mapping for basic types

Table 1-1 Data Type Mappings

OMG IDL	C
short	CORBA_short
long	CORBA_long
long long	CORBA_long_long
unsigned short	CORBA_unsigned_short
unsigned long	CORBA_unsigned_long
unsigned long long	CORBA_unsigned_long_long
float	CORBA_float
double	CORBA_double
long double	CORBA_long_double
char	CORBA_char
wchar	CORBA_wchar
boolean	CORBA_boolean
any	typedef struct CORBA_any { CORBA_TypeCode _type; void *_value; } CORBA_any;

Source: OMG, www.omg.org

IDL-to-Java, mapping of basic types

Table 2-1 Basic Type Mappings

IDL Type	Java type	Exceptions
boolean	boolean	
char	char	CORBA::DATA_CONVERSION
wchar	char	CORBA::DATA_CONVERSION
octet	byte	
string	java.lang.String	CORBA::MARSHAL CORBA::DATA_CONVERSION
wstring	java.lang.String	CORBA::MARSHAL CORBA::DATA_CONVERSION
short	short	
unsigned short	short	
long	int	
unsigned long	int	
long long	long	
unsigned long long	long	
float	float	
double	double	
fixed	java.math.BigDecimal	CORBA::DATA_CONVERSION

Source: OMG, www.omg.org

Hello World in IDL

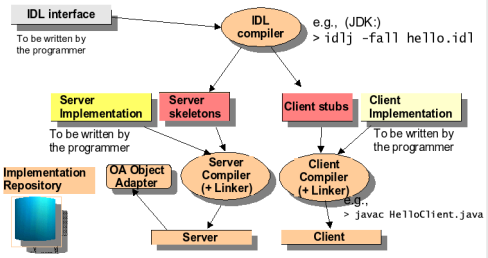
hello.idl

```
#ifndef _HELLOWORLD_IDL
#define _HELLOWORLD_IDL

module HelloWorld {
   interface SimpleHelloWorld {
      string sayHello();
   };
};

#endif
```

count.idl

```
module Counter {
  // unbounded sequence of longs:
  typedef sequence<long> oneDimArray;
  // specify interface for a counter:
  interface Count {
    attribute long sum;  // counter
    long increment();
    void readCtr ( in oneDimArray X,
                   in long position k );
  }
}
```


Which Parts of Clients and Servers are Generated



Example: Counter.idl

```
// IDL

module Counter {
  interface Counter {
    attribute long thecounter;
    void inc( in long k );
    long getcounter ( );
  };
};
```


Example (cont.): IDL compiler result

- **Example:** (for CORBA supplied in JDK 1.2 and later)

  `idlj -fall Counter.idl`

  generates the following files:

  - Counter.java -- the Java interface for Counter
  - CounterOperations.java -- the Java interface for Counter methods
  - CounterPOA.java -- servant impl. class should inherit from this one
    CounterPOATie.java -- or delegate to this one (see later)
  - CounterHolder.java -- serialization/deser. code for passing Counters
  - CounterHelper.java -- type conversion routines for Counters
  - _CounterStub.java -- class with the client-side stub code

(here no Skeleton code required, as the OA already "speaks" Java)

Example (cont.): CounterOperations.java

```
package Counter;

/**
* Counter/CounterOperations.java .
* Generated by the IDL-to-Java compiler (portable), version "3.2"
* from Counter.idl
* den 23 april 2007 kl 10:02 CEST
*/

public interface CounterOperations
{
  int thecounter ();     // getter method for thecounter, created automatically
  void thecounter (int newThecounter);     // setter method for thecounter...
  void inc (int k);
  int getcounter ();
}
```

Example (cont.): Counter.java

```
package Counter;

/**
* Counter/Counter.java .
* Generated by the IDL-to-Java compiler (portable), version "3.2"
* from Counter.idl
* den 23 april 2007 kl 10:02 CEST
*/

public interface Counter
      extends CounterOperations,
                  org.omg.CORBA.Object,
                  org.omg.CORBA.portable.IDLEntity
{
}
```


Example (cont.): CounterPOA.java

```
package Counter;
/**
* Counter/CounterPOA.java .
* Generated by the IDL-to-Java compiler (portable), version "3.2" from Counter.idl den 23 april 2007 kl 10:02
*/
public abstract class CounterPOA extends org.omg.PortableServer.Servant
    implements Counter.CounterOperations, org.omg.CORBA.portable.InvokeHandler
{
  // Registry for Counter-methods:
  private static java.util.Hashtable _methods = new java.util.Hashtable ();
  static {
    _methods.put ("_get_thecounter", new java.lang.Integer (0));
    _methods.put ("_set_thecounter", new java.lang.Integer (1));
    _methods.put ("inc", new java.lang.Integer (2));
    _methods.put ("getcounter", new java.lang.Integer (3));
  }
  public org.omg.CORBA.portable.OutputStream _invoke (String $method,
                                org.omg.CORBA.portable.InputStream in,
                                org.omg.CORBA.portable.ResponseHandler $rh)
  {
    org.omg.CORBA.portable.OutputStream out = null;
    java.lang.Integer __method = (java.lang.Integer)_methods.get ($method);
    // ...
    switch (__method.intValue ())  {  ...  }      // call skeleton by method index – see next page
```


Example (cont.): CounterPOA.java (cont.)

```
switch (__method.intValue ()) {
      case 0:  // Counter/Counter/_get_thecounter
      {
        int $result = (int)0;
        $result = this.thecounter ();
        out = $rh.createReply();
        out.write_long ($result);
        break;
      }
      case 1:  // Counter/Counter/_set_thecounter
      { ...
      }
      case 2:  // Counter/Counter/inc
      {
        int k = in.read_long ();
        this.inc (k);
        out = $rh.createReply();
        break;
      }
      ...
      default:  throw new org.omg.CORBA.BAD_OPERATION (0,
                                  org.omg.CORBA.CompletionStatus.COMPLETED_MAYBE);
    }
    return out;    // result of _invoke
  } ...
```


Example (cont.): _CounterStub.java

```
package Counter;
/**
* Counter/_CounterStub.java .
* Generated by the IDL-to-Java compiler (portable), version "3.2" from Counter.idl den 23 april 2007 kl 10:02
*/
public class _CounterStub extends org.omg.CORBA.portable.ObjectImpl
                          implements Counter.Counter
{
  // some other methods omitted ...
  public void inc (int k)
  {
        org.omg.CORBA.portable.InputStream $in = null;
        try {
          org.omg.CORBA.portable.OutputStream $out = _request ("inc", true);
          $out.write_long ( k );
          $in = _invoke ( $out );
          return;
        } catch (org.omg.CORBA.portable.ApplicationException $ex) {
          $in = $ex.getInputStream ();
          String _id = $ex.getId ();
          throw new org.omg.CORBA.MARSHAL (_id);
        } catch (org.omg.CORBA.portable.RemarshalException $rm)  {  inc ( k );
        } finally {  _releaseReply ($in); }
  } // inc
  ....
```

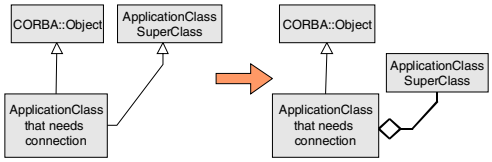

The Top Class: CORBA::Object

CORBA::Object
get_implementation **get_interface** **is_nil** **is_a** **create_request** **duplicate** **release** **....**

- **The class CORBA::Object is inherited to all objects**
  - supports reflection and introspection
- **Reflective functions:**
  - get_interface
    delivers a reference to the entry in the interface repository
  - get_implementation
    a reference to the implementation
- Reflection also by the Interface Repository (list_initial_references from the CORBA::ORB interface).

Problem: Multiple Inheritance

- CORBA::Object includes *code* into a class
- Many languages only offer single inheritance
  - Application superclass must be a delegatee



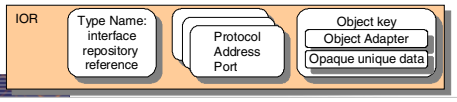
Interoperable Object Reference (IOR)

- **An *object reference* provides information to uniquely specify an object within a distributed ORB system**
- **Unique name or identifier**
- **Language-transparent:**
  Mapped to client's normal source language references
  (unique mapping for each supported language)
- **Implementation in CORBA:**
  Object reference to a server object is given out by the server's OA, shipped to clients as ***IOR object*** and stored there in a proxy object.
  ORB supports stringification / destringification of IOR's.
  Retrieval of references by client: supported by naming service

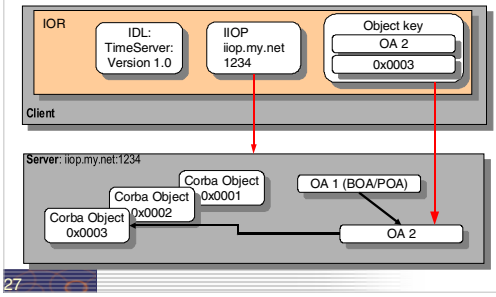
  All referencing goes via the server's ORB
  -> enables distributed reference counting

Interoperable Object Reference (IOR) - cont.

- Transient (terminates with server) or persistent
- IOR is larger, more time-consuming than language-bound references
- Consists of:
  - **Type name** (code), i.e. index into Interface Repository
  - **Protocol and address information**
    (e.g. TCP/IP, port #, host name),
    could support more than one protocol
  - **Object key:**
    - Object adapter name (for OA)
    - Opaque data only readable by the generating ORB (local reference)



IOR Example



How to get an IOR?

- **Object references originate in servers.**
  - If client needs a reference, a server must create it.
  - --> Chicken-and-egg problem...

Solutions:

- **Server write stringified IOR to a file (e.g., stdout)**
  - Ok for tests, but not for realistic distributed systems
- **Use the CORBA naming service**
  - Naming service stores (name, IOR) bindings in central location
  - Only location of naming service needs to be known to client
- **Use the CORBA trading service**
  - Look up IOR for objects by reg. properties, instead of by name

Basic CORBA Connections

Basic Connections in CORBA

- **Static method call with static stubs and skeletons**
  - Local or remote
- **Polymorphic call**
  - Local or remote
- **Event transmission**
- **Callback**
- **Dynamic invocation (DII, request broking)**
  - Searching services dynamically in the web
    (location transparency of a service)
- **Trading**
  - Find services in a yellow pages service, based on properties

Static CORBA Call

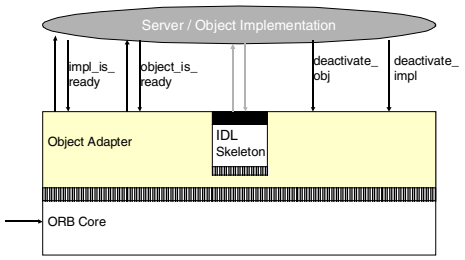
- **Advantage: the participants (methods) are statically known**
  - Call by stub and skeletons, without involvement of an ORB
  - Supports distribution:
    Exchange of local call in one address space to remote call is very easy:
    - Inherit from a CORBA class
    - Write an IDL spec
  - No search for service objects -> rather fast
  - Better type check, since the compiler knows the involved types
- **The call goes through the server object adapter**
  - This hides the detail whether the server is transient or persistent

Client side protocol for static calls

- **Step 1: Initialize the ORB**
  - global_orb = CORBA::ORB_init(argc, argv);
- **Step 2: Obtain an object reference (here: from file)**
  - CORBA::Object obj =
    global_orb -> string_to_object(read_refstring("filename.ref"));

  and narrow it to expected object type (dynamic downcast)
  - Counter::Counter ctr = Counter::Counter::_narrow(obj);
- **Step 3: Invoke on Count object**
  - ctr->increment();
  - ...
- **Step 4: Shut down the ORB**
  - global_orb->shutdown(1); global_orb->destroy();

Server Side, Old-style Protocol (BOA)



Basic Object Adapter BOA

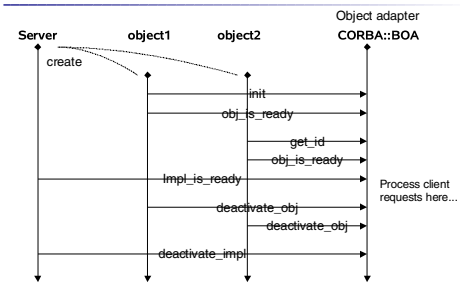
CORBA::BOA

create
get_id
dispose
set_exception
impl_is_ready
obj_is_ready
change_implementation
deactivate_impl
deactivate_obj

create_POA
create_lifespan_policy
activate_object_with_id
the_POAManager (.activate)
servant_to_reference

- The BOA hides
  - Life time of the server object (activation: start, stop)
  - Persistency
- The BOA is implemented in every ORB, for minimal service provision
- The BOA maintains the implementation repository (component registry).
- It supports non-object-oriented code
- In CORBA 3.0 replaced by POA (Portable Object Adapter)

Object Activation on the Server



Object Adapters Support Different Server Models

- **Common server process**
  - Several objects reside in one process on the server;
    the OA initializes them as threads with common address space ("common appartment")
    - e.g. BOA: deactivate_impl, impl_is_ready, obj_is_ready are mapped directly to thread functions
- **Separate server processes**
  - For every object an own process
- **Server-per-request**
  - Every request generates a new process
- **Persistent server**
  - Here starts another application the objects (e.g., a data base).
  - The BOA passes on the queries

POA
Portable Object Adapter

- **The POA is an evolution of the BOA**
- **Nested POAs possible, with nested name spaces**
  - Root POA (one per server) started/accessed by ORB.
  - A POA can create new POAs.
  - A POA may serve a group of objects and handle references to them.
- **POAs can be named**
  - ORB maintains a registry of named POAs, e.g. for reactivation as needed.
- **Policies for object management**
  - e.g. Lifespan: transient / persistent

CORBA::BOA

create
get_id
dispose
set_exception
impl_is_ready
obj_is_ready
change_implementation
deactivate_impl
deactivate_obj

CORBA::POA

create_POA
create_lifespan_policy
activate_object_with_id
the_POAManager (.activate)
servant_to_reference
...

Towards Dynamic Call
(DII, Request Broking)

- **Dynamic call** via the ORB's DII (Dynamic Invocation Interface)
  - Services can be dynamically exchanged, or brought into the play a posteriori
  - Without recompilation of clients
  - Slower than static invocations
- **Requires introspection**
- **Requires descriptions of semantics of service components...**
  - For identification of services
    - Metadata (descriptive data): catalogs of components (interface repository, implem. repository)
    - Naming service, Trading service, Property service (later)
- **... and a mediator that looks up for services: the ORB**

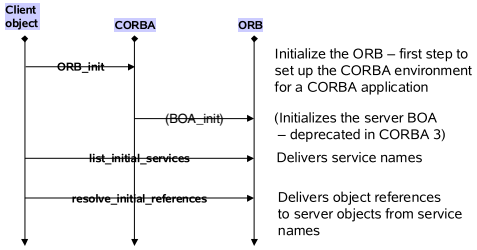
Object Request Broker ORB

CORBA::ORB

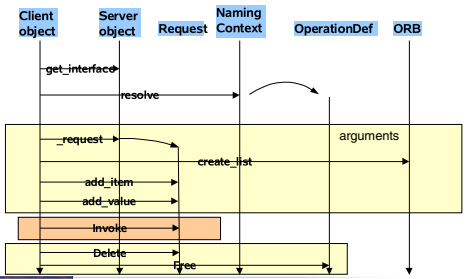
init
object_to_string
string_to_object
create_list
create_operation_list
get_default_context
create_environment
list_initial_services
resolve_initial_references
....

- **ORB is a Mediator**
  Hides the the environment from clients
- **List_initial_services:**
  yields list of names of initial services
  e.g. Naming Service
- **Resolve_initial_references:**
  uses the naming service e.g. to get an IOR to "NameService" or the "RootPOA"
- **ORB is responsible for managing all communication:**
  Can talk to other ORBs on the network (IIOP Internet Inter-ORB protocol)

ORB Activation



Protocol Dynamic Call (DII)



Example for Dynamic Call

```
// Ship.idl

module Ship {

  interface Aircraft {
     string codeNumber();
  };

  interface AircraftCarrier {
     Aircraft launch ( in string name );
  };

};
```

Source: Infowave, Building distributed applications..., www.waveman.com/etac/corba/page13.html, 1998

Example 1: Dynamic Call in C++

Client program

```
CORBA::ORB_ptr orb;

main( int argc, char* argv[])  {
  orb = CORBA::ORB_init(argc,argv, ORBID);
// alternative description of service
  CosNaming::NamingContext_ptr naming =
        CosNaming::NamingContext::_narrow(
          ::resolve_initial_reference("NameService"));
  CORBA::Object_ptr obj;
  try {
     obj = naming->resolve( mk_name("dii_smpl"));
  }  catch (CORBA::Exception)  {
     cerr << "not registered" << endl; exit(1); }

  // Construct arguments:
  CORBA::Any val1;
  val1 <<= (CORBA::Short) 123;
  CORBA::Any val2;
  val2 <<= (CORBA::Short) 0;
  CORBA::Any val3;
  val3 <<= (CORBA::Short) 456;

  // Build request (short form)
  CORBA::Request_ptr rq= obj->_request("op");
  // Create argument list
  rq->arguments() = orb->create_list();
  rq->arguments()->add_value("arg1",val1,CORBA::ARG_IN);
  rq->arguments()->add_value("arg2",val2,CORBA::ARG_OUT);
  rq->arguments()->add_value("arg3",val3,CORBA::ARG_INOUT);

  // Invoke request
  rq->invoke();

  // Analyze result
  CORBA::Short rslt ;
  if (*(rq->result()->value()) >>= rslt) {
     // Analyze the out/inout-parameters (arg1 has index 0)
     CORBA::Short _arg2, _arg3;
     *(rq->arguments()->item(1)->value()) >>= _arg2;
     *(rq->arguments()->item(2)->value()) >>= _arg3;
     cout << " arg2= "  << arg2 << " arg3= " << _arg3
          << " return= " <<  rslt << endl;  }
  else  {
     cout << "result has unexpected type" << endl; }
}
```


Example 2: DII Invocation in Java

Client program (1)

```
// Client.java
// Building Distributed Object Applications with CORBA
// Infowave (Thailand) Co., Ltd.
// Jan 1998

public class Client {
  public static void main(String[] args) {
    if (args.length != 2) {
      System.out.println("Usage: vbj Client <carrier-name> <aircraft-name>\n");
      return;
    }
    String carrierName = args[0];
    String aircraftName = args[1];
    org.omg.CORBA.Object carrier = null;
    org.omg.CORBA.Object aircraft = null;
    org.omg.CORBA.ORB orb = null;
    try {
       orb = org.omg.CORBA.ORB.init( args, null);
    }
    catch (org.omg.CORBA.SystemException se) {
      System.err.println("ORB init failure " + se);
      System.exit(1);
    }
```


Example 2: DII Invocation in Java

Client code (2)

```
    { // scope
        try {
          carrier = orb.bind("IDL:Ship/AircraftCarrier:1.0", carrierName, null, null);
        }
        catch (org.omg.CORBA.SystemException se) {
          System.err.println("ORB init failure " + se);
          System.exit(1);
        }
        //  Build request:
        org.omg.CORBA.Request request = carrier._request("launch");
        request.add_in_arg().insert_string( aircraftName );
        request.set_return_type( orb.get_primitive_tc( org.omg.CORBA.TCKind.tk_objref ) );
        //  Invoke request:
        request.invoke();
        //  Read result value:
        aircraft = request.result().value().extract_Object();
      }
      { // scope
        org.omg.CORBA.Request request = aircraft._request( "codeNumber" );
        request.set_return_type( orb.get_primitive_tc ( org.omg.CORBA.TCKind.tk_string ) );
        request.invoke();
        String designation = request.result().value().extract_string();
        System.out.println ("Aircraft " + designation + " is coming your way");
      }
```


Example 2

Server Implementation, BOA version (now deprecated)

```
public class Server {
   public static void main( String[] args ) {
     org.omg.CORBA.ORB orb = null;
     try {
        orb = org.omg.CORBA.ORB.init( args, null);
     }
     catch (org.omg.CORBA.SystemException se) {
       System.err.println("ORB init failure " + se);
       System.exit(1);
     }
     org.omg.CORBA.BOA boa = null;
     try {
       boa = orb.BOA_init();
     }
     catch (org.omg.CORBA.SystemException se) {
       System.err.println("BOA init failure " + se);
       System.exit(1);
     }

     Ship.AircraftCarrier carrier =
                 new AircraftCarrierImpl("Nimitz");
     try {
         boa.obj_is_ready(carrier);
     } catch (org.omg.CORBA.SystemException se) {
         System.err.println("Object Ready failure " + se);
         System.exit(1);
     }
     System.out.println(carrier + " ready for launch !!!");
     try {
         boa.impl_is_ready();
     } catch (org.omg.CORBA.SystemException se) {
         System.err.println("Impl Ready failure " + se);
         System.exit(1);
     }
   }

   //  Now ready to serve remote invocations on carrier
```


Example 2

Server code (Java, POA version)

```
// Building Distributed Object Applications with CORBA
// Infowave (Thailand) Co., Ltd. http://www.waveman.com, Sep 2000

import java.io.*;
import org.omg.CosNaming.*;

public class Server
{
  public static void main( String[] args )
  {
    org.omg.CORBA.ORB orb =
              org.omg.CORBA.ORB.init( args, null );

    org.omg.CORBA.Object objPOA = null;
    try {
      objPOA = orb.resolve_initial_references("RootPOA");
    }
    catch (org.omg.CORBA.ORBPackage.InvalidName
              ex) {...}
    org.omg.PortableServer.POA rootPOA = null;
    rootPOA = (org.omg.PortableServer.POA) objPOA;
    ...
    org.omg.PortableServer.POA  myPOA = null;
    try {
      myPOA = rootPOA.create_POA(
        "personalPOA",
        rootPOA.the_POAManager() ,
        new org.omg.CORBA.Policy[] {
            rootPOA.create_id_assignment_policy (
                org.omg.PortableServer.
                IdAssignmentPolicyValue.USER_ID)  } );
    }
    catch (java.lang.Exception ex) {
      System.err.println("Create POA Exception " + ex);
      System.exit(1);
    }
    org.omg.PortableServer.Servant carrier = null;
    try {
      carrier = new AircraftCarrierImpl(myPOA);
      myPOA.activate_object_with_id
          ("Nimitz".getBytes(), carrier);
    }
    catch (org.omg.CORBA.SystemException se) {...}
    catch (org.omg.CORBA.UserException ue) {...}
```


Example 2

Server code (Java, POA version) - continued

```
    ....

    // Write object reference to an IOR file

    org.omg.CORBA.Object initRef = null;
    try {
      initRef = myPOA.servant_to_reference( carrier );

      FileWriter output = new FileWriter("ns.ior");
      output.write( orb.object_to_string( initRef ) );
      output.close();
      System.out.println("Wrote IOR to file: ns.ior");

      myPOA.the_POAManager().activate();
      System.out.println( carrier + " ready for launch !!!");
      orb.run();
    }
    catch (java.lang.Exception exb) {
      System.err.println("Exception Last deep in here " + exb);
      System.exit(1);
    }
  }
}
```

Example 2
Servant implementation (Java, POA version)

```
// Building Distributed Object Applications with CORBA
// Infowave (Thailand) Co., Ltd. http://www.waveman.com, Sep 2000

public class AircraftCarrierImpl extends Ship.AircraftCarrierPOA
{
  private org.omg.PortableServer.POA _rootPOA;

  // Constructor:
  public AircraftCarrierImpl(
    org.omg.PortableServer.POA rootPOA) {
      _rootPOA = rootPOA;
  }

  public Ship.Aircraft launch ( String name ) {
    org.omg.PortableServer.Servant aircraft
          = new AircraftImpl( name );
    try {
      _rootPOA.activate_object_with_id(
            "name".getBytes(), aircraft );
    }
    catch (java.lang.Exception ex)
    {
      System.err.println("Exception 2 " + ex);
      System.exit(1);
    }
    ....
    System.out.println( name + " on Catapult 2");

    Ship.Aircraft _aircraft = null;
    try {
      _aircraft = Ship.AircraftHelper.narrow(
          _rootPOA.create_reference_with_id(
            "name".getBytes(),
            aircraft._all_interfaces(null, null)[0]));
    }
    catch (java.lang.Exception ex)
    {
      System.err.println("Exception 3 " + ex);
      System.exit(1);
    }
    return _aircraft;
  }
}
```


Example: Time Service

- Call provides current time (on server)
- Code to write:
  - IDL
  - Server
    - Starts ORB
    - Initializes Service
    - Gives IOR to the output
  - Client
    - Takes IOR
    - Calls service

```
//TestTimeServer.idl

module TestTimeServer{
   interface ObjTimeServer{
       string getTime();
   };
};
```


Time Service Component
as part of the server implementation (Java)

```
//TestTimeServerImpl.java
import CORBA.*;

class ObjTestTimeServerImpl
      extends TestTimeServer.ObjTimeServer_Skeleton
            //which is generated from IDL
{
     //Variables
     //Constructor
     //Method (Service) Implementation
     public String getTime() throws CORBA.SystemException
     {
          return "Time: " + currentTime;
     }
```


Time Service
The other part of the server implementation

```
// TimeServer_Server.java
import CORBA.*;
public class TimeServer_Server{
     public static void main( String[] argv ) {
        try {
           CORBA.ORB orb = CORBA.ORB.init();
           …
           ObjTestTimeServerImpl obj =
                              new ObjTestTimeServerImpl(…);
           …
           // print stringified object reference:
           System.out.println( orb.object_to_string(obj) );
        }
        catch (CORBA.SystemException e){
           System.err.println(e);
```


Time Service
Client Implementation

```
//TimeServer_Client.java
import CORBA.*;

public class TimeServer_Client{
     public static void main( String[] argv ) {
        // pass stringified object reference as argv[0]
        try {
           CORBA.ORB orb = CORBA.ORB.init();
           …
           CORBA.object obj = orb.string_to_object( argv[0] ); //IOR
           …
           TimeTimeServer.ObjTimeServer timeServer =     // downcast
                 TestTimeServerImpl.ObjTimeServer_var.narrow(obj);
           …
           System.out.println( timeServer.getTime() );     // invoke
        }
        catch (CORBA.SystemException e) { System.err.println(e); }
     }
```


Time Service
Execution

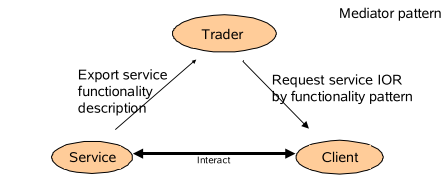
```
C:\>     java TimeServer_Server

IOR:0000000000122342435 …

C:\>     java TimeServer_Client
IOR:0000000000122342435 …

Time: 14:35:44
```

Available ORBs

- **Java-based**
  - IBM WebSphere
  - SUN NEO, Joe: own protocol. the Java Transaction Service JTS is the JOE Corba Object Transaction Service OTS.
  - IONA Orbix: developed in Java, i.e., ORBlets possible, C++, Java-applications
  - BEA WebLogic
  - Borland Visibroker (in Netscape Communicator), IIOP based. Also for C++.
  - **free**: JacORB, ILU, Jorba, DynaORB, OpenORB, JDK1.4+
- **C-based**
  - ACE ORB TAO, University Washington (with trader)
  - Linux ORBIT (gnome) (also for Cygwin).
  - Linux MICO (kde 1.0 used it)
- **Python-based**
  - fnorb
- http://www.omg.org
- [Szyperski CS 13.4]

Beyond Dynamic Call: The Trader Service

- Trader mediates services, based on published properties ("yellow page service")
- Matchmaking

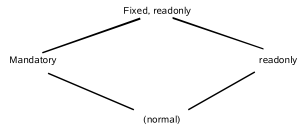


ORBs and Traders

- The ORB resolves operations still based on naming (with the *Naming service* = "White pages")
- The ***Trader service***, however, resolves operations (services) without names, only based on *properties* and *policies* = "Yellow pages"
- The trader gets *offers* from servers, containing new services

Modi of Service Properties

- Service properties can be qualified by modi:
  - "normal" (can be modified/deleted),
  - "fixed" (mandatory, cannot be deleted),
  - "readonly" (cannot be modified).
- The modi of the properties form a lattice.

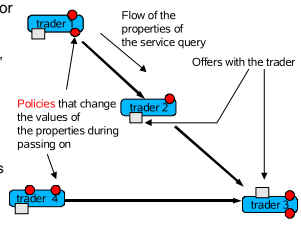


Service offers for the Trader service

- **Service offer (IOR, properties)**
  - Properties describe services
  - Are used by traders to match services to queries
- **Dynamic property**
  - A property can be queried dynamically by the trader of service
  - The service-object can determine the value of a dynamic property anew
- **Matching with the standard constraint language**
  - Boolean expressions about properties
  - Numeric and string comparisons

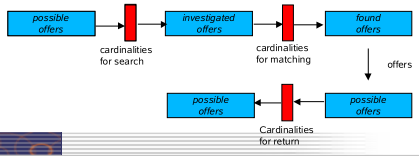
Traders Provide Service Hopping

- If a trader does not find a service, it can ask neighbor traders
  - Design pattern "Chain of Responsibility"
- Graph of traders
  - Links to neighbors via TraderLink
  - TraderLink filters and manipulates queries via policies
- A distributed search algorithm (also used in P2P)



Modification of Queries

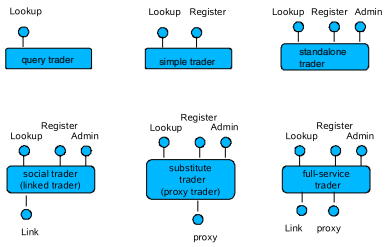
- **Policies parameterize the behavior of the traders and the TraderLinks**
  - Filters, i.e., values, limiting / modifying the queries:
  - max_search_card: maximal cardinality for the ongoing searches
  - max_match_card: maximal cardinality for matchings
  - max_hop_count: maximal search depth in the graph



Interfaces Trading Service

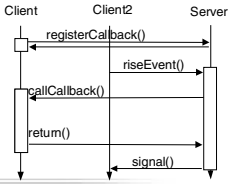
- **Basic interfaces**
  - Lookup (query)
  - Register (for export, retract, import of services)
  - Admin (info about services)
  - Link (construction of trader graph)
- **How does a query look like?**
  - Lookup.*Query*(in ServicetypeName, in Constraint, in PolicySeq, in SpecifiedProperties, in how to y, out OfferSequence, offerIterator)

CORBA Trader Types



Callbacks with the Callback Service

- **Callback function registration**
  - Procedure variable, closure (procedure variable with arguments) or reference to an object
- **Callback works for all languages**
- **Callback reverses roles of client and server**



Events

- **Send event objects from event suppliers to event consumers** unidirectional event channels decouple supplier and consumer
- **Event objects** (also called **messages**) **are immutable once sent**
  - Asynchronous communication; order of events is not respected
  - No return values (except with references to collector objects)
- **Unicast:** one receiver
- **Multicast:** many receivers
- **Dynamically varying receivers** (register at channels as supplier / consumer; event type filtering)
- **Works for every CORBA language**

CORBA Event Service

- **Push model:** Supplier sends event object by calling *push* operation on channel, which calls *push* to deliver event object to all registered consumers
- **Pull model:** Consumer calls *pull* operation on channel (polling for arriving events) which triggers calls to *pull* to registered suppliers
- **As intermediate instances, an event channel can be allocated**
  - They buffer, filter, and map pull to push
- **Untyped generic events, or typed by IDL**
- **Advantage:**
  - Asynchronous working in the Web (with IIOP and dynamic Call)
  - Attachment of legacy systems interesting for user interfaces, network computing etc.
- **Disadvantage:** Very general interface

Corba 3.0
since 1999

- Provides the well-defined packaging for producing components
- Messaging
- Language mappings that avoid hand-writing of IDL
  - Generating IDL from language specific type definitions
  - C++2IDL, Java2IDL, …
- XML integration (SOAP)
- Quality of Service management
- Real-time and small footprint versions
- CORBA Component Model (CCM)
  - similar to EJB, see later
- Scripting (CORBA script), a composition language

Corba 3.0 (cont.)

- **New Basic services:**
  - POA, the Portable Object Adapter, replaces BOA
  - SFA, Server Framework Adapter
  - Value objects
- **Services:**
  - Message Service MOM:
    Objects as asynchronous buffered messages
  - Corba Beans-components
  - Script language
- **Facilities:**
  compound documents, Mobile Agents, BOF (business object facility)

MOM -
Message Oriented Middleware

- **Every object in the Web gets a mailbox**
  - Buffering of all messages in structured files
  - Messages are objects
  - Laptops, palmtops supported
  - Callback-objects can be equipped with messages
  - MOA: Message Object Adapter similar to POA
- **Similar to EJB message beans (see later)**

Evaluation of CORBA

as composition system

Evaluation:
Component Model

- **Mechanisms for secrets and transparency: very good**
  - Interface and Implementation repository
  - Component language hidden (interoperability)
  - Life-time of service hidden
  - Identity of services hidden
  - Location hidden
- **No parameterization**
- **Many standards (see following subchapters)**

Evaluation:
Standardization

- **Quite good!**
  - Services, application services
  - On the other hand, some standards are FAT
- **Technical vs. application specific vs business components:**
  - Corba has standards for technical and application specific components
  - ... but for business objects, standards must be extended
    (vertical facilities)

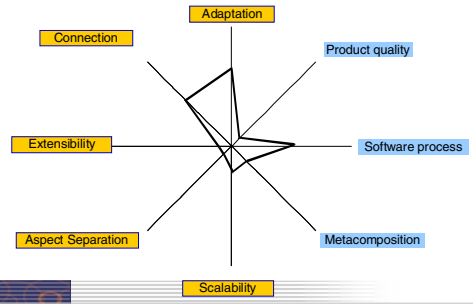
Evaluation: Composition Technique

- **Mechanisms for connection**
  - Mechanisms for adaptation: stubs, skeletons, server adapters
  - Mechanisms for glueing: marshalling based on IDL
- **Mechanisms for aspect separation**
  - Multiple interfaces per object
- **Nothing for extensions**
- **Mechanisms for Meta-modeling**
  - Interface Repositories with type codes, implementation repositories
- **Scalability**
  - Connections cannot easily be exchanged (except static local and remote call)

Evaluation: Composition Language

- **Weak**
  - CORBA scripting provides a facility to write glue code, but only black-box composition

CORBA – Evaluation of composition technique + language



What Have We Learned (1)

- **CORBA is big, but universal:**
  - The Corba-interfaces are very flexible, work, and can be used in practice
  - ... but also complex and fat, maybe too flexible
  - If you have to connect to legacy systems, CORBA works
- CORBA has the advantage of an **open standard**
- **Trading** and **dynamic call** are advanced communication mechanisms
- CORBA was probably only the first step, web services might be taking over

The End

- **Appendix:** advanced material on CORBA
  - CORBA services
  - CORBA facilities
  - CORBA and the web, ORBlets
  - CORBA facilities and UML profiles
  - Licensing for business services

Corba Services

OMG: CORBAservices: Common Object Service Specifications.
http://www.omg.org.

OMG: *CORBAfacilities: Common Object Facilities Specifications.*

Overview on Corba Services

- **16+ standardized service interfaces** (*i.e.*, a library)
  - Standardized, but status of implementation different depending on producer
- **Object services**
  - Deal with features and management of objects
- **Collaboration services**
  - Deal with collaboration, *i.e.*, object contexts
- **Business services**
  - Deal with business applications
- The services serve for standardization.
  They are very important to increase reuse.
  - Available for every language, and on distributed systems!

Object Services

- **Name service** (directory service)
  - Records server objects in a simple tree-like name space
  - (Is a simple component system itself)
- **Lifecycle service** (allocation service)
  - Not automatic; semantics of deallocation undefined
- **Property service** (feature service for objects)
- **Persistency service** (storing objects in data bases)
- **Relationship service** to build interoperable relations and graphs
  - Support of standard relations: reference, containment
  - Divided in standard roles: contains, containedIn, references, referenced
- **Container service** (collection service)

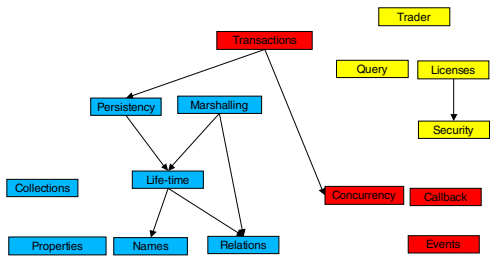
Collaboration Services

- **Communication services**
  - Resemble connectors in architecture systems, but cannot be exchanged to each other
  - Event service
    - push model: the components push events into the event channel
    - pull model: the components wait at the channel and empty it
  - Callback service
- **Concurrency service**
  - Distributed locks
- **Object transaction service, OTS**
  - Flat transactions on object graphs

Business Services

- **Trader service**
  - Yellow Pages, localization of services
- **Query service**
  - Search for objects with attributes and the OQL, SQL (ODMG-93)
- **Licensing service**
  - For application providers (application servers)
  - License managers
- **Security service**
  - Use of SSL and other basic services

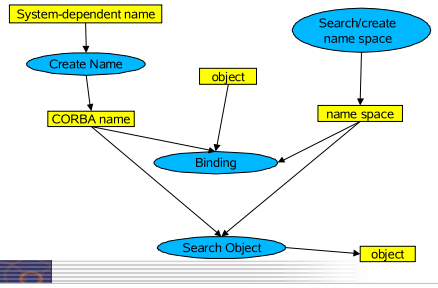
Dependencies Between the Services



Object Services: Names

- **Binding of a name creates an object in a name space (directory, scope, naming context).**
  - A *name space* is a container with a set of bindings of names to values.
  - They can reference each other and build name graphs
- **The representation of a name is based on abstract syntax, not on the concrete syntax of a operating system or URL.**
  - A name consists of a tuple (Identifier, Kind).
  - The Identifier is the real name, the Kind tells how the name is represented (e.g., c_source, object_code, executable, postscript,..).
  - For creation of names there is a library (design pattern Abstract Factory).

Use of Names



Naming Service

CosNaming::NamingContext

bind (in Name n, in Object obj)
rebind (in Name n, in Object obj)
bind_context
rebind_context
mk_name(String s)
Object resolve
unbind (in Name n)
NamingContext new_context;
NamingContext bind_new_context (in Name n)
void destroy
void list (..)
_narrow()

Naming Service

```
void bind( in Name n,  in Object obj)
        raises( NotFound, CannotProceed, InvalidName, AlreadyBound );
void rebind( in Name n,  in Object obj)
        raises( NotFound, CannotProceed, InvalidName );
void bind_context( in Name n,  in NamingContext nc)
        raises( NotFound, CannotProceed, InvalidName, AlreadyBound );
void rebind_context( in Name n,  in NamingContext nc )
        raises( NotFound, CannotProceed, InvalidName );
Name mk_name( String s );
Object resolve( in Name n)
        raises( NotFound, CannotProceed, InvalidName );
void unbind( in Name n)
        raises( NotFound, CannotProceed, InvalidName );
NamingContext new_context();
NamingContext bind_new_context( in Name n)
        raises( NotFound, AlreadyBound, CannotProceed, InvalidName );
void destroy()
        raises( NotEmpty );
void list( in unsigned long how_many,
        out BindingList bl,  out BindingIterator bi );
```


Naming Service in IDL

```
module CosNaming {
  typedef string Istring;
  struct NameComponent {
      Istring id;
      Istring kind;
  };
  typedef sequence <NameComponent> Name;
  enum BindingType { nobject, ncontext };
  struct Binding {
      Name binding_name;
      BindingType binding_type;
  };
  typedef sequence<Binding> BindingList;
  interface BindingIterator;
  interface NamingContext;
}
...
```

```
...
interface NamingContext {
   enum NotFoundReason { missing_node,
                         not_context,  not_object };
   exception NotFound {
       NotFoundReason why;
       Name rest_of_name;
   };
   exception CannotProceed {
       NamingContext ctxt;
       Name rest_of_name;
   };
   exception InvalidName {};
   exception AlreadyBound {};
   exception NotEmpty {};

   void bind ( in Name n,  in Object obj )
        raises (NotFound, CannotProceed, ... )
   ... // other operations omitted, see previous page
}

interface BindingIterator {
   boolean next_one( out Binding b);
   boolean next_n( in unsigned long how_many,
                   out BindingList bl);
   void destroy();
};  .....
```


Naming Service: Example

```
// From: Redlich

import java.io.*;
import java.awt.*;
import IE.Iona.Orbix2.CORBA.SystemException;  // OrbixWeb
import CosNaming.NamingContext;   // name service/context
import CosNaming.NamingContext.*; // name service/exceptions
import Calc5.calc.complex;        // type 'complex' from Calc5

class MyNaming extends CosNaming {
  ...
}
public class client  extends Frame  {
  private Calc5.calc.Ref calc;
  private TextField inR, inI;
  private Button setB, addB, multB,
          divB, quitB, zeroB;

  public static void main( String argv[] )  {
    CosNaming.NamingContext.Ref  ctxt;
    Calc5.calc_factory.Ref  cf;
    Frame  f;

    try {
      ctxt = NamingContext._narrow( MyNaming.
            resolve_initial_references( MyNaming.NameService ));

          cf = Calc5.calc_factory._narrow(
               ctxt.resolve( MyNaming.mk_name("calcfac")));

      f = new client( cf.create_new_calc() );
      f.pack();
      f.show();
    }
    catch  (Exception ex)  {
      System.out.println("Calc-5/Init:" + ex.toString());
    }
  }
```


Object Services: Persistency

- **Definition of a Persistent Object Identifier (PID)**
  - references the *value* of a CORBA object (in contrast to a CORBA object)
- **Interface**
  - connect, disconnect, store, restore, delete
- **Attachment to data bases possible**

Object Services: Property Service

- **Management of lists of features (properties) for objects**
  - Properties are strings
  - Dynamically extensible
- **Concept well-known as**
  - LISP property lists, associative arrays, Java property classes
- **Iterators for properties**
- **Interface:**
  - define_property, define_properties, get_property_value, get_properties, delete_property

Collaboration Services: Transactions

- **What a dream: the Web as data base with nested transactions.**

  Scenarios:
  - Accounts as Web-objects.
    Transfers as transaction on the objects of several banks
  - Parallel working on web sites: how to make consistent?
- **Standard 2-phase commit protocol:**
  - begin_ta, rollback, commit
- **Nested transactions**
  - begin_subtransaction, rollback_subtransaction, commit_subtransaction

CORBA Facilities (Standards for Application Domains)

Application-domain-specific interfaces

Horizontal Facilities
(applicable in many domains)

- **User interfaces**
  - Printing, Scripting
  - Compound documents
    e.g. OpenDoc (since 1996 accepted as standard format. Source code has been released of IBM. Now obsolete.)
- **Information management**
  - Metadata (meta object facility, MOF)
  - Tool interchange:
    a text- and stream-based exchange format for UML (XMI)
  - Common Warehouse Model (CWM):
    MOF-based metaschema for database applications

Vertical Facilities
(Domain-Specific Facilities)

The Domain technology committee (DTC) creates domain task forces DTF for an application domain

- **Business objects**
- **Finance/insurance**
  - Currency facility
- **Electronic commerce**
- **Manufacturing**
  - Product data management enablers (PDM)
- **Medicine (healthcare CorbaMed)**
  - Lexicon Query Service
  - Person Identifier Service PIDS
- **Telecommunications**
  - Audio/visual stream control object
  - Notification service
- **Transportation**

CORBA, Web and Java

Corba and the Web

- **HTML solves many of the CORBA problems**
- **HTTP only for data transport**
  - HTTP cannot call methods, except by CGI-gateway-functionality (CGI = common gateway interface)
  - Behind the CGI-interface is a general program, communicating with HTTP via untyped environment variables (HACK!)
  - HTTP servers are simple ORBs, pages are objects
  - The URI/URL-name schema can be integrated into CORBA
- **IIOP becomes a standard internet protocol**
  - Standard ports, URL-mappings and standard-proxies for firewalls will be available
- **CORBA is an extension of HTTP of data to code**

CORBA and Java

- **Java is an ideal partner for CORBA :**
  - Bytecode is mobile
    - Applets: move calculations to clients (thin/thick client problem)
    - can be used for migration of objects, ORBs, and agents
  - Since 1999 direct CORBA support in JDK 1.2
    - IDL-to-Java mapping, IDL compiler, Java-to-IDL compiler, name service, ORB
  - Corba supports for Java a distributed interoperable infrastructure
- **Java imitates functionality of Corba**
  - Basic services:
    Remote Method Invocation RMI, Java Native code Interface JNI
  - Services: serialization, events
  - Application-specific services (facilities):
    reflection, properties of JavaBeans

Corba and the Web (Orblets)

- ORBs can be written as bytecode applets if they are written in Java (*ORBlet*)
- Coupling of HTTP and IIOP:
  - Download of an ORBlet with HTTP
  - Talk to this ORB to get contact to server
- Replaces CGI hacks!
- Will be realized in web services (see later).

ORBlets