CORBA

[Szyperski, Chapter 13]

Overview, Goals

Basic interoperability:
- IDL
- ORB
- Object Adapter
- IOR
- GIOP/IIOP
- Dynamic Calls

Trader Service

Evaluation of CORBA as a composition system

Following: CCM CORBA Component Model

Appendices:

CORBA Services and CORBA Facilities
CORBA, Web and Java

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

- 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

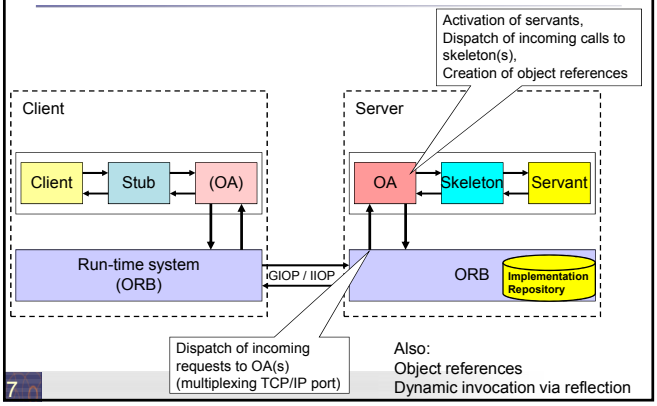
Corba's Hydrocephalus

- **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)

Recall: Solutions for Language and Location Transparency

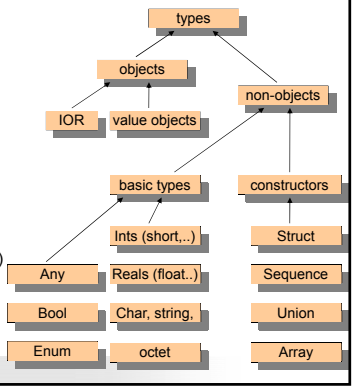


Language Transparency

- **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

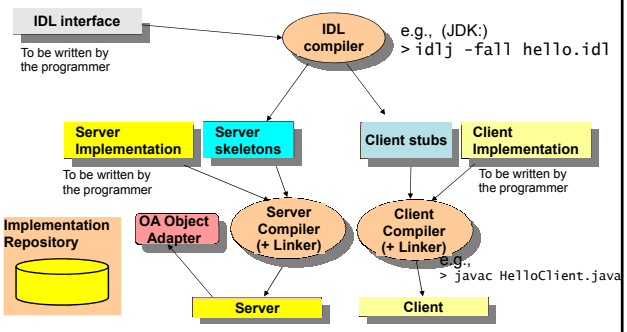
hello.idl

```
#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

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

```
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

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

```
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.id
*/
public abstract class CounterPOA extends org.omg.PortableServer
    implements Counter.CounterOperations, org.omg.CORBA.portabl
{
 // 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
```

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

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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
} ...
```

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

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Example (cont.): _CounterStub.java

```
package Counter;
/**
* Counter/_CounterStub.java .
* Generated by the IDL-to-Java compiler (portable), version "3.2" from Counter.idl den
*/
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
 ...
```

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

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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).

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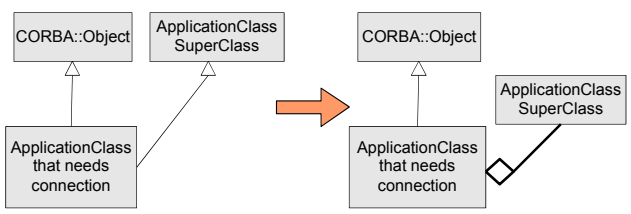
Problem: Multiple Inheritance

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



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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

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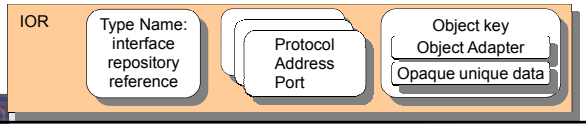
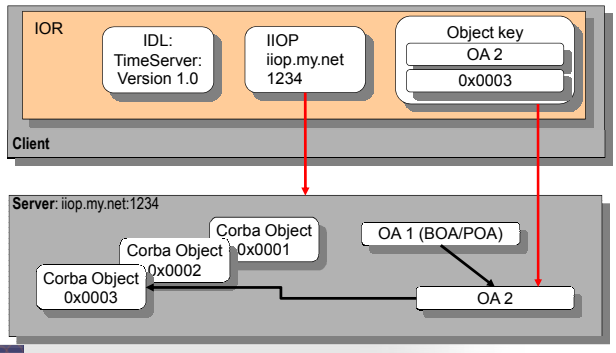
Interoperable Object Reference (IOR) - cont.

- Transient (terminates with server) or persistent
- IOR is larger, more time-consuming than language-bound reference
- 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

Example: Time Service

- Call provides current time (on server)
- Code to write:
  - Interface in 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
…
TestTimeServer.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
```


GIOP / IIOP

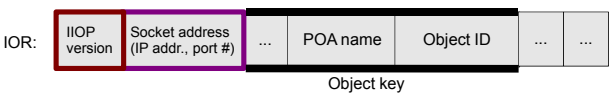
OSI Networking Model layers	CORBA GIOP / IIOP layers
7 Application	ORB
6 Presentation	GIOP
5 Session	IIOP
4 Transport	TCP
3 Network	IP
2 Data Link	Data Link
1 Physical	Physical

GIOP General Inter-ORB Protocol

- **General protocol, simple, abstract**
  - Independent of any particular transport protocol (IIOP: over TCP/IP)
- **Asymmetric (client-server) connections**
  - Client creates connection
  - Server receives requests and replies (without knowing client)
- **Connection-oriented transport, no packet size restrictions**
- **Common data representation (CDR): octet (8-bit bytes) stream**
  - Sender endianness information in header
  - Sender alignment information (1, 2, or 4 bytes) in header
  - Sender sends natively aligned data, receiver adapts if necessary
  - Encoding of the IDL datatypes
- **Message formats:**
  - Request, LocateRequest, CancelRequest (client)
  - Reply, LocateReply (server)
  - MessageError, Fragment, CloseConnection (both)

IIOP (Internet Inter-ORB Protocol)

- **Implementation of GIOP on top of TCP/IP**
- **TCP/IP Socket communication**
- **Adds socket address information to IOR contents**



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

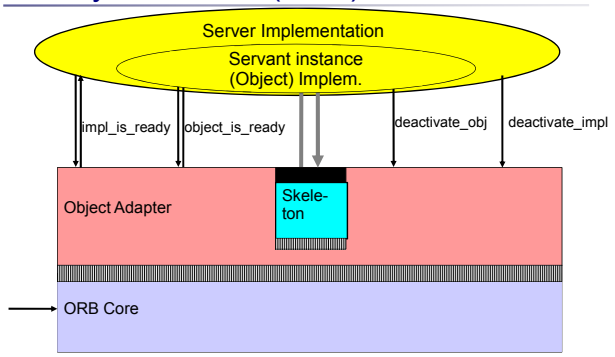
- **Advantage: the participants (methods) are statically known**
  - Call by stub and skeletons, without involvement of an ORB
  - Supports distribution:
    Exchange of local call in one address space to remote call is very easy:
    - Inherit from a CORBA class
    - Write an IDL spec
  - No search 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

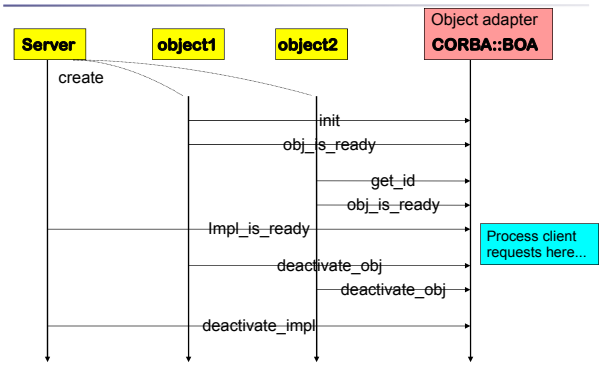
CORBA::BOA

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 (BOA version)



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**

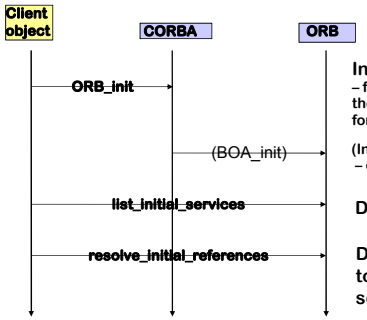
Object Request Broker ORB

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



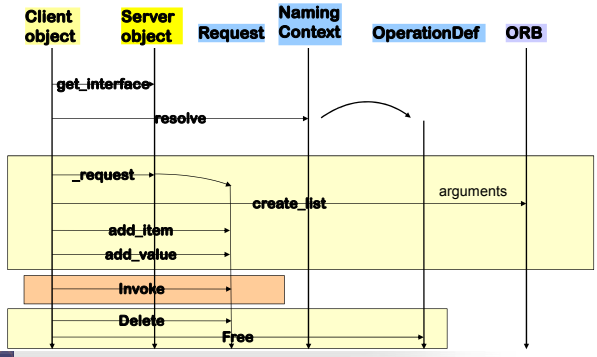
Initialize the ORB
– first step to set up the CORBA environment for a CORBA application

(Initializes the server BOA – deprecated in CORBA 3)

Delivers service names

Delivers object references to server objects from service names

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
// Adapted from:  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);
    }
```

Step 1: Initialize the ORB

Example 2: DII Invocation in Java

Client code (2)

```
{ // scope of request object:
    try { ... (simplified)
      carrier = intf_rep.lookup("IDL:Ship/AircraftCarrier:1.0");
    }
    catch (...) {
      System.err.println("..." + se);
      System.exit(1);
    }
    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 ) );
    //  Step 4:  Invoke request:
    request.invoke();
    //  Step 5:  Read result value:
    aircraft = request.result().value().extract_Object();
  }
  { // scope of another DII call  (use a fresh request object):
    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");
  }
```

Step 2: Query the DII to get a ref to an interface by name

Step 3: Create a DII request object for this interface and fill it with method name, arguments, return type:

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 )
  {  Step 1: Initialize server ORB
    org.omg.CORBA.ORB orb =
          org.omg.CORBA.ORB.init( args, null );

    org.omg.CORBA.Object objPOA = null;
    try {Step 2: Get RootPOA ref from naming s
      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;
    ...
```

Step 3: Narrow it to a RootPOA object (downcast)

```
    ...
    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);
    }  Step 5: Create new servant object:
    org.omg.PortableServer.Servant carrier = null;
    try {   ...pass the POA to its constructor
      carrier = new AircraftCarrierImpl(myPOA);
      myPOA.activate_object_with_id
        ("Nimitz".getBytes(), carrier);  and activate it
    }
    catch (org.omg.CORBA.SystemException se) {...}
    catch (org.omg.CORBA.UserException ue) {...}
```

Step 4: Create new POA with specific policies:

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");
            Step 6: Activate the POA manager:
      myPOA.the_POAManager().activate();
      System.out.println( carrier + " ready for launch !!!");
      orb.run();  Step 7:  Hand over application control to the ORB
    }                      to service incoming calls
    catch (java.lang.Exception exb) {
      System.err.println("Exception Last deep in here " + exb);
      System.exit(1);
    }
  }
}
```


Example 2

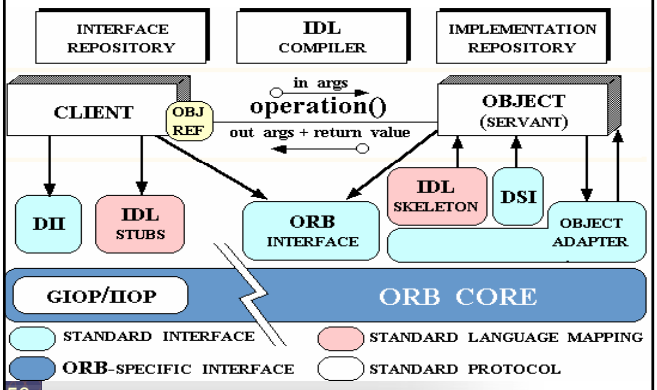
Servant implementation (Java, POA version)

```
// Adapted from:  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 _myPOA;

  // Constructor:
  public AircraftCarrierImpl (
    org.omg.PortableServer.POA myPOA ) {
      _myPOA = myPOA;  Record a ref. to my POA
  }                    (here, in constructor)
  public Ship.Aircraft launch ( String name ) {
    org.omg.PortableServer.Servant aircraft
          = new AircraftImpl( name );
    try {    Can register created objects ...
      _myPOA.activate_object_with_id(
            "name".getBytes(), aircraft );
    }    ... as CORBA objects with my POA
    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(
        _myPOA.create_reference_with_id(
          "name".getBytes(),
          aircraft._all_interfaces(null, null)[0]));
    }
    catch (java.lang.Exception ex)
    {
      System.out.println("Exception 3 " + ex);
      System.exit(1);
    }
    return _aircraft;
  }
}
```

CORBA interoperability mechanisms

Summary and further components



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

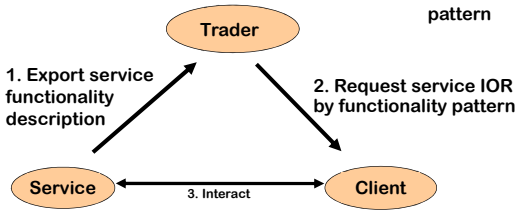
Available ORBs

- **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

→ **Mediator pattern**



ORBs and Traders

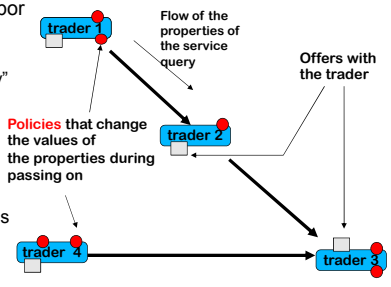
- The ORB resolves operations still based on naming (with the *Naming service* = "White pages")
- The ***Trader service***, however, resolves operations (services) without names, only based on *properties* and *policies* = "Yellow pages"
- The trader gets *offers* from servers, containing new services

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

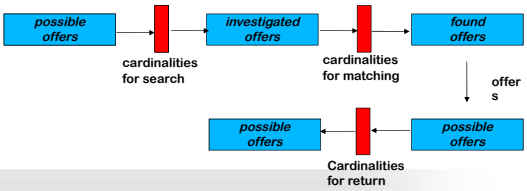
Traders Provide Service Hopping

- 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

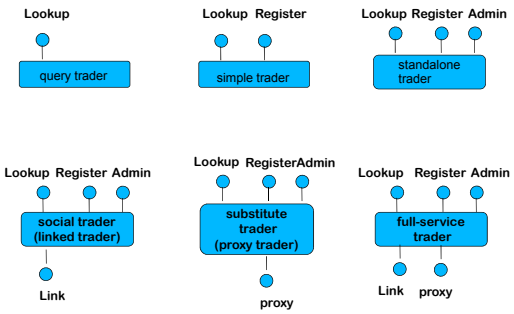
- **Policies parameterize the behavior of the traders and the TraderLinks**
  - Filters, i.e., values, limiting / modifying the queries:
  - max_search_card: maximal cardinality for the ongoing searches
  - max_match_card: maximal cardinality for matchings
  - max_hop_count: maximal search depth in the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



Interfaces Trading Service

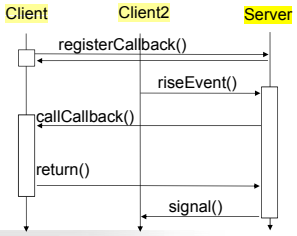
- **Basic interfaces**
  - Lookup (query)
  - Register (for export, retract, import of services)
  - Admin (info about services)
  - Link (construction of trader graph)
- **How does a query look like?**
  - Lookup.*Query*(in ServicetypeName, in Constraint, in PolicySeq, in SpecifiedProperties, in how_to_y,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

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

What Have We Learned (1)

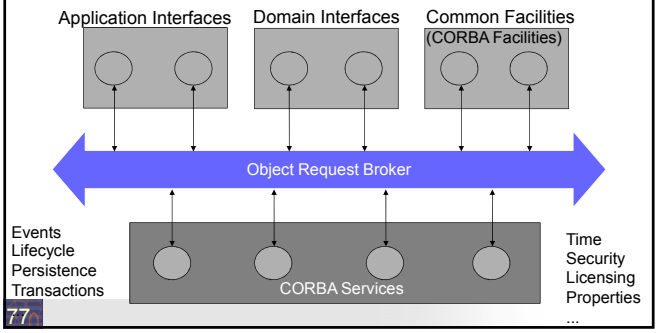
- **CORBA is big, but universal:**
  - The Corba-interfaces are very flexible, work, and can be used in practice
  - ... but also complex and fat, maybe too flexible
  - If you have to connect to legacy systems, CORBA works
- CORBA has the advantage of an **open standard**
- **Trading** and **dynamic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

APPENDIX

- **Advanced material on CORBA (for self-study)**
  - CORBA services
  - CORBA facilities
  - CORBA and the web, ORBlets

OMA (Object Management Architecture)

- **A software bus**



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)

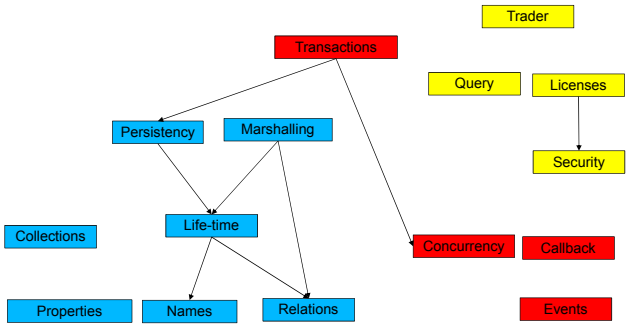
Collaboration Services

- **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

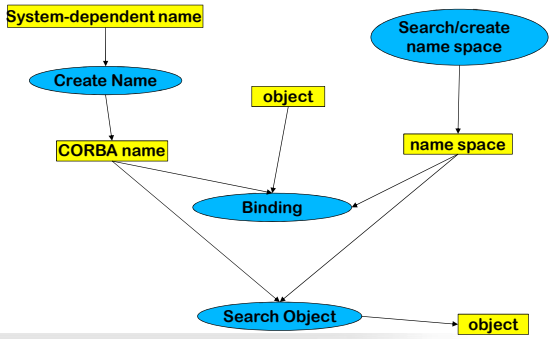
Dependencies Between the Services



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 );
```


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**

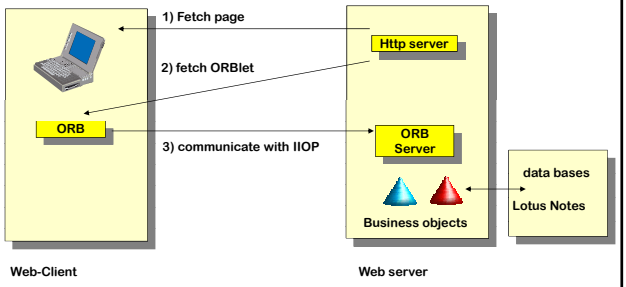
CORBA and Java

- **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


1) Fetch page
2) fetch ORBlet
3) communicate with IIOP
ORB
Http server
ORB Server
Business objects
data bases
Lotus Notes
Web-Client
Web server