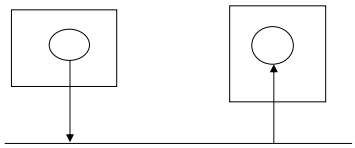
Distributed Programming

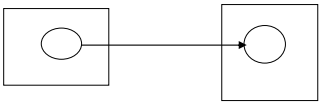
•low level: sending data among distributed computations



•network is visible (to the programmer)

•programmer must deal with many details

•higher level: supporting invocations among distributed computations



•network is invisible (to the programmer)

•programmer focuses on application

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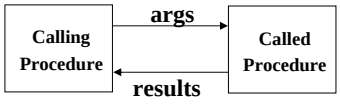
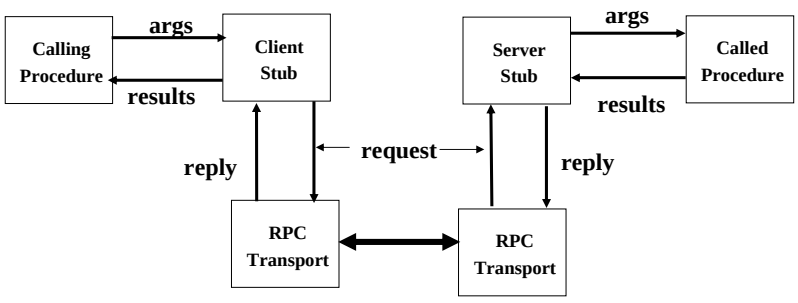
Remote Procedure Call





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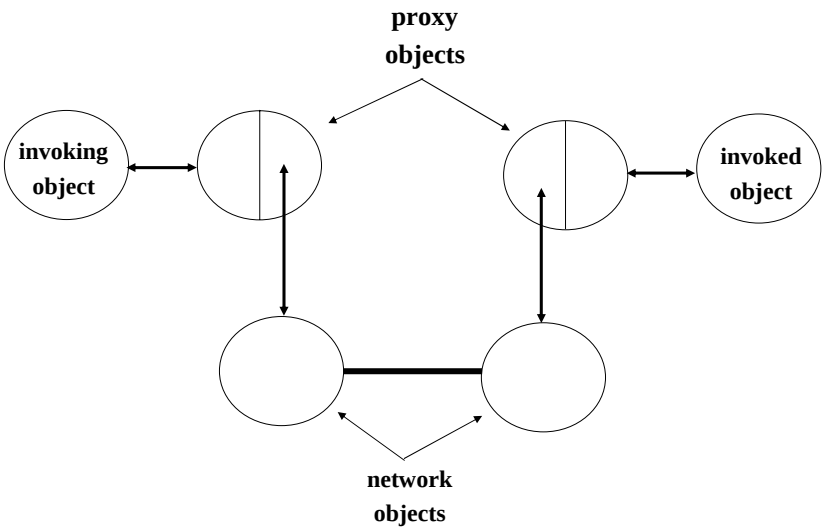
Remote Object Systems



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Remote Invocation Issues

- generating stubs/proxies
- serialization of arguments and return values
- heterogeneity of data representations
- locating servers in a distributed environment (*)
- authentication of called and calling procedures (*)
- semantics of invocation

(*) addressed in other sections of the course

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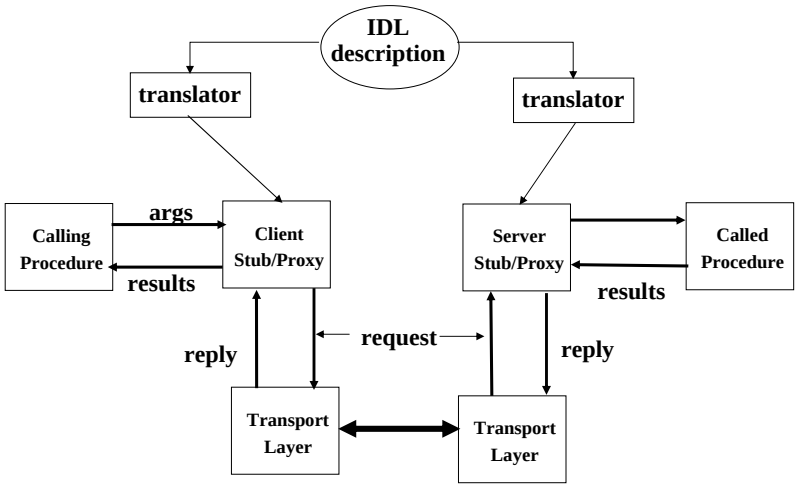
Interface Definition Language



Language binding: how IDL is translated to a given programming language.

IDL Elements

```
module modulename {
  exception exceptionName { [type pname]* };
  typedef type newtype;

  interface newInterface {
   oneway type fname(in type pname1);
   attribute newtype;
  };

  interface newInterface2 : newInterface {
   type fname2 (out newInterface pname3) raises exceptionName;
  };
};
```

From: Ole Arthur Bernsen

IDL Example

```
typedef unsigned long AccountNumber;
typedef unsigned long PersonalIdentificationNumber;

exception NoSuchAccount {};
exception InvalidPin{};
exception InsufficientFunds {};

interface Account {
  struct AccountRecord {
    string owner;
    float balance;
    string lastaccess; };
  void Credit (in float Amount);
  void Debit(in float Amount) raises (InsufficientFunds);
  void List (out AccountRecord List_R1);
};

interface Sbank {
  Account Access (in AccountNumber acct,
                  in PersonalIdentificationNumber pin)
                  raises (NoSuchAccount, InvalidPin);
};
```

From: Nigel Edwards

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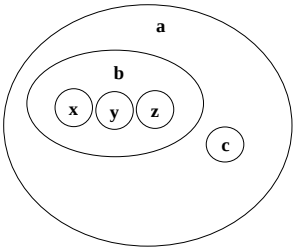
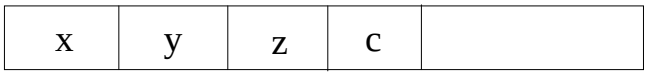
Serialization



Issues:

- how to represent base types (i.e. int)
- how to represent structured types (arrays)
- how to deal with references (pointers)
- how to treat duplicated objects

transforming a typed, highly structured object into a stream of bytes.



Transfer syntax: the description of the encoded data stream.

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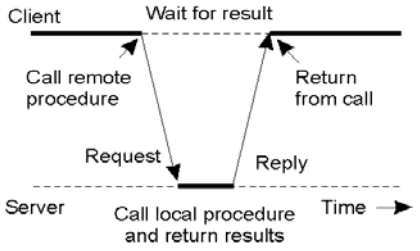
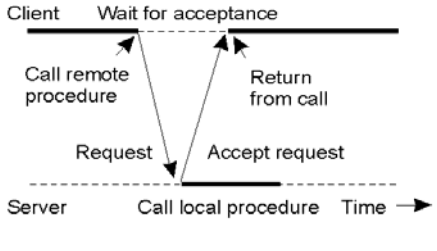
Invocation Semantics - Blocking



synchronous



asynchronous (one-way)

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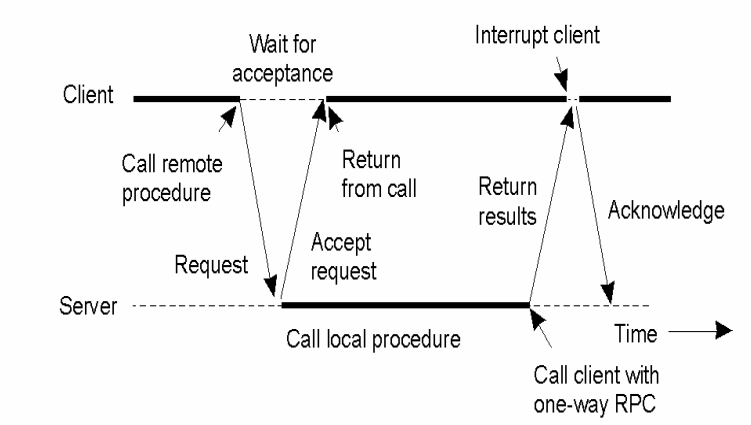
Invocation Semantics - Blocking



asynchronous (with returned result)

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Invocation Semantics –Modes

- At-most once: it is guaranteed that the invocation will not occur or will occur exactly once.
- At-least-once: it is guaranteed that the invocation will occur though perhaps multiple times
- Best-effort: no guarantee

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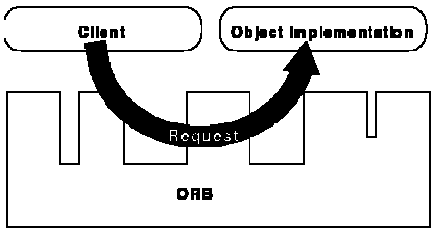
Corba

Goal: interoperability among application components
- written in different programming languages
- executing on heterogeneous architectures
- communicating over different networks.



Corba: Common Object Request Broker Architecture

ORB: Object Request Broker

From: Object Mangagement Group

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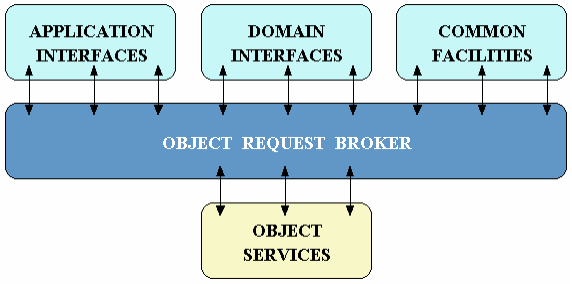
Role of the Object Request Broker



- **Application interfaces**: interfaces for a specific application
- **Domain interfaces**: interfaces shared across applications in a given application domain (publishing)
- **Common Facilities**: generic services that might be needed in several domains (document structure)
- **Object Services**: commonly needed across all applications (e.g., lifetime, naming, trading)

From: Doug Schmidt

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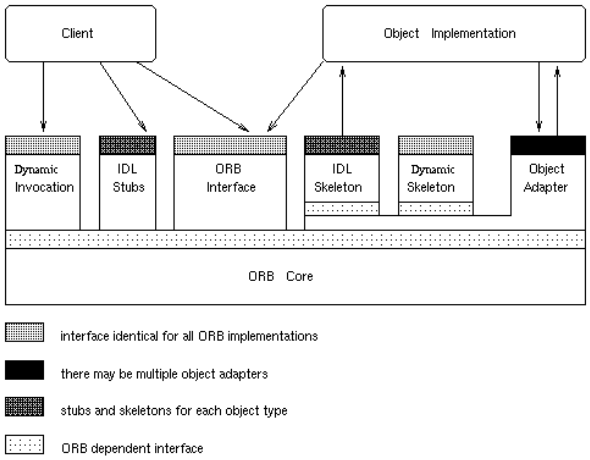
Elements of Corba



From: Kate Keahey

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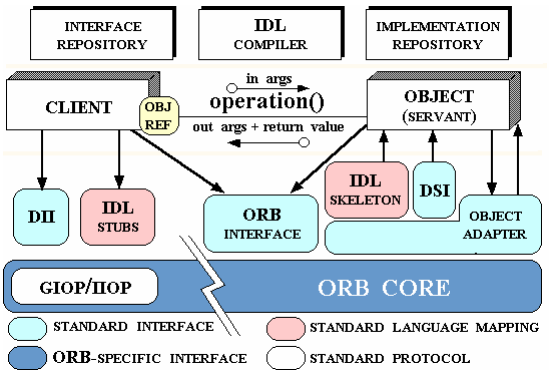
Elements of Corba



From: Doug Schmidt

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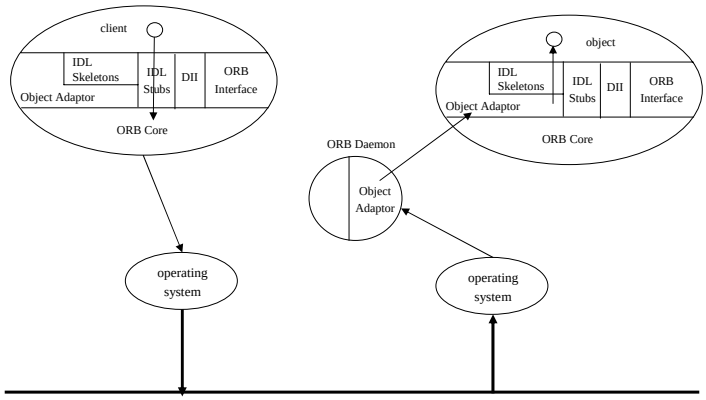
Corba Process Structure



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Corba Services

- Naming - bind of names to objects (*)
- Events - asynchronous notification (*)
- Lifecycle - object management
- Relationship - maintaining relationships among objects
- Transaction - structured, reliable, database operations (*)

(*) - see more about later in the course

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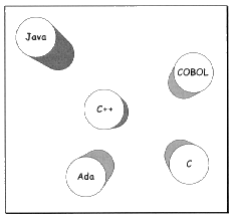
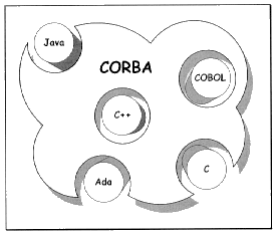
Corba and Java





Corba is still needed to fill in the gaps between Java and system developed in other languages.

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