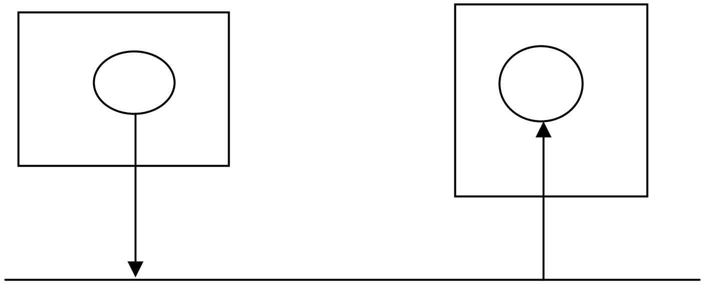
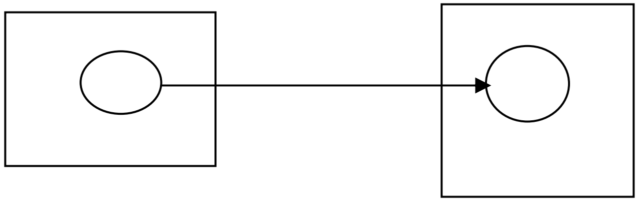
Distributed Programming

- low level: sending data among distributed computations



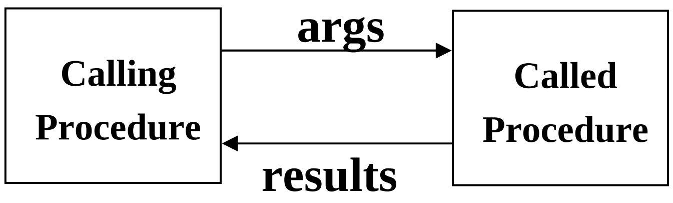
- network is visible (to the programmer)
- programmer must deal with many details

- higher level: supporting invocations among distributed computations



- network is invisible (to the programmer)
- programmer focuses on application

Remote Procedure Call

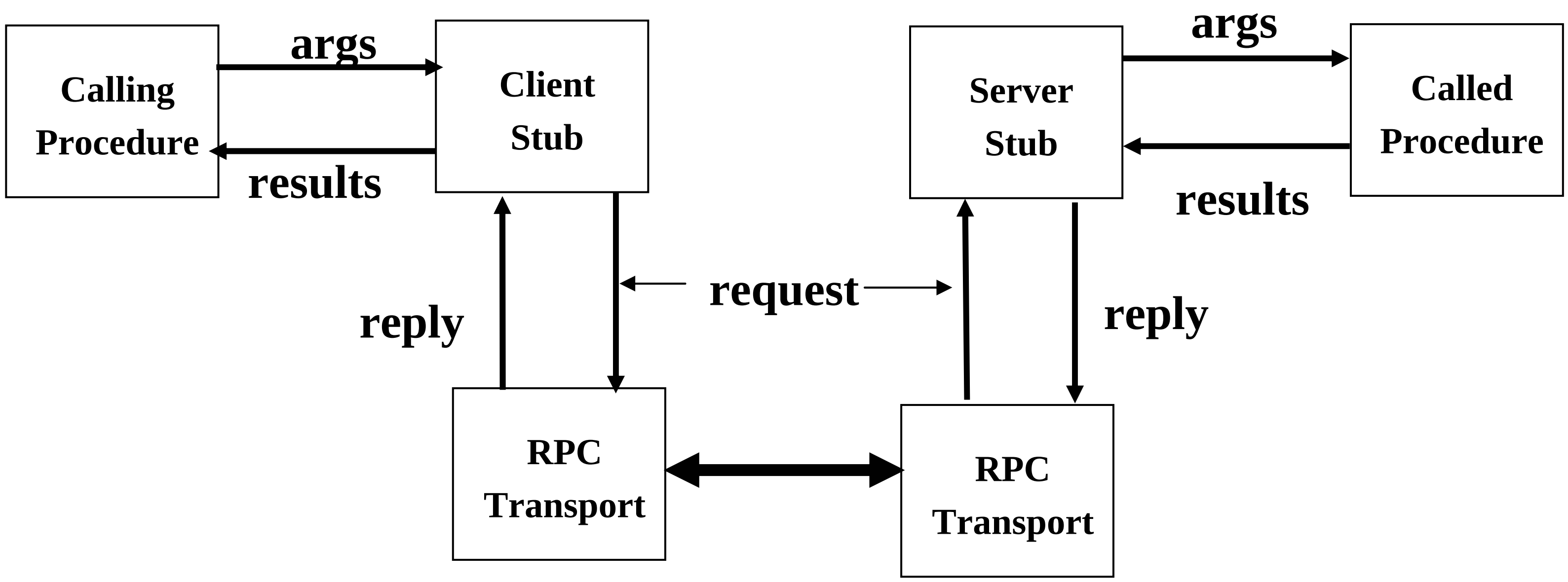


Calling Procedure

args

results

Called Procedure



Calling Procedure

args

results

Client Stub

reply

request

Server Stub

args

results

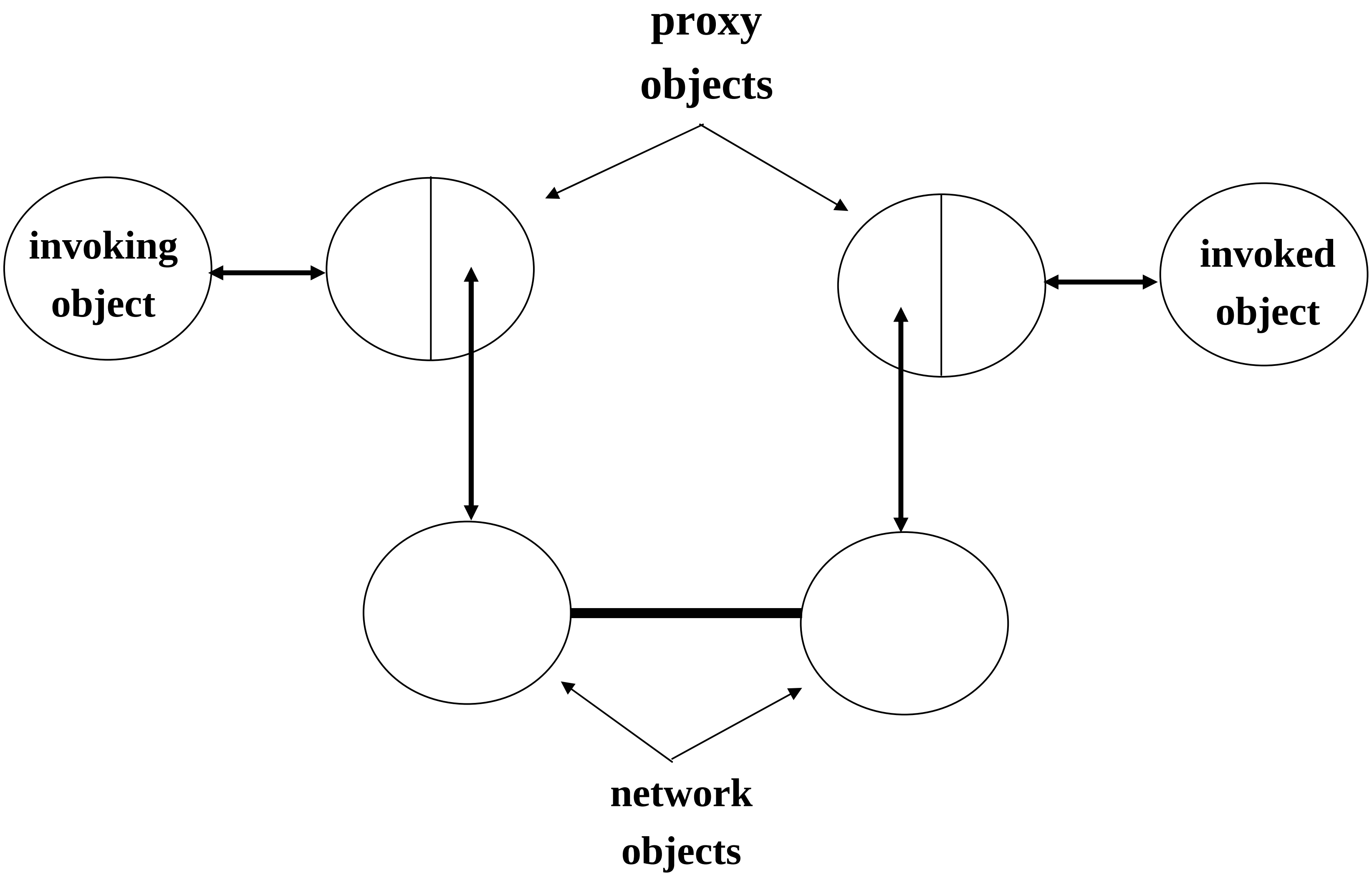
Called Procedure

reply

RPC Transport

RPC Transport

Remote Object Systems



proxy objects

invoking object

invoked object

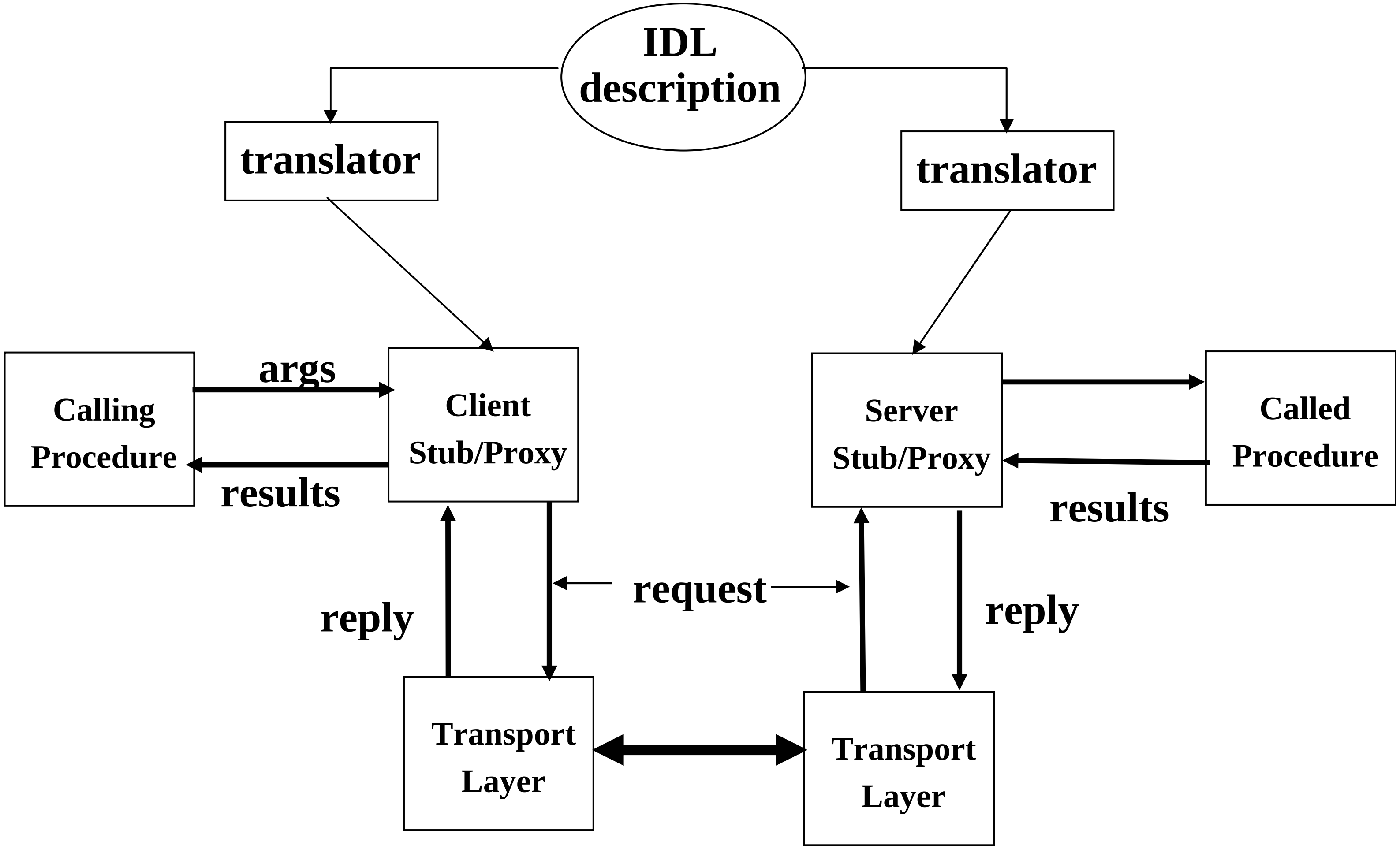
network objects

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

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;
  };
};
```

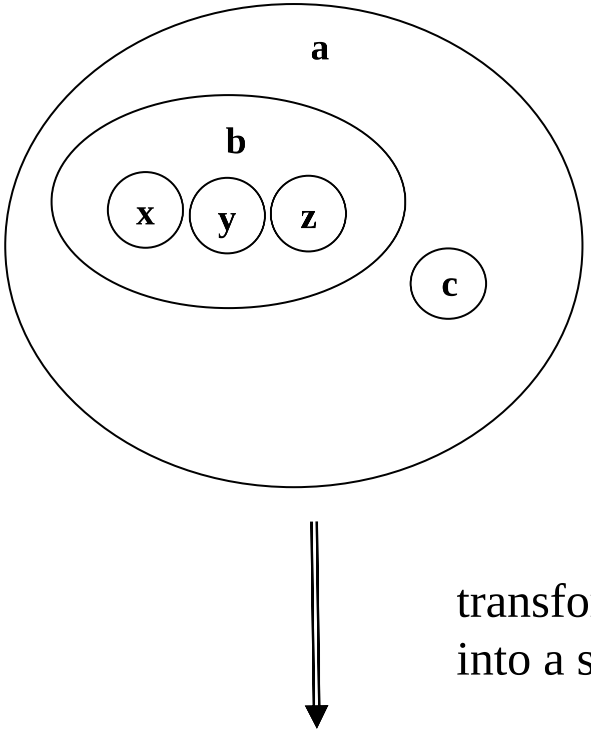
From: Ole Arthur Bernsen

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

Serialization



Issues:

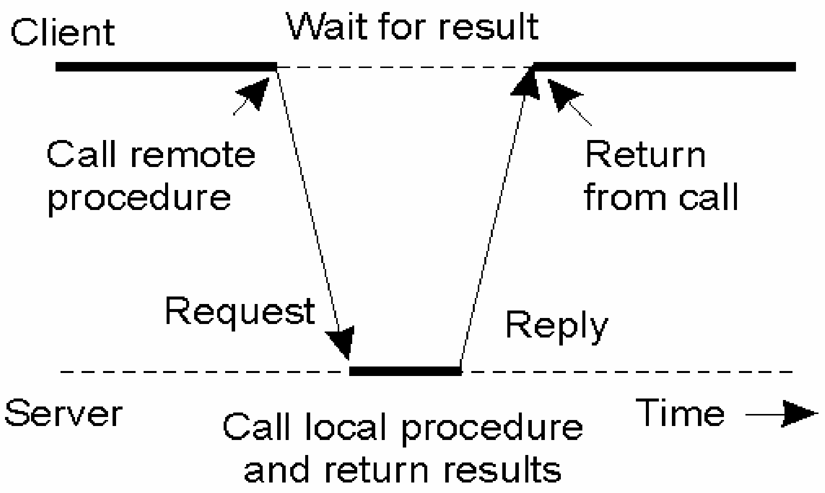
- how to represent base types (i.e. int)
- how to represent structured types (arrays)
- how to deal with references (pointers)
- how to treat duplicated objects

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

x	y	z	c	

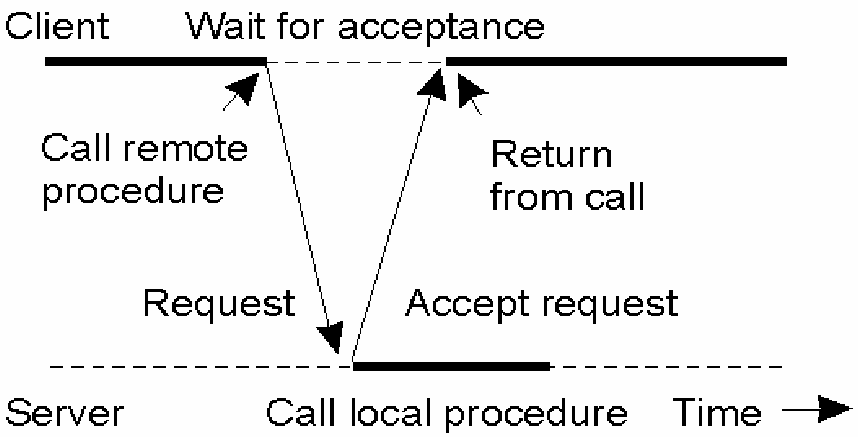
Transfer syntax: the description of the encoded data stream.

Invocation Semantics - Blocking



(a)

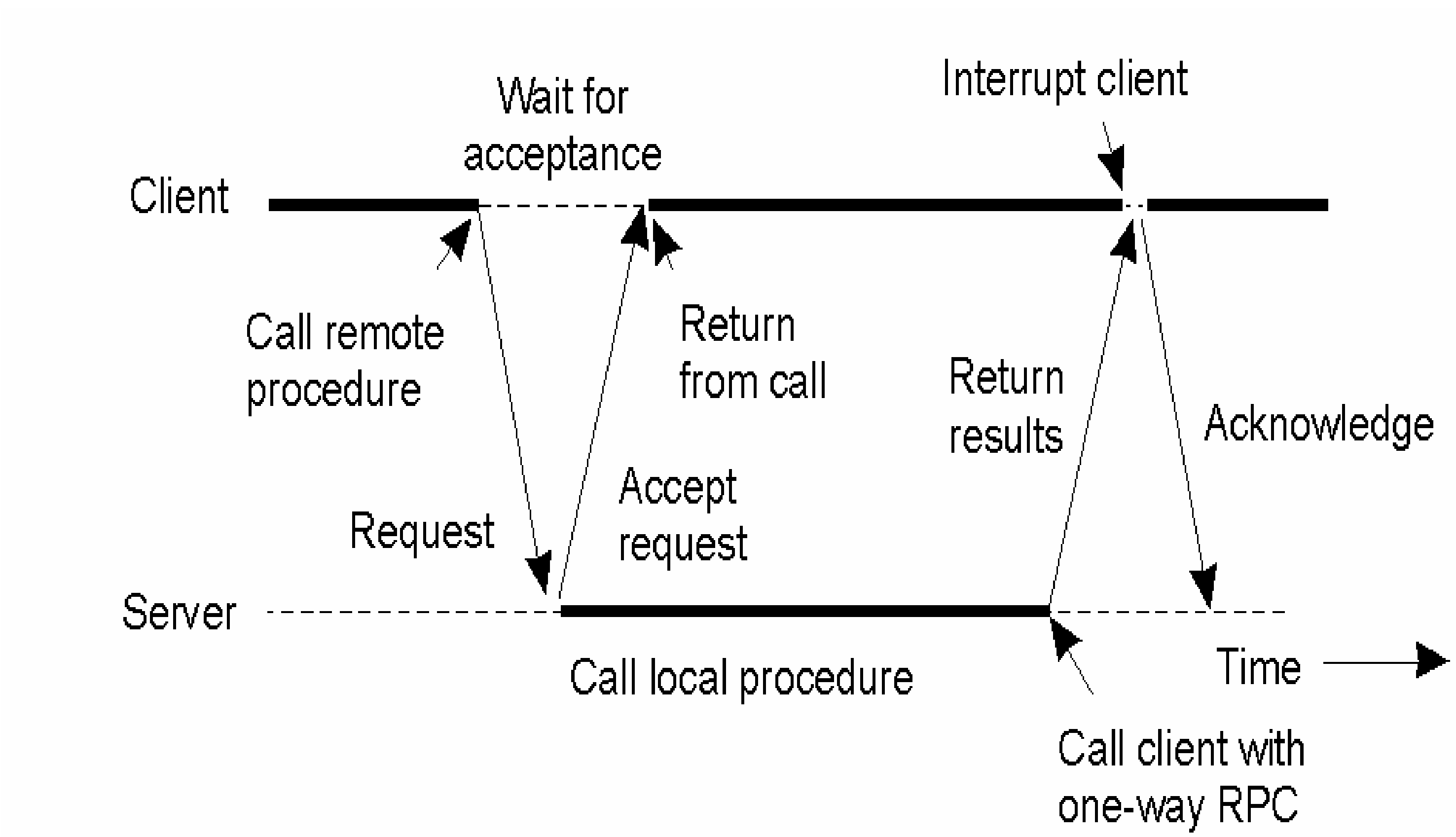
synchronous



(b)

asynchronous (one-way)

Invocation Semantics - Blocking



asynchronous (with returned result)

Invocation Semantics –Modes

- At-most once: it is guaranteed that the invocation will not occur or will occur exactly once.

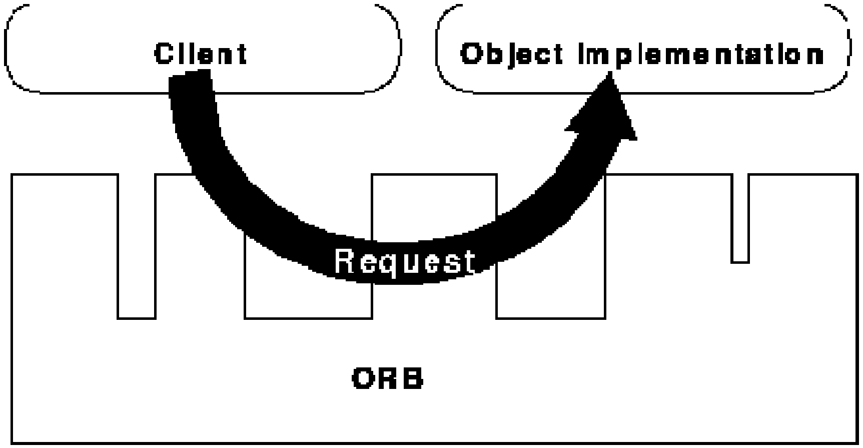
- At-least-once: it is guaranteed that the invocation will occur though perhaps multiple times

- Best-effort: no guarantee

Corba

Goal: interoperability among application components

- written in different programming languages
- executing on heterogeneous architectures
- communicating over different networks.

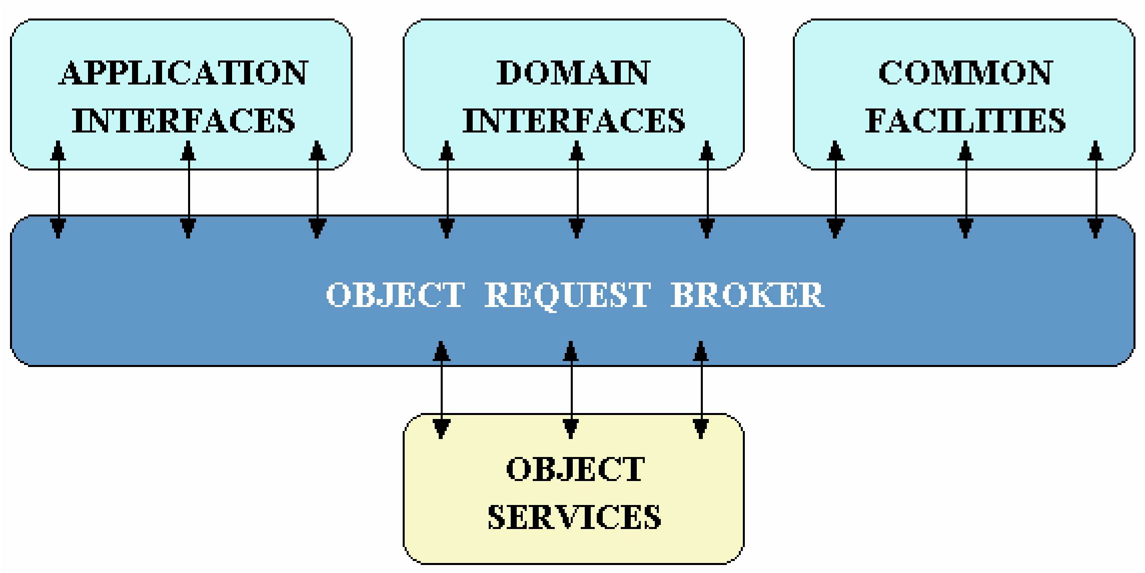


Corba: Common Object Request Broker Architecture

ORB: Object Request Broker

From: Object Mangagement Group

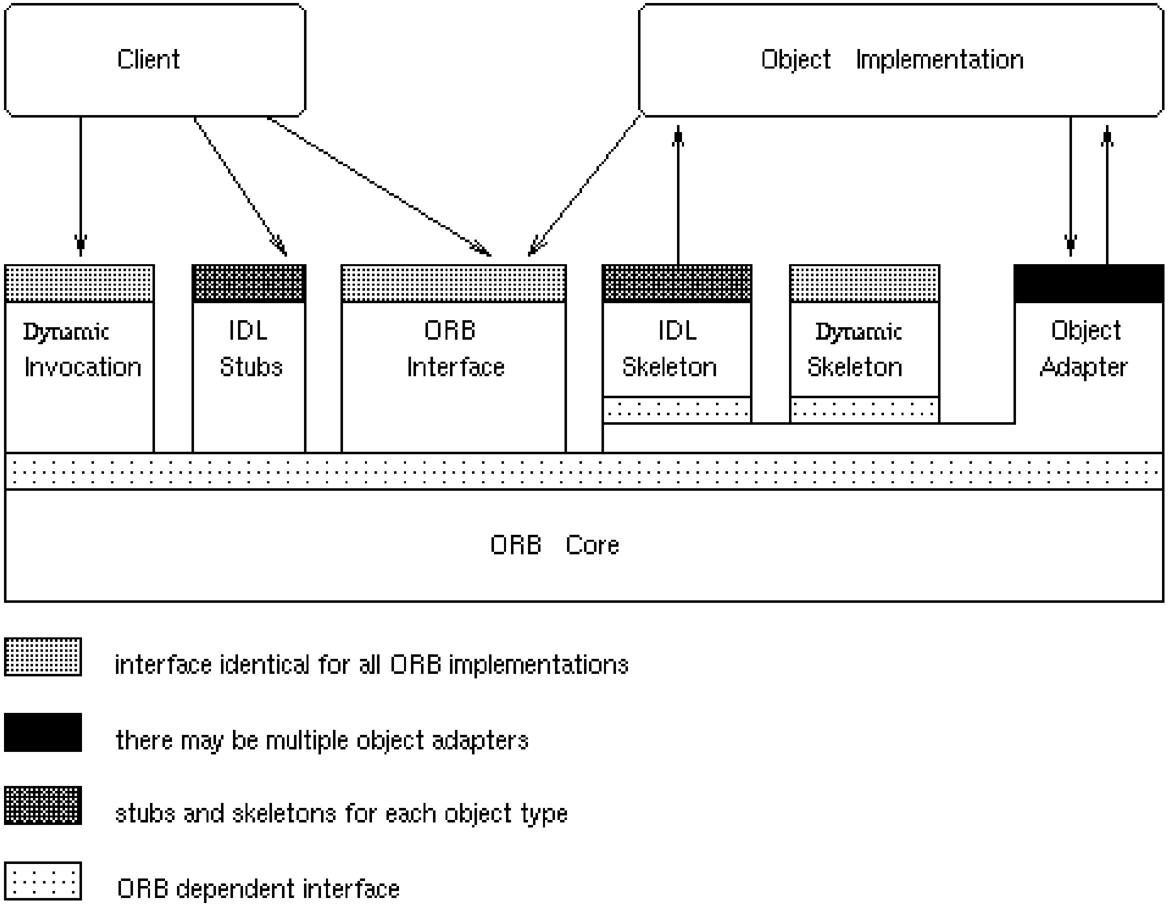
Role of the Object Request Broker



- **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)

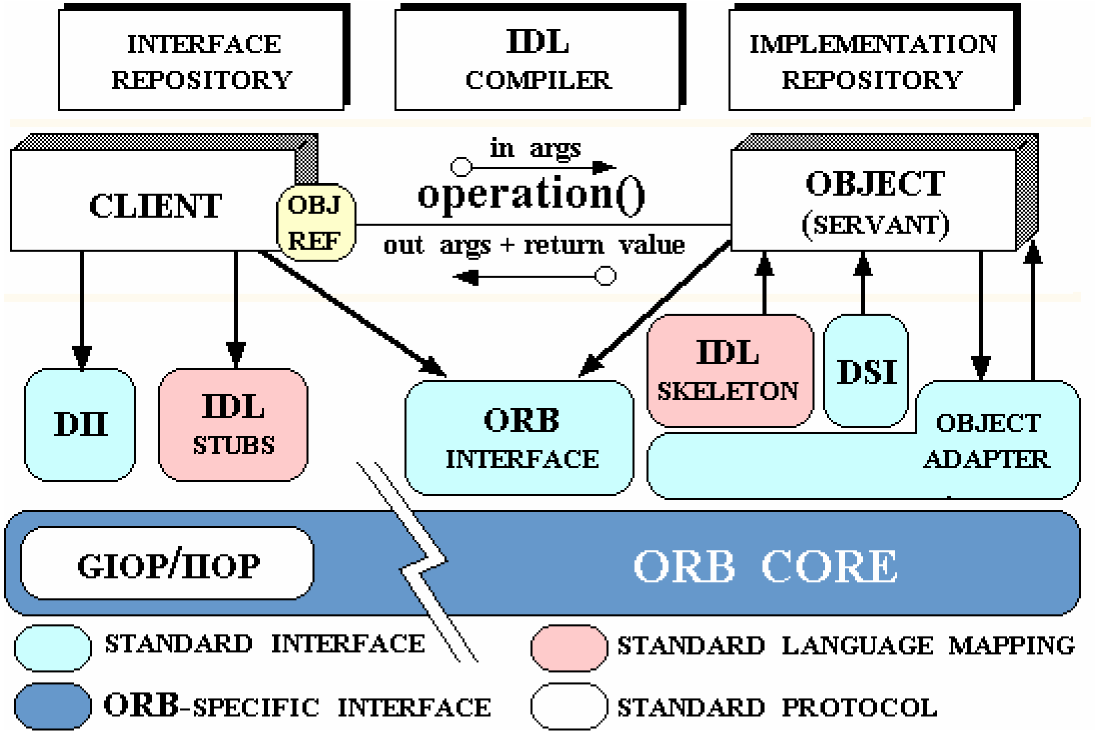
From: Doug Schmidt

Elements of Corba



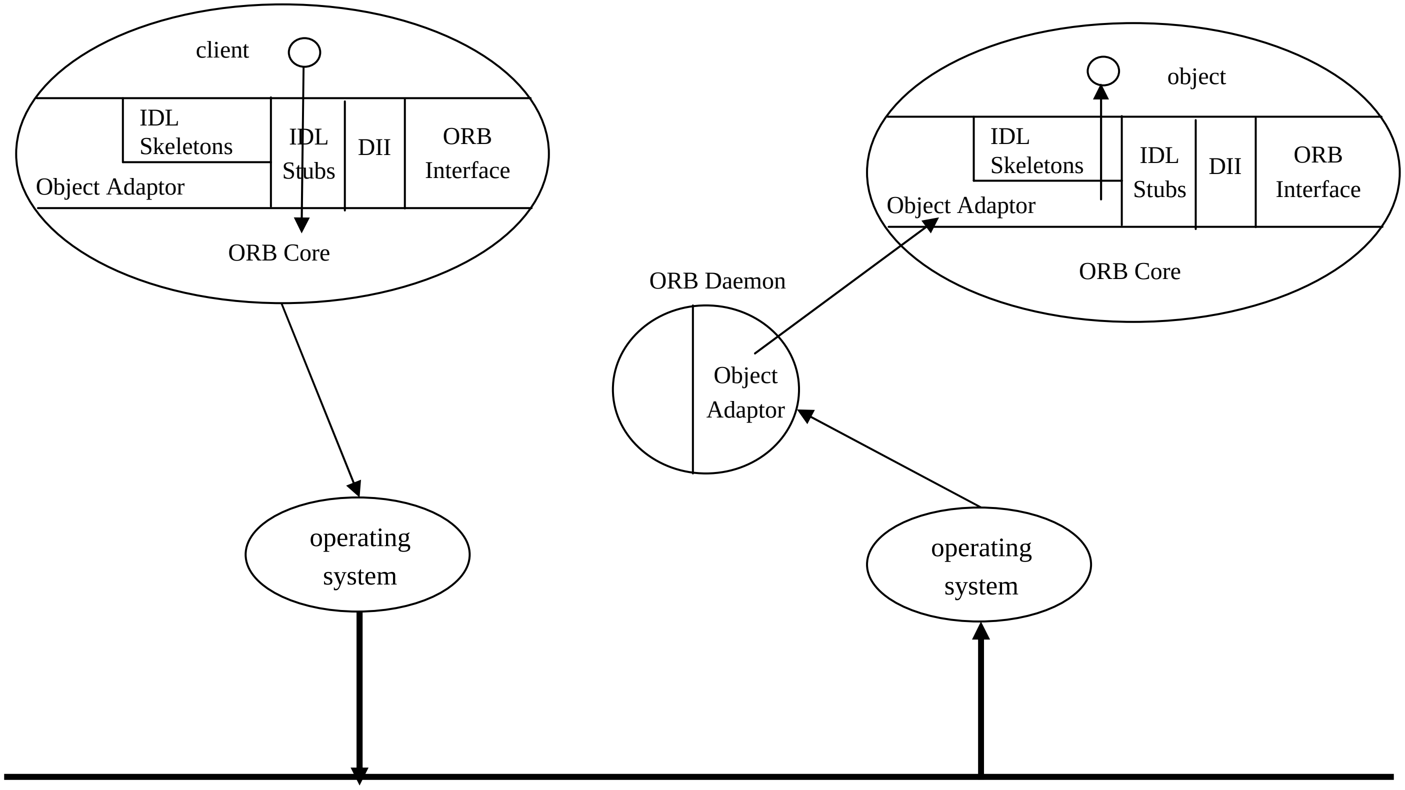
From: Kate Keahey

Elements of Corba



From: Doug Schmidt

Corba Process Structure

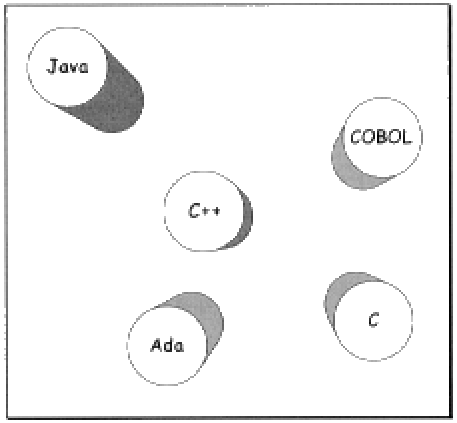


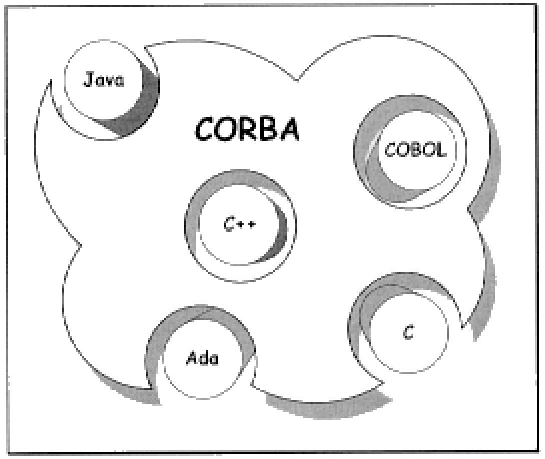
Corba Services

- 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

Corba and Java





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