Object-Oriented Distributed Technology

- Objects
- Objects in Distributed Systems
- Requirements of Multi-User Applications
- *Reading:*
  - *Coulouris: Distributed Systems, Chapter 5*

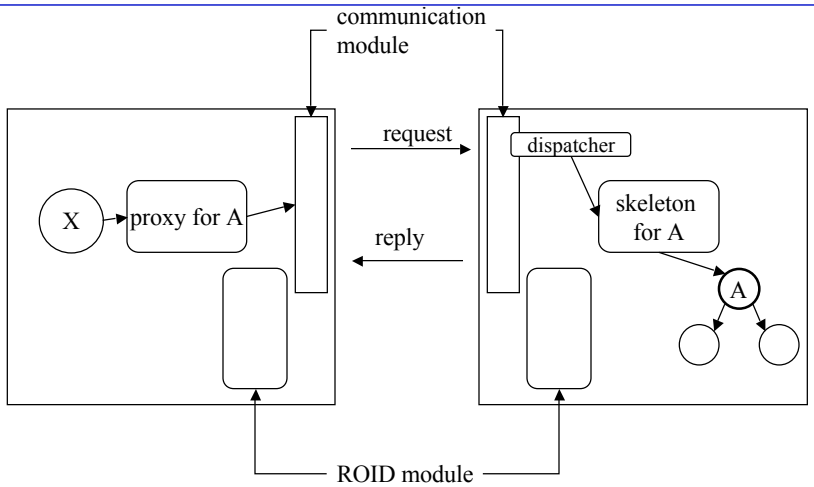
Object-Oriented Languages

- Object Identity
  - "object identifiers" (OIDs)
  - OIDs as first class values
- Actions
  - Initiated by sending message to object requesting method invocation
  - State in object may change
  - cascaded invocations of methods
- Dynamic Binding
  - The method executed is chosen according to the class of the recipient of the message.
- Garbage Collection
  - Dynamically allocated instances may be explicitly *deleted* or space is freed implicitly by garbage collector.
  - GC in distributed systems?

Objects in *Distributed* Systems

- Object Identity in a Distributed System
  - Remote object identifiers (ROIDs)
  - Ex. Java: ROID = endpoint (Java vm) + identifier (ObjID)
  - ROIDs as first-class values
  - Service for comparing remote object identifiers
    - e.g. Java: *RemoteObject::equals()*
- Actions in a Distributed Object System
  - Remote Method Invocation
- The Role of Proxies for Transparent RMI
  - Local proxy for each remote object that can be invoked by local object.
  - Local proxy behaves like local object, but, instead of executing message, forwards it to the remote object. (client stubs)
  - Remote object has skeleton object with server stub procedures

Proxies and Skeletons



Proxies and Skeletons (cont)

- Proxies:
  - Need proxies to invoke remote objects.
  - Proxies are created when needed whenever ROID arrives in Reply message.
  - ROID module manages proxies and ROIDs.
- Dispatchers and Skeletons:
  - Not necessary for systems with reflection capabilities.
  - e.g. class *Method* in Java 1.2 reflection package: method *invoke* can be called on instance of *Method*. Dispatcher now generic and skeleton unnecessary.

Arguments and Results in RMI

- Semantics of passing arguments for RMI in object-oriented languages needs to be defined. Why?
- Argument and Result passing in Java RMI:
  - When type of parameter is defined as remote interface, argument or result is passed as ROID.
  - Other non-remote objects may be passed *by value* if they are *serializable*.
- Which objects can be accessed by RMI?
  - Any object can be accessed by RMI
  - Distinguish between remote objects and local objects. (e.g. keywords or classes with interface compiler)
  - Use interface definition language (IDL)
- Problem: migration/replication

Dynamic Binding

- Dynamic method binding should also apply to RMI.
- Smalltalk: Allow any message to be sent to any object, and raise exception if method is not supported.
  - Distributed Smalltalk: general-purpose proxies.
- Java RMI:
  - dynamic binding as a natural extension of local case
  - Example:

```
Shape aShape = (Shape) stack.pop();
float f = aShape.perimeter();
```

Garbage Collection

- Some languages (Java, Smalltalk) support garbage collection.
- Explicit memory management difficult/impossible in distributed environment.
- Distributed garbage collection typically realized in ROID modules. Each ROID module:
  - keeps track how many sites hold remote ROIDs for each local object (maintains `holders` table)
  - informs other ROID modules about generation/deletion of ROIDs for their local objects (through the use of `addRef()` and `removeRef()`)
- Local garbage collector collects objects with no local or remote references.
- Reference counting (`addROID()`/`removeROID()`) over unreliable networks?