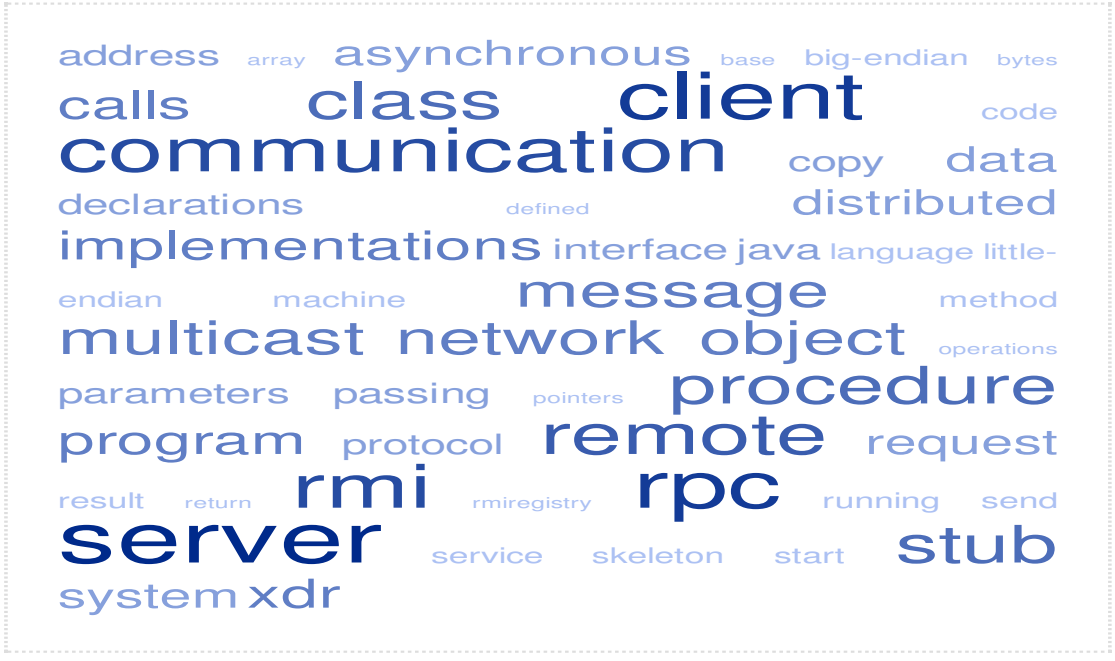
Communication



Overview

- Communication types and role of Middleware
- Remote Procedure Call (RPC)
- Message Oriented Communication
- Multicasting

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  - The sender may be blocked until the middleware notifies that it will take over the transmission of the message.
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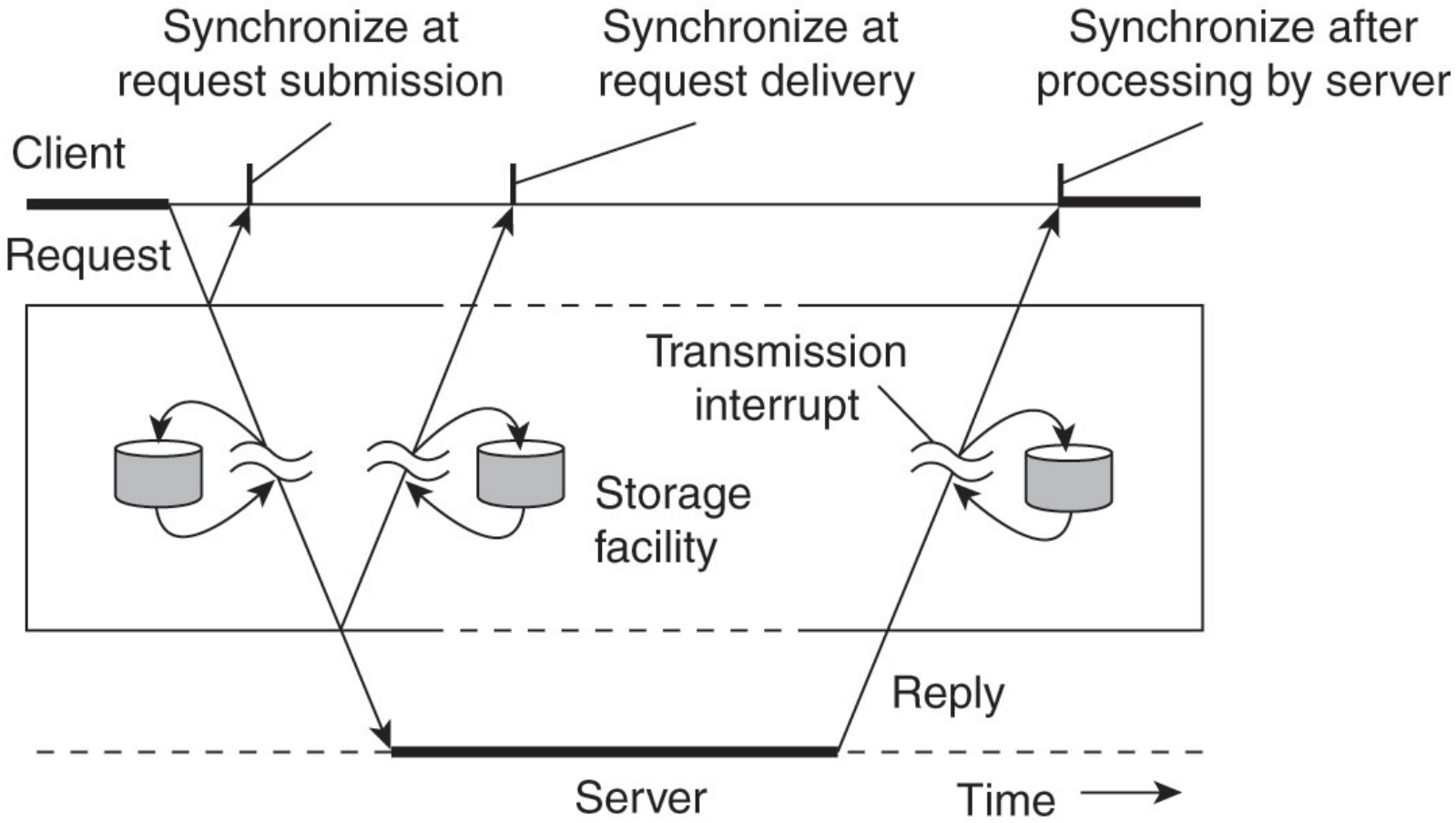
  - The sender waits until its request has been fully processed, that is, up to the time that the recipient returns a response.
- Asynchronous communication. The sender continues immediately after it has submitted its message for transmission. This means that the message is (temporarily) stored immediately by the middleware upon transmission.

Role of Middleware



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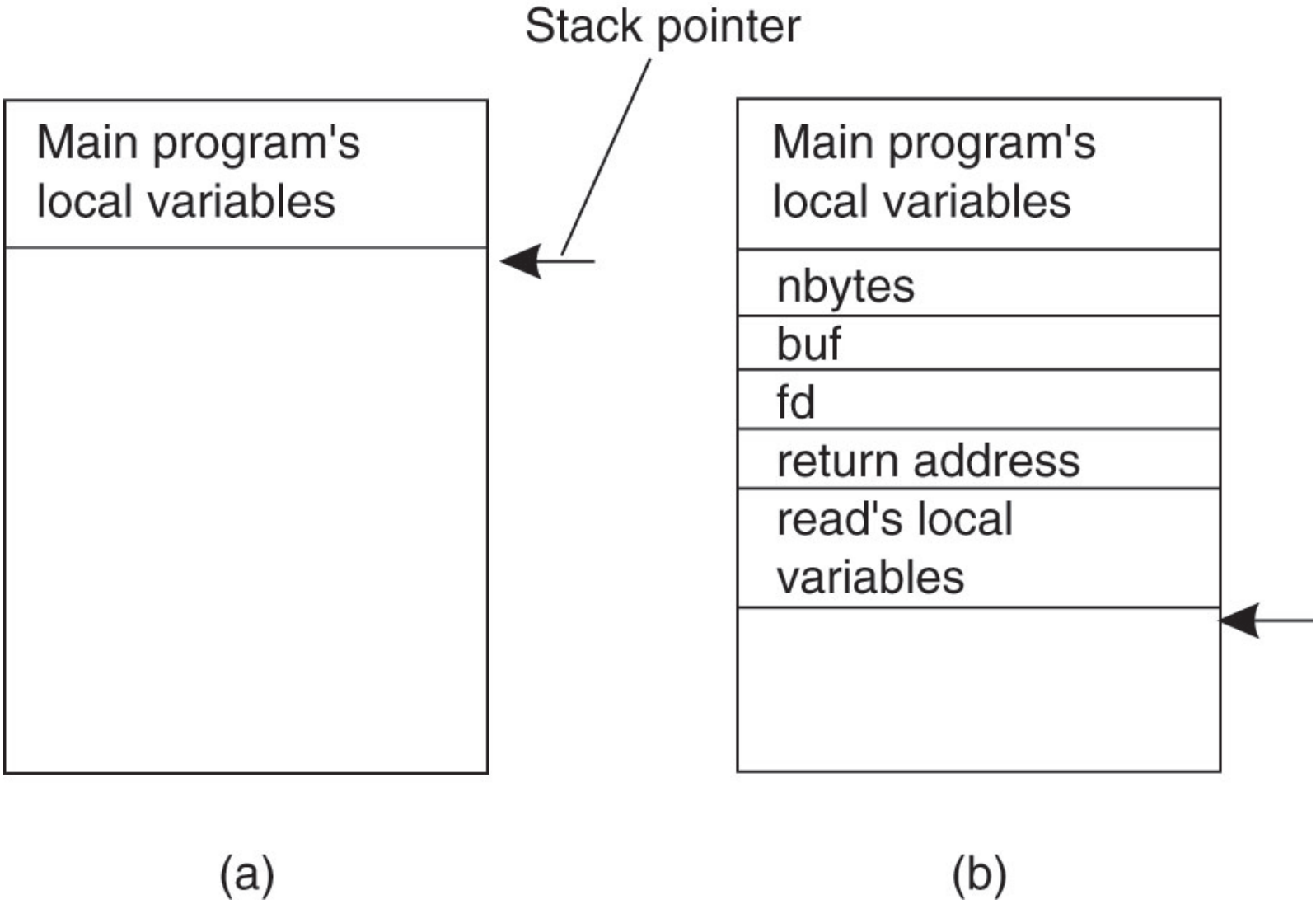
- A widely used technique that underlies many distributed systems.

Conventional Procedure Call




```
count = read(fd, buf, nbytes); //in main
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- **In-class Exercise**. How is call-by-copy/restore different from call-by-reference? Give a concrete example.

Basic Principles of RPC

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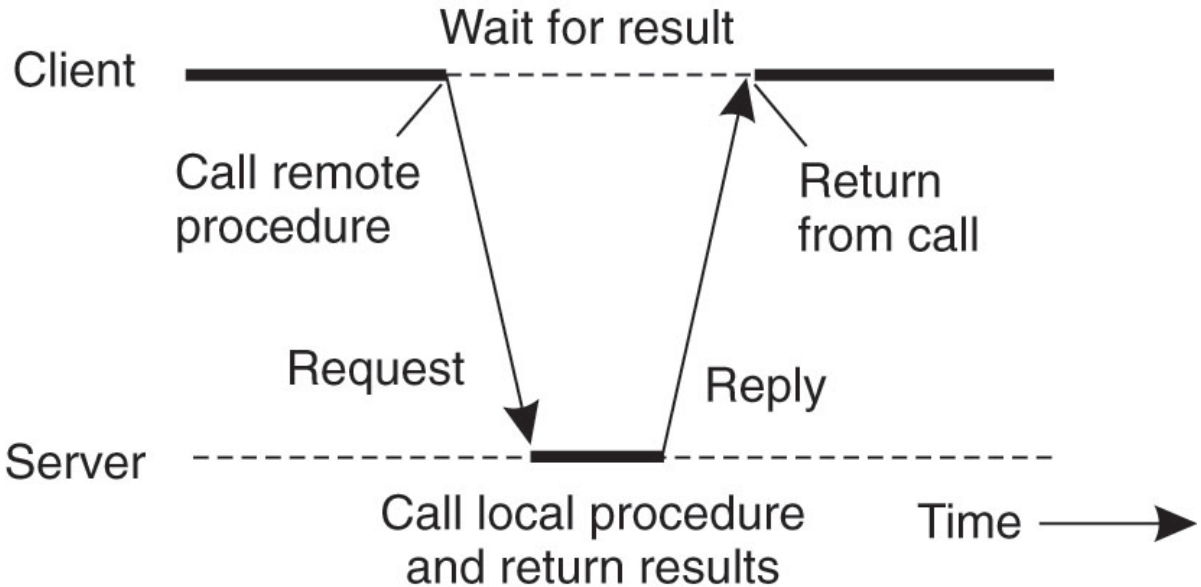

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- The remote OS gives the message to the server stub.
- The server stub unpacks the parameters and calls the server.

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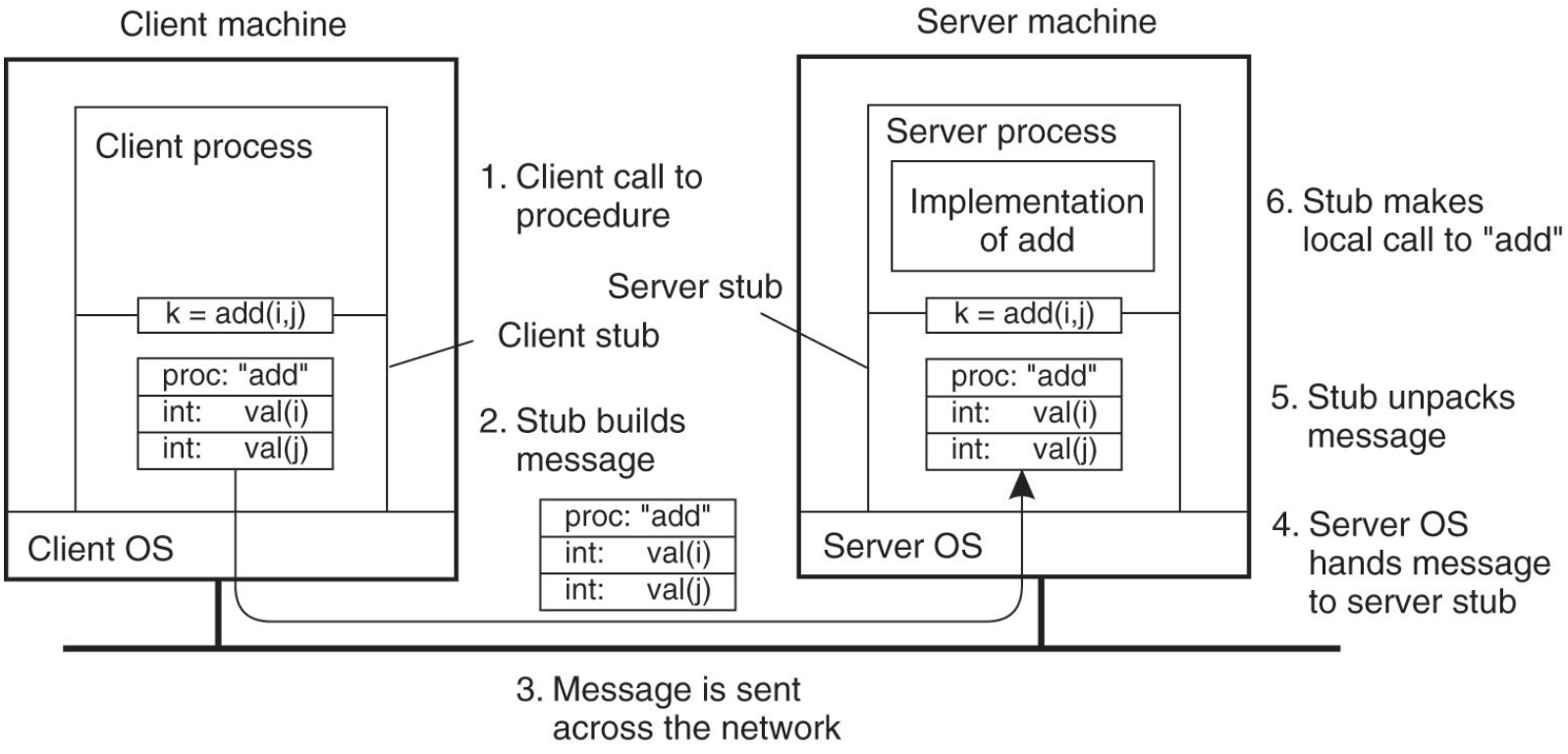
RPC: Passing Parameters



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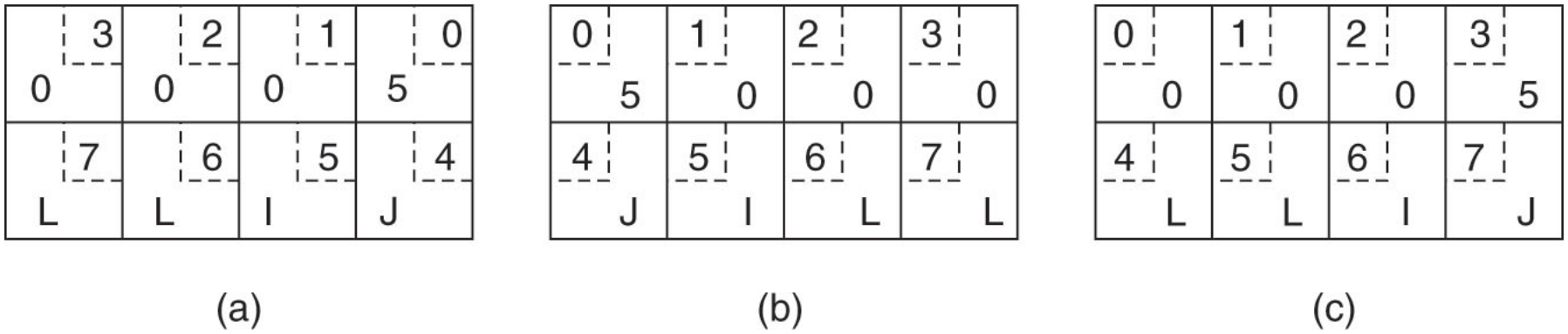
- Bi-endian machine: Choose either setting via software or hardware. E.g. ARM processors, SPARC, POWER PC.

Representation: Little-Endian vs Big-Endian (2)



a. Little endian (data before sending)

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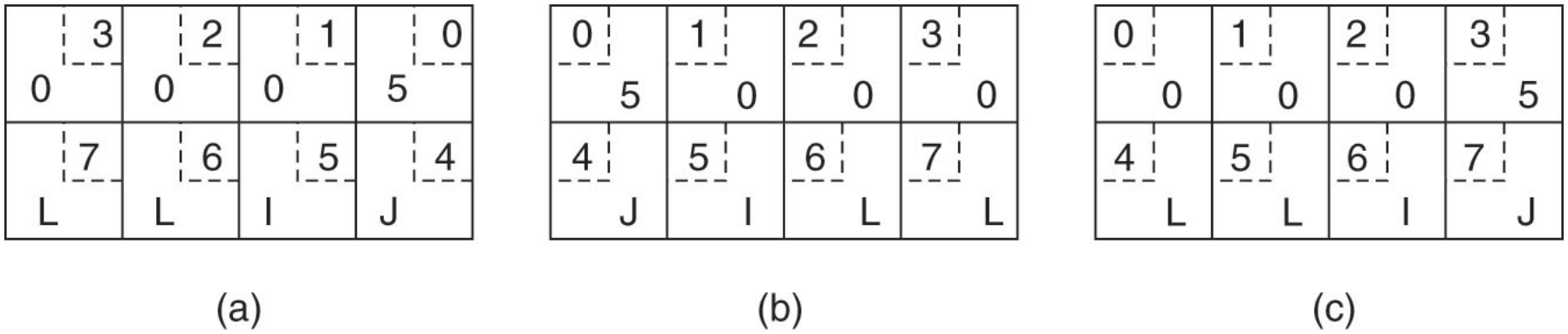

a. Little endian (data before sending)

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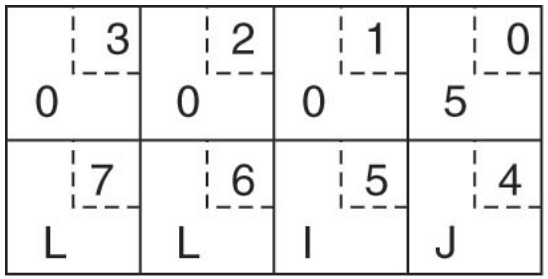

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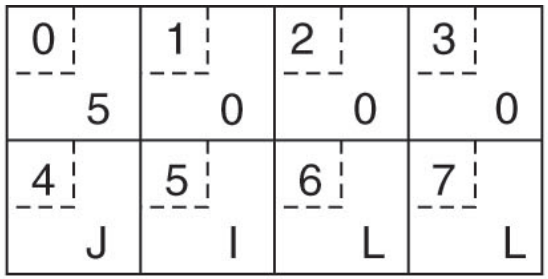

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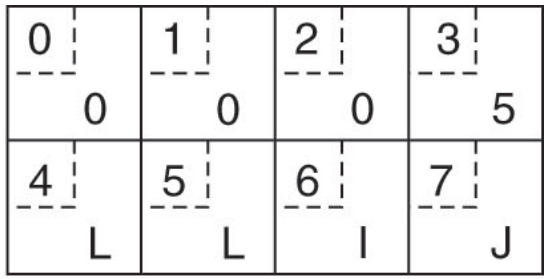

(c)

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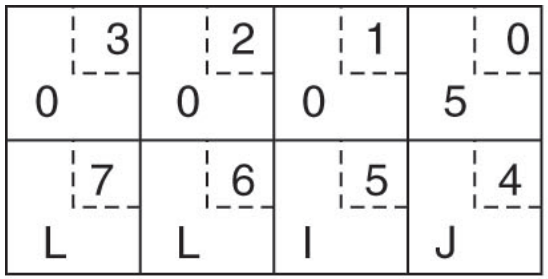

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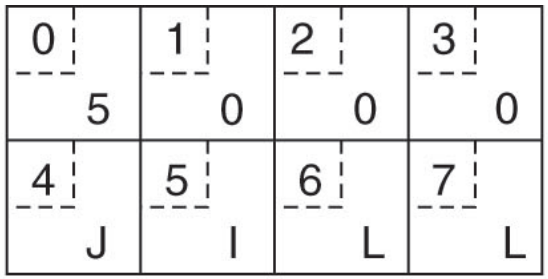

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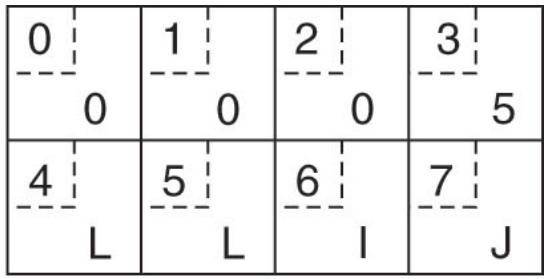

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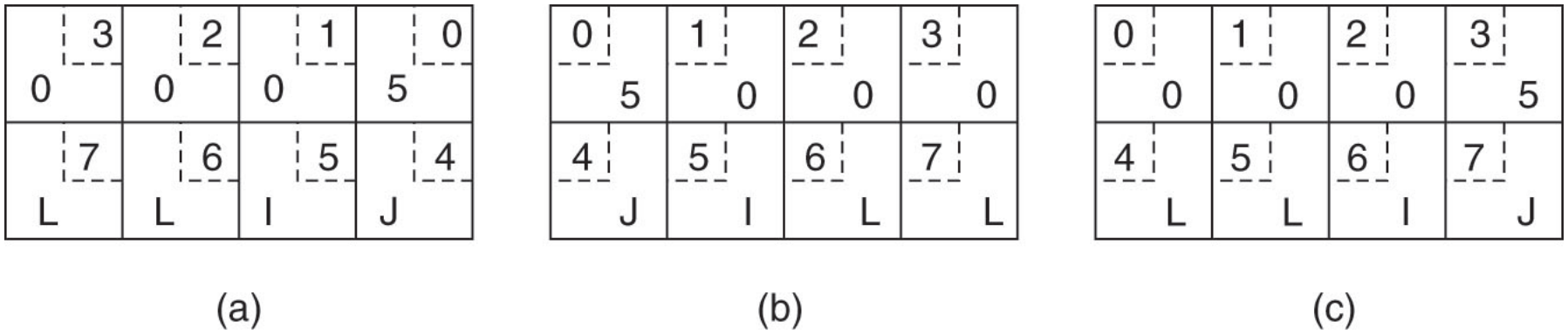

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Does reversing the bytes fix the problem for all data types?

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- **In-class Exercise 2**. Do we need to worry about *endianness* for server and clients written in Java? What if they deal with files written on a machine with different endianness?

Passing Reference Parameters

- *Passing an array or simple structure by reference*: Copy the array into the message. The server stub then calls the server with a pointer to this copy.Changes to the array happen in the message buffer in the server stub that then send back to the client stub, which then copies it back to the client.

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- How about arbitrary data structures with pointers? 

RPC Protocol and Stub Generation

- The RPC protocol would have to define the format of the message, the representation of primitive types and arrays and other data structures. Are integers stored in 2's complement, characters in 16-bit Unicode, floats/doubles in IEEE standard #754 and if everything is big-endian or little-endian?

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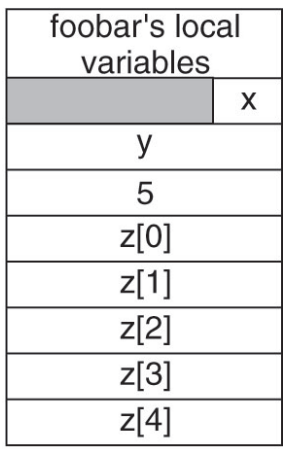

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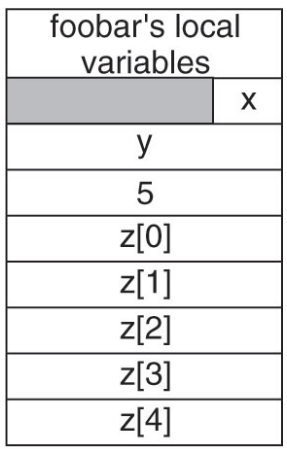

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- Interface Definition Language (IDL) is used to define interfaces for RPC. IDL is then compiled into client and server stub along with the appropriate compile/run-time interfaces.

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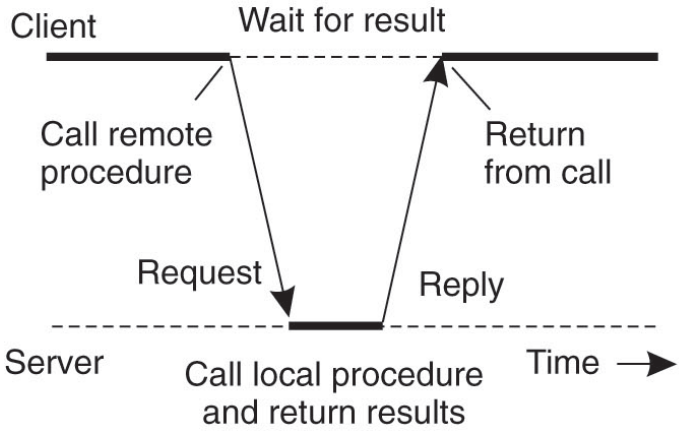
- Deferred asynchronous RPC: The client calls the server with a RPC request and the server immediately acknowledges it. Later the server does a callback to the client with the result.

Asynchronous RPC (2)

- Synchronous (default choice) versus Asynchronous RPC



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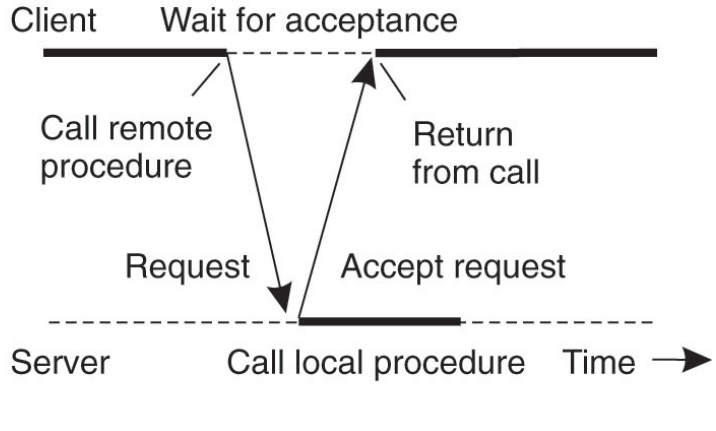

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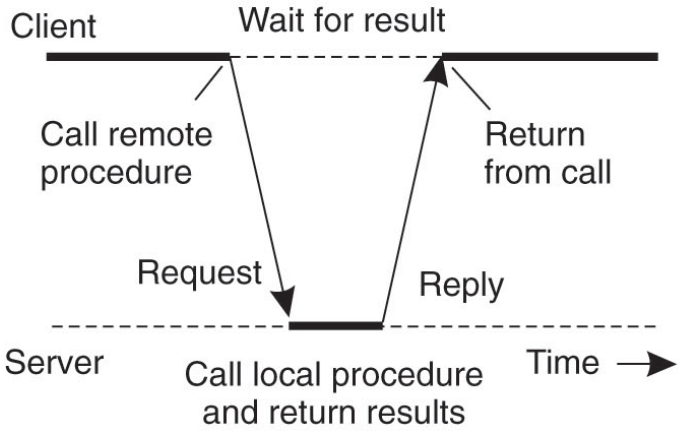

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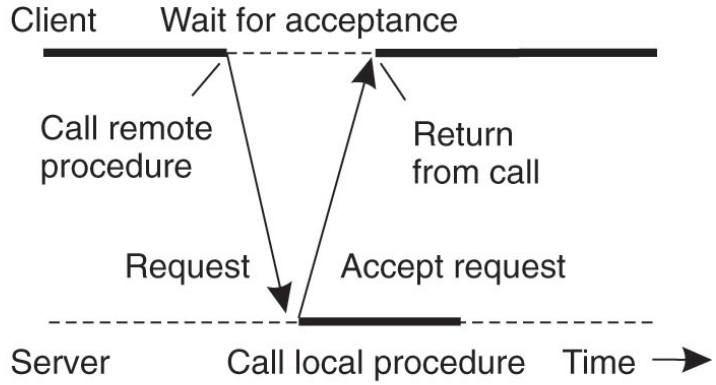
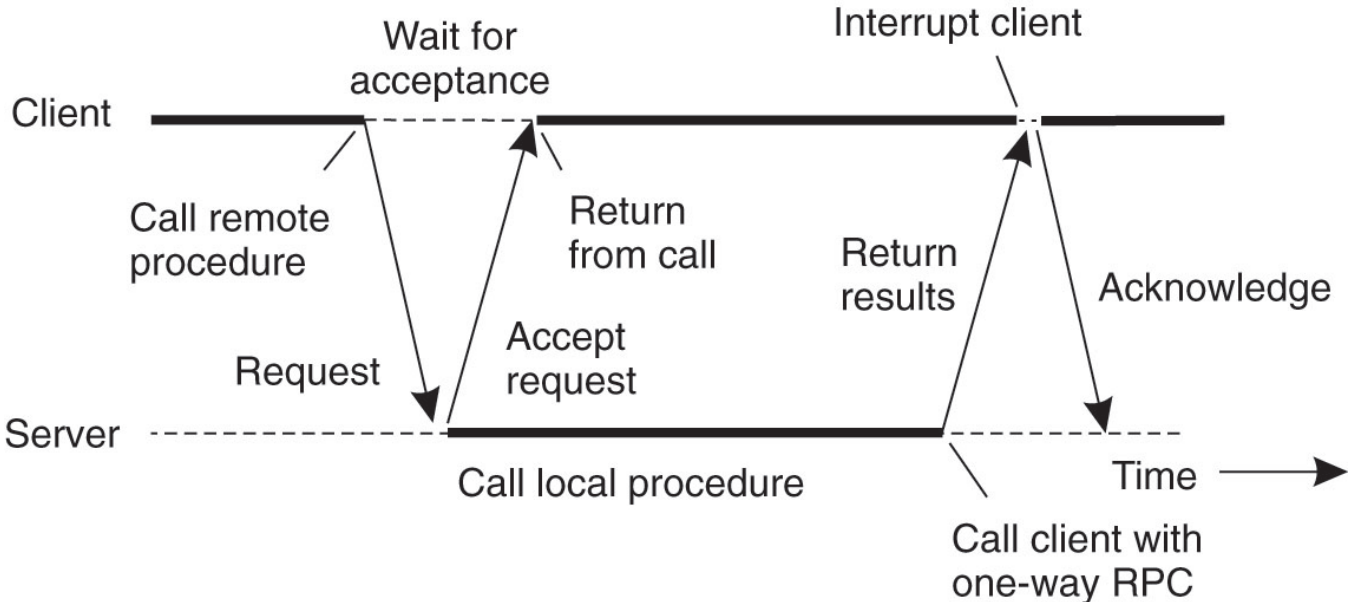


(b)

- Deferred Asynchronous RPC



Classic RPC Implementations

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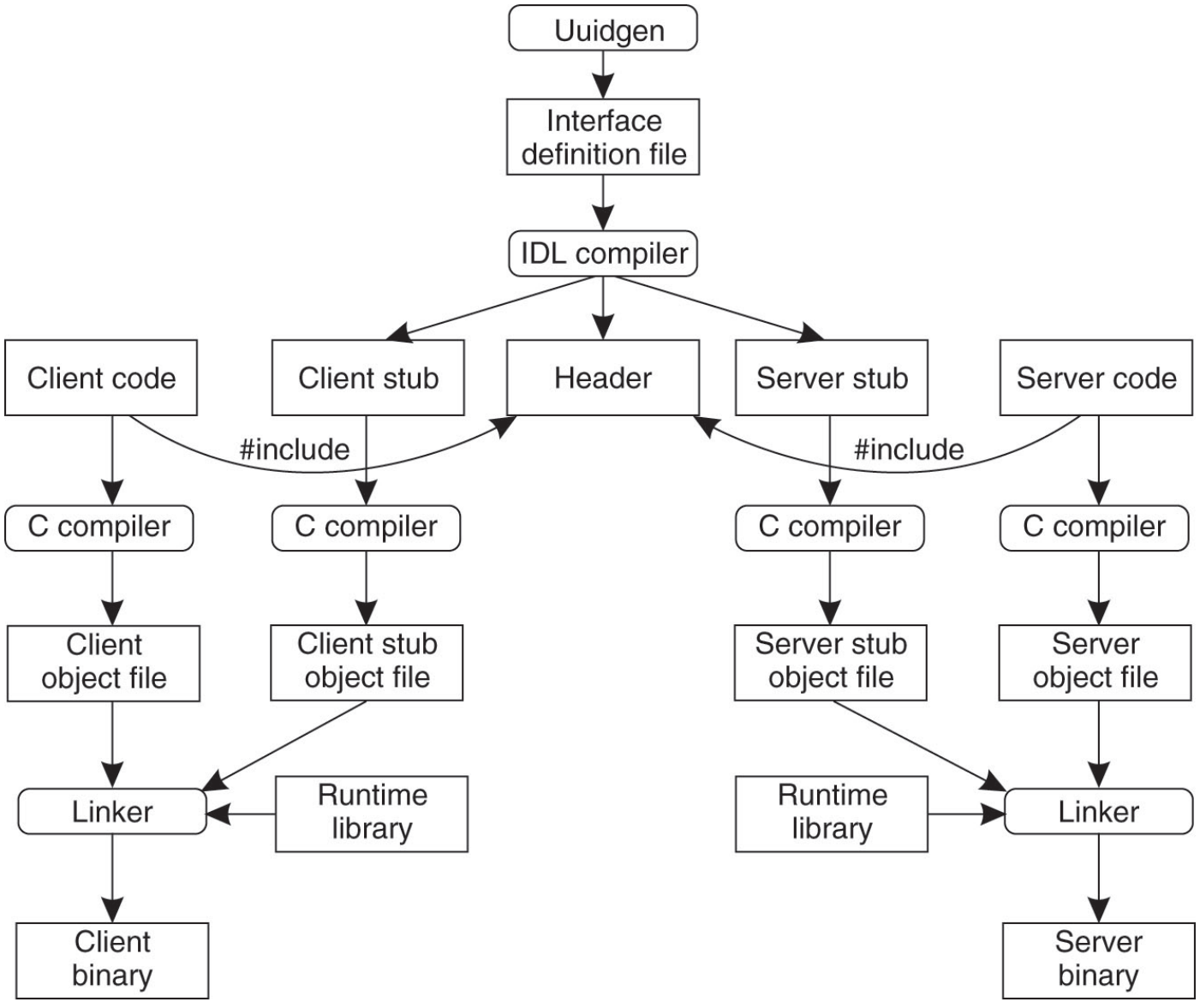
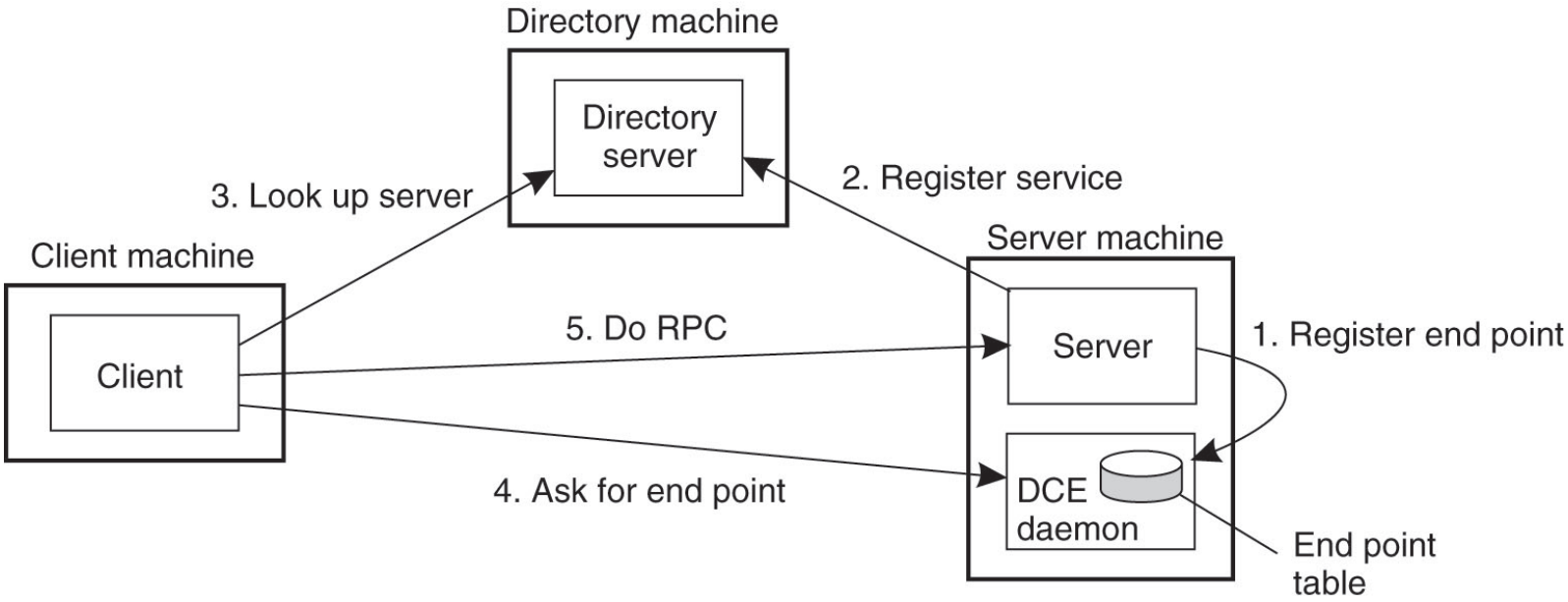
- Open Network Computing Remote Procedure Call (ONC RPC) is a widely deployed remote procedure call system. ONC was originally developed by Sun Microsystems as part of their Network File System project, and is sometimes referred to as Sun ONC or Sun RPC.

Building a RPC Server and Client



Binding a Client to a RPC Server



Note: ONC RPC uses a `portmapper` in place of the DCE daemon. It doesn't use a directory server.

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  - This only works for idempotent operations: something that can be done multiple times without harm.

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- Apache Avro is a RPC and data serialization framework developed for the Apache Hadoop project.

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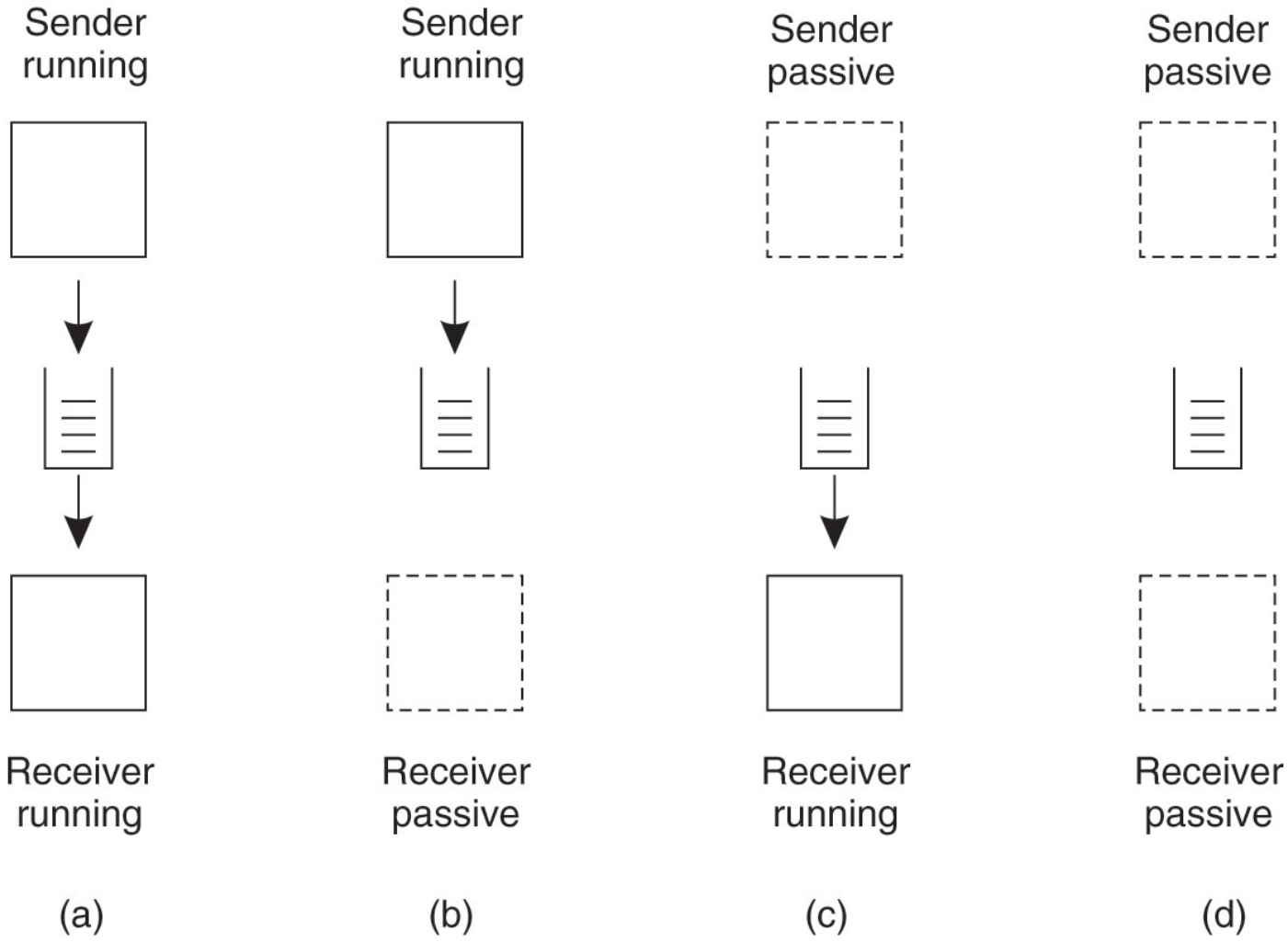
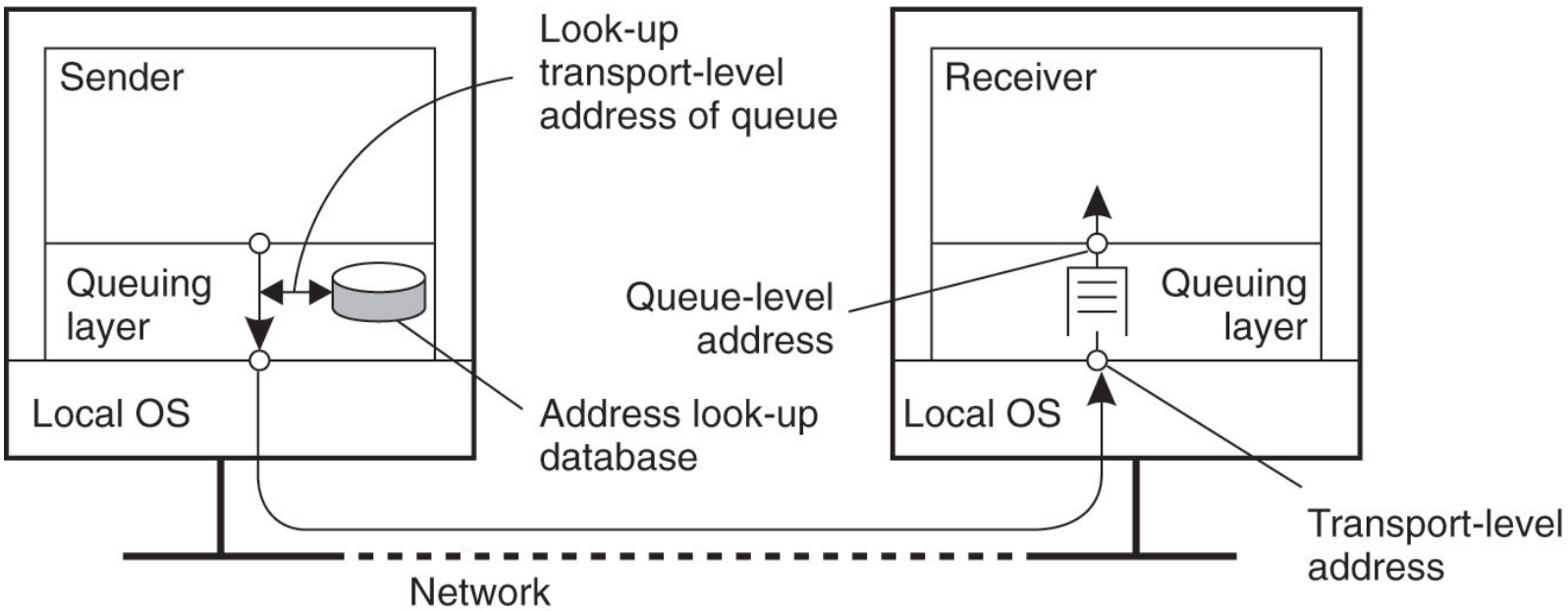
Message Queuing Model (1)



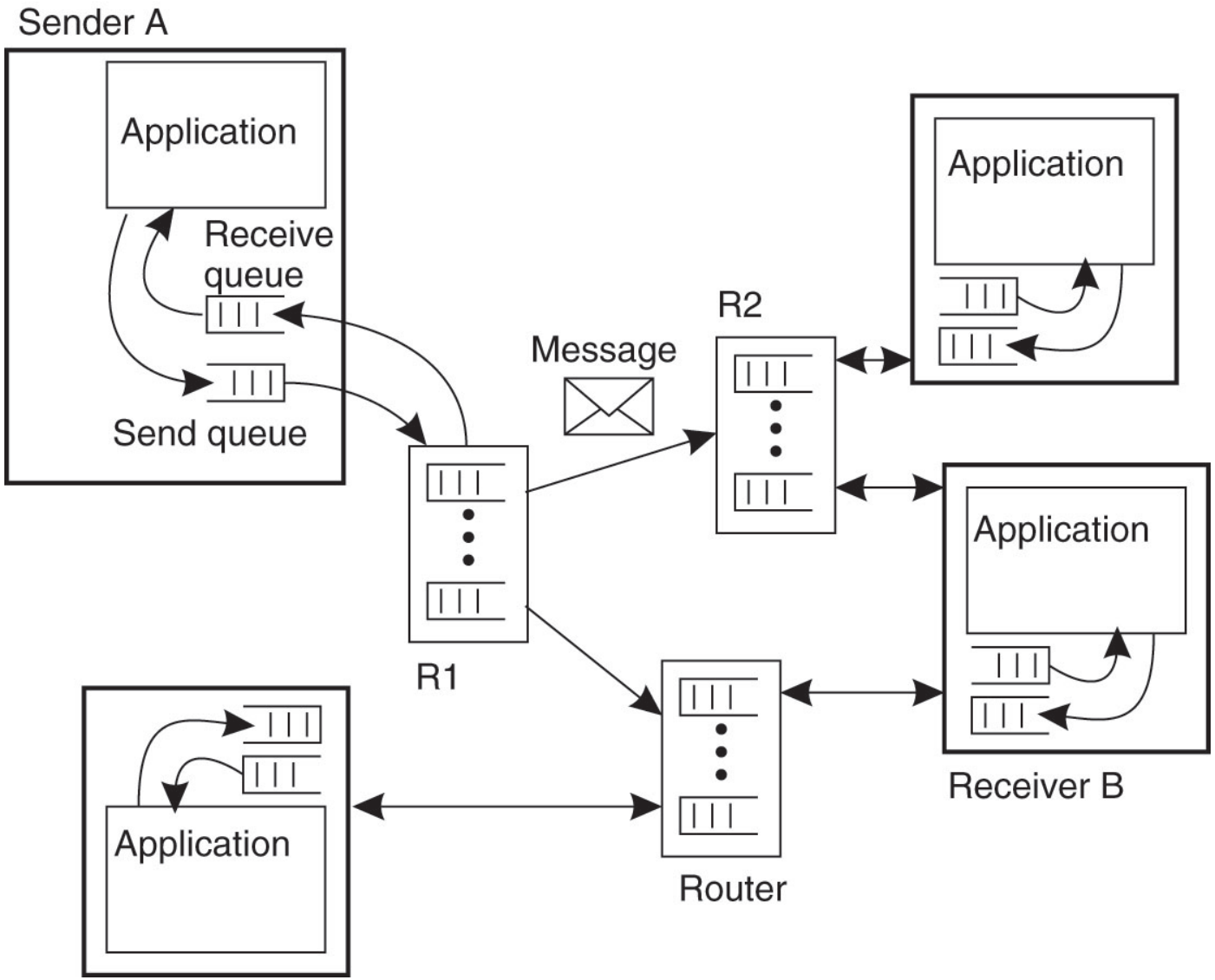
- Four combinations of loosely-coupled communications using queues.

Message Queuing System Architecture (1)



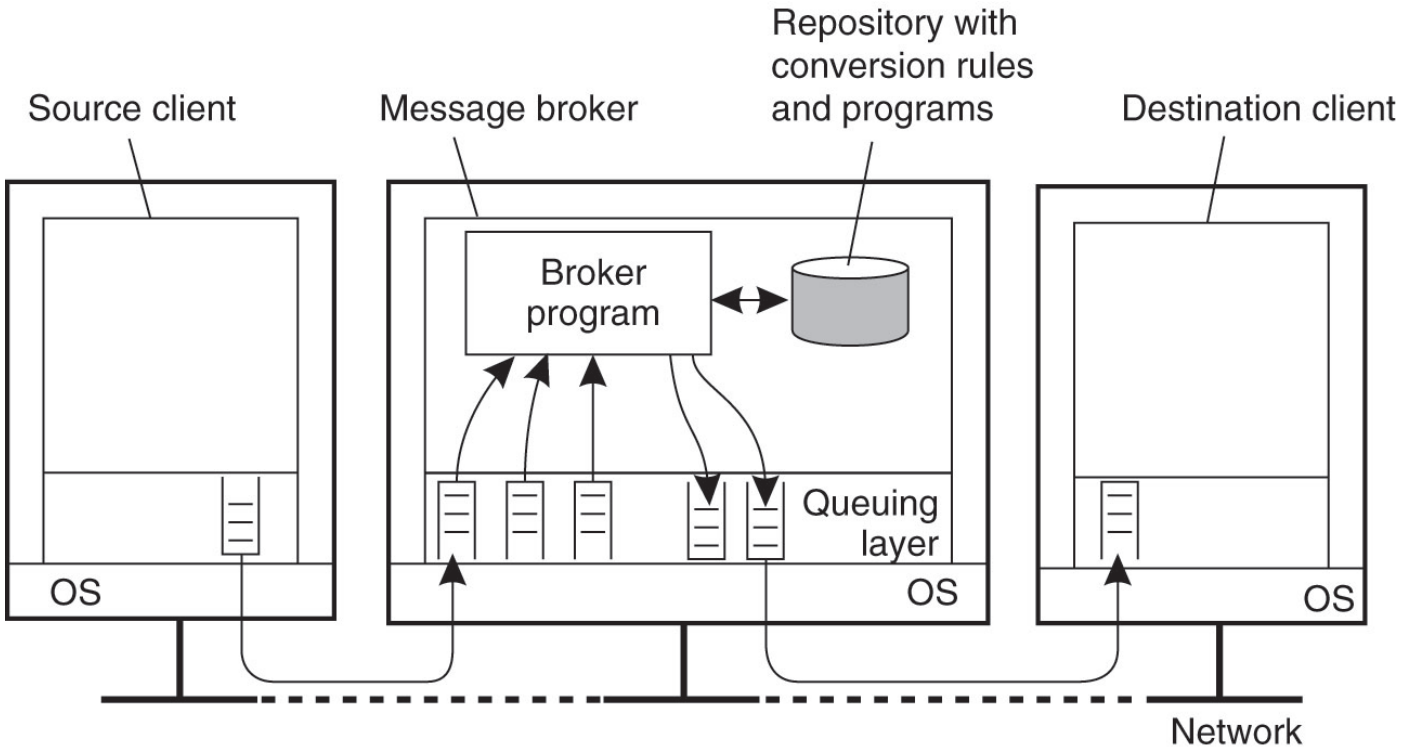
Queue-level and Network-level Addressing

Message Queuing System Architecture (2)



Message Queue System with Routers

Message Brokers



n-level gateway that converts incoming messages so that they can be understood

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  - The broker uses a repository of rules and programs that can transform a message of type *T1* into one of type *T2*.

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- Multicasting requires support from networking hardware such as routers.
- The most common implementation is IP Multicast, used for streaming media. No prior knowledge of who or how many receivers there are is required. Widely used in enterprises, stock exchanges and multimedia content delivery networks.

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- The most common implementation is using UDP (User DataGram Protocol), which isn't reliable — messages may be lost or delivered out of order.

Java Examples

The main class we will use is `java.net.MulticastSocket`. See examples in examples/multicasting

- ex0-setup: Shows how to find out information about network interfaces and if they support multicasting.
- ex1-mcast-hello: Streaming *hello world* using multicasting!
- ex2-mcast-time: Multicast time server
- ex3-mcast-group: Multicast group membership example

References

- Wikipedia article on Endianness
- Linus Torvalds on Endianness
- Multicast Address
- IP Multicast