Agenda

- **Last time (Tues)**
  - Interprocess Communication (chpt 4)
  - Sockets demo
- **This time and tonight (5-6:15)/tomorrow (3-4:15): chpts 4-5**
  - General RPC/RMI example
  - General RPC/RMI terminology
  - Case study: SUNRPC
  - Case study: Java RMI
  - General pros/cons of RPC/RMI
- ***No class Tues Feb 13 (Marty at conference)***
- **Note: we are skipping chpt 6**
- **Note: I'm generally out of contact between 7:30pm – 4am**

Before we start: Recap of the demo

- **Server: sunfire1.cs.virginia.edu:5451**
- **Cygwin is a convenient linux-like runtime on the Win platform (it's NOT required – do it on Linux directly if you wish)**
- **Use "-Wall" on compilation line**
- **Google for documentation (e.g., "man exit") to remove compiler warnings**
  - Find the appropriate header file
- **Differentiate between the "pattern" to establish a sockets-based connection vs. the "application protocol"**

Before we start: Assignment #1

- **If the server crashes, then you'll have to re-register**
  - Hmmm.. Is this not the best server design? Hmmm…
- **If you find iteratively poking at the server to determine your bug annoying, you might want to implement the server yourself (your partner?)**
  - Having both the client and the server might be easier to debug
  - This will give you a headstart on Assignment #2
  - BUT: the requirement is to get your client working against our server
- **Advice: Get the "register" working while I'm still in town!**
- **Advice: Don't try to do everything at once – design and test incrementally!**

Protocol design in general

- **Protocol: the design of the message pattern (and format of the messages) to solve a particular problem**
- **Your past: designing the UI of an app is a kind of protocol design**
  - Distributed systems: machine to machine communication (the machine is NOT as forgiving as the human, so it's MUCH more difficult)
- **What makes a good protocol?**
  - Complete (with extensibility?)
  - Unambiguous
  - Secure (?)
  - Minimal?
  - Efficient? Is a protocol efficient? Or is just the Implementation of the protocol efficient? And is "efficient" the same as "minimal"?
  - Implementable?
- **Is the protocol in Assignment 1 "good"? Hmmm..**

Finishing up sockets

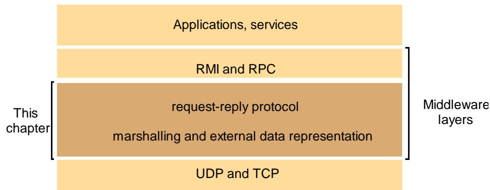
- **Server tends to be at a "well-known" port; client is not**
- **Server can be "connectionless" or "connection-oriented"**
  - Connection-Oriented
    - Server opens socket for "everybody"
    - As part of client contact, a second socket is opened
    - Server forks a process to handle just that one client on the new port
    - Server and Client "stay connected" during session
  - Connectionless
    - Server opens socket for "everybody"
    - Server multiplexes across all messages arriving to that one socket
    - Server is always listening irrespective of any particular client

Well-known Ports

- **ftp: 21**
- **ssh: 22**
- **telnet: 23**
- **finger: 79**
- **http: 80**
- **pop3: 110**
- **sunrpc: 111 (*portmapper*)**
- **imap: 143**
- **https: 443**

- **rough guide (OS dependent):**
  - *System* ports < 1024;
  - User ports > 1024
- **Services/ports defined in /etc/services**
- **Use "netstat –a -b" to check running services**

Interprocess communication (IPC)



Interprocess communication – how?

- **Primitives: *send* and *receive***
- **Types:**
  - Synchronous: The sending and receiving processes synchronize at every message, the send and receive operations are blocking.
  - Asynchronous: The send operation is non-blocking, the receive operation may be either blocking or non-blocking.
- **Queue associated with each message destination.**
- **Senders cause messages to be added to remote queues.**
- **Receivers remove messages from local queues.**
- **Issues**
  - Reliability.
  - Ordering.

Hiding Message-Passing: RPC (nee. 1976)

- **1976: RFC 707; 1984: "Implementing Remote Procedure Calls" by Birrell/Nelson; 1988: SUNRPC**

The request/response communication is a basis for the *remote procedure call* (RPC) model.

- Think of a server as a module (data + methods).
- Think of a request message as a *call* to a server method.

  Each request carries an identifier for the desired method; the rest of the message contains the arguments.
- Think of the reply message as a *return* from a server method.

  Each reply carries an identifier for the matching call; the rest of the message contains the result.

With a little extra glue, the messaging communication can be be hidden and made to look "just like a procedure call" to both the client and the server.

Remote Procedure Call – RPC

- ***Looks* like a nice familiar procedure call**

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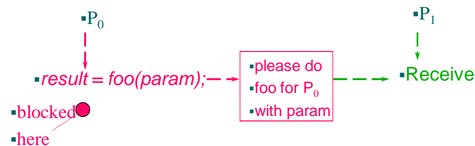

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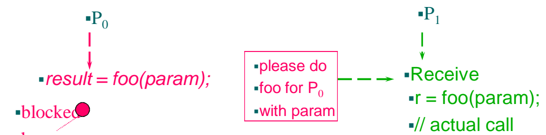

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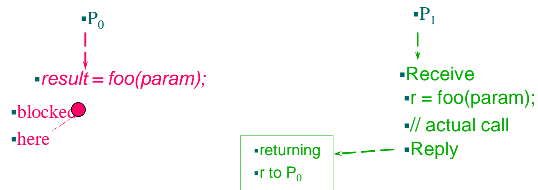

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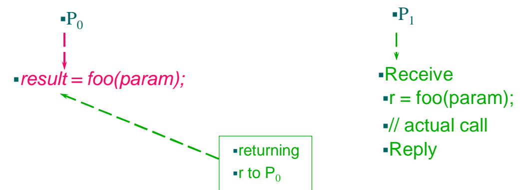

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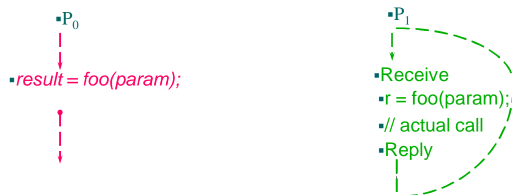

RPC/RMI Concepts

- **Rationale: sockets are nice, but app still knows it's "shoving bits on the wire"**
- **RPC/RMI provides *transparency***
  - Looks like a local procedure invocation, but it's not…
  - "access" + "location" = "network transparency"
- **Stubs are necessary**
  - client side: connect to server machine, send all the parameters, wait for replies, manipulate the stack, and return
  - server side: wait for messages, read the parameters, present/covert for use by local procedure, send response back to client

General Issues in RPC/RMI

1. **How do we specify the interface?**
2. **How we generate stubs?**
3. **How are parameters passed?**
4. **How does a client find/bind to a server?**
5. **What are the invocation semantics?**
6. **Ease of use**
7. **Performance**

[1] Specifying the Interface

- **Generally through use of some kind of *Interface Definition Language (IDL)***
- ***IDL* defines primitive language types**

[2] Generating Stubs

- **An explicit "helper program" is invoked to do this**
- **Uses the IDL, usually generates both client-side and server-side**
- **Compiler must know which are IN parameters and which are OUT parameters**

[3] How are parameters passed?

- **Issue: *how do I pass information between heterogeneous machines?***
- **Motivation: Information in programs represented as data structures, information in messages consists of sequences of bytes.**
  - You can't just "put it on the wire"
- **Issues:**
  - *implicit typing* or *explicit typing???*
  - Certain data types are invalid
  - Character sets - ASCII vs. Unicode vs. ???
  - Byte order: (given multi-byte numeric rep, what does the first byte signify?)
    - big-endian: the most significant value in the sequence is stored at the lowest storage address (Sparc?)
    - little-endian. Intel microprocessors?
    - E.G. decimal 1025 = 00000000 00000000 00000100 00000001 (Big Endian)
      - Little Endian: 00000001 00000100 00000000 00000000
- **Two methods for data exchange:**
  - Convert values to agreed external format before transmission.
  - ~~Transmit values in sender's format ("receiver-make-right"~~)