RPC

Remote Procedure Calls

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Assignments

- Assignment 4 posted on the course home page
  - Due in two weeks
- Start thinking about assignment 5
  - Build your own web application
    - On top of SOAP or HTTP
Remember the SAX ContentHandler?

- The methods
  - setDocumentLocator(locator)
  - startDocument(), endDocument()
  - characters(ch, start, len), ignorableWhitespace(…)
  - startElement(uri, localName, qName, atts)
    endElement(uri, localName, qName)
  - startPrefixMapping(prefix, uri)
    endPrefixMapping(prefix, uri)
  - skippedEntity(name)
  - processingInstruction(target, data)

- How to collect characters?
RPC: The One Slide Overview

- Goal: Make remote interactions real easy
- Approach: Use procedure calls
  - Well-established way to transfer control and data
Remote Procedure Calls
by Hank Levy (UW)
Clients and Servers

- A common model for structuring distributed computation is via the client/server paradigm.

- A server is a program (or collection of programs) that provide some service, e.g., file service, name service, …

- The server may exist on one or more nodes.

- A client is a program that uses the service.

- A client first binds to the server, I.e., locates it in the network and establishes a connection.

- The client then sends requests to perform actions; this is done by sending messages that indicate which service is desired, along with params. The server returns a response.
The Problem with Messages

- While messages provide very flexible communication, they also have certain problems:
  - requires that programmer worry about message formats
  - messages must be packed and unpacked
  - messages have to be decoded by server to figure out what is requested
  - messages are often asynchronous
  - they may require special error handling functions
- Basically, messages are not a natural programming model for most programmers.
A more natural way to communicate is through procedure call:

- every language supports it
- semantics are well defined and understood
- natural for programmers to use

Basic idea: let’s just define a server as a module that exports a set of procedures that can be called by client programs.

To use the server, the client just does a procedure call, as if it were linked with the server.
So, we would like to use procedure call as a model for distributed communication.

Lots of issues:

- how do we make this invisible to the programmer?
- what are the semantics of parameter passing?
- how is binding done (locating the server)?
- how do we support heterogeneity (OS, arch., language)
- etc.
The basic model for Remote Procedure Call (RPC) was described by Birrell and Nelson in 1980, based on work done at Xerox PARC. Goals was to make RPC look as much like local PC as possible. Used computer/language support. There are 3 components on each side:
- a user program (client or server)
- a set of stub procedures
- RPC runtime support
Basic process for building a server:

- Server program defines the server’s interface using an *interface definition language* (IDL)
- The IDL specifies the names, parameters, and types for all client-callable server procedures
- A *stub compiler* reads the IDL and produces two stub procedures for each server procedure: a client-side stub and a server-side stub
- The server writer writes the server and links it with the server-side stubs; the client writes her program and links it with the client-side stubs.
- The stubs are responsible for managing all details of the remote communication between client and server.
 RPC Stubs

- Basically, a client-side stub is a procedure that looks to the client as if it were a callable server procedure.
- A server-side stub looks to the server as if it’s a calling client.
- The client program thinks it is calling the server; in fact, it’s calling the client stub.
- The server program thinks it’s called by the client; in fact, it’s called by the server stub.
- The stubs send messages to each other to make the RPC happen.
RPC Call Structure

client program

client makes local call to stub proc.

server is called by its stub

client stub

stub builds msg packet, inserts params

stub unpacks params and makes call

RPC runtime

runtime sends msg to remote node

runtime receives msg and calls stub

Call
RPC Return Structure

client program

call foo(x,y) → return

client continues

server proc returns

proc foo(a,b) begin foo...

end foo

server program

server stub

call foo(x,y) → send msg

RPC runtime

msg received

runtime receives msg, calls stub

runtime responds to original msg

RPC runtime

stub unpacks msg, returns to caller

stub builds result msg with output args

client stub

proc foo(a,b) → msg received

return

return

return
Binding is the process of connecting the client and server.

The server, when it starts up, exports its interface, identifying itself to a network name server and telling the local runtime its dispatcher address.

The client, before issuing any calls, imports the server, which causes the RPC runtime to lookup the server through the name service and contact the requested server to setup a connection.

The import and export are explicit calls in the code.
Marshalling is the packing of procedure parameters into a message packet.

The RPC stubs call type-specific procedures to marshall (or unmarshall) all of the parameters to the call.

On the client side, the client stub marshalls the parameters into the call packet; on the server side the server stub unmarshalls the parameters in order to call the server’s procedure.

On the return, the server stub marshalls return parameters into the return packet; the client stub unmarshalls return parameters and returns to the client.
RPC is the most common model now for communications in distributed applications.

RPC is essentially language support for distributed programming.

RPC relies on a stub compiler to automatically produce client/server stubs from the IDL server description.

RPC is commonly used, *even on a single node*, for communication between applications running in different address spaces. In fact, most RPCs are intra-node.
Some Recent RPC Systems: RMI, XML-RPC, and SOAP
RMI: Java’s Remote Method Invocation

- Transparency
  - A lot, includes distributed garbage collection
  - But requires special stub compiler (for clients)

- Parameter passing
  - By value and by reference

- Binding
  - Traditional name server

- Heterogeneity
  - Supports only Java
XML-RPC: XML-based RPC over HTTP

- **Transparency**
  - Depending on language, possible for service objects
  - Need to explicitly create invocations on client
  - Need to map complicated objects to XML

- **Parameter passing**
  - By value only

- **Binding**
  - Not specified, need to hardcode servers

- **Heterogeneity**
  - Some, but a very simple data model
XML-RPC Structure Encoding

- `<value>
  <struct>
    <member>
      <name>givenName</name>
      <value><string>Joseph</string></value>
    </member>
  </struct>
</value>

- Can we do better?
SOAP: XML-based Messages
Mostly over HTTP

- Transparency
  - Depending on language, possible for service objects
  - Need to explicitly create invocations on client
  - Need to map complicated objects to XML

- Parameter passing
  - By value only

- Binding
  - UDDI, WSDL

- Heterogeneity
  - Very much, data model based on XML Schema
Not limited to RPC
- Supports asynchronous messaging as well
- Supports free-form XML as well
An Example SOAP-RPC Request

- `<xml version="1.0" encoding="UTF-8"?>
  <SOAP-ENV:Envelope
    xmlns:SOAP-ENV="http://www.w3.org/2002/12/soap-envelope"
    xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
    xmlns:xsd="http://www.w3.org/2001/XMLSchema">
  <SOAP-ENV:Body>
    <calc:add xmlns:calc="urn:g22.3033-008:calculator"
      SOAP-ENV:encodingStyle="http://www.w3.org/2002/12/soap-encoding">
      <calc:numbers xmlns:enc="http://www.w3.org/2002/12/soap-encoding"
        xsi:type="enc:Array" enc:itemType="xsd:double" enc:arraySize="2">
        <calc:number>1.0</calc:number>
        <calc:number>2.0</calc:number>
      </calc:numbers>
    </calc:add>
  </SOAP-ENV:Body>
</SOAP-ENV:Envelope>`
<?xml version="1.0" encoding="UTF-8"?>
<SOAP-ENV:Envelope
xmlns:SOAP-ENV="http://www.w3.org/2002/12/soap-envelope"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xmlns:xsd="http://www.w3.org/2001/XMLSchema">
  <SOAP-ENV:Body>
    <calc:computed xmlns:calc="urn:g22.3033-008:calculator"
SOAP-ENV:encodingStyle="http://www.w3.org/2002/12/soap-encoding">
      <calc:number xsi:type="xsd:double">3.0</calc:number>
    </calc:computed>
  </SOAP-ENV:Body>
</SOAP-ENV:Envelope>
Discussion

- Why XML-RPC and SOAP, and not (say) CORBA?
  - XML-based
  - HTTP as transport protocol
  - Relative simplicity (?)

- What are the pitfalls of RPC?
  - New classes of failures
  - Timing differences
  - As a result, transparency can be misleading