COMP750
Distributed Systems

Remote Procedure Calls

Remote Function Execution

- When a program calls a function or method (or procedure or subroutine), the function is usually executed as part of the main program.

```
x = func(z);
```

- func is run on the same computer as the main.
- Intermediate software or middleware can be used to execute the procedure on a remote computer.

Remote Procedure Call (RPC)

- A remote procedure call is a paradigm for writing distributed programs or programs that communication between machines.
- An RPC calls a function or procedure that is executed on another computer.
- RPC’s provide a more organized, high level interface to writing distributed software than TCP send and receives.

RPC Advantages

- Appears to the user like a call to a function on the local machine.
- RPC concept is similar to conventional programming.
- Procedure calling has well understood semantics.
- RPC can be extended to Remote Method Invocation (RMI) for OO systems.
- RPC simplifies access to remote systems.

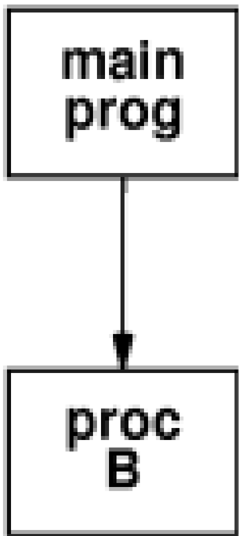
RPC Construction

- Assume the main program is calling

  `int myfunc(float x);`

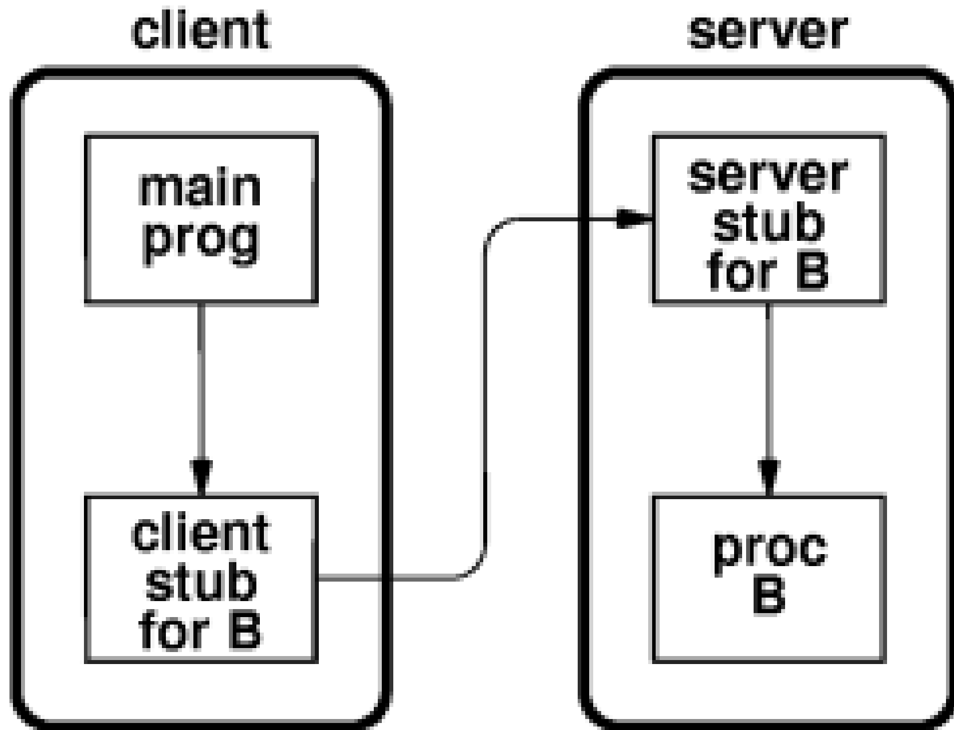
- Write a "*client stub*" called `myfunc` that will not perform the computation, but will send the parameter to a remote system.
- Write a "*server stub*" that will receive the data and call the actual `myfunc` function. The server stub will send back the results.

RPC Overview



(a)

Logical



(b)

Actual execution flow

RPC Operation

- The main program calls the client stub.
- The client stub copies or ***marshals*** the parameters into a communication's packet.
- The client stub send an RPC request to the server.
- The server calls the desired function passing the parameters from the communication's packet.
- When the function returns, the server sends the results to the client stub.
- The client stub returns the results to the caller.

Call Semantics

- **Call by Value** works well with RPC
- **Call by Reference** does not fit RPC semantics.
- **Call by Copy** is similar to call by reference (assuming no aliases) and works will with RPC

RPC Input Parameters

- Input is data passed from caller to function.
- **basic datatype** - pass by value semantics, copy data to server
- **arrays or structures** - copy data to server, may be a lot of data
- **pointers to single datatype** - copy data item to server
- **pointers in general** - not allowed

RPC Output Parameters

- Output parameters are passed from the function back to the calling program.
- C programs use pointers to output variables

  example: **`x = func(&z);`**
- Data, not addresses, copied from server
- Return value copied from server

RPC Execution Environment

- No global variables
- No environment variables
- No access to files on the client computer.

Exception Handling

- What does the communication stub do if the first effort to send a message fails?
  - **no retry** RPC may not work
  - **at-least-once** Keep sending until it gets there (*idempotent* functions)
  - **at-most-once** retry but server must filter repeats

Synchronization

- Normal RPC are synchronous, the calling program waits until the called function completes.
- Normal RPCs do not provide parallelism.
- The logical thread of execution moves to another computer and then back.
- Asynchronous RPCs execute the called function in parallel with the main program.

Asynchronous RPC

- Call without reply - stub returns to caller after sending message.
- Useful for “void” functions that do not return a result.
- A “print” function might be a good candidate for an asynchronous RPC.

Call Backs

- The RPC returns before the result is complete.
- The server calls a completion function in the client program when the RPC has completed.
- Call backs support event driven programming.

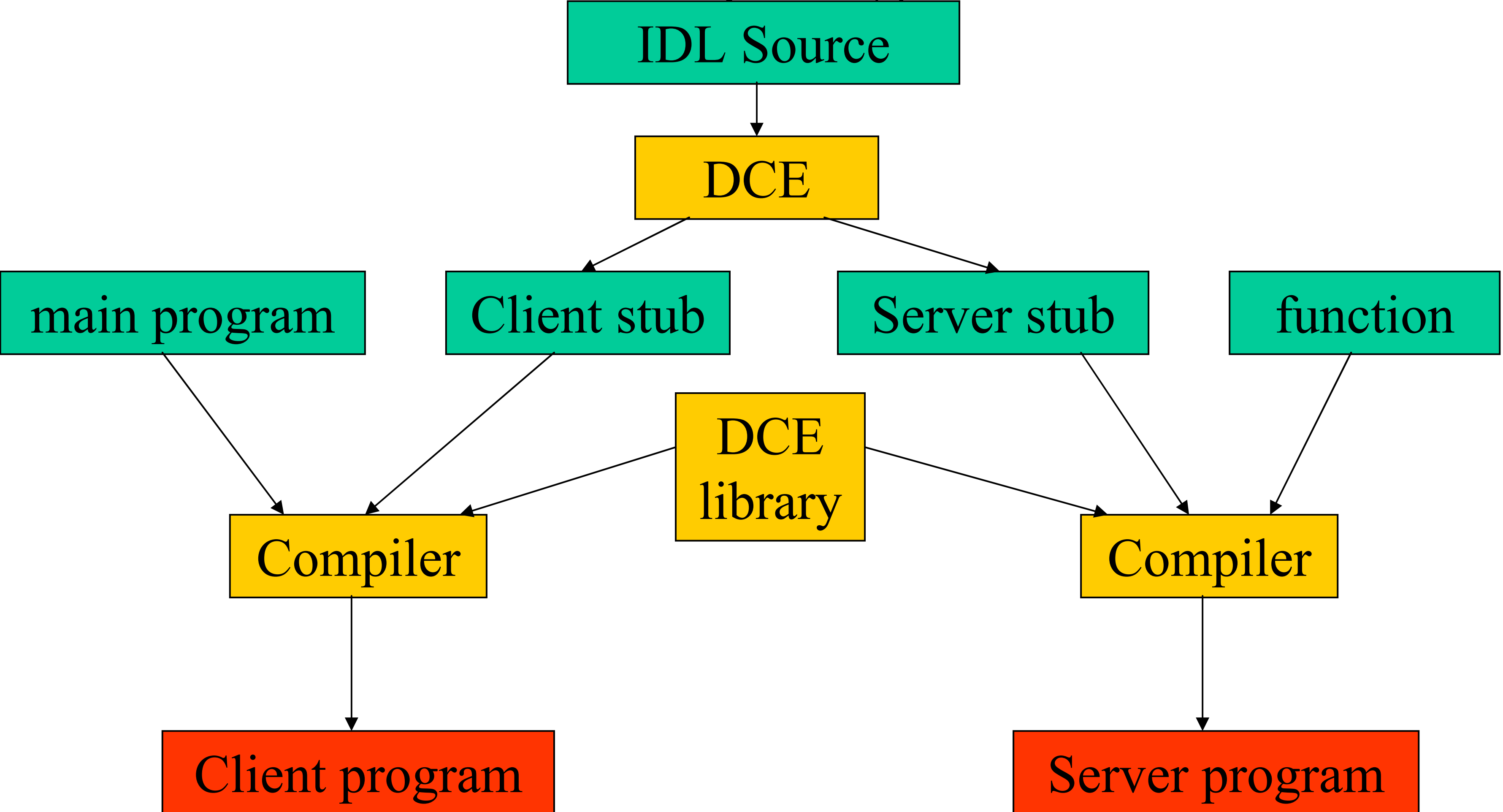
Automatic Stub Generation

- There are several systems that will automatically generate the client and server stubs.
- Distributed Computing Environment (DCE) from the Open Software Foundation (OSF) supports an RPC system.
- The Interface Definition Language (IDL) defines the function interface similar to a function prototype.

IDL Example

```
int funcabc(
        [in]        float   x,
        [out]       long   *y,
        [in out]    double *z
        );
```

Distributed Computing Environment



X- Windows Example

- Main computer is the client. User programs call the server to display data.
- The terminal is the display server.
- Uses Asynchronous RPC.