Implementing Remote Procedural Calls

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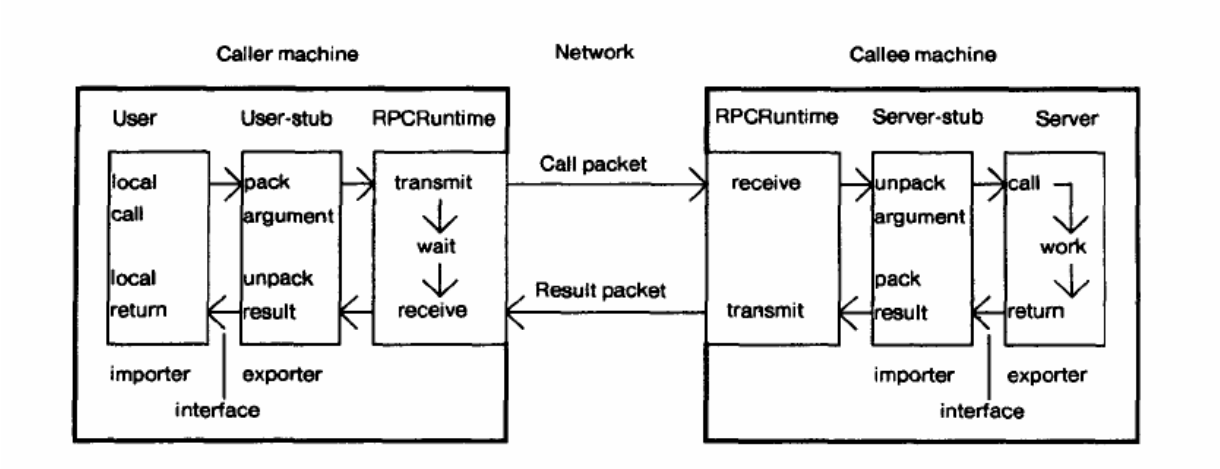
Aims and Fundamental Decisions

- Distributed Computing
- Efficient RPC communication
- Secure end to end communication

- No shared Space
- Lupine generated stubs (Interface Module)

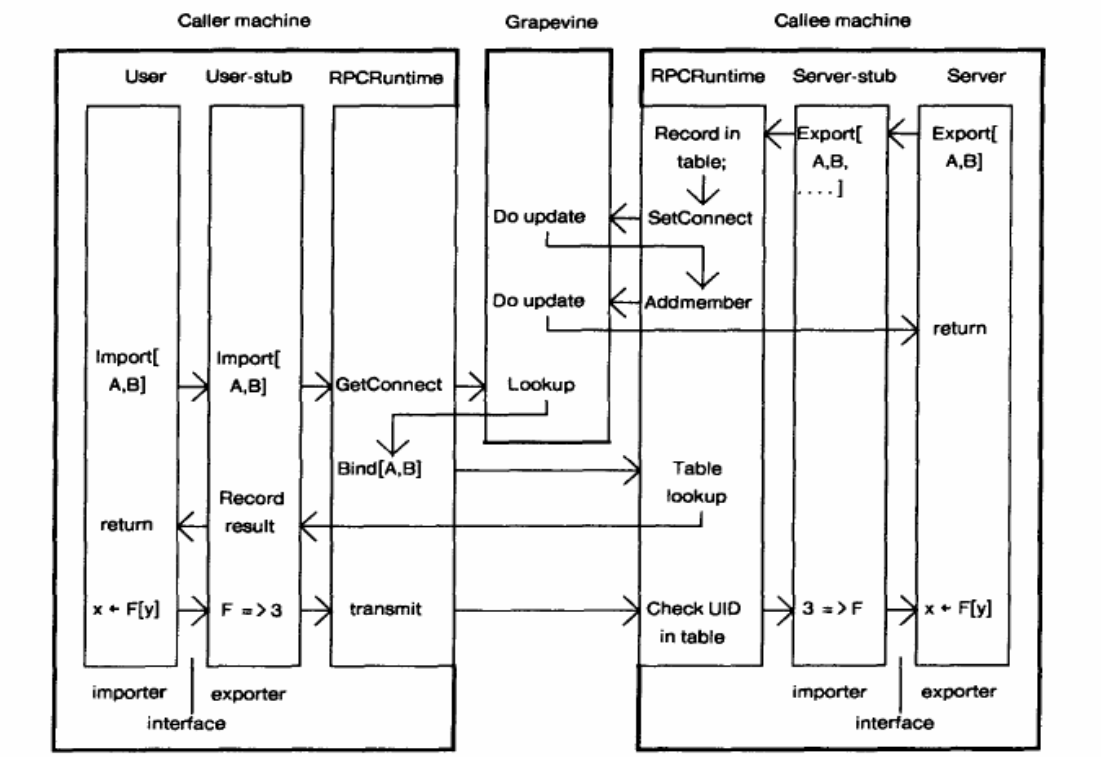
System Component



Binding

- Naming
  - Mapping importer to exporter
  - Type and instance
- Locating an Appropriate Exporter
  - Grapevine servers
    - Highly reliable
    - Replicated Data
- RPCRuntime records export information

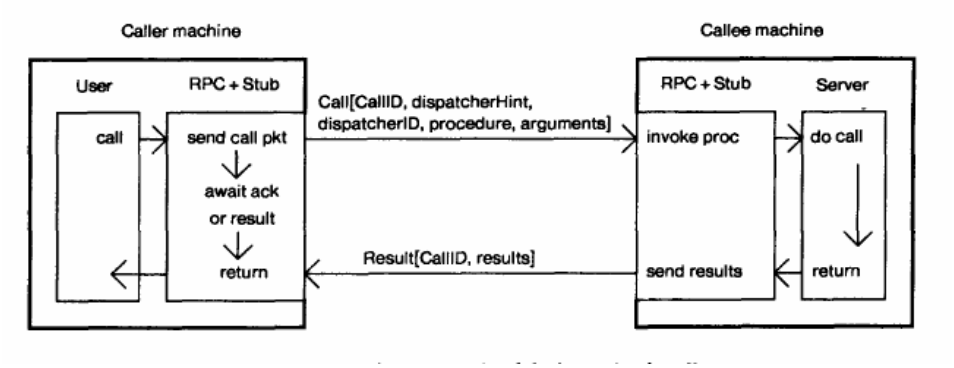
Binding (contd.)



Packet Level Transport Protocol

- Simple Calls
  - All arguments fit in single packet Buffer
    - Call Identifier
    - Desired Procedure (Binding)
    - Arguments
  - Result Packet
  - Activity (Machine identifier, Process)
  - Eliminate Duplicated caused by retransmit
  - Simple calls on local network

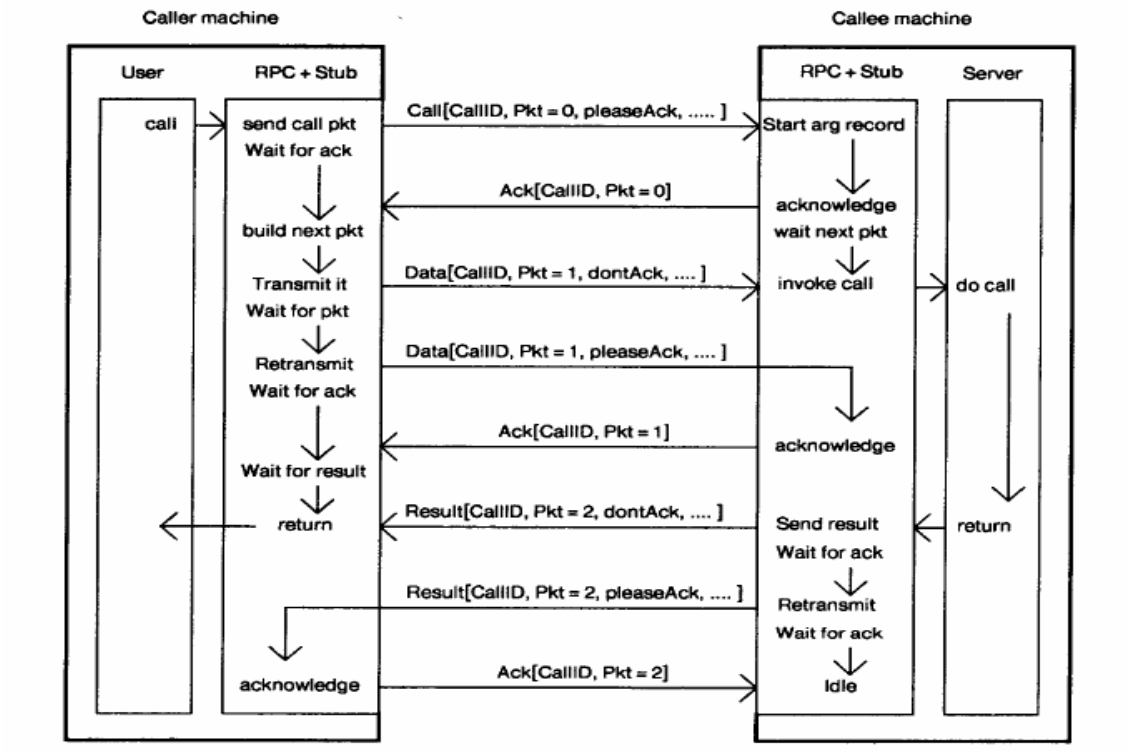
Simple Call


Caller machine
Callee machine
User
RPC + Stub
RPC + Stub
Server
call
send call pkt
await ack
or result
return
Call[CallID, dispatcherHint,
dispatcherID, procedure, arguments]
invoke proc
do call
Result[CallID, results]
send results
return

Complicated Calls

- Transmitter is responsible for retransmit until it receives acknowledgement
- Packet requests explicit acknowledgment.
- Probe Packet
- Arguments may occupy more than one packet
- Call Sequence Number

Complicated Calls



Exception Handling

- With a local procedure call
  - Invalid memory reference, divide by zero, etc.
- With RPC
  - Remote server procedure generates an error
  - The client stub or server stub can encounter network problems or machine crashes

Exception Handling(Contd.)

- Service Error
  - On exception, the call stack is dynamically scanned for catch phrase
  - If found the body of the catch phrase is executed
- Communication infrastructure
  - RPCRuntime may raise a *call failed* exception

Security

- Encryption-based security for calls
- Grapevine is used as *key distribution center*
- Attempts of modification, replay, or creation of calls are detected

Performance

Ethernet 2.94 Megabits/sec.
12,000 calls each procedure

Procedure	Minimum	Median	Transmission	Local-only
no args/results	1059	1097	131	9
1 arg/result	1070	1105	142	10
2 args/results	1077	1127	152	11
4 args/results	1115	1171	174	12
10 args/results	1222	1278	239	17
1 word array	1069	1111	131	10
4 word array	1106	1153	174	13
10 word array	1214	1250	239	16
40 word array	1643	1695	566	51
100 word array	2915	2926	1219	98
resume except'n	2555	2637	284	134
unwind except'n	3374	3467	284	196