FTRMI: Fault-Tolerant Transparent RMI

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Remote Procedure Calls

What?

- A simple approach for distributed computing
- Hides the network from the application (client and server) programmer

Client side

```
 // Do something
x=f(y);
// Do more
```

Server side

```
 int f(int y) {
// Do something
return z;
}
```

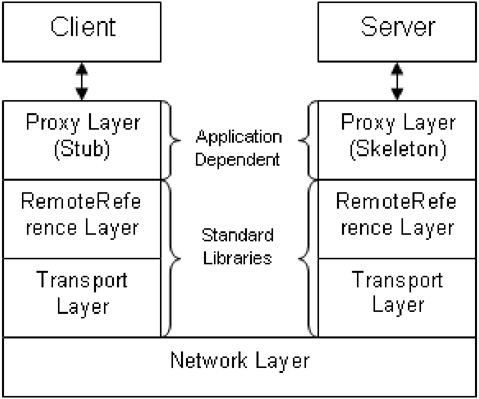
Remote Procedure Calls

Who?

- Implementation examples
  - **Procedural** ONC (SUN) RPCs, Web Services
  - **OO** CORBA, JRMI

Remote Procedure Calls
How?

JRMI as an example



The Availability Limitation of RPC's

- What if server fails?
  - Server name is well-known
  - Stubs cannot reroute remote calls to alternative servers
    - Server state would not be available at the replica

Approaches for State-full Consistent Replication of Servers

Middleware Aware

- Client and server stacks cooperate to support replication
- Disadvantages
  - Clients and servers use non-standard protocol
    - Must run special version of the middleware
- Examples
  - Jgroup/ARM
  - Filterfresh
  - FT-CORBA
  - ...

Approaches for State-full Consistent Replication of Servers

Middleware Unaware

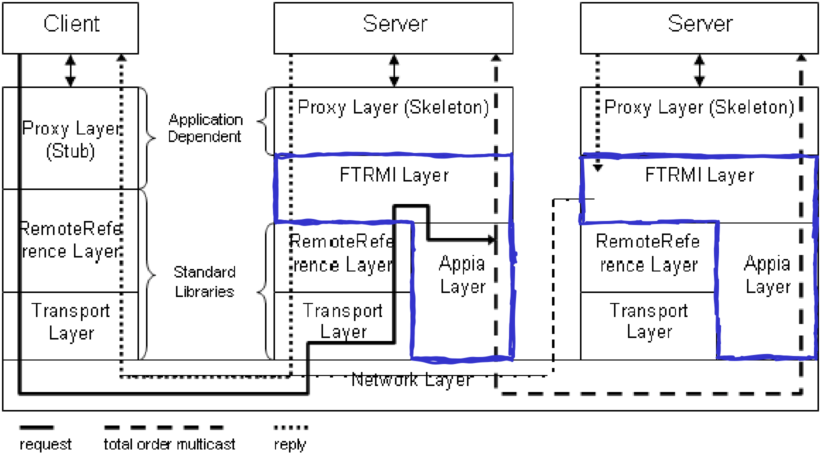
- Replication is hidden from the application and the middleware
- “Proxies” capture and (possibly) interpret the client/server traffic
- Disadvantages
  - Respecting the protocols raises limitations on the operations that can be provided
- Examples
  - Aroma
    - Snoops traffic at client and server side
  - FTRMI

Fault-Tolerant RMI (FTRMI)

Overview

- Proxy placed on the server side
  - Between the standard library class and server skeleton
  - Class with the same name and API of the original JRMI
    - `sun.rmi.server.UnicastServerRef`
  - `-Xbootclasspath/p`
- No code change at the client or server

FTRMI Process



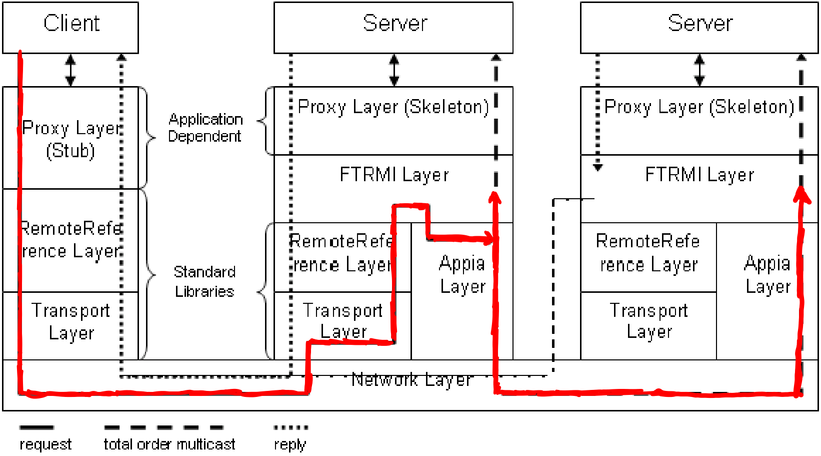
FTRMI Implementation

Incoming calls

- Intercept remote calls before they are delivered to the server
- Use Linux `libcap` to retrieve call's TCP/IP connection information
  - Sequence and Ack number
  - IP origin and destination addresses
- Deliver the call and TCP data to the Appia Group Communication Service
  - Appia enforces the atomic broadcast properties

FTRMI Implementation

Calls received from clients



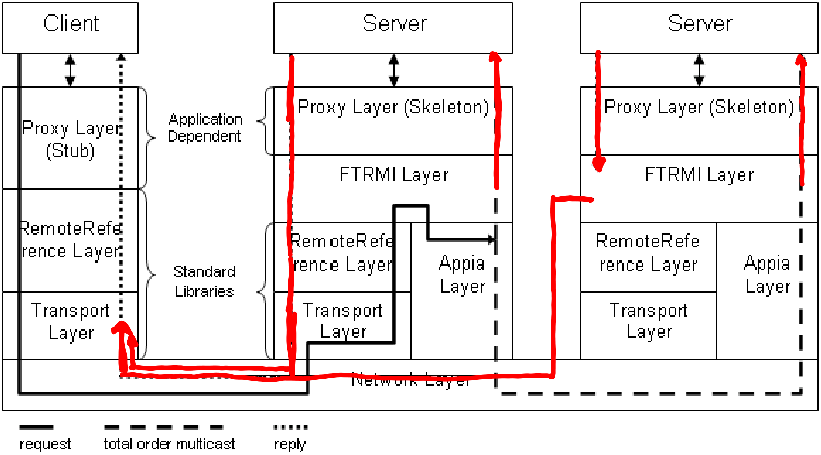
FTRMI Implementation

Calls received from Appia

- Forward the call to skeleton
- Intercept the reply
- Prepare a TCP segment that matches the TCP expected reply at the client
- Send the TCP segment
    - Using raw sockets

FTRMI Implementation

Handling calls received from Appia



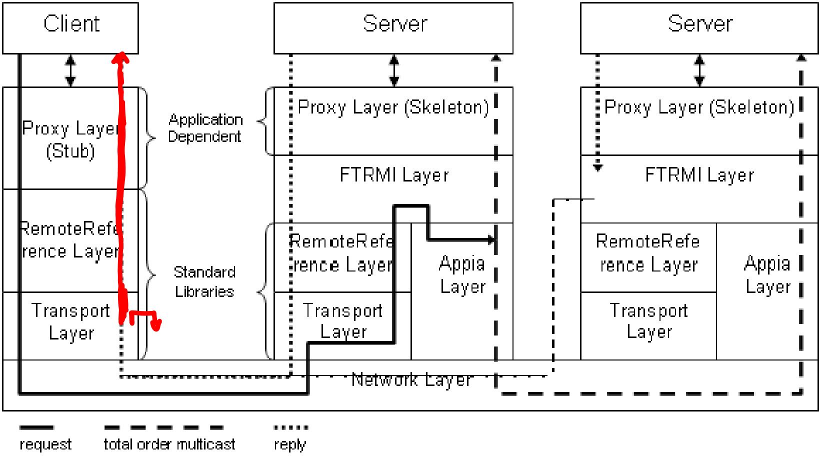
FTRMI Implementation

Client Transparency

- Client's TCP will receive multiple copies of the reply
- Consider all but the first as duplicates
  - Discard

FTRMI Implementation

Multiple reply handling at the clients



Fault Tolerance

- Appia protocols
  - Provide atomic broadcast
  - Support for a distributed state machine
  - Support for state synchronisation when servers recover
- TCP
  - Duplicate detection
    - Case where server that received the request fails

Evaluation

Performance

- FTRMI experimented with 3 distinct total order protocols provided by Appia

  FTRMI-1 Regular, Coordinator-based Total Order

  FTRMI-2 Regular, Causal Order-based Total Order

  FTRMI-U Uniform Total Order

- And compared with 2 approaches

  JRMI Off-the-shelf, not replicated JRMI

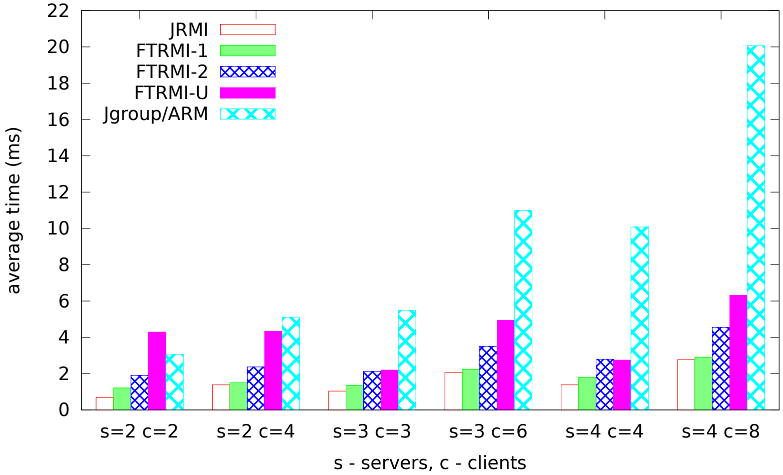
  Jgroup/ARM middleware-aware framework

  - Clients and servers share a GCS

- Remote procedure
  - `int procedure(String s)`

Evaluation

Latency



arguments size: 2000 bytes

Performance Results

Summary

- JRMI always presents the best performance results
- FTRMI scales well
- Server-Server 4×–10× more than Client-Server traffic
- Some protocols don't have a linear relation between latency and traffic

Conclusions & Future Work

- FTRMI
  - Transparent replication of JRMI servers
    - without code changes at the client or the server
    - No need to use specialised libraries at the client side
  - Encouraging performance results
- Future Work
  - Extend fault tolerance to the JRMI Registry
  - Experiment this approach in other RPC frameworks