15-440
Distributed Systems
Recitation 3

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Project 1

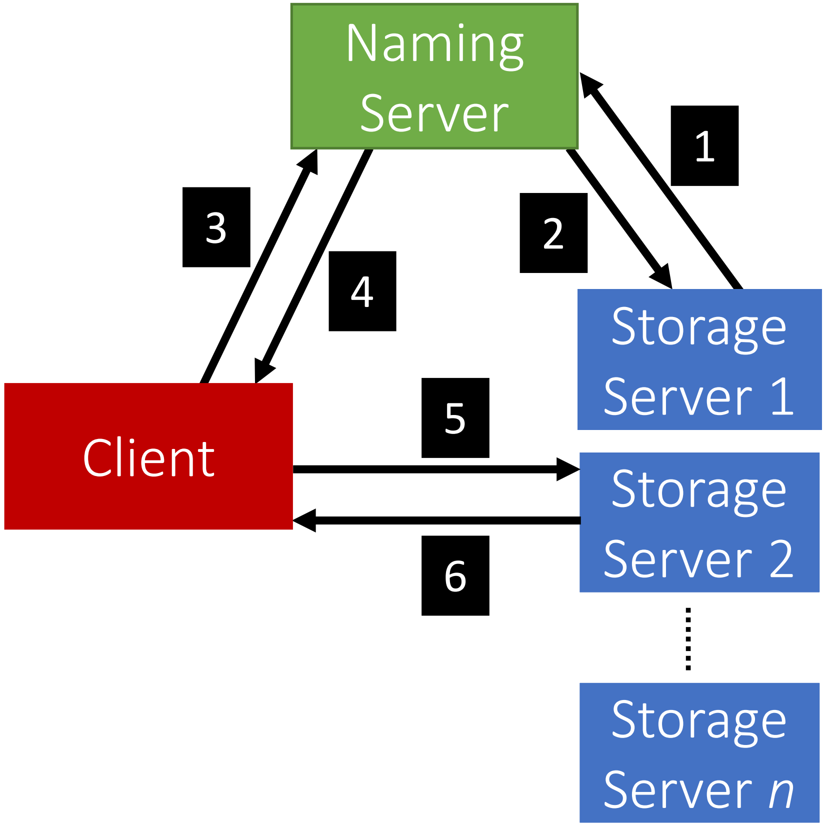
- Involves creating a *Distributed File System* (DFS): *FileStack*
- Stores data that does not fit on a single machine
- Enables clients to perform operations on files stored on remote servers (RMI)

Entities

- Three main entities in FileStack:
    - Client:
        - Creates, reads, writes files using RMI
    - Naming Server:
        - Runs at a predefined address
        - Maps file names to Storage Servers
        - Therefore, it has *metadata*
    - Storage Servers:
        - Physically hosts the files in its local file system

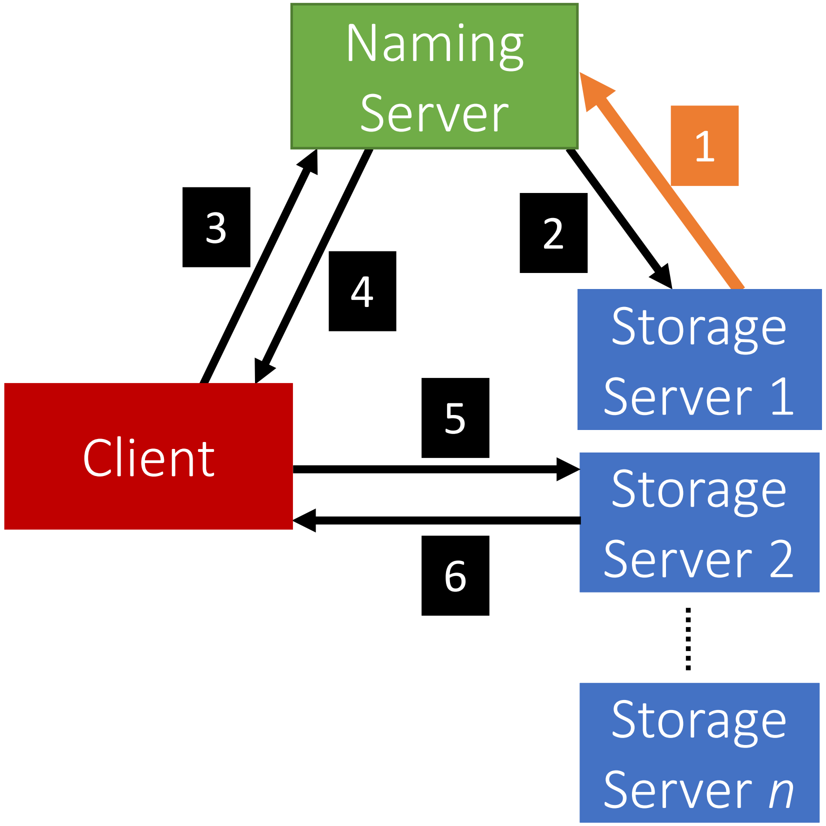
Architecture

- FileStack will boast a Client-Server architecture:



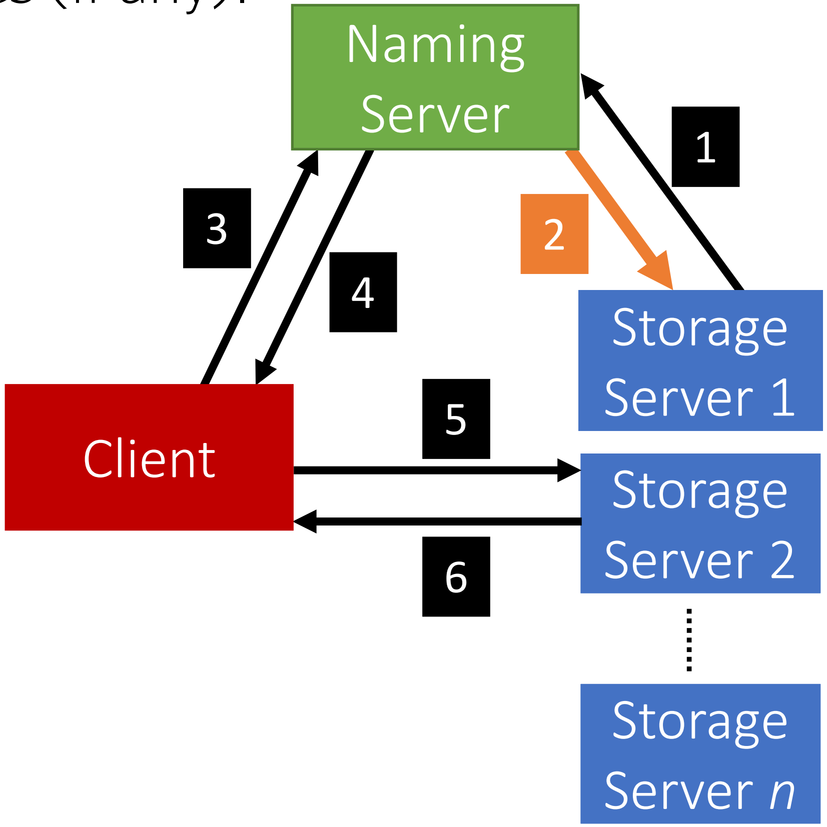
Communication

- Registration phase



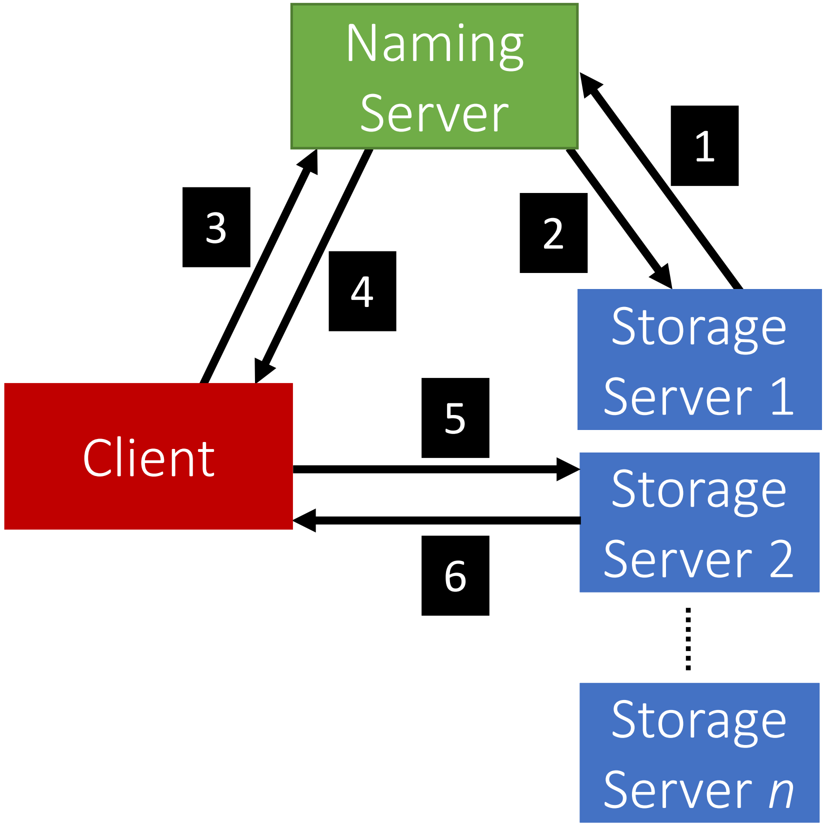
Communication

- Post registration, the Naming Server responds with a list of *duplicates* (if any).



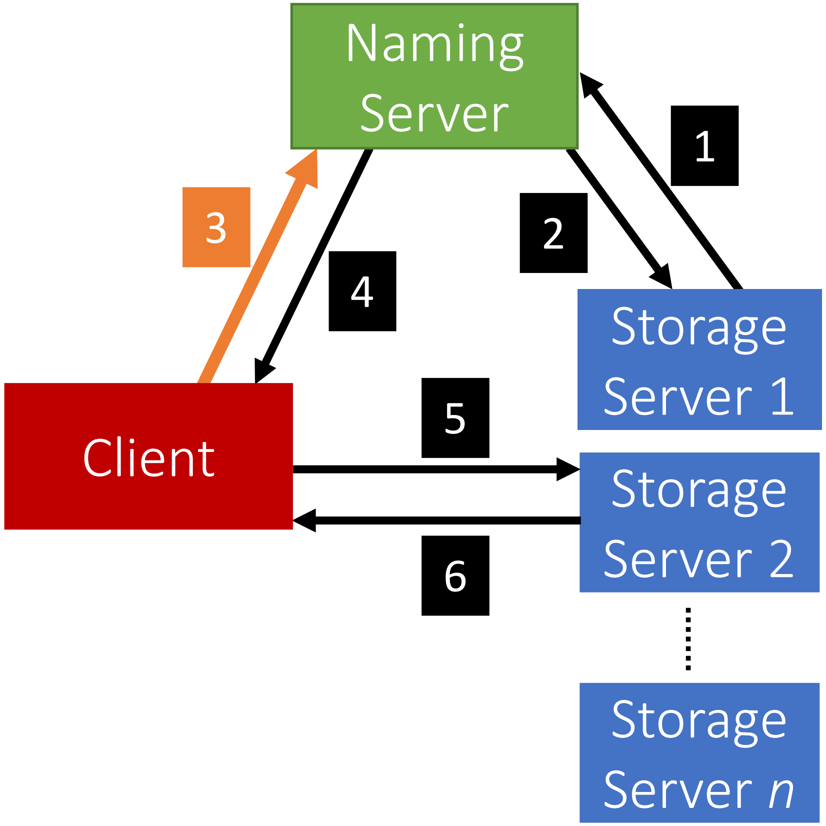
Communication

- System is now ready, the Client can invoke requests.



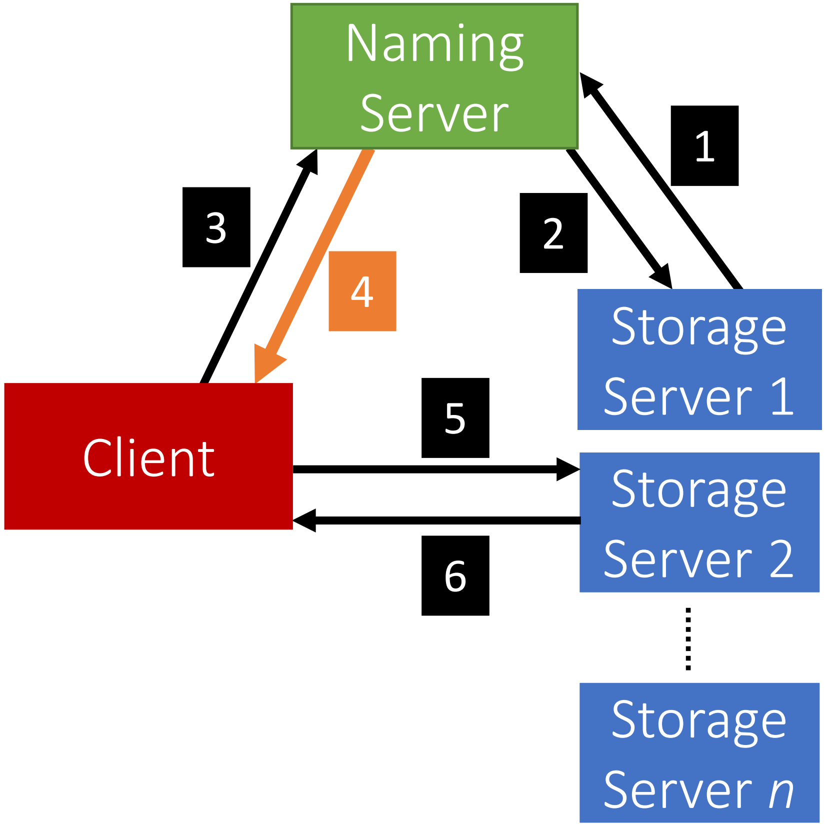
Communication

- Client requests a file (to read, write etc...) from the Naming Server.



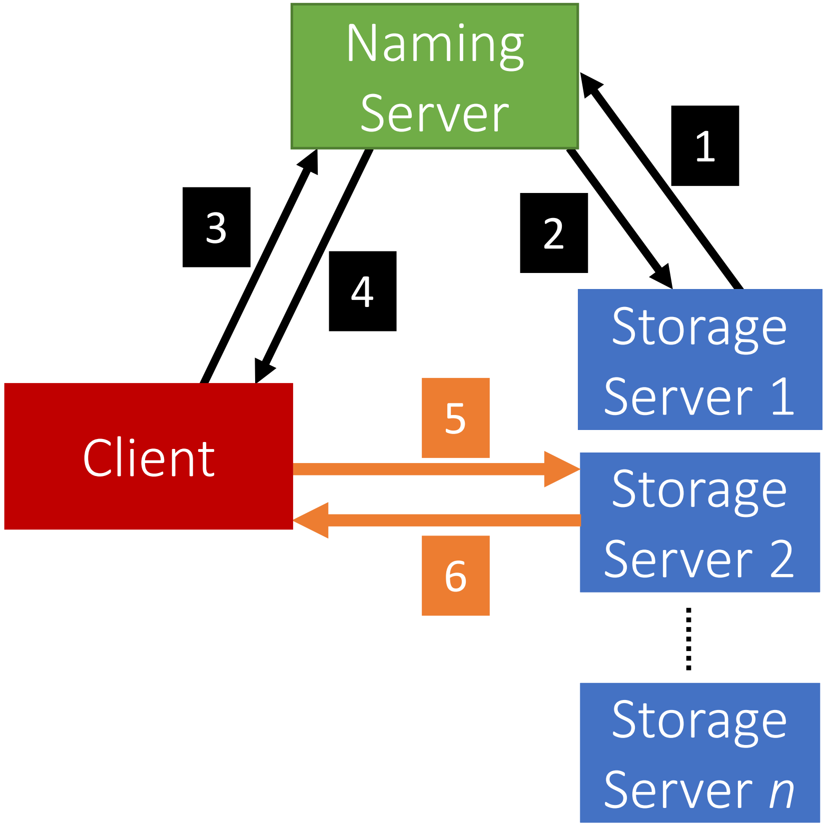
Communication

- Depending on the operation, the Naming Server could either perform it, or, respond back to the Client with the Storage Server that hosts the file.



Communication

- After the Client receives which Storage Server hosts the file, it contacts that Server to perform the file operation.



Communication

- When a Client makes invokes a method, it basically invokes a remote method (*and hence,* R*emote* M*ethod* I*nvocation*)
    - This is because the logic of the method resides on the server
- To perform this remote invocation, we need a library: Java RMI
- RMI allows the following:
    - When the client invokes a request, it is not a aware of where it resides (local or remote). It only knows the method's name.
    - When a server executes a method, it is oblivious to the fact that the method was initiated by a remote client.

RMI

- The RMI library is based on two important objects:
  - Stubs:
    - When a client needs to perform an operation, it invokes the method via an object called the “stub”
      - If the operation is local, it just calls the *helper function that implements this operation’s logic*
      - If the operation is remote:
        - Sends (marshals) the method name and arguments to the appropriate server (*or skeleton*),
        - Receives the results (and unmarshals),
        - Reports them back to the client.

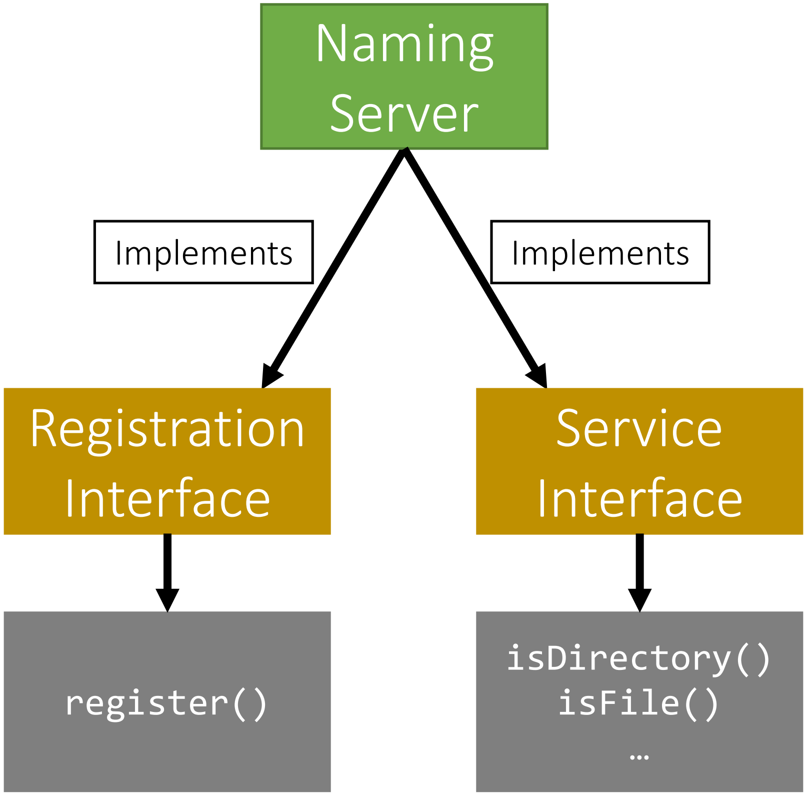
RMI

- The RMI library is based on two important objects:
  - Skeletons:
    - These are counterparts of stubs and reside reversely at the servers
      - Therefore, each stub communicates with a corresponding skeleton
      - It's responsible for:
        - Listening to multiple clients
        - Unmarshalling requests
        - Processing the requests
        - Marshalling & sending results to the corresponding stub

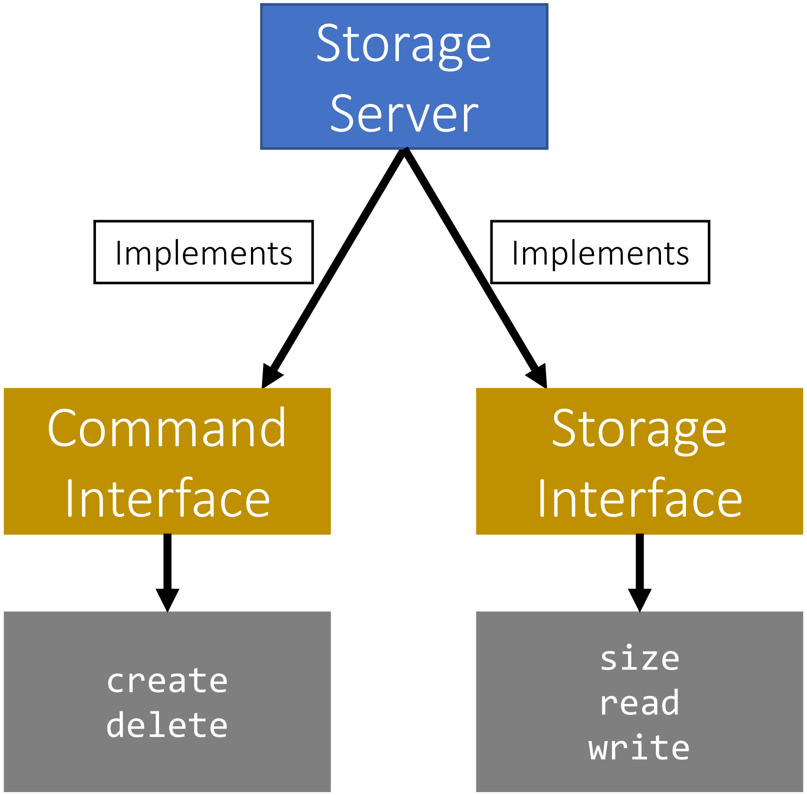
Interfaces

- Servers declare all their methods in interfaces
- Such interfaces contain a subset of the methods the server can perform

Naming Server Interfaces



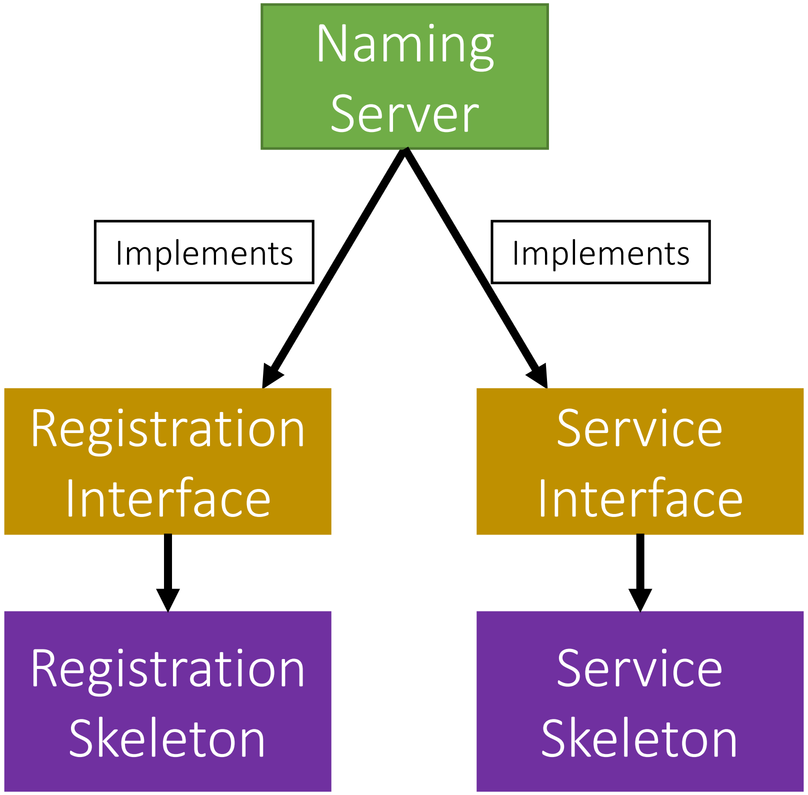
Storage Server Interfaces



Creating Stubs & Skeletons

- For a client to create a Stub, it needs:
  - An interface of the corresponding Skeleton
  - Network address of the corresponding Skeleton
  - *(Skeleton itself)*
- For a server to create a Skeleton, it needs:
  - An interface
  - A class that implements the logic of the methods defined in the given interface
  - Network address of the server

Naming Server Skeletons & Stubs



Naming Server

Implements

Implements

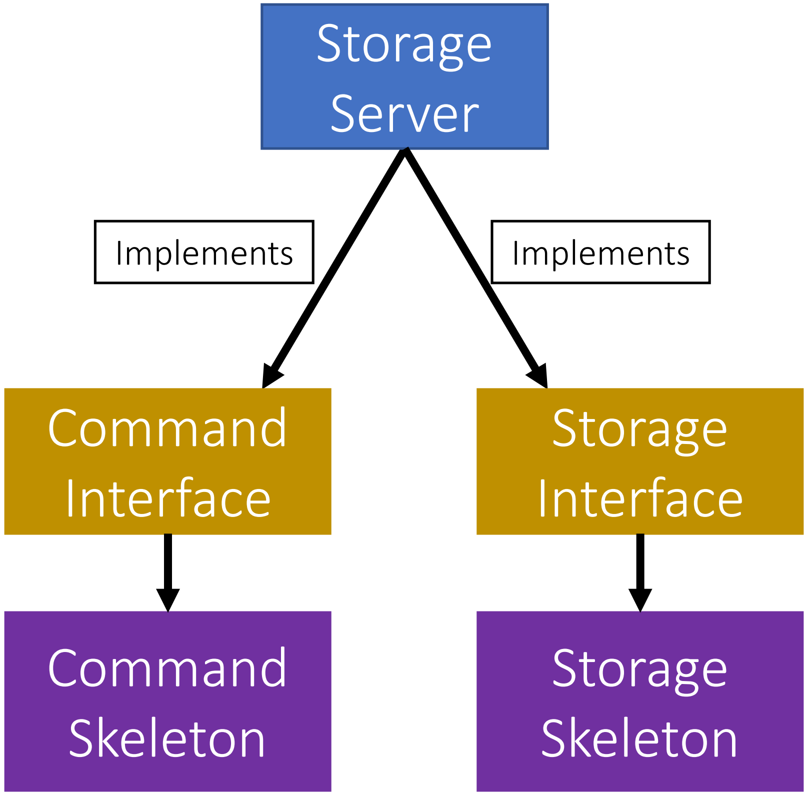
Registration Interface

Service Interface

Registration Skeleton

Service Skeleton

Storage Server Skeletons & Stubs



Storage Server

Implements

Implements

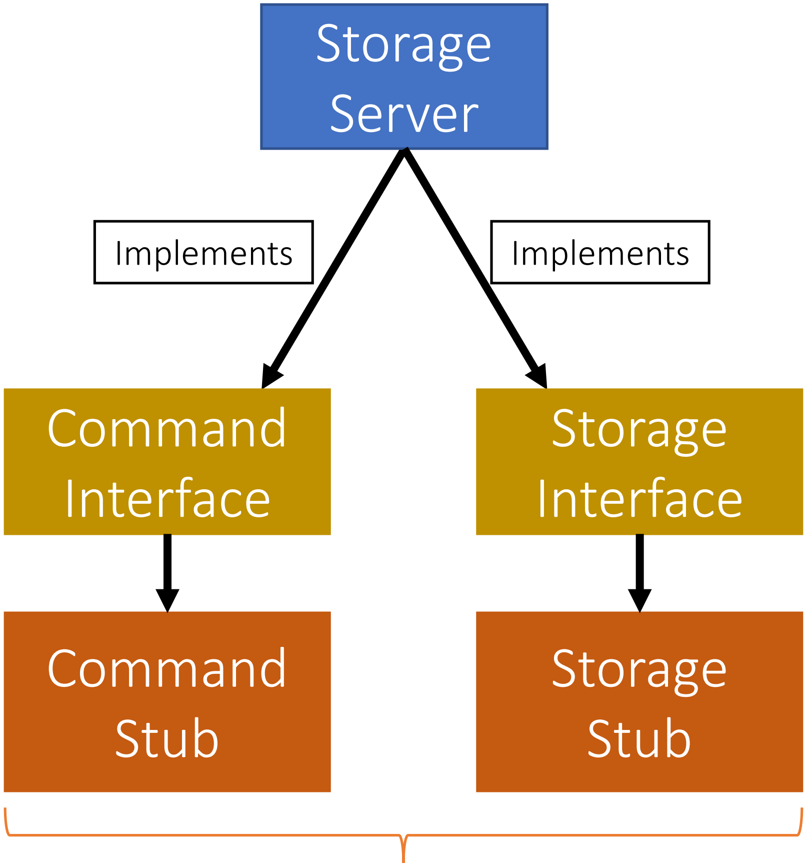
Command Interface

Storage Interface

Command Skeleton

Storage Skeleton

Storage Server Skeletons & Stubs



Storage Server

Implements

Implements

Command Interface

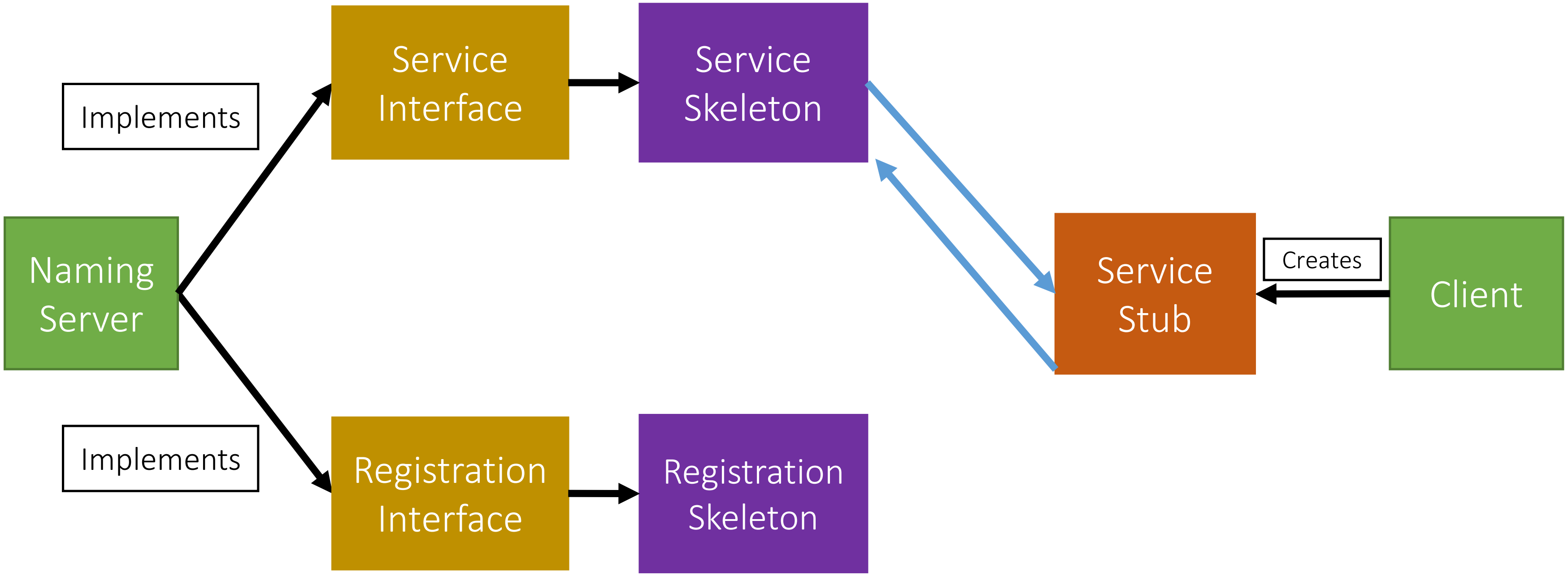
Storage Interface

Command Stub

Storage Stub

These stubs are sent to the Naming server during registration

Simple Stub-Skeleton Communication



Full Example: Client Read

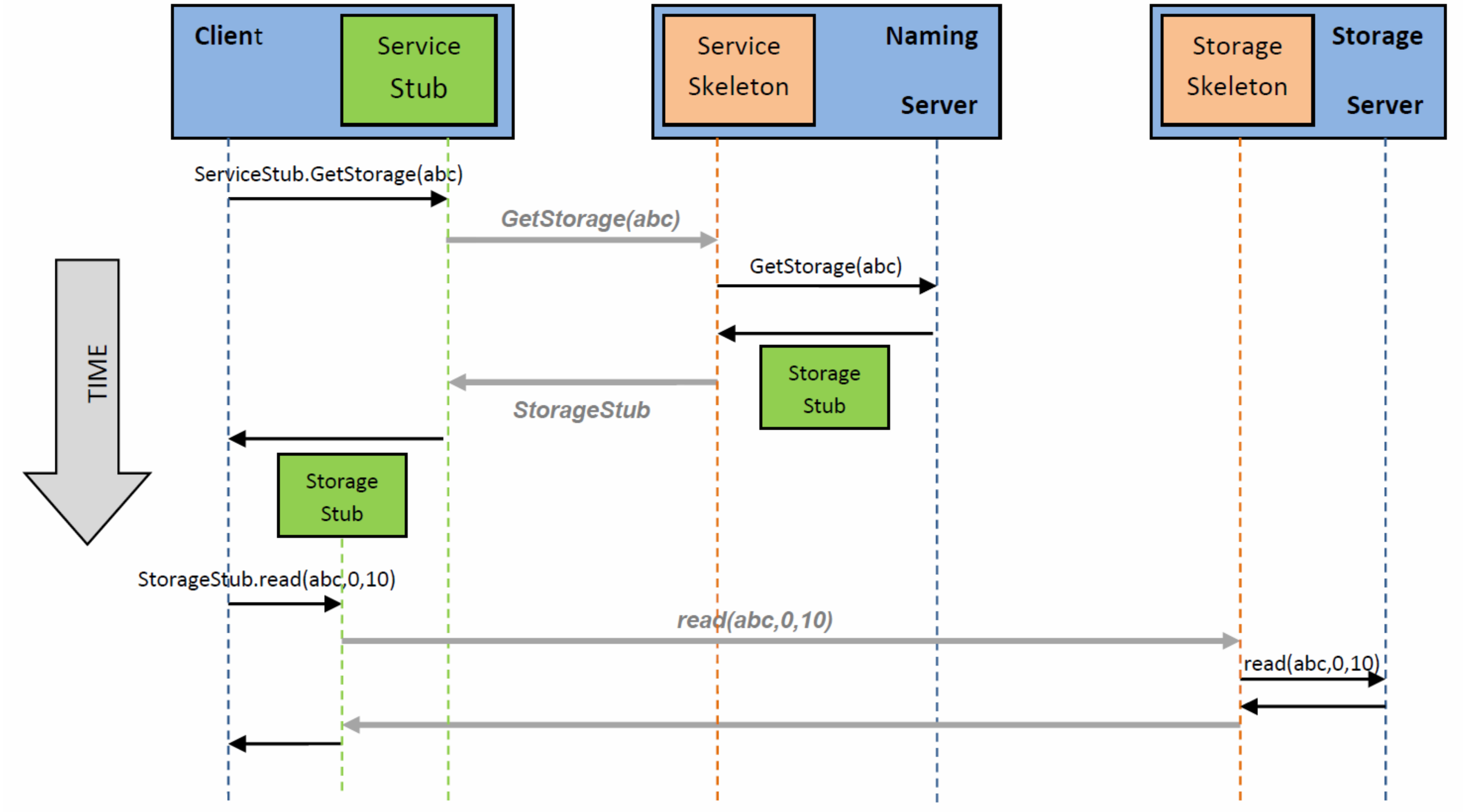


Figure 2: An example of a Client performing a read operation on file 'abc'.

Creating a Stub

- In Java, a stub is implemented as a dynamic proxy
- A proxy has an associated invocation handler
- Example: **`getStorage`** in Figure 2:
    - When **`getStorage`** is invoked on the Service Stub, the proxy encodes the method name (getStorage) and the argument(s) (file *abc*)
    - The proxy sends the encoded data to the invocation handler
    - The invocation handler determines if it is a local or remote procedure, and acts accordingly (as how it was shown earlier)