DISTRIBUTED SYSTEM DESIGN

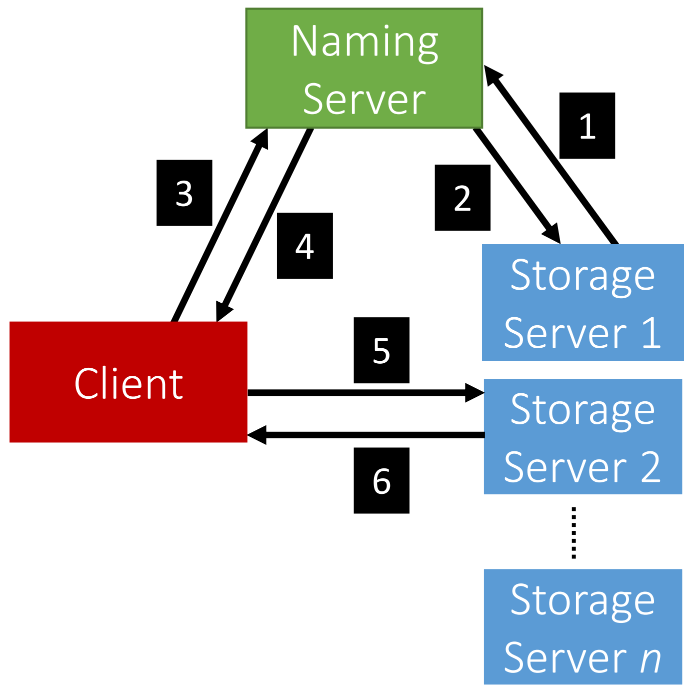
- Involves creating a *Distributed File System* (DFS):

- Stores data that does not fit on a single machine
- Enables clients to perform operations on files stored on **remote servers** (RMI)

Entities

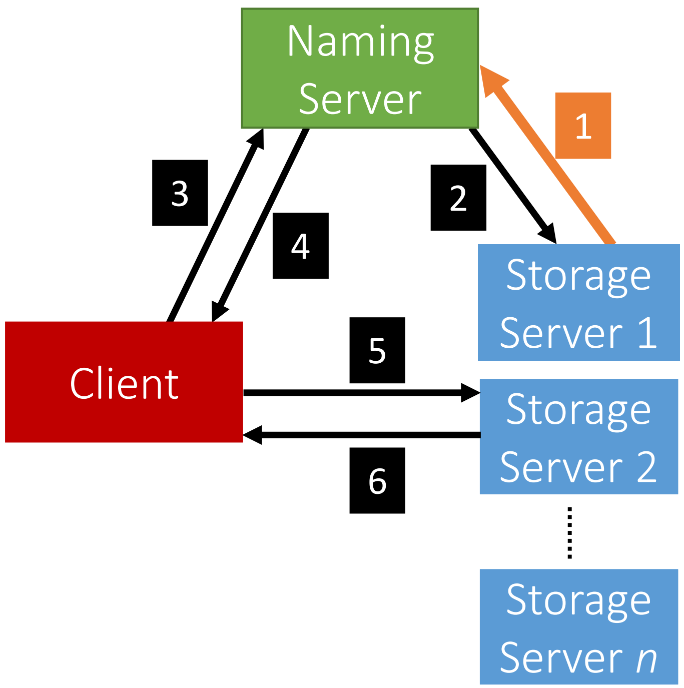
- Three main entities
  - Client:
    - Creates, reads, writes files using RMI
  - Storage Servers:
    - Physically hosts the files in its local file system
  - Naming Server:
    - Runs at a predefined address
    - Maps file names to Storage Servers
    - Therefore, it has *metadata*

Architecture



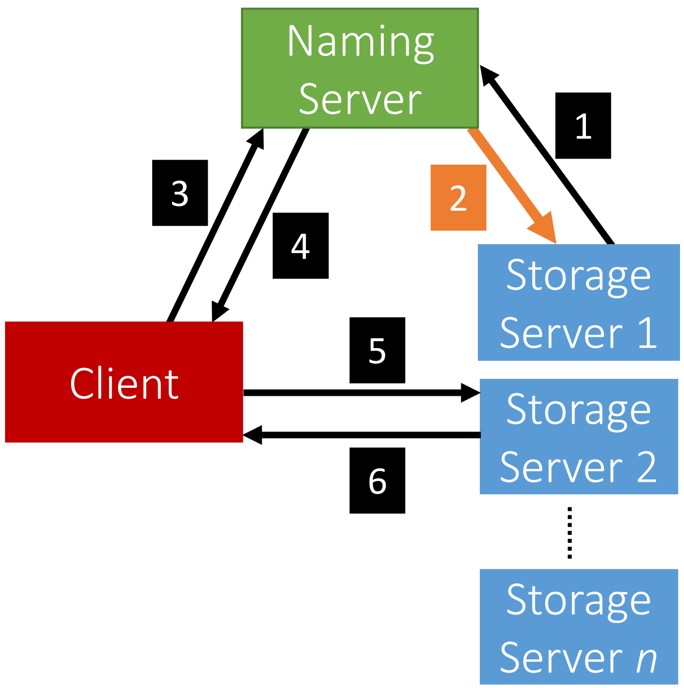
Communication

- Registration phase



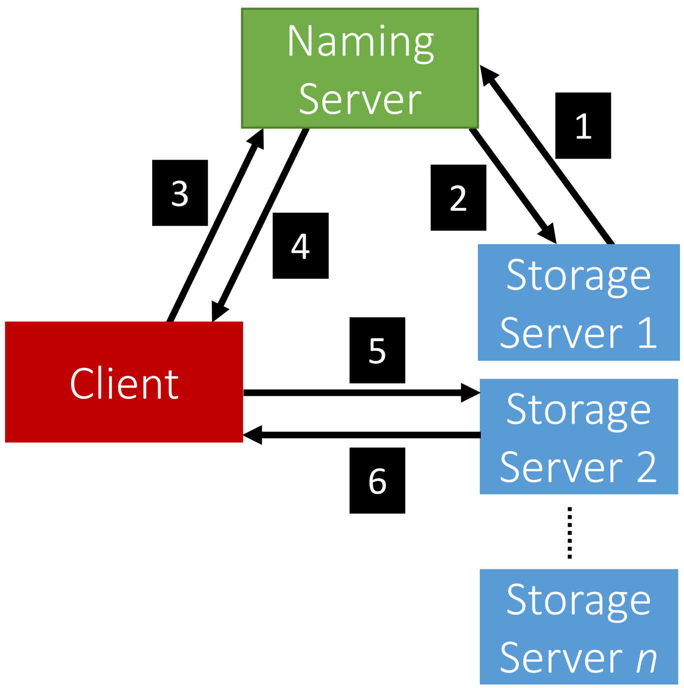
Communication

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



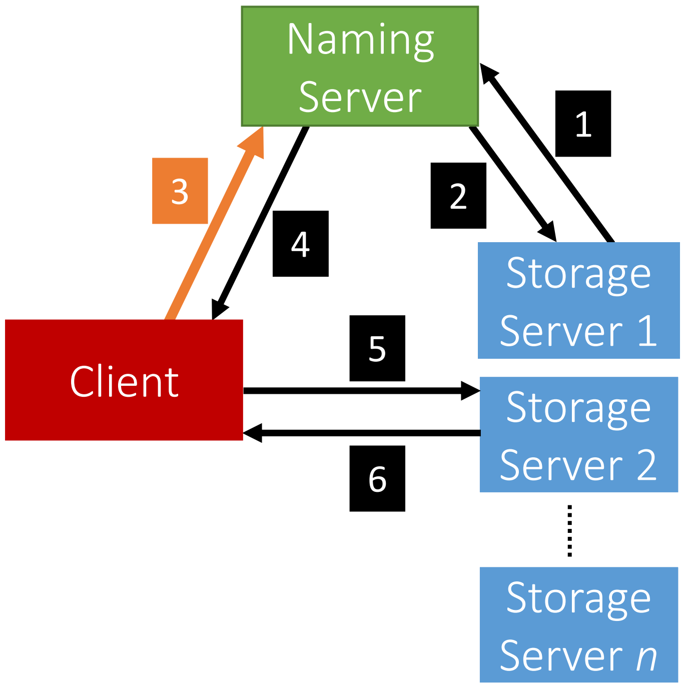
Communication

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



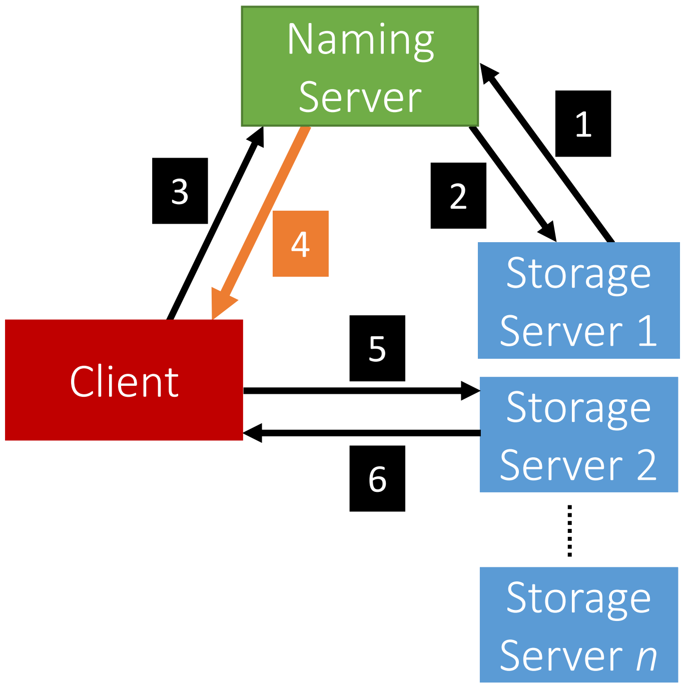
Communication

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



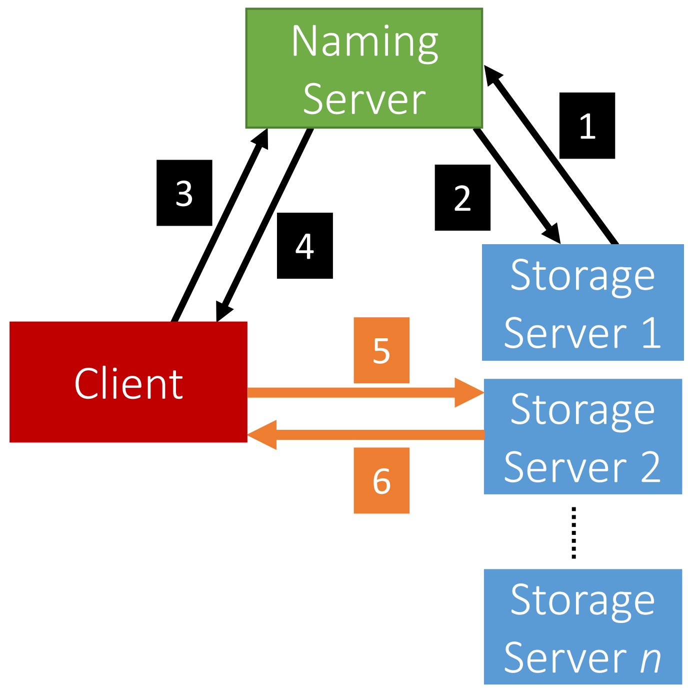
Communication

- 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 invokes a method, it basically invokes a **remote** method (*and hence, Remote Method Invocation*)
  - 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, the stub just calls the *helper function that implements this operation's logic*
      - If the operation is remote, the stub does the following:
        - **Sends (*marshals*) the method name and arguments** to the appropriate server (*or skeleton*),
        - **Receives the results (and *unmarshals*),**
        - **Reports them back to the client.**

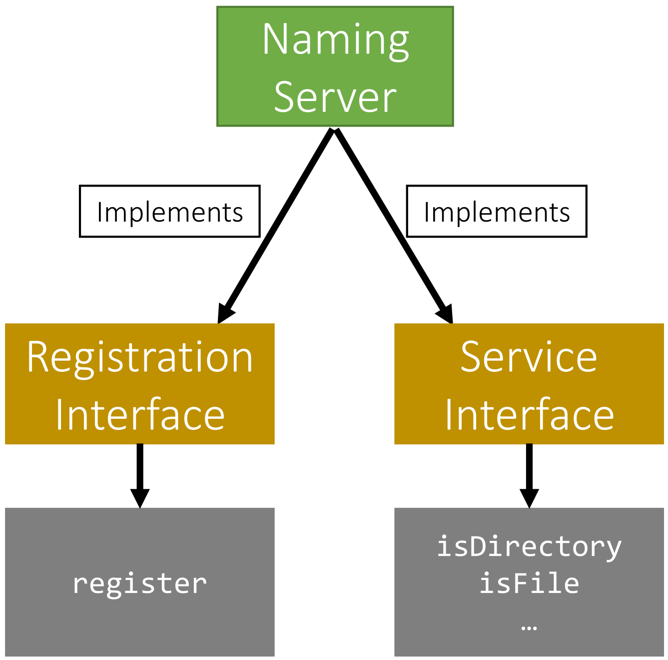
RMI

- 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 (**method name** & **method arguments**)
        - **Processing** the requests
        - **Marshalling & sending results** to the corresponding stub

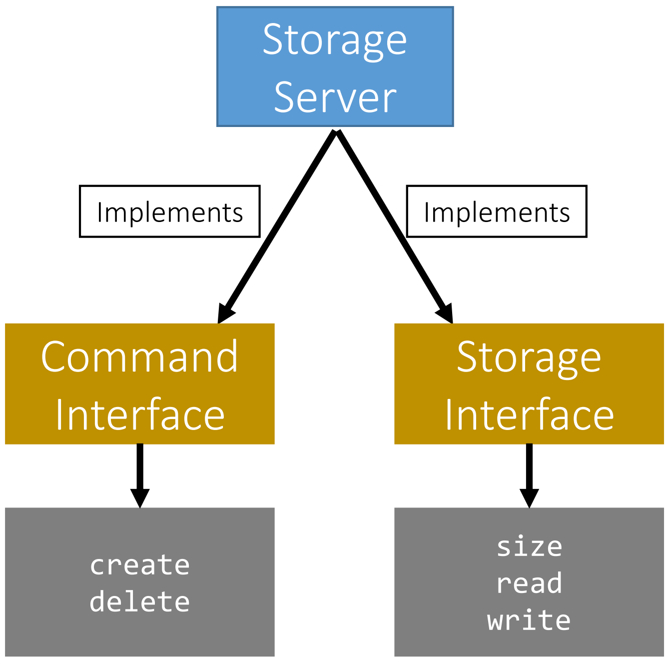
Interfaces

- 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

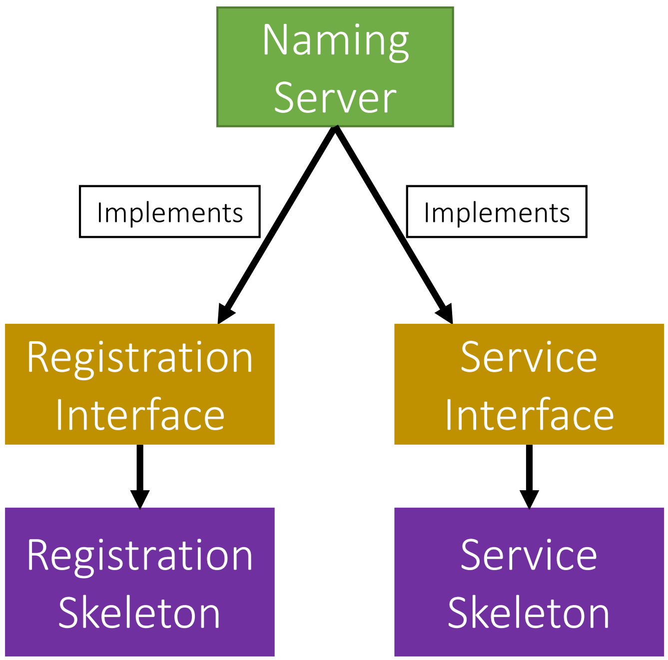


Creating Stubs & Skeletons

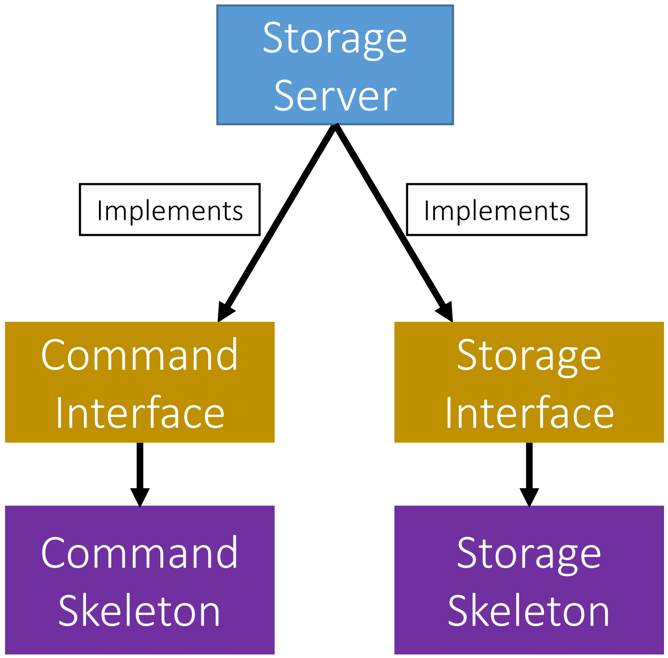
- For a client to create a Stub, it needs:
  - An **interface** of the corresponding **Skeleton**
  - **Network address** of the corresponding **Skeleton**

- 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

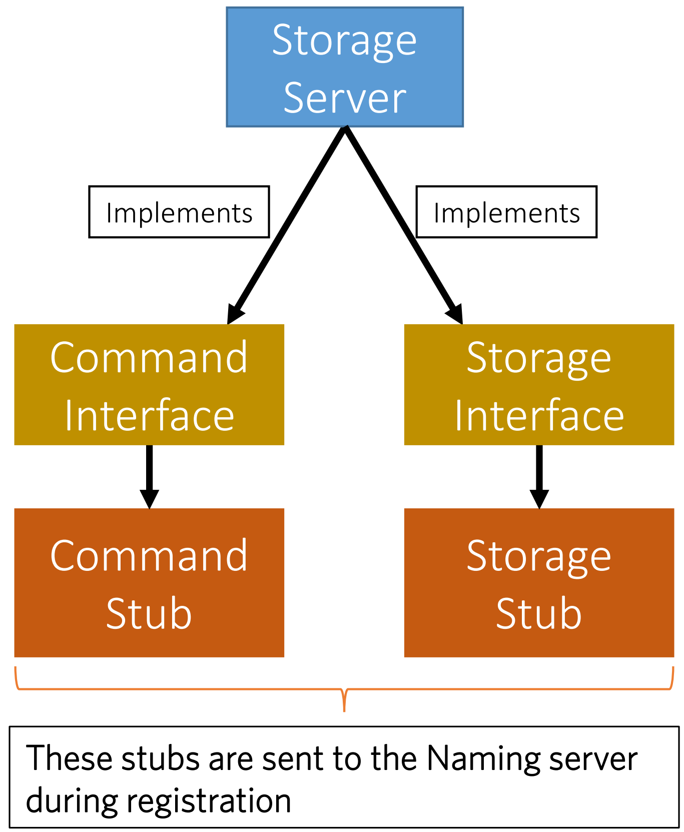
Naming Server Skeletons & Stubs



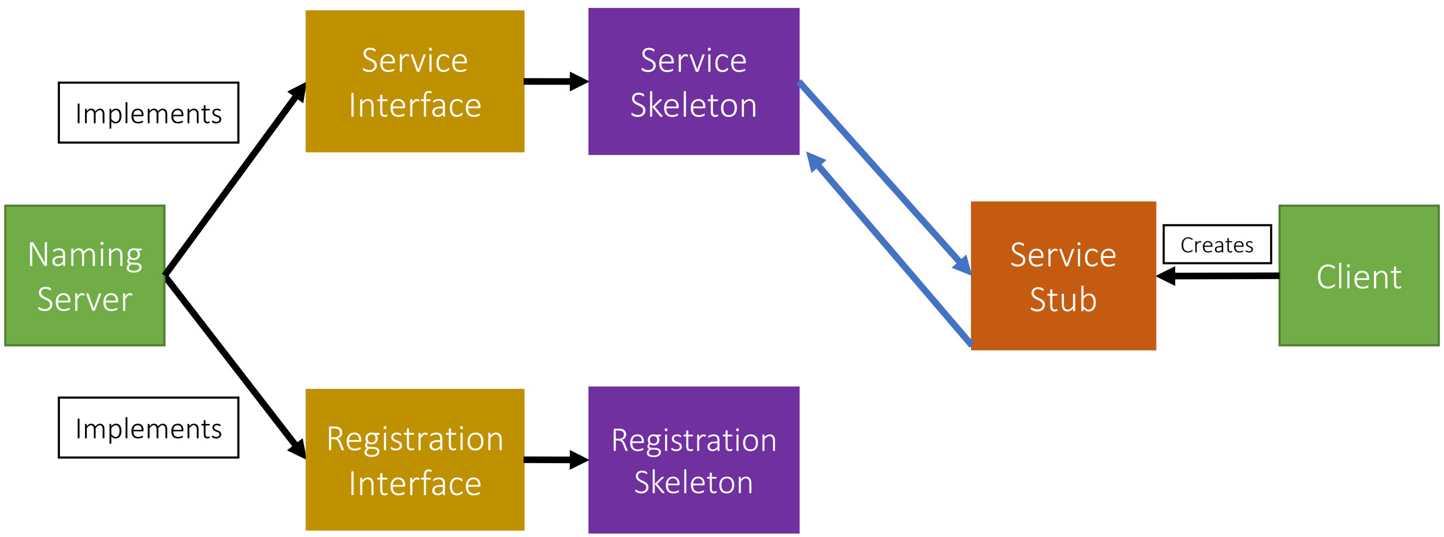
Storage Server Skeletons & Stubs



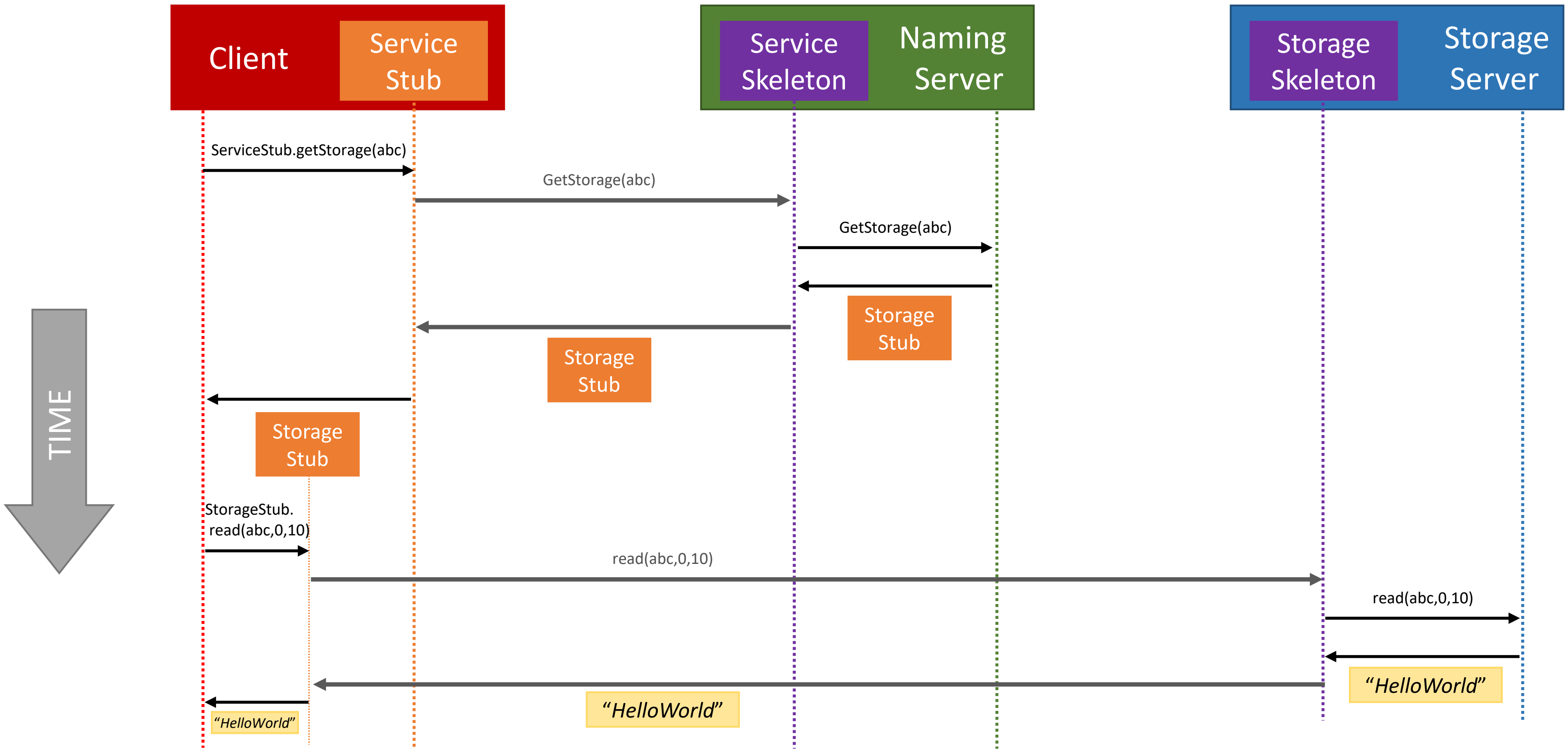
Storage Server Skeletons & Stubs



Simple Stub-Skeleton Communication



Full Example: Client Read



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)
- Go over **`java.lang.reflect.Proxy`** via the JavaDocs!