Sistemas Distribuídos

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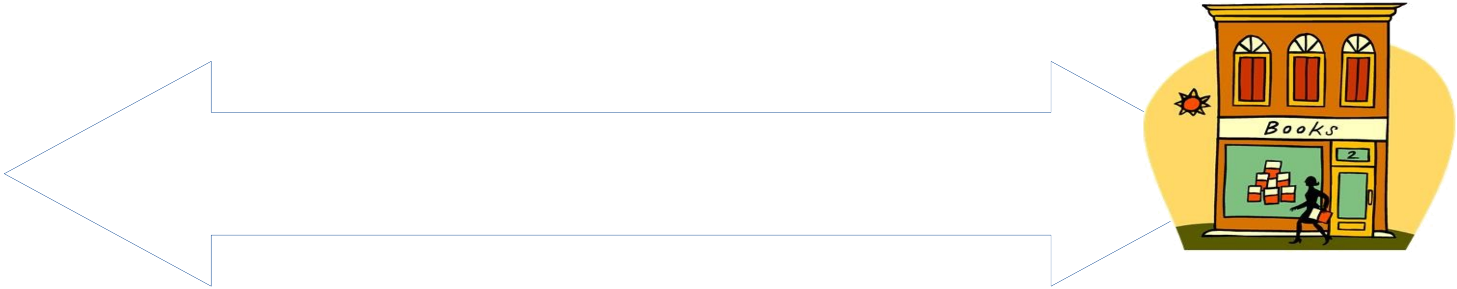
Example: Book store

- Book store operations:
  - Search books
  - Book details
  - ...



Search, Buy, ...

Client

Paradigms

- Remote terminal:
  - Network used to trasmit user input and output (UI)
- Shared resource:
  - Network used to share a resource (e.g., files)
- Client/server:
  - Logical operations, that encapsulate state and algorithms

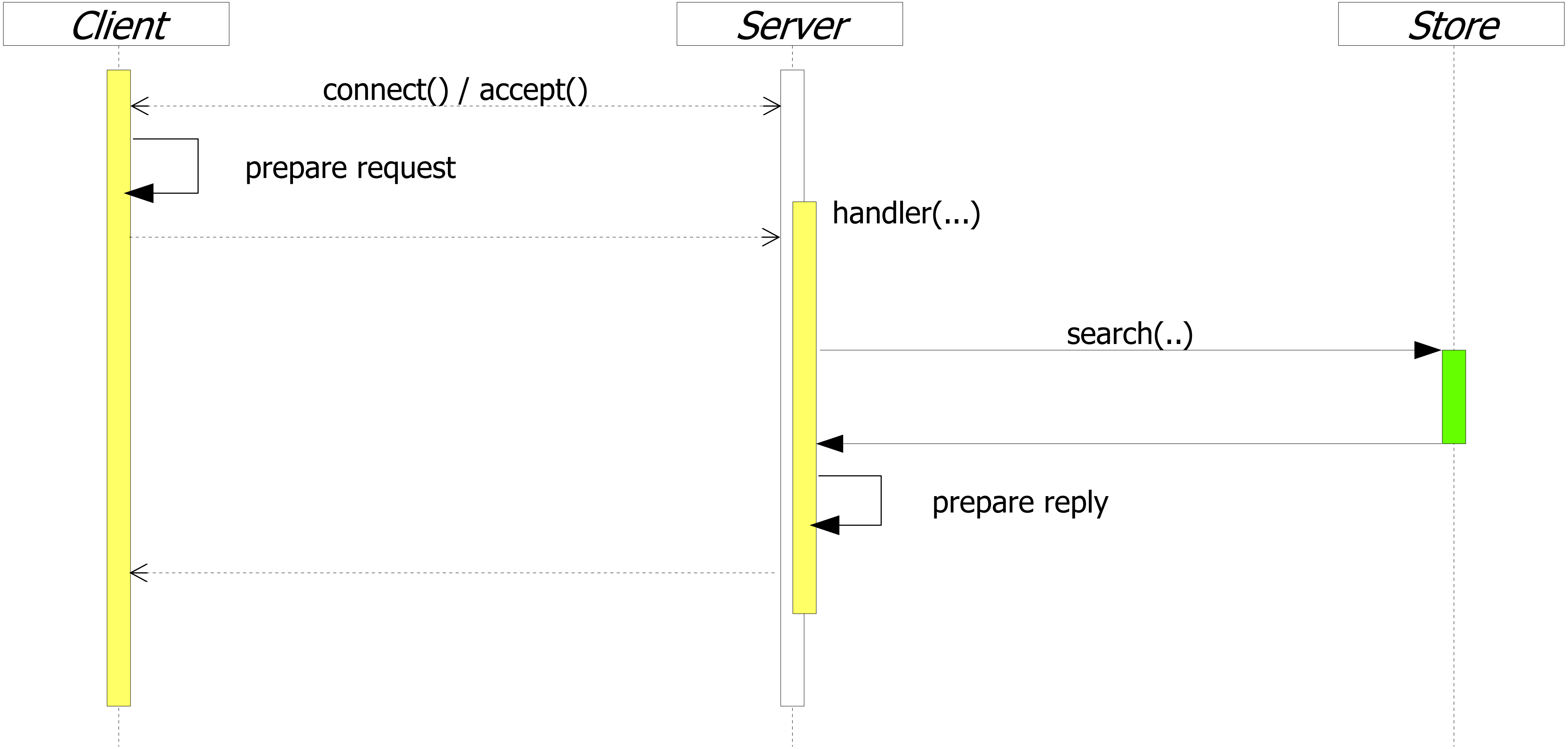
Key issues

- Reliability
  - Protection of shared state
- Performance and scale
  - Maintenance of session state
  - Latency and bandwidth
- Complexity
  - Implementation of protocol → <u>Harder in client/server</u>

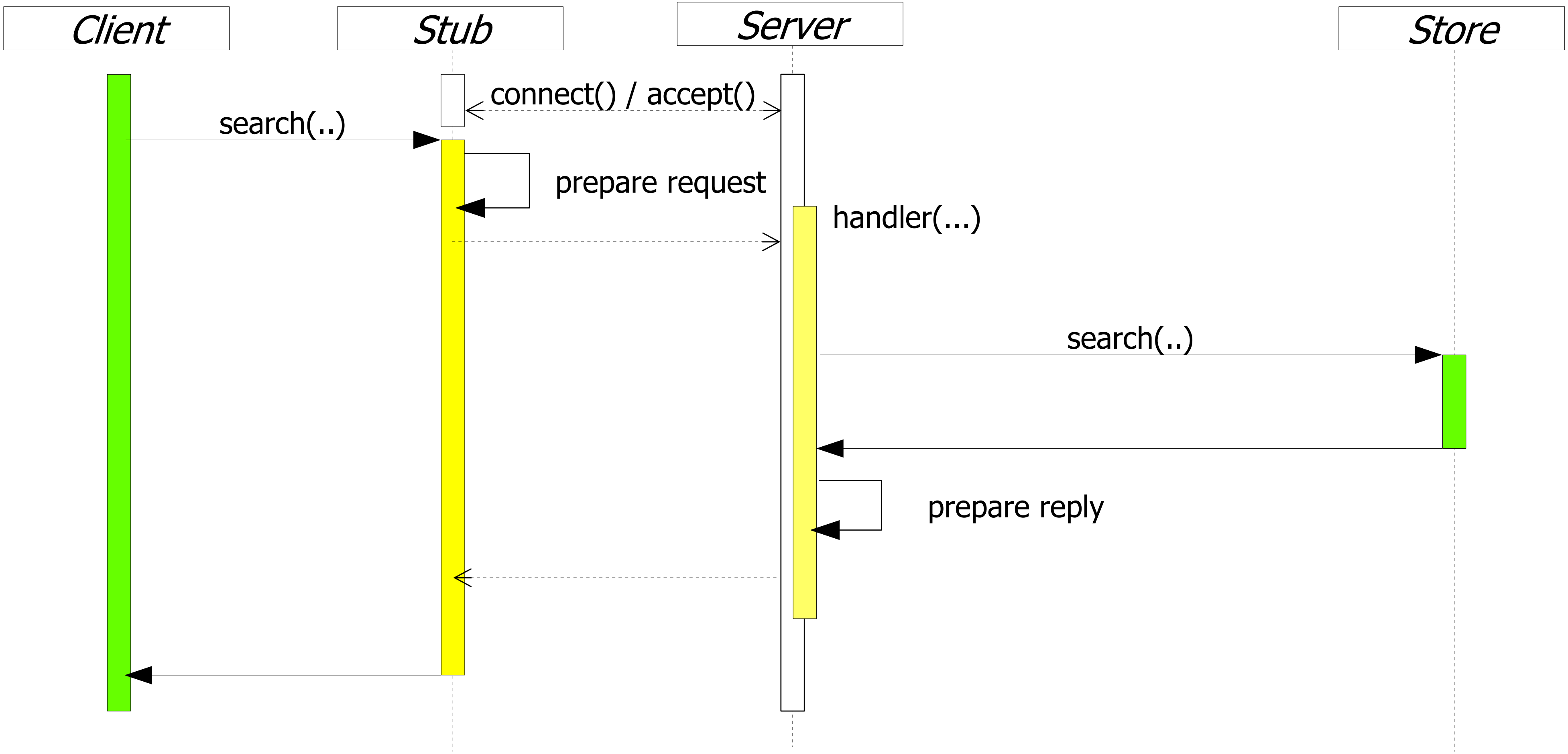
RPC / RMI

- Middleware that hides client/server interaction as a procedure (method) invocation
- Puts it all together:
  - Communication with sockets
  - Serialization
  - Threading strategies
- Building block for client/server systems

Client/server with sockets

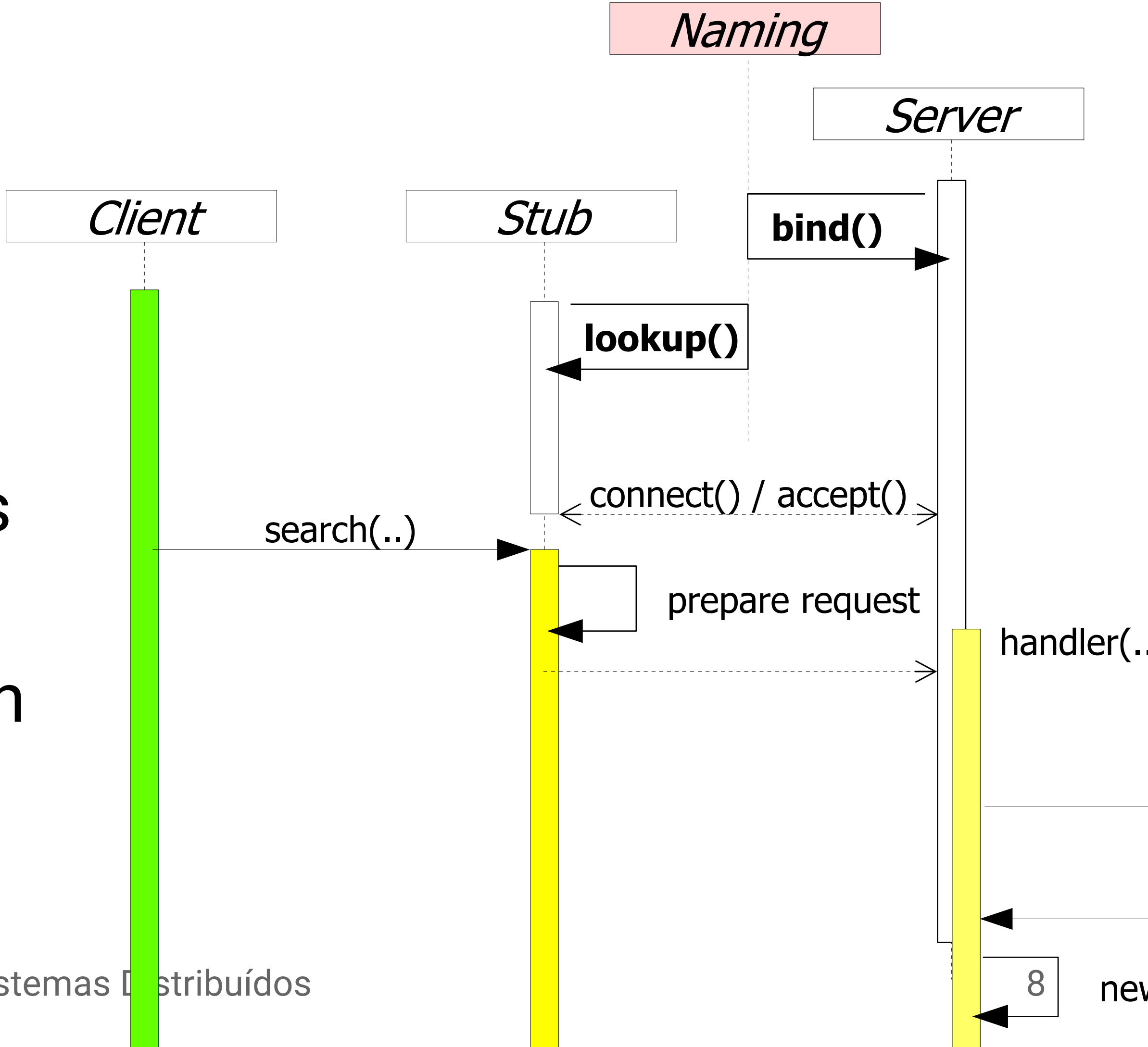


Client encapsulation with stubs



Naming service

- Provides location transparency
- Server registers reference in naming service
- Client looks up address using name
- Lookup encapsulated in client code



Code generation

- Stub and server code is mechanically determined by the interface protocol
- Can be generated from a description
- Code first:
  - Write code, generate stubs using reflection
- Protocol first:
  - Write abstract interface definition, generate stubs with a compiler
  - Uses an Interface Definition Language (IDL)

Parameter passing

- Parameters are copied from client to server
- In some cases, they can be copied back:
  - Pointer parameters in C
  - Objects in Java (not int, etc.)
- Parameters can be labeled as in, out or in-out

Error handling

- Connection problems / server not available cannot be hidden:
  - No corresponding situation in non-distributed system
- Possible semantics:
  - Exactly once: Ideal, hard in a real system
  - <u>At least once</u>: Try repeatedly until acknowledged
    - May block forever
    - Valid only for idempotent operations
  - <u>At most once</u>: Try once and throw exception

Summary

- Remote invocation middleware hides the complexity of distrbuted client/server programs
  - Access transparency
- Complete transparency is impossible and even undesirable
  - Parameter passing and performance over the network
  - Invocation semantics and exceptions

Example: gRPC

- Protocol first with Protobuf interface language
  - Multiple target languages, little effort in total transparency for any of them
  - Single-input, single-output parameters, described as Protobuf messages
  - Support for streaming input and output