

Proxy

CSCI 4448/5448: Object-Oriented Analysis & Design

Lecture 27

Before we start...

- Project 5 (and 6 & 7) assignment review
- Graduate research peer reviews
- Exam accommodations
- Piazza extra credit posts

Accommodations for Exams

- My intent, as we discussed several times in class prior to the exam, was that the exam was targeted at an hour, and opened for three to provide the time to anyone who needed it.
 - Note that even if the average time for taking the exam went to two hours, a three-hour window still provides a 1.5x accommodation.
- Regardless, with the exam now in process, I can only provide two solutions:
 - One, if you have not taken the exam, you can email me to request access to a six-hour version of the current exam for more time
 - Two, if you've taken the exam and felt your accommodation was not allowed for, you can email me for an alternative exam for a six-hour window, and you may take the best score of either midterm
- I sincerely apologize for any miscommunication on this issue. I fully support providing for student accommodations, and I believed that this had been adequately discussed and that I had so provided.

Extra Credit from Piazza Resource Posts

- If you're attending class live, you'll have opportunities to pick up 10 bonus points from in-class activities
- If you miss those bonus activities, there's another way to get those points
- Make a post in the class Piazza site sharing a useful OO resource:
 - <https://piazza.com/colorado/fall2021/csci44485448/home>
- The post must have:
 - A description of a useful OO-related resource
 - Why you think it's worth using
 - A link or other reference to the resource
 - Make sure your post is NOT anonymous, so I can get you your points
- The details
 - You will not get credit if you duplicate a resource someone has already posted
 - Your post must be published to the "resource_links" folder to get credit
 - Each valid post is worth 5 bonus points
 - **You can not earn more than 10 bonus points from these posts and points earned from in class activities – this does not include bonus points from projects!**
 - You may provide these posts up to end of the day on the last day of classes – Thursday December 9

Next Steps

- Project 4 code repo for Part 2 today
- Graduate research draft presentation is due today – next stage is to begin your peer reviews as discussed
- Online midterm from 10/16 – due on ~~10/20~~ 10/21 midnight
 - Email me for any accommodation concerns
- No new Piazza discussion topic this week, catch up on your comments for participation grade
- Bruce is out of office all day Friday 10/22 – Dwight will use the Friday class for a Q&A recitation on class concepts and code issues at the normal time, location, and Zoom link
- Coming soon...
 - Final GOF patterns from book
 - More on design
 - Advanced OO concepts
- Office hours and GitHub user IDs for class staff are on Piazza and Canvas
- If you'd like to see Dwight, Max, or Roshan at times other than their office hours, ping them on Piazza or email
- If you'd like to see Bruce outside of office hours, use my appointment app: <https://brucem.appointlet.com>

Acknowledgement & Materials Copyright

- I'd like to start by acknowledging Dr. Ken Anderson
- Ken is a Professor and the Chair of the Department of Computer Science
- Ken taught OOAD on several occasions, and has graciously allowed me to use his copyrighted material for this instance of the class
- Although I will modify the materials to update and personalize this class, the original materials this class is based on are all copyrighted © Kenneth M. Anderson; the materials are used with his consent; and this use in no way challenges his copyright

Head First Design Patterns

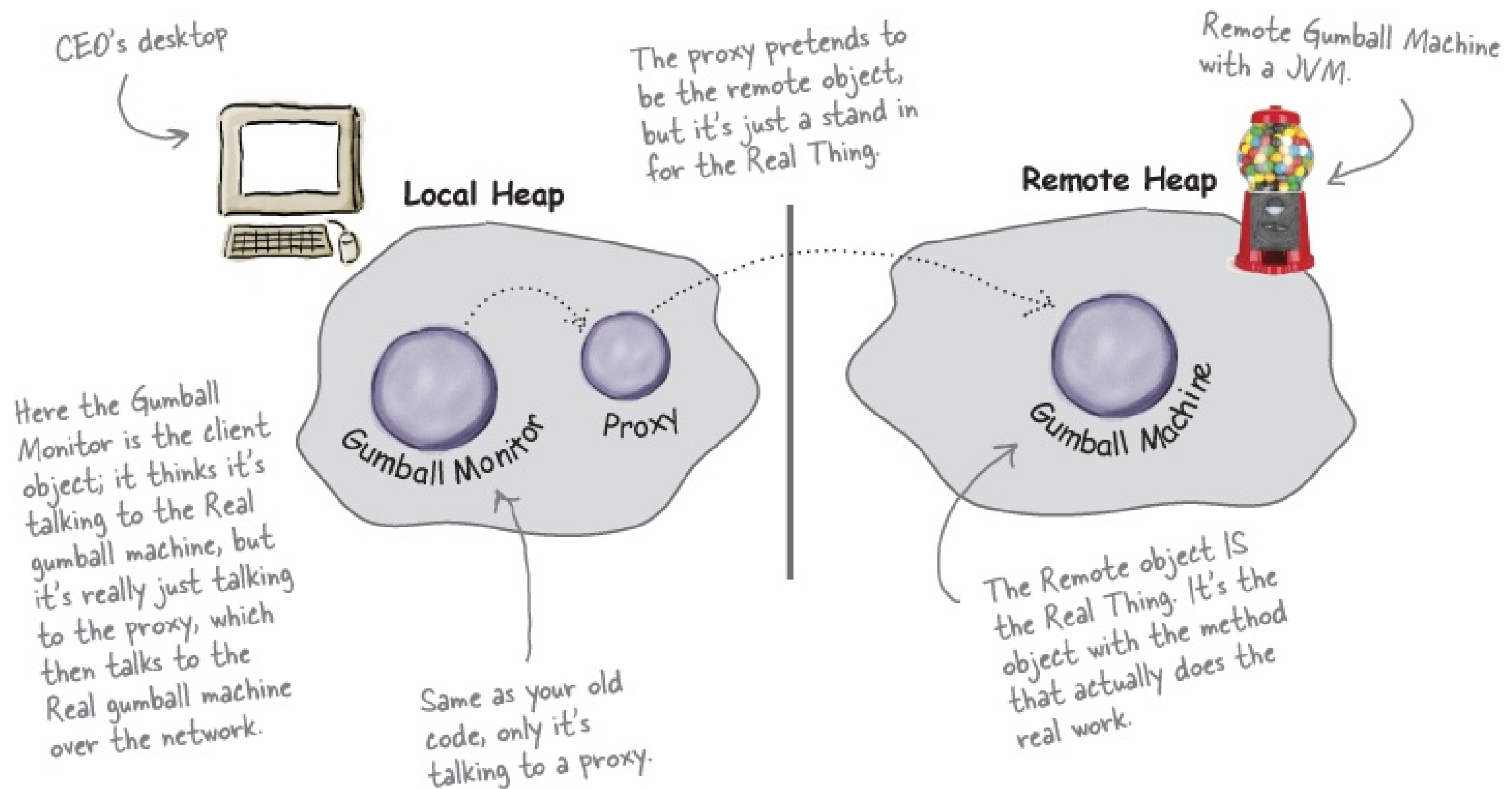
- This material is from Chapter 11 of the Head First book, and it continues using the Gumball Machines from the Chapter 10 State examples

Local monitoring approach

- The initial request is to monitor the state of Gumball Machines (for count and current state)
- The initial code pass creates
 - An updated GumballMachine class that knows its location, its gumball count, and the current state
 - Public methods are provided for those elements
 - A new GumballMonitor class that is given a reference to a machine, and is then able to report() on the values of location, count, and state for that machine instance
 - A test frame that creates both a GumballMachine and a GumballMonitor object, and has the monitor call its report() method

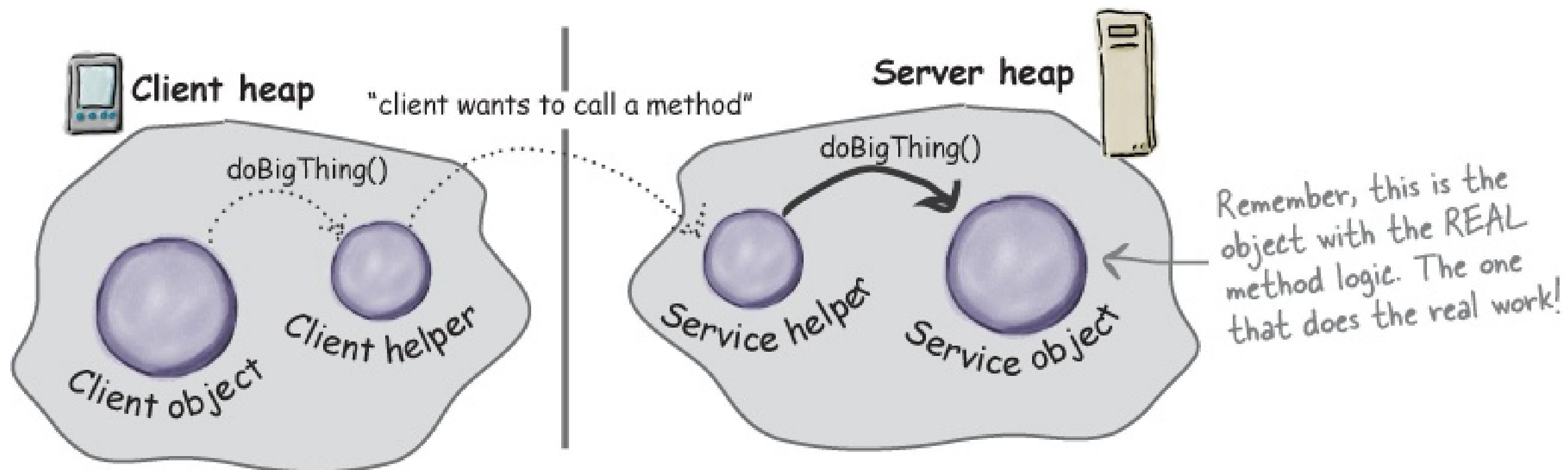
Extension to “Remote” Proxy

- In this case, the GumballMachine is a remote object, living in the heap of a different JVM somewhere else
- To talk to that remote object, we want to interact with a proxy



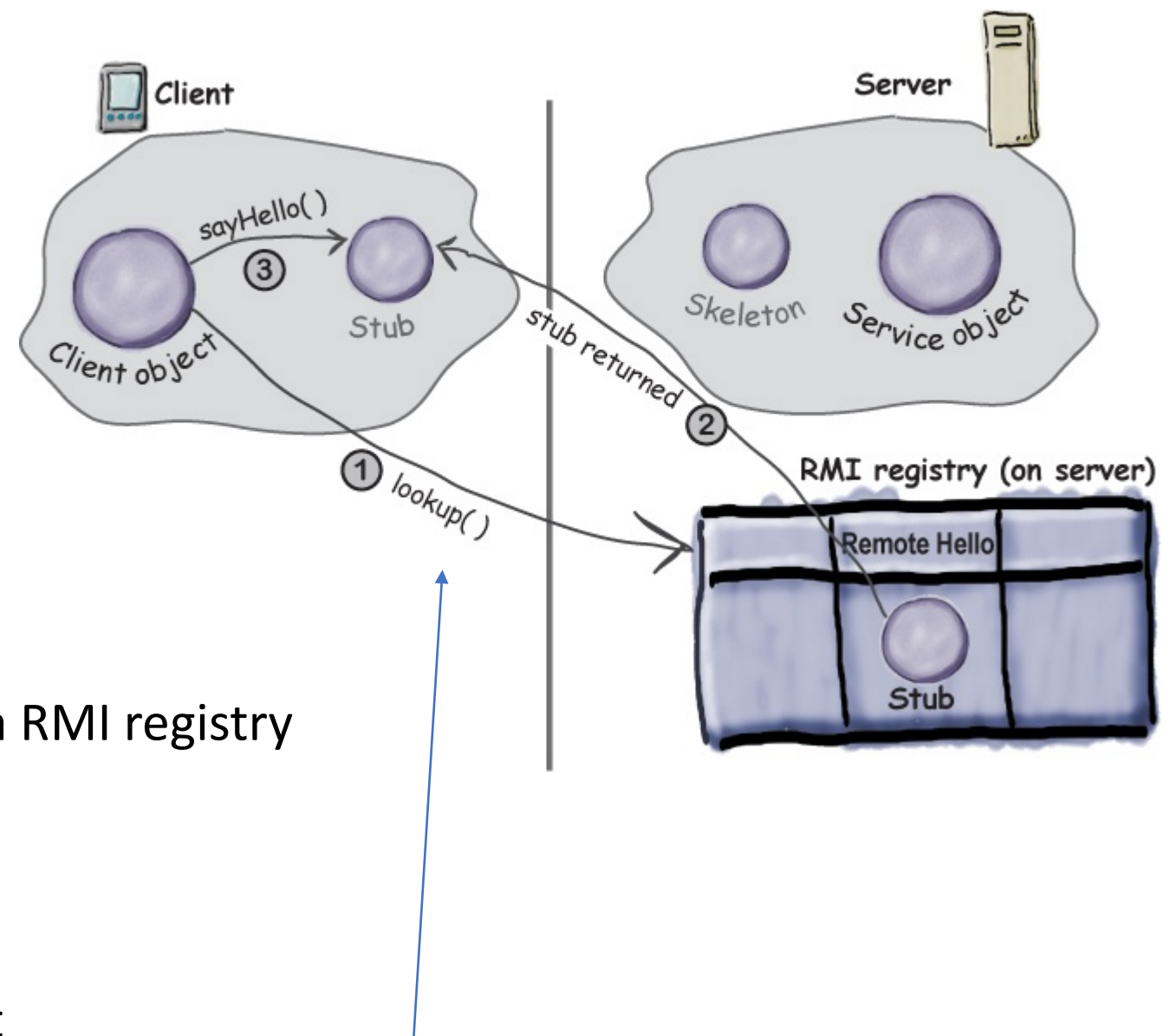
Java RMI – Remote Method Invocation

- RMI provides a client helper and a service helper object, connected via a Socket connection to allow a client object to call methods on a remote service object in a remote memory space

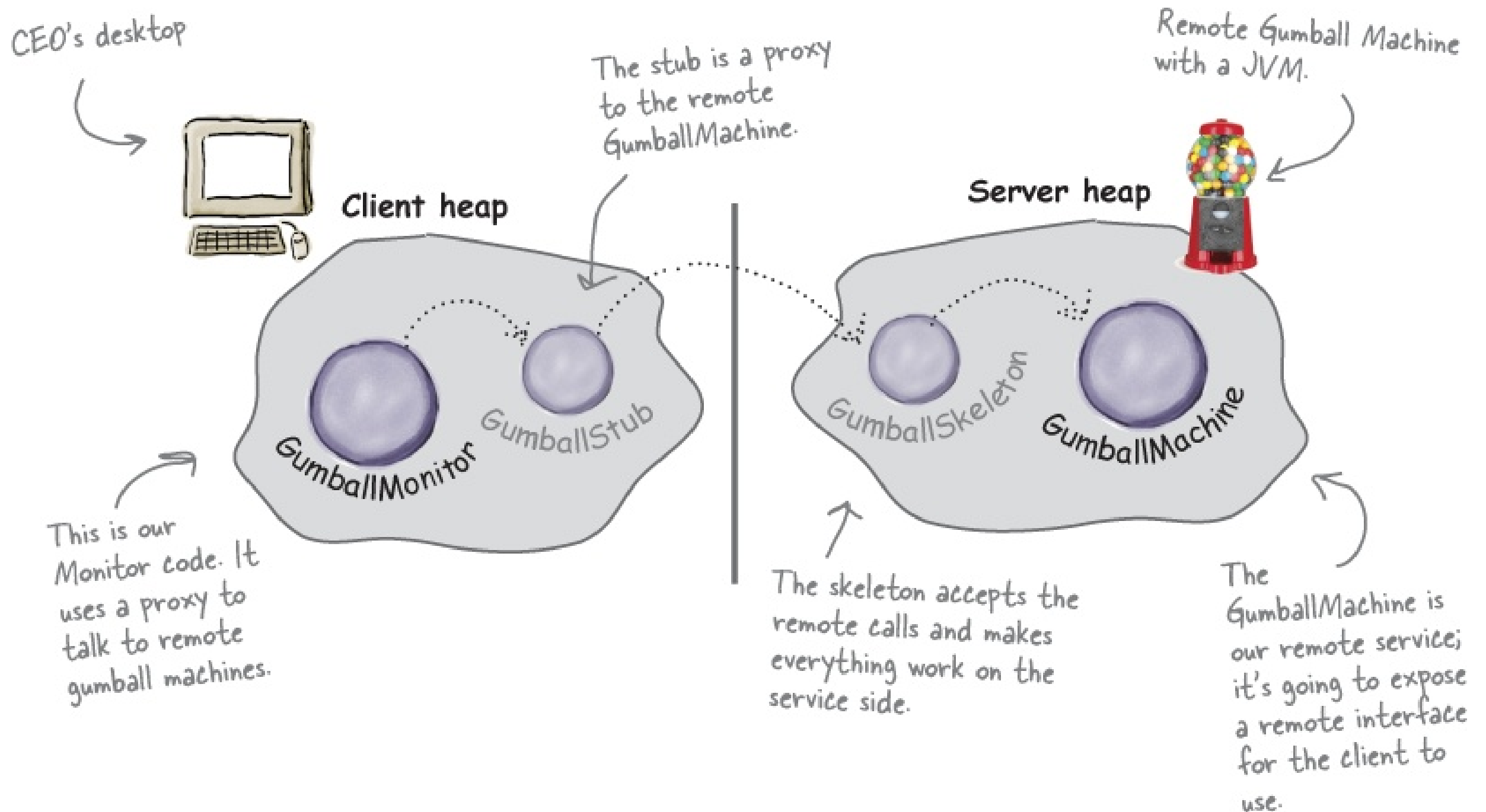


Java RMI Steps

- Make remote interface
- Implement the remote server
 - Create and export a remote object
 - Extend `UnicastRemoteObject`
 - Register the remote object with a Java RMI registry
- Run `rmiregistry` on the server's host
- Start remote server
- Implement the client
 - Obtain stub for registry on server host
 - Look up the remote object's stub by name in the registry
 - Invoke remote method on remote object via the stub
- Network communication is subject to failure and exceptions
- Remote methods should throw `RemoteException`
- Data being returned or passed should be primitives or `Serializable` objects
- <https://docs.oracle.com/javase/8/docs/technotes/guides/rmi/hello/hello-world.html>



After RMI



Careful...

Don't forget to import java.rmi.*

```
import java.rmi.*;
```

This is the remote interface.

```
public interface GumballMachineRemote extends Remote {  
    public int getCount() throws RemoteException;  
    public String getLocation() throws RemoteException;  
    public State getState() throws RemoteException;  
}
```

All return types need to be primitive or Serializable...

Here are the methods were going to support. Each one throws RemoteException.

- We want to pass state from the remote server, but there are two issues. First, State must be Serializable if we are to pass it from a remote method, so...

Serializable is in the java.io package.

```
import java.io.*;
```

```
public interface State extends Serializable {  
    public void insertQuarter();  
    public void ejectQuarter();  
    public void turnCrank();  
    public void dispense();  
}
```

Then we just extend the Serializable interface (which has no methods in it). And now State in all the subclasses can be transferred over the network.

One more issue...

- State objects have a reference to a GumballMachine so it can call that machine's methods and change it's state
- We don't want the entire gumball machine serialized...

```
public class NoQuarterState implements State {  
    private static final long serialVersionUID = 2L;  
    transient GumballMachine gumballMachine;  
    // all other methods here  
}
```

In each implementation of State, we add the `serialVersionUID` and the `transient` keyword to the `GumballMachine` instance variable. The `transient` keyword tells the JVM not to serialize this field. Note that this can be slightly dangerous if you try to access this field once the object's been serialized and transferred.

A remoteable GumballMachine class...

First, we need to import the rmi packages.

```
import java.rmi.*;  
import java.rmi.server.*;
```

GumballMachine is going to subclass the UnicastRemoteObject; this gives it the ability to act as a remote service.

GumballMachine also needs to implement the remote interface...

```
public class GumballMachine  
    extends UnicastRemoteObject implements GumballMachineRemote  
{  
    private static final long serialVersionUID = 2L;  
    // other instance variables here  
  
    public GumballMachine(String location, int numberGumballs) throws RemoteException {  
        // code here  
    }  
  
    public int getCount() {  
        return count;  
    }  
  
    public State getState() {  
        return state;  
    }  
  
    public String getLocation() {  
        return location;  
    }  
    // other methods here  
}
```

...and the constructor needs to throw a remote exception, because the superclass does.

That's it! Nothing changes here at all!

Registering the remote service with RMI

- When the remote GumballMachine starts, it has to register with the RMI Registry

```
public class GumballMachineTestDrive {  
  
    public static void main(String[] args) {  
        GumballMachineRemote gumballMachine = null;  
        int count;  
  
        if (args.length < 2) {  
            System.out.println("GumballMachine <name> <inventory>");  
            System.exit(1);  
        }  
  
        try {  
            count = Integer.parseInt(args[1]);  
  
            gumballMachine = new GumballMachine(args[0], count);  
            Naming.rebind("//" + args[0] + "/gumballmachine", gumballMachine);  
        } catch (Exception e) {  
            e.printStackTrace();  
        }  
    }  
}
```

First we need to add a try/catch block around the gumball instantiation because our constructor can now throw exceptions.

We also add the call to Naming.rebind, which publishes the GumballMachine stub under the name gumballmachine.

Minor client-side changes for Monitor

```
import java.rmi.*;

public class GumballMonitor {
    GumballMachineRemote machine;

    public GumballMonitor(GumballMachineRemote machine) {
        this.machine = machine;
    }

    public void report() {
        try {
            System.out.println("Gumball Machine: " + machine.getLocation());
            System.out.println("Current inventory: " + machine.getCount() + " gumballs");
            System.out.println("Current state: " + machine.getState());
        } catch (RemoteException e) {
            e.printStackTrace();
        }
    }
}
```

← We need to import the RMI package because we are using the RemoteException class below...

← Now we're going to rely on the remote interface rather than the concrete GumballMachine class.

← We also need to catch any remote exceptions that might happen as we try to invoke methods that are ultimately happening over the network.

Now we can connect to several proxies...

Here's the monitor test drive. The CEO is going to run this!

```
import java.rmi.*;
```

```
public class GumballMonitorTestDrive {
```

```
    public static void main(String[] args) {
```

```
        String[] location = {"rmi://santafe.mightygumball.com/gumballmachine",  
                             "rmi://boulder.mightygumball.com/gumballmachine",  
                             "rmi://seattle.mightygumball.com/gumballmachine"};
```

```
        GumballMonitor[] monitor = new GumballMonitor[location.length];
```

```
        for (int i=0; i < location.length; i++) {
```

```
            try {
```

```
                GumballMachineRemote machine =
```

```
                    (GumballMachineRemote) Naming.lookup(location[i]);
```

```
                monitor[i] = new GumballMonitor(machine);
```

```
                System.out.println(monitor[i]);
```

```
            } catch (Exception e) {
```

```
                e.printStackTrace();
```

```
            }
```

```
        }
```

```
        for (int i=0; i < monitor.length; i++) {
```

```
            monitor[i].report();
```

```
        }
```

```
    }
```

```
}
```

Here's all the locations
we're going to monitor.

We create an array
of locations, one for
each machine.

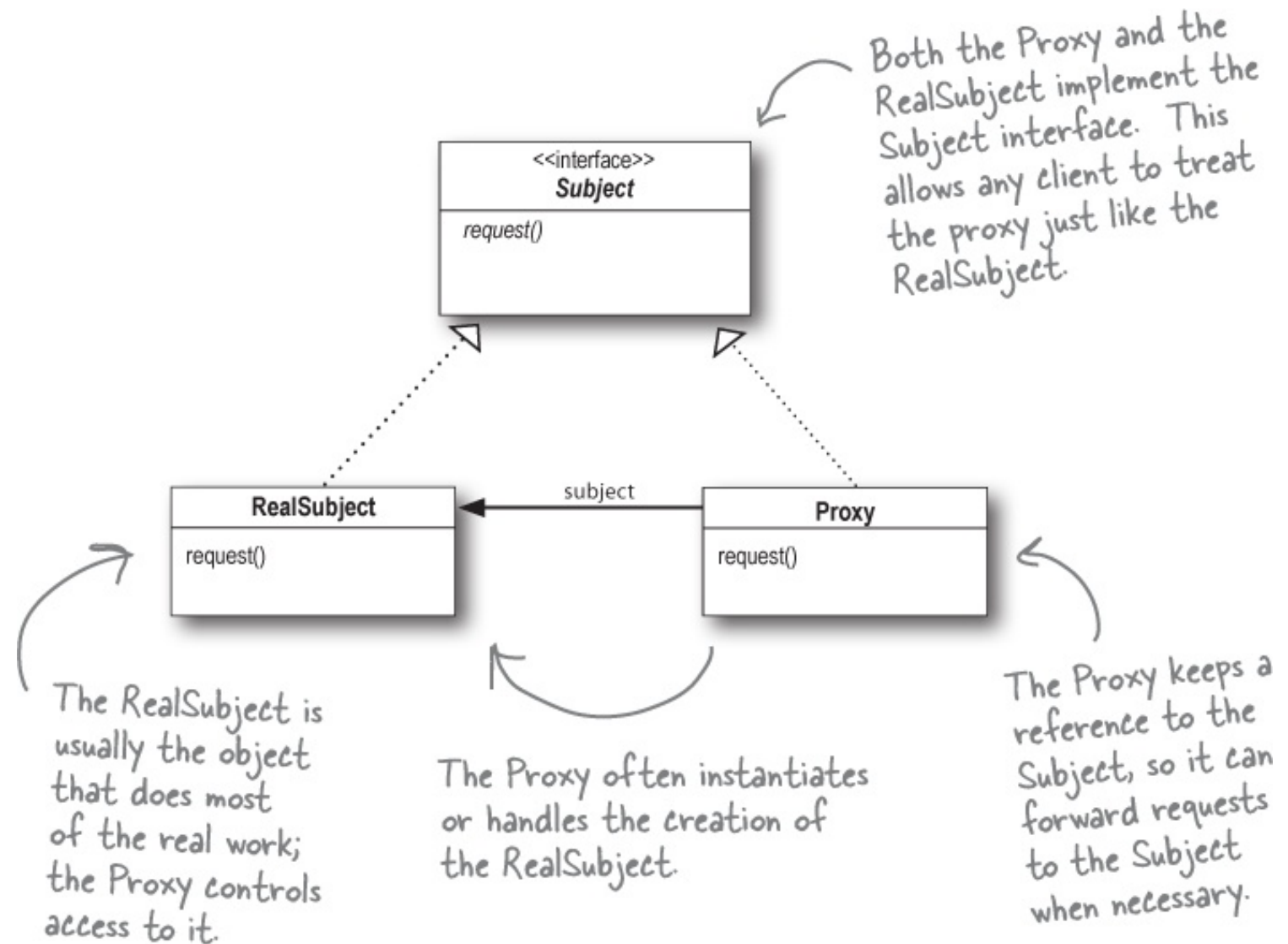
We also create an
array of monitors.

Now we need to get a proxy
to each remote machine.

Then we iterate through each
machine and print out its report.

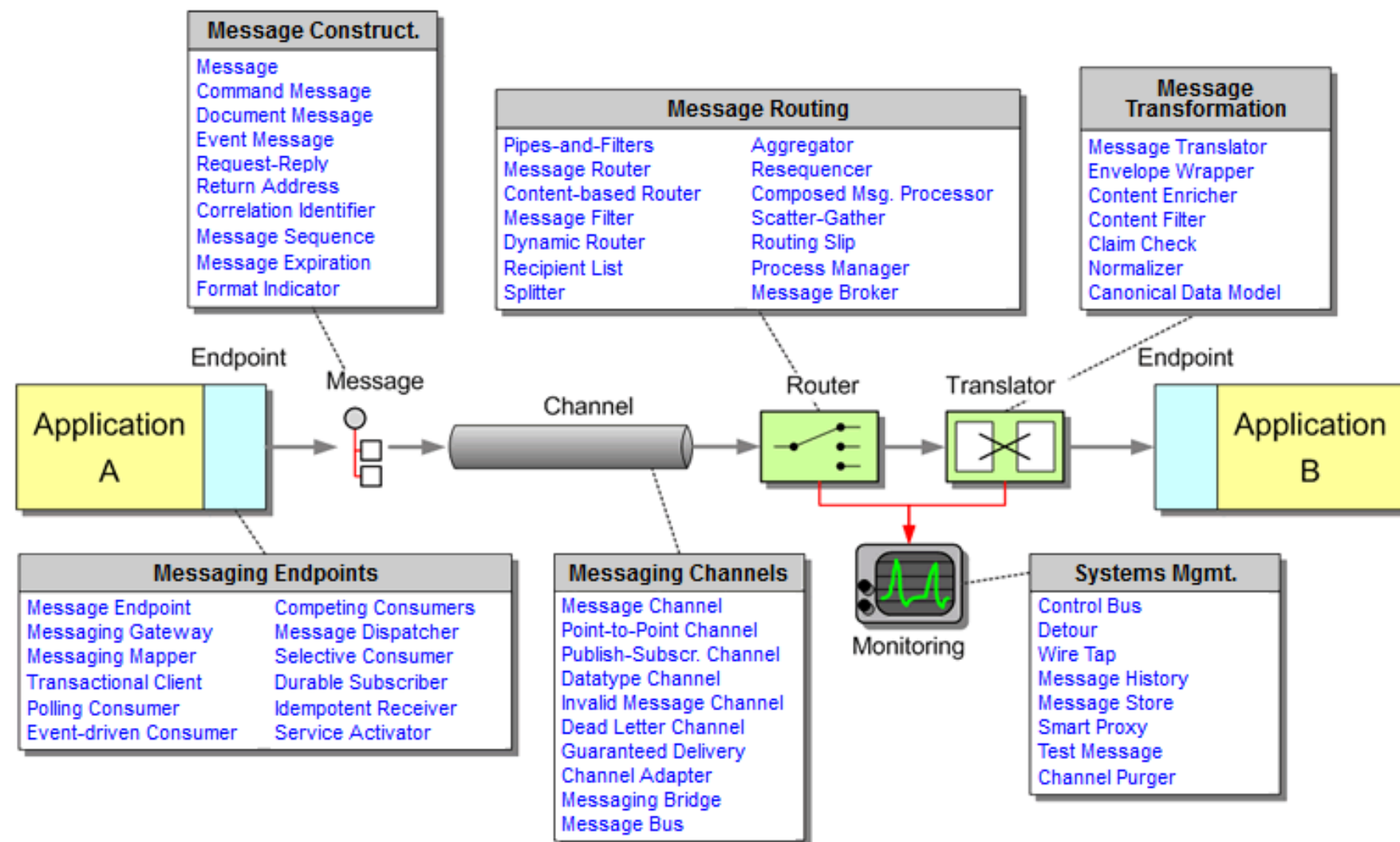
The Proxy Pattern

- The Proxy Pattern provides a surrogate or placeholder for another object to control access to it.
- Use the Proxy Pattern to create a representative object that controls access to another object
 - which may be remote (remote proxy) – what we just did
 - expensive to create (virtual proxy)
 - or in need of securing (protection proxy)



Alternatives to RMI – Messaging Patterns

- Messaging – publish/subscribe, point to point, request/response
- The Enterprise Integration Patterns book has defined 65 messaging patterns
 - <http://www.enterpriseintegrationpatterns.com/patterns/messaging/index.html>
- Typical Message Queuing Tools
 - ZeroMQ
 - RabbitMQ
 - AWS SQS

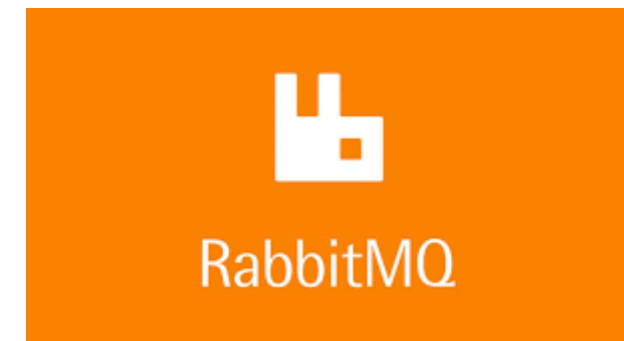


ZeroMQ

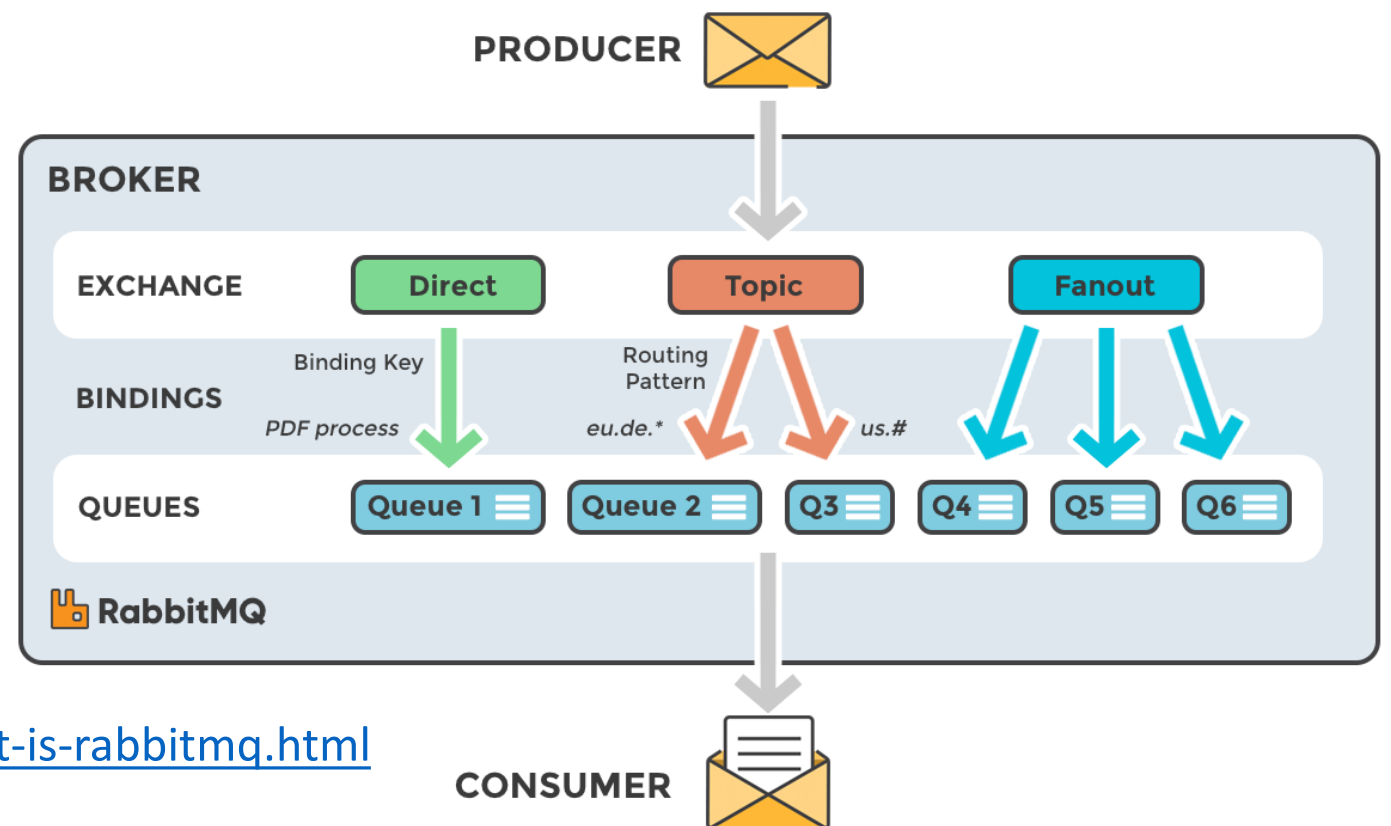


- 0MQ was initially developed in 2007, and is now an open-source project [5]
- Provides **sockets** that carry atomic messages across various transports (in-process, inter-process, TCP, and multicast)
- Designed to be an ultra-simple API (Application Programming Interface) based on BSD sockets.
- Implements real messaging patterns like topic pub-sub, fan-out, and request-response.
- Available for most programming languages, operating systems, and hardware. It provides a single consistent model for all language APIs; It is simple to learn and use, with a learning curve of roughly one hour
- Designed as a library linked with applications - **no brokers** to start and manage, fewer moving pieces - less to break and go wrong - low CPU footprint
- Licensed as LGPL code
- <https://zeromq.org/>

RabbitMQ



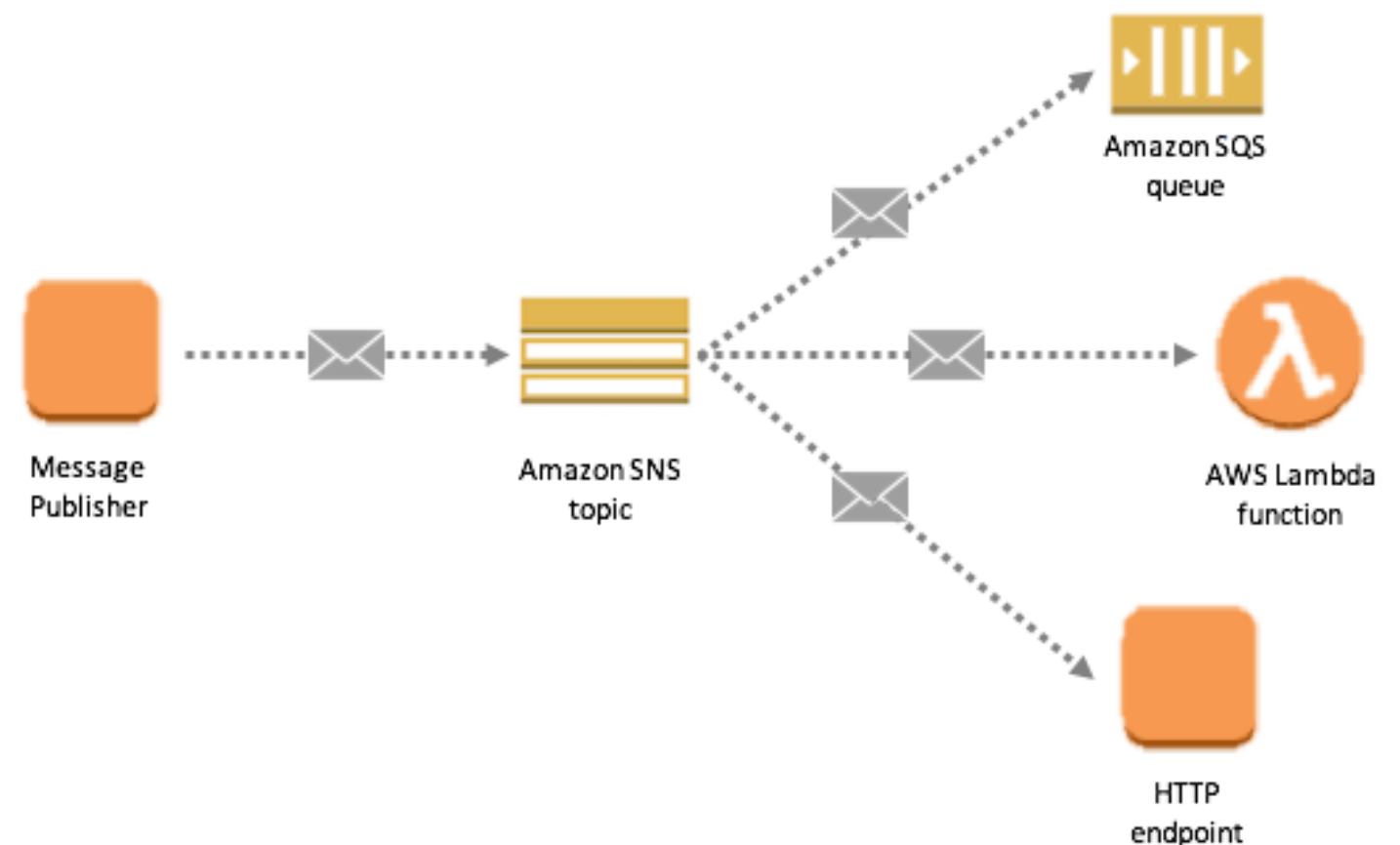
- “Most Widely Deployed Open Source Message Broker”
- RabbitMQ is a **message broker**, containing and managing queues for messages, producers, and consumers
- Base RabbitMQ uses asynchronous messaging with AMQP 0.9.1, but it supports multiple alternative protocols including STOMP, MQTT, AMQP 1.0, and HTTP
- Support for most programming languages
- Supports work queues, pub/sub, request/reply, and other messaging architectures
- Supports TLS & LDAP for authentication and authorization
- Has a management and monitoring infrastructure – HTTP-API
- Reference <https://www.rabbitmq.com/> , <https://www.cloudamqp.com/blog/2015-05-18-part1-rabbitmq-for-beginners-what-is-rabbitmq.html>



Cloud Based Message Queues – AWS SQS

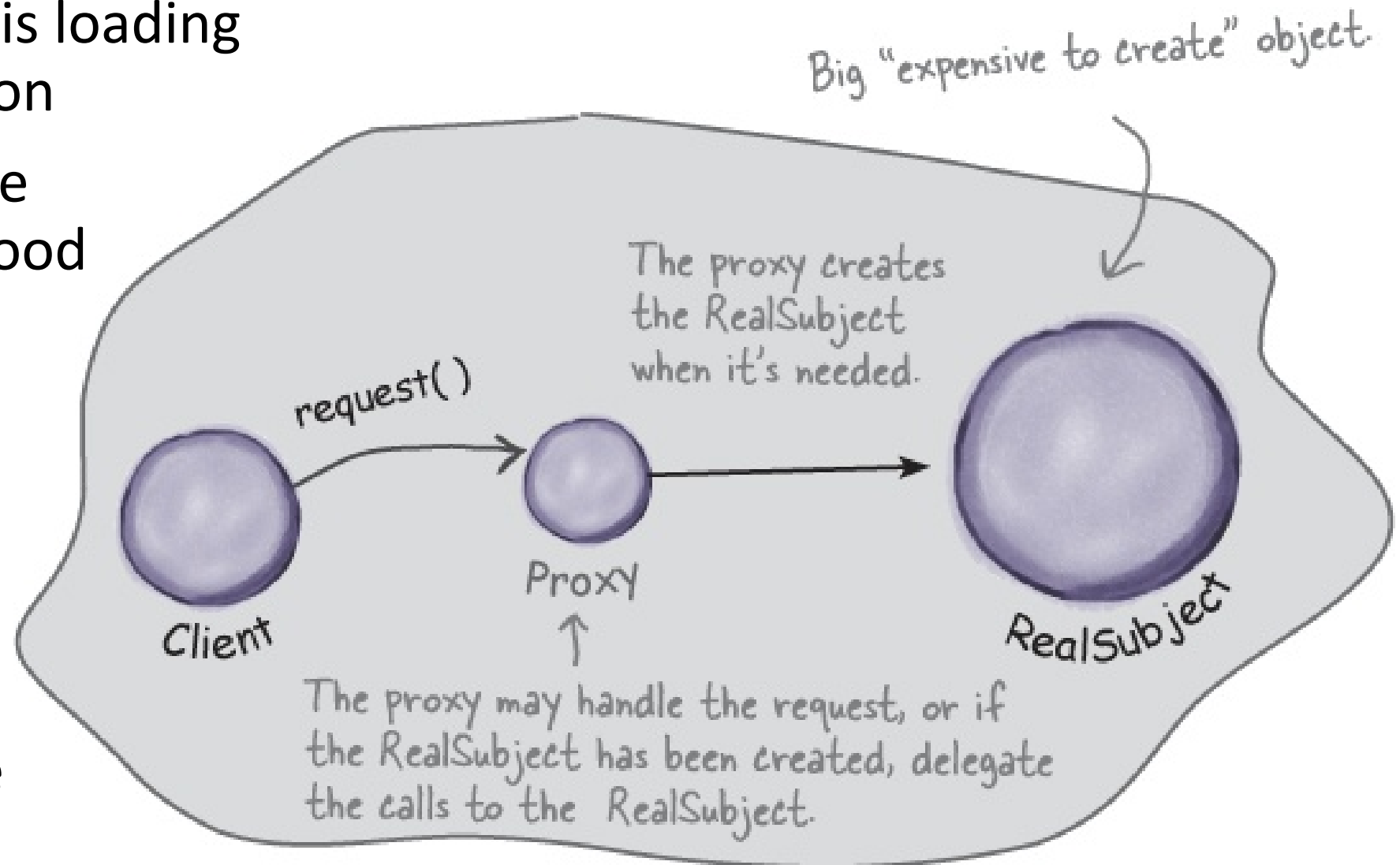
- Fully managed cloud-based message queuing service
- Two types of message queues
 - Standard queues offer maximum throughput, best-effort ordering, and at-least-once delivery
 - SQS FIFO queues are designed to guarantee that messages are processed exactly once, in the exact order that they are sent
- Easily administrated, reliable
- Easy to integrate with IoT tools, AWS Lambda Serverless processes and other AWS tools
- Can integrate with server-side encryption
- Scale easily
- Reference

<https://aws.amazon.com/sqs/>



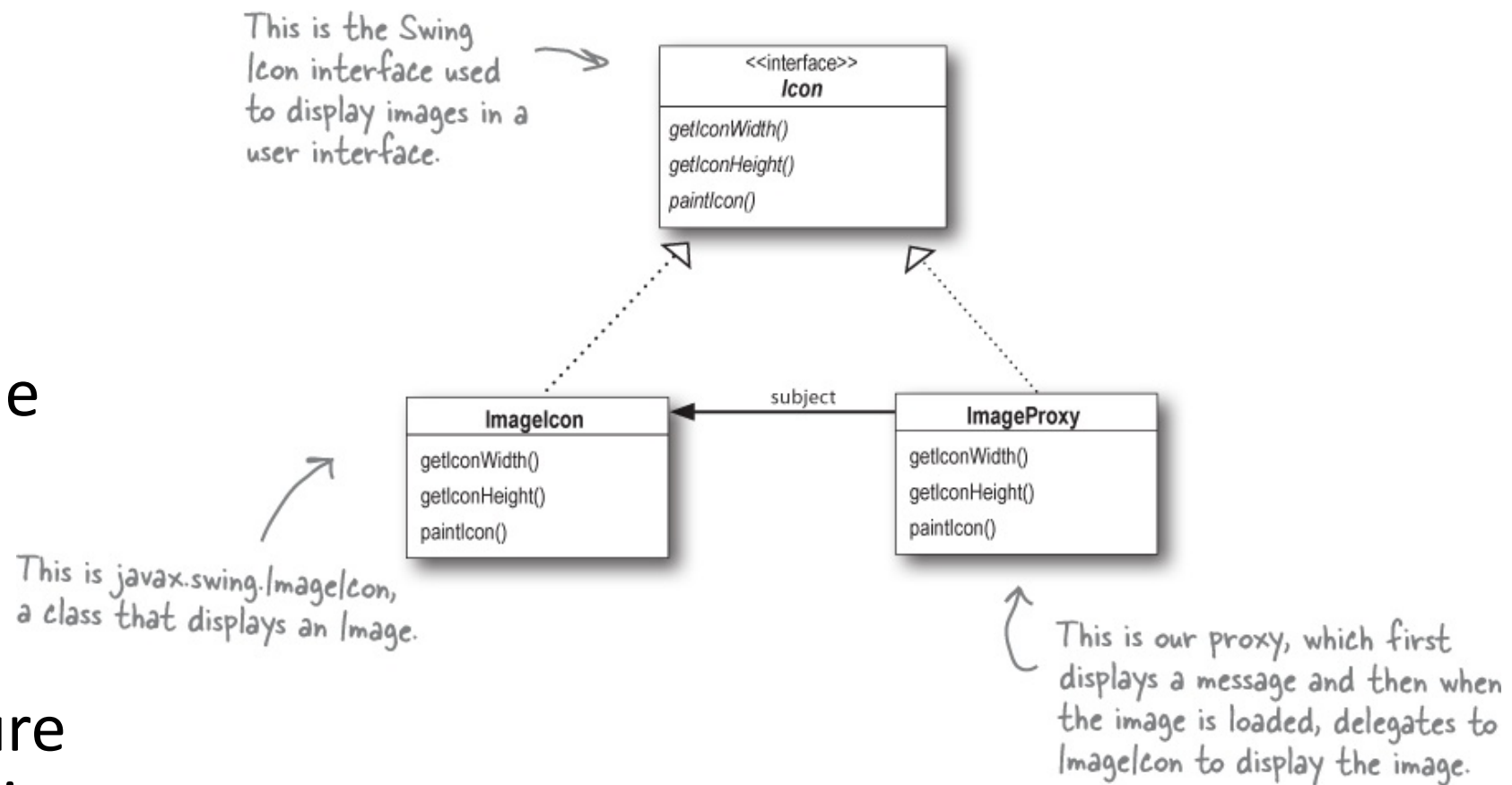
Virtual Proxy

- Virtual Proxy – why? Creating the RealSubject is “expensive”; if the Proxy can handle the issue, it will
- Example in book is loading a music album icon
- If we already have the icon, we’re good
- We only do the icon request if we need to
- And the proxy provides a temporary icon until the real one loads



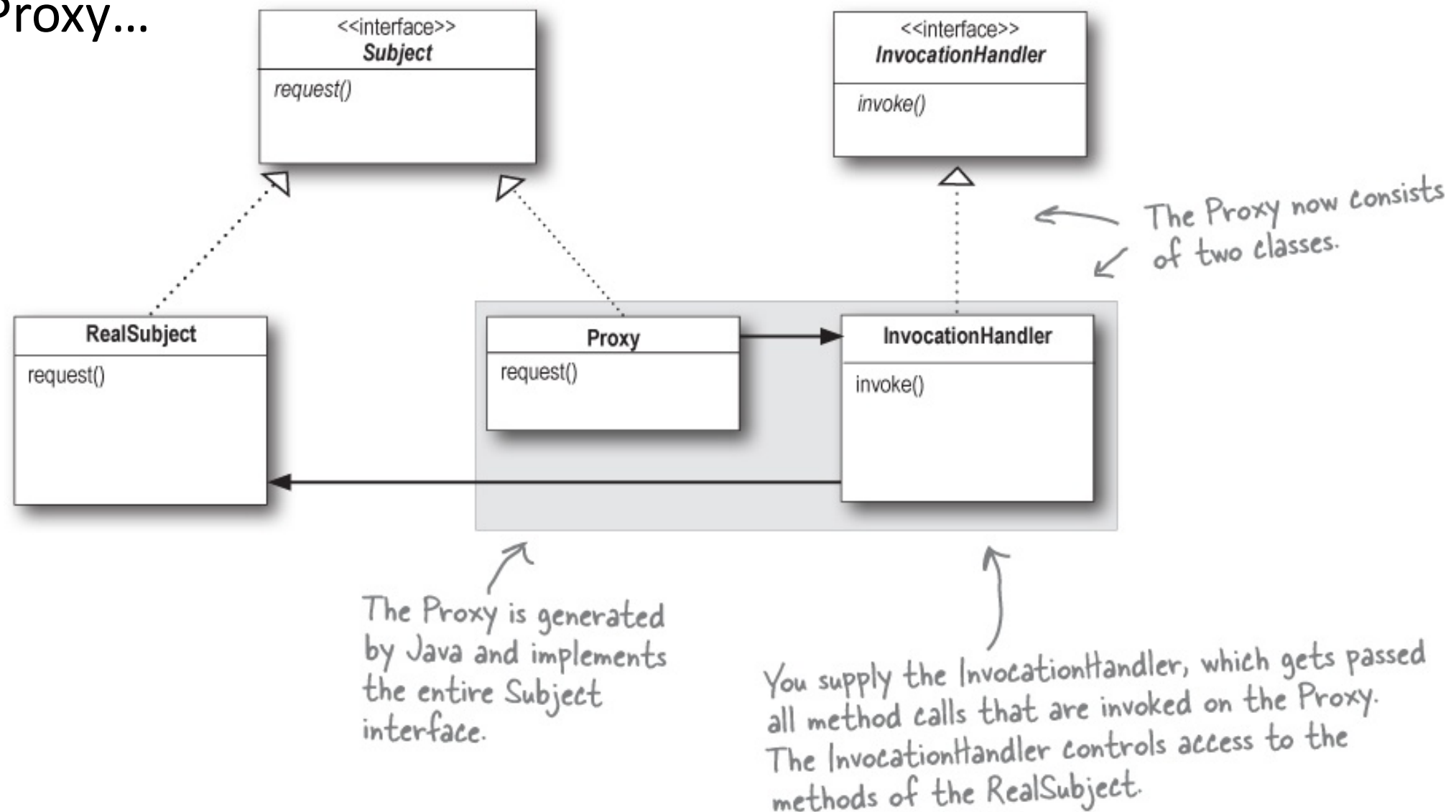
Looks a bit like Decorator...

- They do look a bit alike...
- The difference is, Decorator is extending behavior of a class, while Proxy is controlling access to the class
- You can combine Proxy with Factory to make sure clients use the Proxy object instead of instantiating the RealSubject you're controlling access to...
- Proxy also looks a bit like Adapter, since it sits in front of another object, but Proxy implements the exact same interface, Adapter changes the interface of objects it adapts...



Protection Proxy

- If we use the RMI approach, Java is creating the Proxy class for you, so you need a way to tell Proxy what to do.
- For this, we create an InvocationHandler that responds to any calls on the Proxy...



Creating the Protection Proxy

- The example is for a service that sets attributes on something “owned” by an individual
 - But there are some methods the individual shouldn’t be allowed to use
 - And there are some methods others accessing that individual shouldn’t be allowed to use
- Create two InvocationHandlers – one for invocations by the individual owner, one for invocations by others

Other Proxy Types

- Firewall Proxy – controls access to a set of network resources, protecting subject from bad clients
- Smart Reference Proxy – provides additional actions when a subject is referenced, such as maintaining a reference count
- Caching Proxy – a version of Virtual Proxy to maintain temporary storage that can be referenced rather than asking the subject to do an expensive task
- Synchronization Proxy – provide safe access to a subject from multiple threads
- Complexity Hiding (or Façade) Proxy – Unlike Façade, this proxy provides both an alternative interface and access control
- Copy-on-Write Proxy – Controls copying an object by deferring copy until required by a client (another Virtual Proxy variant)

Python Proxy?

A Smart Reference Proxy implementation...

Subjects...

```
from abc import ABC, abstractmethod
```

```
class Subject(ABC):
```

```
    # The Subject interface declares common operations for both RealSubject and  
    # the Proxy. As long as the client works with RealSubject using this  
    # interface, you'll be able to pass it a proxy instead of a real subject.
```

```
    @abstractmethod
```

```
    def request(self) -> None:  
        pass
```

```
class RealSubject(Subject):
```

```
    # The RealSubject contains some core business logic. Usually, RealSubjects are  
    # capable of doing some useful work which may also be very slow or sensitive -  
    # e.g. correcting input data. A Proxy can solve these issues without any  
    # changes to the RealSubject's code.
```

```
    def request(self) -> None:
```

```
        print("RealSubject: Handling request.")
```

Python Proxy?

Proxy and Client...

```
class Proxy(Subject):
    # The Proxy has an interface identical to the RealSubject.

    def __init__(self, real_subject: RealSubject) -> None:
        self._real_subject = real_subject

    def request(self) -> None:
        # The most common applications of the Proxy pattern are lazy loading,
        # caching, controlling the access, logging, etc.

        if self.check_access():
            self._real_subject.request()
            self.log_access()

    def check_access(self) -> bool:
        print("Proxy: Checking access prior to firing a real request.")
        return True

    def log_access(self) -> None:
        print("Proxy: Logging the time of request.", end="")

def client_code(subject: Subject) -> None:
    # The client code is supposed to work with all objects (both subjects and
    # proxies) via the Subject interface in order to support both real subjects
    # and proxies. In real life, however, clients mostly work with their real
    # subjects directly. In this case, to implement the pattern more easily, you
    # can extend your proxy from the real subject's class.

    subject.request()
```

Python Proxy!

Main and Runtime

Example from:

<https://refactoring.guru/design-patterns/proxy/python/example>

```
if __name__ == "__main__":  
    print("Client: Executing the client code with a real subject:")  
    real_subject = RealSubject()  
    client_code(real_subject)  
  
    print("")  
  
    print("Client: Executing the same client code with a proxy:")  
    proxy = Proxy(real_subject)  
    client_code(proxy)
```

Output:

Client: Executing the client code with a real subject:
RealSubject: Handling request.

Client: Executing the same client code with a proxy:
Proxy: Checking access prior to firing a real request.
RealSubject: Handling request.
Proxy: Logging the time of request.

Key Points

- The Proxy Pattern provides a representative for another object in order to control the client's access to it. There are a number of ways it can manage that access.
- A Remote Proxy manages interaction between a client and a remote object.
- A Virtual Proxy controls access to an object that is expensive to instantiate.
- A Protection Proxy controls access to the methods of an object based on the caller.
- Many other variants of the Proxy Pattern exist including caching proxies, synchronization proxies, firewall proxies, copy-on-write proxies, and so on.
- Proxy is structurally similar to Decorator, but the two differ in their purpose.
- The Decorator Pattern adds behavior to an object, while a Proxy controls access.
- Java's built-in support for Proxy can build a dynamic proxy class on demand and dispatch all calls on it to a handler of your choosing.
- Like any wrapper, proxies will increase the number of classes and objects in your designs.