

Command

CSCI 4448/5448: Object-Oriented Analysis & Design

Lecture 18

Acknowledgement & Materials Copyright

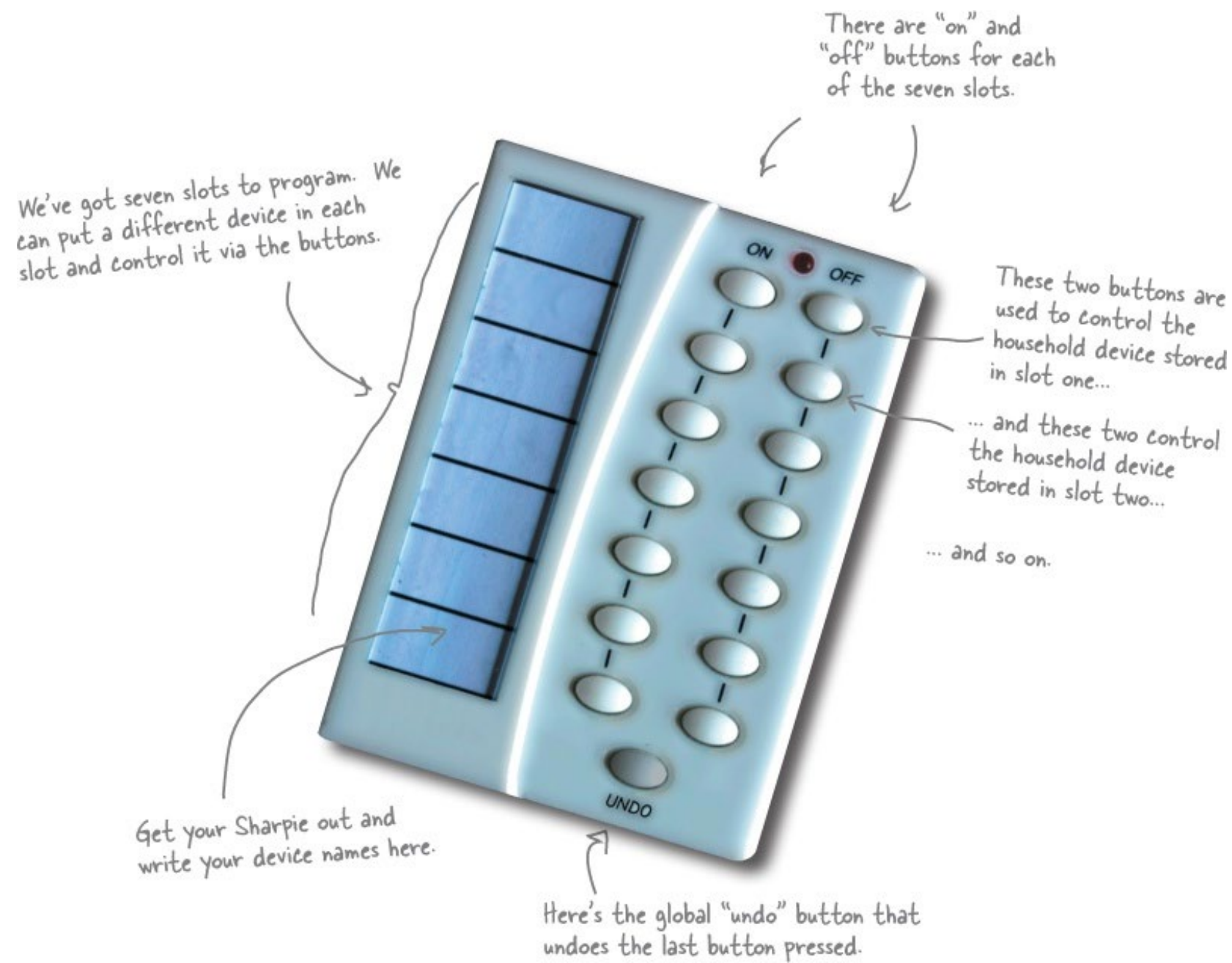
- I'd like to start by acknowledging Dr. Ken Anderson
- Ken is a Professor and the Chair of the Department of Computer Science
- Ken taught OOAD on several occasions, and has graciously allowed me to use his copyrighted material for this instance of the class
- Although I will modify the materials to 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

Command Pattern

- Today's discussion on Command is largely from Chapter 6 of the Head First Design Patterns book
 - Read through it when you can for more details...

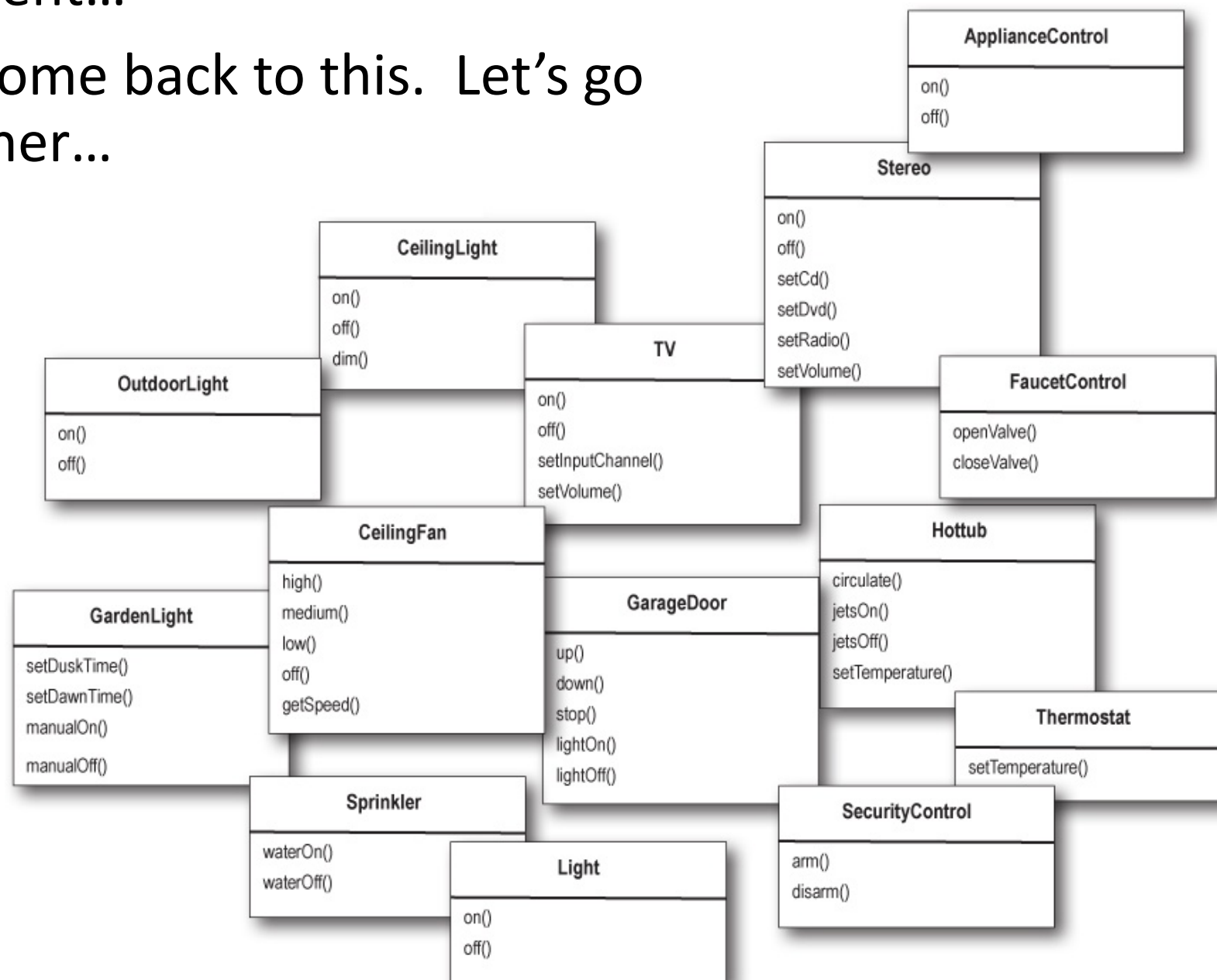
The Problem – A Remote Control

- The book presents a remote control with 7 programmable slots, each with an on and off button, plus a global undo button



The Other Problem – Many Different Devices

- The book presents a set of classes for the different commands each device controlled by the remote can respond to, and they're not consistent...
- We'll come back to this. Let's go to a diner...



The Diner

- Customer -> Order -> Waitress -> Order Slip
- Waitress -> Order Slip -> Order Counter
- Cook -> gets Order Slip -> makes Order



The Command Pattern is Here!

- Customer -> Order -> Waitress -> Order Slip
- Waitress -> Order Slip -> Order Counter
- Cook -> gets Order Slip -> makes Order
- Customer is a **Client**, needs this action, an Order, to be executed
- Order Slip – Encapsulates a Request – a **Request** object
 - It has one method – OrderUp() – containing the actions needed to prepare the Order
 - In fact, the Waitress does not need to know what's in the Order or who prepares the Order, they just have to deliver, or invoke, the request
- The Waitress is the **Invoker**
 - The Cook doesn't really care who asked for the Order, they just need to see an Order has arrived and act on it per the Order Slip
- The Cook is the **Receiver** – they do the action outlined in the request

Command Pattern

- Start at Client
- **Client** Object – CreateCommandObject() - a Request
 - Command_Object knows
 - Who is the target Receiver
 - What actions do I need the Receiver to execute? (Receiver methods)
- **Command_Object** – defines Execute()
 - Command.Execute() will be called to invoke specified Receiver actions
- Client Object - Invoker.SetCommand(Command_Object)
 - Client tells Invoker I have a Command_Object for you
- **Invoker** – Command_Object.Execute()
 - The Invoker calls Command_Object.Execute()...
 - What the timing is of executing that command may vary
- **Receiver** – executes the Receiver actions in the Command_Object when the Invoker says to

Implementing a Command Interface and a Command

```
public interface Command {  
    public void execute();  
}
```

```
public class LightOnCommand implements Command {  
    Light light; //reference to the command Receiver  
  
    // constructor – sets the specific light to command  
    public LightOnCommand(Light light) {  
        this.light = light;  
    }  
  
    // override for execute with specifically what action the light needs to do  
    public void execute() {  
        light.on();  
    }  
}
```

Using the Command Object

- If we had a remote control with one button, we could have it hold a command and control a device. The remote is the Invoker:

```
public class SimpleRemoteControl {  
    Command slot;  
  
    public SimpleRemoteControl() { }  
  
    public void setCommand(Command command) {  
        slot = command;  
    }  
  
    public void ButtonPressed() {  
        slot.execute();  
    }  
}
```

Testing a Command

```
public class RemoteControlTest {  
    public static void main(String[] args) {  
        SimpleRemoteControl remote = new SimpleRemoteControl();  
        Light light = new Light();  
        LightOnCommand lightOn = new LightOnCommand(light);  
  
        remote.setCommand(lightOn);  
        remote.buttonWasPressed();  
    }  
}
```

This is our Client in Command Pattern—speak.

The remote is our Invoker; it will be passed a command object that can be used to make requests.

Now we create a Light object. This will be the Receiver of the request.

Here, create a command and pass the Receiver to it.

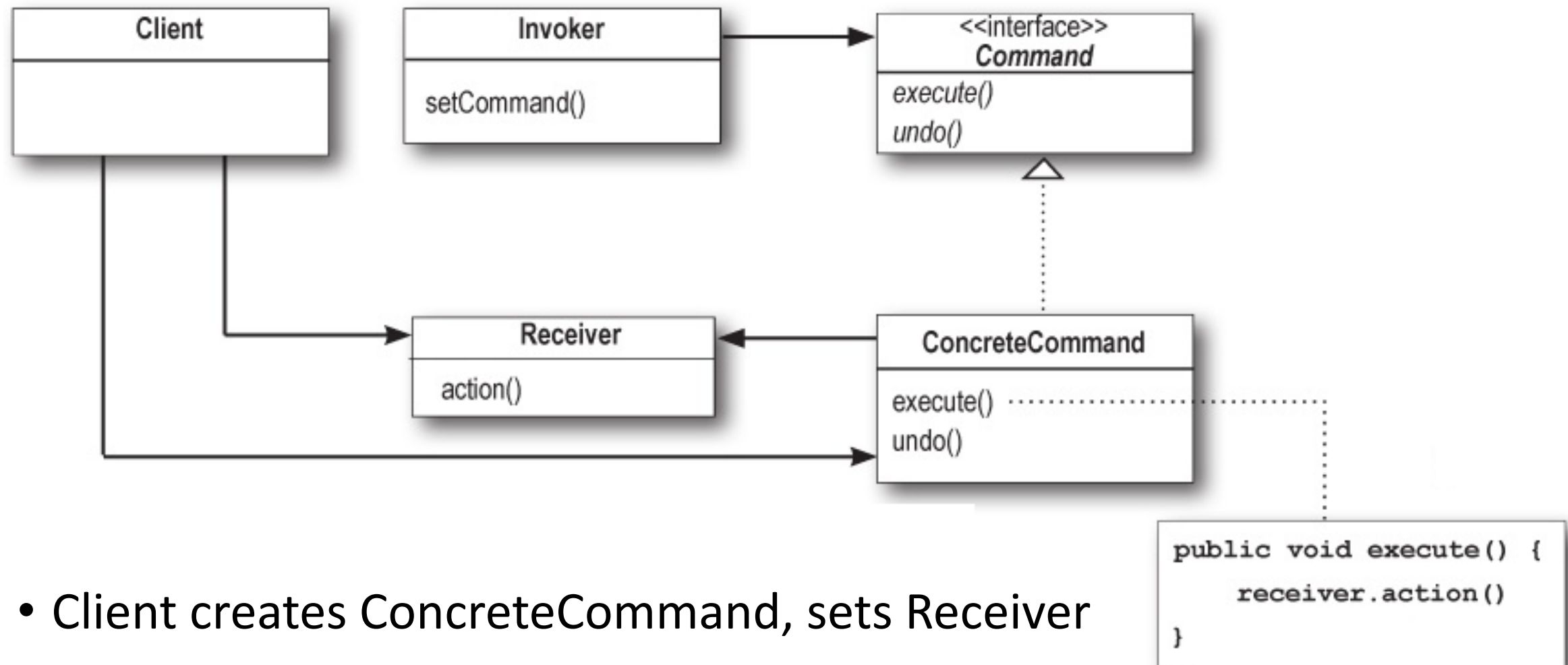
Here, pass the command to the Invoker.

And then we simulate the button being pressed.

Here's the output of running this test code.

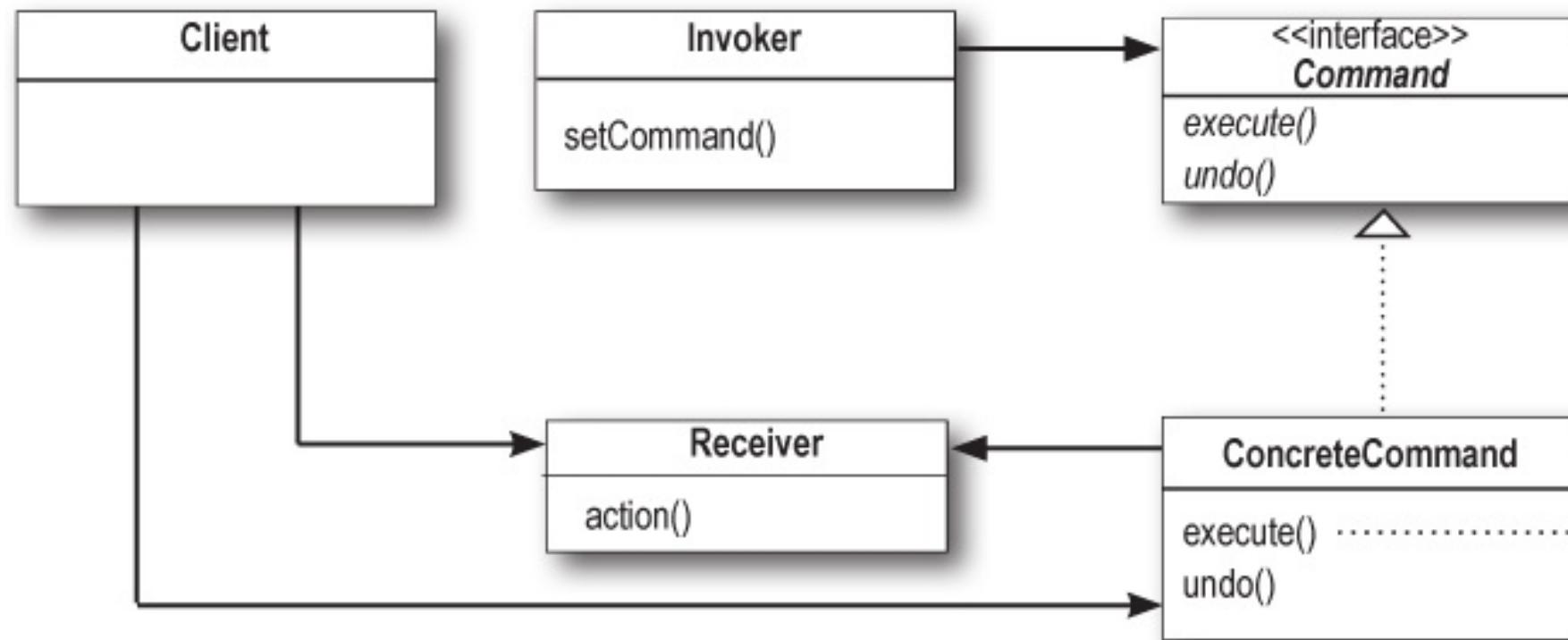
```
File Edit Window Help DinerFoodYum  
%java RemoteControlTest  
  
Light is On  
  
%
```

UML for Command Pattern



- Client creates ConcreteCommand, sets Receiver
- Invoker holds command, calls execute()
- Command interface specifies common command methods
- ConcreteCommand is the binding between Receivers and actions
- Receiver provide actions to execute (any class can be a Receiver)

UML for Command Pattern



Note here that the command is delegating the `action()` to the receiver set by the client. If the action was simple, the command could do it directly (eliminates receiver)...

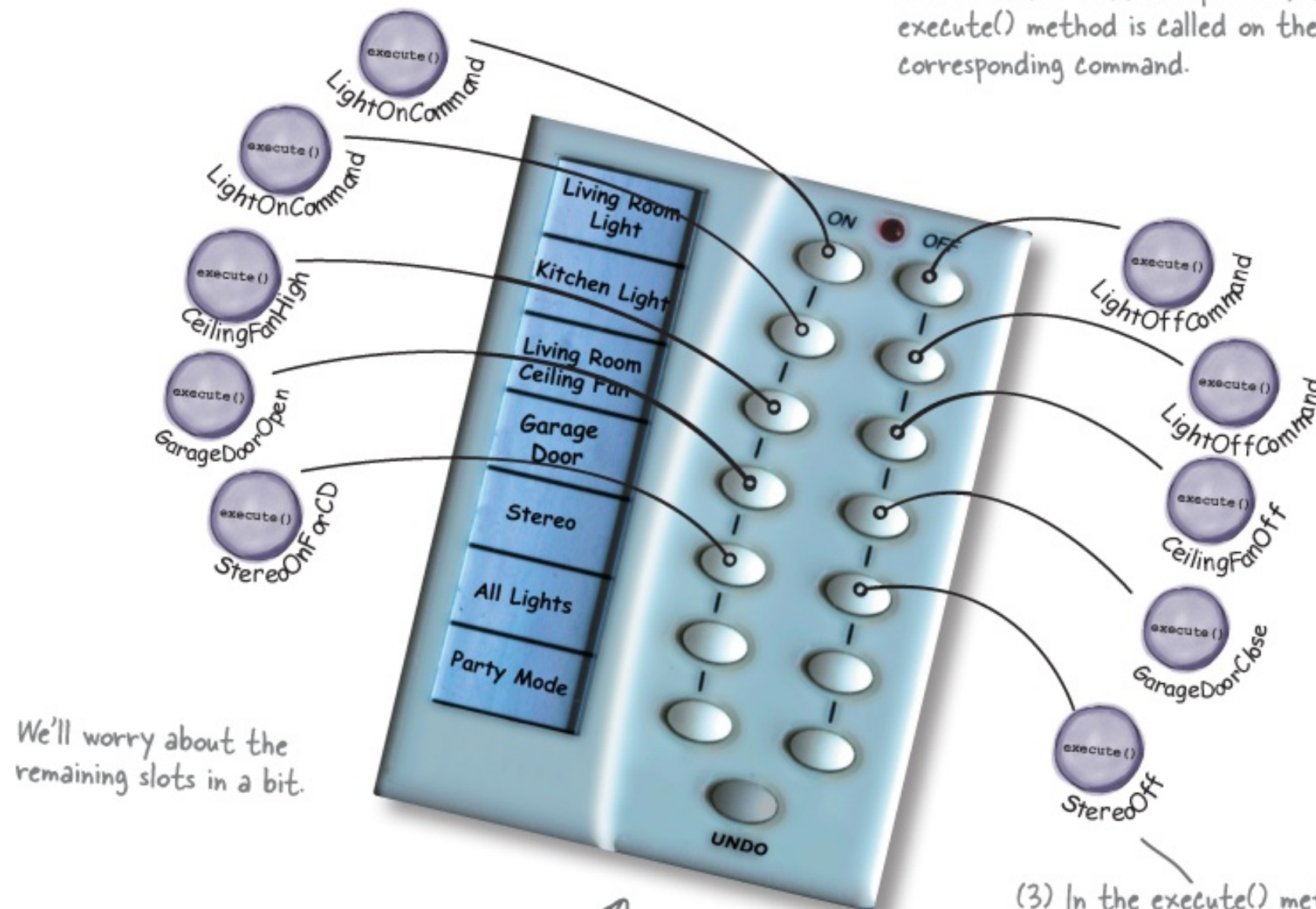
```
public void execute() {
    receiver.action()
}
```

- Client creates **ConcreteCommand**, sets **Receiver**
- **Invoker** holds command, calls `execute()`
- **Command** interface specifies common command methods
- **ConcreteCommand** is the binding between **Receivers** and actions
- **Receiver** provide actions to execute (any class can be a **Receiver**)

That Remote Control...

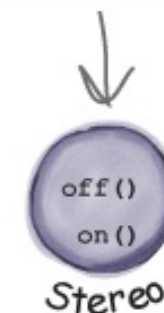
(1) Each slot gets a command.

(2) When the button is pressed, the `execute()` method is called on the corresponding command.



We'll worry about the remaining slots in a bit.

(3) In the `execute()` method actions are invoked on the receiver.



You can look in the book at the Invoker code for the remote. It's big, but simple.

The Invoker

More Complicated Commands

- Most of the devices execute in their implemented Command class just call on or off – but they could do more – consider the Stereo

Stereo
on() off() setCd() setDvd() setRadio() setVolume()

```
public class StereoOnWithCDCommand implements Command {  
    Stereo stereo;
```

```
    public StereoOnWithCDCommand(Stereo stereo) {  
        this.stereo = stereo;  
    }
```

```
    public void execute() {  
        stereo.on();  
        stereo.setCD();  
        stereo.setVolume(11);  
    }
```

```
}
```

Just like the LightOnCommand, we get passed the instance of the stereo we are going to be controlling and we store it in a local instance variable.

To carry out this request, we need to call three methods on the stereo: first, turn it on, then set it to play the CD, and finally set the volume to 11. Why 11? Well, it's better than 10, right?

What about the remote buttons without commands?

- Create a command that does nothing:


```
public class NoCommand implements Command {  
    public void execute() { }  
}
```

- Sneakily, this is actually another pattern...
- This is a **Null Object Pattern**
- Null objects are used when you don't have anything to return, but you don't want the client to have to handle null cases

What about the undo? Undo is a method in the command interface...

```
public class LightOnCommand implements Command {  
    Light light;  
  
    public LightOnCommand(Light light) {  
        this.light = light;  
    }  
  
    public void execute() {  
        light.on();  
    }  
  
    public void undo() {  
        light.off();  
    }  
}
```

execute() turns the light on, so undo() simply turns the light back off.



- The opposite case for LightOff and undo is probably easy to see?

Macro Commands

- Once we have a set of commands, it's easy to build combinations of them

```
Light light = new Light("Living Room");  
TV tv = new TV("Living Room");  
Stereo stereo = new Stereo("Living Room");  
Hottub hottub = new Hottub();
```

Create all the devices: a light,
tv, stereo, and hot tub.

```
LightOnCommand lightOn = new LightOnCommand(light);  
StereoOnCommand stereoOn = new StereoOnCommand(stereo);  
TVOnCommand tvOn = new TVOnCommand(tv);  
HottubOnCommand hottubOn = new HottubOnCommand(hottub);
```

Now create all the On
commands to control them.

```
Command[] partyOn = { lightOn, stereoOn, tvOn, hottubOn};  
Command[] partyOff = { lightOff, stereoOff, tvOff, hottubOff};
```

Create an array for
On and an array for
Off commands...

```
MacroCommand partyOnMacro = new MacroCommand(partyOn);  
MacroCommand partyOffMacro = new MacroCommand(partyOff);
```

...and create two
corresponding macros
to hold them.

That's a LOT of little Command Classes!

Light
on() off()

- Maybe we could use **lambda expressions**?
- `Light livingRoomLight = new Light("Living Room");`
- Now, when I set the command in the Invoker, instead of passing commands, I could pass lambdas.

`remoteControl.setCommand(0, () -> { livingRoomLight.on(); }, () -> { livingRoomLight.off(); });`

Here are the two lambda expressions.

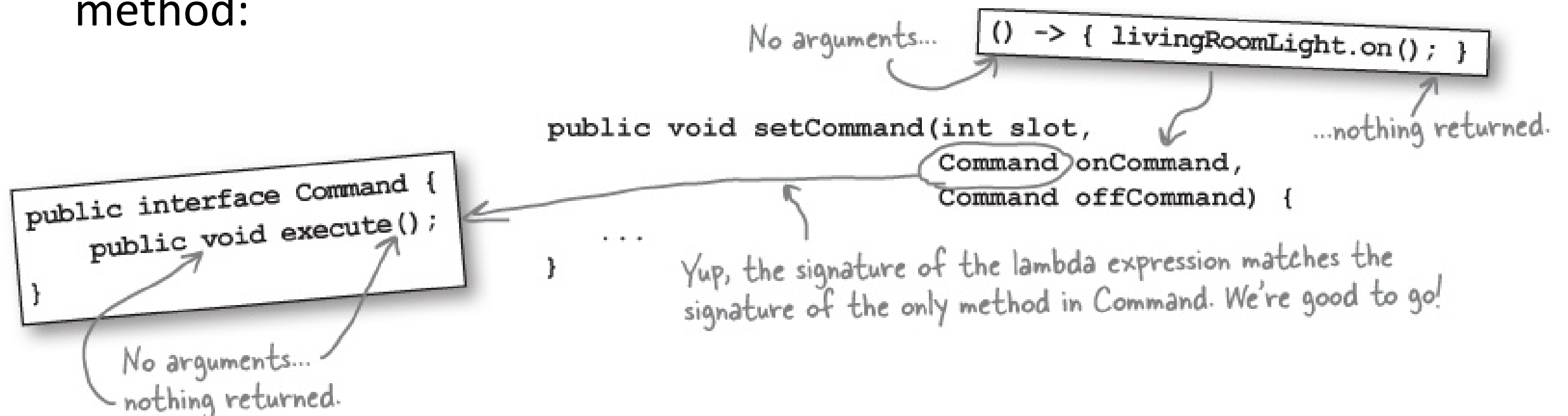
The lambdas get passed as commands to `setCommand`.

```
public void setCommand(int slot, Command onCommand, Command offCommand) {  
    onCommands[slot] = onCommand;  
    offCommands[slot] = offCommand;  
}
```

- How could this work if the system is looking for an execute method to call for normal Command objects?

Lambda Magic

- The Lambda Expressions can stand in for a Command object if that Command interface has **one** method: execute() ...AND...
- The Lambda Expression must have the same signature as that one method:




- The compiler will look to see that Command has one method with a matching signature, and will use the lambda instead

Java Method References


- If the lambda you're passing in has just one method, you can use a method reference to replace a single-method lambda expression
- Looks like this:

```
remoteControl.setCommand(0, livingRoomLight::on, livingRoomLight::off);
```

This is a reference to the `on()` method
of the `livingRoomLight` object.



This is a reference to the `off()`
method of the `livingRoomLight` object.



- Maybe
 `livingRoomLight::on`
- is a little cleaner than
 `() -> { livingRoomLight.on(); }`
- but otherwise, not much different...

Multiple actions in a Lambda

- If the lambda signature matches the signature of the one method we're calling (in this case, `execute()`), we can bundle up multiple actions...

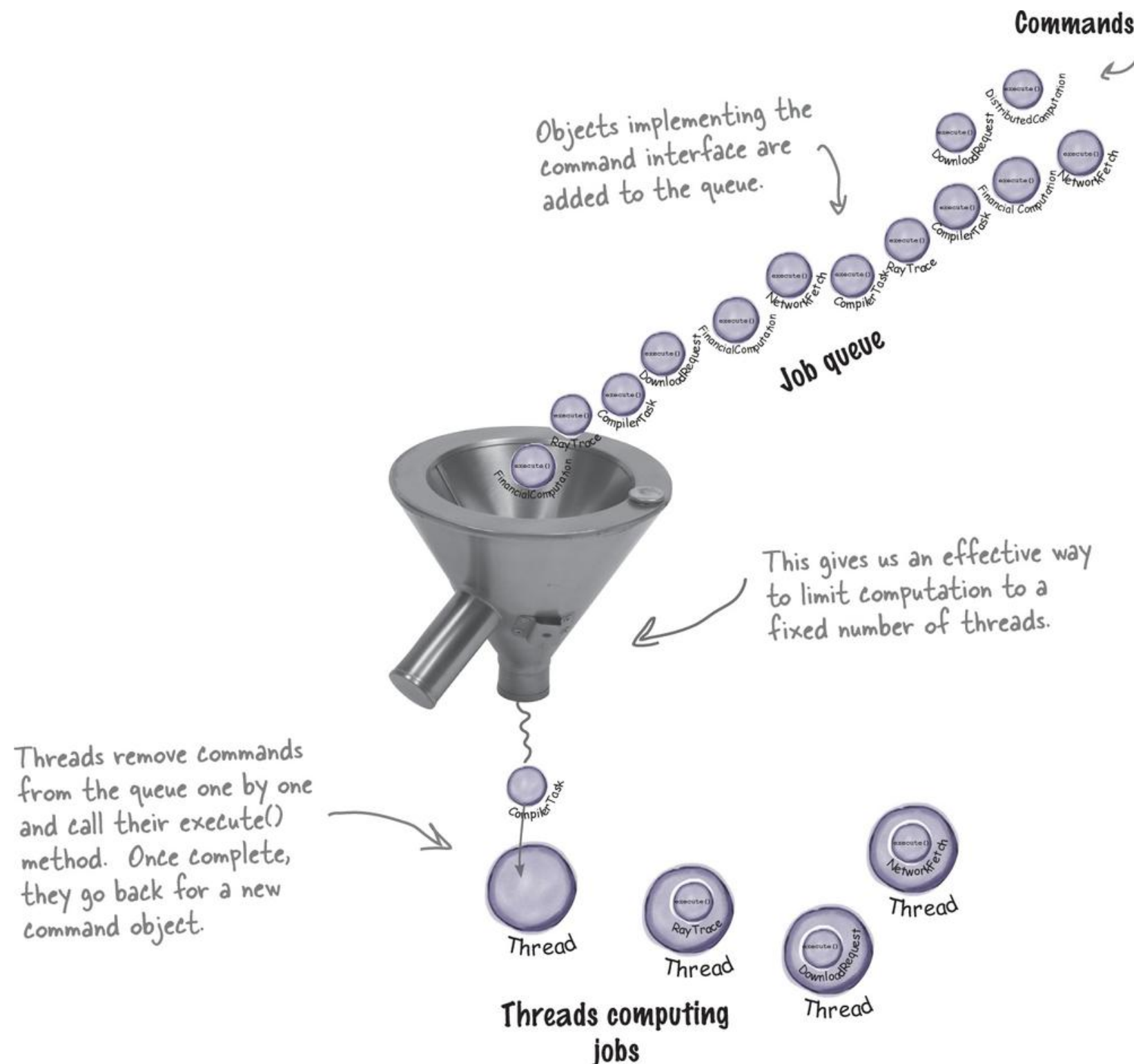
```
Command stereoOnWithCD = () -> {  
    stereo.on(); stereo.setCD(); stereo.setVolume(11);  
};  
remoteControl.setCommand(3, stereoOnWithCD, stereo::off);
```

← This lambda expression does three things (just like the `stereoOnWithCDCommand`'s `execute()` method did).

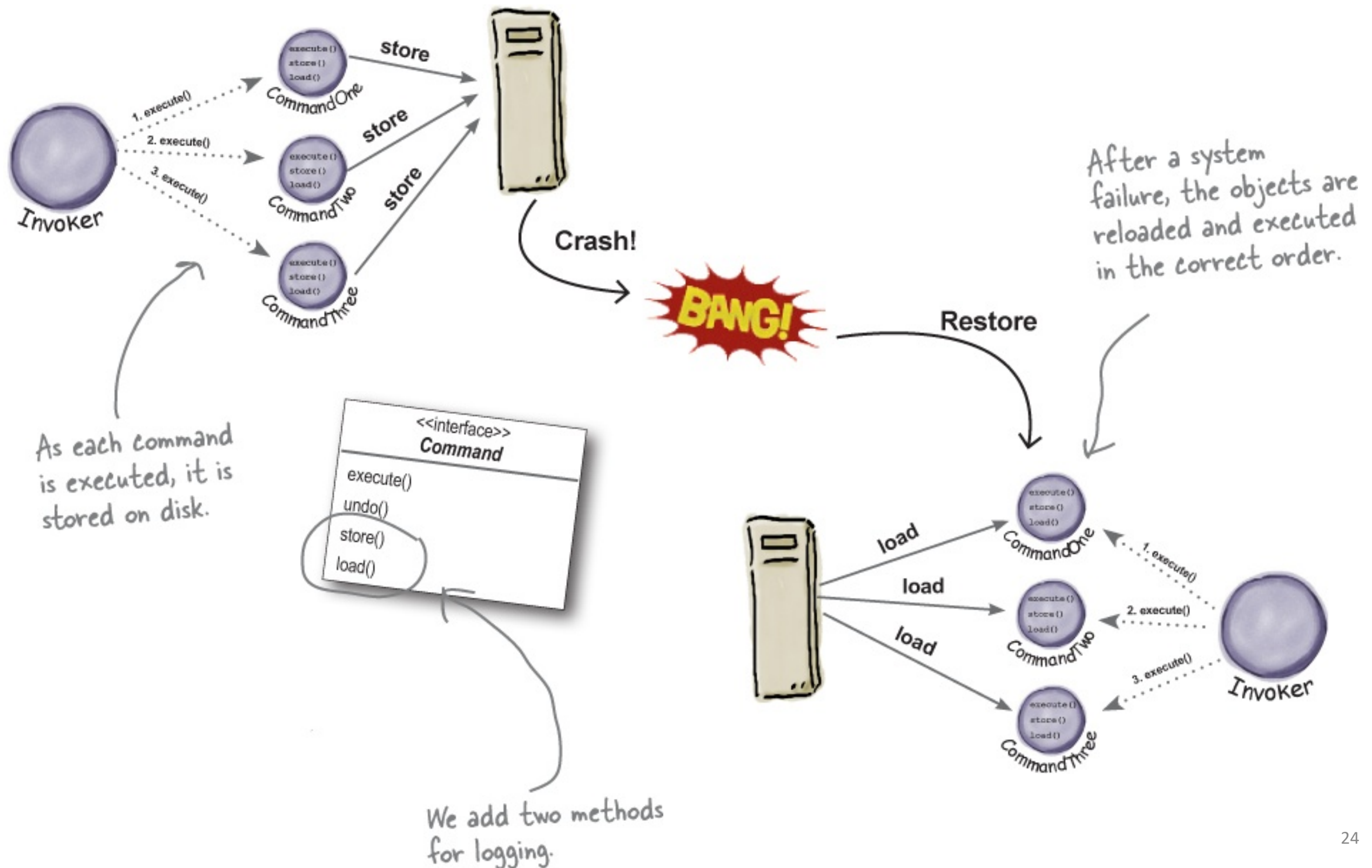
← We can pass the lambda expression using its name.

- Using lambdas can really drive down the number of classes in an implementation. For the remote control example, it goes from 22 classes down to 9.
- Note that lambdas can have 0 to n parameters and return values (see the Java docs)
- Also note that this lambda implementation only works there is a single method in the Command interface, like `execute()`. If you add `undo()`, you'll have to consider other implementation...

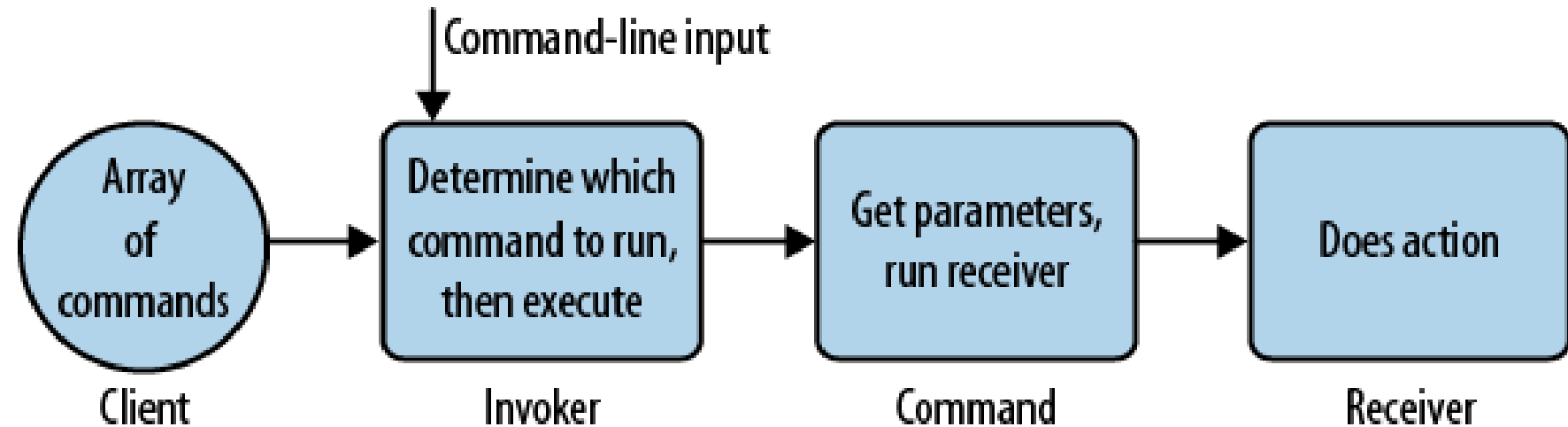
Other uses for Command: Queuing Requests



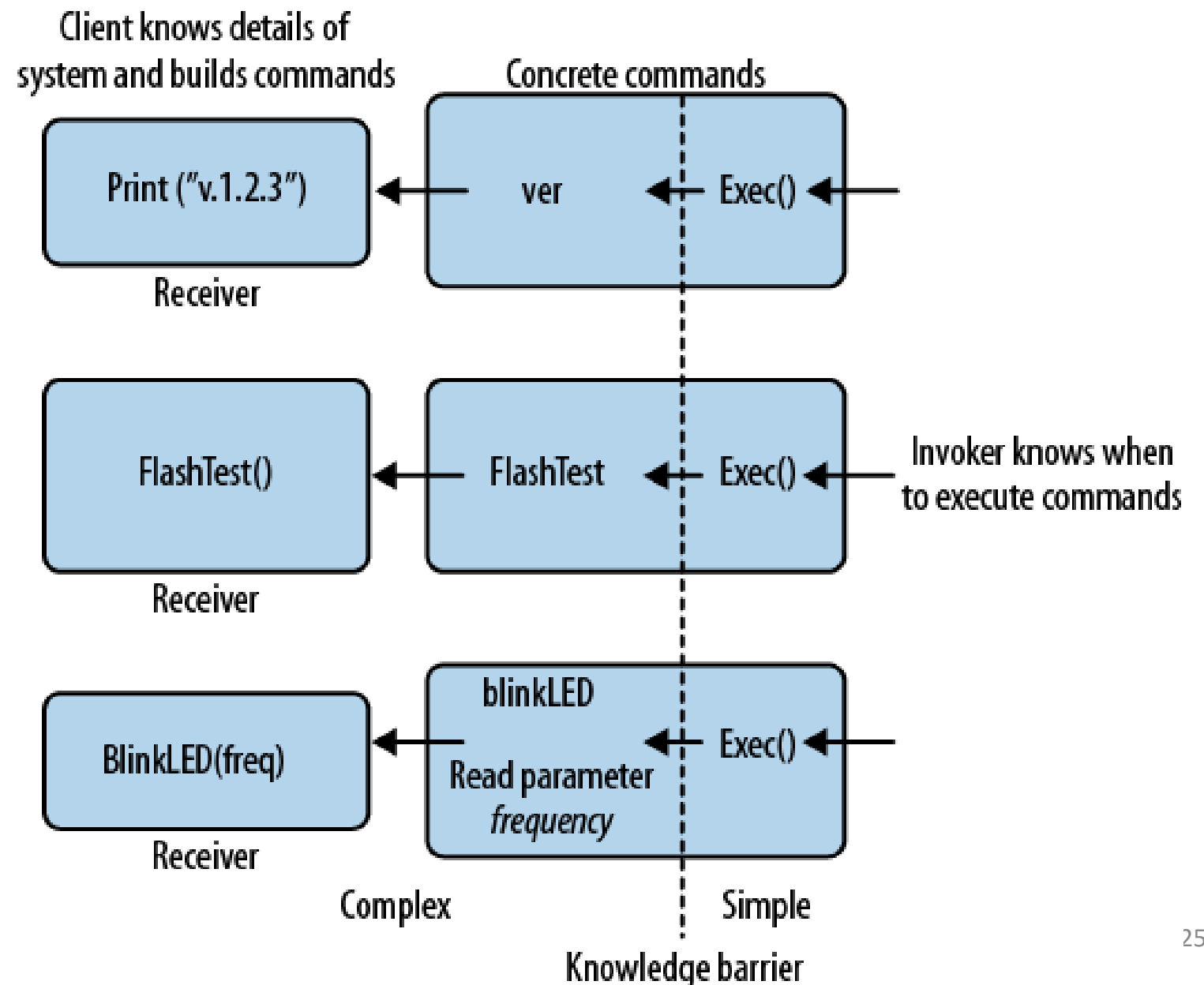
Other uses for Command: Logging Requests



One more...



- The Command Pattern popped up in my Firmware class...
 - From Making Embedded Systems, Elecia White, 2011, O'Reilly
- The pattern was used to create a framework of commands to test new boards, and to be able to easily add more tests
- Commands are C structures with a function pointer for executing an operation



Python Command Pattern Implementation

```
import abc
```

```
class Command(metaclass=abc.ABCMeta):  
    # The command interface that declares a method (execute) for a particular action.  
    @abc.abstractmethod  
    def execute(self):  
        pass
```

```
class Sandwich:  
    # Receiver with method for action  
    def make_sandwich(self):  
        print("A sandwich is being made")
```

```
class SandwichCommand(Command):  
    #A concrete / specific Command class, implementing execute()  
  
    def __init__(self, sandwich: Sandwich):  
        self._sandwich = sandwich  
  
    def execute(self):  
        self._sandwich.make_sandwich()
```

<https://medium.com/@rrfd/strategy-and-command-design-patterns-wizards-and-sandwiches-applications-in-python-d1ee1c86e00f>

Python Command Pattern Implementation

```
class MealInvoker:
```

```
    # Has a reference to the Command, and can execute the method
```

```
    def __init__(self, command: Command):
```

```
        self._command = command
```

```
        self._command_list = [] # type: List[Command]
```

```
    def set_command(self, command: Command):
```

```
        self.command = command
```

```
    def get_command(self):
```

```
        print(self.command.__class__.__name__)
```

```
    def add_command_to_list(self, command: Command):
```

```
        self._command_list.append(command)
```

```
    def execute_commands(self):
```

```
        # Execute all the saved commands, then empty the list.
```

```
        for cmd in self._command_list:
```

```
            cmd.execute()
```

```
        self._command_list.clear()
```

```
    def invoke(self):
```

```
        self._command.execute()
```

```
    # Command pattern in action
```

```
    sandwich = Sandwich() # receiver
```

```
    command_sandwich = SandwichCommand(sandwich) # concrete command
```

```
    meal_invoker = MealInvoker(command_sandwich) # invoker
```

```
    meal_invoker.invoke() # Starting the method calls
```

```
    meal_invoker.add_command_to_list(command_sandwich)
```

```
    meal_invoker.execute_commands()
```

```
    >> A sandwich is being made
```

```
    >> A sandwich is being made
```

<https://medium.com/@rrfd/strategy-and-command-design-patterns-wizards-and-sandwiches-applications-in-python-d1ee1c86e00f>

Command Summary

- The Command Pattern decouples an object making a Request from the one that knows how to perform it
- A Command object is at the center of this decoupling and encapsulates a Receiver with an action (or set of actions)
- An Invoker makes a request of a Command object by calling its execute() method, which invokes those actions on the receiver
- Invokers can be parameterized with Commands, even dynamically at runtime
- Commands may support undo by implementing an undo method that restores the object to its previous state before the execute() method was last called
- Meta or Macro Commands are a simple extension of Command that allow multiple commands to be invoked at once (by, for instance, creating an array of commands)
- In practice, it is not uncommon for “smart” Command objects to implement the request themselves rather than delegating to a receiver
- Commands may also be used to implement logging and transactional systems
- And don’t forget the secret Null Object Pattern we discovered

Midterm Exam

- In class on 3/6 (will review exam topics in class on 2/28)
- Closed book exam
- You may have one 8.5 x 11 inch note paper, you can use both sides
- You may write out or type your notes
- **You cannot use other people's note materials, the notes must be your own**
- You will turn in your notes with the exam papers
- You will be given spare paper for scratch paper or for writing out longer answers if needed
- Distance students – if you need a proctor (vs. taking the exam on campus), get it done two weeks prior to the exam (see the posting for details)

Next Steps

- New quiz is up; Grading continues...
- TA Assessment FCQ for Manjunath
 - Should be in your e-mail, please respond by 2/19
- Assignments active
 - Semester Project Topic paper due Fri 2/21 (not graded but required)
 - Graduate Project Topic Peer Review paper due Fri 2/28
 - Project 3 due Mon 3/2: be warned, don't underestimate the work...
- Next topics: Adapter/Façade, Template, Expanding Horizons...
- Exams
 - Midterm Friday 3/6 in class – distance students see posted policies
 - Optional Canvas-based Final – Wednesday 5/6 1:30 to 4 PM in class ECCR 150
 - Final exam score does not affect Midterm grade
 - Final exam grade will be highest of Midterm grade and Final grade (if taken)
- Class Staff can help!
 - Bruce: Tue 4 - 5 PM and Wed 10:30 - 11:30 AM in ECOT 242
 - Manjunath: Monday 1 – 3 PM in DLC Lobby
 - Neethi: Tuesday 1 – 3 PM in DLC Lobby
 - Anirudh: By request
 - Ask for any other coverage you need