Imperative Programming 3

MVC and *Command*

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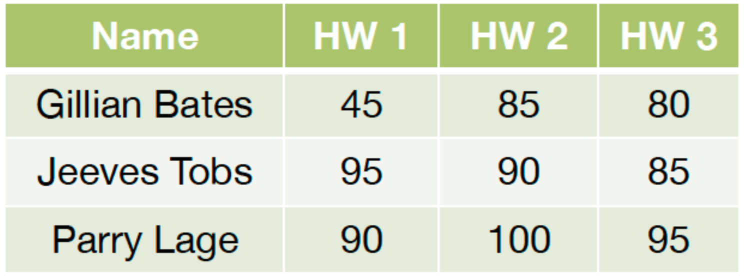
Trinity Term 2019

Agenda

- Observer pattern
- MVC architecture
- Applying MVC in the text editor
- Command pattern
- Applying Command in the text editor

Example: Student Database

- Database of grades
  - centralized storage of grade data



Name	HW 1	HW 2	HW 3
Gillian Bates	45	85	80
Jeeves Tobs	95	90	85
Parry Lage	90	100	95

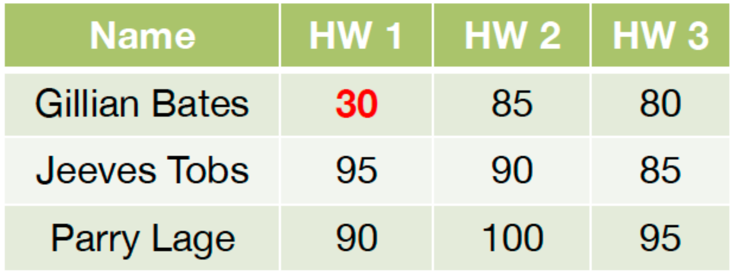
- Spreadsheet viewer
  - provides up-to-date view of grades
  - is notified of changes by the database

```
val ssv = new SpreadsheetView()
```

Change notification

- Regrade HW 1 of G. Bates
  - change score from 45 to 30

- Propagate change to view



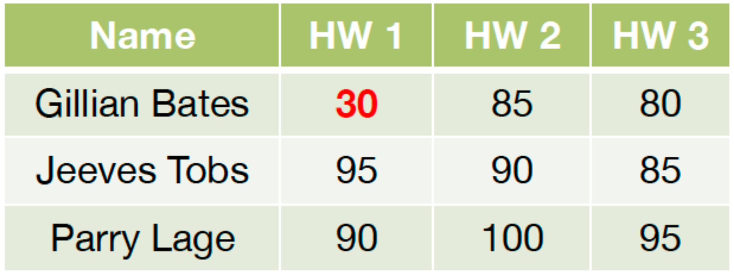
Name	HW 1	HW 2	HW 3
Gillian Bates	**30**	85	80
Jeeves Tobs	95	90	85
Parry Lage	90	100	95

```
val ssv = new SpreadsheetView()

// ...
ssv.update(“OOP”, “Gillian Bates”, “HW 1”, 30)
```

Multiple views

- Multiple views for same data
  - spreadsheet for instructor, bar chart for dean, pie charts for president, …
- Affects code on DB server
  - tight coupling



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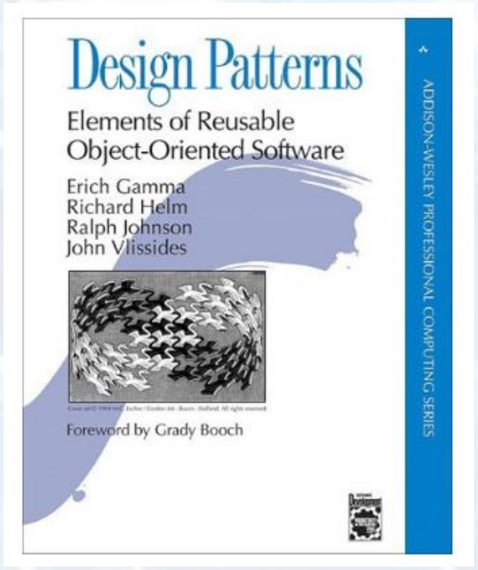
```
val ssv = new SpreadsheetView()
val bcv = new BarchartView()

// ...
ssv.update("OOP", "Gillian Bates", "HW 1", 30)
bcv.update("OOP", "Gillian Bates", "HW 1", 30)
```

Creational Patterns

Abstract Factory
Builder
Factory Method
Factory Object
Lazy Initialization
Prototype
Singleton

Structural Patterns

Adaptor
Bridge
Composite
Decorator
Façade
Flyweight
Proxy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Behavioral Patterns

Chain of Responsibility
Command
Interpreter
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Architectural

Model-View-Controller
Service-oriented Architecture

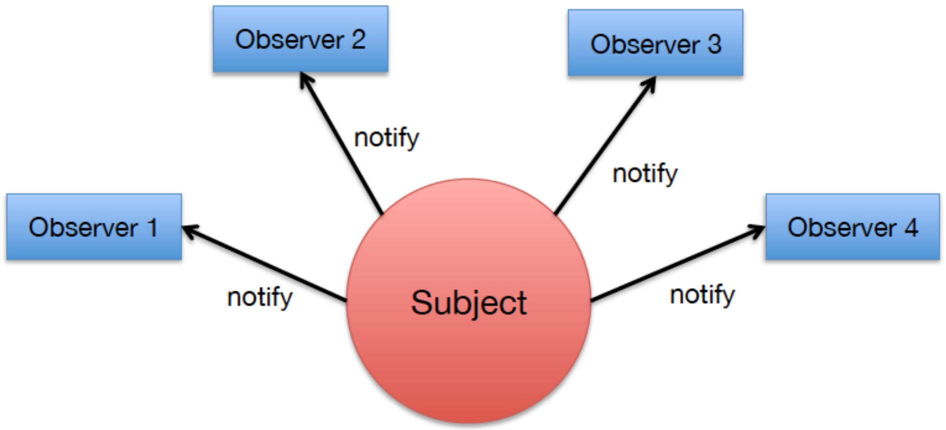
Concurrency Patterns: Active Object
Monitor
Thread Pool

Observer pattern

- Problem = several users of the same data…
  - can end up tightly coupled
  - adding new users means re-writing/recompiling
- Solution = make a modifiable list of observers
  - observers can be added and removed at runtime
  - data owner notifies all registered observers of changes
- Consequences
  - Interface not obvious - must choose either to simply notify that some change has happened or specify exactly what changed
  - Cannot rely on a specific order amongst observers

Observer pattern

- One-to-many dependency between Subject and any number of Observers
- Subject changes => all Observers are notified by invoking a fixed method in their interface
- Loose coupling
  - subject knows nothing about observers



All observers share the same interface

```
trait GradeDBObserver {
   def update(course: String, name: String, ...)
}
```

```
val observers = new ListBuffer[GradeDBObserver]()

def addObserver(obs: GradeDBObserver) =
  observers += obs
```

Add/remove observers dynamically

```
def removeObserver(obs: GradeDBObserver) =
  observers -= obs

observers.foreach(o => o.update("OOP", "G. Bates", …))
```

Notify all observers of changes to the DB

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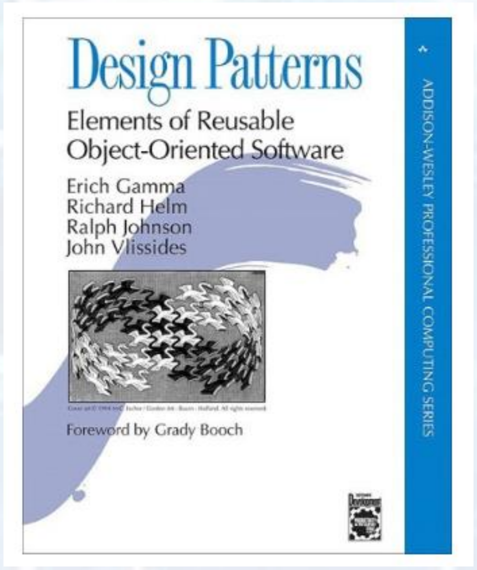
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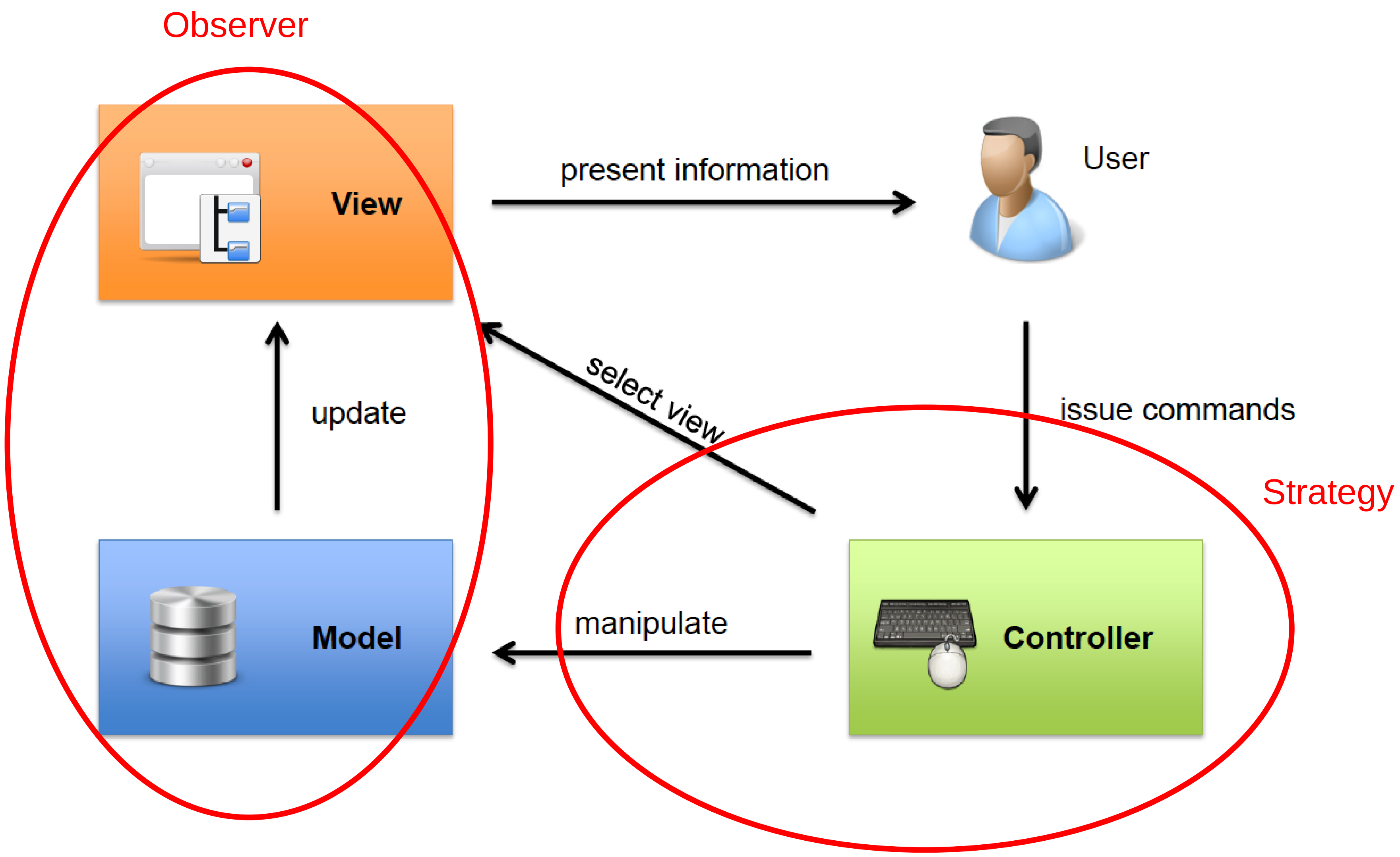
Model-View-Controller Architecture

- Typical programs
  - process input, manipulate data, and display results
  - so have to co-ordinate a range of very different tasks
- Model-View-Controller
  - defines roles, *separates concerns*
  - introduced in SmallTalk at Xerox PARC in 1979
  - today’s standard design for GUIs and web applications
- Not (exactly) a pattern
  - an overall architecture combining several patterns

Model-View-Controller Architecture



MVC Architecture

- Separate Model, View, and Controller roles
  - each role can be spread over multiple modules
    - e.g., in web apps, part on client side, part on server side
  - but each module has only one role
  - can be fuzzy at times, choose cleanest solution with roles in mind
- Modularity
  - multiple views, possibly parallel and nested
  - controller can be substituted
  - logic can change without touching the user interface

Model-View-Controller in Ewoks?

Editor

Text

insert(int

currentP

insertOpera

deleteOperation()

saveOperation()

loadOperation()

Keymap

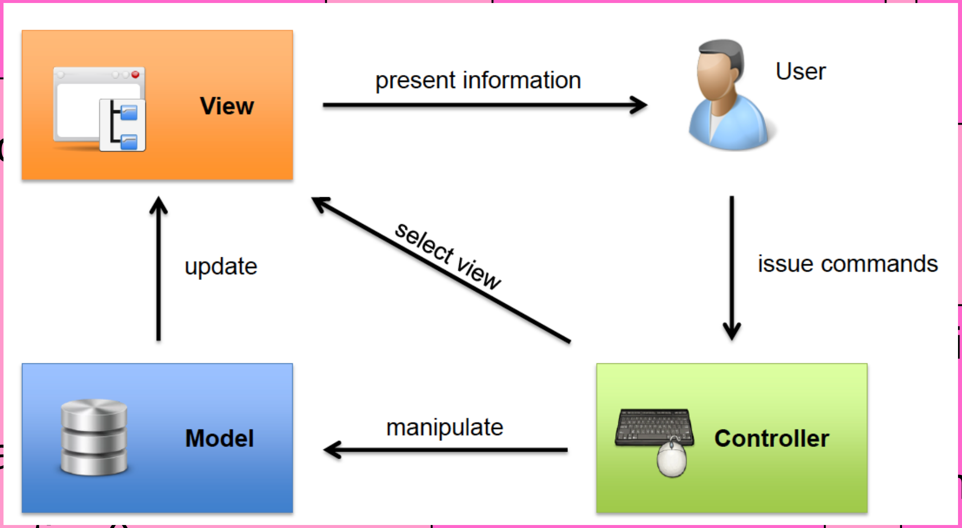
getLast()

InputStream

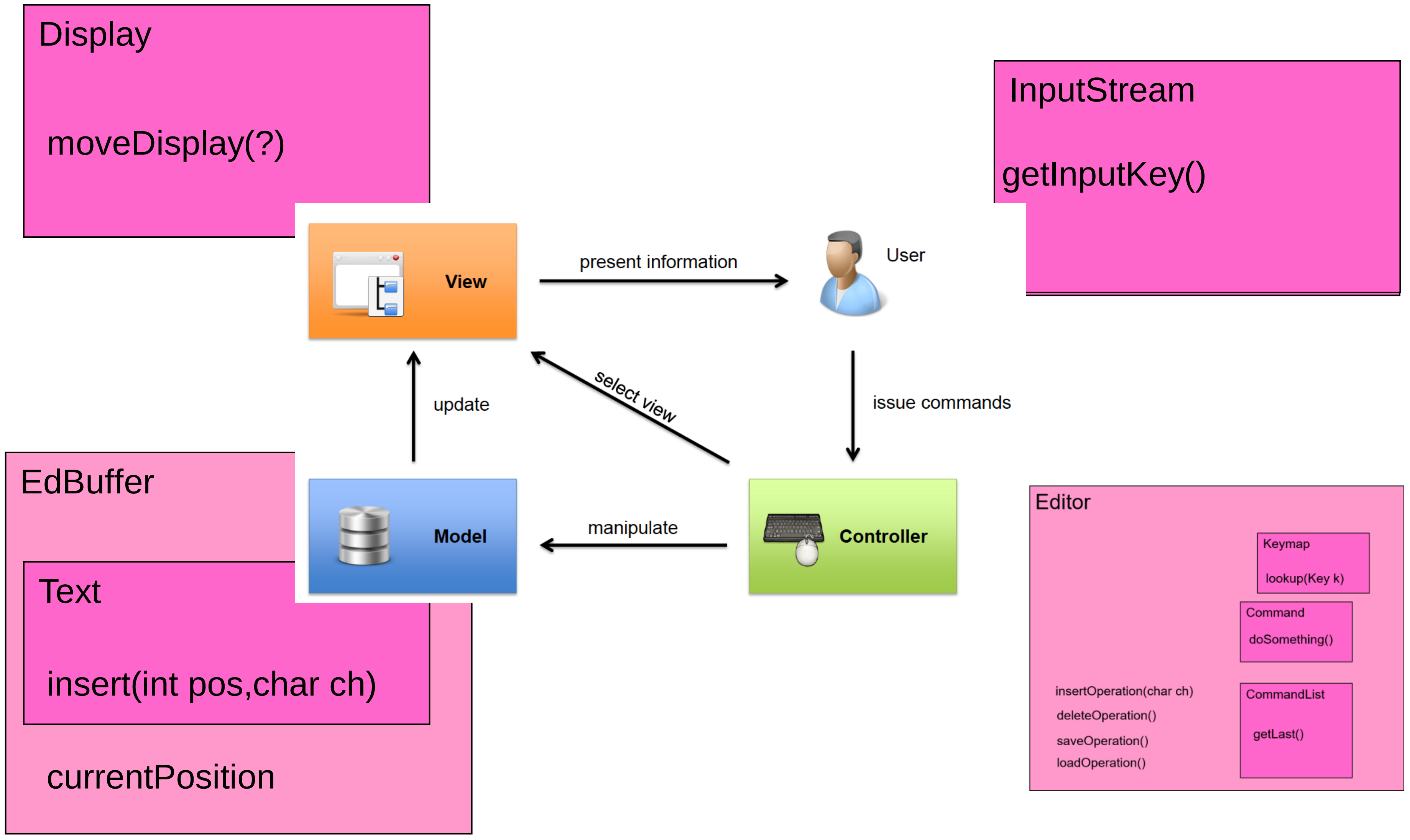
getInputKey()

isplay

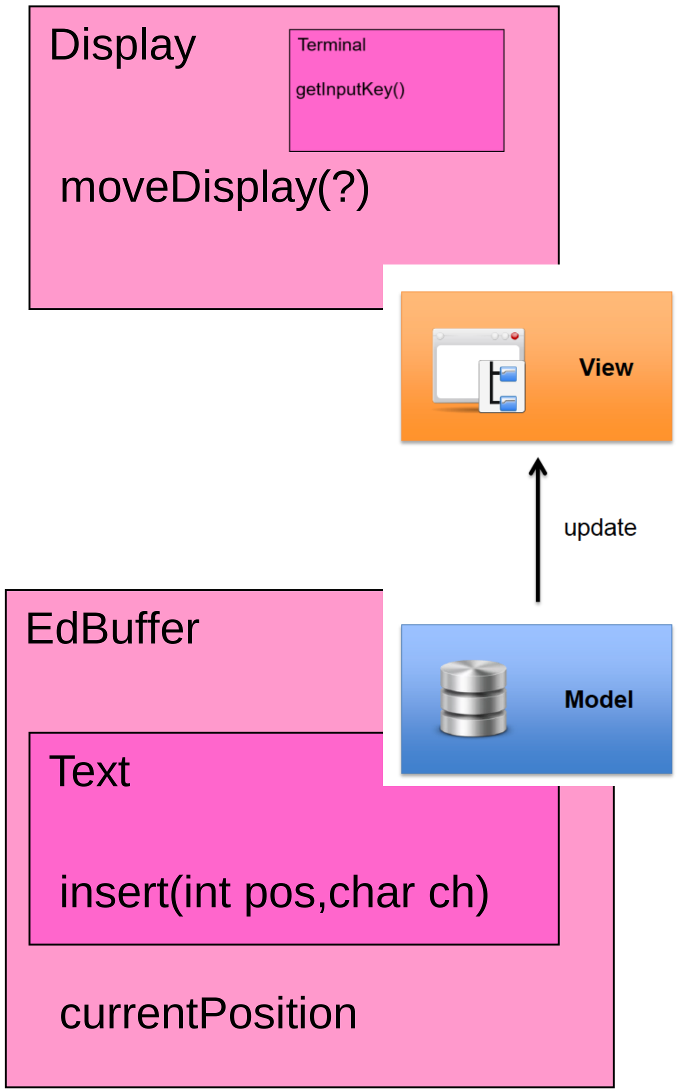
noveDisplay(?)



Model-View-Controller in Ewoks



Model-View in Ewoks



- It also has a `Display` object whose job is to provide a view of the text model
- When the state of the model changes, we need to update the display at some point
- The editor has an `EdBuffer` object whose job is to hold the current state of the text model

Updating the Display

- In our new architecture the controller simply invokes the `update` method of the `EdBuffer` object after processing each command

```
class Editor {
   protected val ed = new EdBuffer
   ...

   def obey(cmd: Command) = {
      cmd.execute(this)
      ed.update()
   }
}
```

Updating the Display

- When asked to `update`, the `EdBuffer` object will first check whether anything in the model has changed...

Question: How can we detect if the state of the model has changed?

Updating the Display

- Each command that changes the model sets an instance variable of the `EdBuffer` object to record the fact that change has occurred
- This variable can take several different values to indicate the degree of change…

The update method

```
class EdBuffer
    private val text = new PlaneText()
    private var point = 0

    private var damage = EdBuffer.CLEAN
    ...

    def update() {
        display.refresh(damage,
             text.getRow(point), text.getColumn(point))
        damage = EdBuffer.CLEAN
    }
```

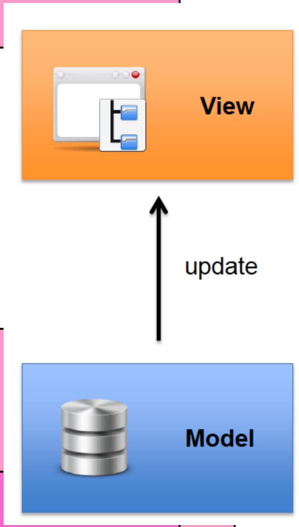
Model-View in Ewoks

Display

Terminal

getInputKey()

moveDisplay(?)



EdBuffer

Text

insert(int pos,char ch)

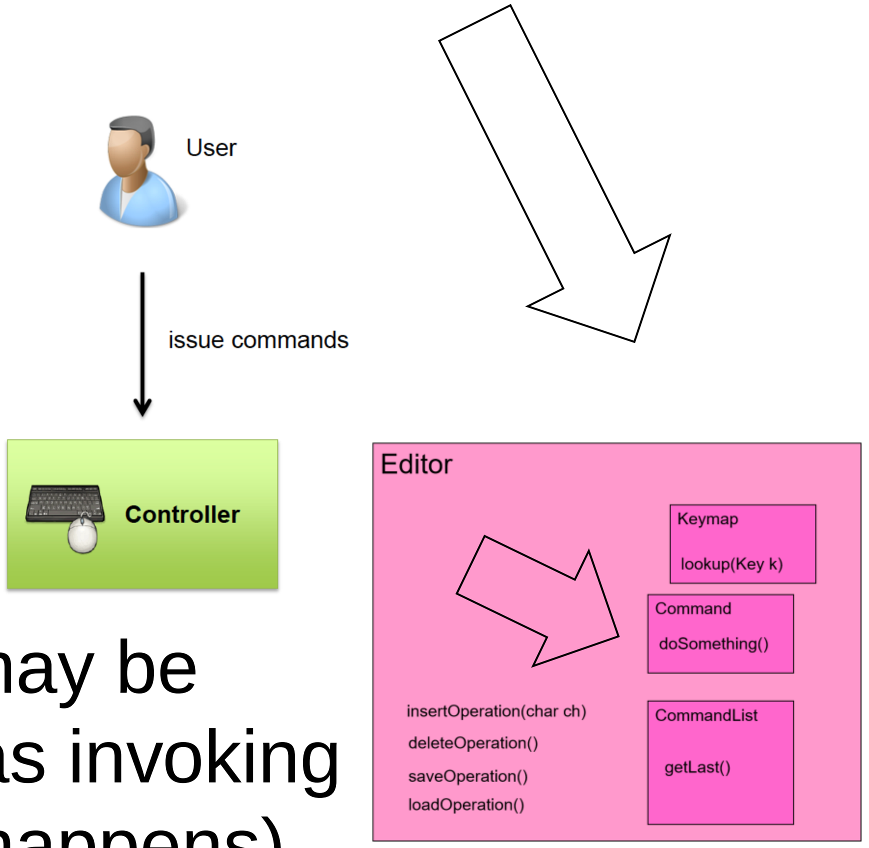
currentPosition

Controller in Ewoks

- The editor has an `Editor` object whose job as controller is to respond to user commands

- When the user presses a key, we will need to respond by carrying out some `Command`

- Each `Command` will do different things, but there may be common behaviour (such as invoking `update` or recording what happens)



Example: InsertCommand

```
class InsertCommand(val ch: Char) {

  def execute(editor: Editor) = {
    editor.insertOperation(ch)
  }

}
```

Defines some method to be invoked

On some "receiver" object

Example: DeleteCommand

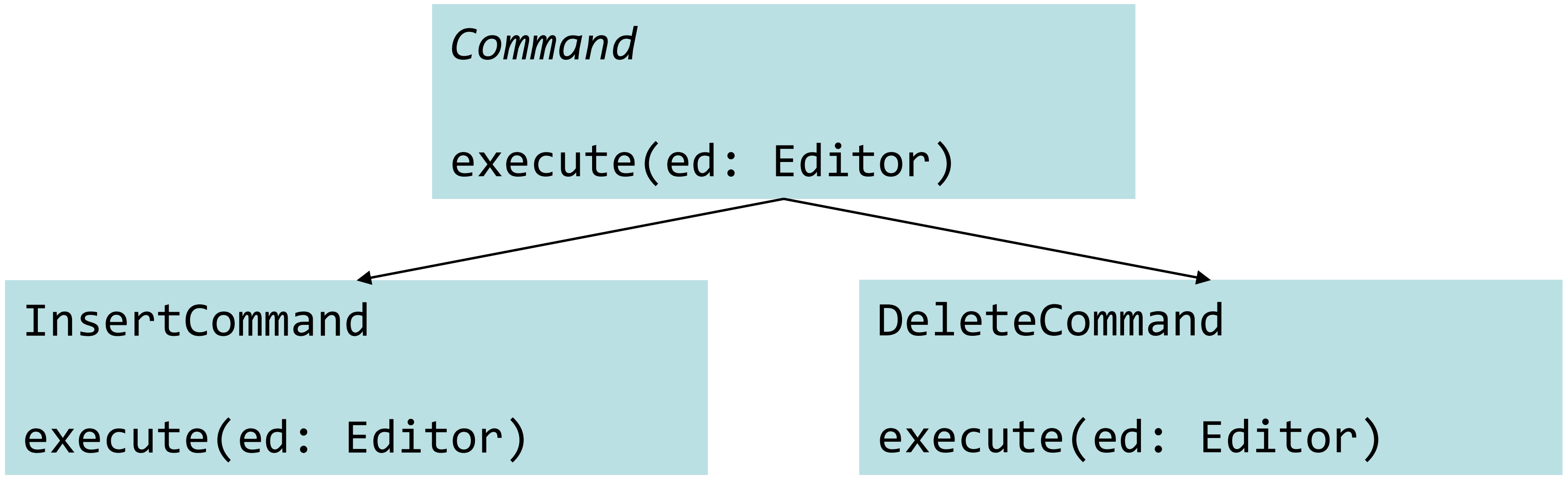
```
class DeleteCommand {

    def execute(editor: Editor) {
        editor.deleteOperation();
    }

}
```

The Command interface

- We now have two different kinds of command
  - `InsertCommand` and `DeleteCommand`
- They both provide an `execute` method



Example: InsertCommand

- Other classes can use the `InsertCommand` class in the following way:

```
val ed = new Editor()

val cmd: Command = new InsertCommand('a')

cmd.execute(ed)
```

Example: DeleteCommand

- Other classes can use the `DeleteCommand` class in the following way:

```
val ed = new Editor()

val cmd: Command = new DeleteCommand()

cmd.execute(ed)
```

- A common interface allows us to treat all commands uniformly:

“Program to the interface”

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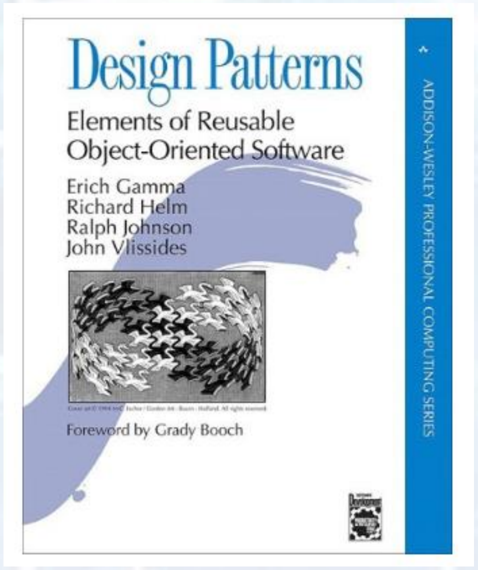
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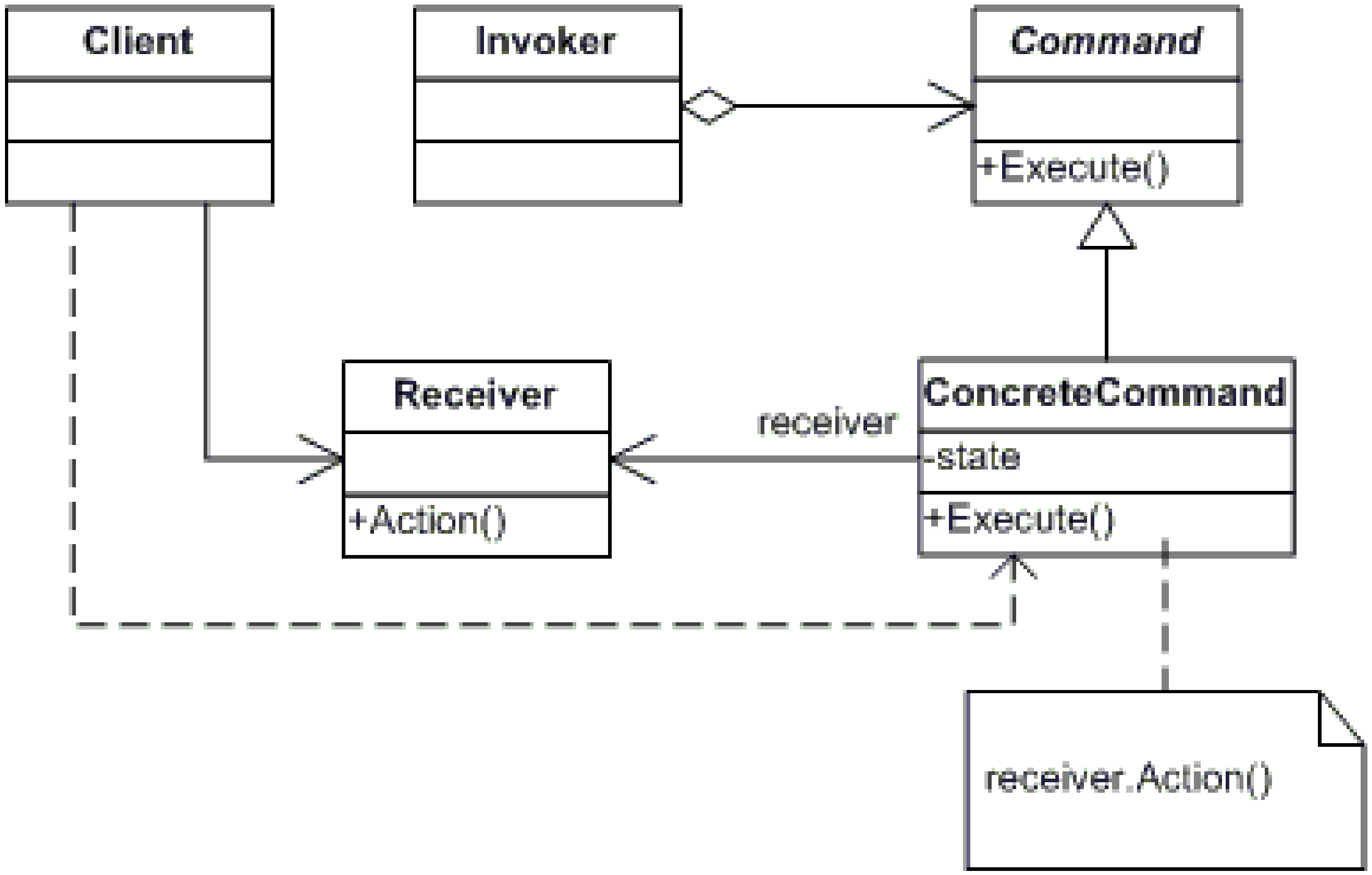
Command pattern

The command interface is like a *button* on a remote control

- It does *one thing*: `execute`, such as delete a character (or turn off the TV)
  - High cohesion
- It may have no internal logic and simply invoke a *remote method,*
  e.g. `editor.deleteOperation()`
  - Loose coupling (separation of concerns)

Command pattern



Command pattern

- To add a command to any system we need three things:
  - A method in the **`Receiver`** class that carries out the effect of the command;
  - A **`ConcreteCommand`** class that implements the `Command` interface and carries out the command by calling the appropriate method in the `Receiver` (via its `execute` method);
  - An entry in the **`Client`** class that provides some way to access this concrete command and pass it to the **`Invoker`**

Issues

- This pattern seems to require a lot of classes (e.g. one for each command)

Question: Is this a good feature or a bad feature?

Commands in Ewoks

- To add a command to our editor we need three things:
  - A method in the **`Editor`** class that carries out the effect of the command;
  - A *function* of type **`Command`** that carries out the command by calling the appropriate method in the `Editor` (via its `apply` method);
  - An entry in the **`Keymap`** that links a keypress to this function so it can be carried out in the main command loop of the **`Editor`**.

Commands as Functions

```
type Command = (Editor => Boolean)
```

- Scala has shortcuts for writing functions so these are equivalent:

```
(editor: Editor) => editor.insertCommand(’x’)

editor => editor.insertCommand(’x’)

(_.insertCommand(’x’))
```

```
 for (ch <- Display.printable)
        keymap += ch -> (_.insertCommand(ch.toChar))
```

Ewoks: the whole story (so far)

- When a key is pressed the following things happen in the main loop of the editor:
  - The `key` value is requested from the `display` …
  - a `cmd` is found by looking up the `key` in the `keymap` …
  - `obey(cmd)` is invoked, which carries out tasks common to all editing commands like updating the display …
  - it also calls `cmd(editor)` to carry out the actions specific to this command, such as …
  - `editor.deleteCommand(RIGHT)` which actually performs the changes in the current text buffer.

Summary

- Observer pattern
- MVC architecture
  - clean separation of roles
  - standard for GUI programs
  - combines several patterns
- Command pattern
  - encapsulates requests as objects
  - each command has an invoker, and a receiver

See also *Head First Design Patterns*: Chapters 2 & 6

Next lecture: undoing commands