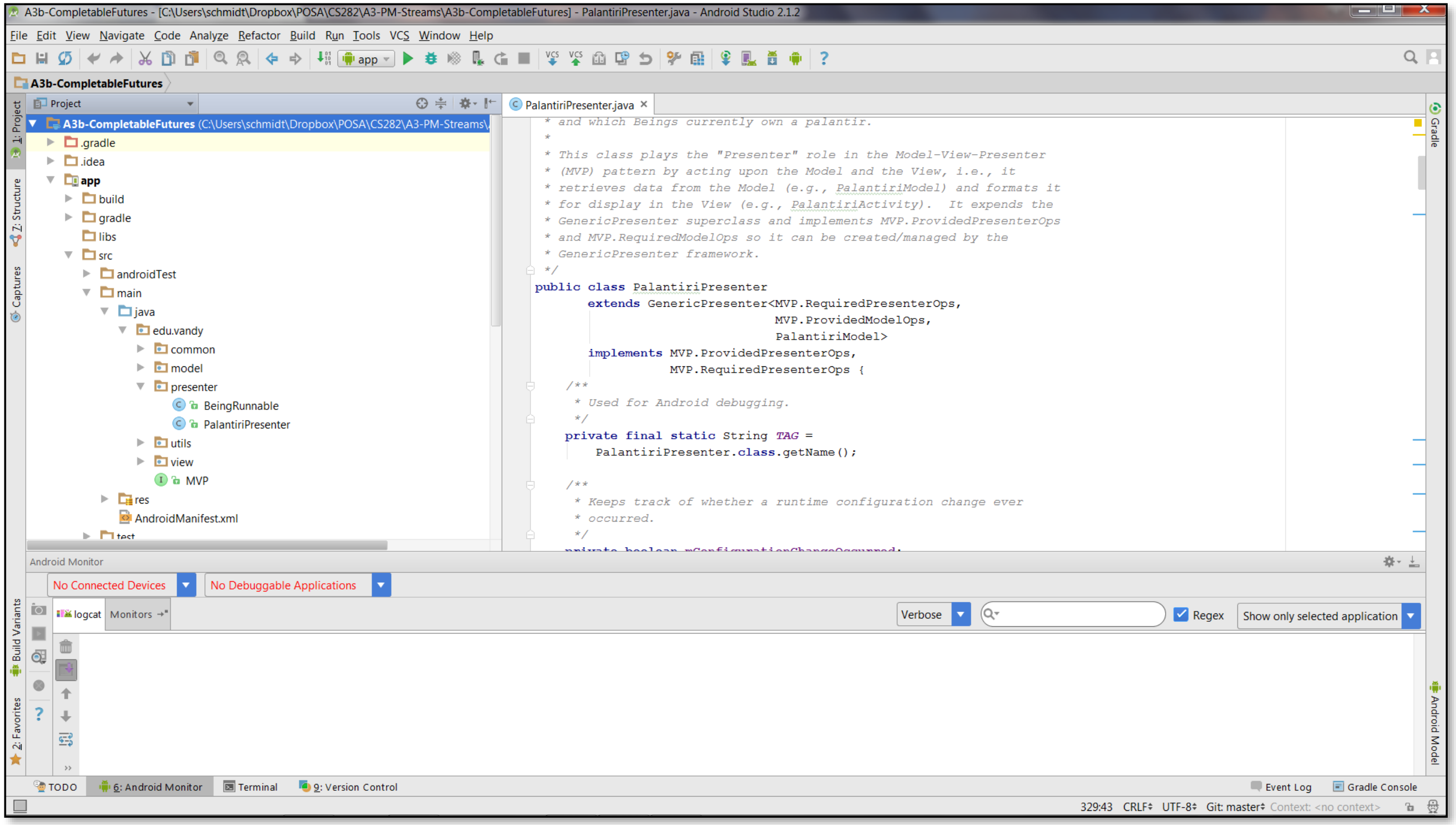
The Command Pattern

Implementation in C++

Douglas C. Schmidt

Learning Objectives in This Lesson

- Recognize how the *Command* pattern can be applied to perform user-requested commands consistently & extensibly in the expression tree processing app.
- Understand the structure & functionality of the *Command* pattern.
- Know how to implement the *Command* pattern in C++.



```
 * and which Beings currently own a palantir.
 *
 * This class plays the "Presenter" role in the Model-View-Presenter
 * (MVP) pattern by acting upon the Model and the View, i.e., it
 * retrieves data from the Model (e.g., PalantiriModel) and formats it
 * for display in the View (e.g., PalantiriActivity).  It expends the
 * GenericPresenter superclass and implements MVP.ProvidedPresenterOps
 * and MVP.RequiredModelOps so it can be created/managed by the
 * GenericPresenter framework.
 */
public class PalantiriPresenter
       extends GenericPresenter<MVP.RequiredPresenterOps,
                                MVP.ProvidedModelOps,
                                PalantiriModel>
       implements MVP.ProvidedPresenterOps,
                  MVP.RequiredPresenterOps {
    /**
     * Used for Android debugging.
     */
    private final static String TAG =
        PalantiriPresenter.class.getName();

    /**
     * Keeps track of whether a runtime configuration change ever
     * occurred.
     */
    private boolean mConfigurationChangeOccurred;
```

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Implementing the Command Pattern in C++

Command example in C++

- Plays role of “Command” in the *Command* pattern
  - Defines an API for “Concrete Command” implementations that perform an operation on the expression tree when it's executed

```
class User_Command_Impl {
  Tree_Context &tree_context_;



  User_Command_Impl(Tree_Context &
                    tree_context) {
    tree_context_ = tree_context;
  }

  virtual void execute() = 0;
```

Command example in C++

- Plays role of "Command" in the *Command* pattern
  - Defines an API for "Concrete Command" implementations that perform an operation on the expression tree when it's executed

```
class User_Command_Impl {
  Tree_Context &tree_context_;
```

Holds the expression tree that's the target of commands

```
  User_Command_Impl(Tree_Context &
                    tree_context) {
    tree_context_ = tree_context;
  }

  virtual void execute() = 0;
```

See upcoming lesson on the *State* pattern

Command example in C++

- Plays role of "Command" in the *Command* pattern
  - Defines an API for "Concrete Command" implementations that perform an operation on the expression tree when it's executed

```
class User_Command_Impl {
  Tree_Context &tree_context_;
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Constructor sets the field

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  User_Command_Impl(Tree_Context &
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  }

  virtual void execute() = 0;
```

Concrete implementations run the command via this method

Command example in C++

- Encapsulate the execution of a command object that sets the desired input expression.
  - e.g., "−5×(3+4)"

```
class Expr_Command
       : public User_Command_Impl {
  string expr_;



  Expr_Command(Tree_Context &context,
               string newexpr)
     : User_Command_Impl(context),
       expr_ (std::move(newexpr)) {
  }


  void execute() override {
     tree_context_.expr(expr_);
  }
```

Command example in C++

- Encapsulate the execution of a command object that sets the desired input expression.
  - e.g., "−5×(3+4)"

```
class Expr_Command
       : public User_Command_Impl {
  string expr_;
```

Store the requested expression

```
  Expr_Command(Tree_Context &context,
               string newexpr)
    : User_Command_Impl(context),
      expr_ (std::move(newexpr)) {
  }

  void execute() override {
     tree_context_.expr(expr_);
  }
```

Command GoF Object Behavioral

Command example in C++

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  void execute() override {
     tree_context_.expr(expr_);
  }
```

Provide Tree_Context & requested expression

Command GoF Object Behavioral

Command example in C++

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    : User_Command_Impl(context),
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  void execute() override {
     tree_context_.expr(expr_);
  }
```
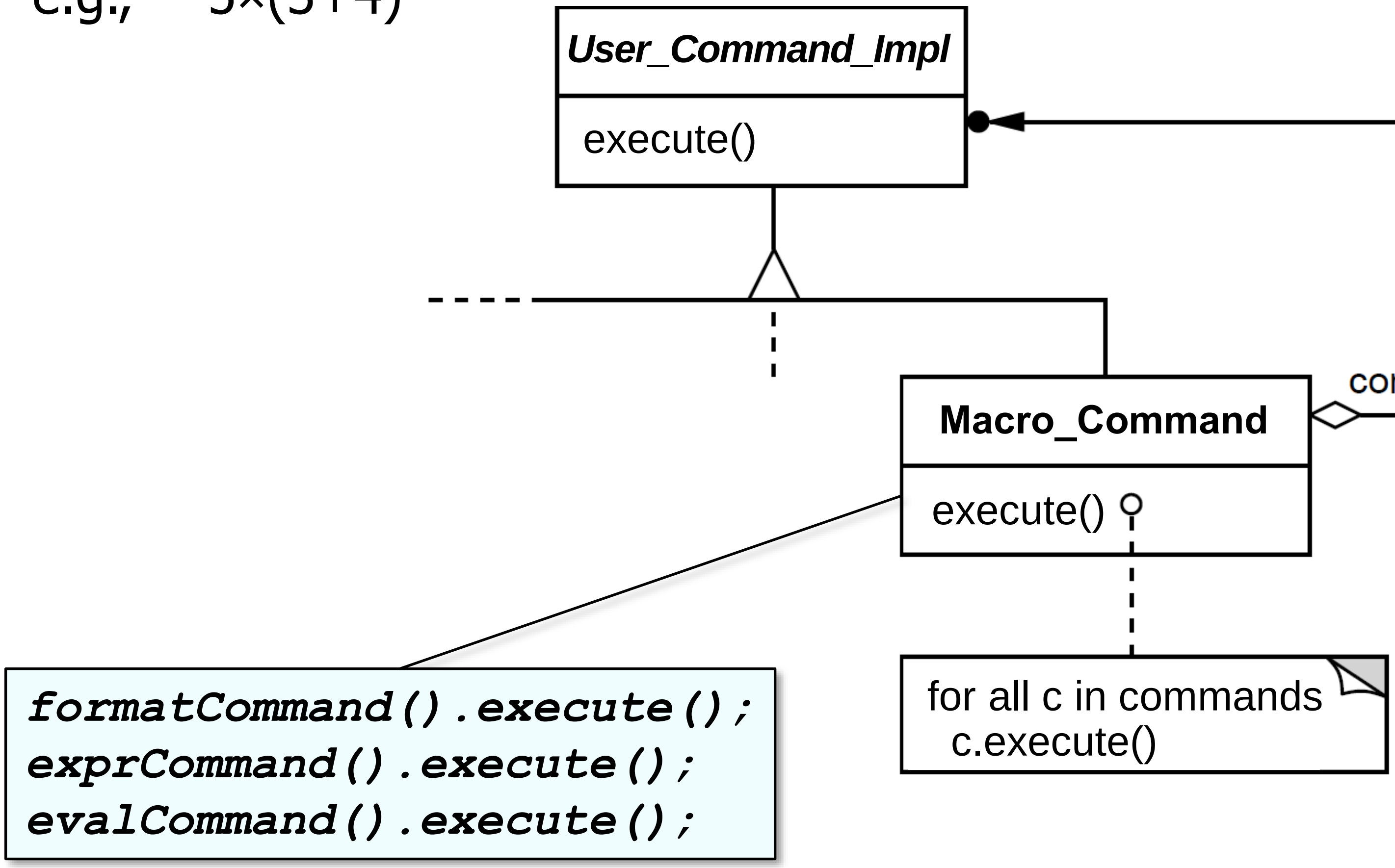

Forward to Tree_Context to create desired expression tree

See upcoming lesson on the *State* pattern

Command example in C++

- Encapsulate the execution of a sequence of commands as an object, which is used to implement the “succinct mode.”
  - e.g., “−5×(3+4)”



```
formatCommand().execute();
exprCommand().execute();
evalCommand().execute();
```

Command example in C++

- Encapsulate the execution of a sequence of commands as an object, which is used to implement the “succinct mode.”

```
class Macro_Command : public User_Command_Impl {
  ...
  vector<User_Command> macro_command_;



  Macro_Command(Tree_Context &context,
                vector<User_Command> macro_command)
    : User_Command_Impl(context),
      macro_command_(std::move(macro_command);
  }

  void execute() override {
    for (auto &command : macro_command_) command.execute();
  }
  ...
```

Command example in C++

- Encapsulate the execution of a sequence of commands as an object, which is used to implement the “succinct mode.”

```
class Macro_Command : public User_Command_Impl {
  ...
  vector<User_Command> macro_command_;
```

List of commands to execute as a macro

```
  Macro_Command(Tree_Context &context,
                vector<User_Command> macro_command)
    : User_Command_Impl(context),
      macro_command_(std::move(macro_command);
  }

  void execute() {
    for (auto &command : macro_command_) command.execute();
  }  ...
```

Command example in C++

- Encapsulate the execution of a sequence of commands as an object, which is used to implement the "succinct mode."

```
class Macro_Command : public User_Command_Impl {
  ...
  vector<User_Command> macro_command_;
```

Constructor initializes the field

```
  Macro_Command(Tree_Context &context,
                vector<User_Command> macro_command)
    : User_Command_Impl(context),
      macro_command_(std::move(macro_command);
  }

  void execute() {
    for (auto &command : macro_command_) command.execute();
  }  ...
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Command example in C++

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      macro_command_(std::move(macro_command);
  }

  void execute() {
    for (auto &command : macro_command_) command.execute();
  }
  ...
```

C++ range-based for loop runs all commands to implement "succinct mode"

The Command Pattern

Other Considerations

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Learning Objectives in This Lesson

- Recognize how the *Command* pattern can be applied to perform user-requested commands consistently & extensibly in the expression tree processing app.
- Understand the structure & functionality of the *Command* pattern.
- Know how to implement the *Command* pattern in C++.
- Be aware of other considerations when applying the *Command* pattern.

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Other Considerations of the Command Pattern

Command GoF Object Behavioral

Consequences

+ Abstracts the executor of a service
  - Makes programs more modular & flexible

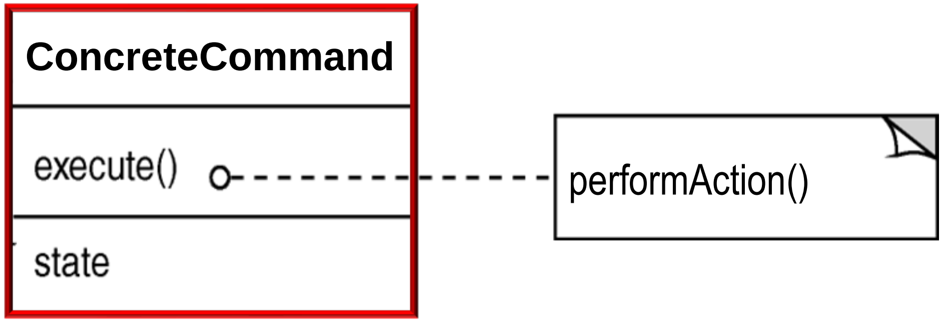
Command GoF Object Behavioral

Consequences

+ Abstracts the executor of a service

  - Makes programs more modular & flexible, e.g.,

    - Can bundle state & behavior into an object

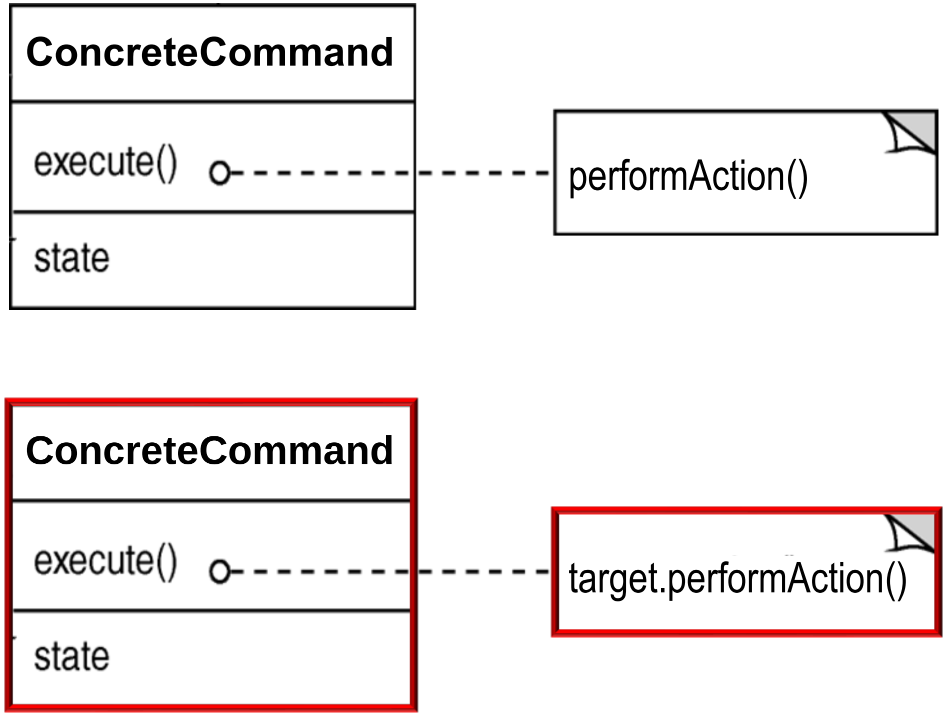


Command GoF Object Behavioral

Consequences

+ Abstracts the executor of a service

  - Makes programs more modular & flexible, e.g.,
    - Can bundle state & behavior into an object
    - Can forward behavior to other objects

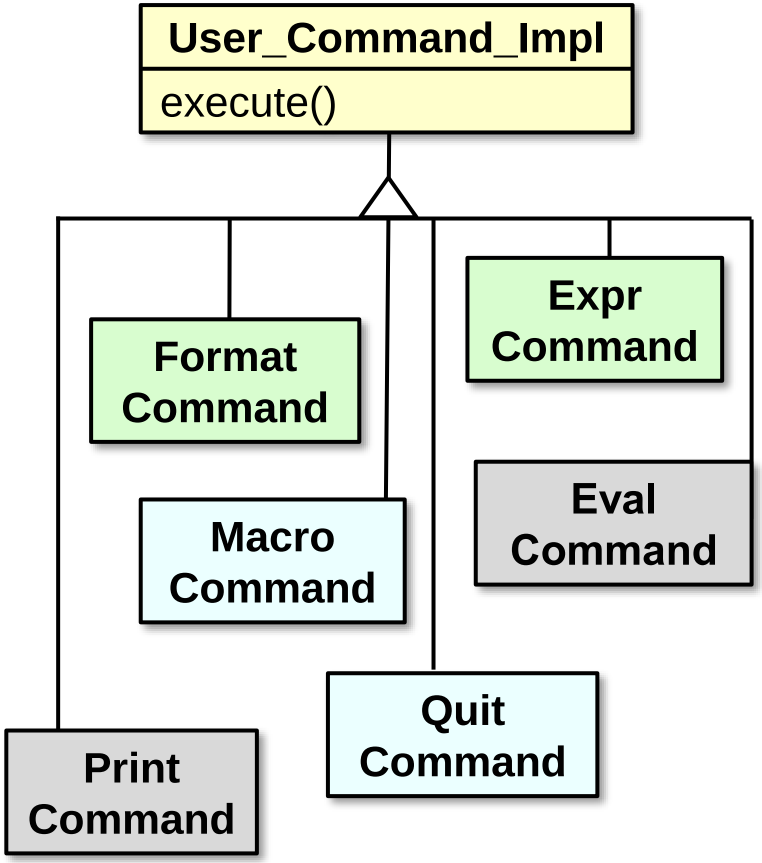


See upcoming lesson on the *State* pattern for an example of forwarding.

Command GoF Object Behavioral

Consequences

+ Abstracts the executor of a service
  - Makes programs more modular & flexible, e.g.,
    - Can bundle state & behavior into an object
    - Can forward behavior to other objects
    - Can extend behavior via derived classing



Command GoF Object Behavioral

Consequences

+ Abstracts the executor of a service
  - Makes programs more modular & flexible, e.g.,
    - Can bundle state & behavior into an object
    - Can forward behavior to other objects
    - Can extend behavior via derived classing
    - Can pass a command object as a parameter

```
void handle_input() {
  ...
  User_Command command =
    make_command(input);




  execute_command(command);
```

The handle_input() method in Input_Handler plays the role of "invoker."

Command GoF Object Behavioral

Consequences

+ Abstracts the executor of a service
  - Makes programs more modular & flexible, e.g.,
    - Can bundle state & behavior into an object
    - Can forward behavior to other objects
    - Can extend behavior via derived classing
    - Can pass a command object as a parameter

```
void handle_input() {
  ...
  User_Command command =
    make_command(input);


  execute_command(command);
```

Call a hook (factory) method to make a command based on user input

See the next lesson on "*The Factory Method Pattern*" for `User_Command_Factory`.

Command GoF Object Behavioral

Consequences

+ Abstracts the executor of a service

- Makes programs more modular & flexible, e.g.,
  - Can bundle state & behavior into an object
  - Can forward behavior to other objects
  - Can extend behavior via derived classing
  - Can pass a command object as a parameter

```
void handle_input() {
  ...
  User_Command command =
    make_command(input);



  execute_command(command);
```

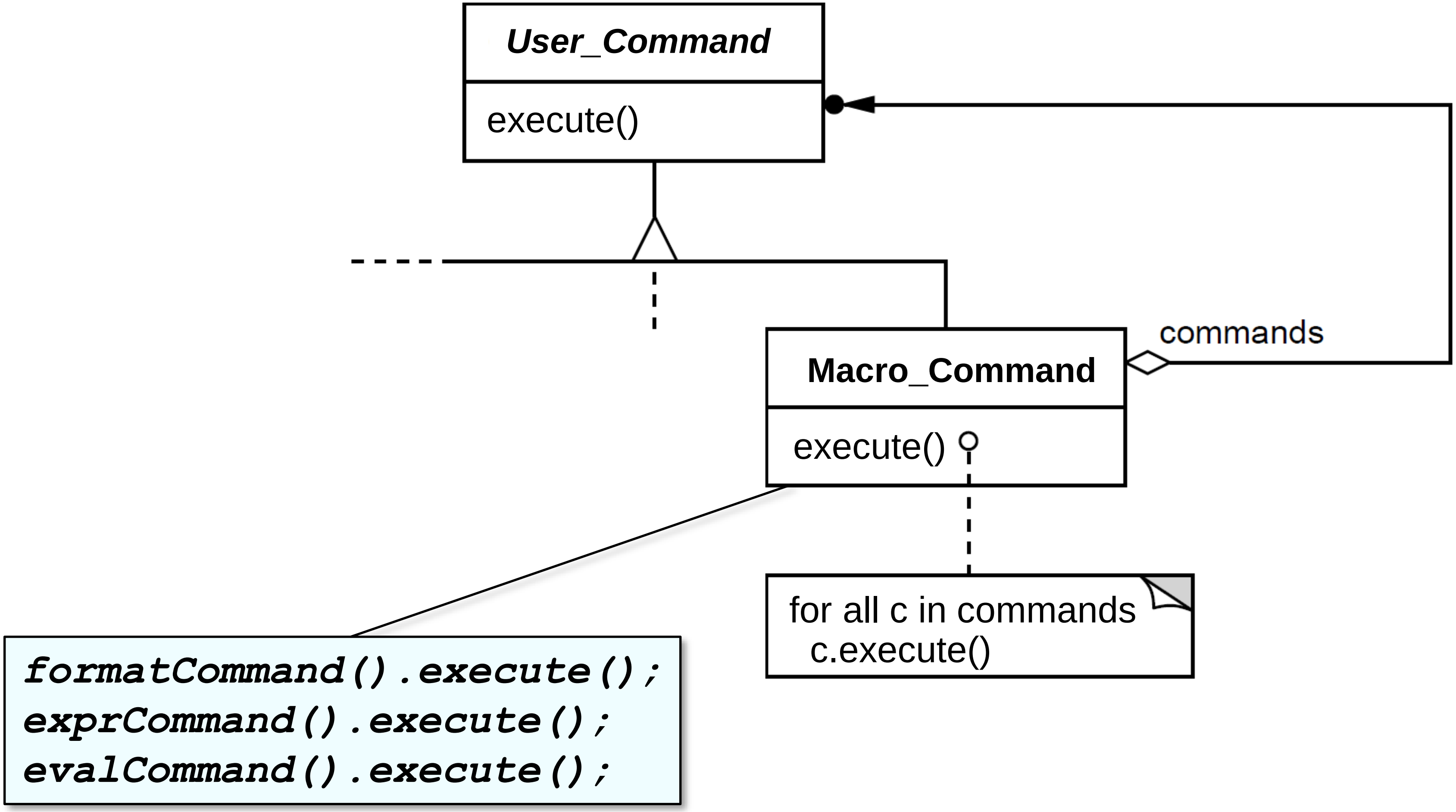
Call a hook method & pass a command to execute

See upcoming lesson on "*The Template Method Pattern*"

Command GoF Object Behavioral

Consequences

+ Composition yields macro commands



for all c in commands
  c.execute()

```
formatCommand().execute();
exprCommand().execute();
evalCommand().execute();
```

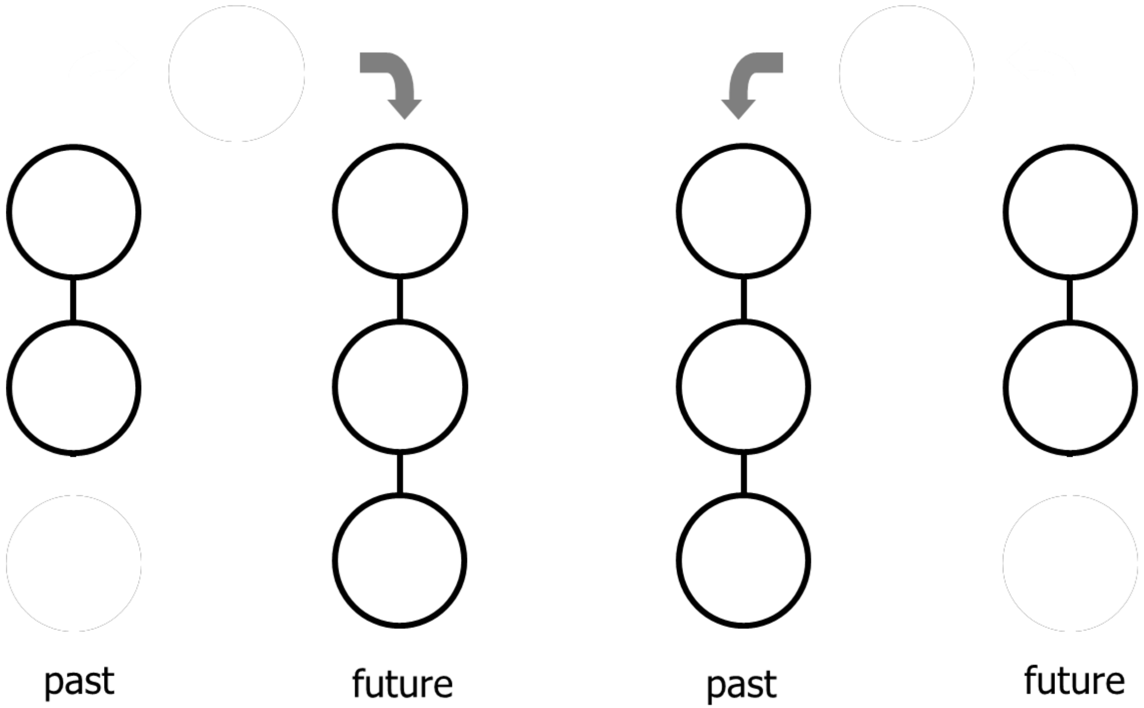
Command GoF Object Behavioral

Consequences

+ Supports arbitrary-level undo-redo

Undo: `unexecute()`

Redo: `execute()`

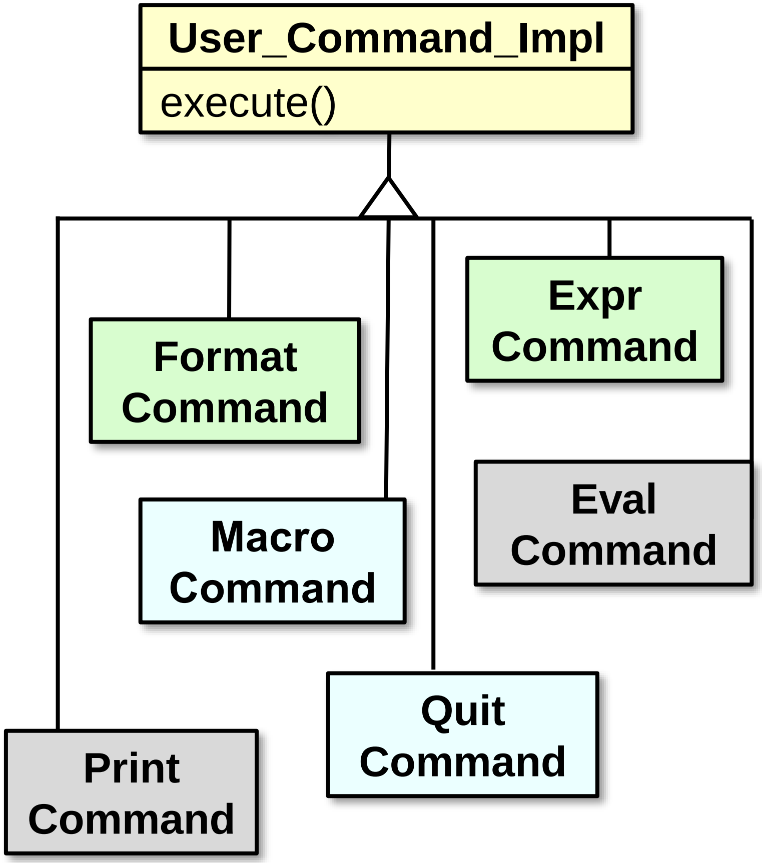


past future past future

Case study doesn't use **`unexecute()`**, but it's a common *Command* feature.

Consequences

– Might result in lots of trivial command derived classes



Command GoF Object Behavioral

Consequences

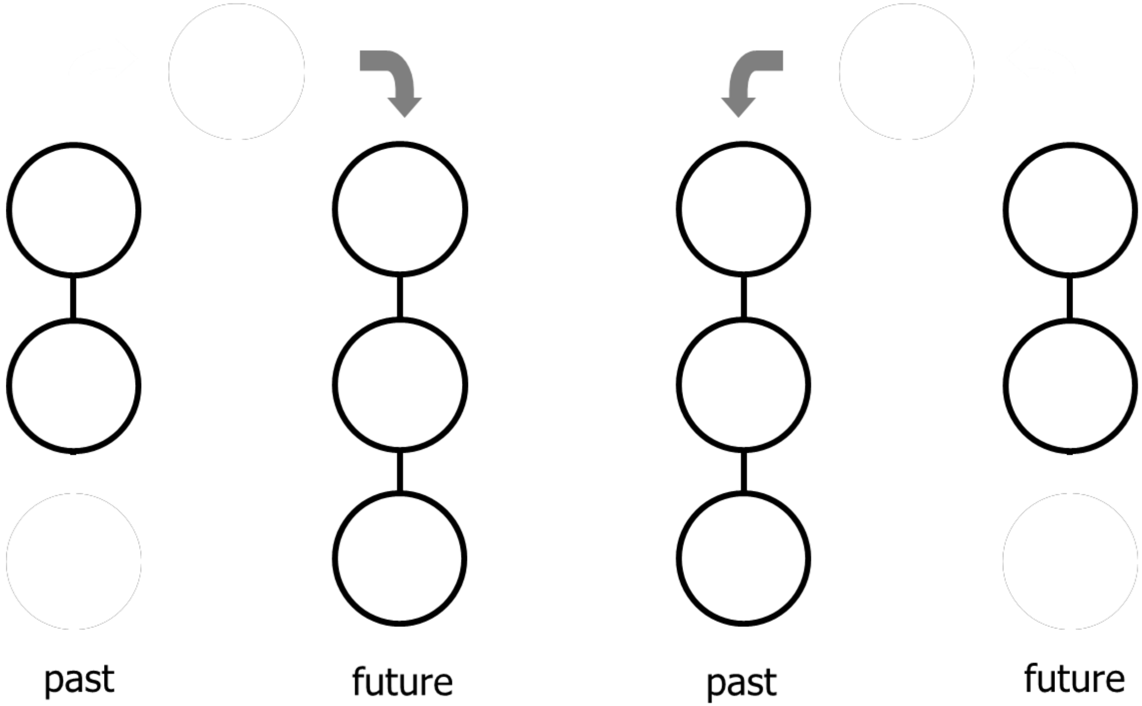
– Excessive memory may be needed to support undo/redo operations

Undo:

`unexecute()`

Redo:

`execute()`

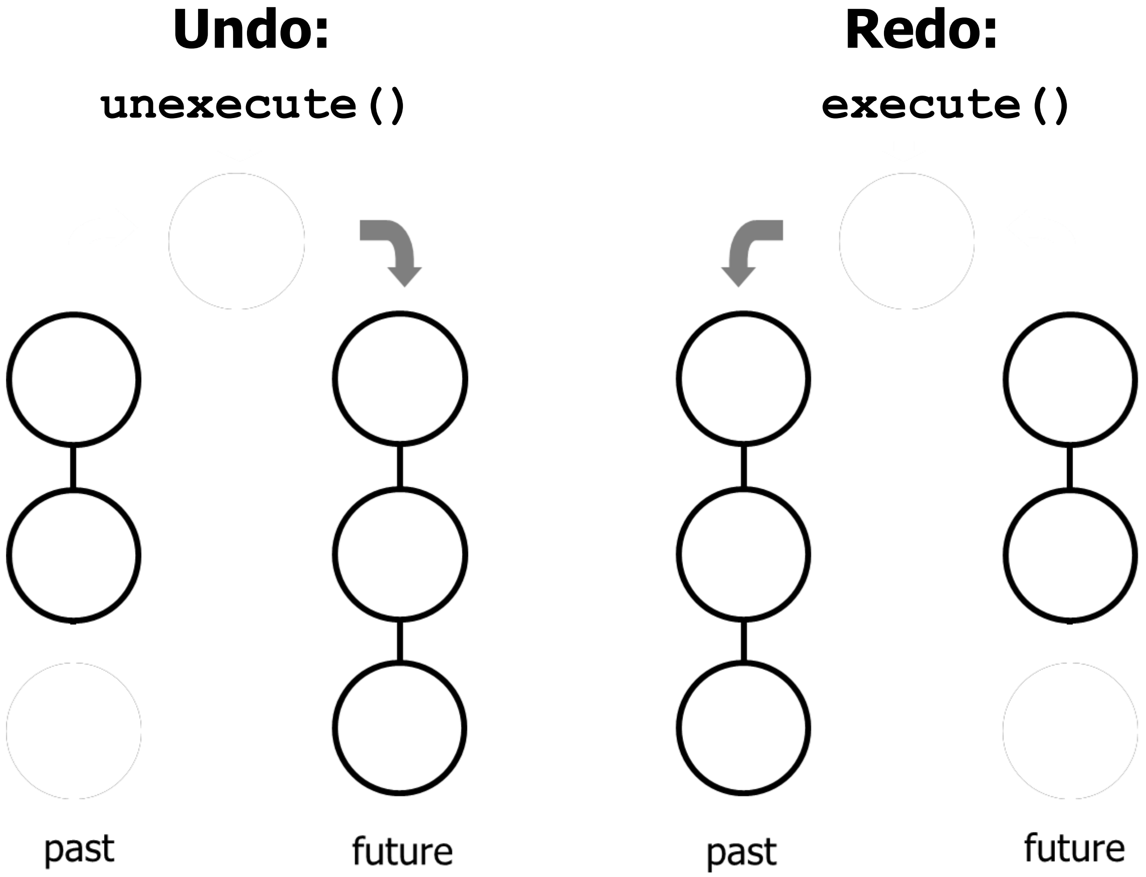


past future past future

Command GoF Object Behavioral

Implementation considerations

- Copying a command before putting it on a history list



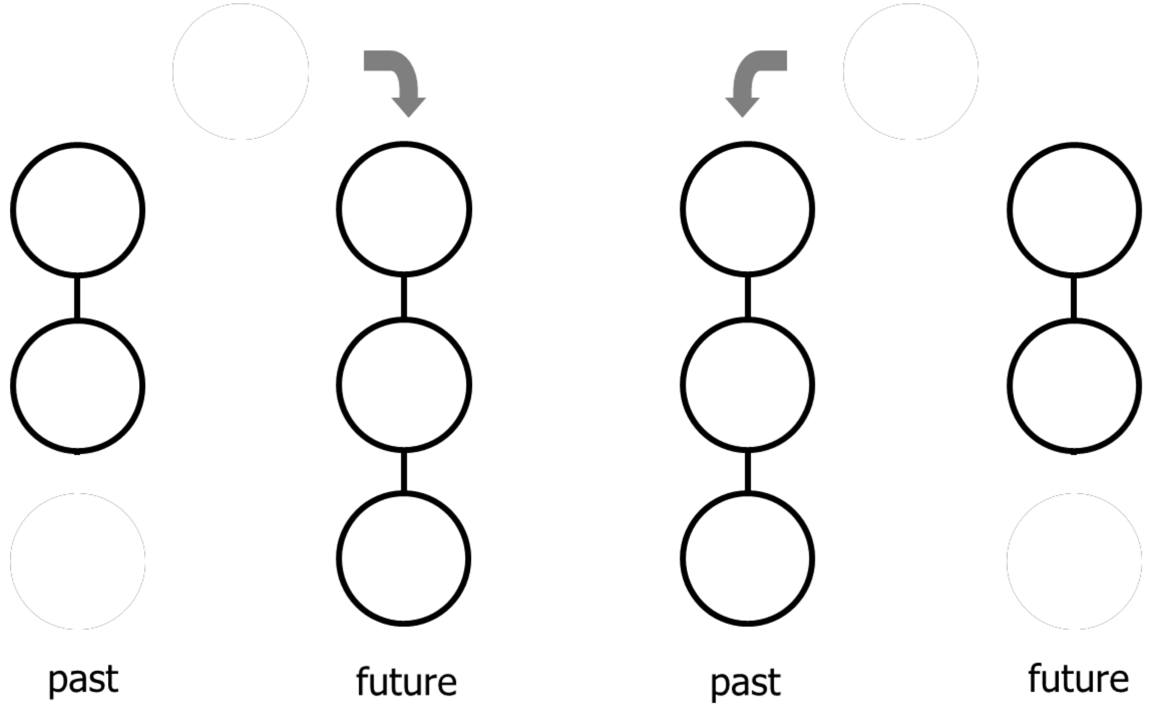
Command GoF Object Behavioral

Implementation considerations

- Avoiding error accumulation during undo/redo

Undo: `unexecute()`

Redo: `execute()`



past

future

past

future

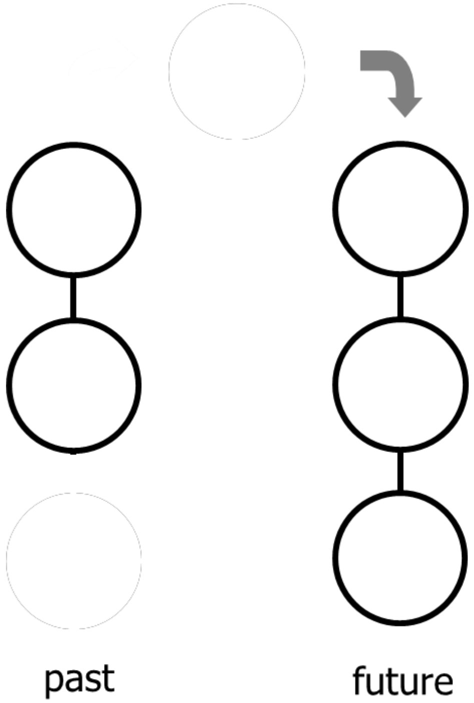
Command GoF Object Behavioral

Implementation considerations

- Supporting transactions

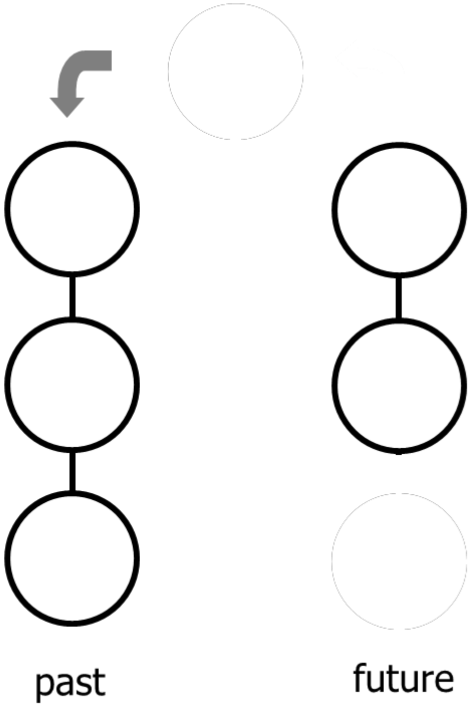
Undo:

`unexecute()`



Redo:

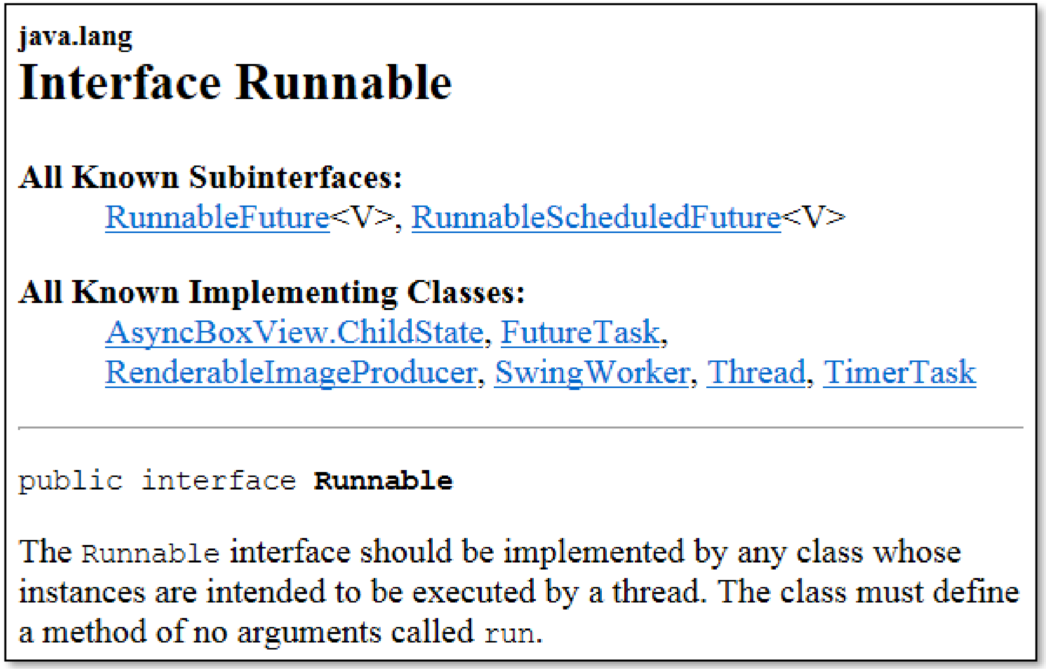
`execute()`



Command GoF Object Behavioral

Known uses

- InterViews Actions
- MacApp, Unidraw Commands
- JDK's UndoableEdit, AccessibleAction
- GNU Emacs
- Microsoft Office tools
- Java **`Runnable`** interface



java.lang

Interface Runnable

All Known Subinterfaces:

RunnableFuture<V>, RunnableScheduledFuture<V>

All Known Implementing Classes:

AsyncBoxView.ChildState, FutureTask, RenderableImageProducer, SwingWorker, Thread, TimerTask

```
public interface Runnable
```

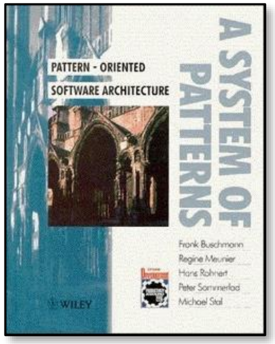
The `Runnable` interface should be implemented by any class whose instances are intended to be executed by a thread. The class must define a method of no arguments called `run`.

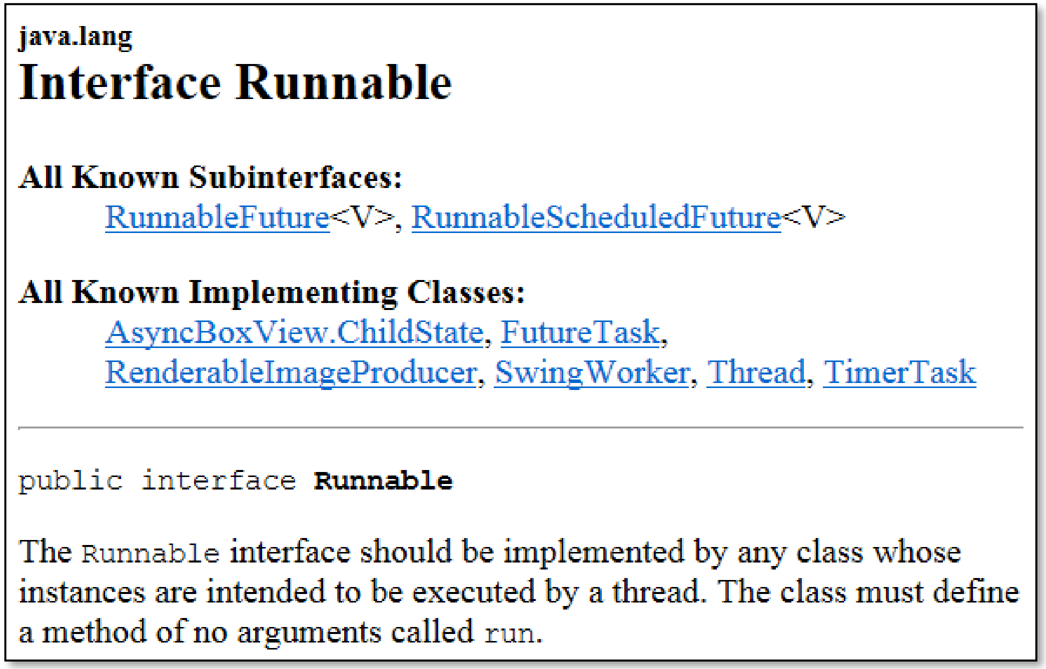
See docs.oracle.com/javase/8/docs/api/java/lang/Runnable.html

Command GoF Object Behavioral

Known uses

- InterViews Actions
- MacApp, Unidraw Commands
- JDK's UndoableEdit, AccessibleAction
- GNU Emacs
- Microsoft Office tools
- Java **`Runnable`** interface
  - **`Runnable`** can also be used to implement the *Command Processor* pattern





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`public interface` **`Runnable`**

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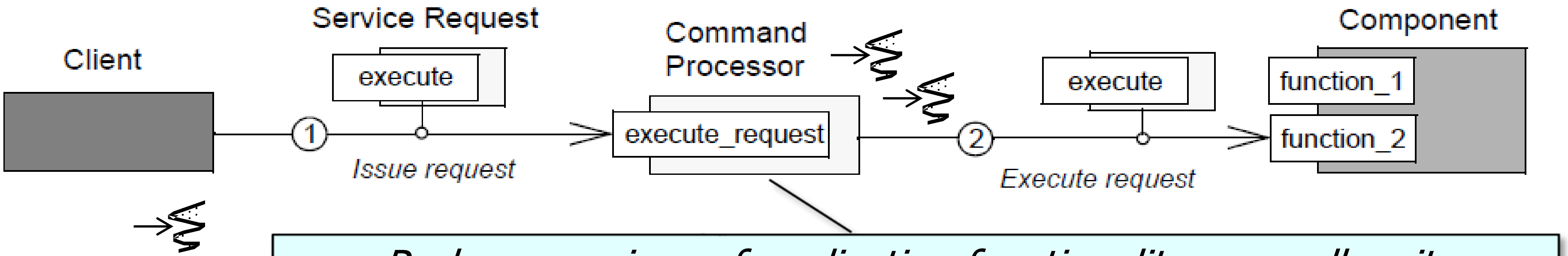
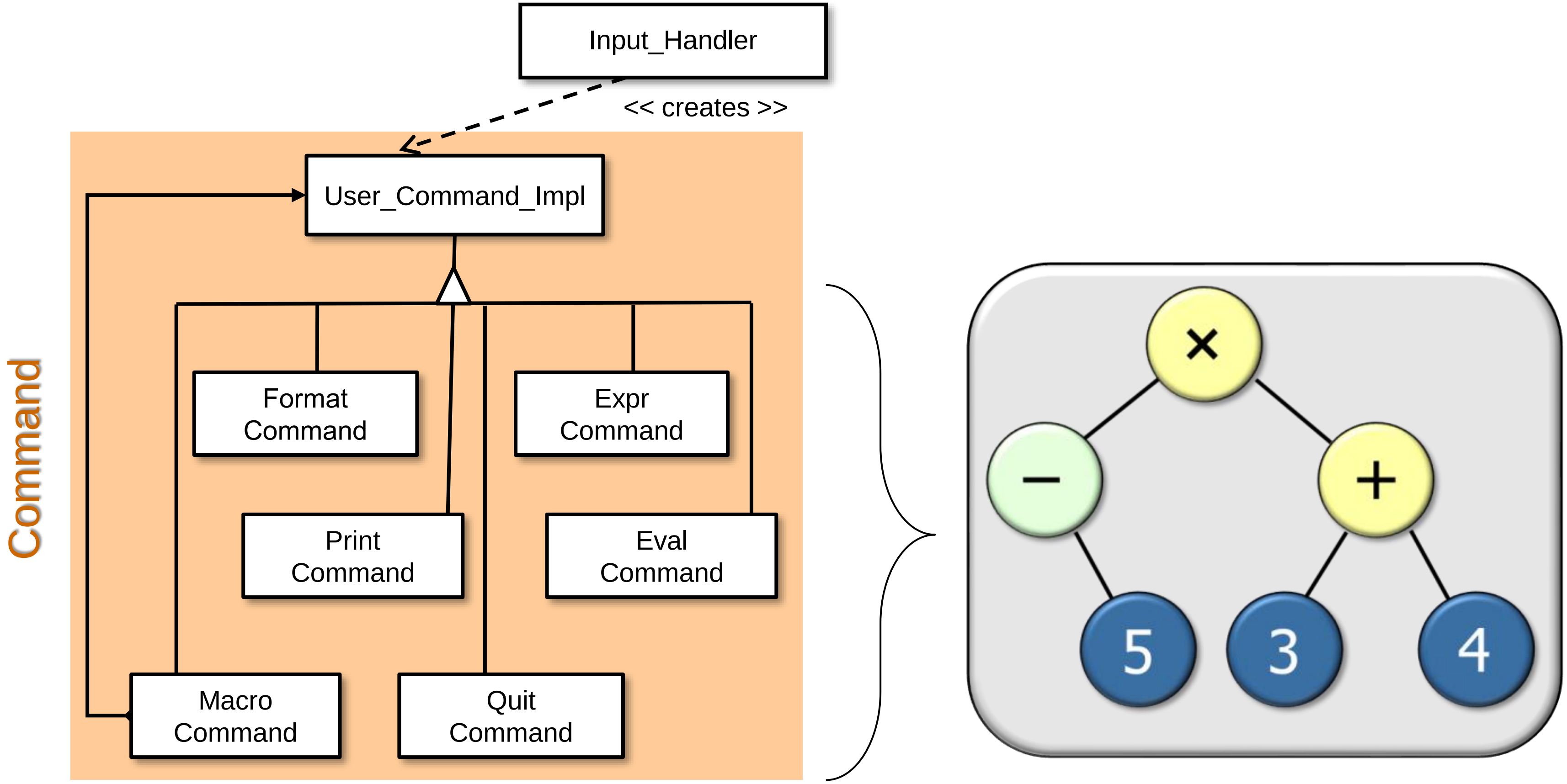


Packages a piece of application functionality—as well as its parameterization in an object—to make it usable in another context

See www.dre.vanderbilt.edu/~schmidt/CommandProcessor.pdf

Summary of the Command Pattern

- *Command* ensures users interact with the expression tree processing app in a consistent & extensible manner.



Command provides a uniform means to process all user-requested operations.