Case Study
Command Do–Undo Interaction

The Domain

- Interactive systems usually have an **undo** operation to be able to back up one or more steps
- To preserve symmetry need to have a corresponding **redo** operation
- One keystroke gives undo another gives redo
- Not all actions are undo-able
  - » **print, save, fire missile**

The Requirements

- Should be applicable to a wide class of interactive applications
- Should not require redesign for each new command that can be undone
  - » **Implies that undo and redo are different in nature than the other commands**
- Make reasonable use of storage
  - » **Cannot save entire state**
  - » **Incremental saves**
- Applicable for one-level undo or multi-level undo

Finding the Abstractions

- Undo and redo are properties of particular commands
- Redo is actually execution of the command in the current context
    - » **Do not need a separate command**

```
deferred class COMMAND feature
   execute is deferred end
   undo is deferred end
end
```

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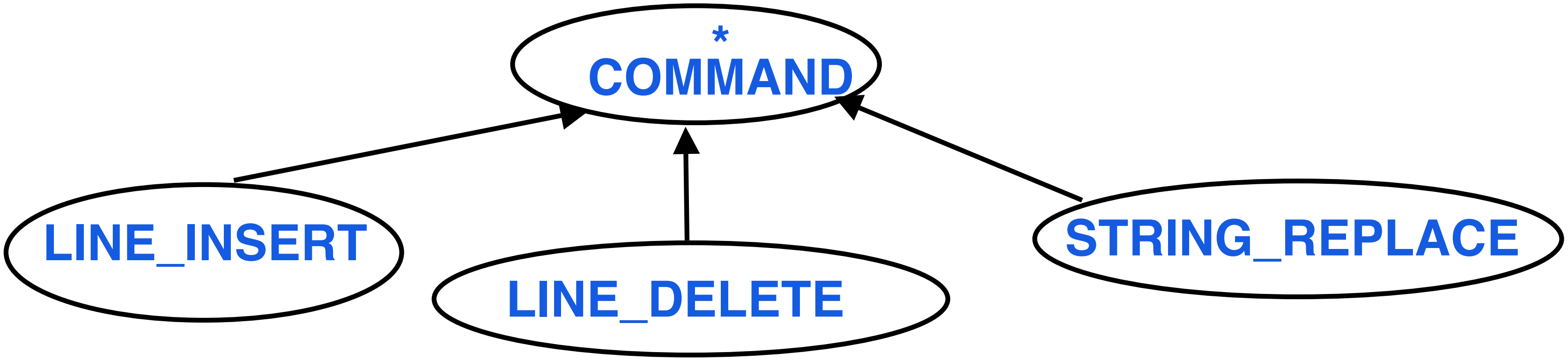
Partial Inheritance Hierarchy



- Each class provides attributes sufficient to support local variants of execute and undo
- Undo/redo spread through the system
  - » **Operations distributed over data**

Class LINE_DELETE

```
class LINE_DELETE inherit  COMMAND
feature
   deleted_line_index : INTEGER
   deleted_line : STRING

   set_deleted_line_index ( n : INTEGER ) is
      do deleted_line_index := n end

   execute is
      -- delete line
   end

   undo is
      -- restore the last line
   end
end
```

45	deleted_line_index
"text line"	deleted_line

INTERPRETER Class – Run feature

- The root for execution

```
class INTERPRETER create run feature
 ...
  run is do
    from
      start
    until
      quit_confirmed
    loop
      interactive_step
    end
  end
 ...
end
```

Interactive Step – 1 level Undo – template

```
interactive_step  is do
  -- get latest user request and decode it
  if normal_command then
      -- execute the command
  elseif request is undo then -- toggle undo/redo
    if there is a command to undo then
      -- undo last command
    elseif there is a command to redo then
      -- redo the command
    end
  else report erroneous request
  end
end
```

Interactive Step – One Level Undo

```
requested : COMMAND      -- remember only 1cmd

 interactive_step  is
local cmd_type : INTEGER
do
   cmd_type :=   get_and_decode_user_request

         -- create object and attach it to requested
   create_command (cmd_type) -- sets requested

   -- Do the command

end
```

Interactive Step – Do the Command

```
if normal_command then
    requested.execute ; undoing := False
elseif request is undo and requested /= void then
   if undoing then --  2'nd undo in a row is a redo !
            requested.execute ; undoing := False
    else requested.undo ; undoing := True
    end
else report erroneous request
end
```

Technicalities

- Do not store the full state, just the difference
- Key to solution
  - » **dynamic binding & polymorphism**
    - > **requested.execute & requested.undo**
- Nothing application specific
  - » **Add specific subclasses of COMMAND**

Creating a COMMAND Object

- Do after decoding a request
- All commands created are descendants of COMMAND
- What about commands with no undo?

```
create_command (cmd_type : INTEGER) is do
    if cmd_type is Line_Insert then
        create {LINE_INSERT} requested.make(...)
    elseif cmd_type is Line_Delete then
        create {LINE_DELETE} requested.make(...)
    elseif ....
end
```

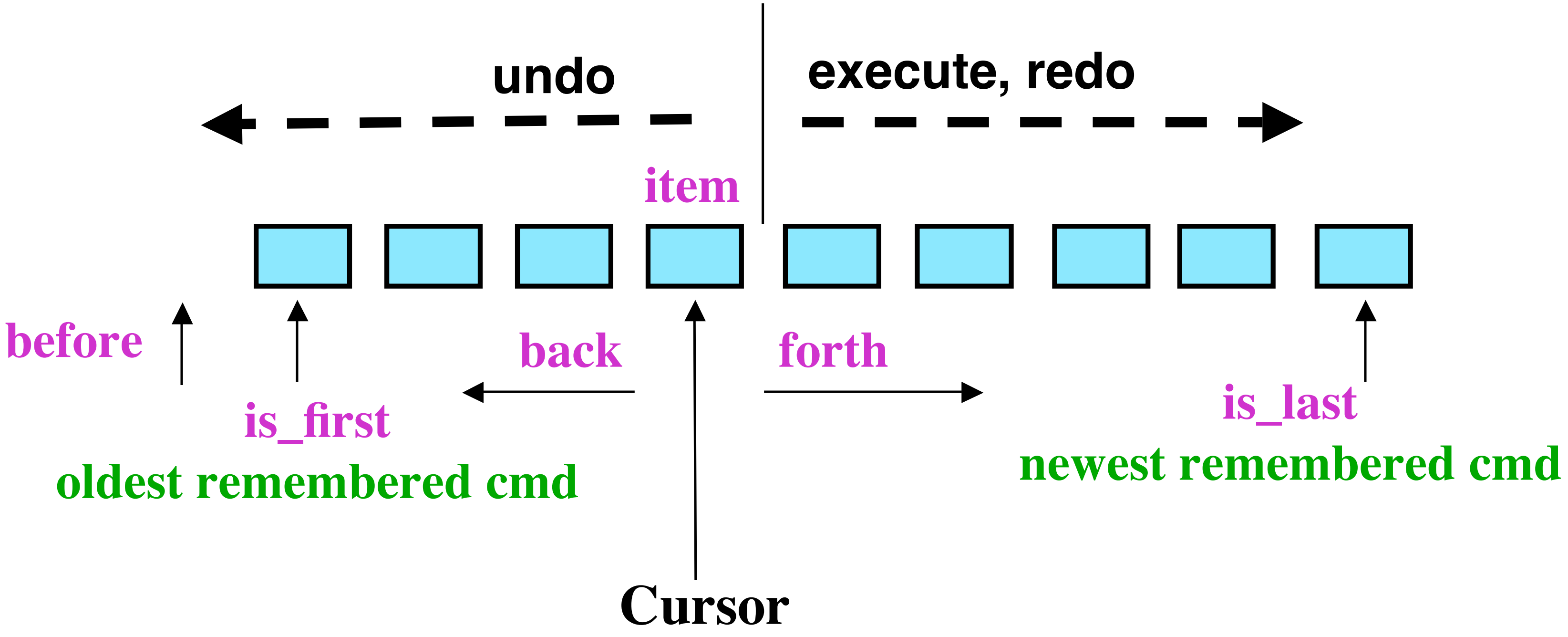
Multi-Level Undo

- Need to maintain a history of previous commands
  - **Actually keep only the commands in the path from start to last command**
    - **or as far back as we are able to remember**
- Also have a cursor to move back and forth through that single path

History List

history : LIST [COMMAND]

- Features in magenta



Undo

```
history : LIST [ COMMAND ]

if not history.empty and not history.before then
    history.item.undo
    history.back
else
    message ("Nothing to undo")
end
```

Redo

```
history : LIST [ COMMAND ]

if not history.is_last then
    history.forth
    history.item.redo   -- redo a synonym for execute
else
    message ("Nothing to redo")
end
```

Execute Normal Command

```
history : LIST [ COMMAND ]

if not history.is_last then
    history.remove_all_right
end
    history.put ( requested )
    requested.execute
```

Issue: Command Arguments

- Some commands will need arguments
  > LINE_INSERT need lines of text
- Solution
  > Add to COMAND an attribute and a procedure to set the argument

```
argument : ANY
set_argument (a : like argument ) is
do  argument := a  end
```

Many arguments?

- Alternate is to pass the argument through execute

```
execute ( argument : ANY ) is ...
```

Issue: create_command Structure

- We can do better than the **if ... then ... elseif ...** structure of **create_command**

- Pre-compute an instance of every command
  - » **polymorphic instance set**

```
commands : ARRAY [ COMMAND ]

create commands.make ( 1, command_count )
create {LINE_INSERT} requested .make
   commands.put ( requested , 1 )
create {LINE_DELETE} requested .make
   commands.put ( requested , 2 )
...
```

Issue: create_command Structure – 2

- Replace the feature **create_command** with ...

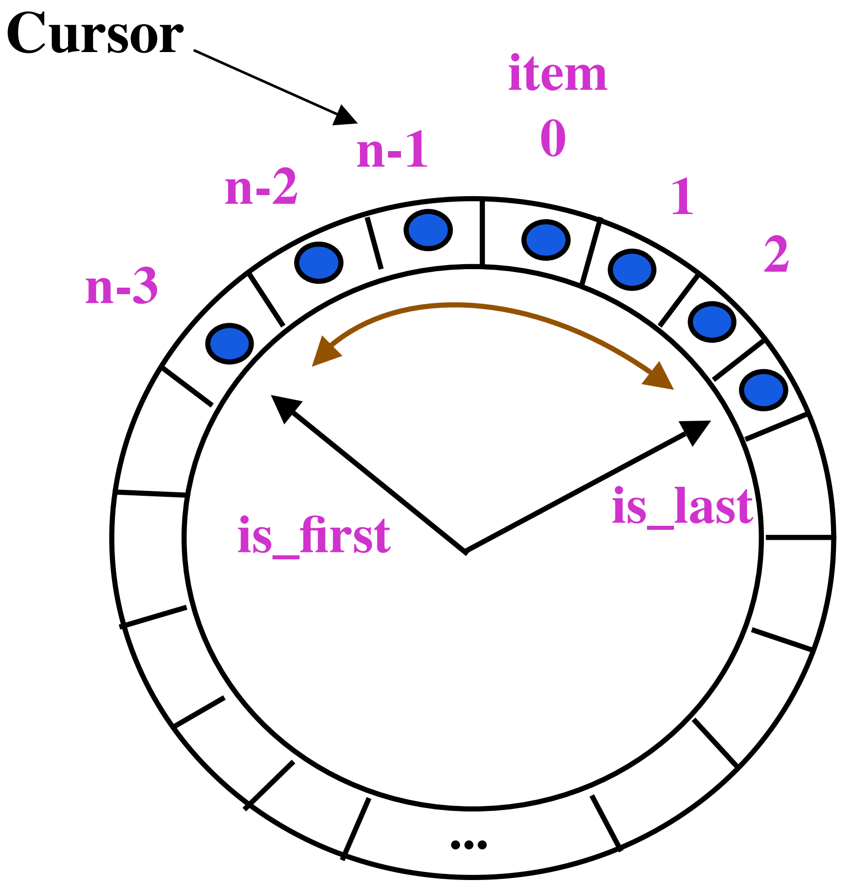
  requested := (commands @ cmd_type) . twin

- If the argument is passed through execute, then only one instance of each command is needed. Do not need to clone.

  requested := commands @ cmd_type

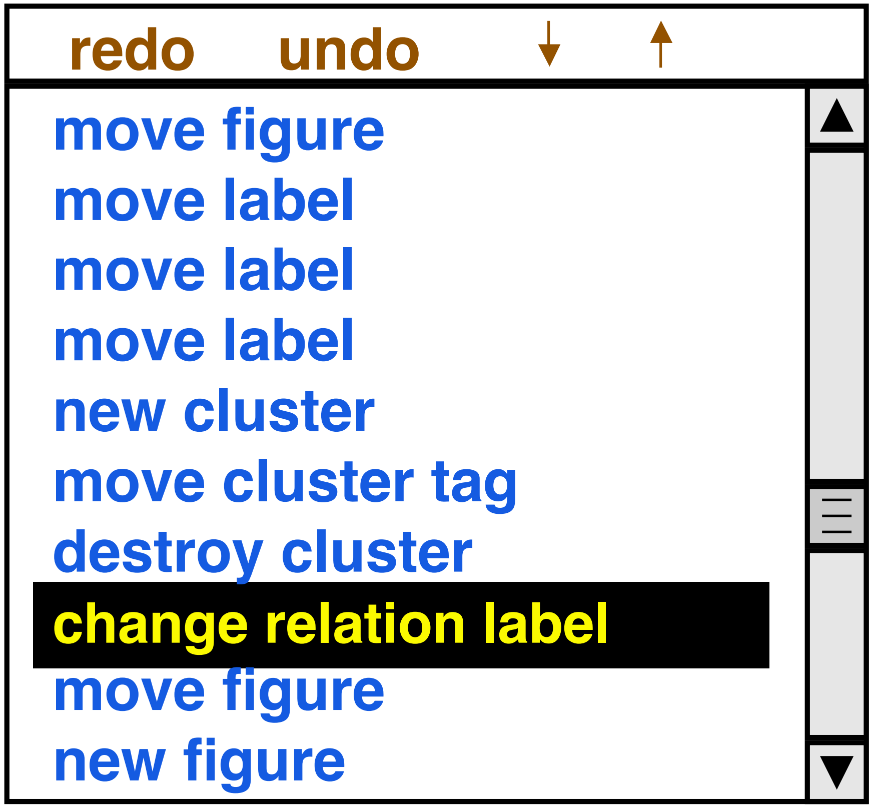
History List Implementation

- Circular Array if bounded capacity is suitable



User Interface

- Correspondence with implementation
  - » **Could have derived either from the other**



move figure
move label
move label
move label
new cluster
move cluster tag
destroy cluster
change relation label
move figure
new figure

Points to Ponder – 1

- Design may involve many relatively small classes
  - » **one for each type of command**
- Simple inheritance structure, so efficiency is not a concern
- Efficiency concerns often arise when you introduce classes to represent actions
  - » **Does this abstraction deserve to be a class?**
    - > **Individual sort algorithms**
    - > **Can pass the algorithm to use in other routines**
    - > **Example FlexOr sort**

InsertSort as Object – Java

```
public class InsertSort implements ArraySort {

  public void sort ( final Object[] array,
                           final BinaryPredicate bp ) {

     execute ( array , bp );
  }

   public static void execute ... // see next slide
     // can also use without an instance in Java
    //         InsertSort.execute (.... )
}

// Notice that BinaryPredicate is also an executable
// object
```

InsertSort – 2

```
public static void execute ( final Object [] array,
                             final BinaryPredicate bp) {
    Object tmp;
    for (int i = 1 ; i < array.length ; i++) {
      for ( int j = i
           ; j > 0  && bp.execute (array [ j ] , array [ j – 1 ] )
           ; j-- ) {
         tmp = array [ j ];
         array[j] = array [ j – 1 ];
         array [ j – 1 ] = tmp;
      }
    }
  }
// BinaryPredicate is an executable object defined in a
// similar way to InsertSort
```

Points to Ponder – 2

- Alternate is to pass functions as arguments
- Example function passing
  - » **Numerical integration that needs the function f to use for integration**
    - > **C approach pass f to the integration routine**
    - > **OO approach f as an object**
      - – **Use data abstraction to make it a class**
      - – **With the desired function as a feature**
      - – **Pass the object to the integration method**

Points to Ponder – 3

- Not all function passing is poor practice
    - > **Different paradigm**
  - » **Agents in Eiffel**
  - » **Functional programming**
    - > **Pass functions a input**
    - > **Return functions as output**
      - – **Functions compute functions to use later !**