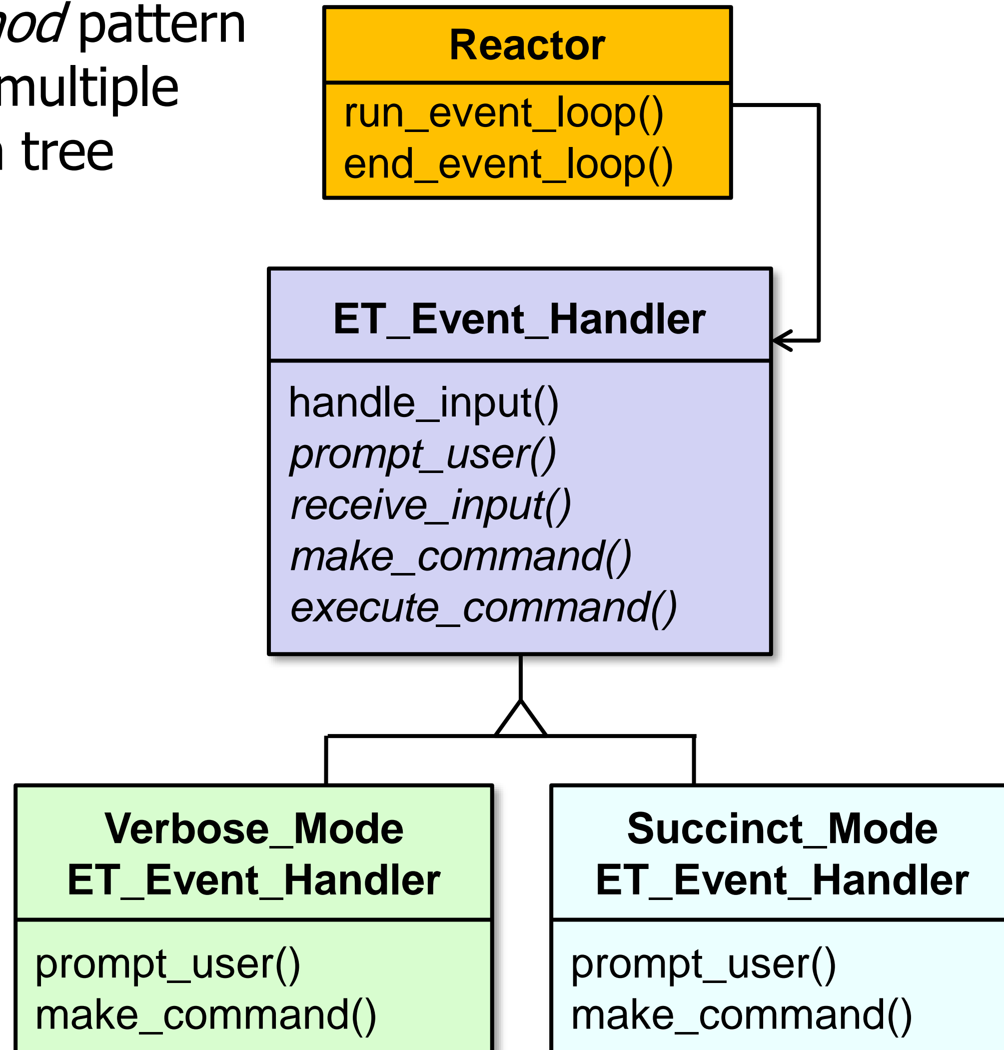
The Template Method Pattern

Motivating Example

Douglas C. Schmidt

Learning Objectives in This Lesson

- Recognize how the *Template Method* pattern can be applied to flexibly support multiple operating modes in the expression tree processing app.



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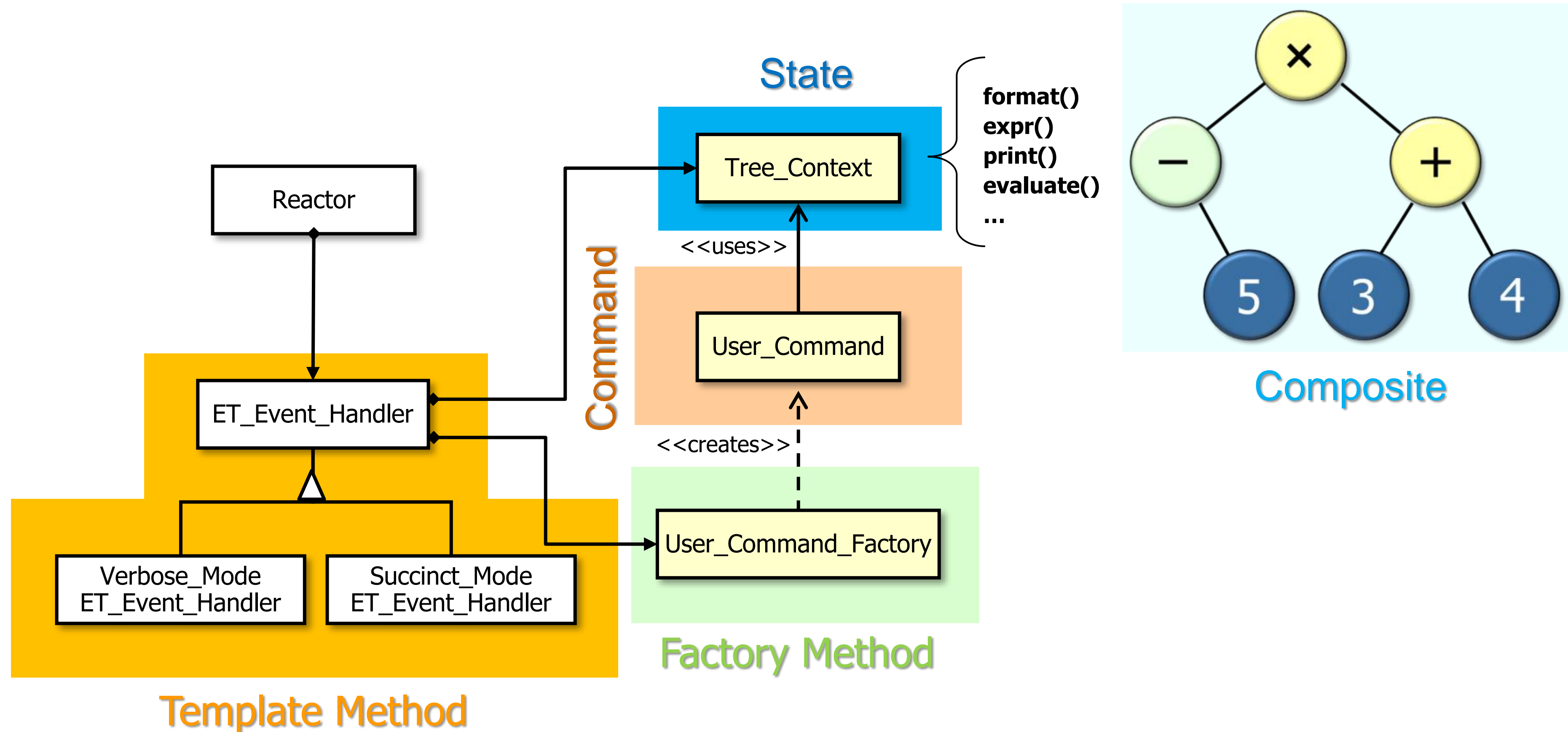
Motivating the Need for the Template Method Pattern in the Expression Tree App

A Pattern for Encapsulating Algorithm Variability

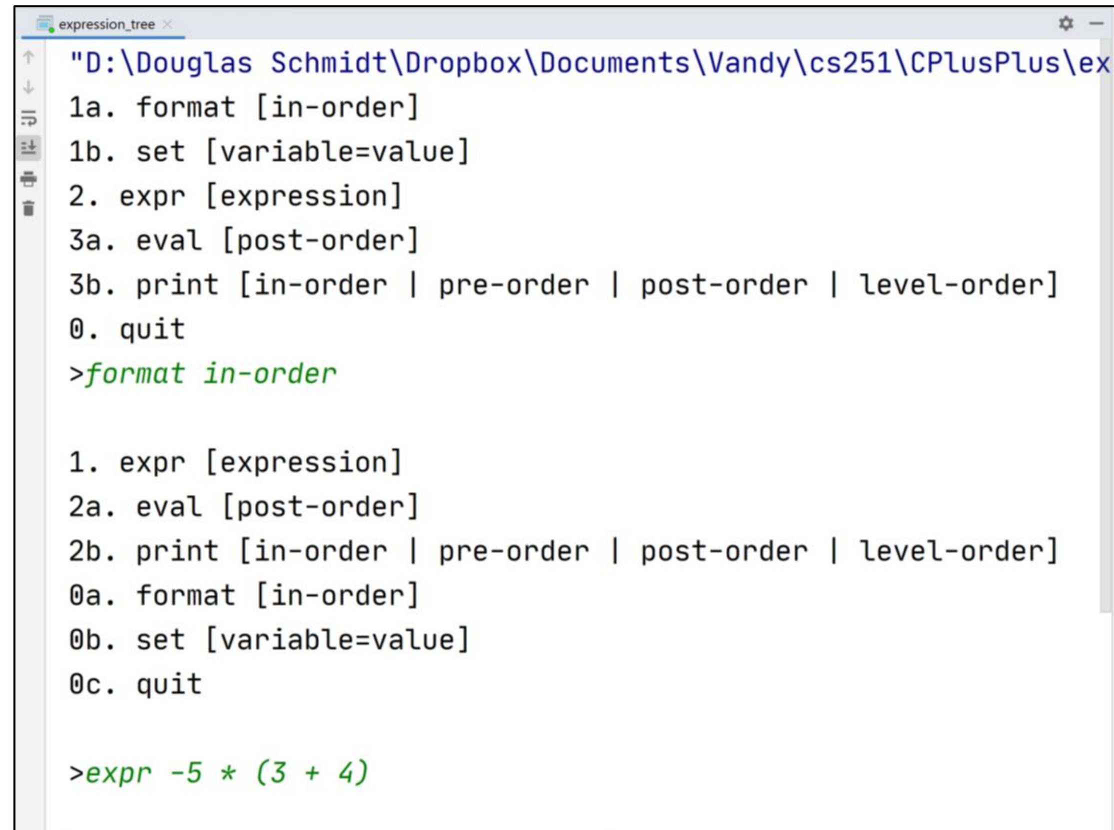
***Purpose**: Factor out common code to support multiple operating modes (succinct vs. verbose).*



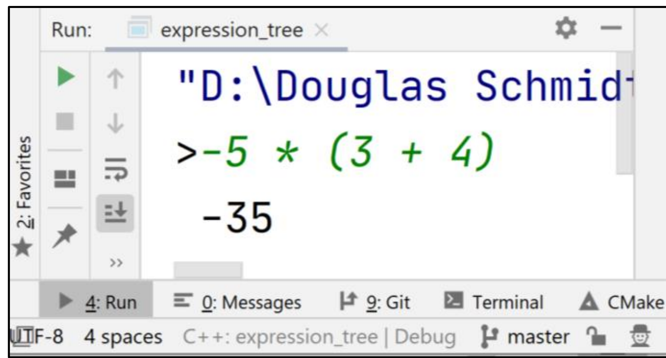
Template Method supports controlled variability of steps in an algorithm.

Context: OO Expression Tree Processing App

- This app has two primary operating modes: *verbose* & *succinct*.



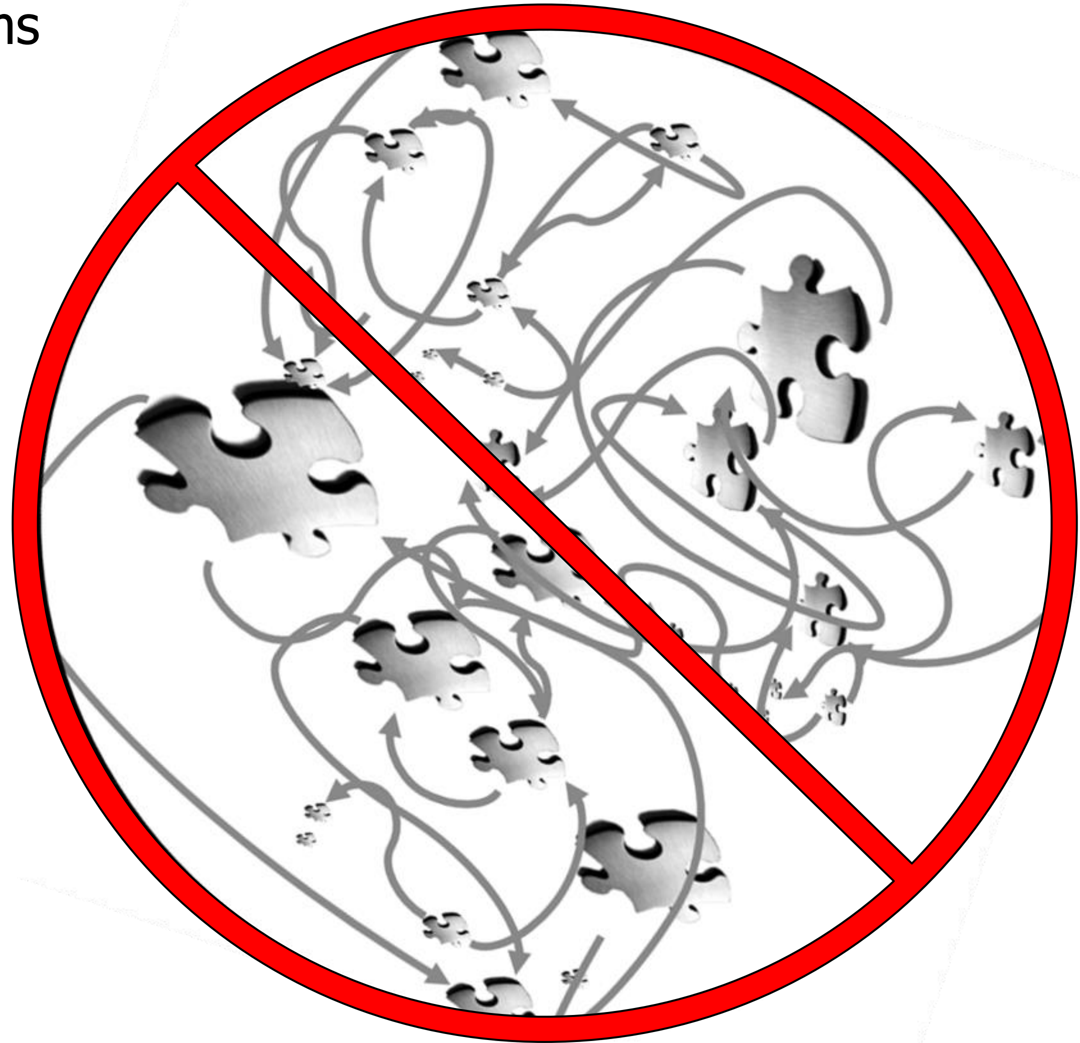
Succinct mode



Verbose mode

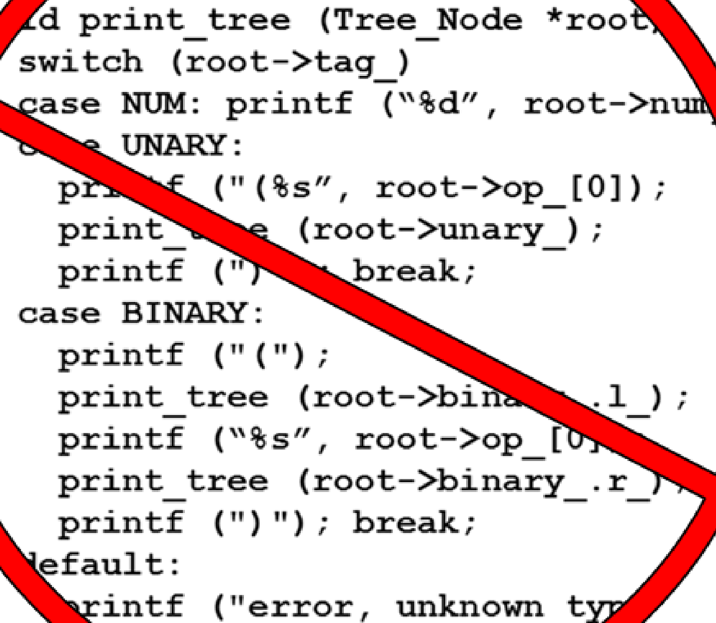
Problem: Non-Extensible Operating Modes

- Structuring the program in terms of the two operating modes' algorithms is problematic.



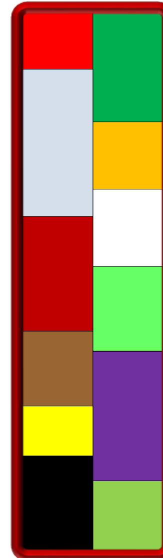
Problem: Non-Extensible Operating Modes

- Structuring the program in terms of the two operating modes' algorithms is problematic, e.g.,
  - Incurs many of the same limitations as algorithmic decomposition
    - e.g., complexity will reside in (variable) algorithms rather than (stable) structure



Problem: Non-Extensible Operating Modes

- Structuring the program in terms of the two operating modes' algorithms is problematic, e.g.,
  - Incurs many of the same limitations as algorithmic decomposition
  - Impedes maintainability & evolution of the code base due to "silo'ing"



```
expression_tree
"D:\Douglas Schmidt\Dropbox\Documents\Vandy\cs251\CPlusPlus\ex
1a. format [in-order]
1b. set [variable=value]
2. expr [expression]
3a. eval [post-order]
3b. print [in-order | pre-order | post-order | level-order]
0. quit
>format in-order

1. expr [expression]
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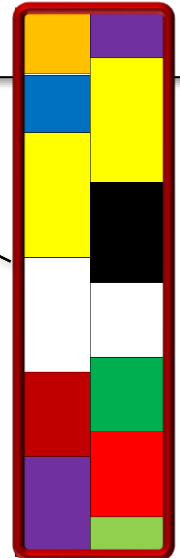
0a. format [in-order]
0b. set [variable=value]
0c. quit

>expr -5 * (3 + 4)
```

Silo'ing (non-reusable) code

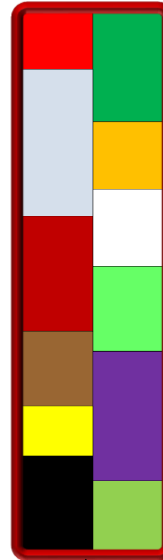
```
Run: expression_tree
"D:\Douglas Schmidt
>-5 * (3 + 4)
 -35
```

4: Run   0: Messages   9: Git   Terminal   CMake
UTF-8   4 spaces   C++: expression_tree | Debug   master



Problem: Non-Extensible Operating Modes

- Structuring the program in terms of the two operating modes' algorithms is problematic, e.g.,
  - Incurs many of the same limitations as algorithmic decomposition
  - Impedes maintainability & evolution of the code base due to "silo'ing", e.g.,
    - Verbose mode algorithm bug fixes & improvements won't be reused by succinct mode algorithms



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>expr -5 * (3 + 4)
```

Stovepiped (non-reusable) code

```
Run: expression_tree
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4: Run   0: Messages   9: Git   Terminal   CMake
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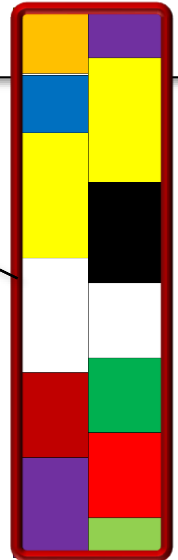

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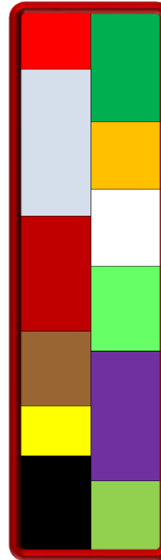
- Structuring the program in terms of the two operating modes' algorithms is problematic, e.g.,
  - Incurs many of the same limitations as algorithmic decomposition
  - Impedes maintainability & evolution of the code base due to "silo'ing", e.g.,
    - Verbose mode algorithm bug fixes & improvements won't be reused by succinct mode algorithms
    - Violates the "Don't Repeat Yourself" (DRY) principle



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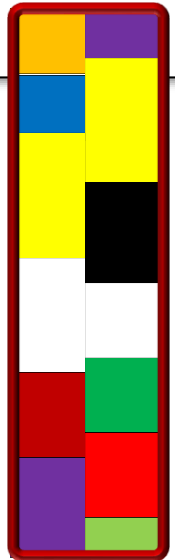
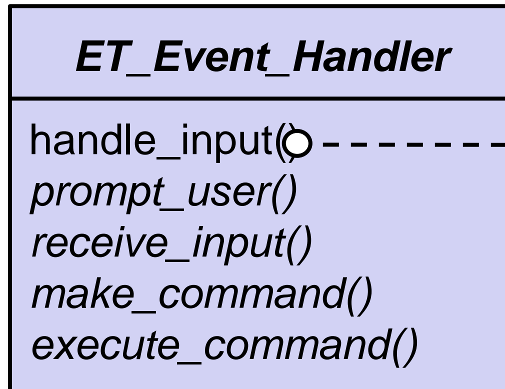


See en.wikipedia.org/wiki/Don't_repeat_yourself

Solution: Encapsulate Algorithm Variability

- Implement algorithm once in super class

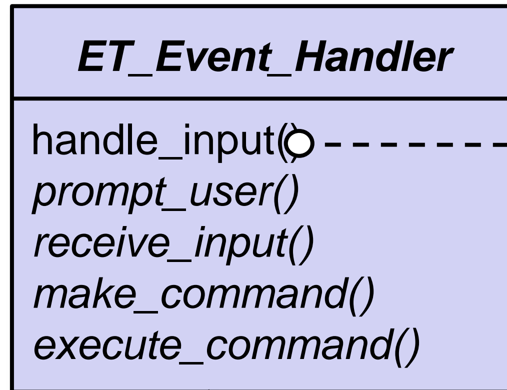



```
void handle_input(){
  prompt_user();
  string input = receive_input();
  User_Command command =
                    make_command(input);
  execute_command(command))
}
```

handle_input() is a template method.

Solution: Encapsulate Algorithm Variability

- Implement algorithm once in super class

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void handle_input(){
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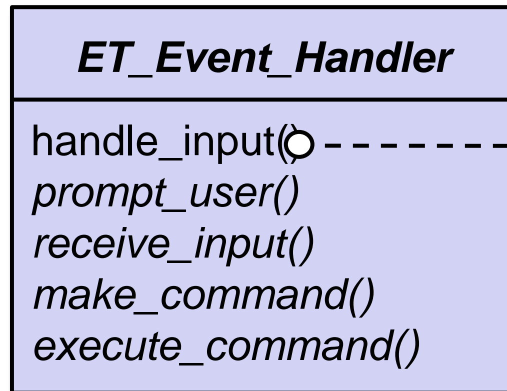
```

The other four methods are "hook methods."

handle_input() is a template method.

Solution: Encapsulate Algorithm Variability

- Implement algorithm once in super class & let subclasses define variants.




```
void handle_input(){
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}
```

Verbose_Mode ET_Event_Handler

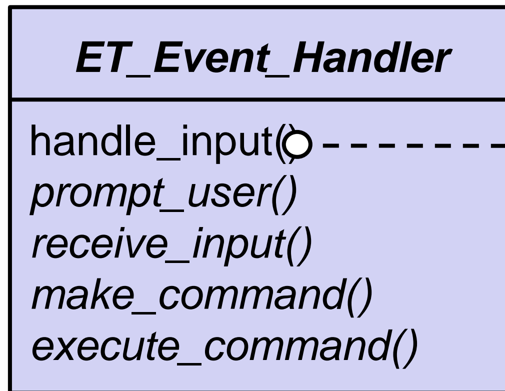
prompt_user()
make_command()

Succinct_Mode ET_Event_Handler

prompt_user()
make_command()

Solution: Encapsulate Algorithm Variability

- Implement algorithm once in super class & let subclasses define variants.

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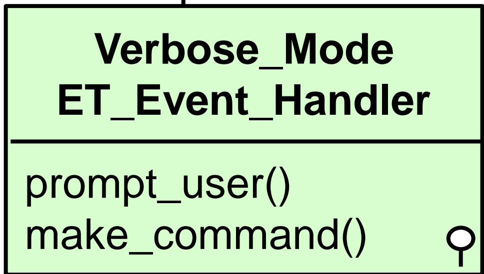
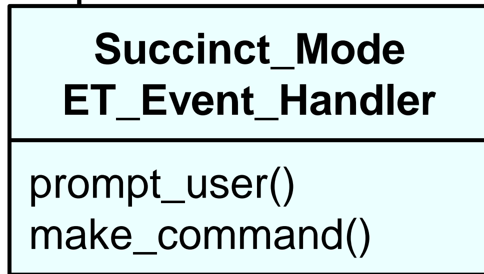




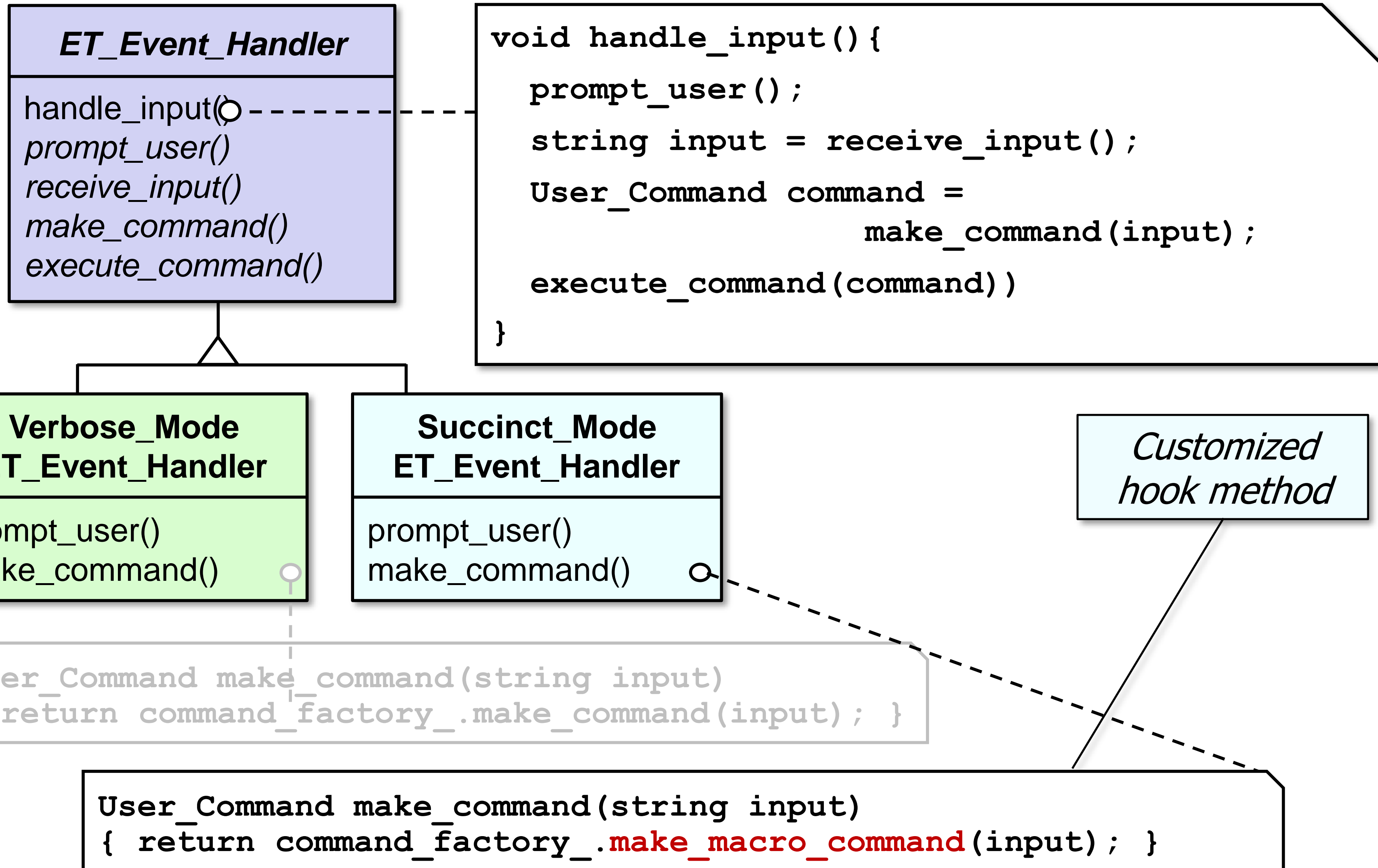
Customized hook method

```
User_Command make_command(string input)
{ return command_factory_.make_command(input); }
```

See earlier lesson on "*The Command Pattern: Implementation in C++*."

Solution: Encapsulate Algorithm Variability

- Implement algorithm once in super class & let subclasses define variants.



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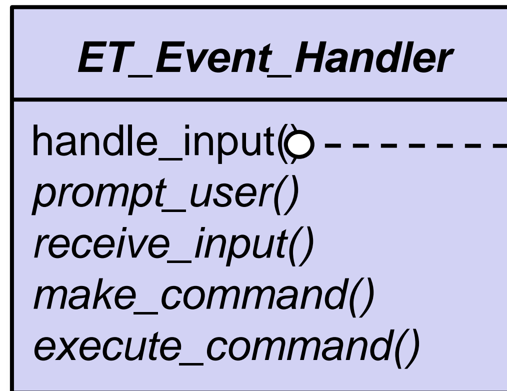


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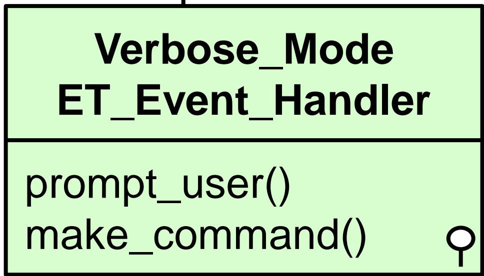

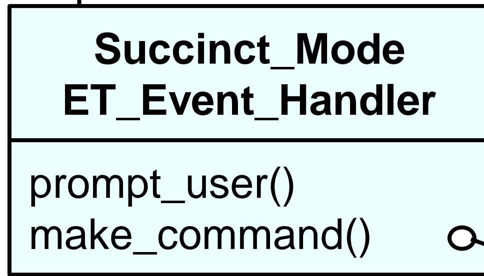

```
User_Command make_command(string input)
{ return command_factory_.make_command(input); }
```

```
User_Command make_command(string input)
{ return command_factory_.make_macro_command(input); }
```

This solution increases opportunities for systematic software reuse.

ET_Event_Handler Class Overview

- An abstract class that provides the boilerplate algorithm for controlling the operating modes of the expression tree processing app

Class methods

```
                 void handle_input()
                 void prompt_user()
               String receive_input()
         User_Command make_command(string input)
                 void execute_command(User_Command command)
                static
     ET_Event_Handler make_handler(bool verbose)
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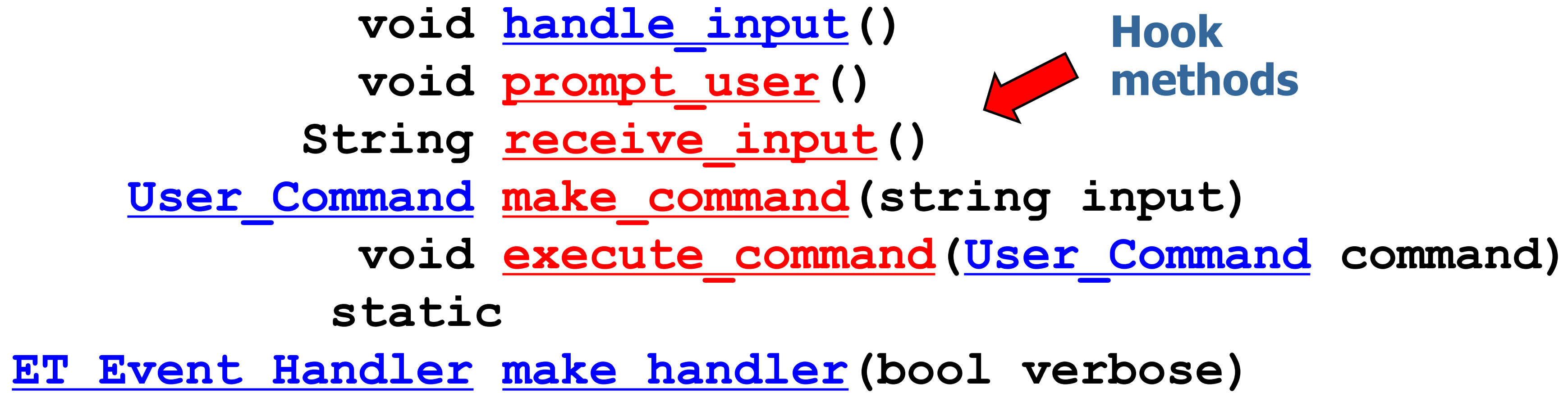

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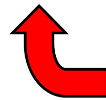

Factory method

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```

- **Commonality**: provides a common interface for handling user input events & performing steps in the expression tree processing algorithm
- **Variability**: subclasses implement various operating modes, e.g., verbose vs. succinct mode

ET_Event_Handler Class Hierarchy Overview

- The subclasses of **`ET_Event_Handler`** override several of its hook methods to implement the "verbose" & "succinct" operating modes.