CS
3

Introduction to Software Design

Design Patterns

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You should care about them because...

- You could come up with these solutions on your own, but you shouldn't have to!
- Programming languages do not build in solutions to every problem

The Output Tree ("Abstract Syntax Tree")

We can represent any mathematical expression as a tree where the root is the operation and the children are the operands.

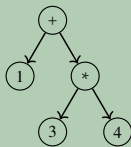### The Output Tree ("Abstract Syntax Tree")

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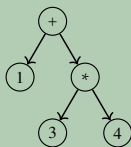
For example, given $1 + 3 * 4$, we would have:


```
 1 class Expression { }
 2 class BinaryExpression { }
 3 class AdditionExpression extends BinaryExpression {
 4     Expression left, right;
 5 }
 6 class MultiplicationExpression extends BinaryExpression {
 7     Expression left, right;
 8 }
 9 class NumberExpression extends Expression {
10     int value;
11 }
```

Problem (Inheritance)

We want to be able to model a relationship across types (e.g., a `BinaryExpression` **is a subtype of** `Expression`).

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Solution (Casting Structs)

*If two structs have the same **beginning layout**, the larger one can be cast to the smaller one. (What?)*
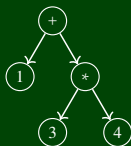
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Example

```
1  struct Int {
2      int i;
3  };
4
5  struct IntAndDouble {
6      int i;
7      double d;
8  };
9
10 struct DoubleAndInt {
11     double d;
12     int i;
13 };
```

```
 1 enum expression_type_t {
 2     NUMBER_EXPRESSION,
 3     ADDITION_EXPRESSION,
 4     MULTIPLICATION_EXPRESSION
 5 };
 6 struct expression {
 7     expression_type_t type;
 8 };
 9 struct binary_expression {
10     expression_type_t type;
11     expression *left, *right;
12 };
13 struct number_expression {
14     expression_type_t type;
15     int value;
16 };
```

How should we decompose the following program flow?
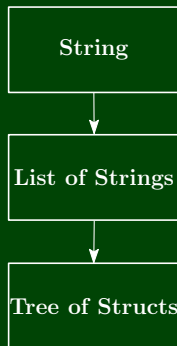
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A header file is really just a listing of types and functions defined by the corresponding C file. We can use it as a specification for what the implementation should do.

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Example

You've seen many of these, but here's the AST example from the previous slide.

Problem (Encapsulation)

Users should not know or be able to edit our internal representation.

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- *Define the typedef in the header file, but put the actual definition inside a C file.*
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Example

You've seen this plenty of times. (Most notably, you've done this with `list_t`.)

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Example

- `void swap(int *a, int *b)`
- `void divrem(int *quotient, int *remainder)`
- `void eat(char **buf, char *token)`

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