DIGITAL ARTS & ENTERTAINMENT

Byte code

howest
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Problem

How bad do you think it can be?

Problem

Game Designers

- Want to define behavior in the game
  - NPC’s
  - Items
  - Enemies
  - Spells
  - ...
- Are not programmers
- Want to iterate quickly

Game Programmers

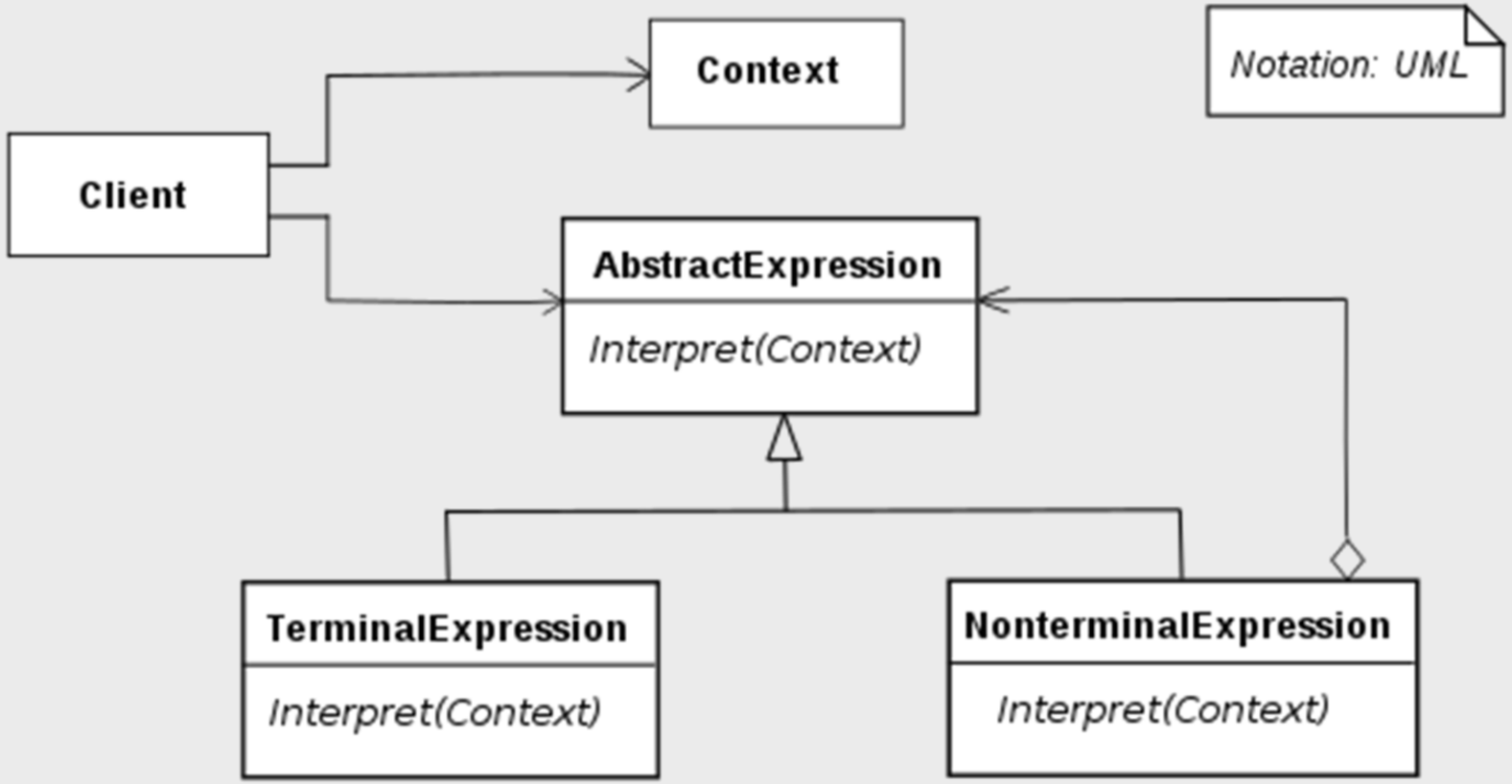
- Want optimized code
- Want working code
- Don’t want anyone to meddle with their code.

Solution

- Define behavior outside the code.
- Define behavior in separate data files.
- Load and run that behavior.
  - No compile times
  - Fast iteration
  - Hot reloading
  - No meddling in the code
  - ...

Solution – how?

Interpreter pattern



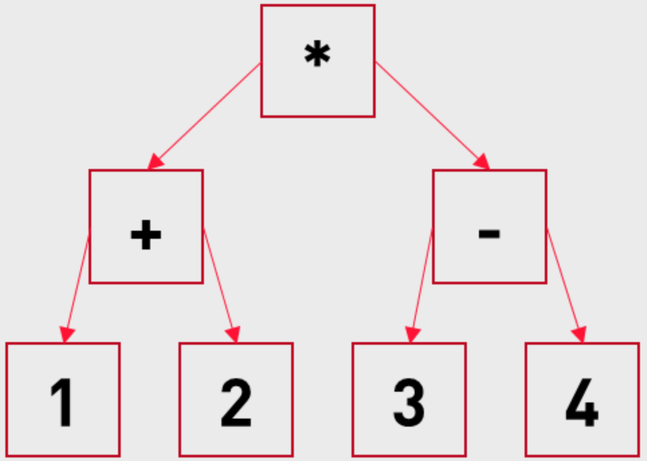
Interpreter pattern

Example

```
(1 + 2) * (3 – 4)
```

The literals are terminal expressions – they just return their value

The operators are compound expressions, they combine the results of the child nodes



This is not so good - why?

What is better?

Byte code

Machine code is better.

But we don’t want it to be complex (or you’d better switch to C++ again)

Byte code – from the book:

“An **instruction set** defines the low-level operations that can be performed. A series of instructions is encoded as a **sequence of bytes**. A **virtual machine** executes these instructions one at a time, using a **stack for intermediate values**. By combining instructions, complex high-level behavior can be defined.”

VM

Say we have some methods in our game we want to expose

```
void add_npc(int id);
void remove_npc(int id);
void set_health(int id, int amount);
int get_health(int id);
//...
```

We create an instruction set:

```
enum class instruction
{
    add_npc = 0x00,
    remove_npc = 0x01,
    set_health = 0x02,
    get_health = 0x03,
    //...
    literal = 0x25,
    //..
};
```

VM

Executed by some VM we wrote ourselves:

```
class virtual_machine {
public:
    void interpret(char bytecode[], int size)
    {
        for (int i = 0; i < size; i++) {
            char instruction = bytecode[i];
            switch (instruction)
            {
                case add_npc:
                    npc_manager::get_instance().add_npc(id);
                    break;
                case remove_npc:
                    npc_manager::get_instance().remove_npc(id);
                    break;
                case set_health:
                    npc_manager::get_instance().get_npc(id).set_health(health);
                    break;
                // etc ...
            }
        }
    }
};
```

VM Stack

The VM maintains a stack:

```
class virtual_machine {
private:
    static const int max_stack = 128;
    int stack_size;
    int stack_[max_stack];

    void push(int value)
    {
        stack_[stack_size++] = value;
    }

    int pop()
    {
        return stack_[--stack_size];
    }
};
```

VM Stack

Pop the parameters from the stack:

```
switch(instruction)
{
    // ...
    case set_health:
            int id = pop();
            int health = pop();
        npc_manager::get_instance().get_npc(id).set_health(health);
        break;
    // ...
}
```

Who pushes those values on the stack?

VM Stack

The `literal` command:

```
switch(instruction)
{
    // ...
    case literal:
        int value = bytecode[++i];
        push(value);
        break;
    // ...
}
```

VM Stack

This is the bytecode for setting the health of npc 245 to 100:

VM Stack

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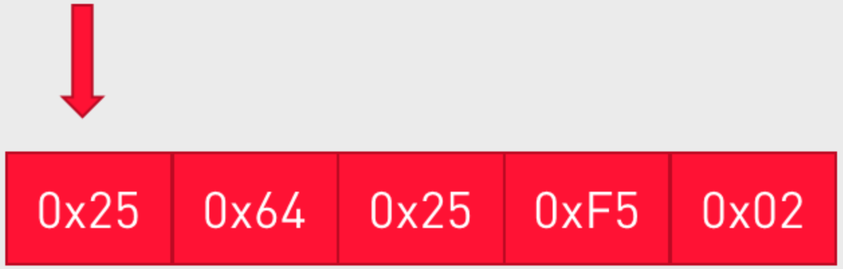


```
case literal:
    int value = bytecode[++i];
    push(value);
    break;
```

VM Stack

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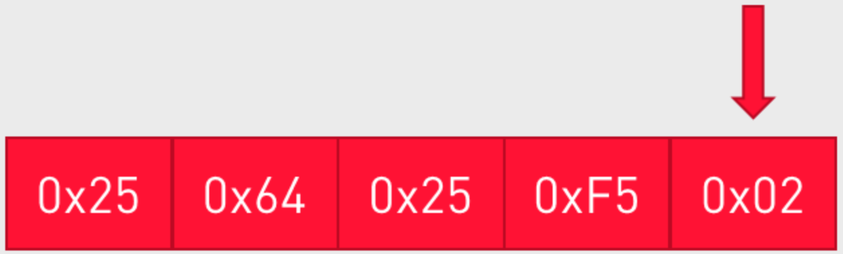


```
case set_health:
    int id = pop();
    int health = pop();
    npc_manager::get_instance().get_npc(id).set_health(health);
    break;
```

VM

You get the picture.

- We need to add instructions for combining results, like add, subtract, compare, control flow (if then else), etc…
- And many more.
- How are other values than integers handled?

Considerations

- A designer does not want to create buffers of integers.
- You'll need to provide some tool – can be a lot of work!
  - Can be graphical
  - Or text (like some scripting language)

VM

Lots of engines provide some sort of VM and a scripting language

Engine	Language
Source	Lua
Unreal	UnrealScript
GameMaker	GML
Godot	GDScript
Lumberyard	Lua
CryEngine	Lua