Instance method, new and delete

Bachelor of Science - École polytechnique

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Key concepts

- A data structure or an array is an object
  - The type of an object is called its class
  - The object o is instance of C ⇔ the class of the object o is C
- An instance method is a function defined inside a structure
  - It receives a `this` parameter named the pointer to the receiver
  - `this` can be omitted when we access a field of the object
- We can allocate and free an object
  - With `new` and `delete` for a data structure
  - With `new[]` and `delete[]` for an array

The C++ language

- C++ is another language based on C
  - Most of the C constructs exist in C++
  - But is not a superset: some C constructs do not exist in C++

- C++ extends the C language with new object abstractions
  - Better code reuse and structure
  - Allow the developer to write more generic code

- In this course, we study the c++20 standard
  - Compile with `g++ -std=c++20`

The object abstraction

- The C++ language is based on the object abstraction
  - An object is a data structure
  - that can have associated methods
- A method is a function that acts on an object
- Main advantages:
  - Links a data structure with the code that manipulates it
  - Make the code clearer and simpler

The object abstraction

- With this definition, data structures and arrays are objects

```
int tab[42]; // the 42 elements of the array is an object
struct monster_t m1;  // m1 is an object
struct monster_t* m2  // *m2 is an object
  = (struct monster_t*)malloc(...);
```

The object abstraction

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```
int tab[42]; // the 42 elements of the array is an object
struct monster_t m1;  // m1 is an object
struct monster_t* m2  // *m2 is an object
  = (struct monster_t*)malloc(...);
```

- An object has a type, and we call this type its class
  - The class of `tab` is `int[]`
  - The classes of `m1` and `*m2` are `monster_t`

- If an object o has the class C, we say that o is an instance of C
  - `tab` is an instance of `int[]`
  - `m1` and `*m2` are instances of `monster_t`

Instance method

- In C
  - We define a data structure
  - And often a function that acts on the data structure

acts on a `struct monster_t`

```
// header file
struct monster_t {
  const char* name;
  int health;
};

extern void print_monster(struct monster_t* m);

// source file
void print_monster(struct monster_t* m) {
  printf("(%s, %d)\n", m->name, m->health);
}
```

Instance method

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  - We define a data structure
  - And often a function that acts on the data structure

```
// header file
struct monster_t {
  const char* name;
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};

extern void print_monster(struct monster_t* m);

// source file
void print_monster(struct monster_t* m) {
  printf("(%s, %d)\n", m->name, m->health);
}
```

But naming a function `print_monster` because it acts on a monster is only a convention

Instance method

- In C
  - We define a data structure
  - And often a function that acts on the data structure

Add having a parameter with the type `struct monster_t*` seems obvious

```
// header file
struct monster_t {
  const char* name;
  int health;
};

extern void print_monster(struct monster_t* m);

// source file
void print_monster(struct monster_t* m) {
  printf("(%s, %d)\n", m->name, m->health);
}
```

Instance method

- C++ introduces instance methods
  - Move `print_monster` inside the structure declaration
  - Which adds it an implicit parameter with the type `monster_t*` named `this`

```
// header file
struct monster_t {
  const char* name;
  int health;

  void print();
};

// source file
void monster_t::print() {
  printf("(%s, %d)\n", this->name, this->health);
}
```

`this` is now an implicit parameter with the type `struct monster_t*`

Instance method

- C++ introduces instance methods
  - Move `print_monster` inside the structure declaration
  - Which adds it an implicit parameter with the type `monster_t*` named `this`

```
// header file
struct monster_t {
  const char* name;
  int health;

  void print();
};

// source file
void monster_t::print() {
  printf("(%s, %d)\n", name, health);
}
```

`this` can be omitted

Instance method

- C++ introduces instance methods
  - Move `print_monster` inside the structure declaration
  - Which adds it an implicit parameter with the type `monster_t*` named `this`

```
// header file
struct monster_t {
  const char* name;
  int health;

  void print();
};

// source file
void monster_t::print() {
  printf("(%s, %d)\n", name, health);
}
```

`print` is the `print` method that belongs to `monster_t`
=> no need to name it `print_monster`

Instance method

- C++ introduces instance methods
  - Move `print_monster` inside the structure declaration
  - Which adds it an implicit parameter with the type `monster_t*` named `this`

```
// header file
struct monster_t {
  const char* name;
  int health;

  void print();
};

// source file
void monster_t::print() {
  printf("(%s, %d)\n", name, health);
}
```

We now say that `print` is an **instance method** of the class `monster_t`

Using an instance method

- Call an instance method with `var.f()`

```
int main(int argc, char* argv[]) {
  struct monster_t m = { "Pikachu", 42 };

  m.print(); // this in monster_t::print points to m
             // like a call to monster_t::print(&m);
  return 0;
}
```

We say that the object `m` is the receiver of the method call
=> `this` is a pointer to the receiver

Code simplification

- In C++, we can also get rid of `struct` when we use the type `monster_t`

```
int main(int argc, char* argv[]) {
  monster_t m = { "Pikachu", 42 };

  m.print(); // this in monster_t::print points to m
             // like a call to monster_t::print(&m);
  return 0;
}
```

Code simplification

- In C++, the `=` is also useless: initialize the fields of `m` with the parameters between the braces without `=`

```
int main(int argc, char* argv[]) {
  monster_t m { "Pikachu", 42 };

  m.print(); // this in monster_t::print points to m
             // like a call to monster_t::print(&m);
  return 0;
}
```

The `new` keyword

- Allocating and initializing a data structure remains painful
  - `malloc` takes the allocated size as argument
  - Its result has to be casted into a `monster_t`
  - And the fields have to be initialized manually

```
int main(int argc, char* argv[]) {
  monster_t* m = (monster_t*)malloc(sizeof(*m));

  m->name = "Pikachu";
  m->health = 42;

  m->print();

  ...
}
```

The new keyword

- new: simplifies the allocation code
  - Allocates the data structure without explicitly giving its size
  - And initializes the fields in the same statement

```
int main(int argc, char* argv[]) {
  monster_t* m = new monster_t { "Pikachu", 42 };

  m->print();

  ...
}
```

The `delete` keyword

- Use `delete` instead of `free` to free a data structure allocated with `new`

```
int main(int argc, char* argv[]) {
  monster_t* m = new monster_t { "Pikachu", 42 };

  m->print();

  delete m;
  ...
}
```

Dynamically allocated arrays

- Similarly, allocate / free an array with `new[]` / `delete[]`
  - With an explicit size in `new`

```
int main(int argc, char* argv[]) {
  monster_t* m = new monster_t[2];

  m[0] = { "Pikachu", 42 };
  m[1] = { "Blastoise", 83 };

  delete[] m;

  return 0;
}
```

Dynamically allocated arrays

- Similarly, allocate / free an array with `new[]` / `delete[]`
  - With an explicit size in `new`
  - Or with an implicit size because of the initializer

```
int main(int argc, char* argv[]) {
  monster_t* m = new monster_t[] {
    { "Pikachu", 42 },
    { "Blastoise", 83 }
  };

  delete[] m;

  return 0;
}
```

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