Class

Object-Oriented Programming in C++

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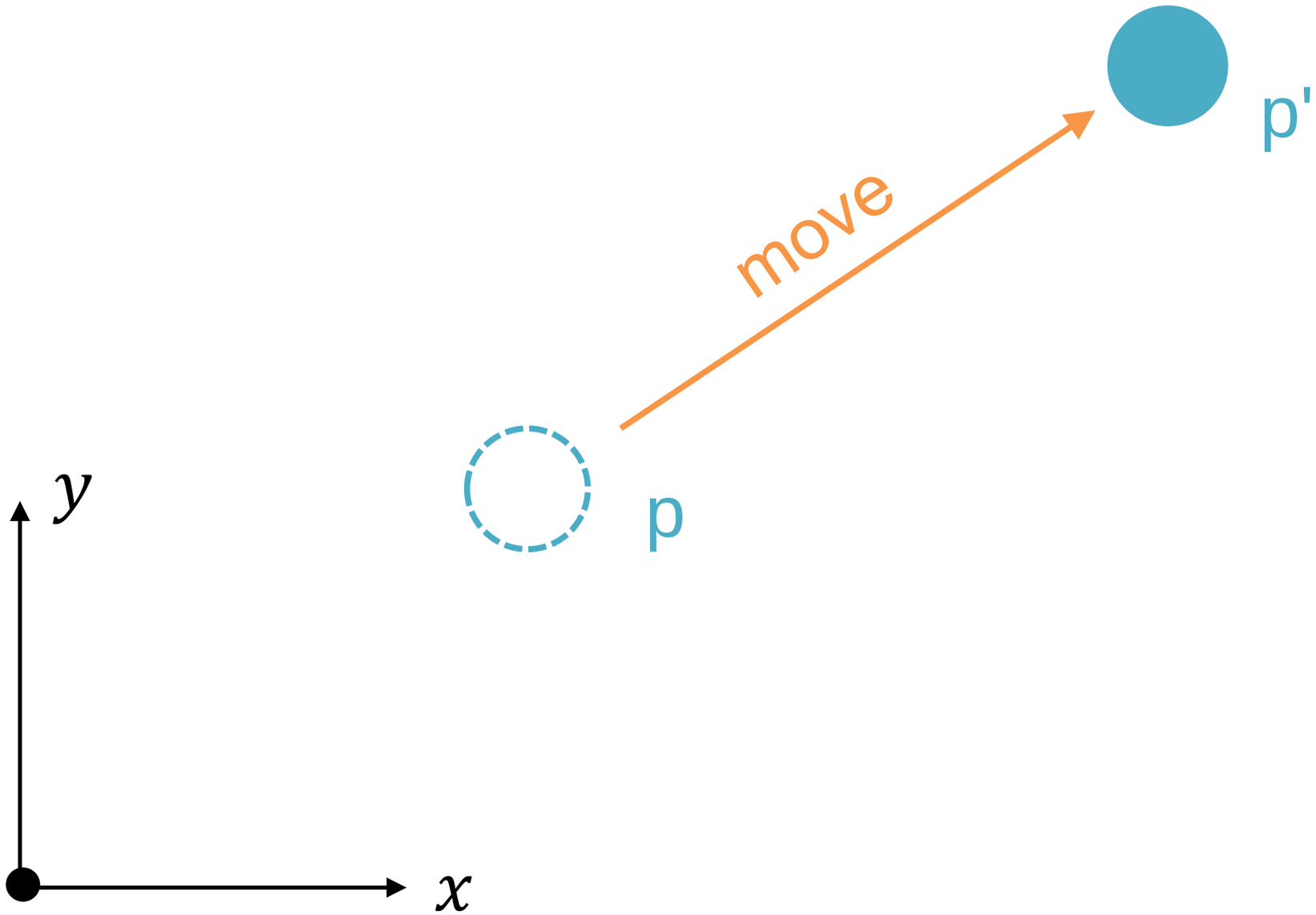

p'
move
p
y
x

Point

```
typedef struct point {
    float x;
    float y;
} Point;
```

Point

```
typedef struct point {
    float x;
    float y;
} Point;
```

```
Point a;
a.x = 1;a.y = 2;
```

Point

```
typedef struct point {
    float x;
    float y;
} Point;
```

```
Point a;
a.x = 1;a.y = 2;
void print(const Point* p){
    printf("%d %d\n",p->x,p->y);
}
```

Point

```
typedef struct point {
    float x;
    float y;
} Point;
```

```
Point a;
a.x = 1;a.y = 2;
void print(const Point* p){
    printf("%d %d\n",p->x,p->y);
}
print(&a);
```

move (dx,dy)?

move (dx,dy)?

```
void move(Point* p,int dx, int dy) {
        p->x += dx;
        p->y += dy;
}
```

Prototypes

```
typedef struct point {
    float x;
    float y;
 } Point;
void print(const Point* p )j
void move(Point* p,int dx, int d y)j
```

Usage

```
Point a;
Point b;
a.x = b.x = 1; a.y = b.y = 1;
move(&a,2,2);
print(&a);
print(&b);
```

C++ version

```
class Point {
public:
    void init(int x,int y);
    void move(int dx,int dy);
    void print() const;

private:
    int x;
    int y;
} ;
```

implementations

```
void Point::init(int ix, int iy) {
    x = ix; y = iy;
}
void Point::move(int dx,int dy) {
    x+= dx; y+= dy;
}
void Point::print() const {
    cout << x << ' ' << y << endl;
}
```

:: resolver

- <Class Name>::<function name>
- ::<function name>

```
void S::f() {
    ::f(); // Would be recursive otherwise!
    ::a++; // Select the global a
    a--; // The a at class scope
}
```

C vs. C++

```c
typedef struct point {
    float x;
    float y;
} Point;

void print(const Point* p);
void move(Point* p,int dx,
int dy);

Point a;
a.x = 1; a.y = 2;
move(&a,2,2);
print(&a);
```

```c++
class Point {
public:
    void init(int x,int y);
    void print() const;
    void move(int dx,int dy);

private:
    int x;
    int y;
} ;

Point a;
a.init(1,2);
a.move(2,2);
a.print();
```

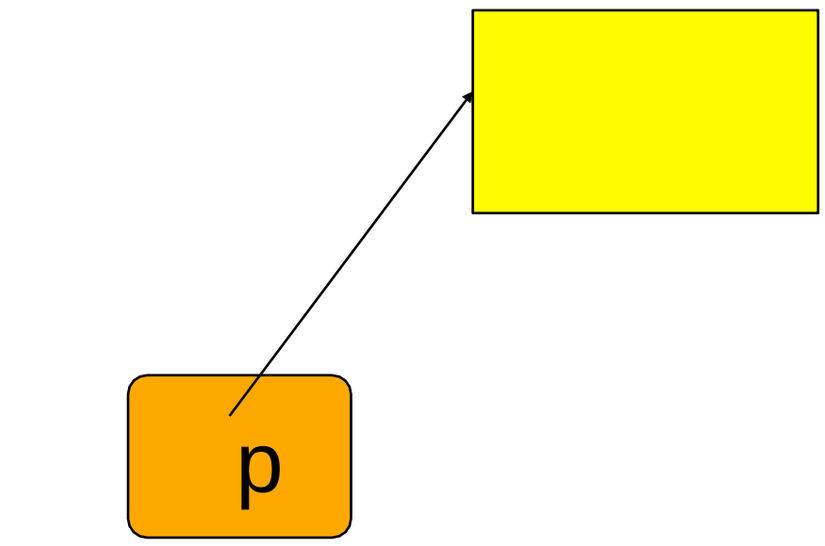
Stash

Container

- Container is an object that holds other objects.
- For most kinds of containers, the common interface is put() and get().
- Stash is a container that stores objects and can be expanded during running.

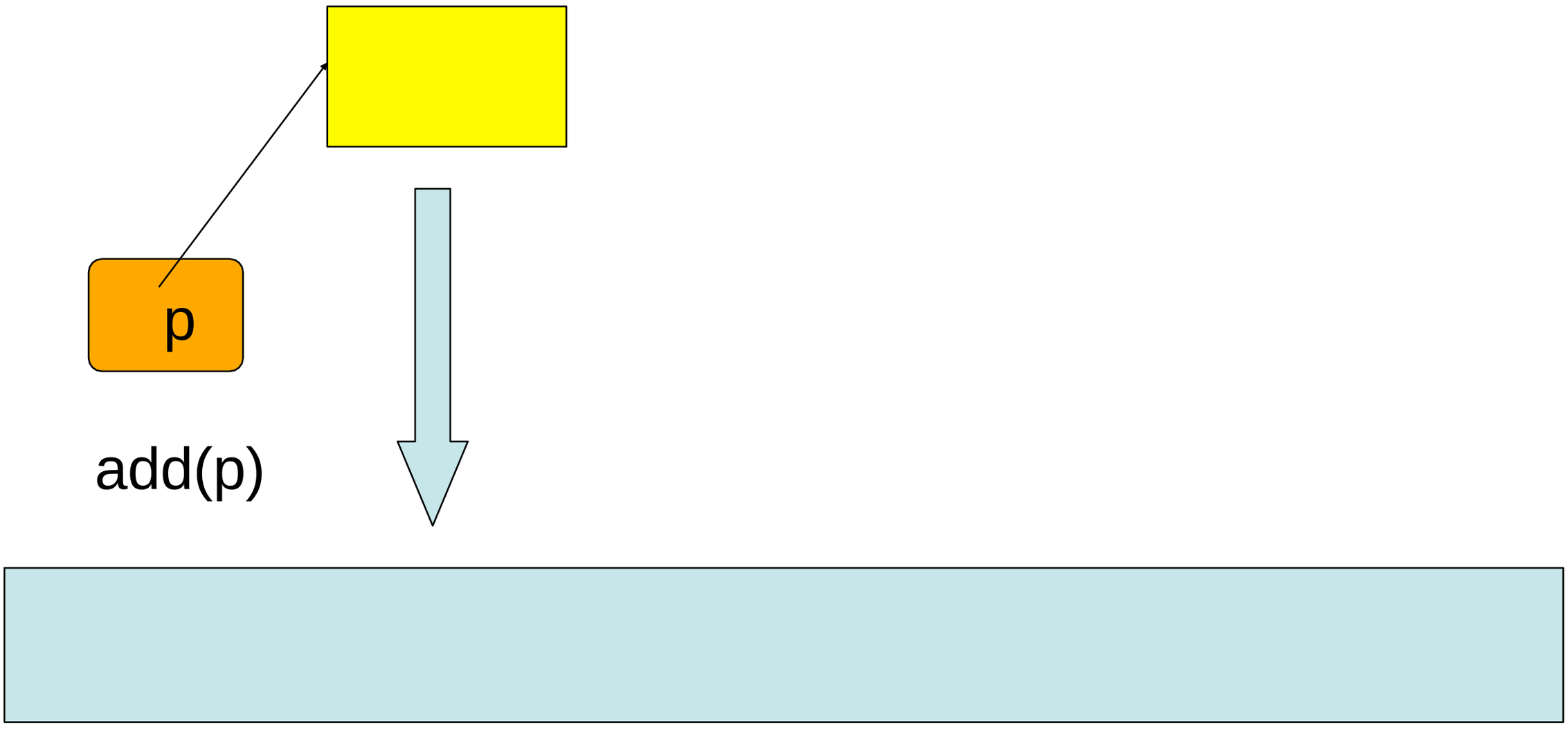
Stash

Stash

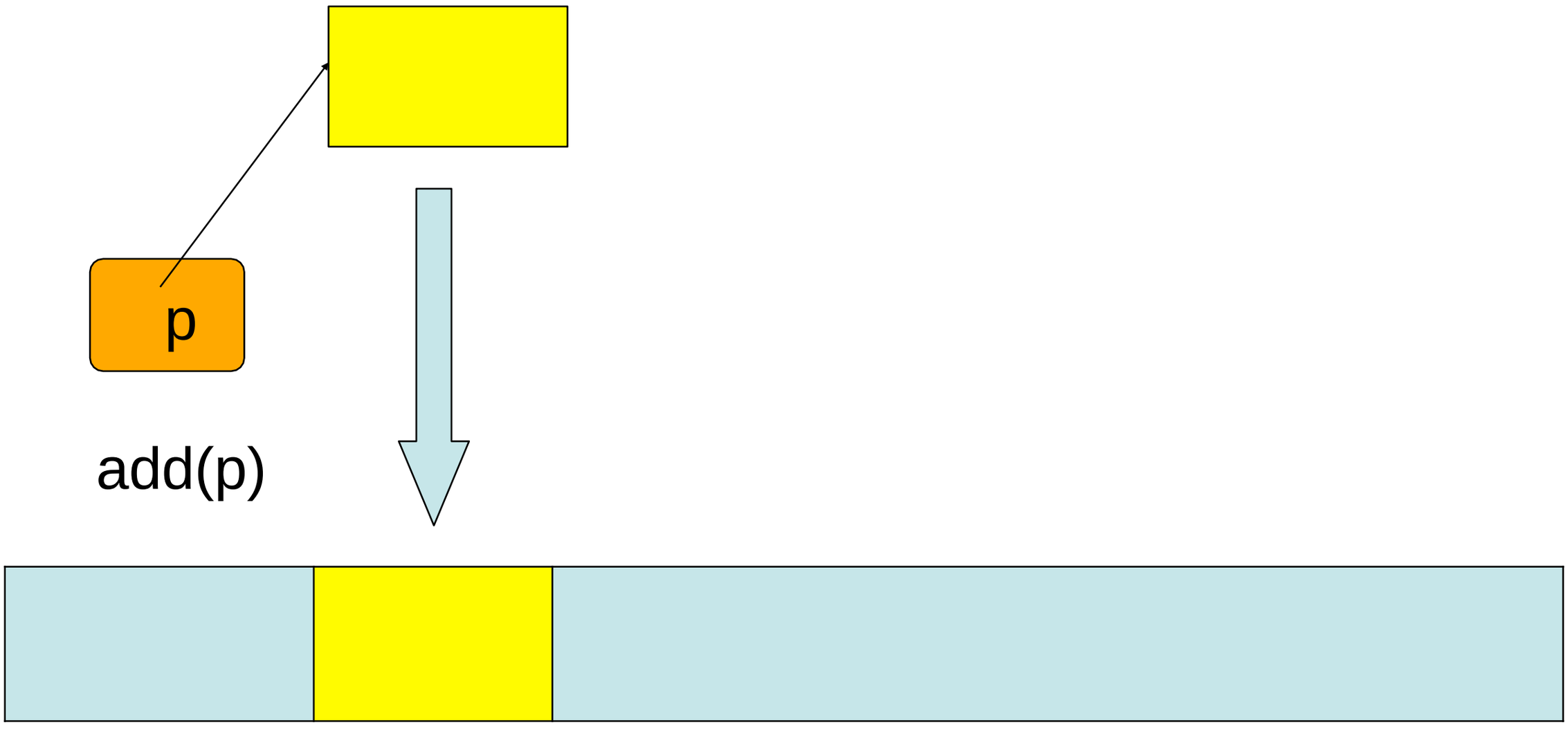


add(p)

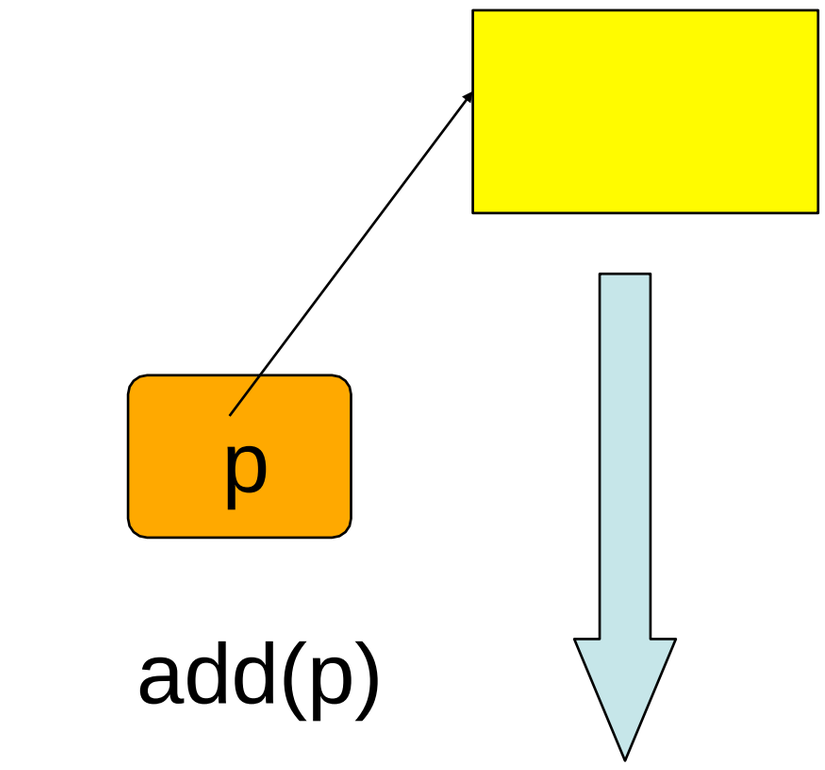
Stash



Stash



Stash



add(p)

Each element in Stash is a clone of the object.

Stash

- Typeless container.
- Stores objects of the same type.
  - Initialized w/ the size of the type
  - Doesn’t care the type but the size
- add() and fetch()
- Expanded when needed

- See: Stash2.h, Stash2.cpp, Stash2Test.cpp

Functions in struct

```
struct Stash {
   int size; // Size of each space
   int quantity; // Number of storage spaces
   int next; // Next empty space
   // Dynamically allocated array of bytes:
   unsigned char* storage;
   // Functions!
   void initialize(int size);
   void cleanup();
   int add(const void* element);
   void* fetch(int index);
   int count();
   void inflate(int increase);
};
```

See: Stash2.h

Implementation of the functions

- We just defined in the header file that there will be these functions in this struct.
- All the bodies of these functions will be in a source file.

See: Stash2.cpp

Call the functions in a struct

```
Stash a;
a.initialize(10);
```

- There is a relationship with the function be called and the variable to call it.
- The function itself knows it is doing something w/ the variable.
- Example: Stash2Test.cpp

this: the hidden parameter

- **this** is a hidden parameter for all member functions, with the type of the struct
  `void Stash::initialize(int sz)`
  ➔ (can be regarded as)
  `void Stash::initialize(Stash* this, int sz)`

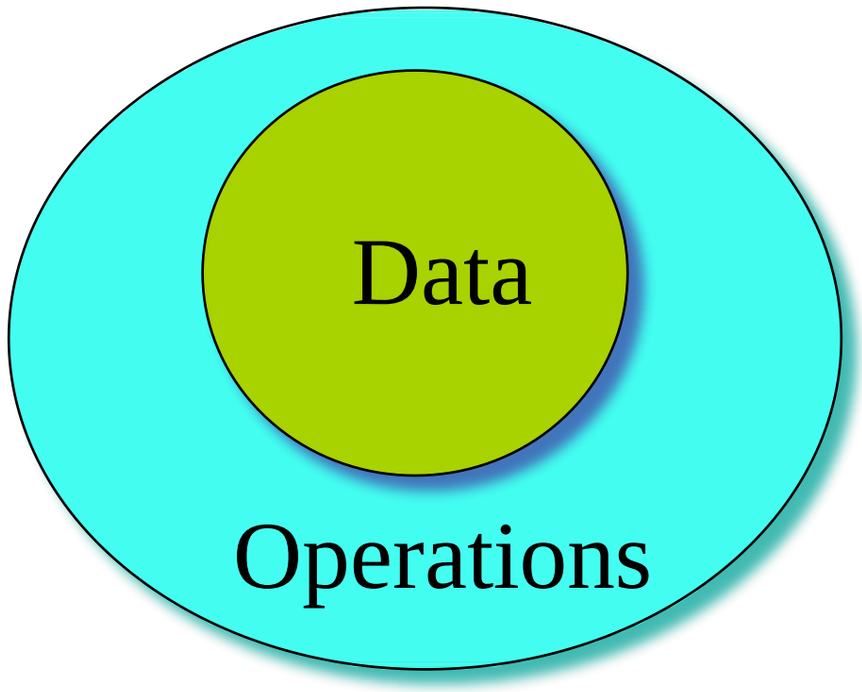
- To call the function, you must specify a variable
  ```
  Stash a;
  a.initialize(10);
  ```
  ➔ (can be regarded as)
  `Stash::initialize(&a,10);`

this: the pointer to the variable

- Inside member functions, you can use **this** as the pointer to the variable that calls the function.
- **this** is a natural local variable of all structs member functions that you can not define, but can use it directly.

Objects = Attributes + Services

- Data: the properties or status
- Operations: the functions



Objects

- In C++, an object is just a variable, and the purest definition is “a region of storage”.

Ticket Machine

- Ticket machines print a ticket when a customer inserts the correct money for their fare.
- Our ticket machines work by customers' inserting money into them, and then requesting a ticket to be printed. A machine keeps a running total of the amount of money it has collected throughout its operation.

Procedure-Oriented

- Step to the machine
- Insert money into the machine
- The machine prints a ticket
- Take the ticket and leave

Procedure-Oriented

- Step to the machine
- Insert money into the machine
- We make a program simulate the procedure of buying tickets. It works. But there is no such machine. There's nothing left for the further development.

Something is there

Something is there

PRICE

balance

total

Something is there

PRICE

balance

total

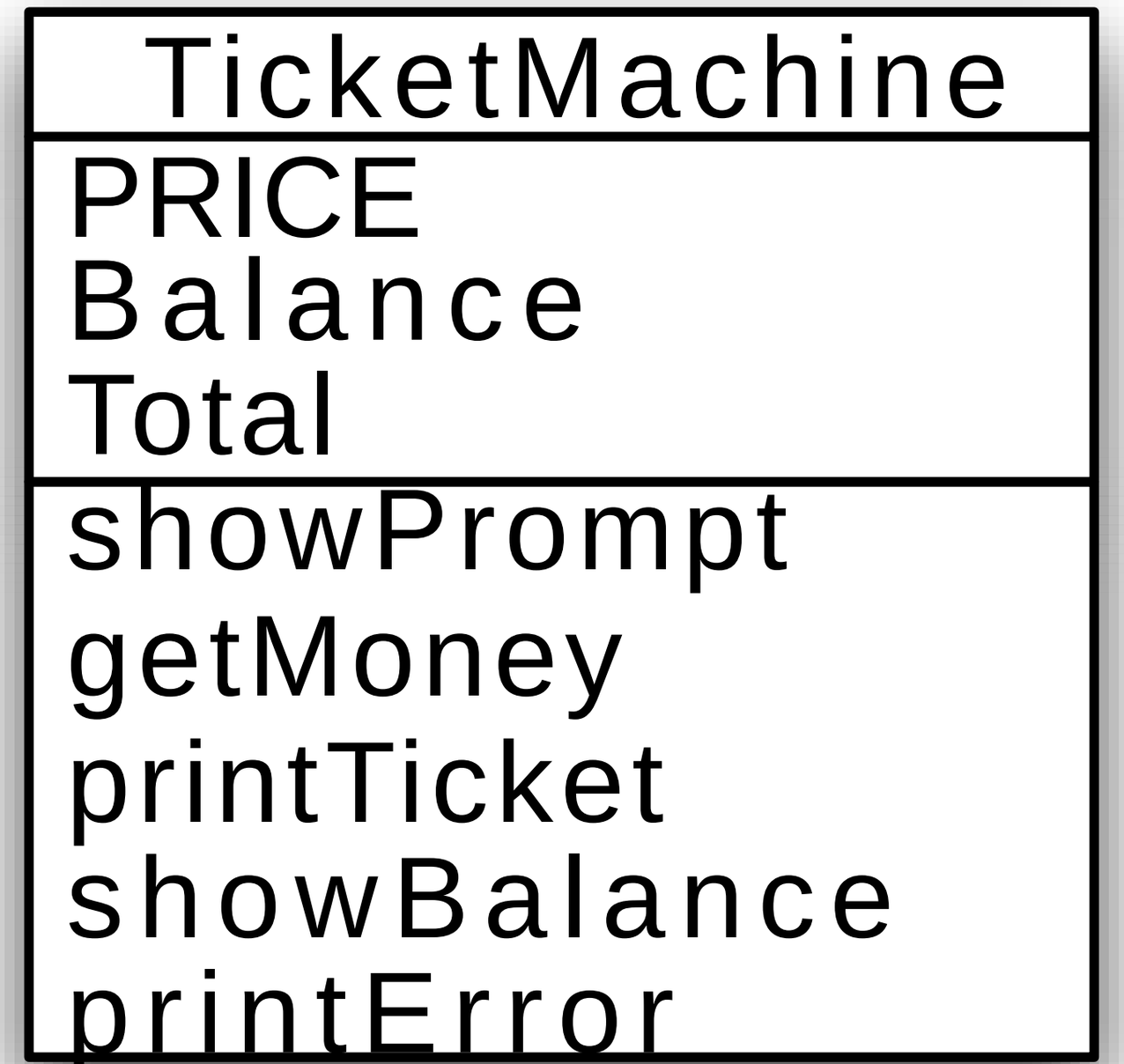
show prompt

print balance

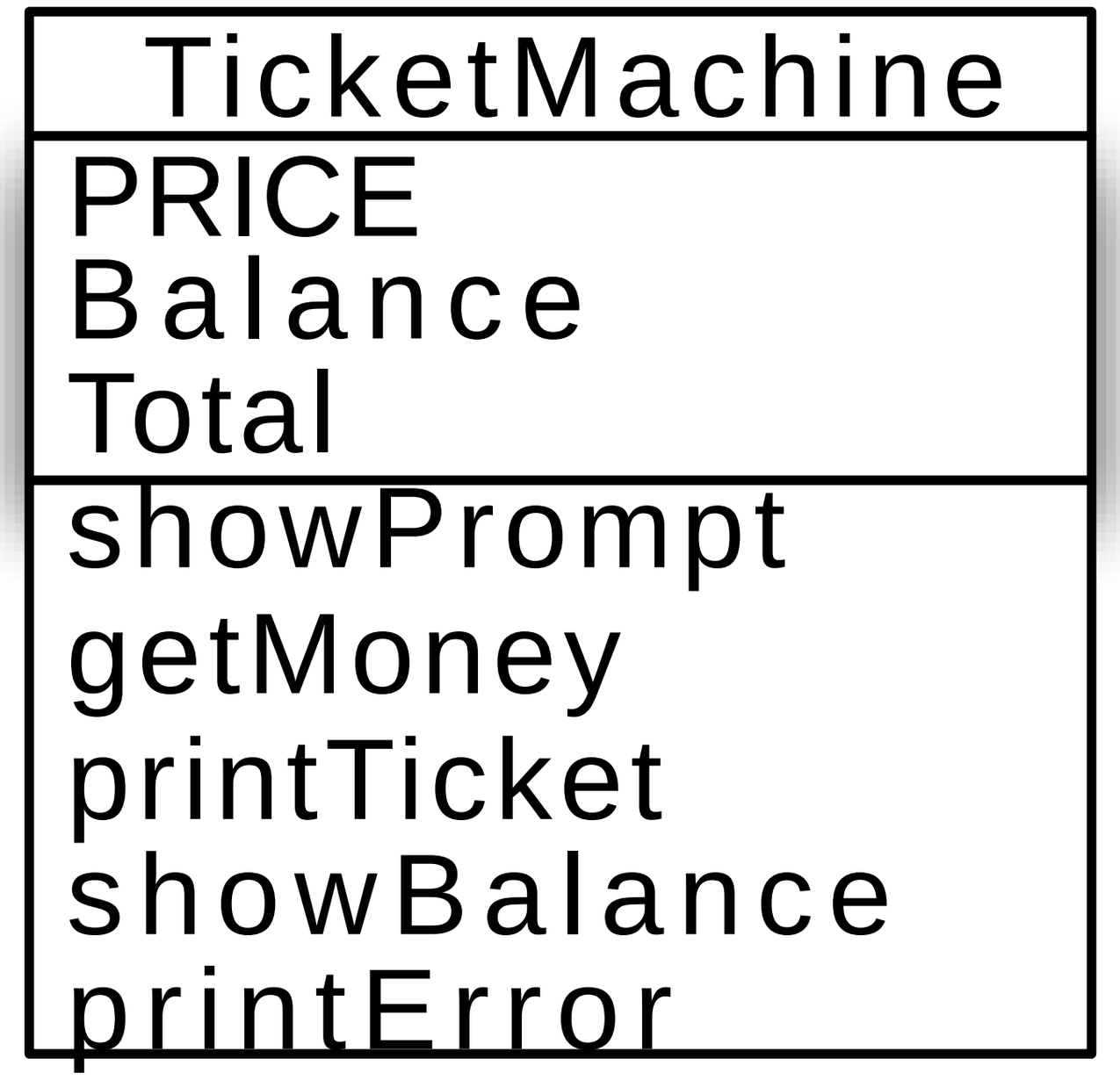
insert money

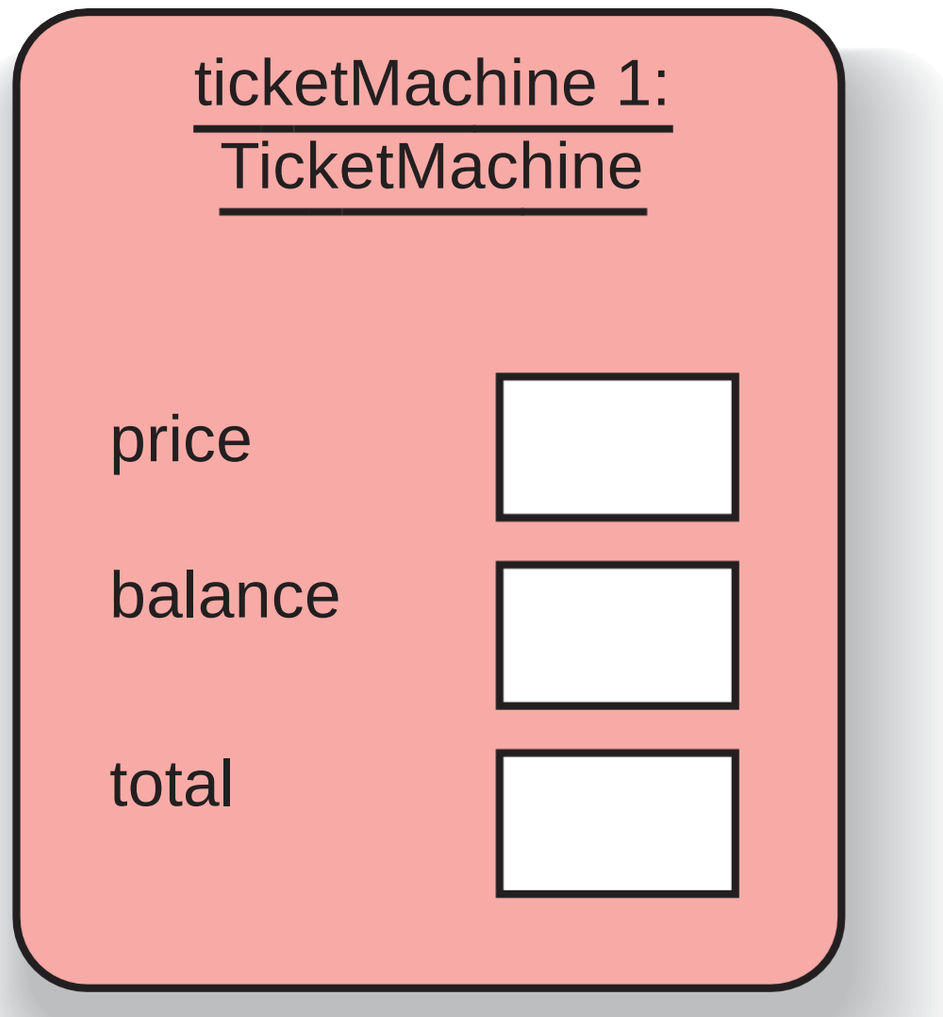
print ticket

Something is here



Something is here





Turn it into code

TicketMachine

PRICE

showBalance

printError

```
class TicketMachine {
 private:
    const int PRICE;
    int balance;
    int total;
};
```

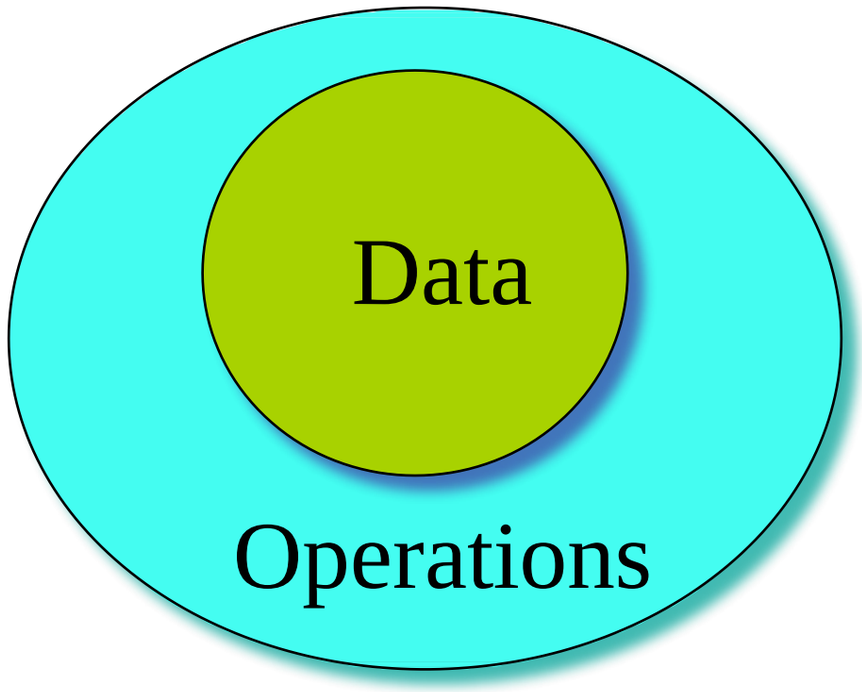
ticketMachine 1:

Turn it into code

```
class TicketMachine {
public:
    void showPrompt();
    void getMoney();
    void printTicket();
    void showBalance();
    void printError();
private:
    const int PRICE;
    int balance;
    int total;
};
```

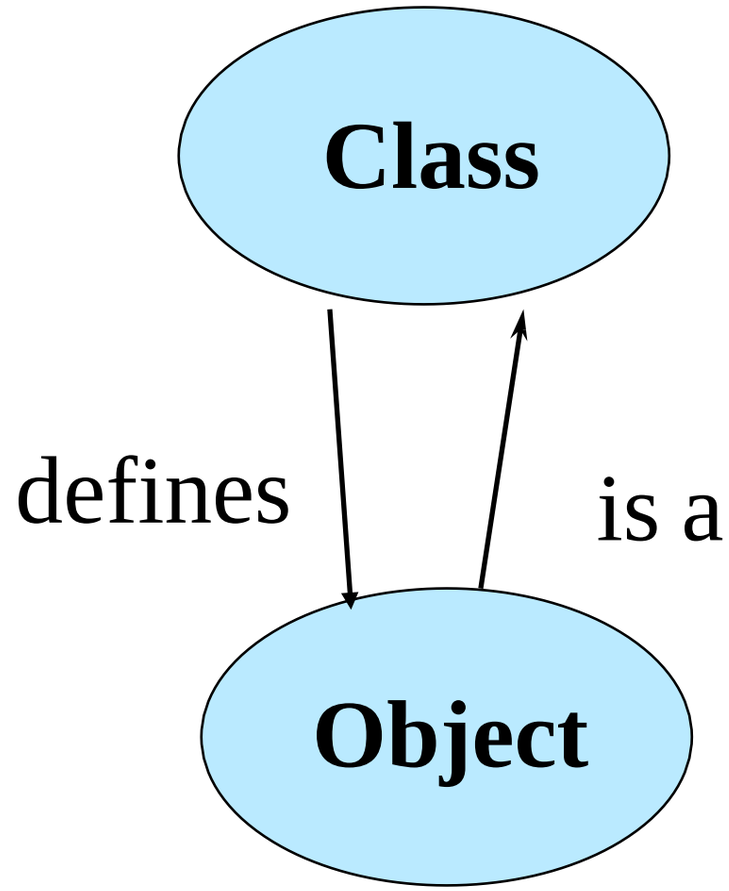
Objects = Attributes + Services

- Data: the properties or status
- Operations: the functions



Object vs. Class

- Objects (cat)
  - Represent things,events, or concepts
  - Respond to messages at run-time
- Classes (cat class)
  - Define properties of instances
  - Act like types in C++



OOP Characteristics

1. Everything is an object.
2. A program is a bunch of objects telling each other what to do by sending messages.
3. Each object has its own memory made up of other objects.
4. Every object has a type.
5. All objects of a particular type can receive the same messages.

Definition of a class

- In C++, separated .h and .cpp files are used to define one class.
- Class declaration and prototypes in that class are in the header file (.h).
- All the bodies of these functions are in the source file (.cpp).

Compile unit

- The compiler sees only one .cpp file, and generates .obj file
- The linker links all .obj into one executable file
- To provide information about functions in other .cpp files, use .h

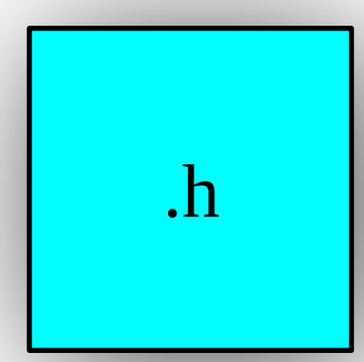
The header files

- If a function is declared in a header file, you *must* include the header file everywhere the function is used and where the function is defined.
- If a class is declared in a header file, you *must* include the header file everywhere the class is used and where class member functions are defined.

Header = interface

- The header is a contract between you and the user of your code.
- The compile enforces the contract by requiring you to declare all structures and functions before they are used.

Structure of C++ program



Structure of C++ program

declaration

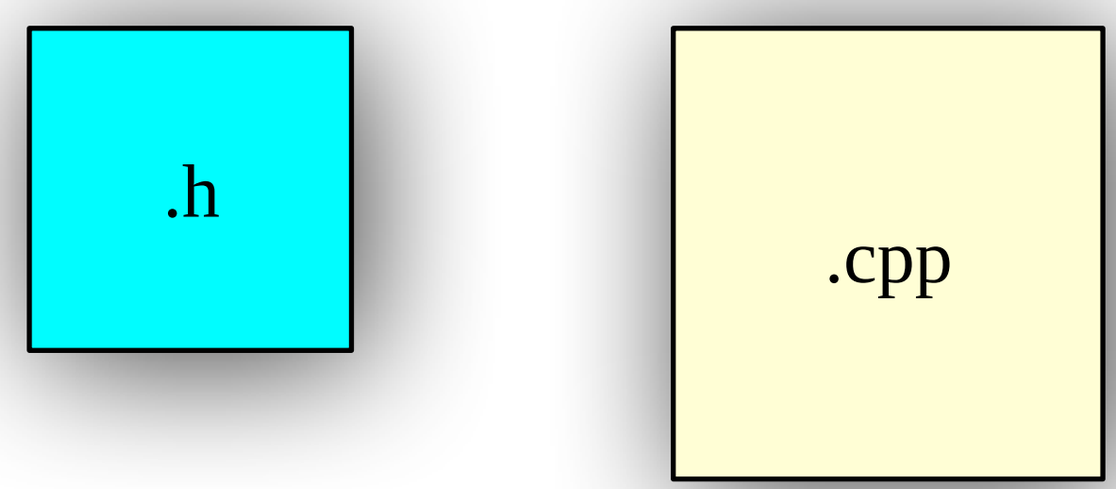
s

.h

Structure of C++ program

declarations

definitions



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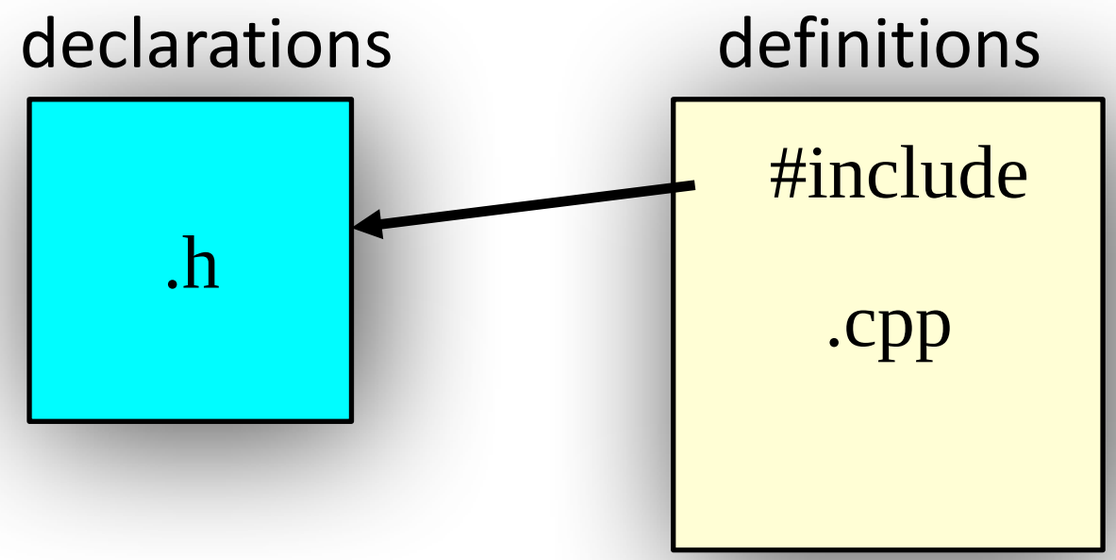
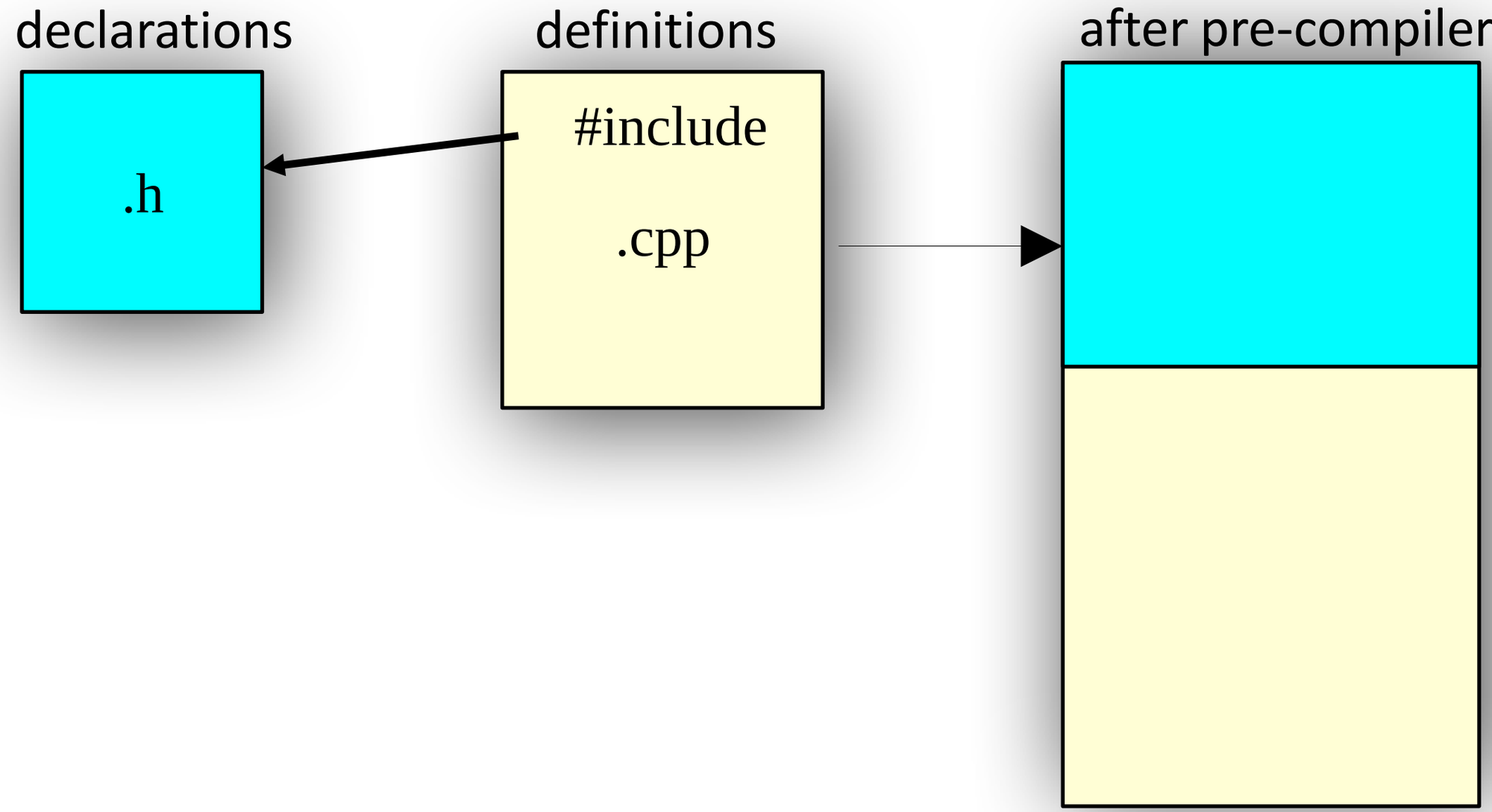


Structure of C++ program



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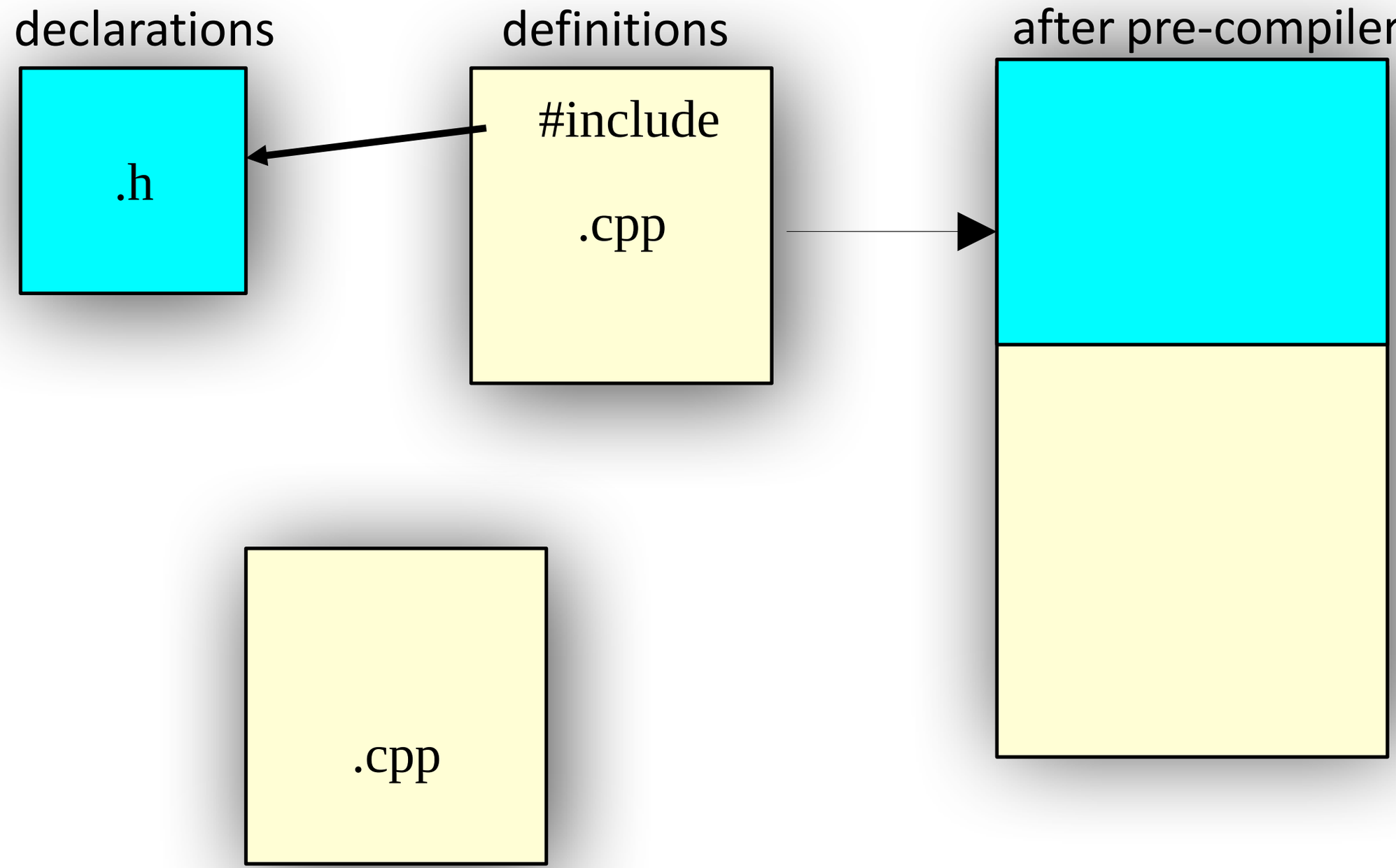
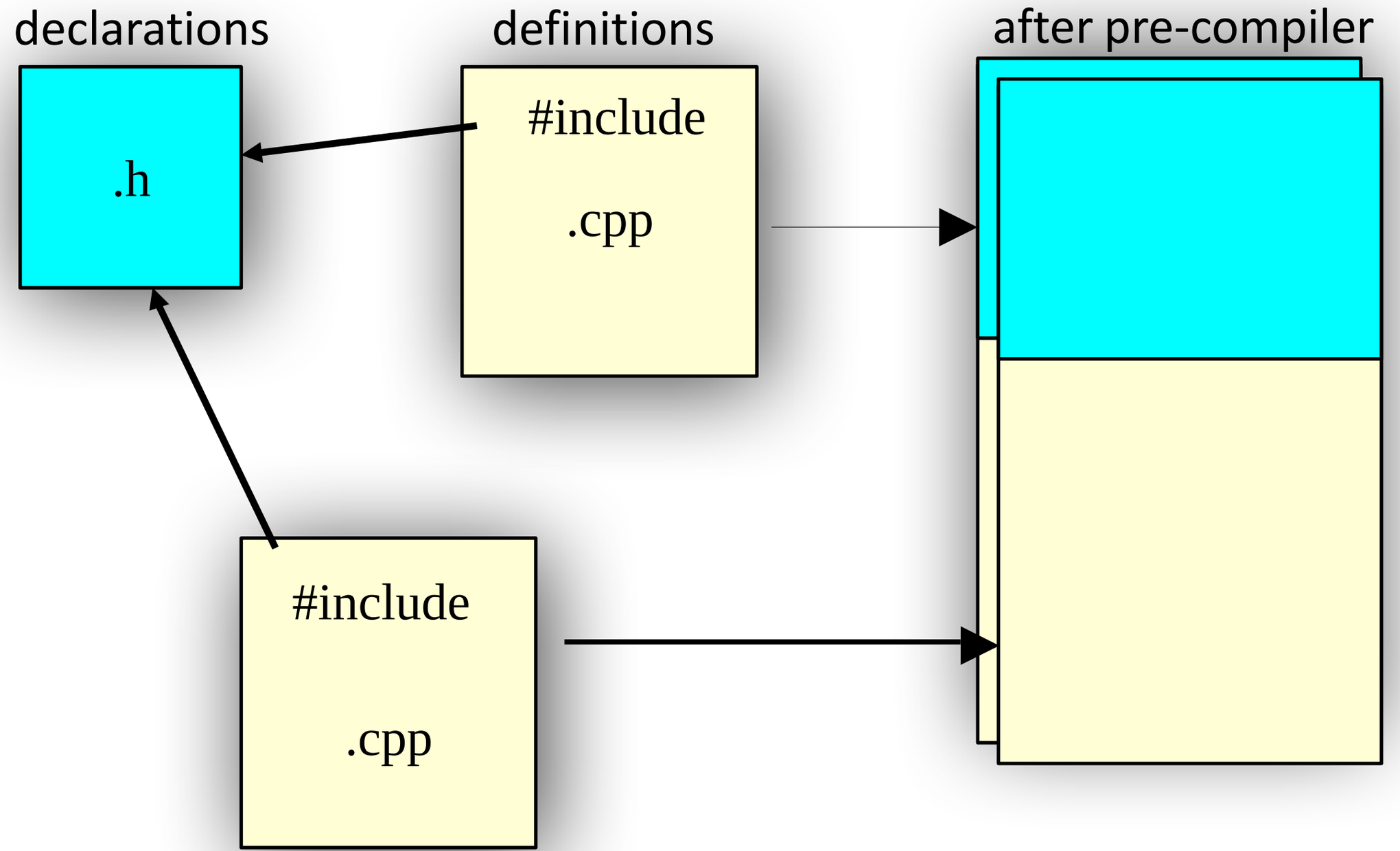


Other modules that use the functions

Structure of C++ program



Other modules that use the functions

Declarations vs. Definitions

- A .cpp file is a compile unit
- Only declarations are allowed to be in .h
  - extern variables
  - function prototypes
  - class/struct declaration

#include

#include

- `#include` is to insert the included file into the .cpp file at where the `#include` statement is.
  - `#include "xx.h"`: usually search in the current directory, implementation defined
  - `#include <xx.h>`: search in the specified directories
  - `#include <xx>`: same as #include <xx.h>

Standard header file structure

```
#ifndef __HEADER__FLAG
#define __HEADER__FLAG

// Type declaration here...

#endif // __HEADER__FLAG
```

Tips for header

1. One class declaration per header file
2. Associated with one source file in the same prefix of file name.
3. The contents of a header file is surrounded with #ifndef #define… #endif
4. #pragma once equivalent to #ifndef…#endif

The Makefile utility

Motivation

- Small programs ⟶ single file

- "Not so small" programs :
  - Many lines of code
  - Multiple components
  - More than one programmer

Motivation – continued

- Problems:
  - Long files are harder to manage (for both programmers and machines)
  - Every change requires long compilation
  - Many programmers can not modify the samefile simultaneously
  - Division to components is desired

Motivation – continued

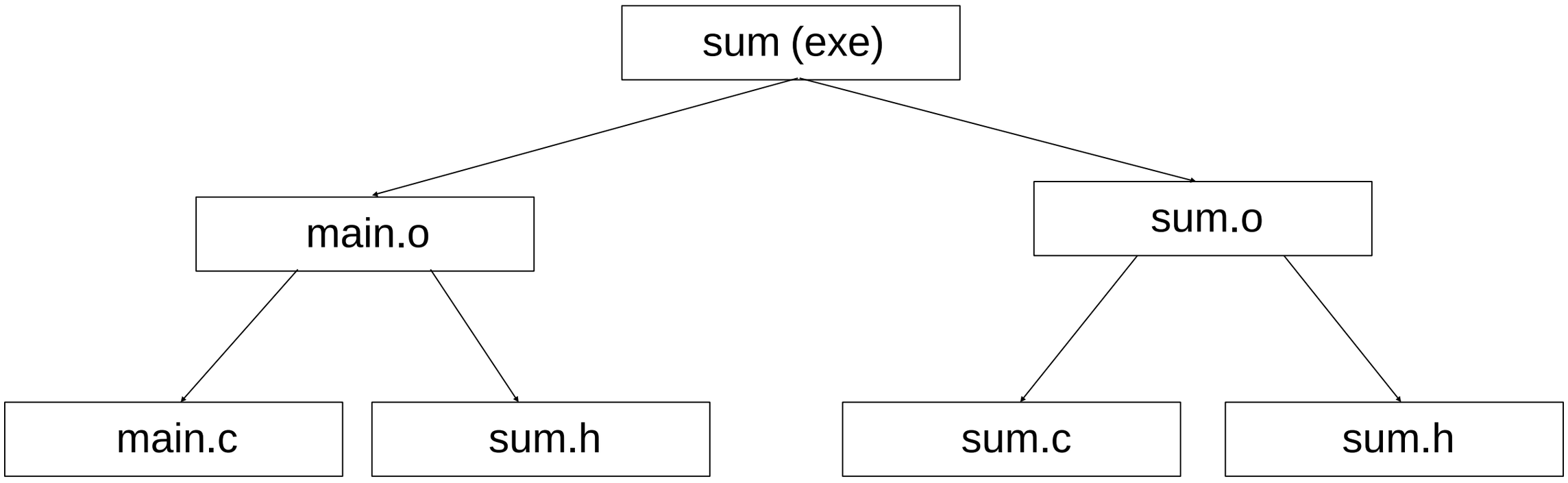
- Solution : divide project to multiple files
- Targets:
  - Good division to components
  - Minimum compilation when something is changed
  - Easy maintenance of project structure, dependencies and creation

Project maintenance

- Done in Unix by the Makefile mechanism
- A makefile is a file (script) containing :
  - Project structure (files, dependencies)
  - Instructions for files creation
- The make command reads a makefile, understands the project structure and makes up the executable
- Note that the Makefile mechanism is not limited to C programs

Project structure

- Project structure and dependencies can be represented as a DAG (= Directed Acyclic Graph)
- Example :
  - Program contains 3 files
  - main.c., sum.c, sum.h
  - sum.h included in both .c files
  - Executable should be the file sum


sum (exe)
main.o
sum.o
main.c
sum.h
sum.c
sum.h

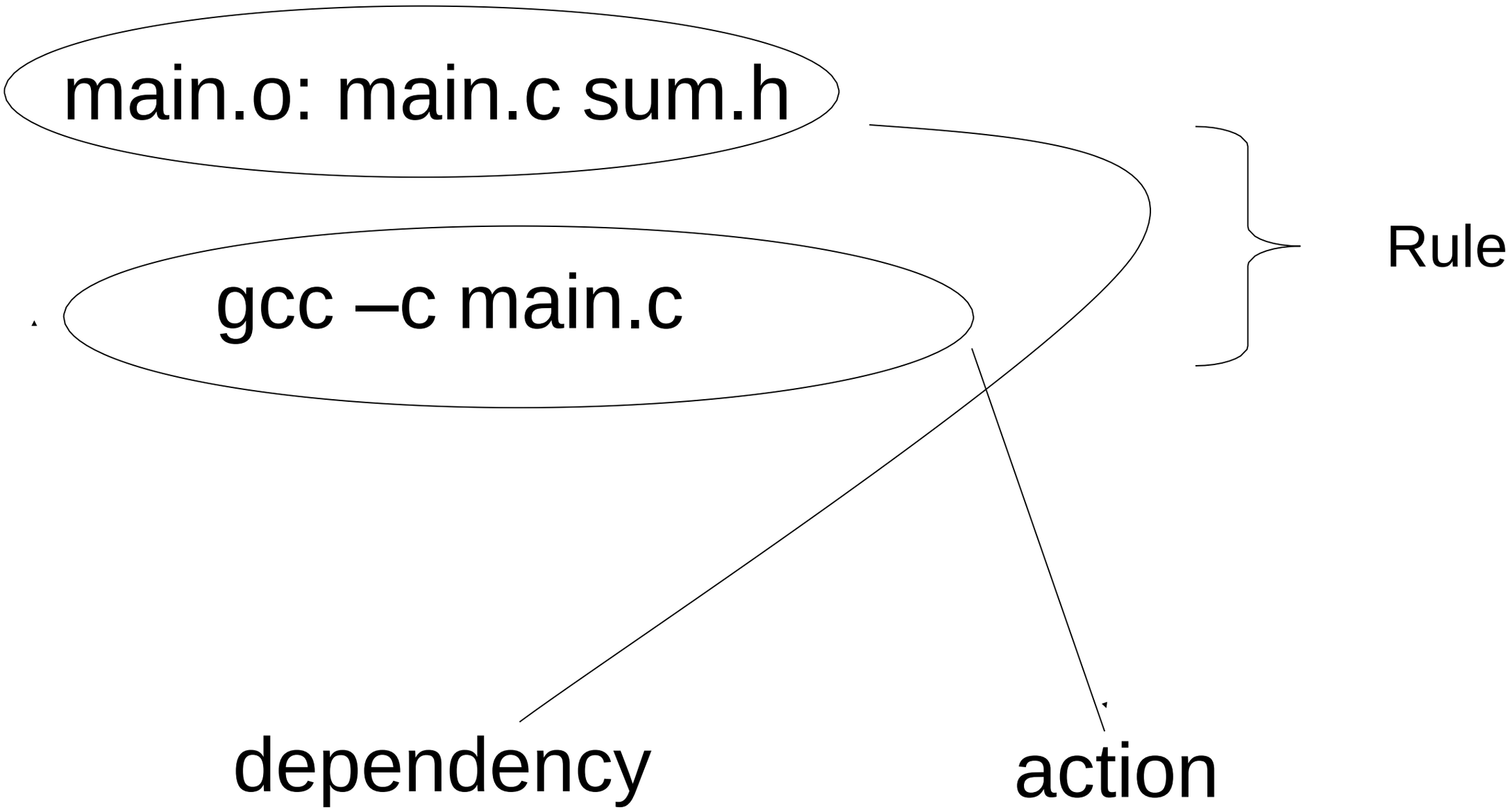
makefile

```
sum: main.o sum.o
    gcc –o sum main.o sum.o

main.o: main.c sum.h
    gcc –c main.c

sum.o: sum.c sum.h
    gcc –c sum.c
```

Rule syntax



make operation

- Project dependencies tree is constructed
- Target of first rule should be created
- We go down the tree to see if there is a target that should be recreated. This is the case when the target file is older than one of its dependencies
- In this case we recreate the target file according to the action specified, on our way up the tree. Consequently, more files may need to be recreated
- If something is changed, linking is usually necessary

make operation - continued

- make operation ensures minimum compilation, when the project structure is written properly

- Do not write something like:

```
prog: main.c sum1.c sum2.c
    gcc -o prog main.c sum1.c sum2.c
```

which requires compilation of all project when something is changed

Make operation - example

File	Last Modified
sum	10:03
main.o	09:56
sum.o	09:35
main.c	10:45
sum.c	09:14
sum.h	08:39

Make operation - example

- Operations performed:

  gcc –c main.c

  gcc –o sum main.o sum.o

- main.o should be recompiled (main.c is newer).
- Consequently, main.o is newer than sum and therefore sum should be recreated (by re-linking).

Reference

- Good tutorial for makefiles

https://www.gnu.org/software/make/manual/make.html

The CMake utility

CMake

- A cross-platform, open-source build system
- Cmake is used to control software compilation process using simple platform and compiler independent configuration files.
- Cmake generates native makefiles and workspaces that can be used in the compiler environment of your choice.

CMake

- You write a single configuration that CMake understands.
- CMake takes care that it works on all compliers and platforms.
- Don't make any assumption about the platform or compiler!

A Simple Example

- 1. Set the minimum required version of Cmake

  cmake_minimum_required (VERSION 2.8)

- 2. Set the project information

  project (point_design)

- 3. Add an executable target

  add_executable(point_design main.cpp Point.cpp)