Hackathon

I2P(II)_2020_SR

Tower Defense

Mini Project 2 Package

Before we start,

Announcements

- You should have finished installing Allegro5 and set up your IDE on your own computer last semester in I2P course.
- If you did not take the course, see the Tutorial and videos.
- Our template requires Allegro5 and C++11 and you should compile and run the template successfully beforehand.
- If you use Visual Studio, you can download the project directly: Visual Studio Project Template

Outline

- Quick review
- Resources
- Scenes
- Objects & Sprites
- Objects & Controls
- Template & Code structure
- Goal & Grading Policy

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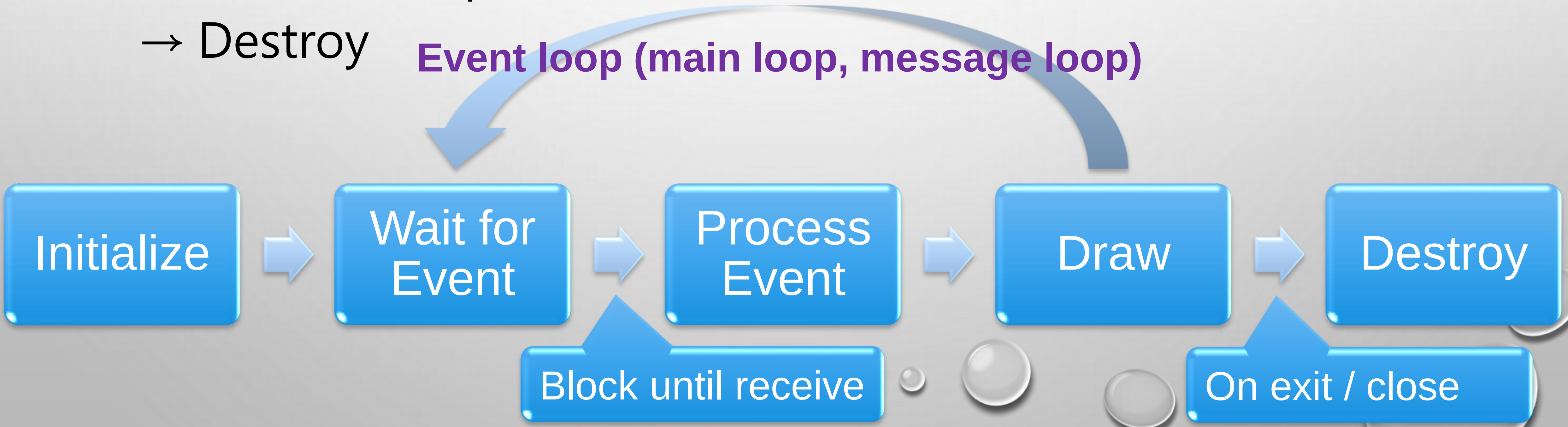
Quick Review

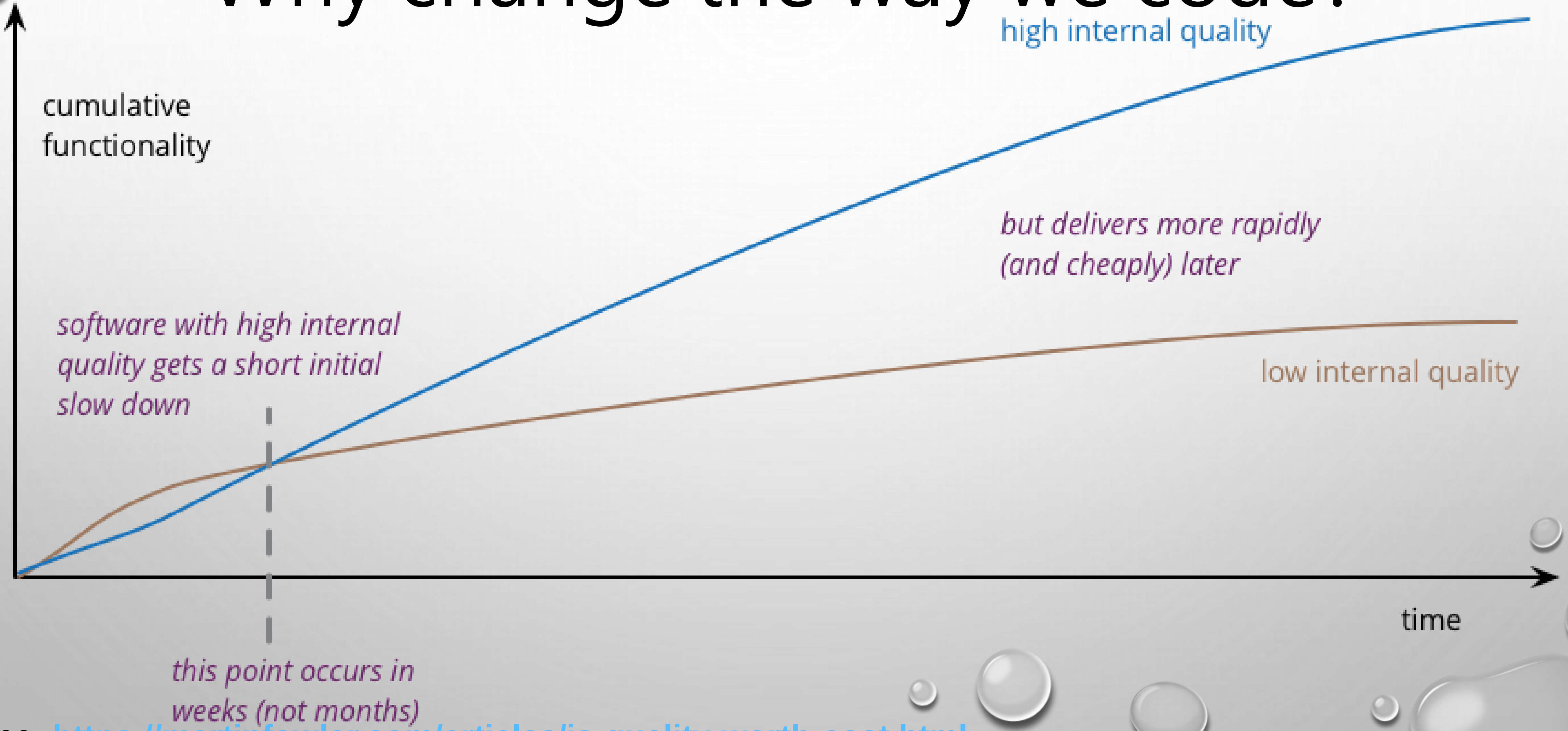
Allegro5 in C

Program Flow in Allegro5

- Your codes are still sequential.
- Initialize → loop (Wait for event → Process event → Draw) → Destroy



Why change the way we code?



Source: https://martinfowler.com/articles/is-quality-worth-cost.html

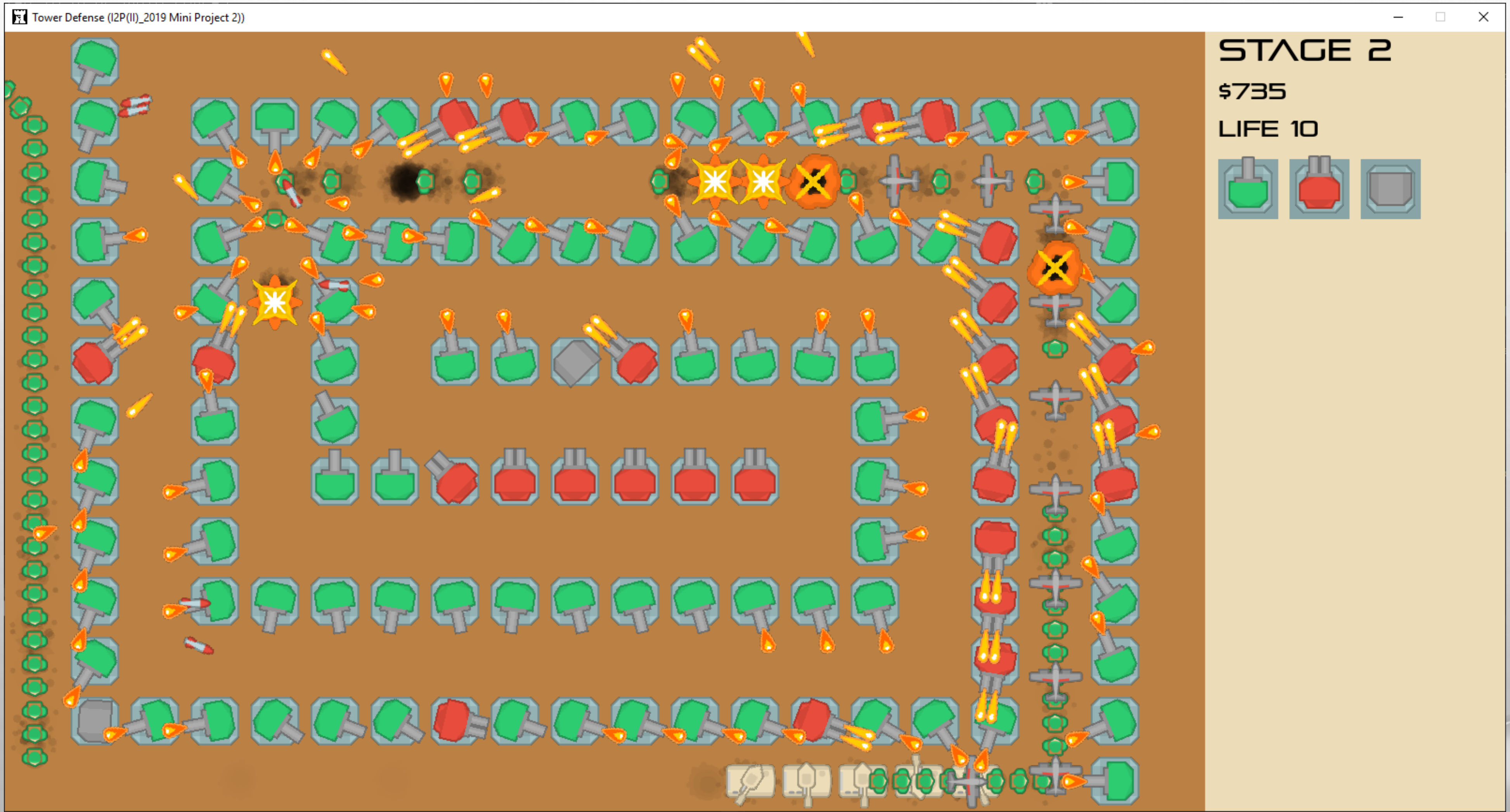
Quick Demo

Tower Defense game demo

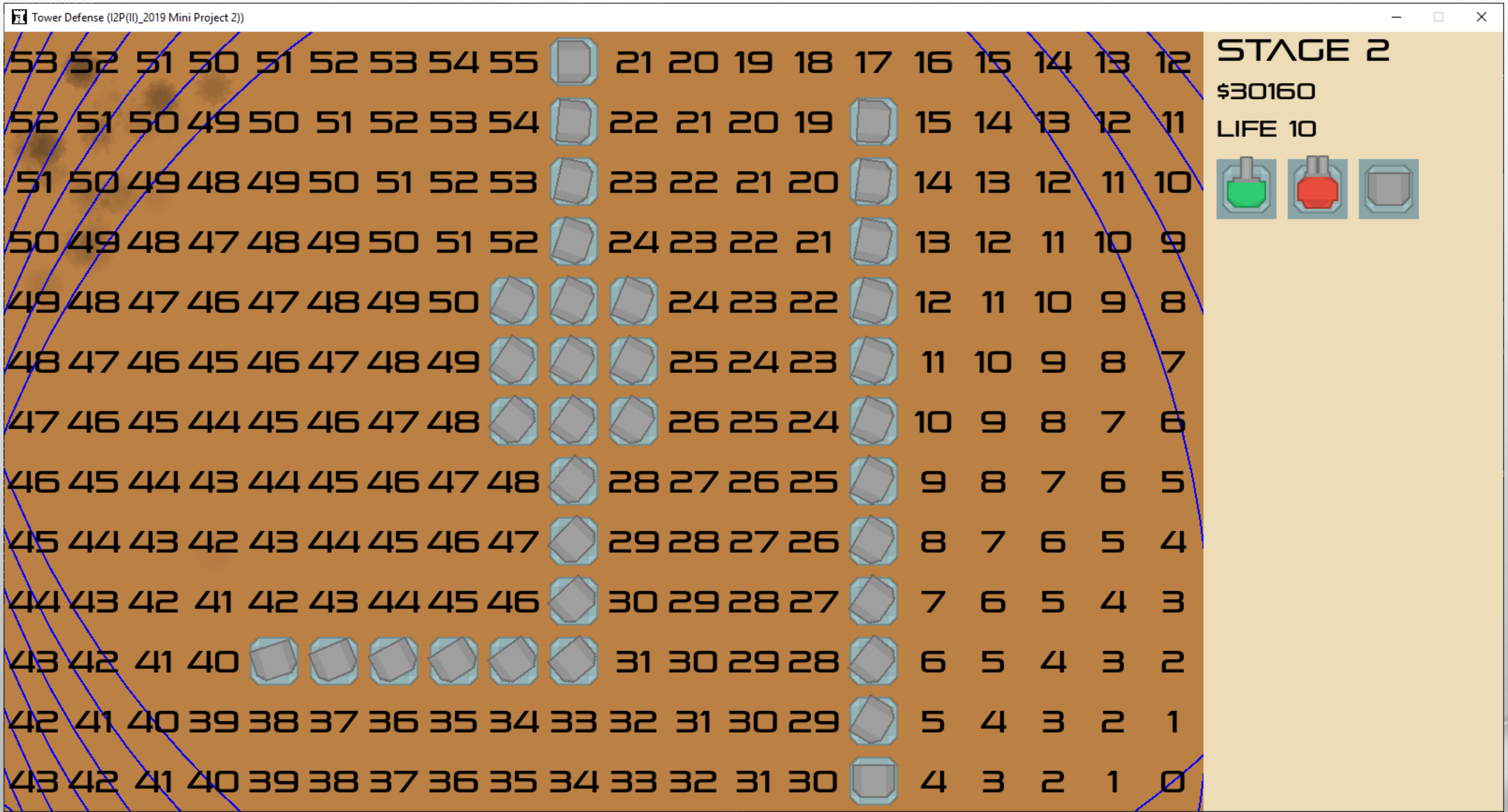
What do we care?

and what we don’　t care?

Template Preview



Debug Mode



Tower Defense (I2P(II)_2019 Mini Project 2))

```
53 52 51 50 51 52 53 54 55    21 20 19 18 17 16 15 14 13 12
52 51 50 49 50 51 52 53 54    22 21 20 19    15 14 13 12 11
51 50 49 48 49 50 51 52 53    23 22 21 20    14 13 12 11 10
50 49 48 47 48 49 50 51 52    24 23 22 21    13 12 11 10  9
49 48 47 46 47 48 49 50          24 23 22    12 11 10  9  8
48 47 46 45 46 47 48 49          25 24 23    11 10  9  8  7
47 46 45 44 45 46 47 48          26 25 24    10  9  8  7  6
46 45 44 43 44 45 46 47 48    28 27 26 25     9  8  7  6  5
45 44 43 42 43 44 45 46 47    29 28 27 26     8  7  6  5  4
44 43 42 41 42 43 44 45 46    30 29 28 27     7  6  5  4  3
43 42 41 40                   31 30 29 28     6  5  4  3  2
42 41 40 39 38 37 36 35 34 33 32 31 30 29     5  4  3  2  1
43 42 41 40 39 38 37 36 35 34 33 32 31 30     4  3  2  1  0
```

STAGE 2

$30160

LIFE 10

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Resources

- Specify only what type of resources and where can we load them.

Images (Bitmap)

Audios (Samples)

Fonts

Resources Management

- Manually loading / destroying resources is unnecessary and causes memory leak if we are not careful enough.

```
ALLEGRO_BITMAP* img = al_load_bitmap("img.png");
if (!img)
    game_abort("failed to load image: img.png");
//...
al_destroy_bitmap(img);
```

Resources Management

- We can ignore resource management when using the wrapped **`Resources`** class: more convenient and less error prone.

```
Resources::GetInstance().GetBitmap("img.png");
//...
// Automatically free resources.
```

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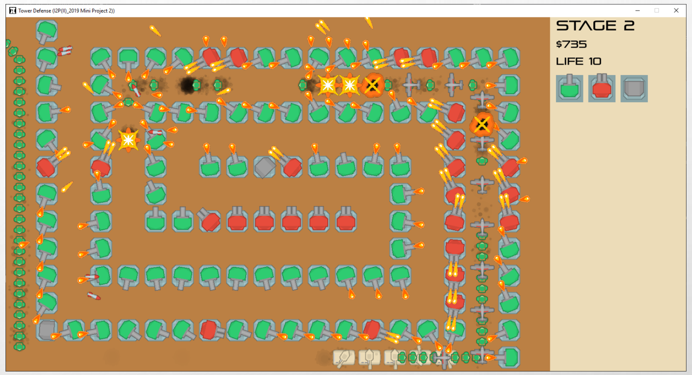
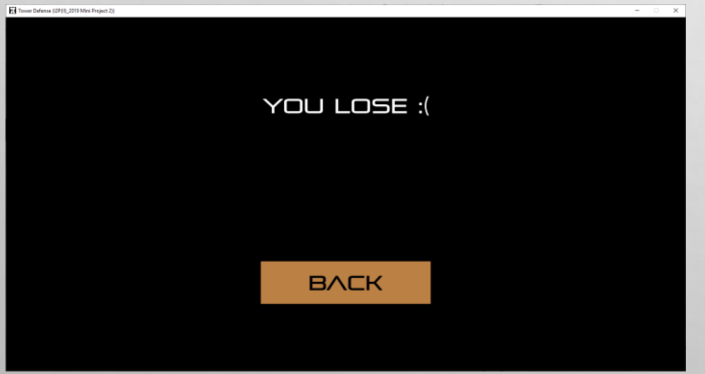
Scenes

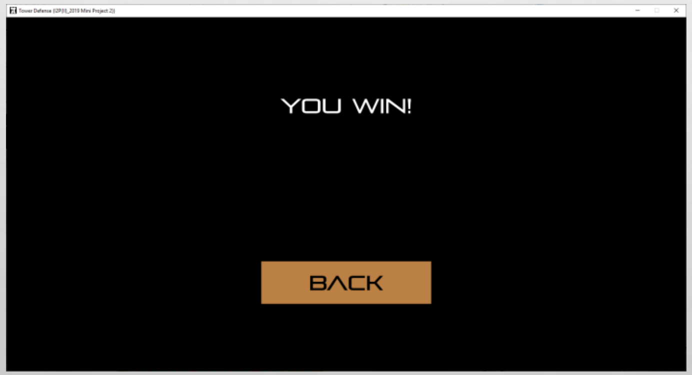
- All scenes should be independent.
- Change between scenes with only a function call.



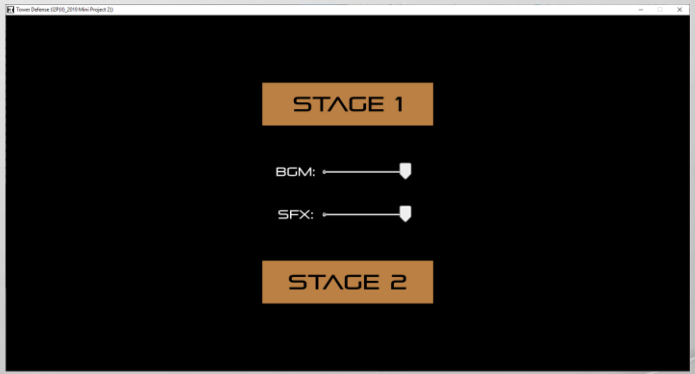
Play Scene



Lose Scene



Win Scene



Stage Select Scene

Multiple Scenes

- Manually checking which scene to update / draw is redundant, and we cannot have same variable names in different scenes.

```
void game_update(void) {
    if (active_scene == SCENE_A) {
        //...
    } else if (active_scene == SCENE_B) {
        //...
    } // Maybe we have up to 5 scenes...
}
// The same structure above is also used in
`game_draw`, `game_change_scene`, and various events
```

Multiple Scenes

- We can ignore the existence of other scenes and see each scene as independent `IScene` class: more encapsulation.

```cpp
class SceneA final : public Engine::IScene {
public:
    explicit SceneA() = default;
    void Initialize() override;
    void Terminate() override;
    void Update() override;
    void Draw() const override;
};
```

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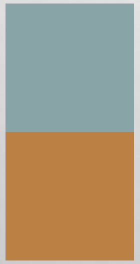
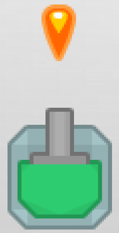
Controls & Objects

- Static images
- Images that can move, rotate, …
- Buttons
- Label (Text)



Image


Sprite

STAGE 2
STAGE 2
ImageButton

STAGE 1
$150
LIFE 10
Label (Text)

Objects & Sprites

- A simple sprite requires too much code.

```
void draw_movable_object(MovableObject obj) {
    if (obj.hidden) return;
    al_draw_bitmap(obj.img, round(obj.x - obj.w / 2),
        round(obj.y - obj.h / 2), 0);
}
void game_update() {
    for (i = 0; i < MAX_OBJ; i++) {
        if (objs[i].hidden) continue;
        objs[i].x += objs[i].vx;
        objs[i].y += objs[i].vy;
    }
}
```

Objects & Sprites

- We can define a class and specify some behaviors of the objects. Then, we can add and forget about it: one-liner for every object.

```
void SceneA::Shoot(int x, int y) {
    AddNewObject(new Bullet(x, y));
}
```

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Objects & Controls

- A simple button requires too much code.

```
void on_mouse_down(int btn, int x, int y) {
    if (btn == 1 && pnt_in_rect(x, y, btnX, btnY, btnW, btnH)) {
        // Button clicked.
    }
}
void game_draw() {
    if (pnt_in_rect(mouse_x, mouse_y, btnX, btnY, btnW, btnH))
        al_draw_bitmap(img_btn_in, btnX, btnY, btnW, btnH);
    else
        al_draw_bitmap(img_btn_out, btnX, btnY, btnW, btnH);
}
```

Objects & Controls

- We can ignore the drawing and mouse-in detection. For buttons, we only want to know when it is clicked. Declaring a variable just for the button is also unnecessary: higher abstraction.

```
void SceneA::BtnOnClick() { // Button clicked. }
void SceneA ::Initialize() {
    ImageButton* btn = new ImageButton("img_out.png", "img_in.png", 0, 0);
    btn->SetOnClickCallback(std::bind(&SceneA::BtnOnClick, this));
    AddNewControlObject(btn);
}
```

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Template Naming Convention

- Usually, C++ uses snake case, but we use camel case here to distinguish between STL and self-defined code.
- `std::???` `(snake_case) → C++11 STL`
- `al_???`, `ALLEGRO_???` `→ Allegro5 libraries' API.`
- `Engine::???` `(CamelCase) → Our own defined wrapper`

  `::???` `→ Classes used in game.`

Template Diagram

- Class Diagram
- Engine Class Diagram
- Engine Class Diagram Minimized
- Game Class Diagram
- Game Class Diagram Minimized
- Game Class Diagram Minimized Annotated

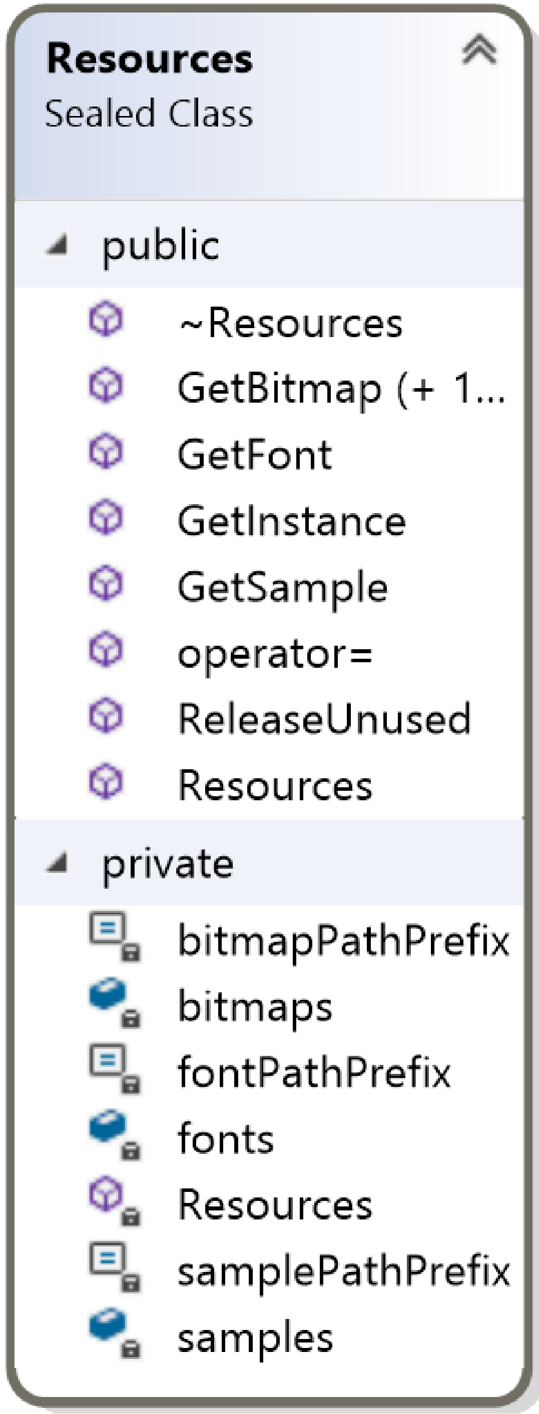
Engine code

Tower Defense

Template: Resources

`Engine::Resources`

- Abstracts all resources loading and destroy.
- Resources can be retrieved from this class directly.


Resources
Sealed Class

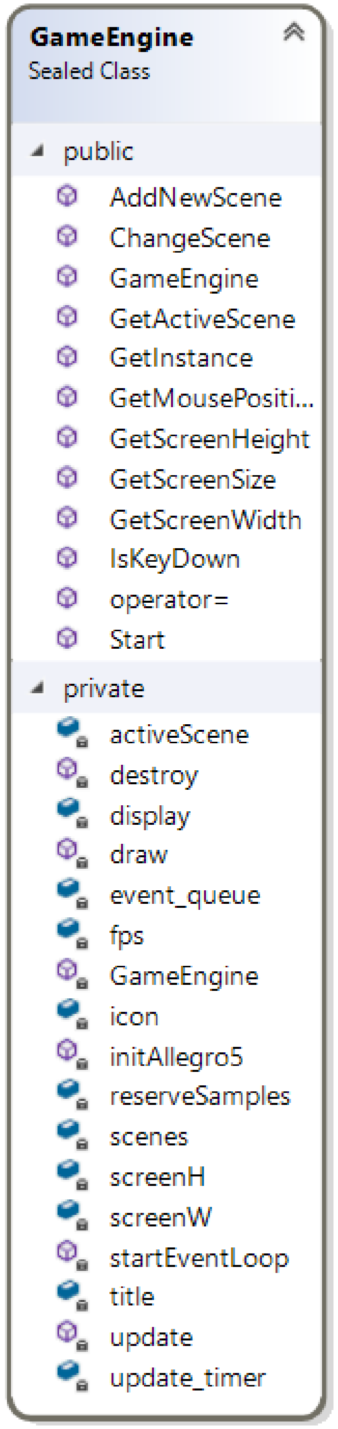
public
- ~Resources
- GetBitmap (+ 1...
- GetFont
- GetInstance
- GetSample
- operator=
- ReleaseUnused
- Resources

private
- bitmapPathPrefix
- bitmaps
- fontPathPrefix
- fonts
- Resources
- samplePathPrefix
- samples

Template: Game Engine

```
Engine::GameEngine
```

- Abstracts the entire message loop
- Manages current scene and scene changes.



GameEngine
Sealed Class

public
- AddNewScene
- ChangeScene
- GameEngine
- GetActiveScene
- GetInstance
- GetMousePositi...
- GetScreenHeight
- GetScreenSize
- GetScreenWidth
- IsKeyDown
- operator=
- Start

private
- activeScene
- destroy
- display
- draw
- event_queue
- fps
- GameEngine
- icon
- initAllegro5
- reserveSamples
- scenes
- screenH
- screenW
- startEventLoop
- title
- update
- update_timer

Template: IScene, Group

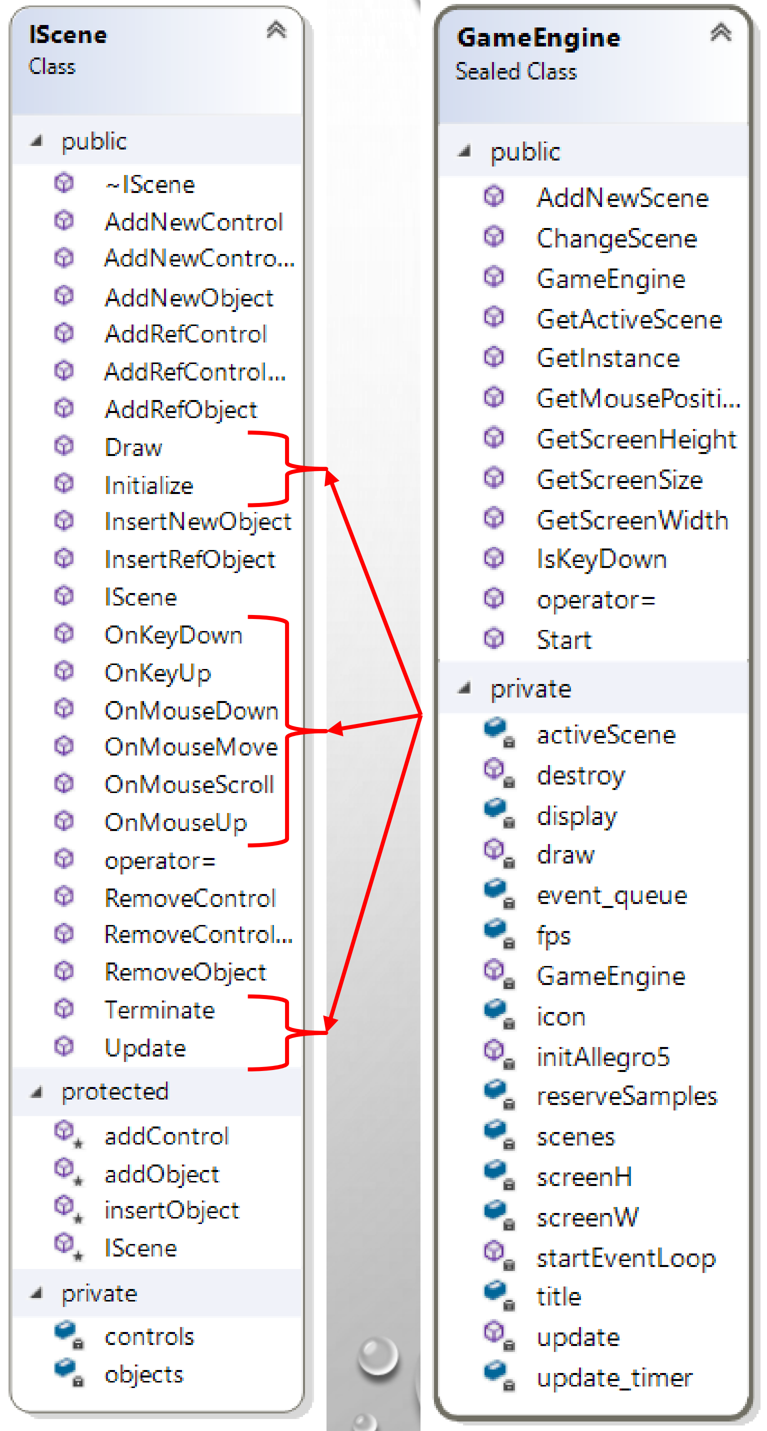
`Engine::IScene`

- Encapsulates a scene, must be inherited and customized.

`Engine::Group`

- Draw and update everything for you.

Note: We combined Group and IScene in this diagram



IScene
Class

public
- ~IScene
- AddNewControl
- AddNewContro...
- AddNewObject
- AddRefControl
- AddRefControl...
- AddRefObject
- Draw
- Initialize
- InsertNewObject
- InsertRefObject
- IScene
- OnKeyDown
- OnKeyUp
- OnMouseDown
- OnMouseMove
- OnMouseScroll
- OnMouseUp
- operator=
- RemoveControl
- RemoveControl...
- RemoveObject
- Terminate
- Update

protected
- addControl
- addObject
- insertObject
- IScene

private
- controls
- objects

GameEngine
Sealed Class

public
- AddNewScene
- ChangeScene
- GameEngine
- GetActiveScene
- GetInstance
- GetMousePositi...
- GetScreenHeight
- GetScreenSize
- GetScreenWidth
- IsKeyDown
- operator=
- Start

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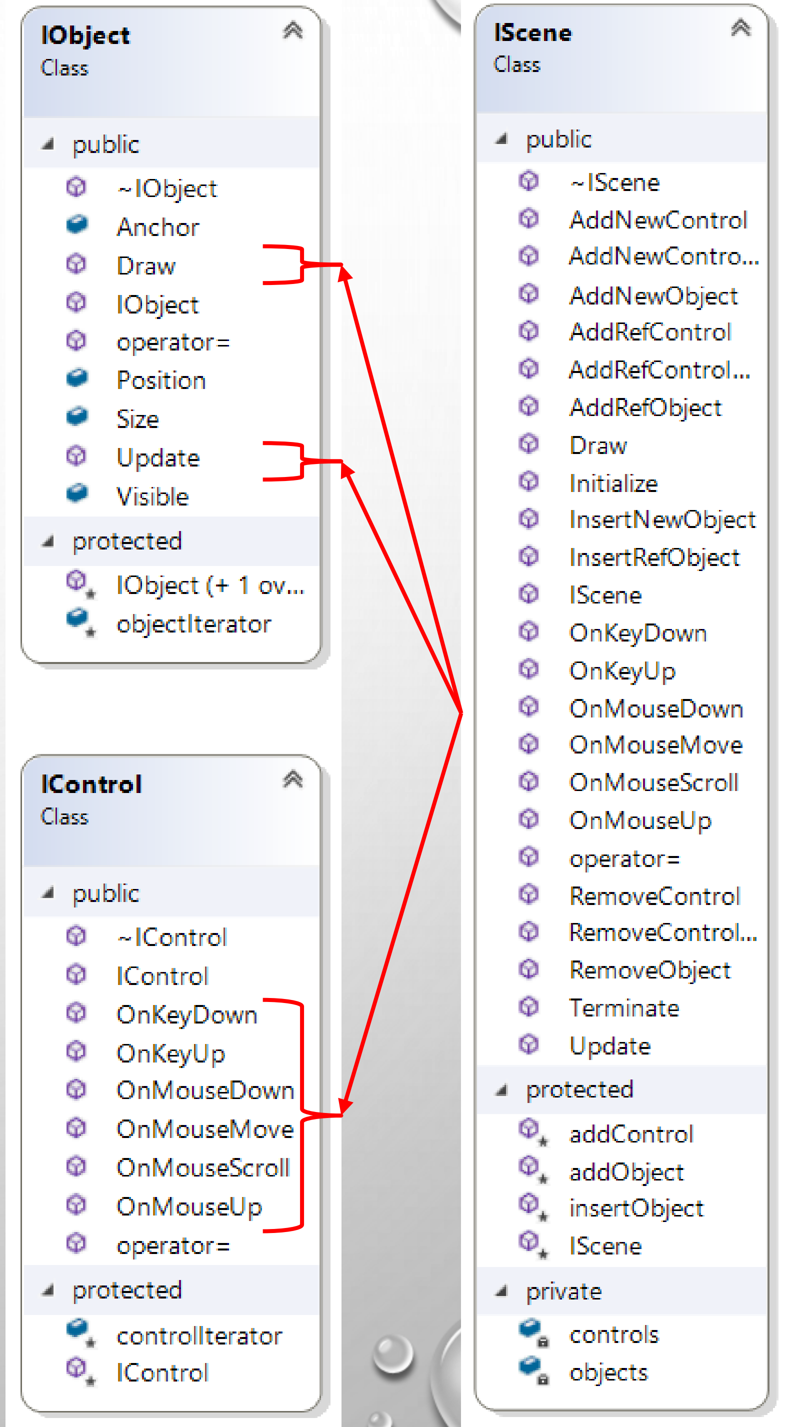
Template: IObject, IControl

Engine::IObject

- The base class of everything that can be drawn.

Engine::IControl

- The base class of everything that can receive events.



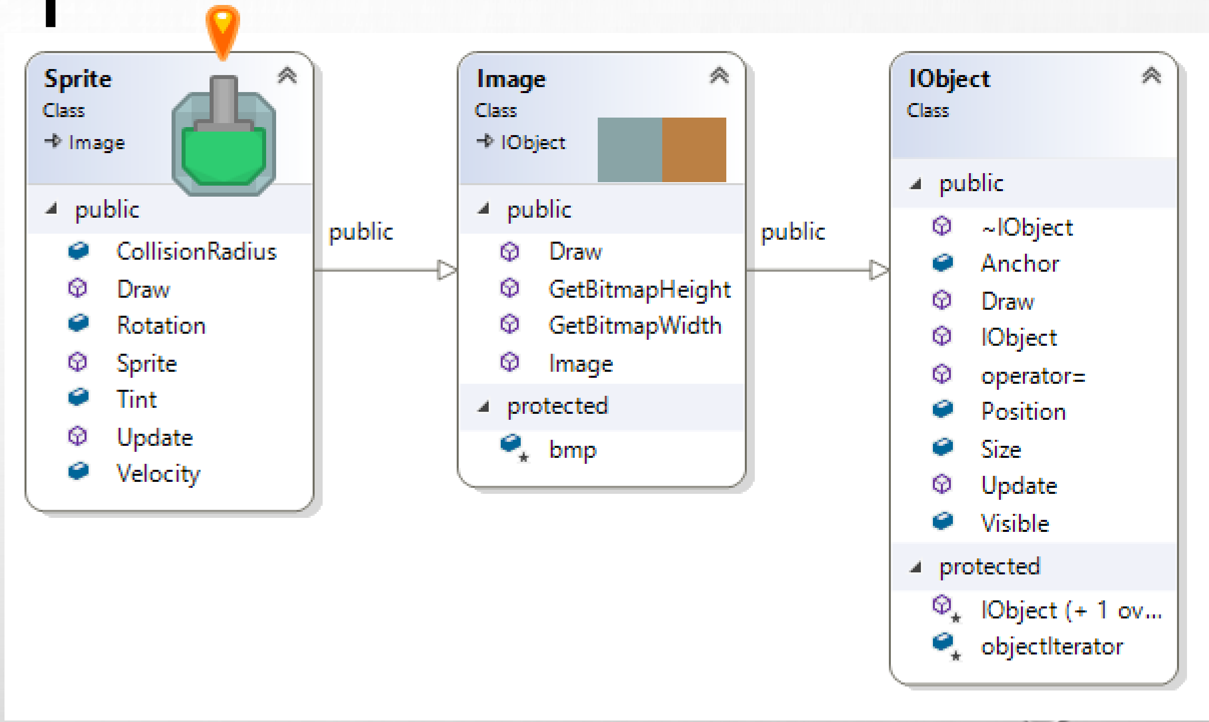
Template: Image, Sprite

```
Engine::Image :
   public Engine::IObject
```

- A simple static image object.

```
Engine::Sprite :
   public Engine::Image
```

- Supports rotation, velocity, tint, and collision radius.



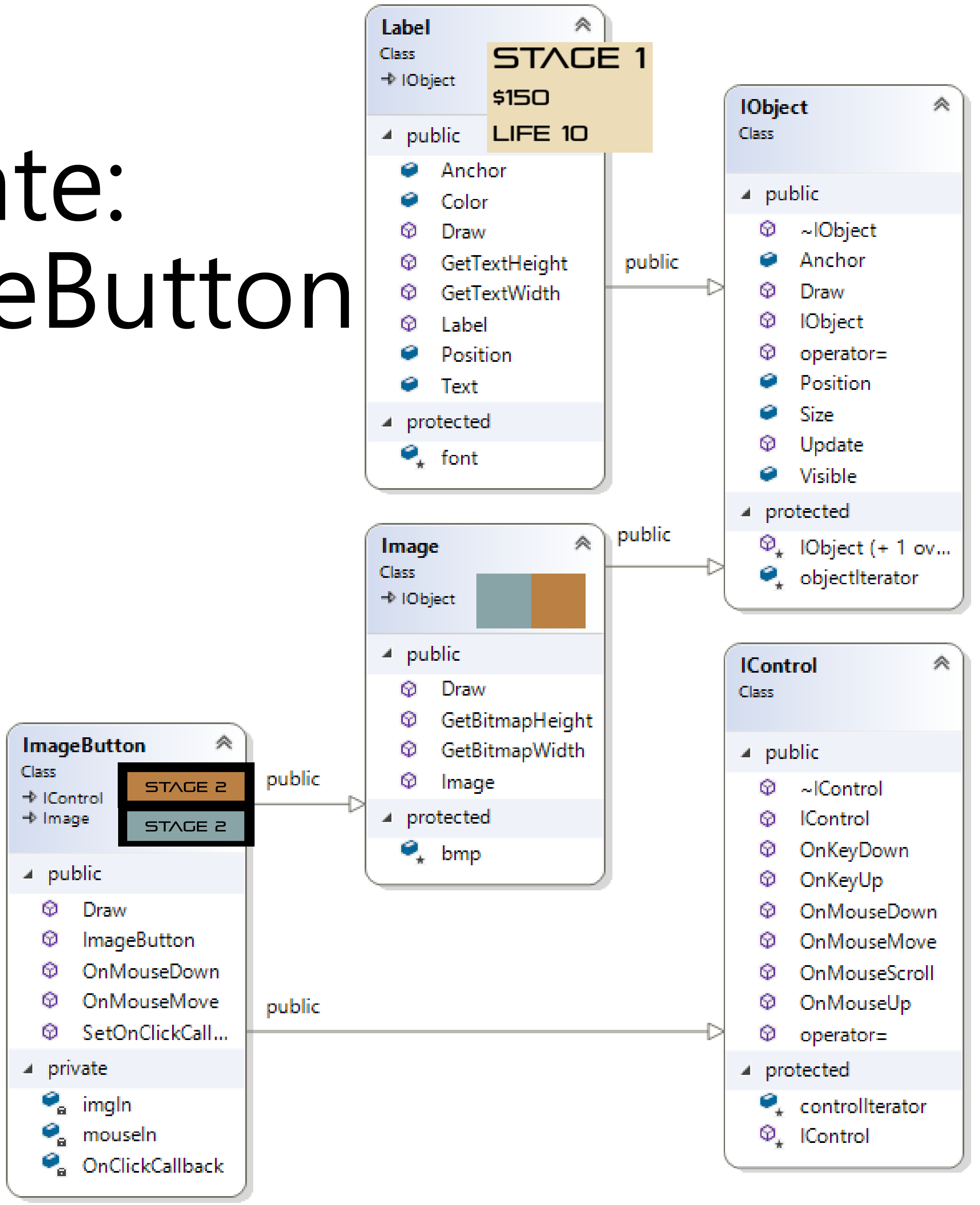
Template: Label, ImageButton

```
Engine::Label :
   public Engine::IObject
```

- A simple static text object.

```
Engine::ImageButton :
   public Engine::IObject,
   public Engine::IControl
```

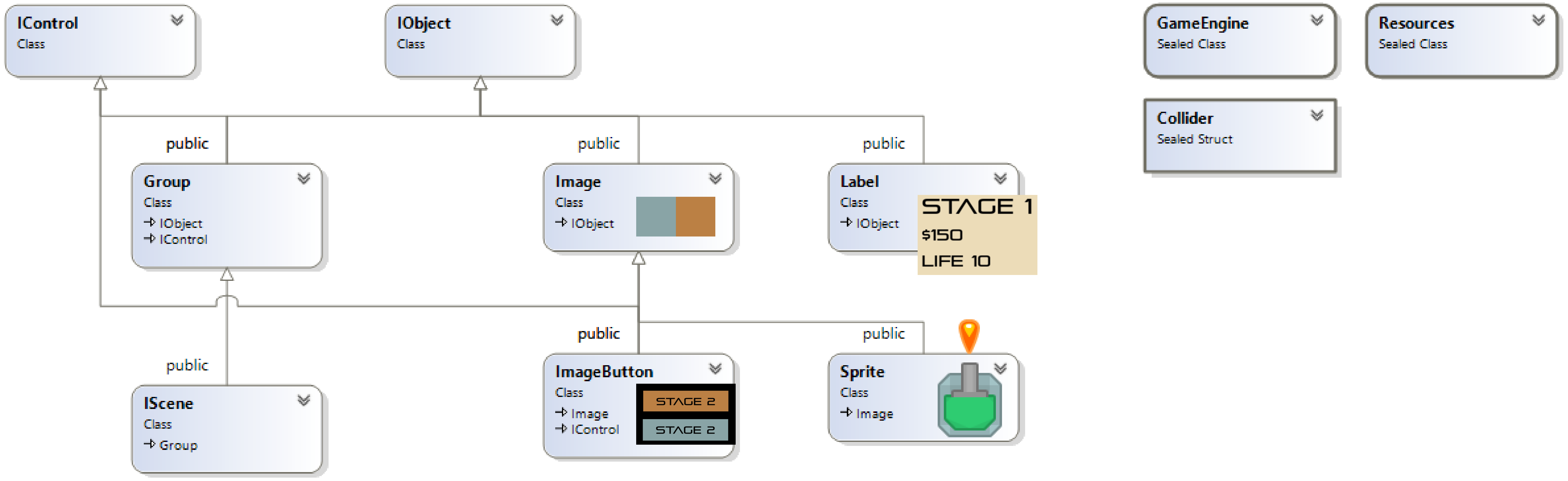
- A clickable button, changes image when mouse move.



Engine Diagram (Minimized)

(OnMouseMove, OnMouseDown, …)

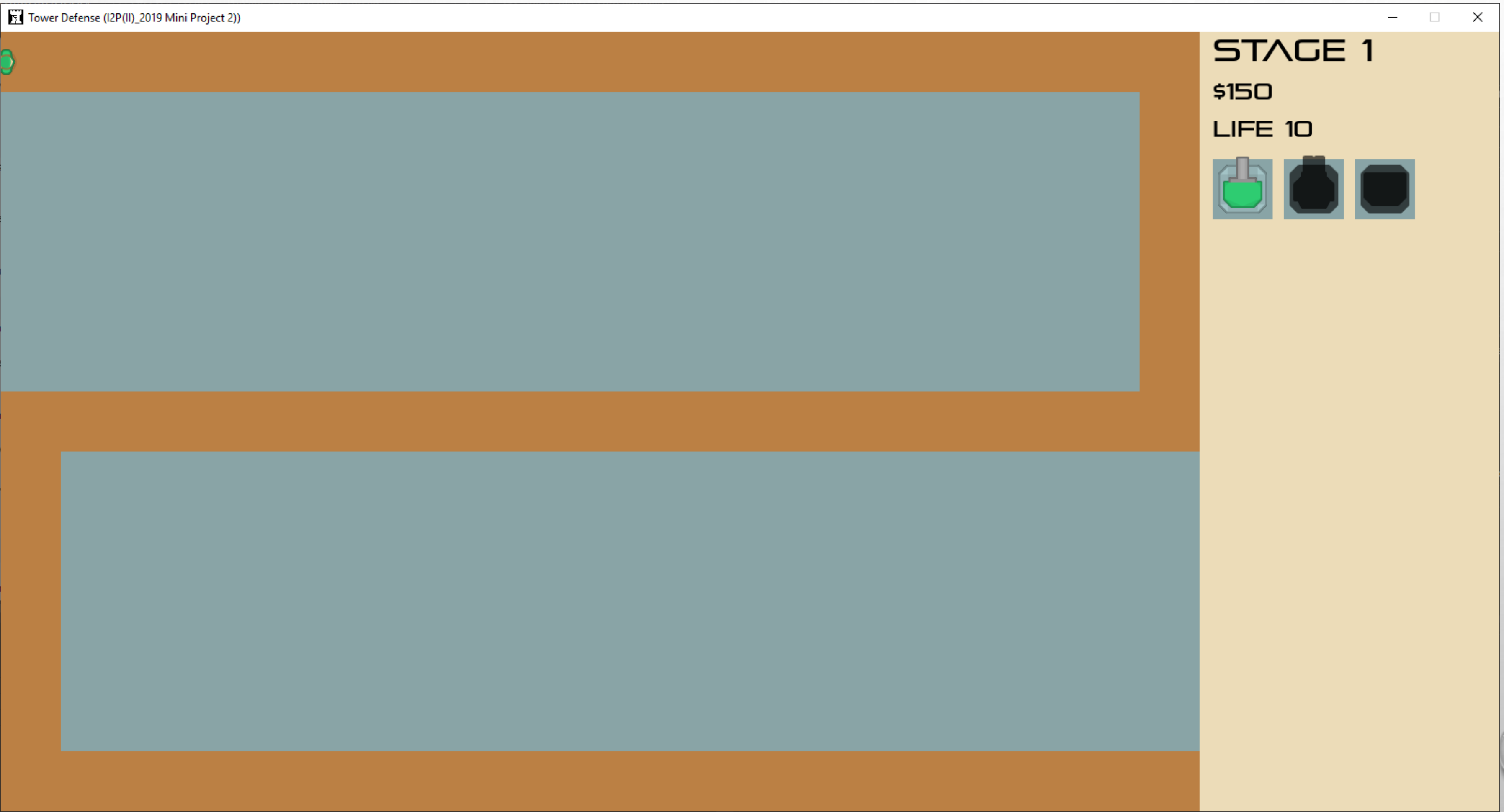
(Update, Draw)



Game code

Tower Defense

Map file format



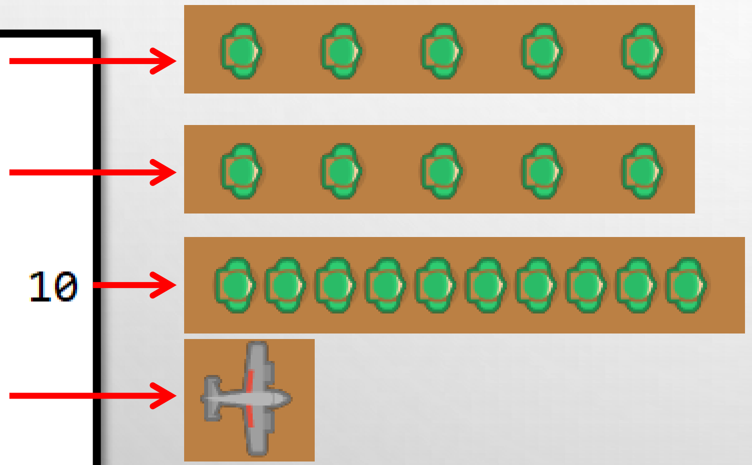
```
00000000000000000000
11111111111111111110
11111111111111111110
11111111111111111110
11111111111111111110
11111111111111111110
00000000000000000000
01111111111111111111
01111111111111111111
01111111111111111111
01111111111111111111
01111111111111111111
00000000000000000000
```

resources/map1.txt

Enemy file format

- EnemyType TimeDelayBetween Count

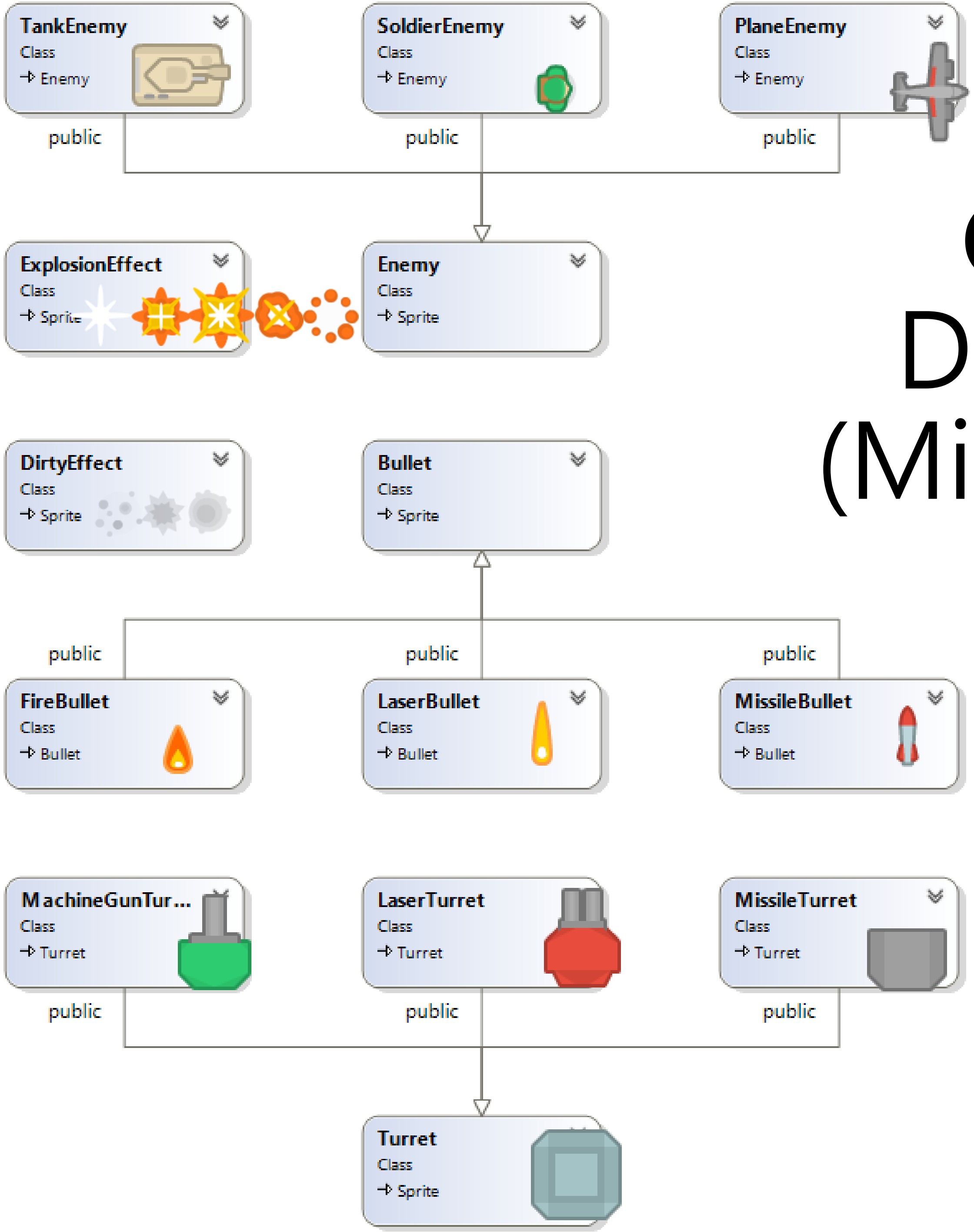
```
1 1 5
0 2 1
1 1 5
0 2 1
1 0.5 10
0 6 1
2 1 1
0 2 1
1 0.5 20
0 12 1
2 1 5
0 2 1
1 0.5 20
```

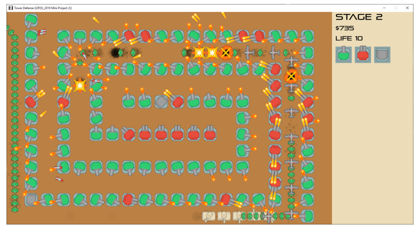


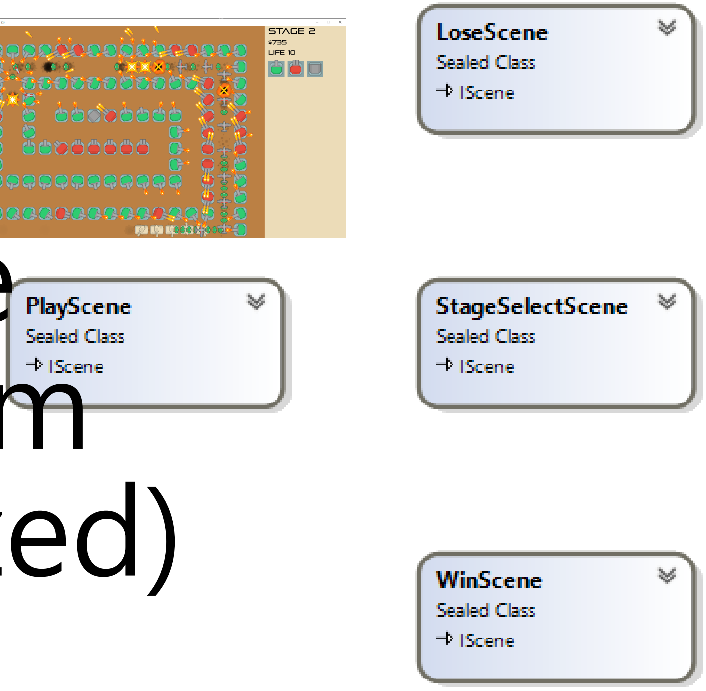
You should edit this file after adding new enemy

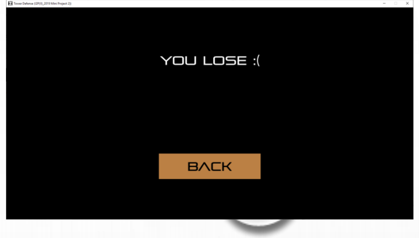
resources/enemy1.txt

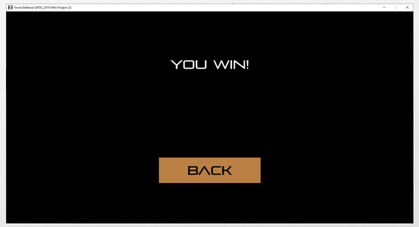
Game Diagram (Minimized)











Future of game programming

- Component system
- Physics engine
- Functional programming
- Entity component system (ECS)

- However, OOP is still a concept that cannot be abandoned in most programs.

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Othello

Mini Project 3 Package

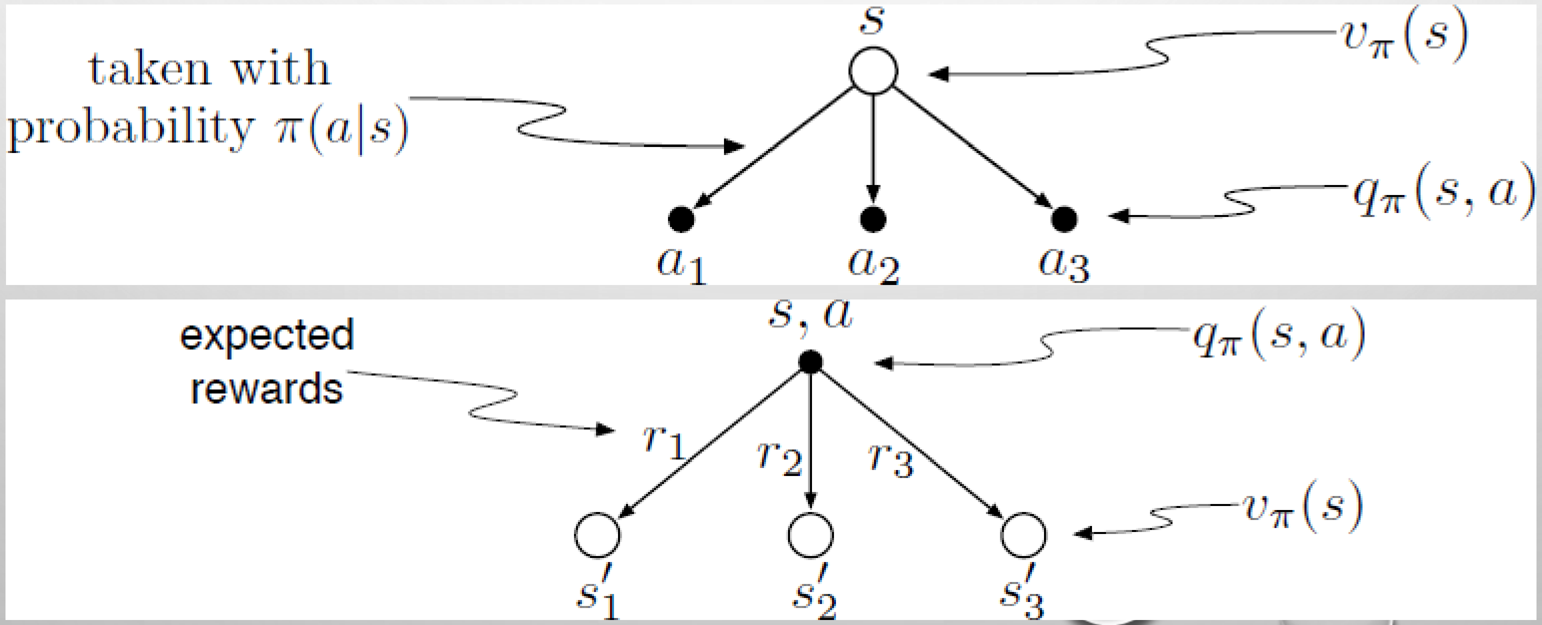
Outline

- State Value & State-Action Value
- Minimax
- Alpha-Beta Pruning
- Goal & Grading Policy

State Value & State-Action Value

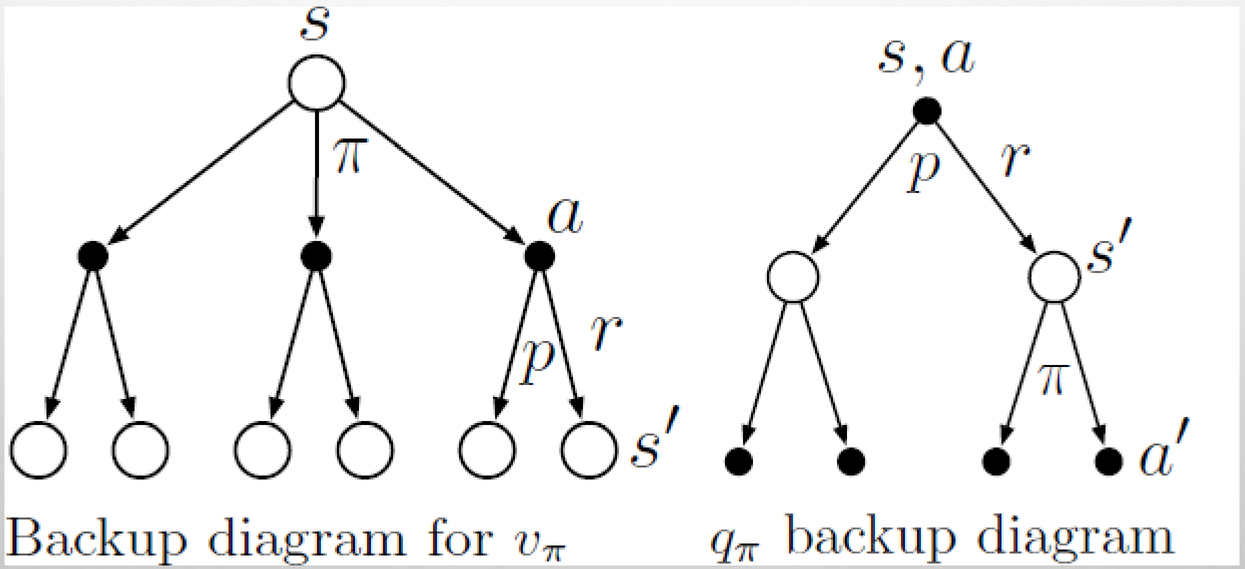
$V(s)$: How good is the current board in my point of view

$Q(s,a)$: How good is a certain action on the current board

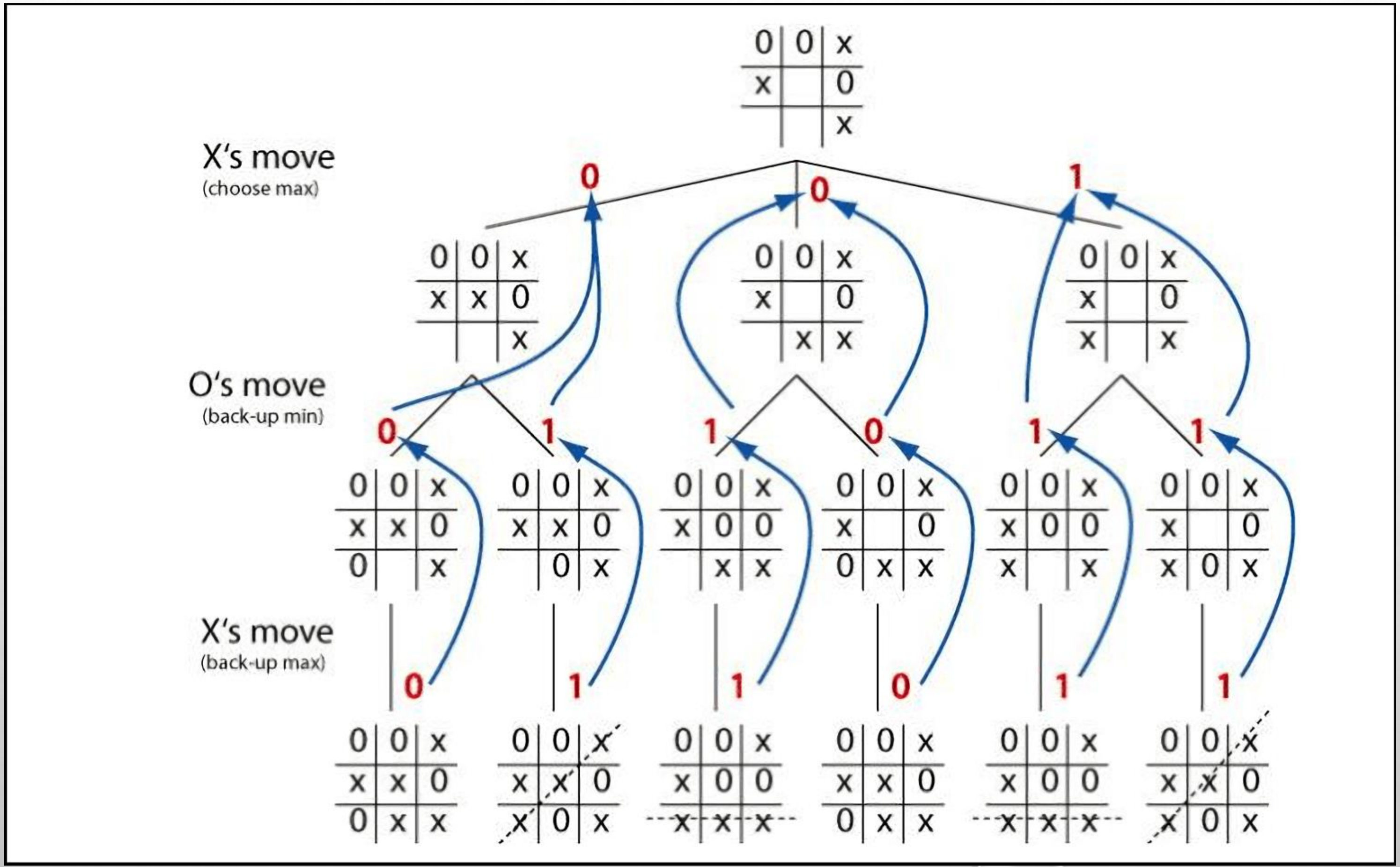


State Value & State-Action Value

The general case for all games

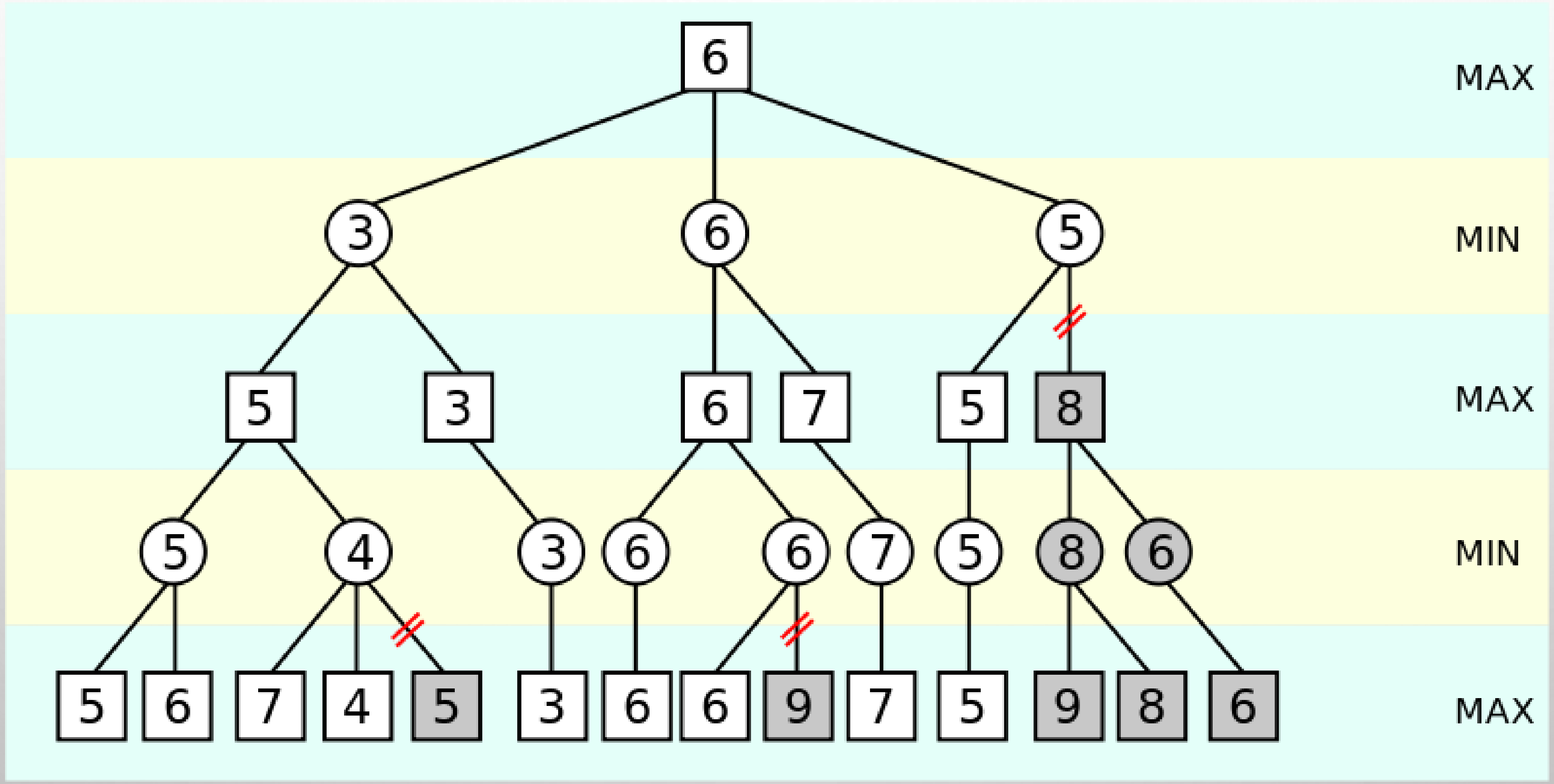


Minimax



Source: https://www.researchgate.net/figure/Game-tree-for-Tic-Tac-Toe-game-using-MiniMax-algorithm_fig1_262672371

Alpha-Beta Pruning



Source: https://en.wikipedia.org/wiki/Alpha%E2%80%93beta_pruning

Q&A

Feel free to ask any question.