Allegro5 Tutorial

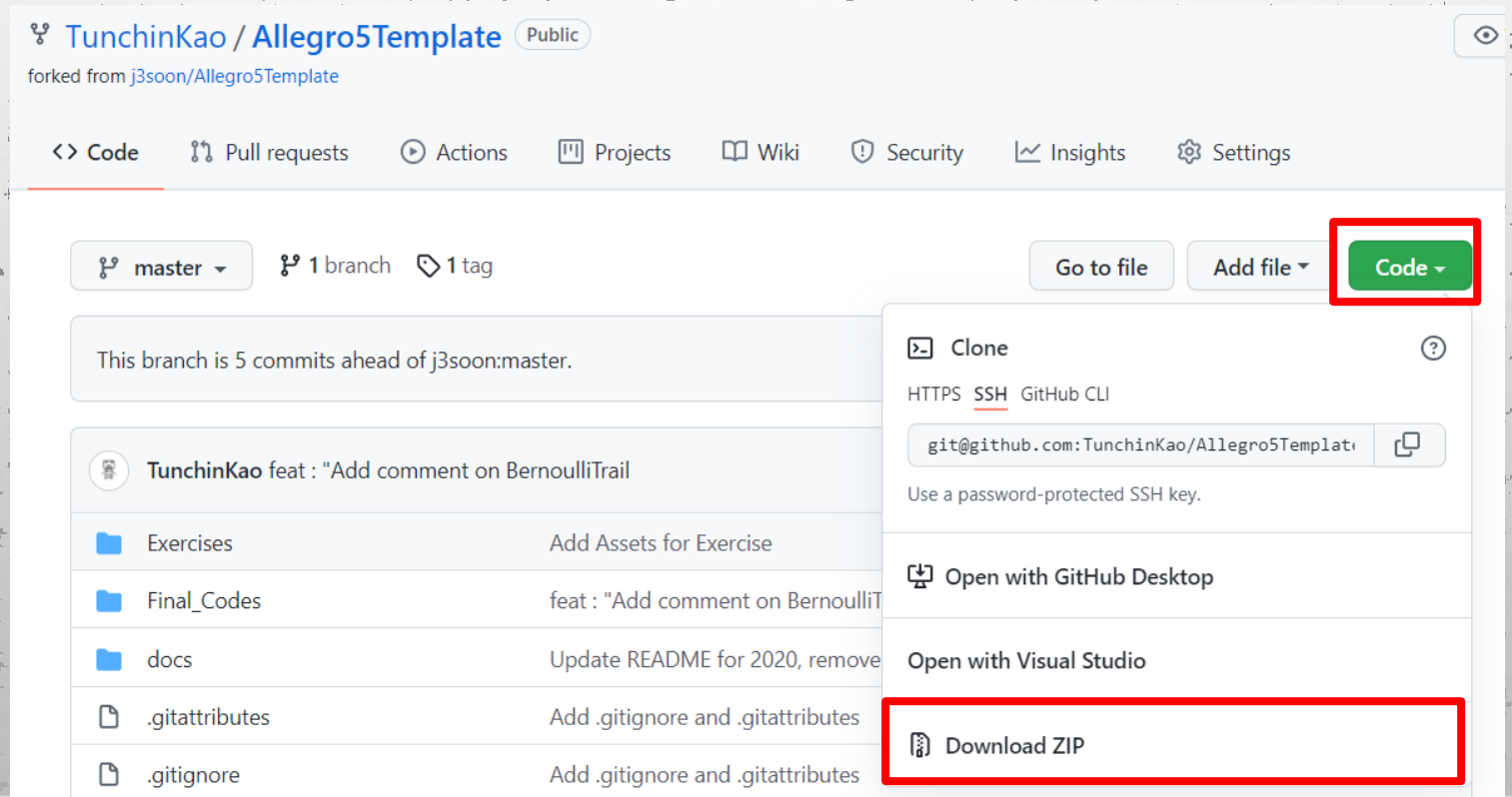
Before we start…

Announcements

- You should finish installing and setting up Allegro5 on your own computer and practice the tasks before Hackathon.
- Hackathon (grading: 3%)
  - 12/19 (Sunday) 09:00-20:00 (Prof. Hu's class/Prof. Yang's class)
- Final Project Demo (grading: 17%)
  - 01/17, 18 (Mon, Tue), details will be announced one week ahead

Announcements

- For the materials, please refer to:
- [TunchinKao/Allegro5Template (github.com)]



A new data type - bool

- A kind of data type that can only be `true(1)` or `false(0)`.
- Implemented in C++, C#, Java (boolean), Python, ...
- Allegro5 has defined its own bool data type.
- No need to include `stdbool.h`.

```
bool is_SR_handsome = true;
if (is_SR_handsome) {...}
```

Outline

- Introduction
- Display & draw image
- Events (display, timer, keyboard, mouse)
- Tips on debugging
- Tasks
- References & Tutorials

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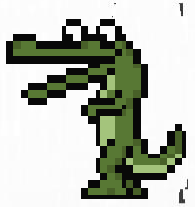
Allegro
(Atari Low-LEvel Game ROutines)

- Atari Low-Level Game Routines
- A software library written in C for video game development.
- Initially released in early 1990.

Allegro5



- A cross-platform library mainly aims at video game and multimedia programming.
- Supported on Windows, Linux, Mac OSX, iPhone and Android.
- User-friendly, intuitive C API usable from C++ and many other languages.
- Hardware accelerated bitmap and graphical primitive drawing support. (via OpenGL or Direct3D)

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Display (Window)

```
#include <allegro5/allegro.h>
int main(int argc, char **argv) {
    al_init();
    ALLEGRO_DISPLAY* display =
        al_create_display(800, 600);
    al_clear_to_color(
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    al_flip_display();
    al_rest(5.0);
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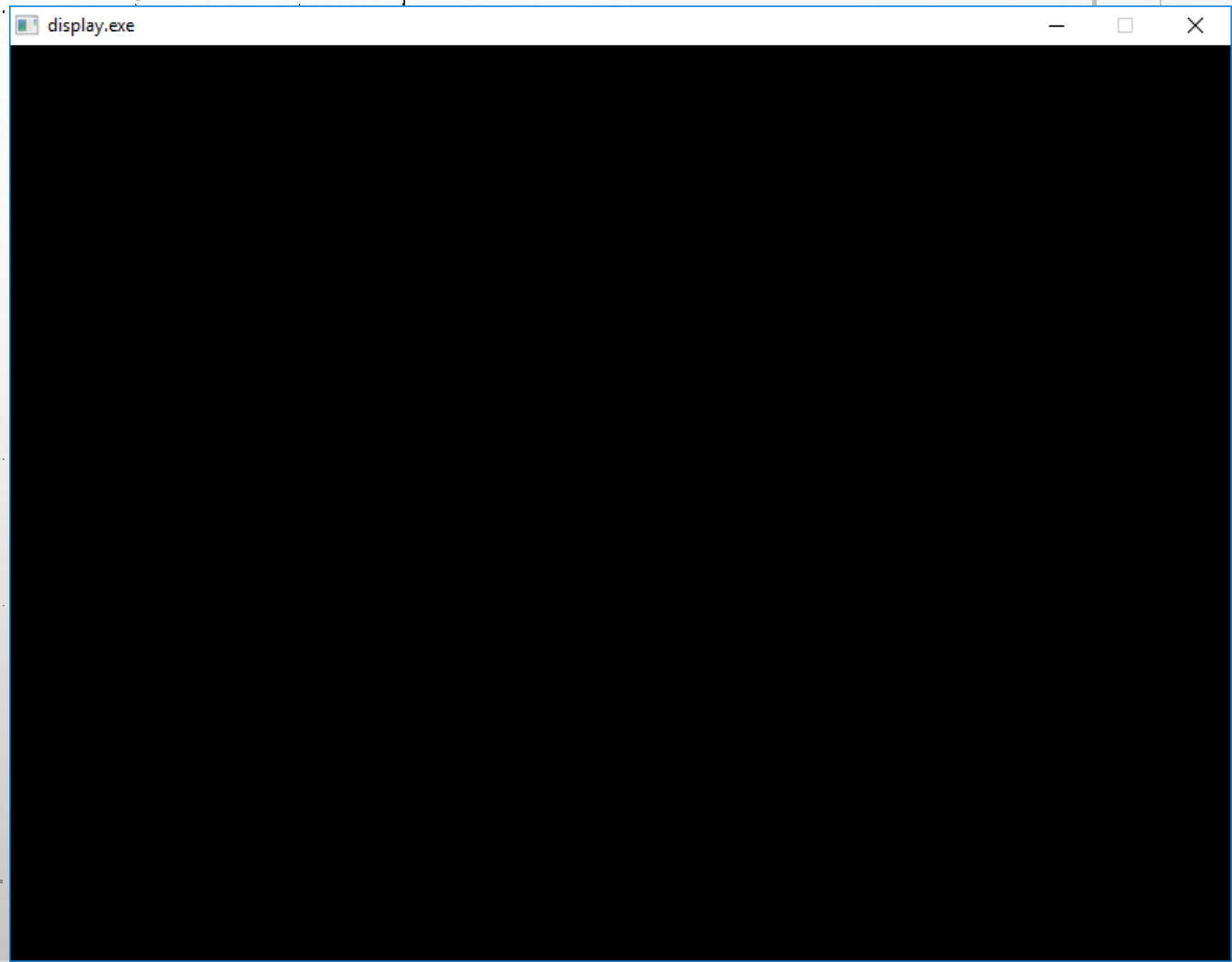
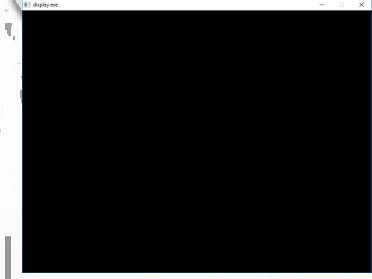


Display (Window)

Buffer:



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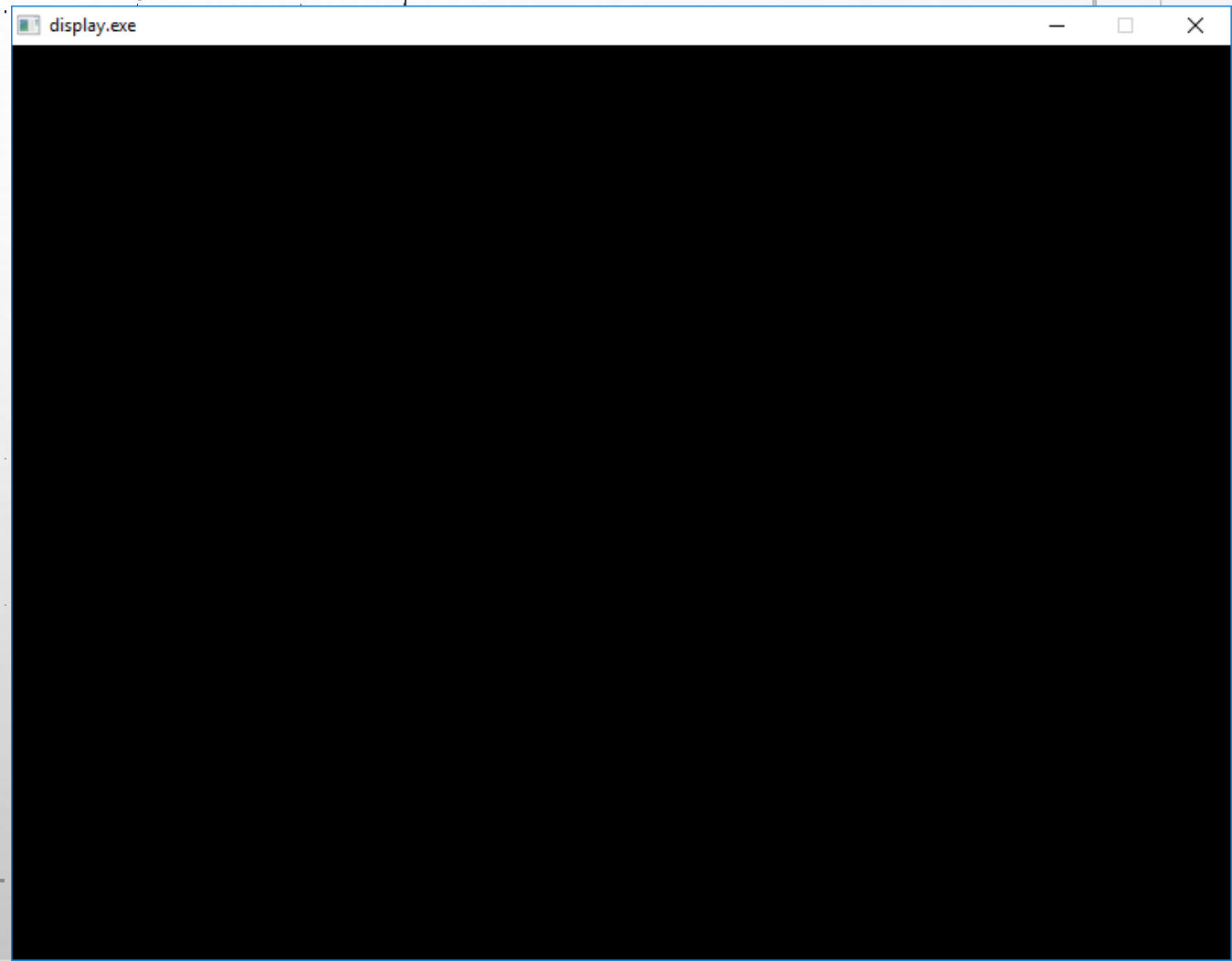

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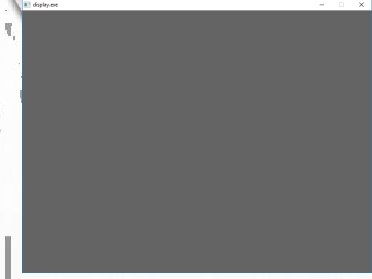

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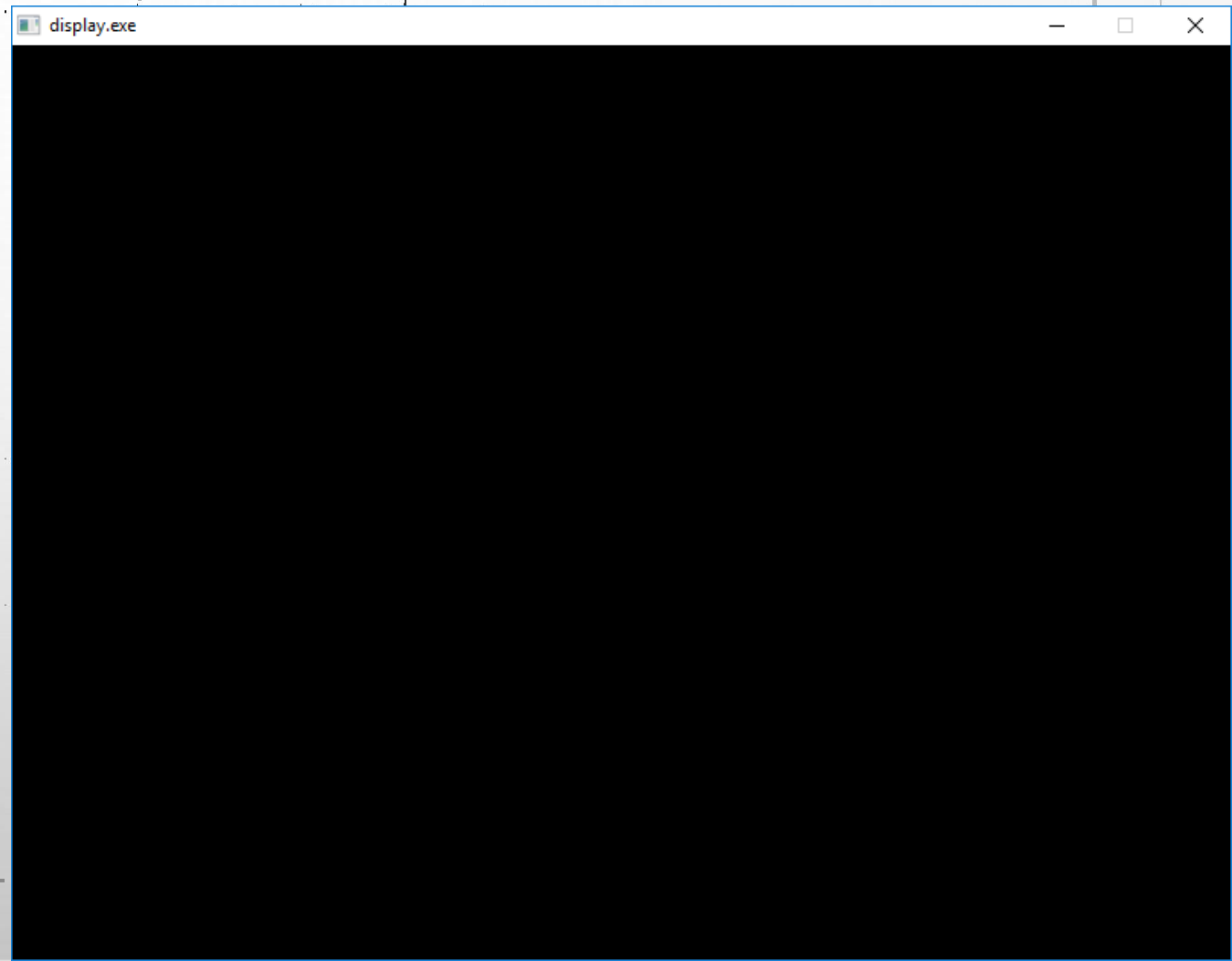

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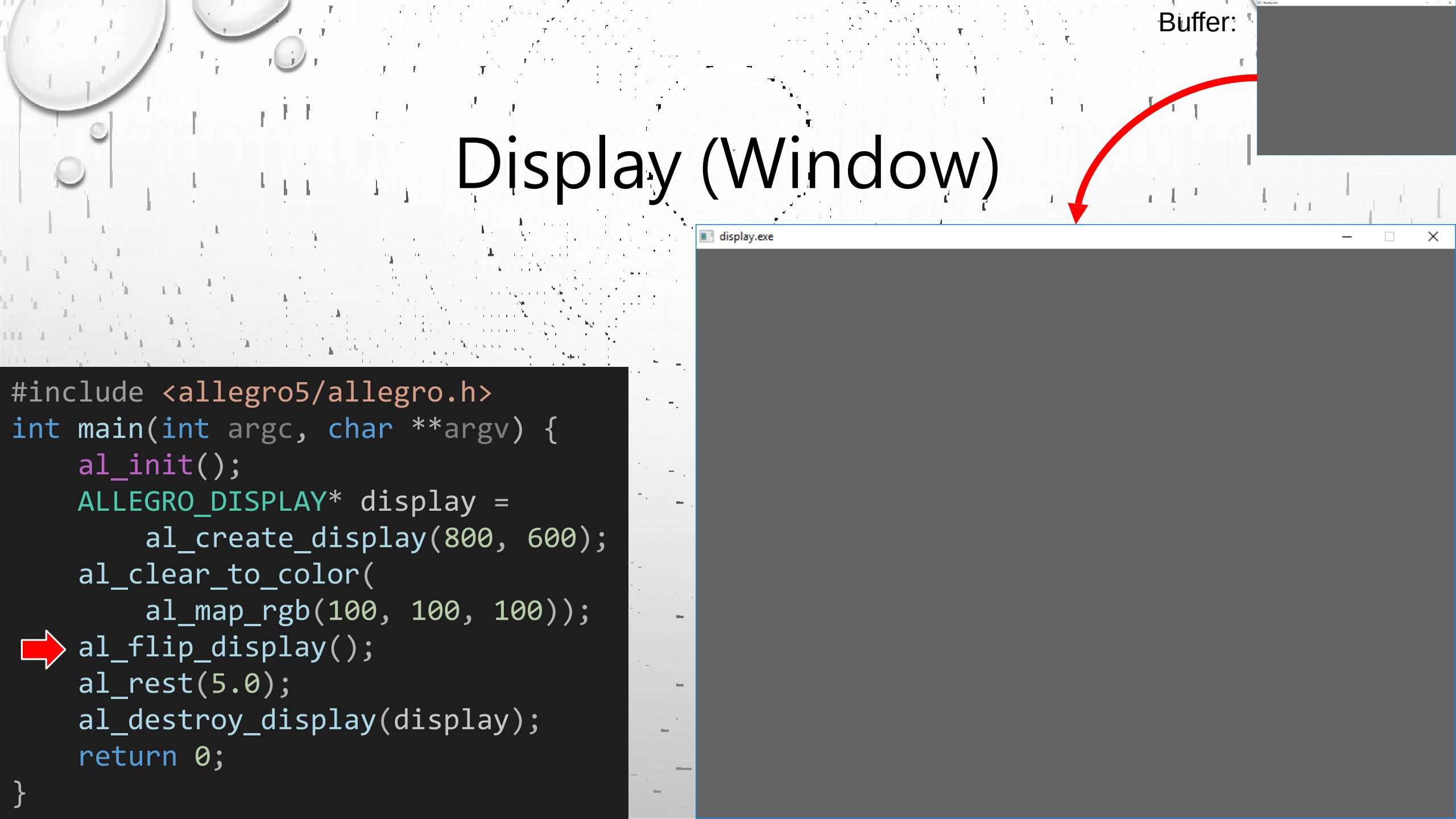


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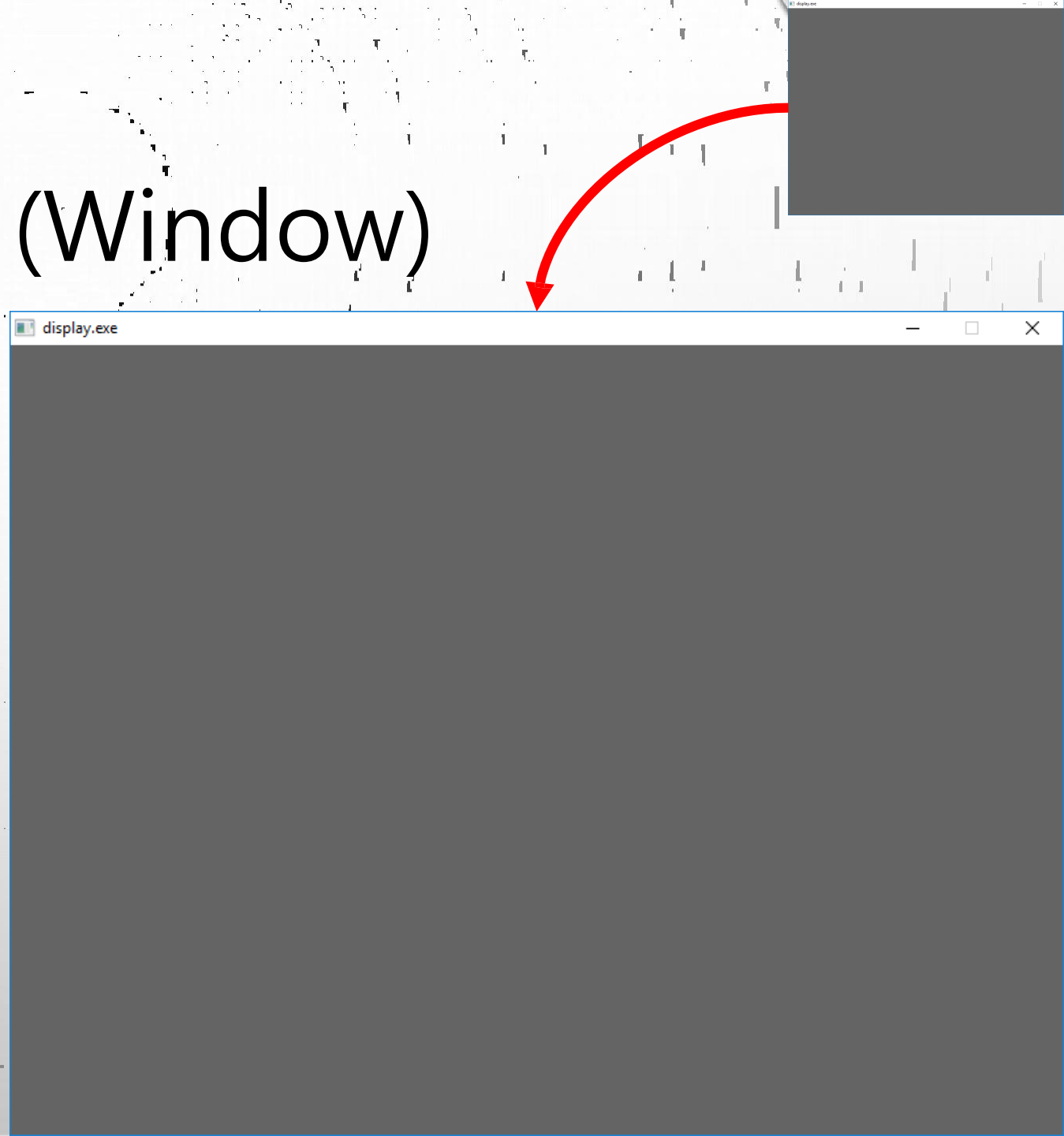

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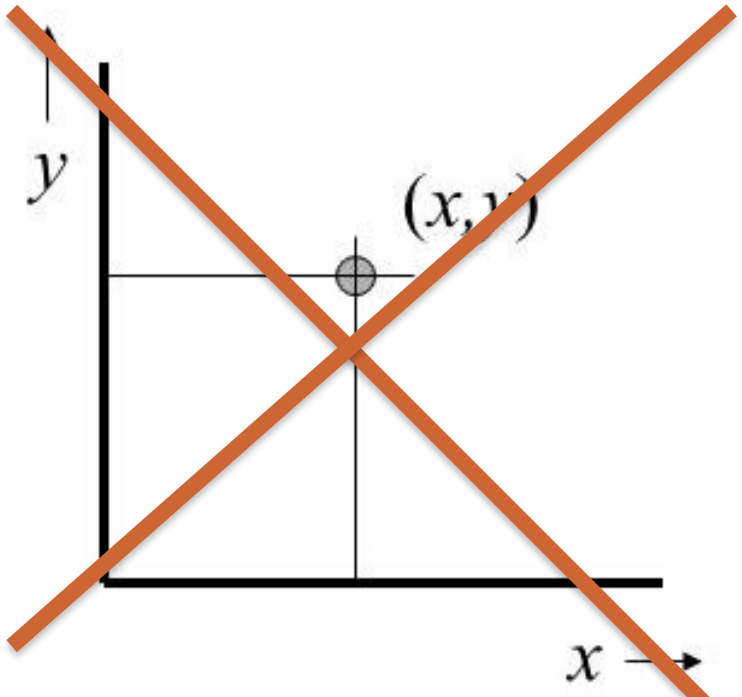
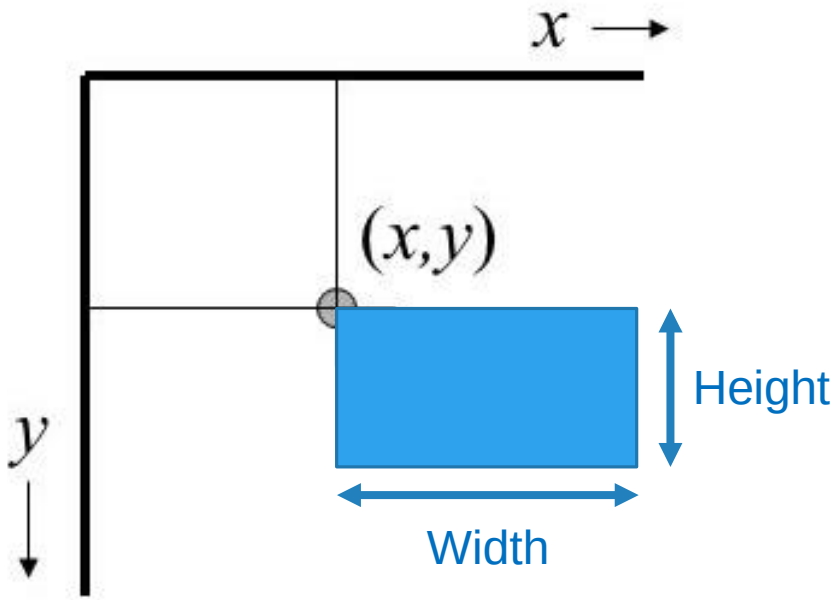
Coordinates on Display

2D computer graphics often have the origin in the top left corner and the y-axis down the screen.



~~Standard~~



Screen (output, input)

Source: https://slideplayer.com/slide/6064012/

Image (Bitmap / Picture)

```
#include <allegro5/allegro.h>
#include <allegro5/allegro_image.h>
int main(int argc, char **argv) {
    al_init();
    al_init_image_addon();
    //...
    ALLEGRO_BITMAP* img =
        al_load_bitmap("save.png");
    al_draw_bitmap(img, 0, 0, 0);
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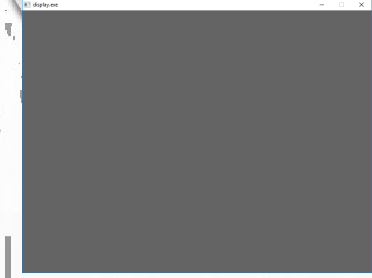
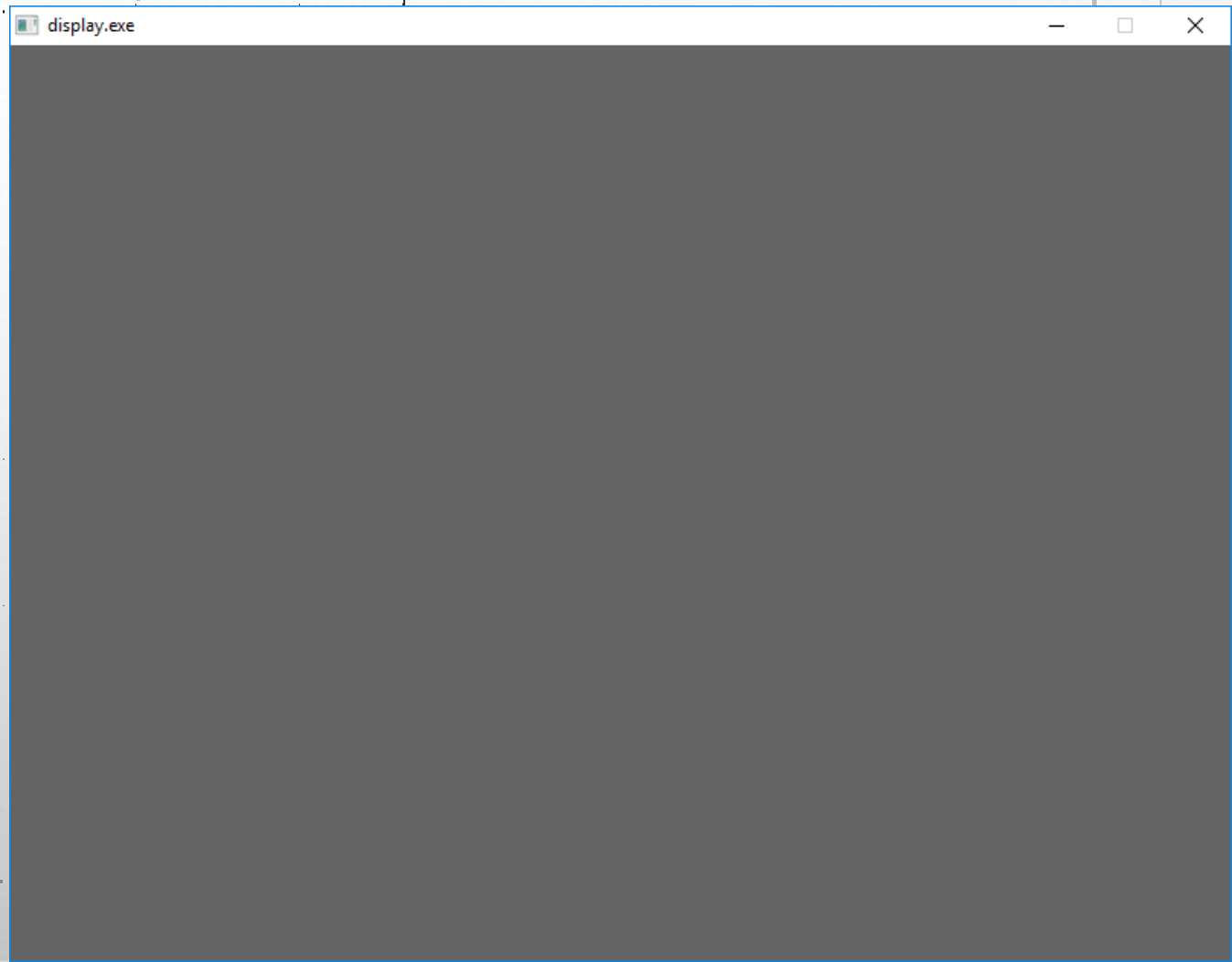
img:

Buffer:





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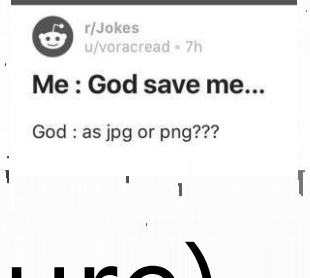

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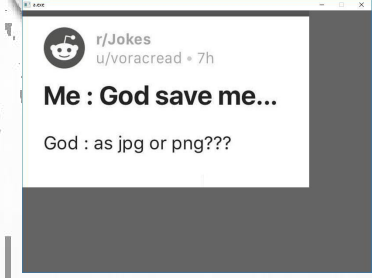

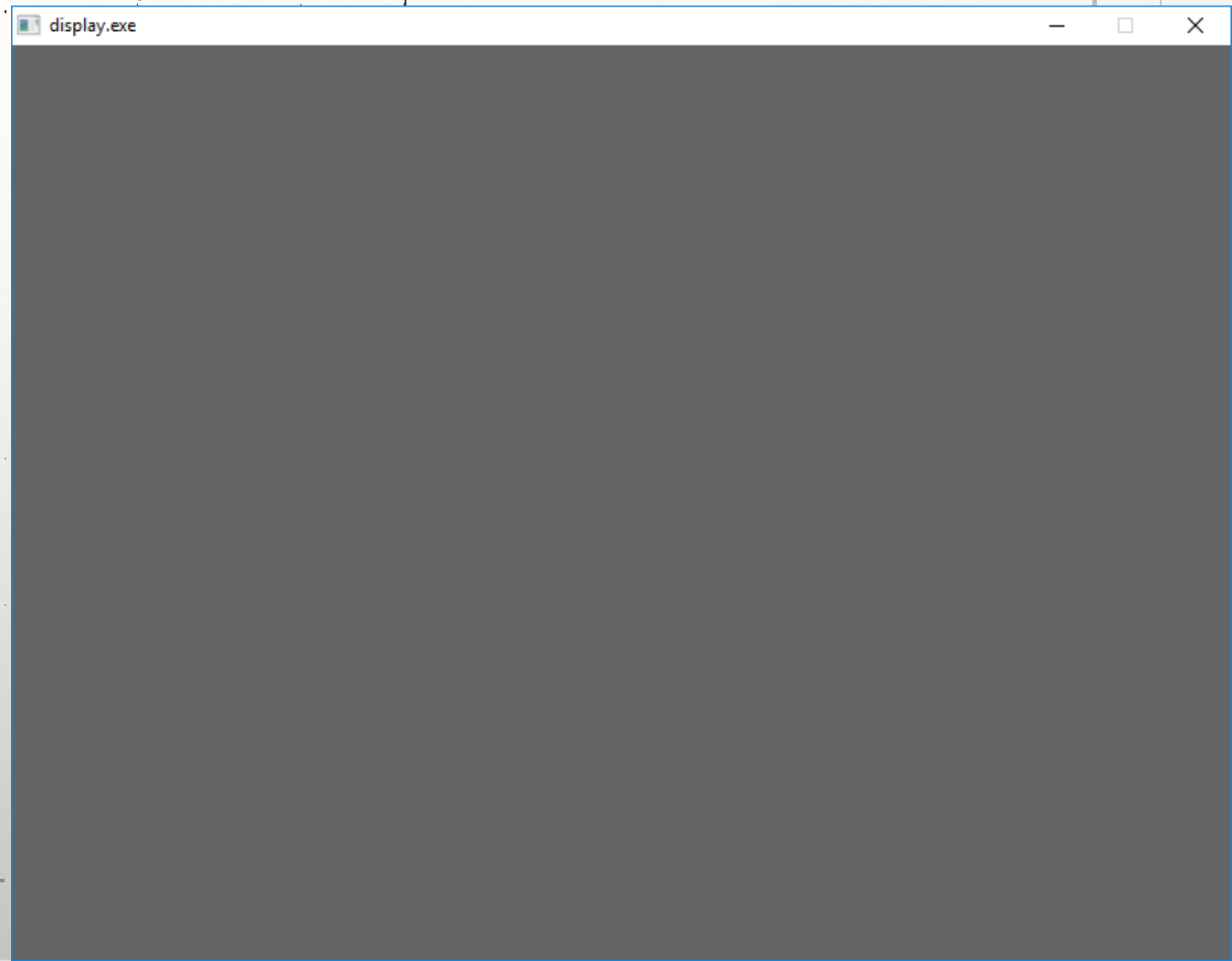

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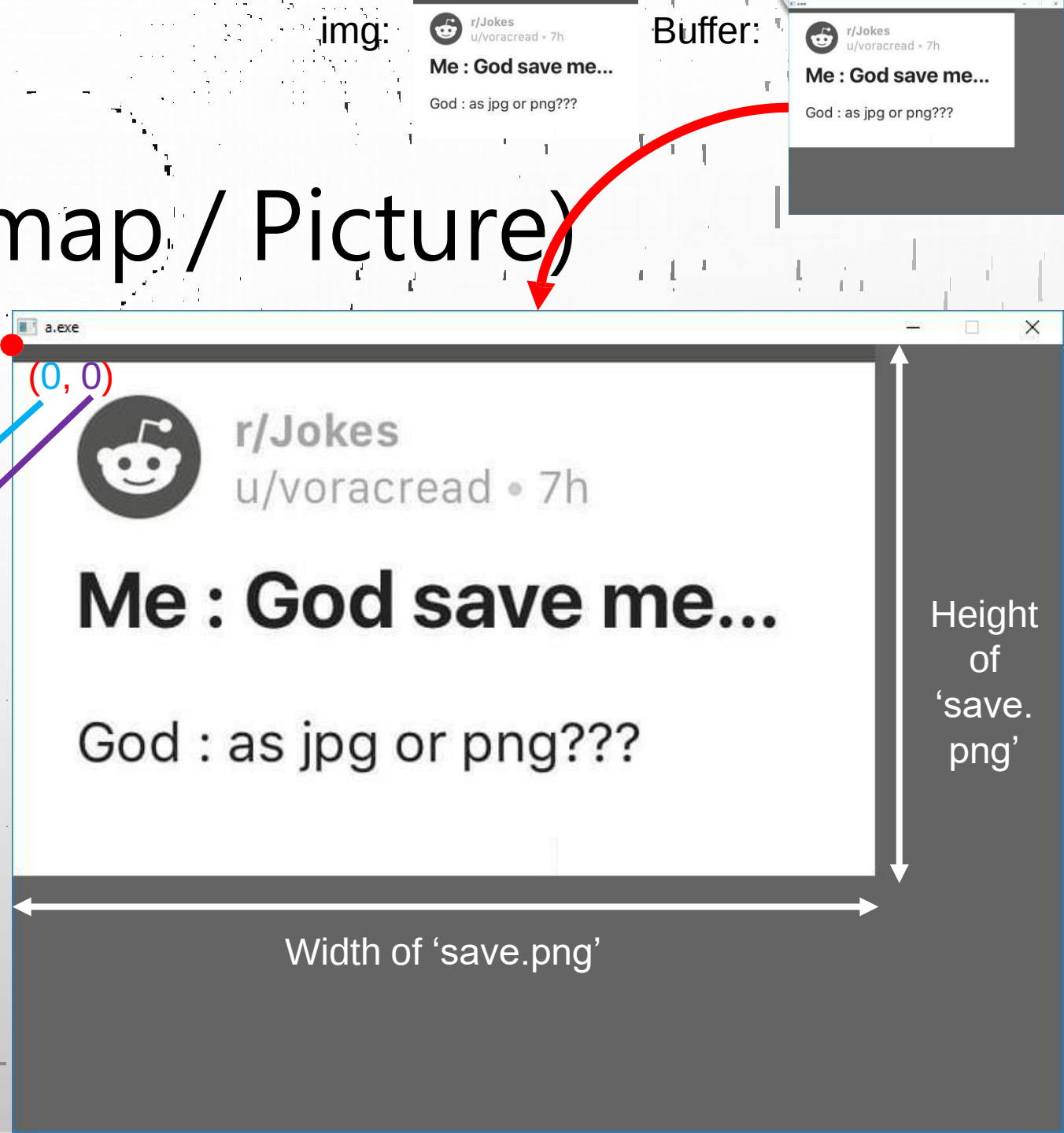

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```

a.exe

r/Jokes
u/voracread • 7h

Me : God save me...

God : as jpg or png???

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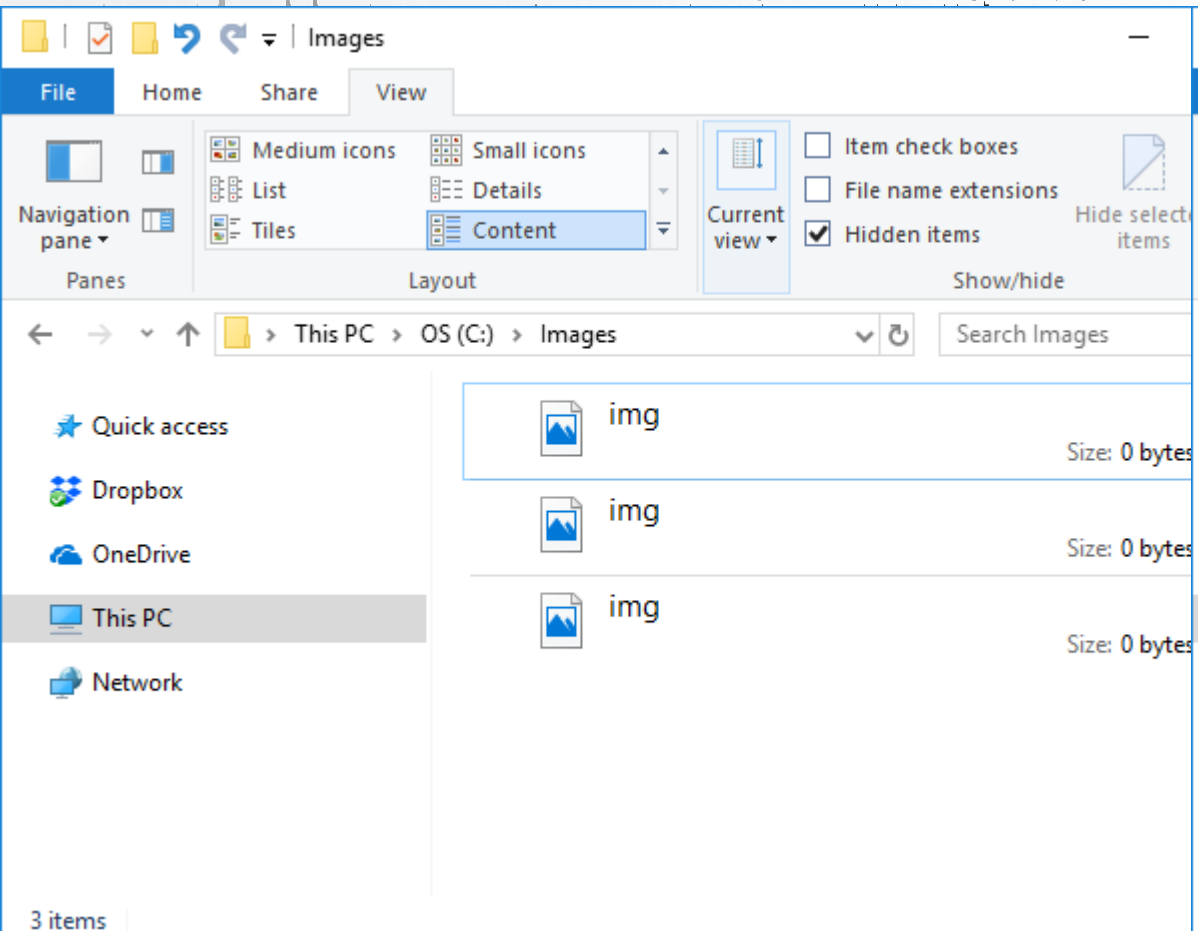
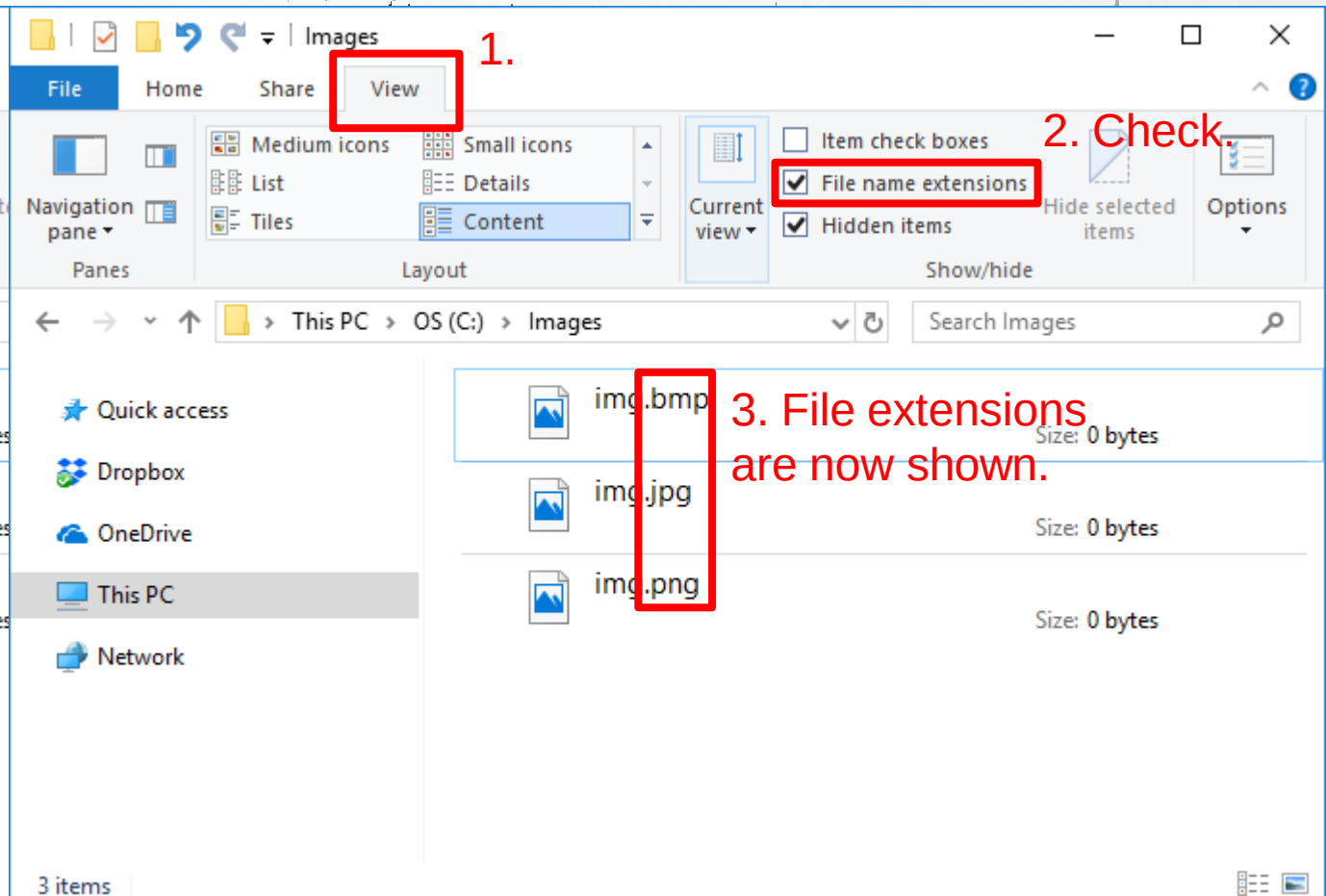
File Extensions

Take Windows Explorer as example.





Others

- Font (Text / String)
- GIF
- Audio (BGM / SFX)
- Video
- …

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Input? (Events?)

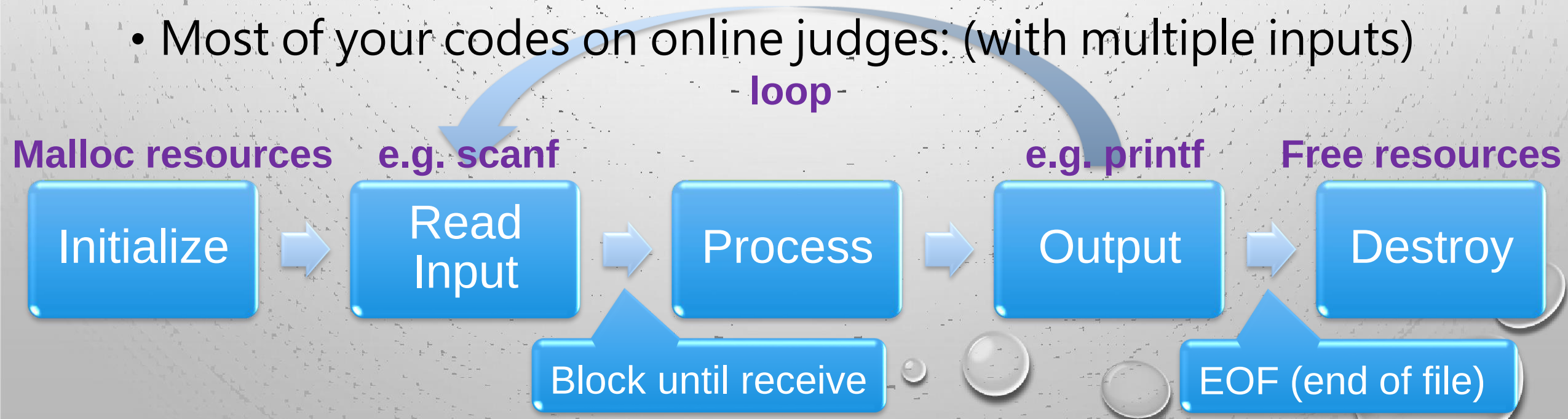
- Keyboard (Key down, Key up, …)
- Mouse (Move, Button down, Button up, …)
- Joystick
- The close button  (Alt + F4) or maybe Escape key
- Timer (Refresh display)
- Callbacks (Audio / Video finished)

Program Flow on OJ

- Your codes are sequential.
  (can only execute code in a specific order)
- Most of your codes on online judges:

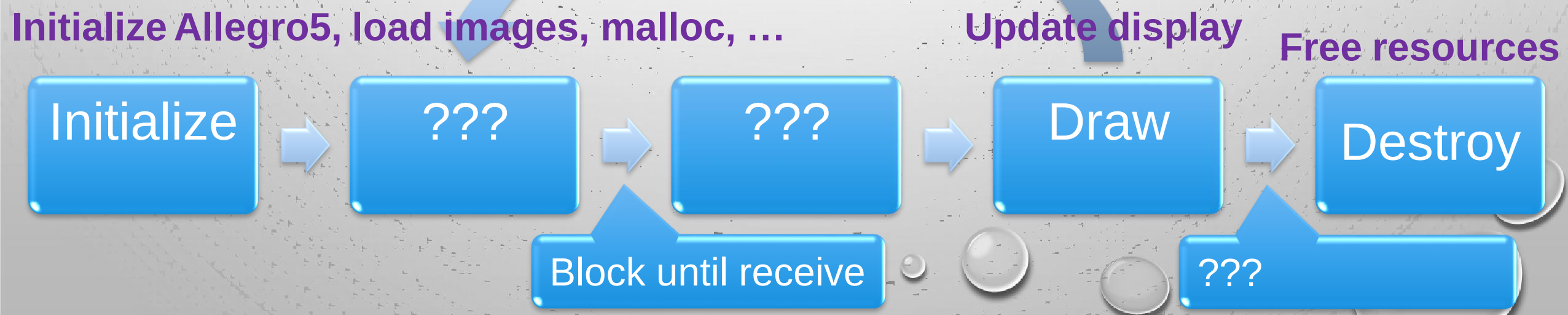
Program Flow on OJ

- Your codes are sequential.
  (can only execute code in a specific order)
- Most of your codes on online judges: (with multiple inputs)



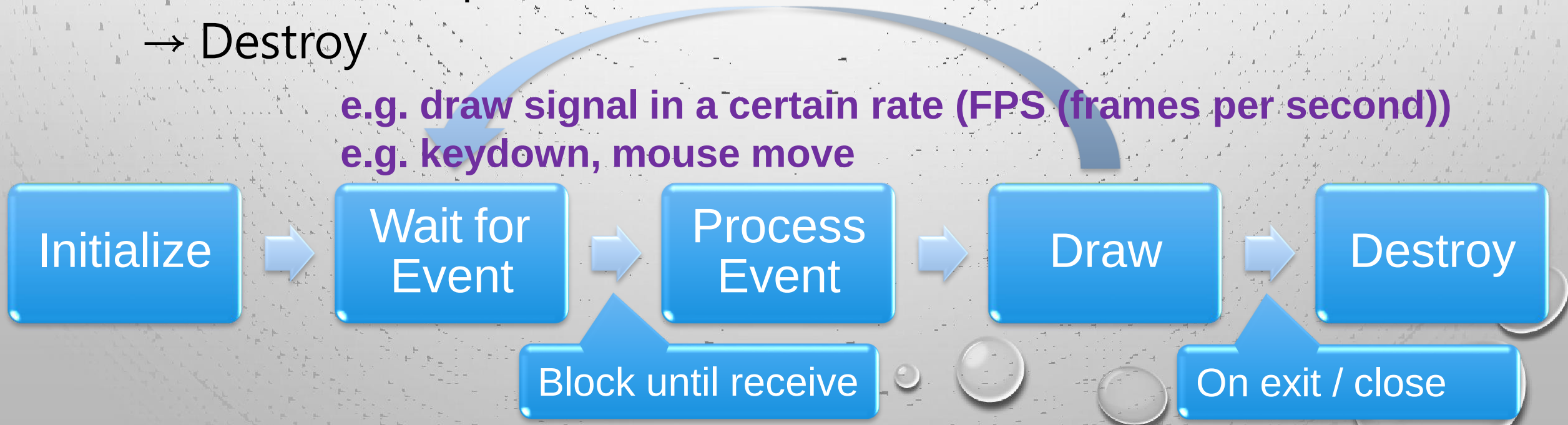
Program Flow on Allegro5

- Your codes are still sequential.
  (can only execute code in a specific order)
- Initialize → ??? → ??? → Draw → Destroy



Program Flow on Allegro5

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



Program Flow on Allegro5

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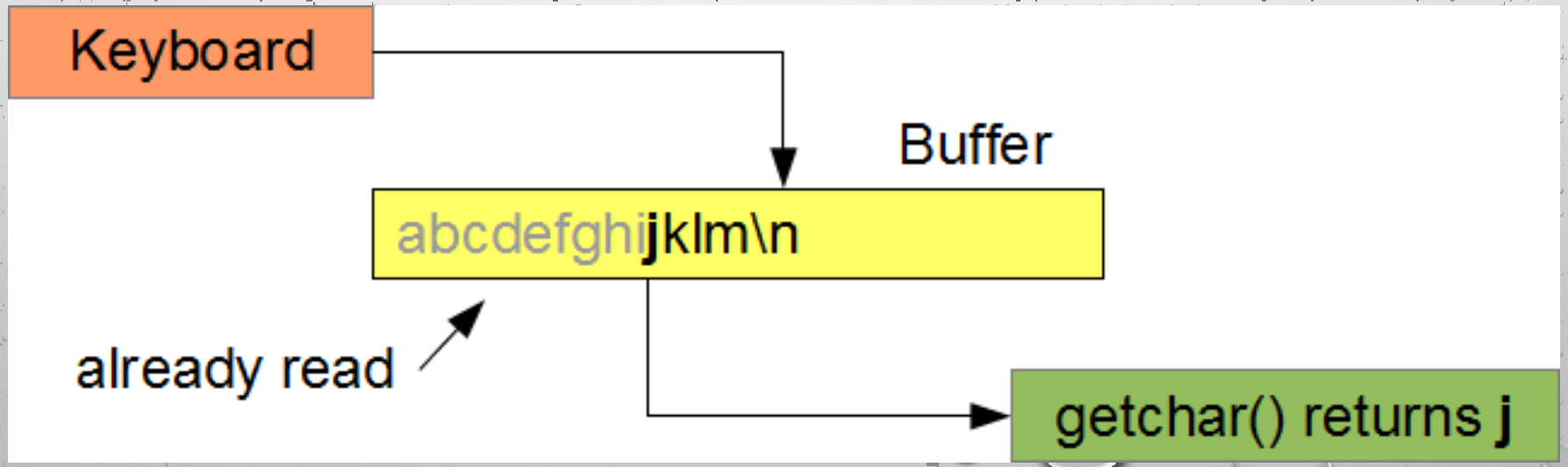
Buffer used in stdin

- The buffer used in stdin can store the inputs. When the input is read by scanf, getchar, …, the characters are removed and returned.



Source: https://scs.senecac.on.ca/~btp100/pages/content/formi_p.html

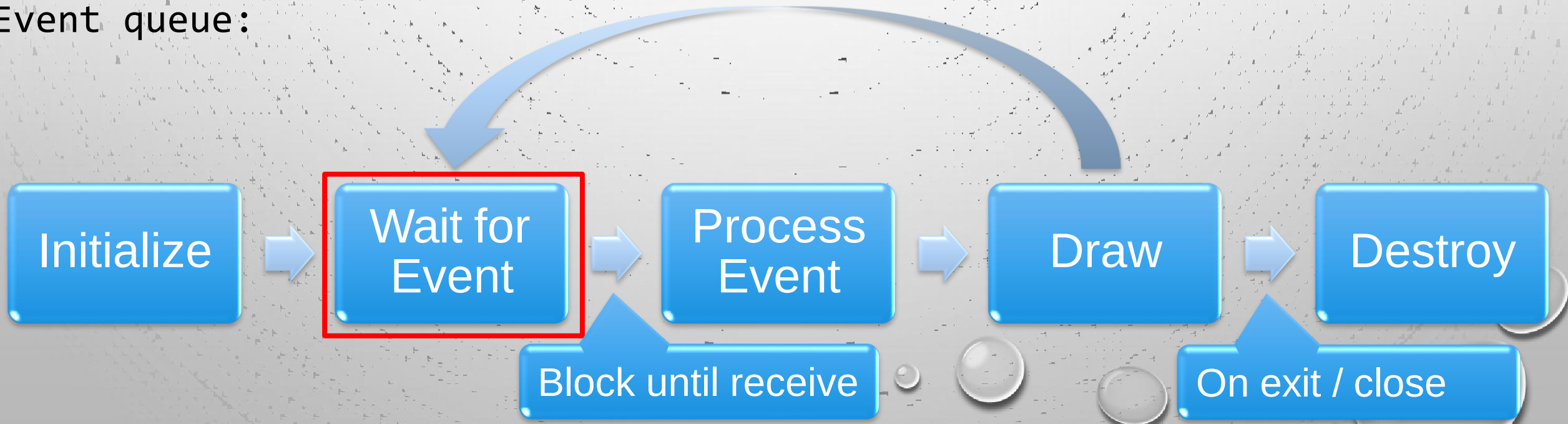
Event Queue (Buffer for events)

- In an event-driven application, there is generally a main loop that listens for events, and then triggers a callback function when one of those events is detected.
- Used in Windows, MacOS, …
- Most event-driven programming environments already provide this main loop.

Event Queue (Buffer for events)

- If we have a timer that ticks for every 10ms, and an update display event is send to the queue when the timer ticks.

Event queue:



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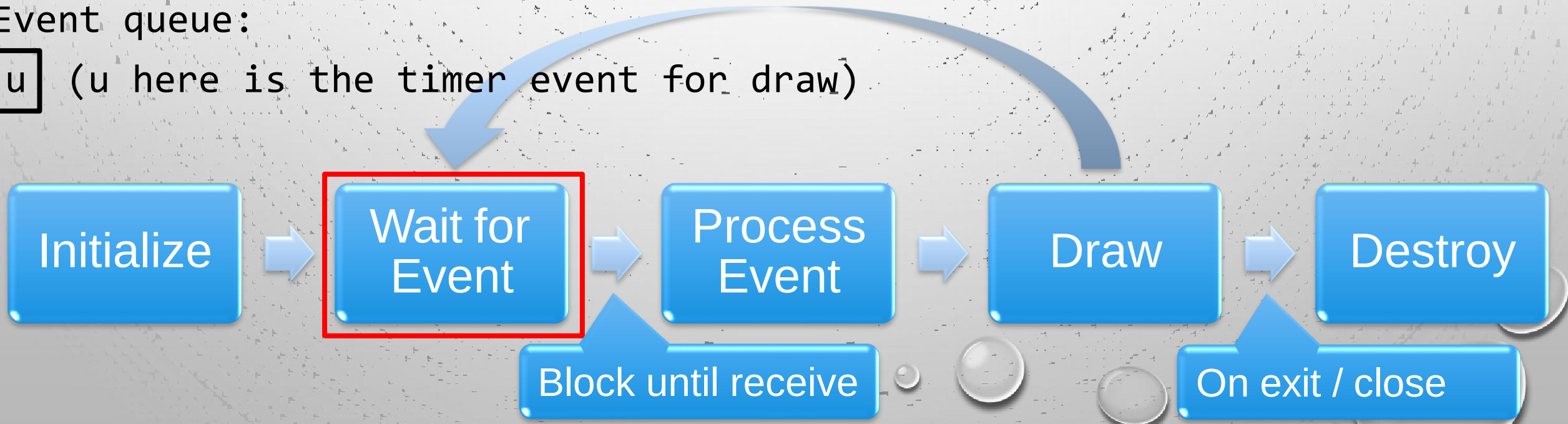
```
Event queue:
[u] (u here is the timer event for draw)
```



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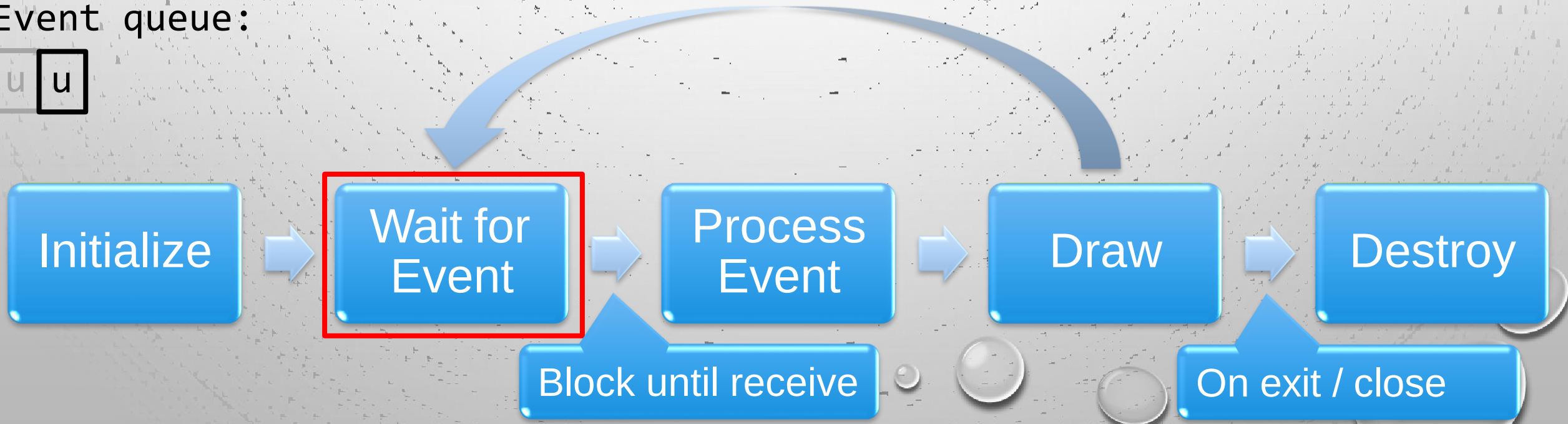

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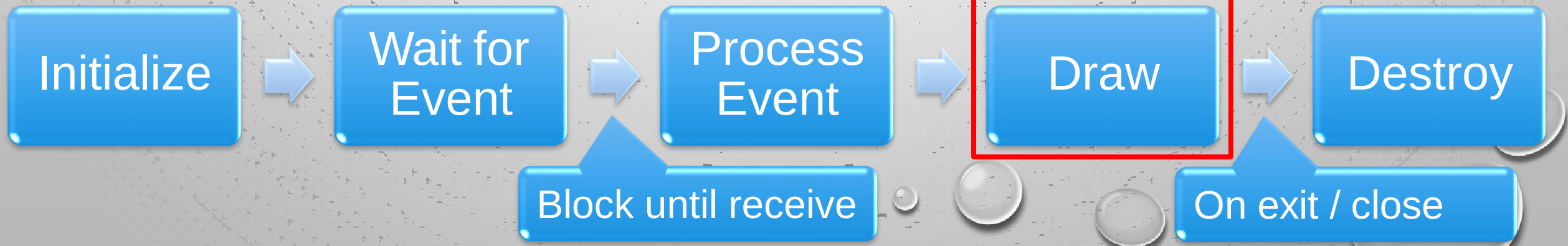
Event queue:

↑ Events are added to event queue asynchronously.



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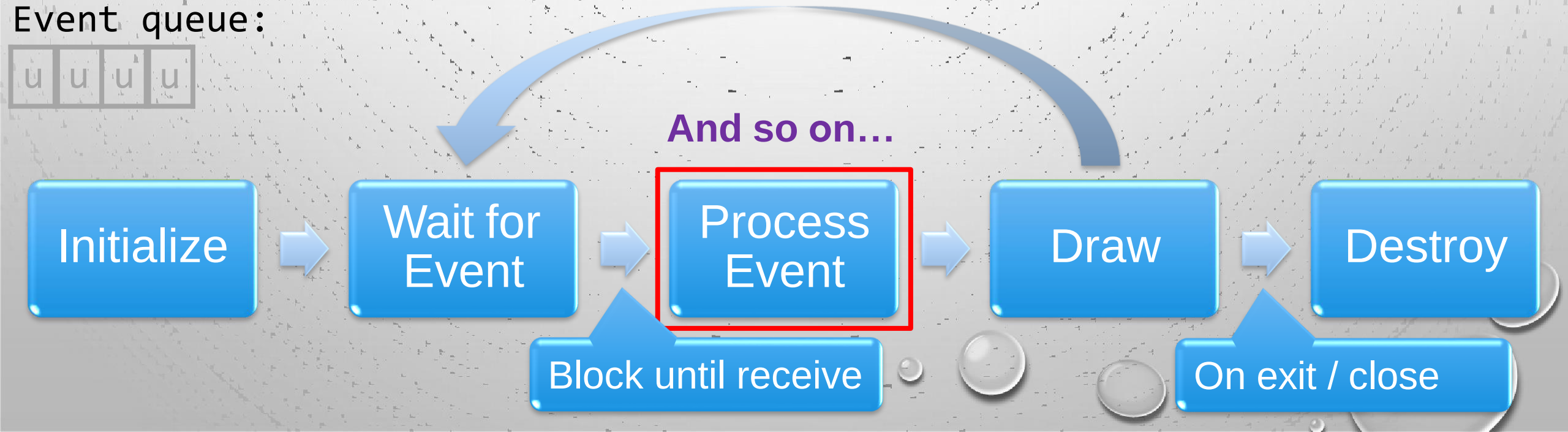
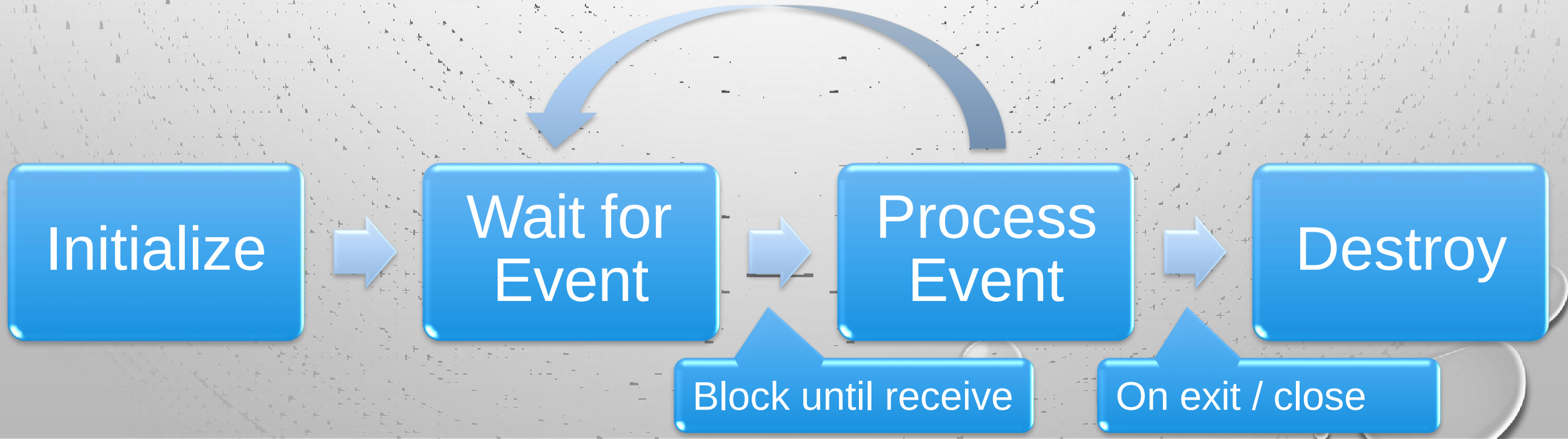
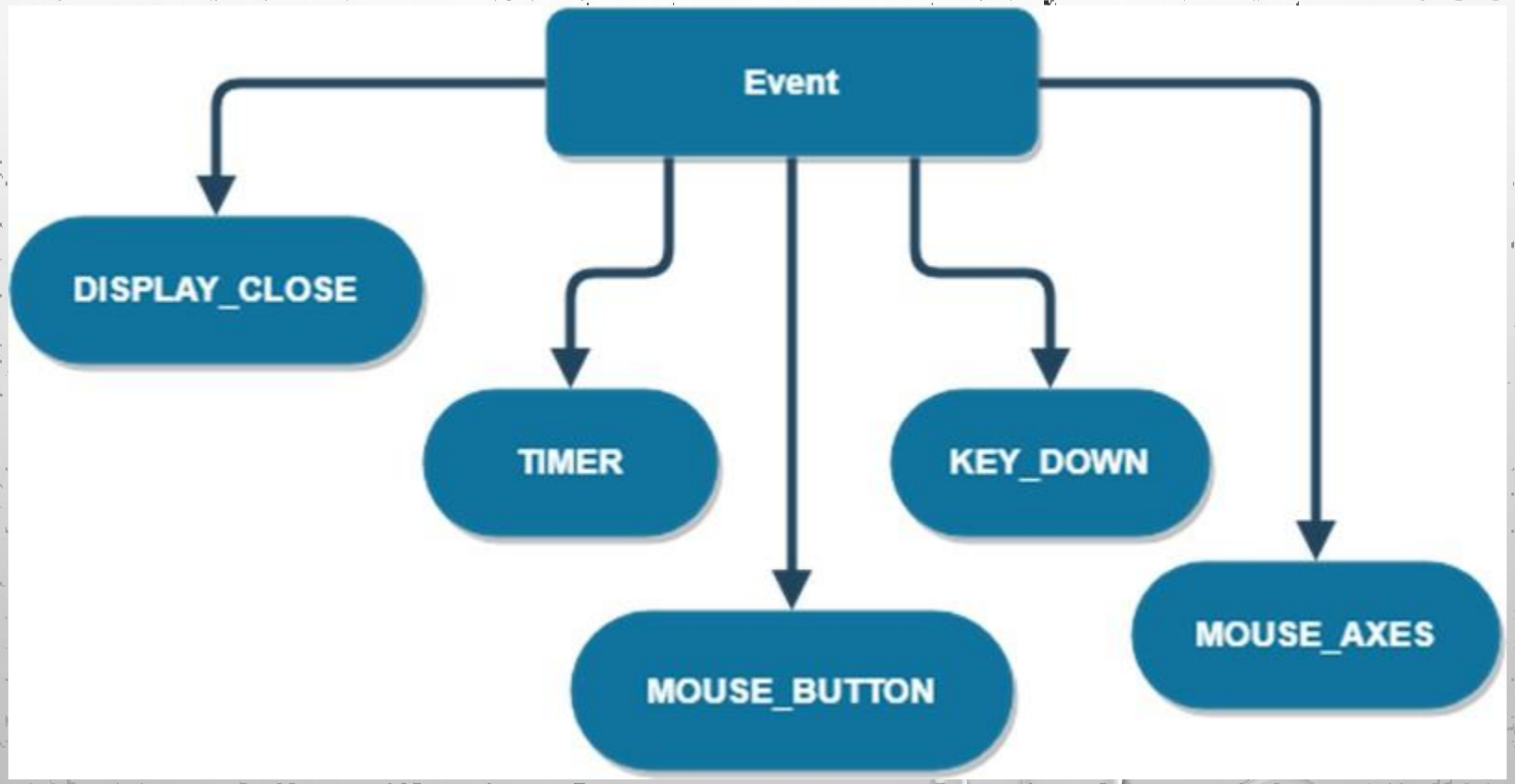


The Generalized Program Flow

- Process event including draw, keyboard, mouse, …



Types of Events



The Generalized Program Flow

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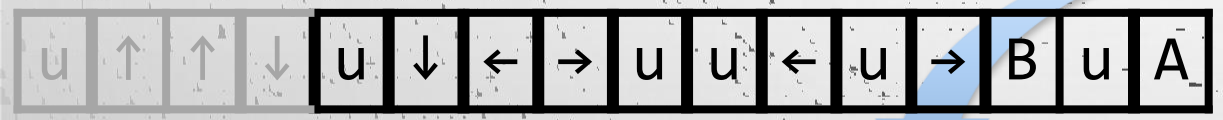
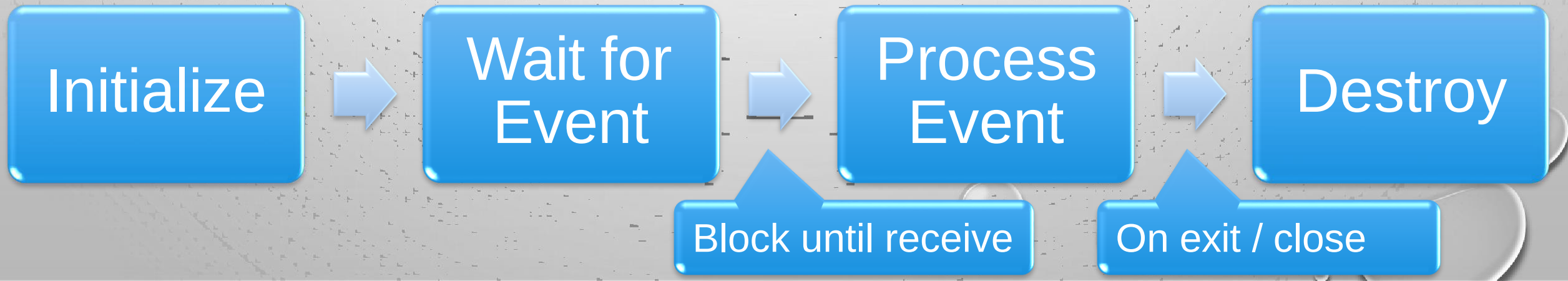
Keys pressed: ↑ ↑ ↓ ↓ ← → ← → B

A Event queue:





Event Queue (Buffer for events)

```
const int FPS = 30;
ALLEGRO_TIMER* game_update_timer = al_create_timer(1.0f / FPS);
ALLEGRO_EVENT_QUEUE* game_event_queue = al_create_event_queue();
bool done = false;
ALLEGRO_EVENT event;
al_register_event_source(game_event_queue, al_get_timer_event_source(game_update_timer)
al_register_event_source(game_event_queue, al_get_keyboard_event_source());
while (!done) {
    al_wait_for_event(game_event_queue, &event);
    if (event.type == ALLEGRO_EVENT_TIMER && event.timer.source == game_update_timer) {
        // Draw to display.
    } else if (event.type == ALLEGRO_EVENT_KEY_DOWN) {
        // Key pressed.
    } else if (event.type == ALLEGRO_EVENT_KEY_UP) {
        // Key released.
    } //...
}
```

Event Queue (Buffer for events)

```
const int FPS = 30;
ALLEGRO_TIMER* game_update_timer = al_create_timer(1.0f / FPS);
ALLEGRO_EVENT_QUEUE* game_event_queue = al_create_event_queue();
bool done = false;
ALLEGRO_EVENT event;
```

Initialize variables

```
al_register_event_source(game_event_queue, al_get_timer_event_source(game_update_timer));
al_register_event_source(game_event_queue, al_get_keyboard_event_source());
while (!done) {
    al_wait_for_event(game_event_queue, &event);
    if (event.type == ALLEGRO_EVENT_TIMER && event.timer.source == game_update_timer) {
        // Draw to display.
    } else if (event.type == ALLEGRO_EVENT_KEY_DOWN) {
        // Key pressed.
    } else if (event.type == ALLEGRO_EVENT_KEY_UP) {
        // Key released.
    } //...
}
```

Event Queue (Buffer for events)

```
const int FPS = 30;
ALLEGRO_TIMER* game_update_timer = al_create_timer(1.0f / FPS);
ALLEGRO_EVENT_QUEUE* game_event_queue = al_create_event_queue();
bool done = false;
ALLEGRO_EVENT event;
```

Register event sources

```
al_register_event_source(game_event_queue, al_get_timer_event_source(game_update_timer));
al_register_event_source(game_event_queue, al_get_keyboard_event_source());
while (!done) {
    al_wait_for_event(game_event_queue, &event);
    if (event.type == ALLEGRO_EVENT_TIMER && event.timer.source == game_update_timer) {
        // Draw to display.
    } else if (event.type == ALLEGRO_EVENT_KEY_DOWN) {
        // Key pressed.
    } else if (event.type == ALLEGRO_EVENT_KEY_UP) {
        // Key released.
    } //...
}
```

Event Queue (Buffer for events)

```
const int FPS = 30;
ALLEGRO_TIMER* game_update_timer = al_create_timer(1.0f / FPS);
ALLEGRO_EVENT_QUEUE* game_event_queue = al_create_event_queue();
bool done = false;
ALLEGRO_EVENT event;
al_register_event_source(game_event_queue, al_get_timer_event_source(game_update_timer));
al_register_event_source(game_event_queue, al_get_keyboard_event_source());
```

Main event loop

```
while (!done) {
    al_wait_for_event(game_event_queue, &event);
    if (event.type == ALLEGRO_EVENT_TIMER && event.timer.source == game_update_timer) {
        // Draw to display.
    } else if (event.type == ALLEGRO_EVENT_KEY_DOWN) {
        // Key pressed.
    } else if (event.type == ALLEGRO_EVENT_KEY_UP) {
        // Key released.
    } //...
}
```

Event Queue (Buffer for events)

```
const int FPS = 30;
ALLEGRO_TIMER* game_update_timer = al_create_timer(1.0f / FPS);
ALLEGRO_EVENT_QUEUE* game_event_queue = al_create_event_queue();
bool done = false;
ALLEGRO_EVENT event;
al_register_event_source(game_event_queue, al_get_timer_event_source(game_update_timer));
al_register_event_source(game_event_queue, al_get_keyboard_event_source());
while (!done) {
    al_wait_for_event(game_event_queue, &event);
    if (event.type == ALLEGRO_EVENT_TIMER && event.timer.source == game_update_timer) {
        // Draw to display.
    } else if (event.type == ALLEGRO_EVENT_KEY_DOWN) {
        // Key pressed.
    } else if (event.type == ALLEGRO_EVENT_KEY_UP) {
        // Key released.
    } //...
}
```

Wait for new event

Event Queue (Buffer for events)

```
const int FPS = 30;
ALLEGRO_TIMER* game_update_timer = al_create_timer(1.0f / FPS);
ALLEGRO_EVENT_QUEUE* game_event_queue = al_create_event_queue();
bool done = false;
ALLEGRO_EVENT event;
al_register_event_source(game_event_queue, al_get_timer_event_source(game_update_timer));
al_register_event_source(game_event_queue, al_get_keyboard_event_source());
while (!done) {
    al_wait_for_event(game_event_queue, &event);
    if (event.type == ALLEGRO_EVENT_TIMER && event.timer.source == game_update_timer) {
        // Draw to display.
    } else if (event.type == ALLEGRO_EVENT_KEY_DOWN) {
        // Key pressed.
    } else if (event.type == ALLEGRO_EVENT_KEY_UP) {
        // Key released.
    } //...
}
```

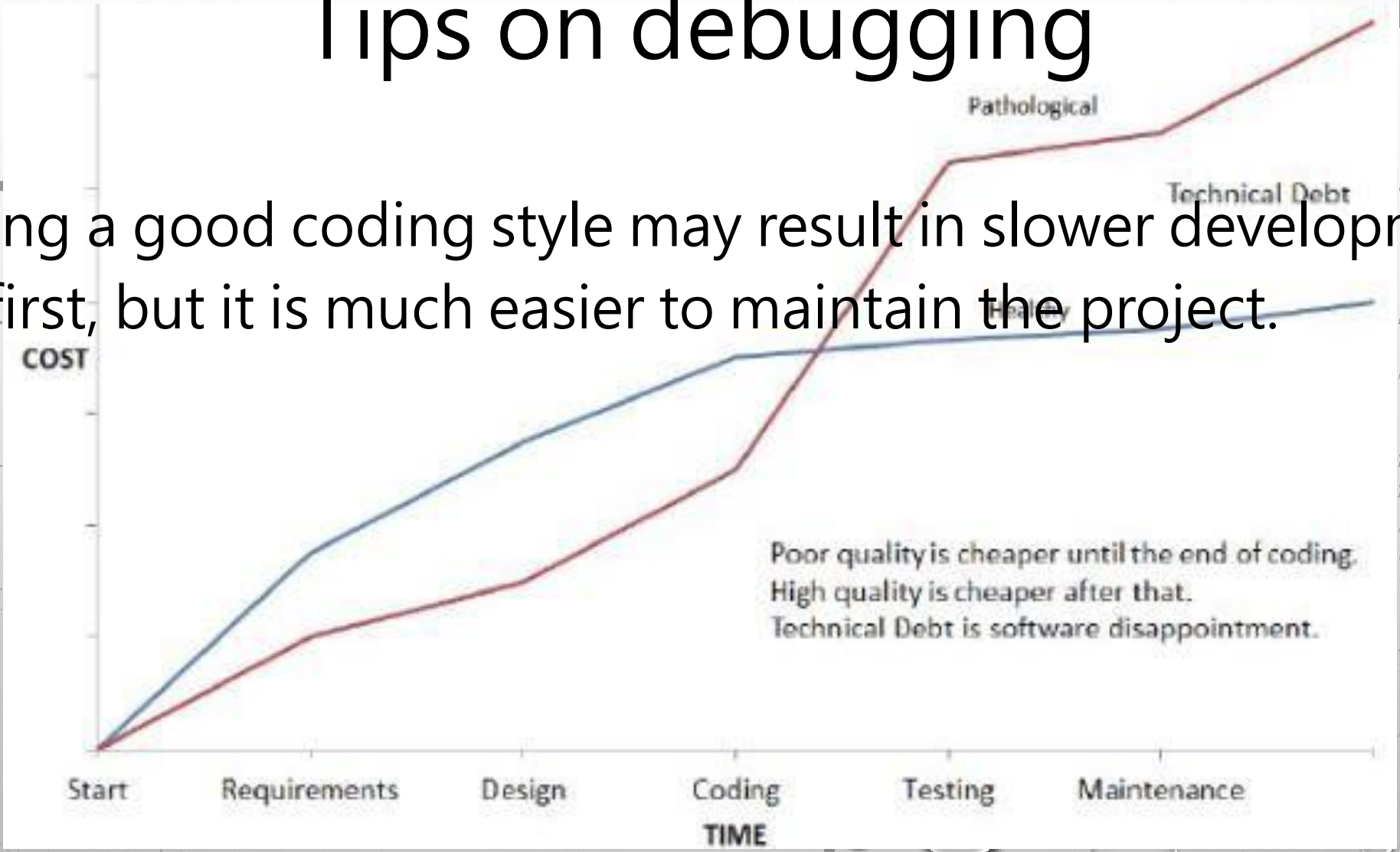
Process Event

Outline

- Introduction
- Display & draw image
- Events (display, timer, keyboard, mouse)
- Tips on debugging
- Tasks
- References & Tutorials

Tips on debugging

- Using a good coding style may result in slower development at first, but it is much easier to maintain the project.



Source: http://www.critical-logic.com/services/qa-project-management/

Tips on debugging (Use helper functions to log to files)

- Can be used just like printf. Both functions will automatically add a newline character at the end and save the logs to file for debugging information if the program crashes.
  - game_abort – print error message and exit program after 2 secs.
  - game_log – print logs.
  - LOG_ENABLED – If not defined, game_abort and game_log won't do anything.

```
#define LOG_ENABLED
void game_abort(const char* format, ...)
void game_log(const char* format, ...)
```

Tips on debugging (Log important events or states)

- Use game_log every once a while. (kind of like a checkpoint)

```
int main(int argc, char **argv) {
    allegro5_init();
    game_log("Allegro5 initialized");
    game_log("Game begin");
    game_init();
    game_log("Game initialized");
    game_draw(); // Draw the first frame.
    game_log("Game start event processing loop");
    game_process_event_loop(); // This call blocks until the game is finished.
    game_log("Game end");
    game_destroy();
    return 0;
}
```

Tips on debugging (Always check the return value)

- Check return value of functions and log if they failed. e.g.
  - malloc returns NULL if failed.
  - al_init, al_init_image_addon, … returns false if failed.
  - al_load_bitmap returns NULL if failed.
    - maybe file doesn't exist, image addon is not initialized, …
- See the API references for all function calls

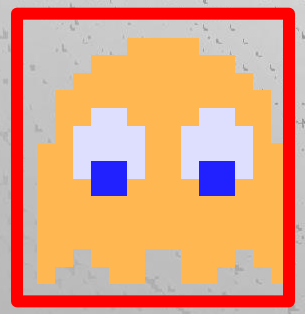
```
if (!al_init())
    game_abort("failed to initialize allegro");
```

Tips on debugging (Freeing the resources)

- Free resources that will not be used to avoid memory leaks.
  - malloc vs. free
  - al_load_bitmap vs. al_destroy_bitmap
- Free the resources when
  - the resources will never be used again, or
  - the program enters another state and the resource will only be used again after some time.
  - the program ends.
- Not necessary on most cases but highly recommended. letting the OS being able to allocate the block of memory to some other processes.

Tips on debugging (Mark areas by primitive shapes)

- For character hitbox or mouse interaction, we will use collision detection frequently. Draw some primitive shapes above the character's image to indicate the region.
- When releasing the game, just comment out the definition of LOG_ENABLED, then the primitives will not be drawn.



```
bool debug_mode = false;
//debugging mode
    if (debug_mode) {
        draw_hitboxes();
    }
```

Tips on debugging (Declare constant variables)

- If some constant number is kept begin used, declare it as a constant variable for better maintenance.

```
const  int  FPS = 60;
const  int  SCREEN_W =   800;
const  int  SCREEN_H =   800;
const  int  GAME_TICK_CD  = 64;
```

Tips on debugging (Make duplicate codes into functions)

- e.g. when loading bitmap, there are many duplicated codes.
  - If failed to load bitmap, output failed message and abort.
  - If success, log the success action.

```
// Load bitmap and check if failed.
ALLEGRO_BITMAP* load_bitmap(const char* filename) {
    ALLEGRO_BITMAP* bmp = al_load_bitmap(filename);
    if (bmp == NULL)
        game_abort("failed to load image: %s", filename);
    else
        game_log("loaded image: %s", filename);
    return bmp;
}
```

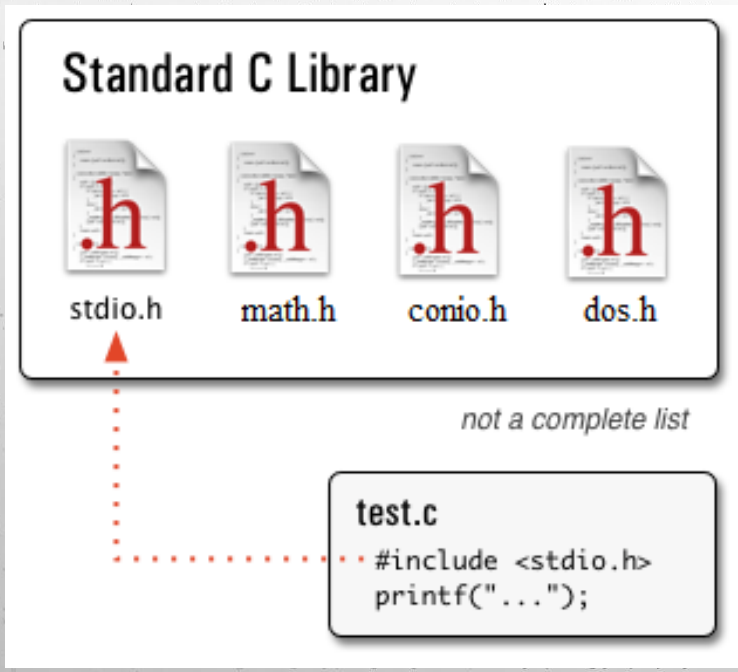
Tips on debugging (Make repeat variable groups into struct)

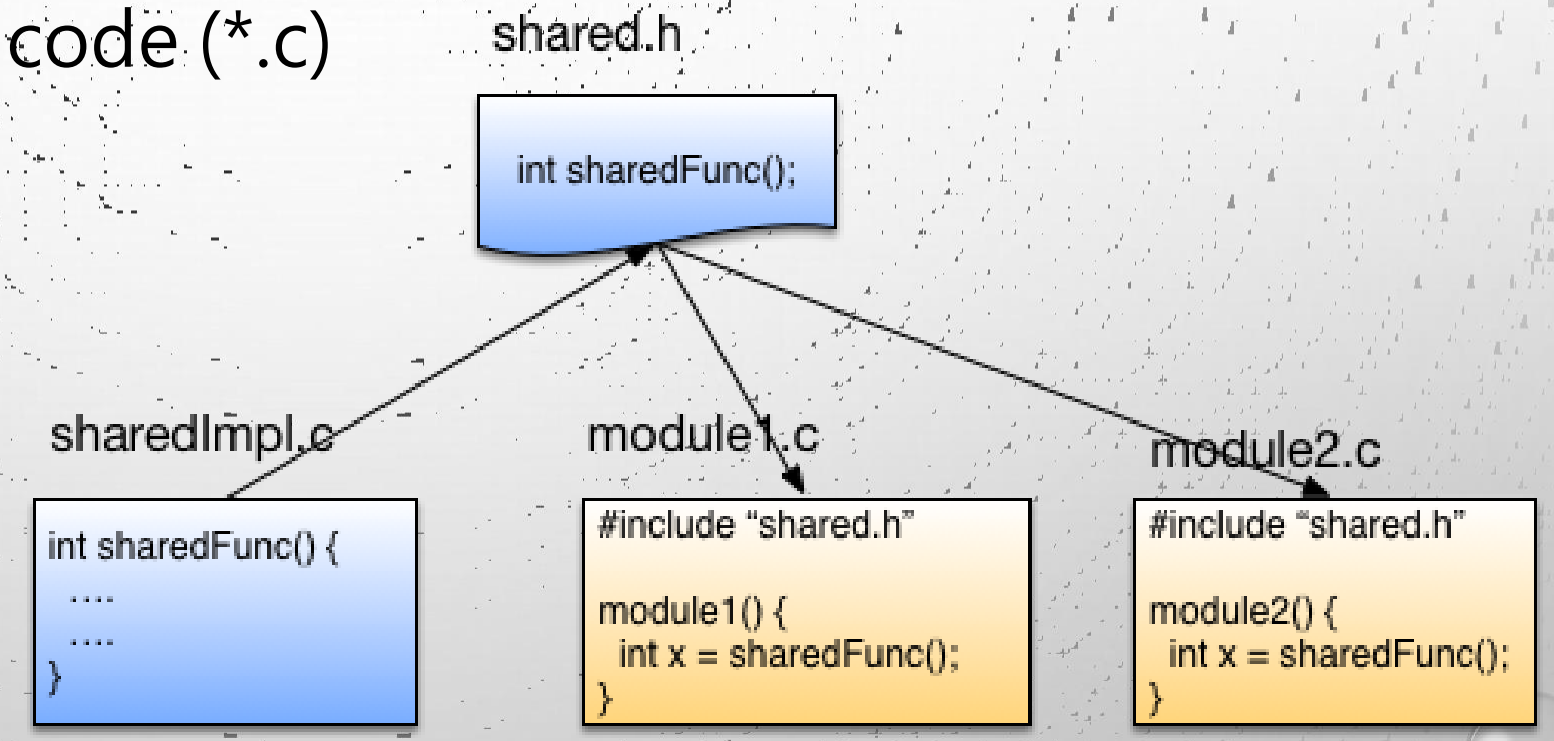
- e.g. objects (both self & enemy & bullets) will usually have the same variable groups.
  - The x, y coordinates on the display.
  - The velocity vx, vy for updating x, y coordinates.
  - Width and height of the object. (AABB box collision)
  - Image for drawing the object.
  - More…

```
typedef struct object {
    Pair_IntInt Coord; //
    Pair_IntInt Size; // x f
    Directions facing;
    Directions preMove;
    Directions nextTryMove;
    uint32_t moveCD;
} object;
```

Tips on debugging (Store source codes in different files)

- Header (*.h), Source code (*.c)



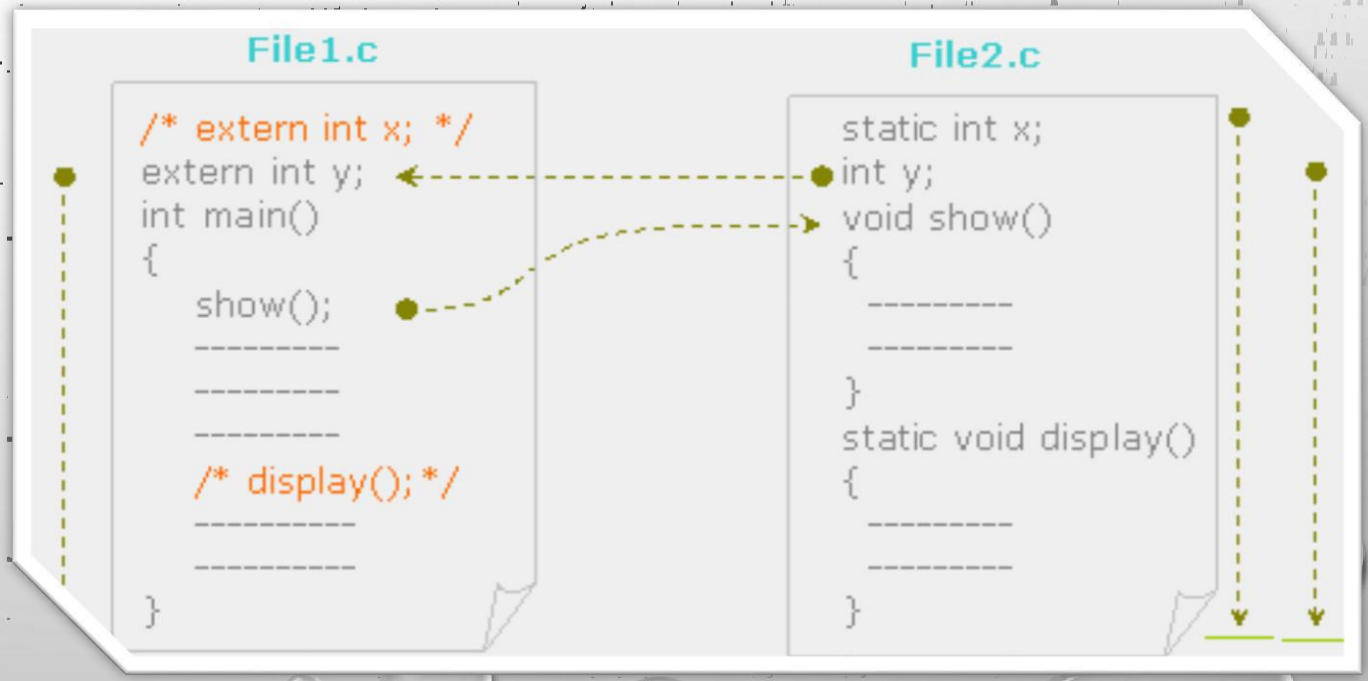


Source: https://www.quora.com/What-is-a-header-file-and-its-use-in-C-program-Also-tell-me-what-does-function-mean-in-c-programming

Source: http://hanxue-it.blogspot.com/2014/04/why-include-cc-implementation-code-in.html

Tips on debugging (Store source codes in different files)

- Extern in (*.h), make variables exposed to other files that includes the (*.h) file.
- Static in (*.c), only visible within the file. Variables or functions with the same name but in different files are considered different.



Source: https://codingfox.com/12-14-internal-linkage-in-c-language/

Outline

- Introduction
- Display & draw image
- Events (display, timer, keyboard, mouse)
- Tips on debugging
- Tasks
- References & Tutorials

Tasks (Practice only)

- Task 1 – Blank window.
- Task 2 – Draw images and texts.
- Task 3 – Implement event loop and quit when the close button is clicked.
- Task 4 – Using keyboard.
- Task 5 – Using mouse.

Outline

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References

- Allegro 5 Wiki
  https://www.allegro.cc/manual/5/
  https://wiki.allegro.cc/index.php?title=Allegro_5_API_Tutorials
- Allegro 5 reference manual
  https://liballeg.org/a5docs/trunk/
- Allegro5 examples on GitHub
  https://github.com/liballeg/allegro5/tree/master/examples

Tutorials

- C++ Allegro 5 Made Easy
  https://www.youtube.com/watch?v=IZ2krJ8Ls2A&list=PL6B459AAE1642C8B4
- 2D Game Development Course
  http://fixbyproximity.com/2d-game-development-course/
- Allegro Game Library Tutorial Series
  https://www.gamefromscratch.com/page/Allegro-Tutorial-Series.aspx

Questions?