# How does Async work?

# ~ Matthias Endler ~

# Matthias Endler

BACKEND ENGINEER AT TRIVAGO

# ~ Matthias Endler ~

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MOSTLY GO, RUST, PYTHON

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INTERESTED IN LOW LEVEL STUFF

# Matthias Endler

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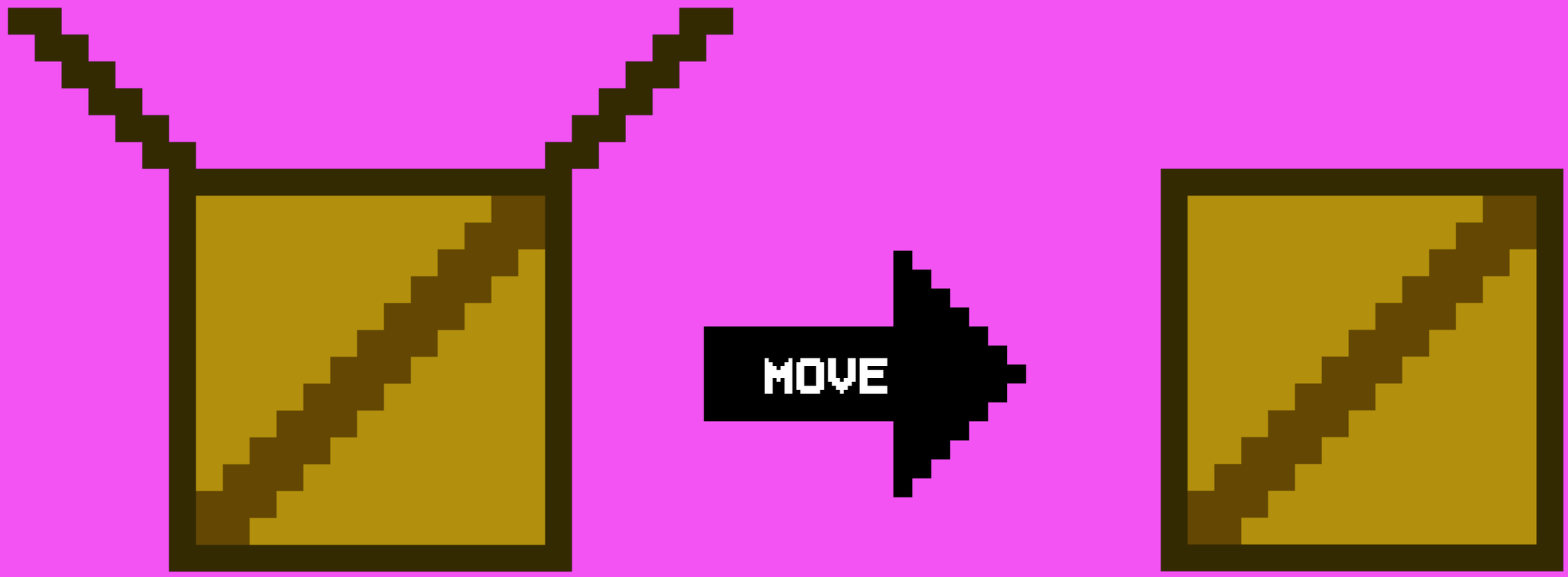
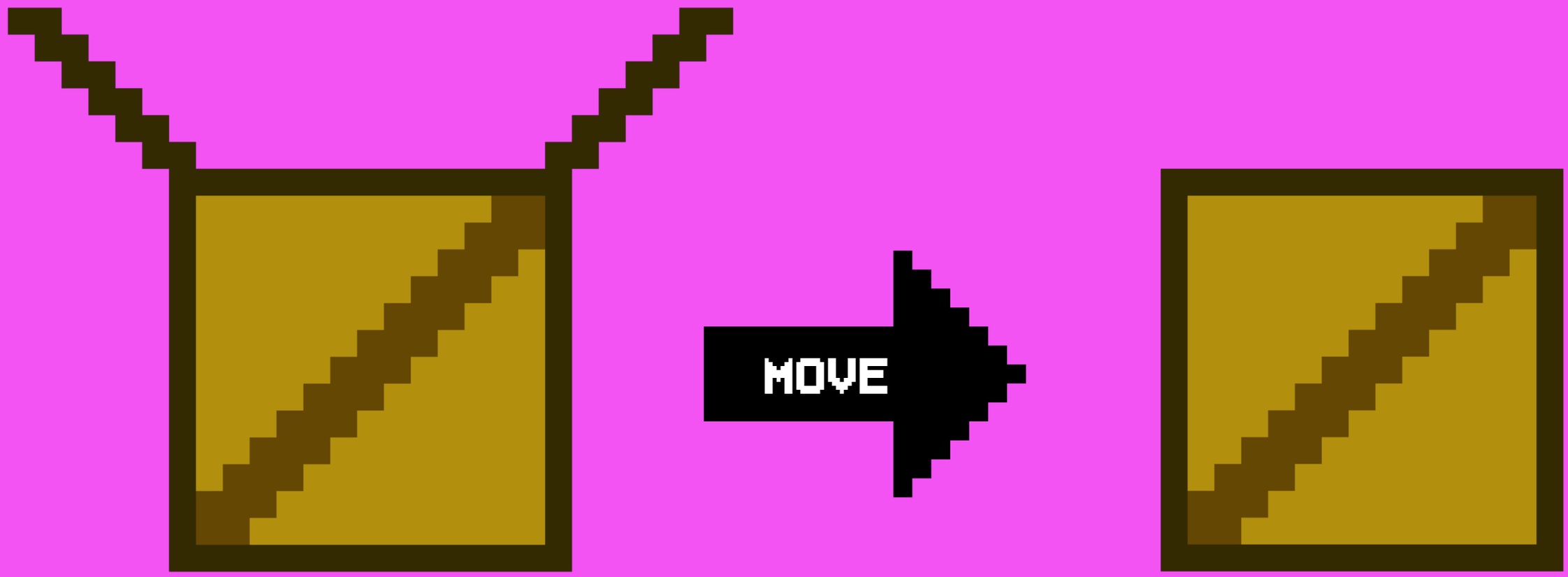
ENDLER.DEV AND HELLO-RUST.SHOW


MOVE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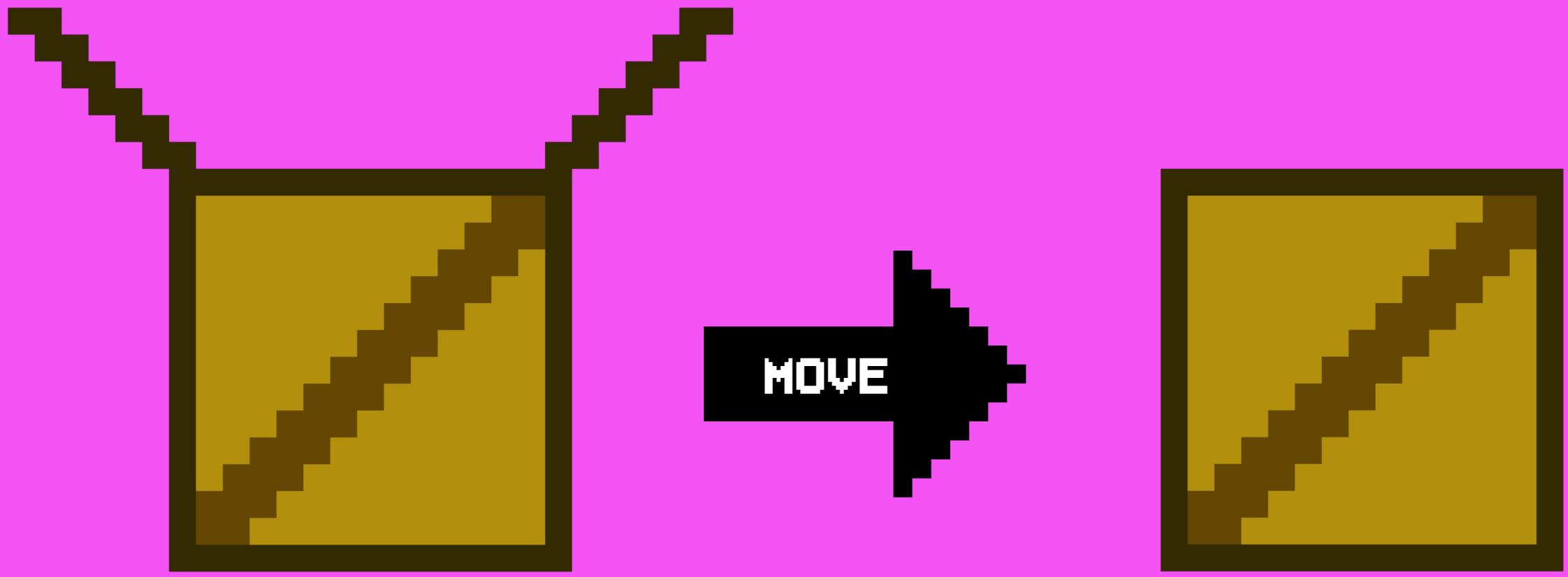
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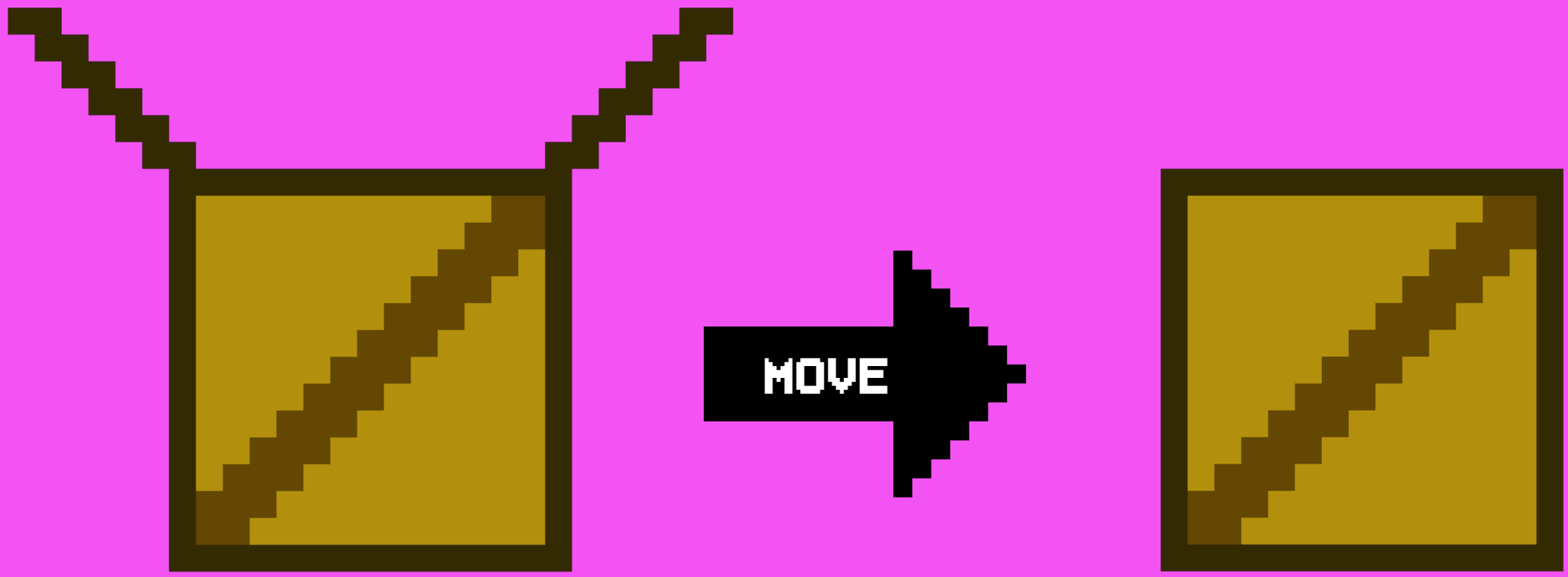
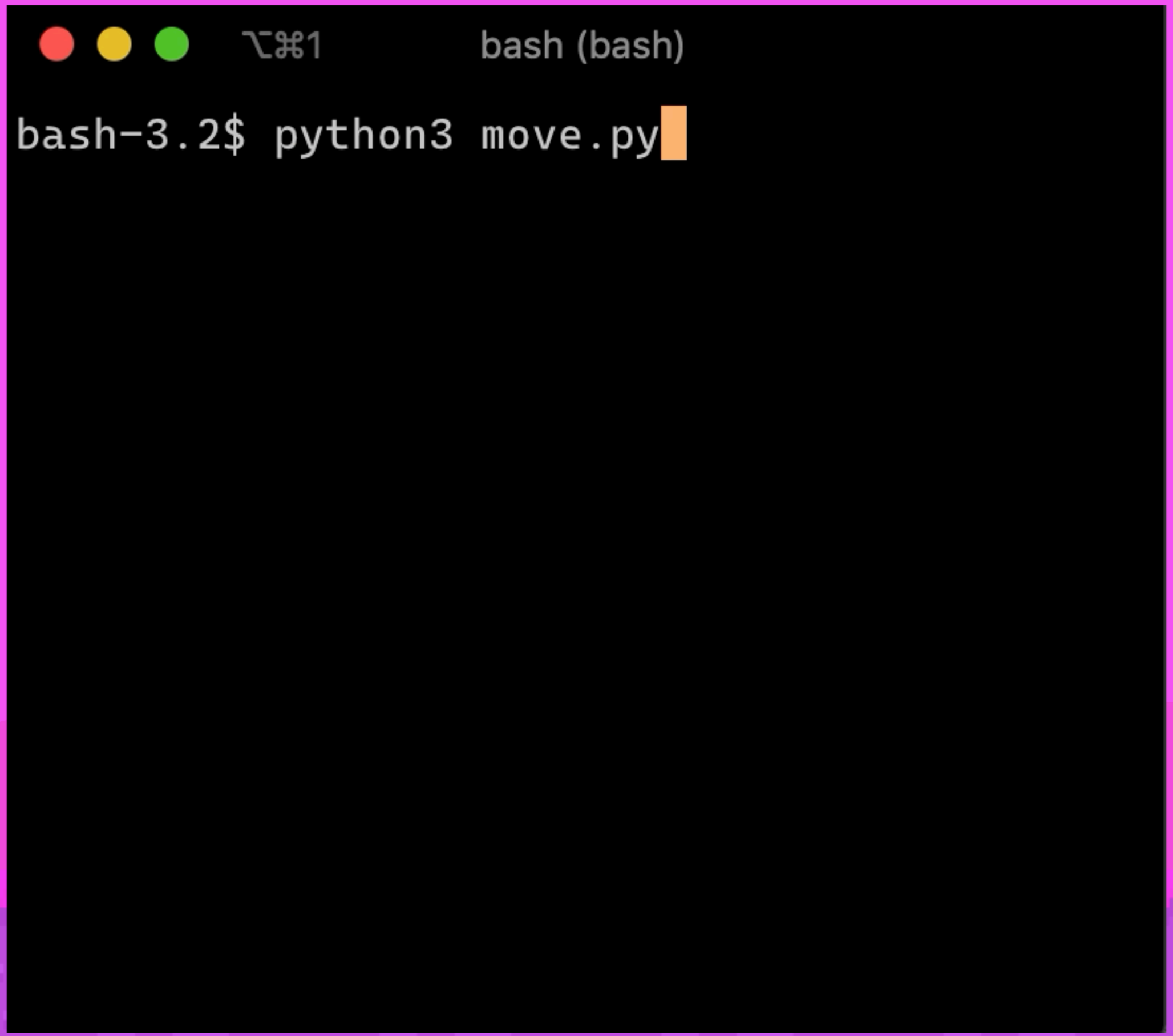

MOVE

# ~ Python ~

```python
def move(batch):
    pack(batch)
    transport(batch)
    unpack(batch)


def main():
    for batch in batches(boxes, 10):
        move(batch)
```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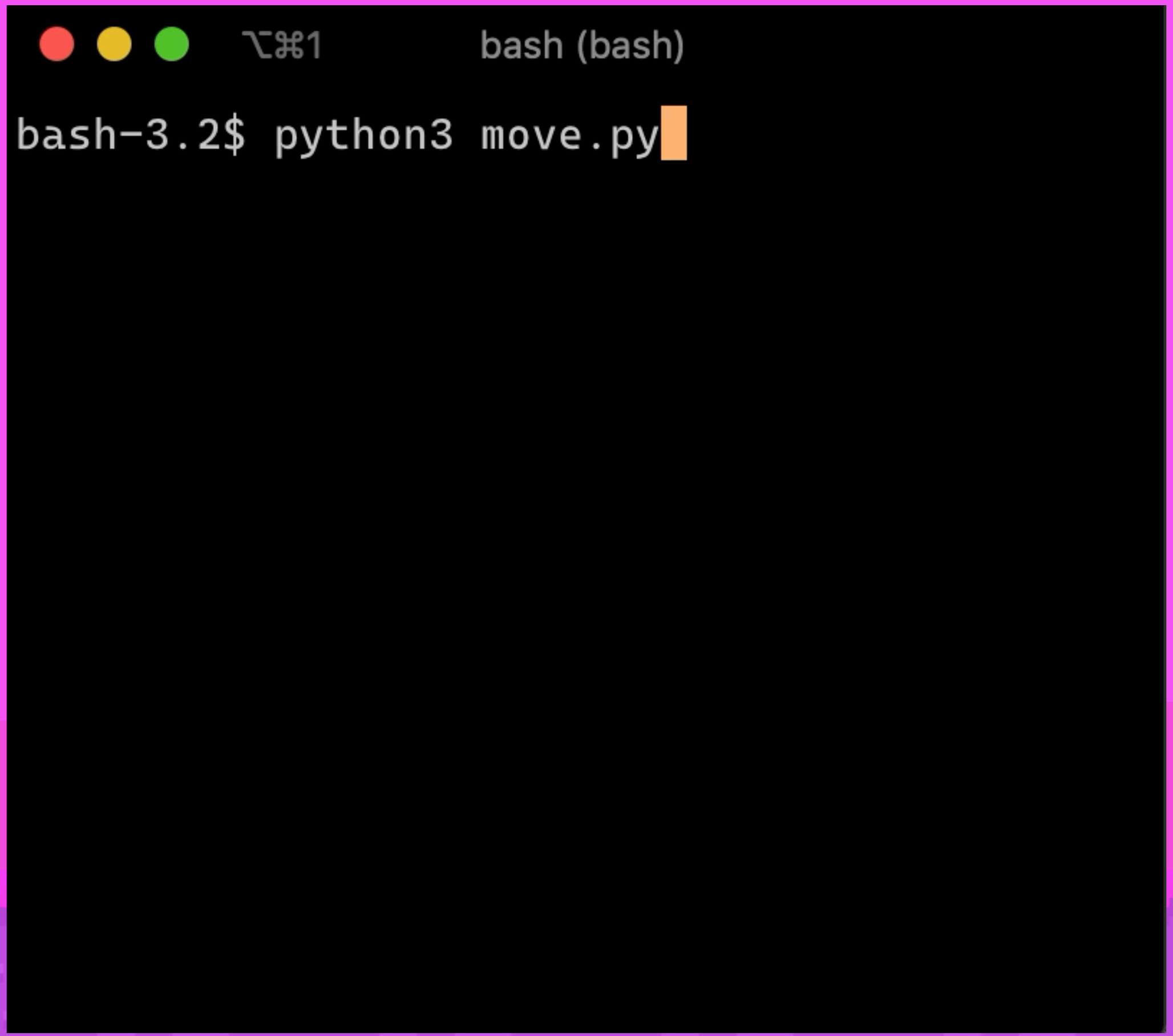
bash (bash)
bash-3.2$ python3 move.py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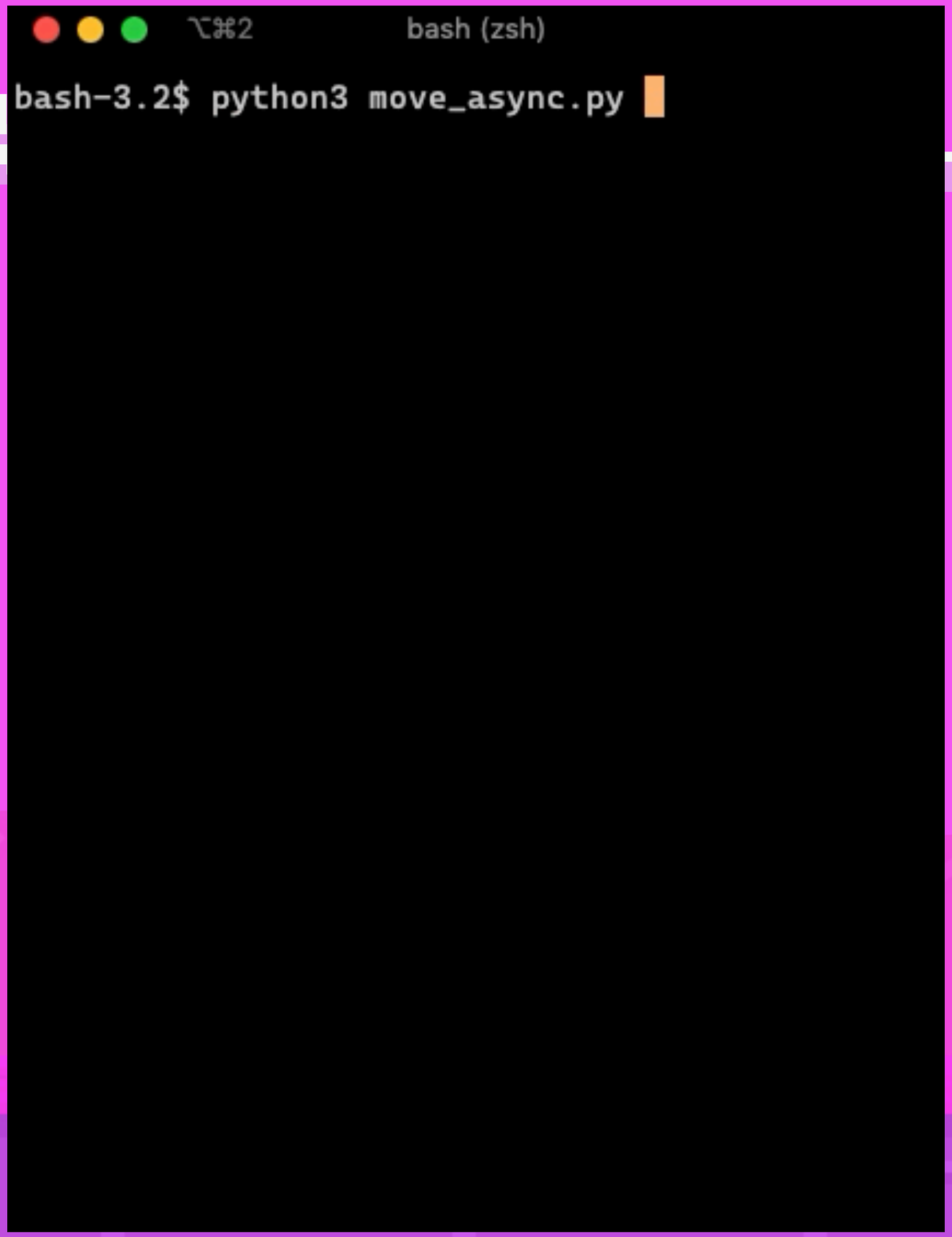
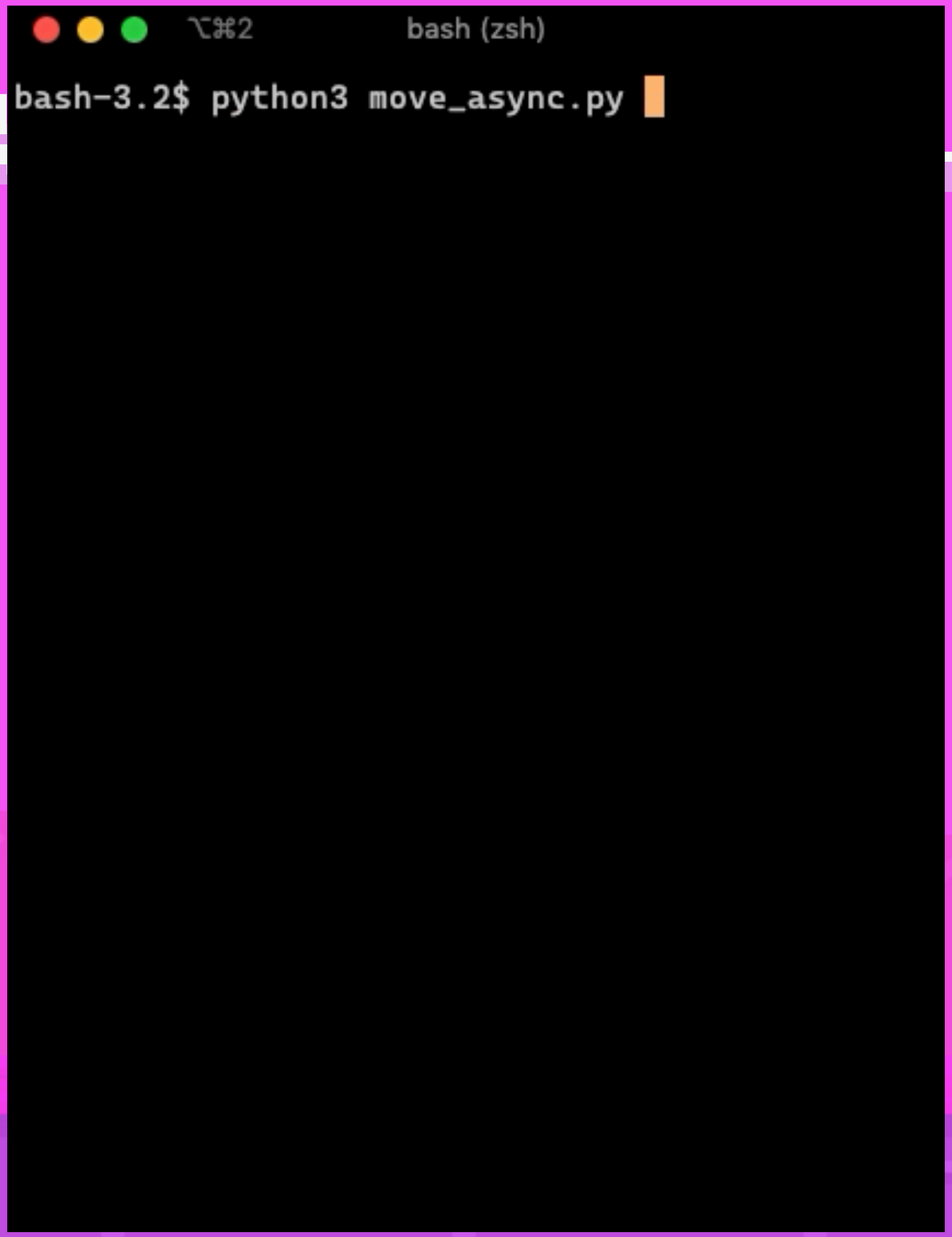
def move(batch):
    pack(batch)
    transport(batch)
    unpack(batch)


def main():
    for batch in batches(boxes, 10):
        move(batch)
```

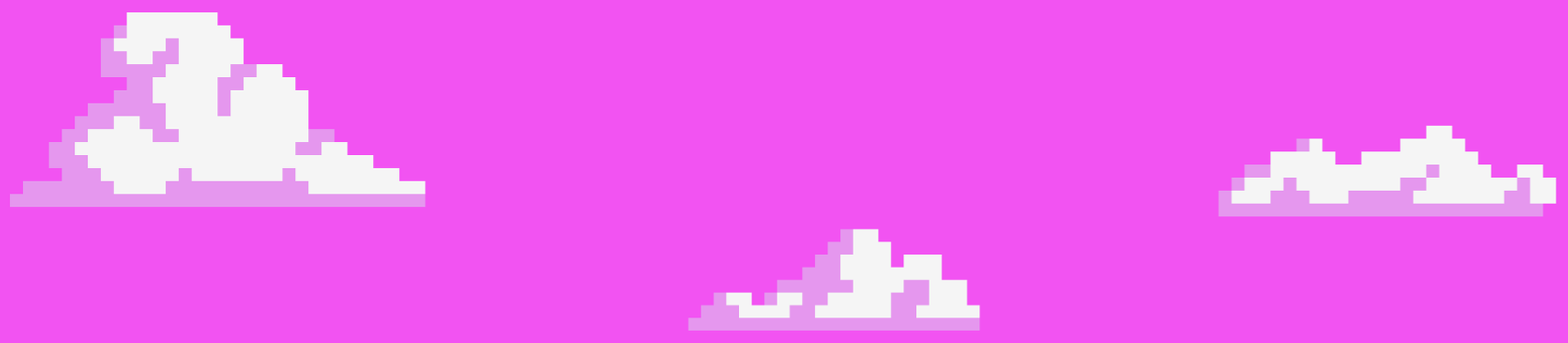
```python
async def move(batch):
    await pack(batch)
    await transport(batch)
    await unpack(batch)


async def main():
    all_batches = [move(batch) for batch in batches(boxes, 10)]
    await asyncio.gather(*all_batches)
```


⌥⌘2
bash (zsh)
bash-3.2$ python3 move_async.py

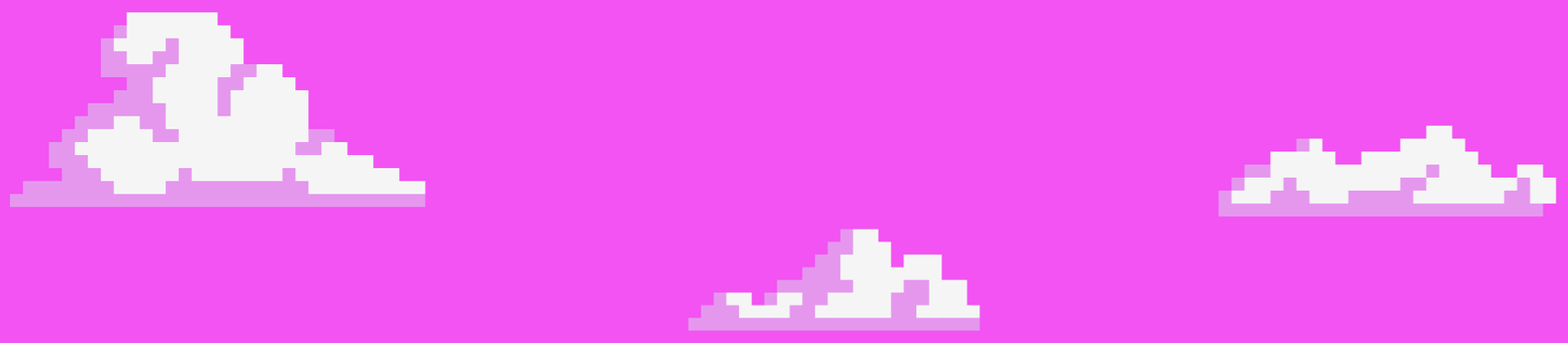

⌥⌘2
bash (zsh)
bash-3.2$ python3 move_async.py

# Python's asyncio

* COROUTINES
* TASKS
* EVENT LOOP
* SELECT



```python
async def pack(boxes):
    print("Packing...")
    await asyncio.sleep(PACK_TIME
```



```python
async def pack(boxes):
    print("Packing...")
    await asyncio.sleep(PACK_TIME
```

# COROUTINE

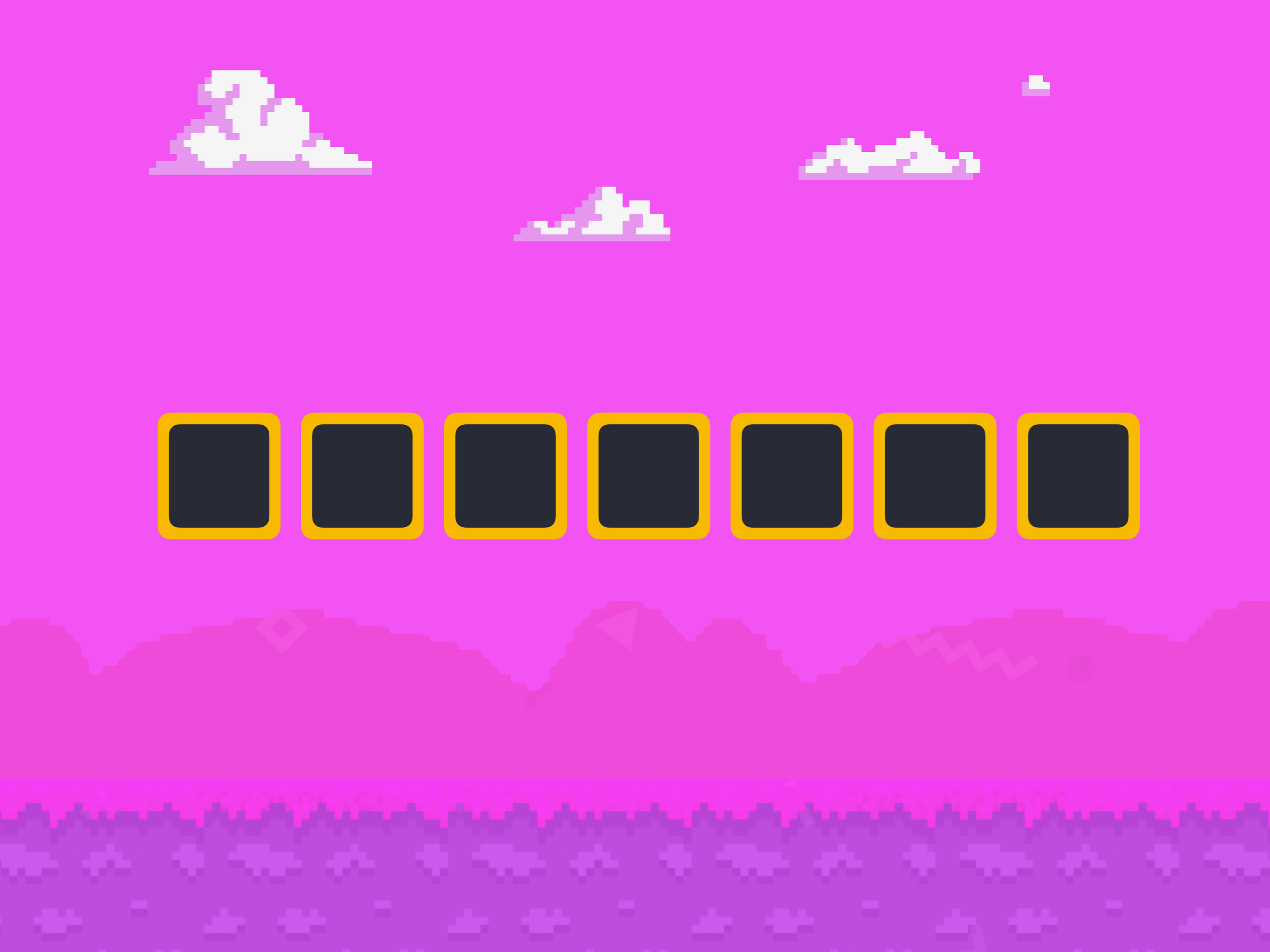
ASYNCIO.GATHER( COROUTINE )

TASK

COROUTINE

ASYNCIO.RUN( )

TASK



USERSPACE

SELECT

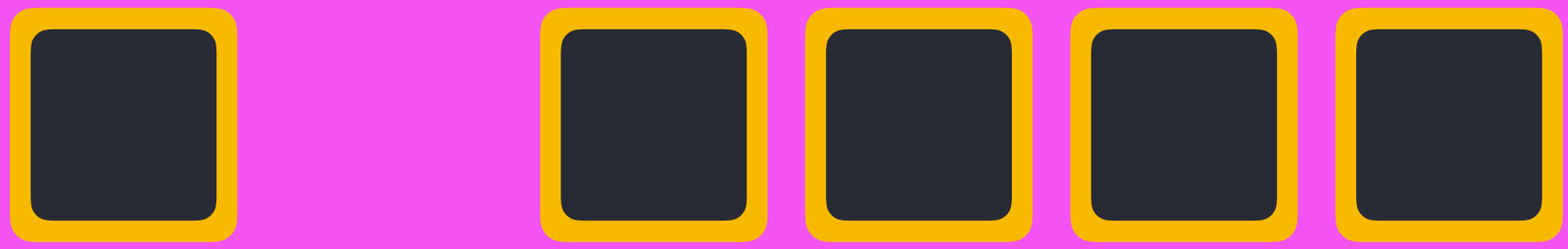
KERNEL

USERSPACE

SELECT

KERNEL

USERSPACE



SELECT

KERNEL

USERSPACE

SELECT

KERNEL

USERSPACE

$ELECT

KERNEL

USERSPACE

$ELECT

KERNEL

USERSPACE

$ELECT

KERNEL

USERSPACE

$ELECT

KERNEL

## DESCRIPTION top

**select**() and **pselect**() allow a program to monitor multiple file descriptors, waiting until one or more of the file descriptors become "ready" for some class of I/O operation (e.g., input possible). A file descriptor is considered ready if it is possible to perform a corresponding I/O operation (e.g., read(2), or a sufficiently small write(2)) without blocking.

Previous topic
Networking and Interprocess Communication

Next topic
Coroutines and Tasks

This Page
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# asyncio — Asynchronous I/O

asyncio is a library to write **concurrent** code using the **async/await** syntax.

asyncio is used as a foundation for multiple Python asynchronous frameworks that provide high-performance network and web-servers, database connection libraries, distributed task queues, etc.

asyncio is often a perfect fit for IO-bound and high-level **structured** network code.

asyncio provides a set of **high-level** APIs to:

- run Python coroutines concurrently and have full control over their execution;
- perform network IO and IPC;
- control subprocesses;
- distribute tasks via queues;
- synchronize concurrent code;

Additionally, there are **low-level** APIs for *library and framework developers* to:

- create and manage event loops, which provide asynchronous APIs for `networking`, running `subprocesses`, handling `OS signals`, etc;
- implement efficient protocols using transports;
- bridge callback-based libraries and code with async/await syntax.

**Hello World!**

```
import asyncio

async def main():
    print('Hello ...')
    await asyncio.sleep(1)
    print('... World!')

# Python 3.7+
asyncio.run(main())
```

**Reference**

High-level APIs

- Coroutines and Tasks
- Streams
- Synchronization Primitives

python / cpython

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aeros167 and asvetlov bpo-34037: Fix test_asyncio failure and add loop.shutdown_default_exe... ··· ✓ Latest commit 9fdc64c 3 days ago

| | | |
|---|---|---|
| .. | | |
| __init__.py | bpo-36889: Merge asyncio streams (GH-13251) | 4 months ago |
| __main__.py | bpo-37028: asyncio REPL; activated via 'python -m asyncio'. (GH-13472) | 4 months ago |
| base_events.py | bpo-34037: Fix test_asyncio failure and add loop.shutdown_default_exe... | 3 days ago |
| base_futures.py | bpo-34622: Extract asyncio exceptions into a separate module (GH-9141) | last year |
| base_subprocess.py | bpo-32528: Make asyncio.CancelledError a BaseException. (GH-13528) | 4 months ago |
| base_tasks.py | bpo-34270: Make it possible to name asyncio tasks (GH-8547) | last year |
| constants.py | bpo-33734: asyncio/ssl: a bunch of bugfixes (#7321) | last year |
| coroutines.py | bpo-36921: Deprecate **@coroutine** for sake of async def (GH-13346) | 4 months ago |
| events.py | bpo-34037: Fix test_asyncio failure and add loop.shutdown_default_exe... | 3 days ago |
| exceptions.py | bpo-32528: Make asyncio.CancelledError a BaseException. (GH-13528) | 4 months ago |
| format_helpers.py | bpo-33672: Fix Task.__repr__ crash with Cython's bogus coroutines (GH... | last year |
| futures.py | bpo-34622: Extract asyncio exceptions into a separate module (GH-9141) | last year |
| locks.py | bpo-36373: Fix deprecation warnings (GH-15889) | 12 days ago |
| log.py | Rename the logger to plain "logger". | 6 years ago |
| proactor_events.py | bpo-34679: Restore instantiation Windows IOCP event loop from non-mai... | 28 days ago |
| protocols.py | bpo-35394: Add empty slots to abstract asyncio protocols (#10889) | 10 months ago |
| queues.py | bpo-36373: Fix deprecation warnings (GH-15889) | 12 days ago |

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| events.py | bpo-34037: Fix test_asyncio failure and add loop.shutdown_default_exe... | 3 days ago |
| exceptions.py | bpo-32528: Make asyncio.CancelledError a BaseException. (GH-13528) | 4 months ago |
| format_helpers.py | bpo-33672: Fix Task.__repr__ crash with Cython's bogus coroutines (GH... | last year |
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| queues.py | bpo-36373: Fix deprecation warnings (GH-15889) | 12 days ago |
| runners.py | bpo-34037: Fix test_asyncio failure and add loop.shutdown_default_exe... | 3 days ago |
| selector_events.py | bpo-37027: Return a proxy socket object from transp.get_extra_info('s... | 4 months ago |
| sslproto.py | bpo-37035: Don't log OSError (GH-13548) | 4 months ago |
| staggered.py | bpo-32528: Make asyncio.CancelledError a BaseException. (GH-13528) | 4 months ago |
| streams.py | bpo-36889: Document Stream class and add docstrings (GH-14488) | 10 days ago |
| subprocess.py | bpo-36373: Deprecate explicit loop in task and subprocess API (GH-16033) | 10 days ago |
| tasks.py | bpo-36373: Deprecate explicit loop in task and subprocess API (GH-16033) | 10 days ago |
| transports.py | bpo-38148: Add slots to asyncio transports (GH-16077) | 9 days ago |
| trsock.py | bpo-37027: Return a proxy socket object from transp.get_extra_info('s... | 4 months ago |
| unix_events.py | Fix typos in docs, comments and test assert messages (#14872) | 2 months ago |
| windows_events.py | bpo-29883: Asyncio proactor udp (GH-13440) | 4 months ago |
| windows_utils.py | asyncio: __del__() keep reference to warnings.warn (GH-11491) | 9 months ago |

# JavaScript

# Async JavaScript

* CALLBACKS
* PROMISES
* ASYNC/AWAIT

# JavaScript Callbacks

* THE PROBLEM
* THE SOLUTION

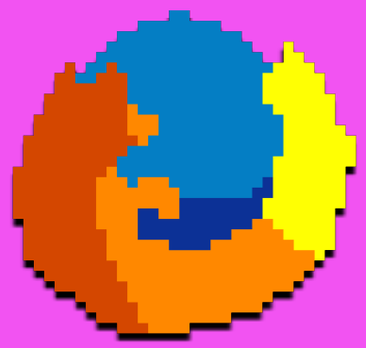
```
var button = document.getElementById('button');

button.onclick = function() {
    while (true);
};
```

```
document.querySelector('button').addEventListener('click', () => {
  function loop() {
    setTimeout(loop, 0);
  }
  loop();
});
```

V8

V8



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V8

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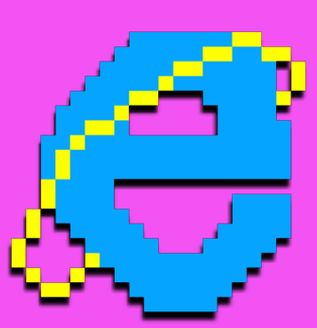

CHAKRA CORE

JS

HEAP

STACK

EVENT LOOP

WEB APIS

SETTIMEOUT

DOM

AJAX

CALLBACK QUEUE

JS

HEAP

STACK

EVENT LOOP

WEB APIS

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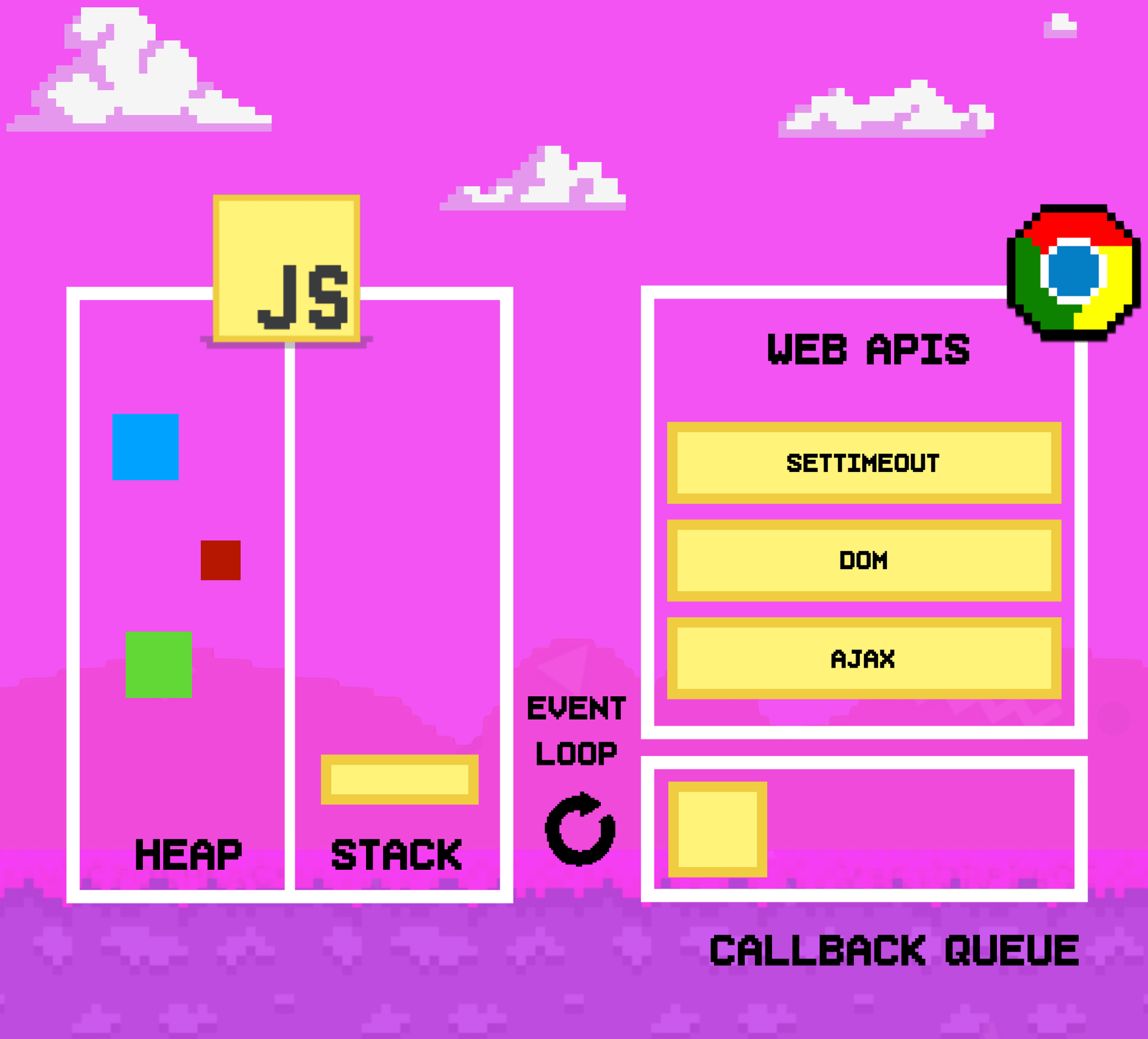
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DOM

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JS

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WEB APIS

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```
console.log("One");

setTimeout(function () {
    console.log("Two")
}, 0);

console.log("Three");
```

JS

WEB APIS

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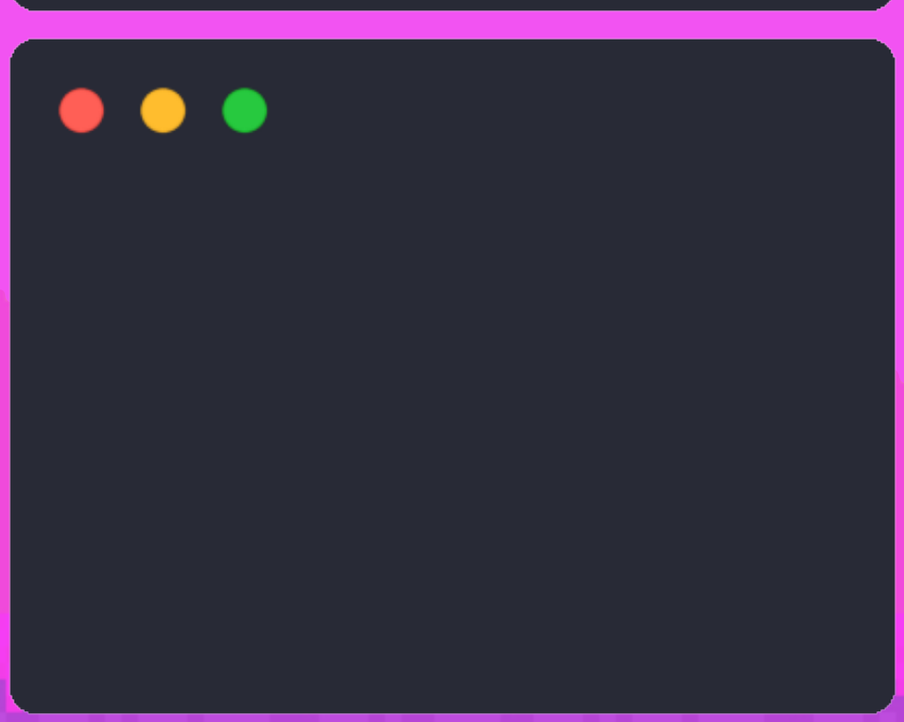

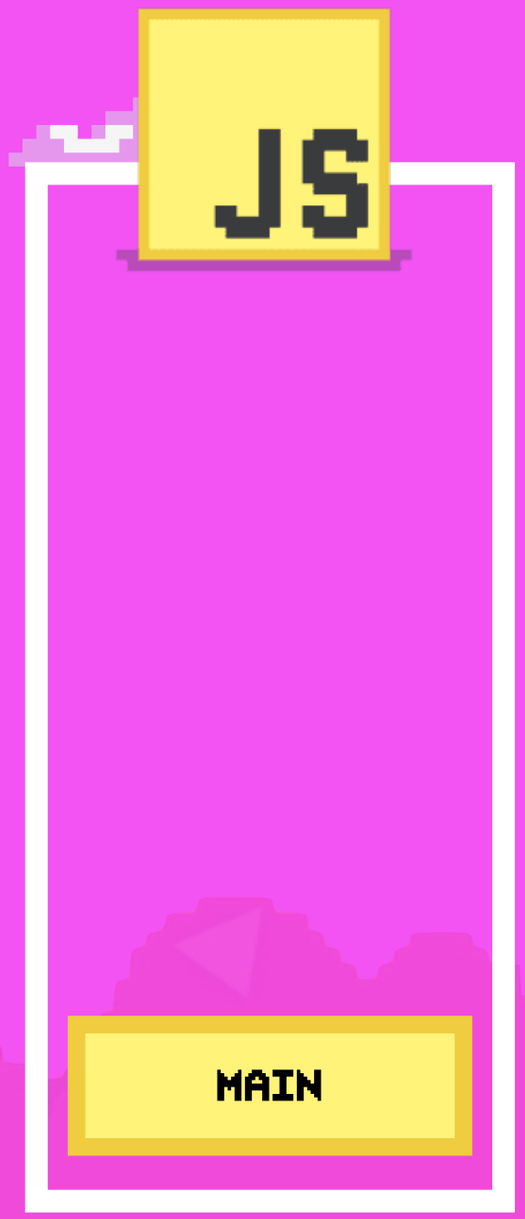


EVENT LOOP

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JS

CONSOLE.LOG

MAIN

STACK

EVENT LOOP

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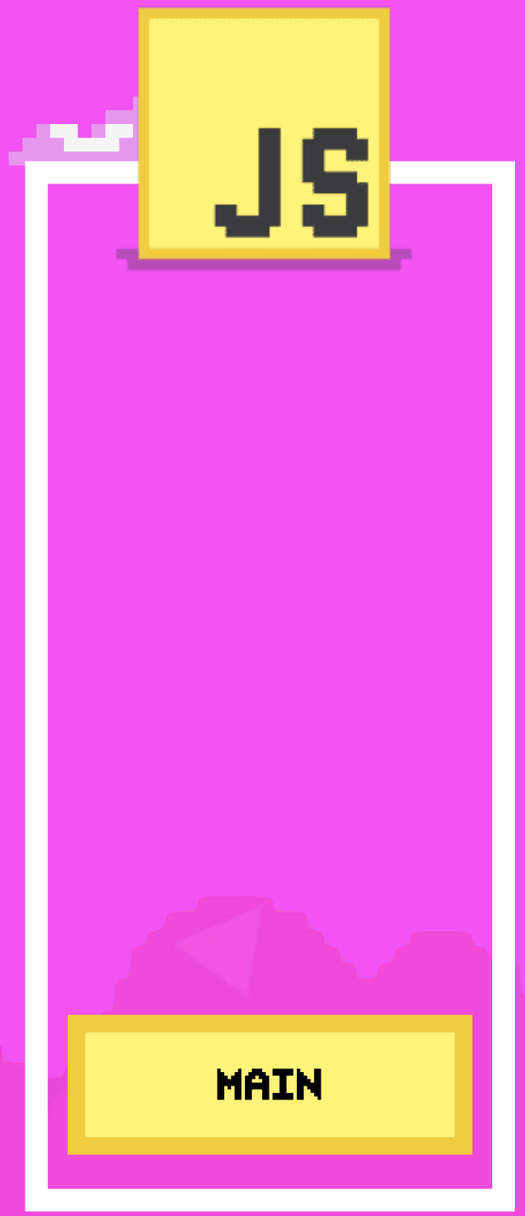


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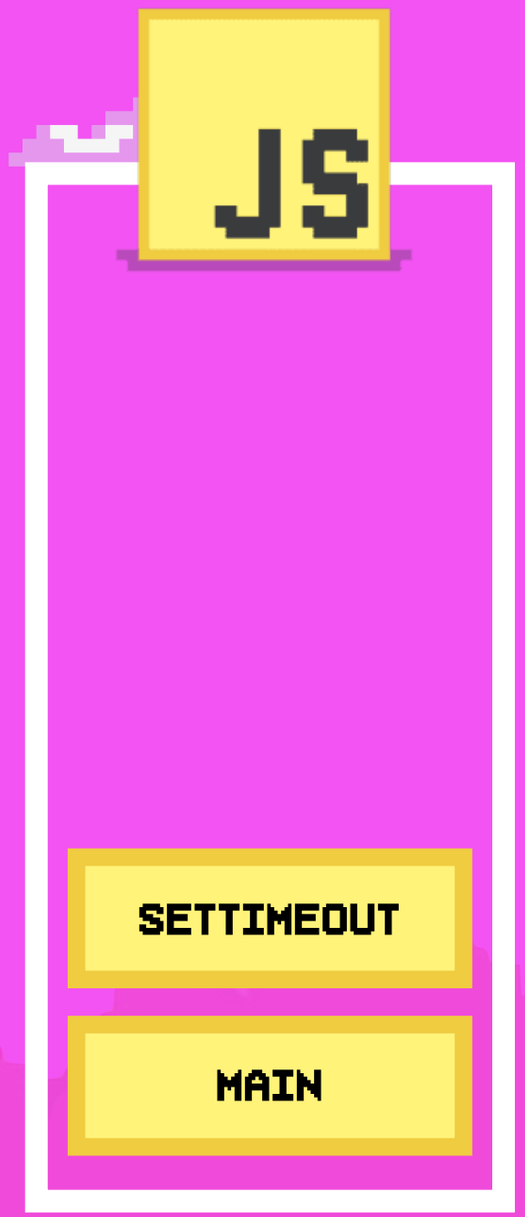

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JS

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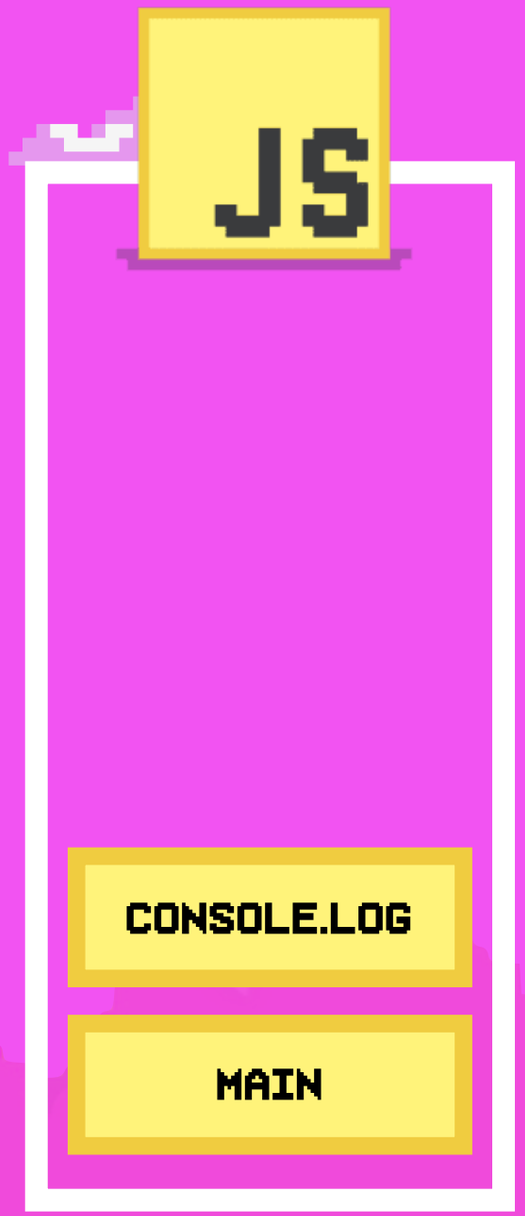


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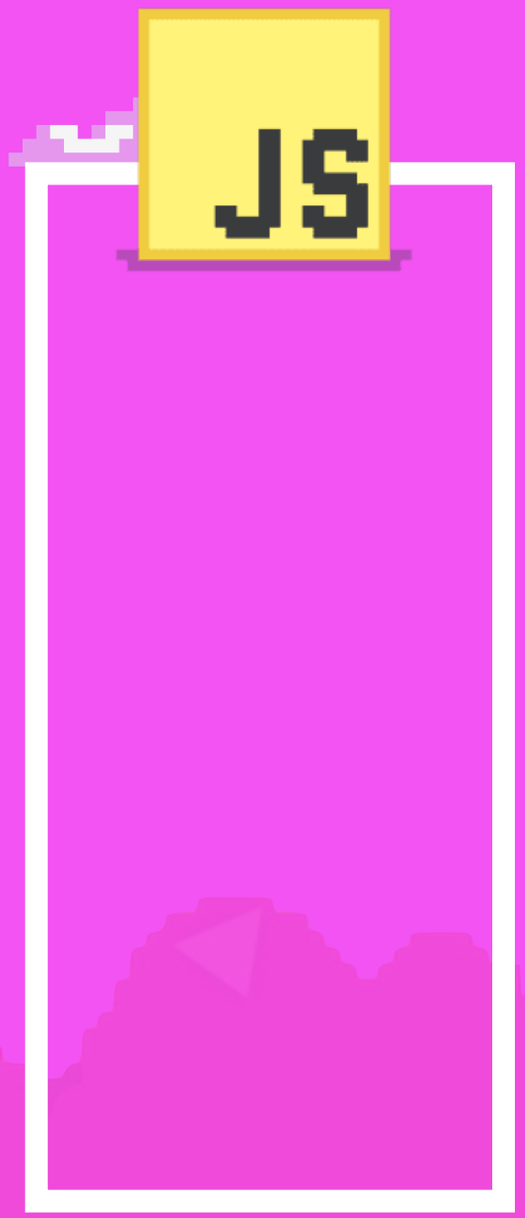
```
ONE
THREE
```

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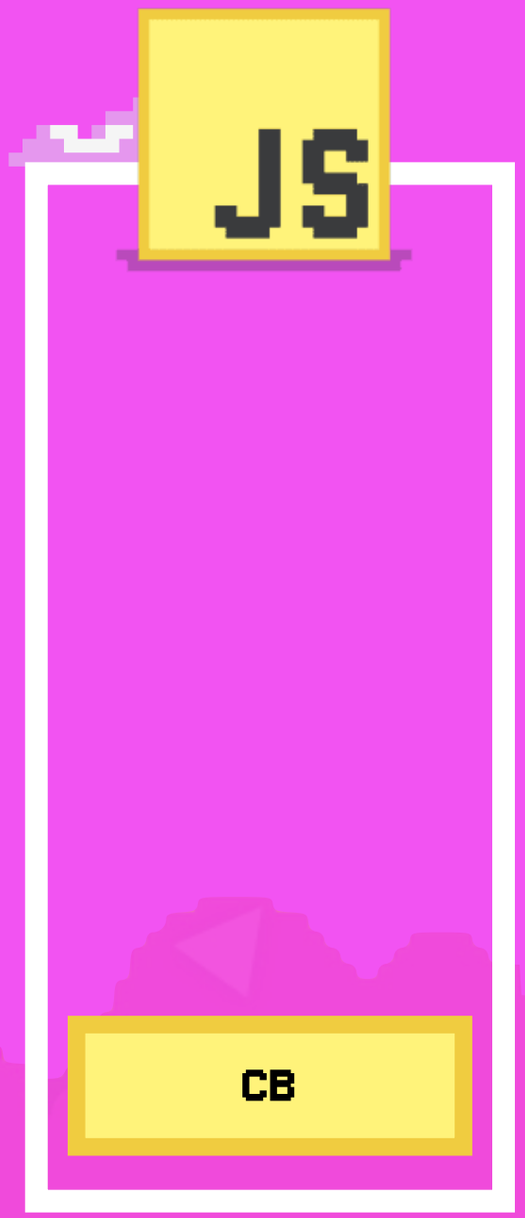


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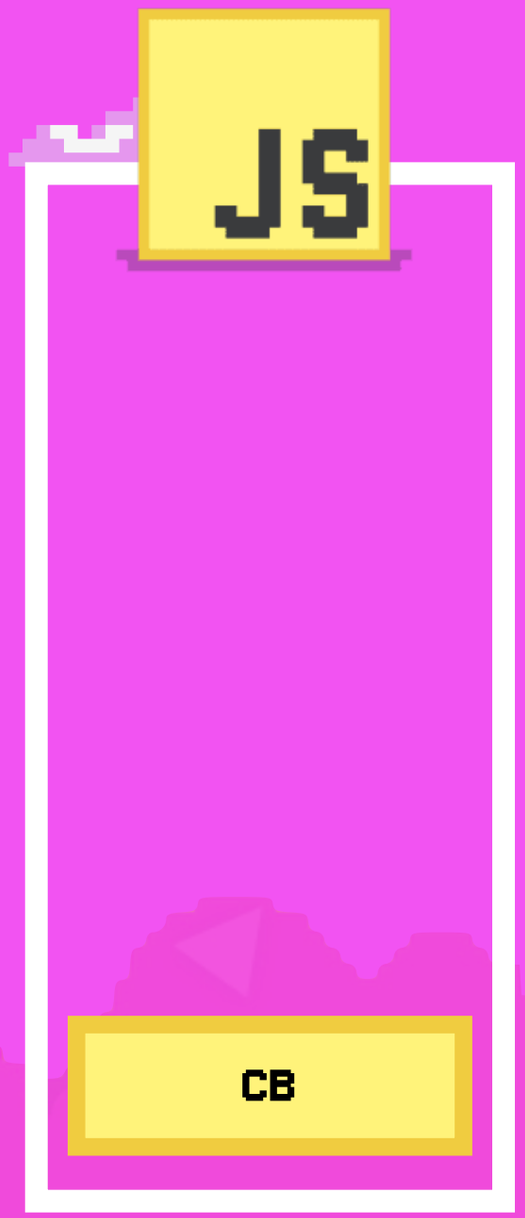


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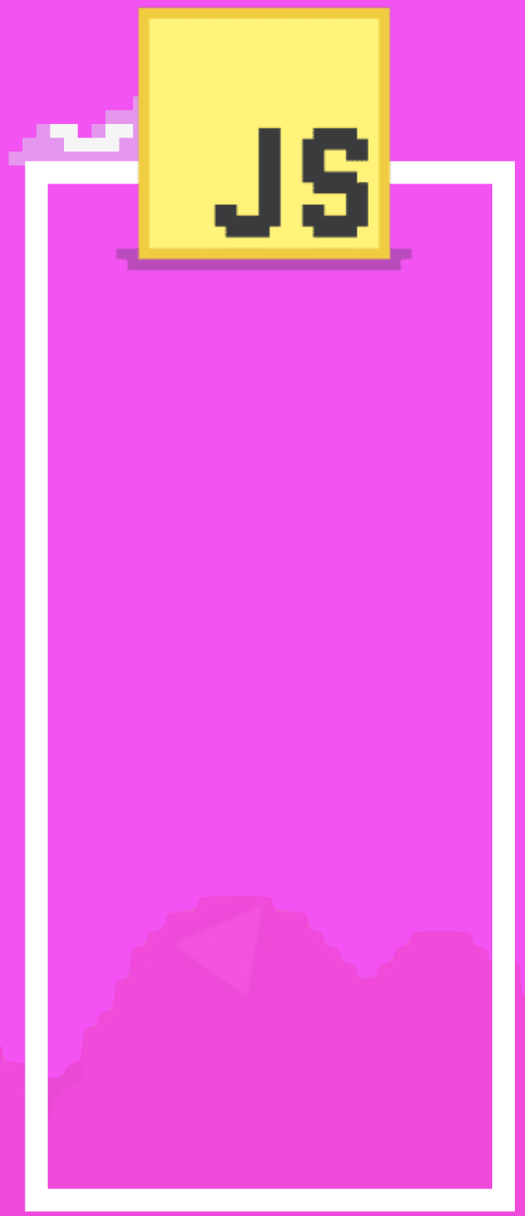
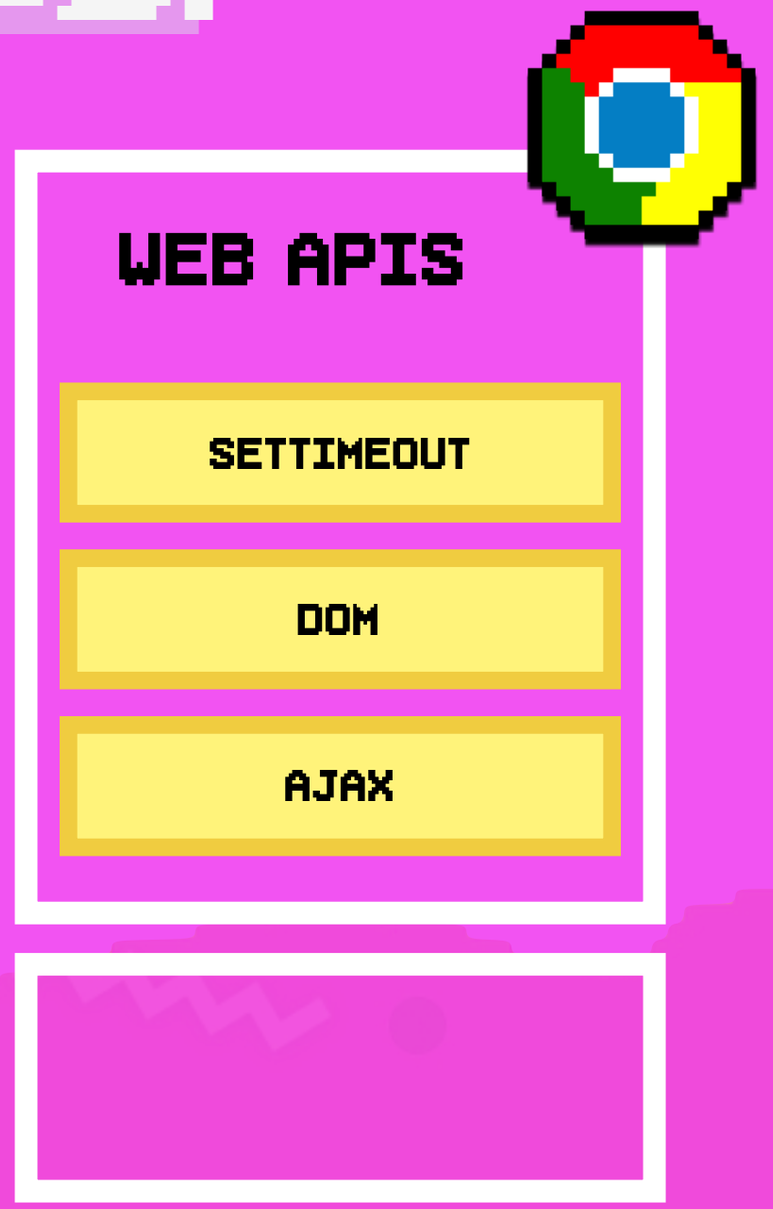
```
ONE
THREE
TWO
```




EVENT LOOP



V8

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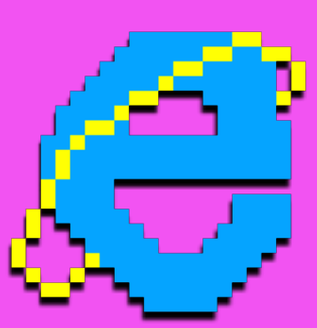

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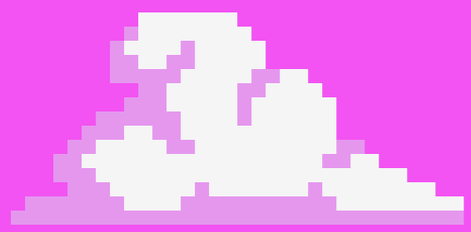
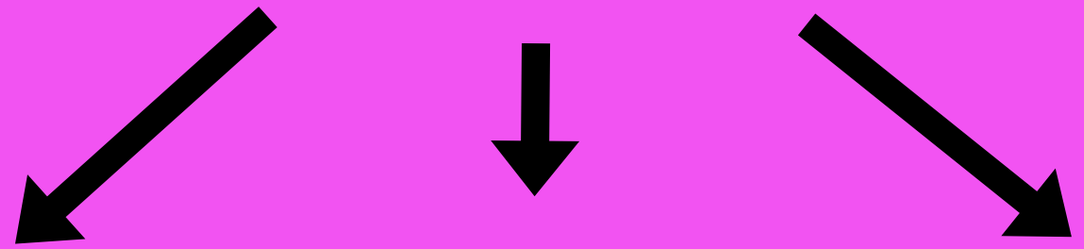
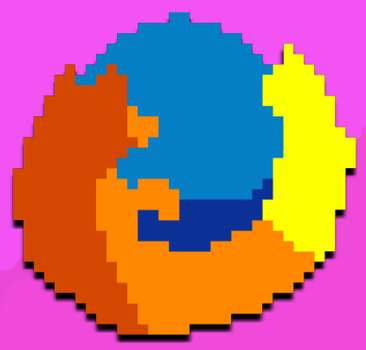


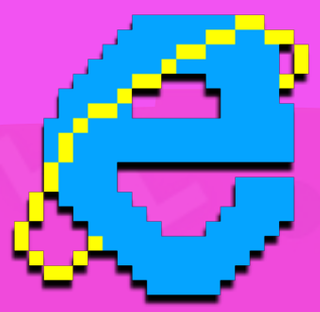
NODE.JS



V8

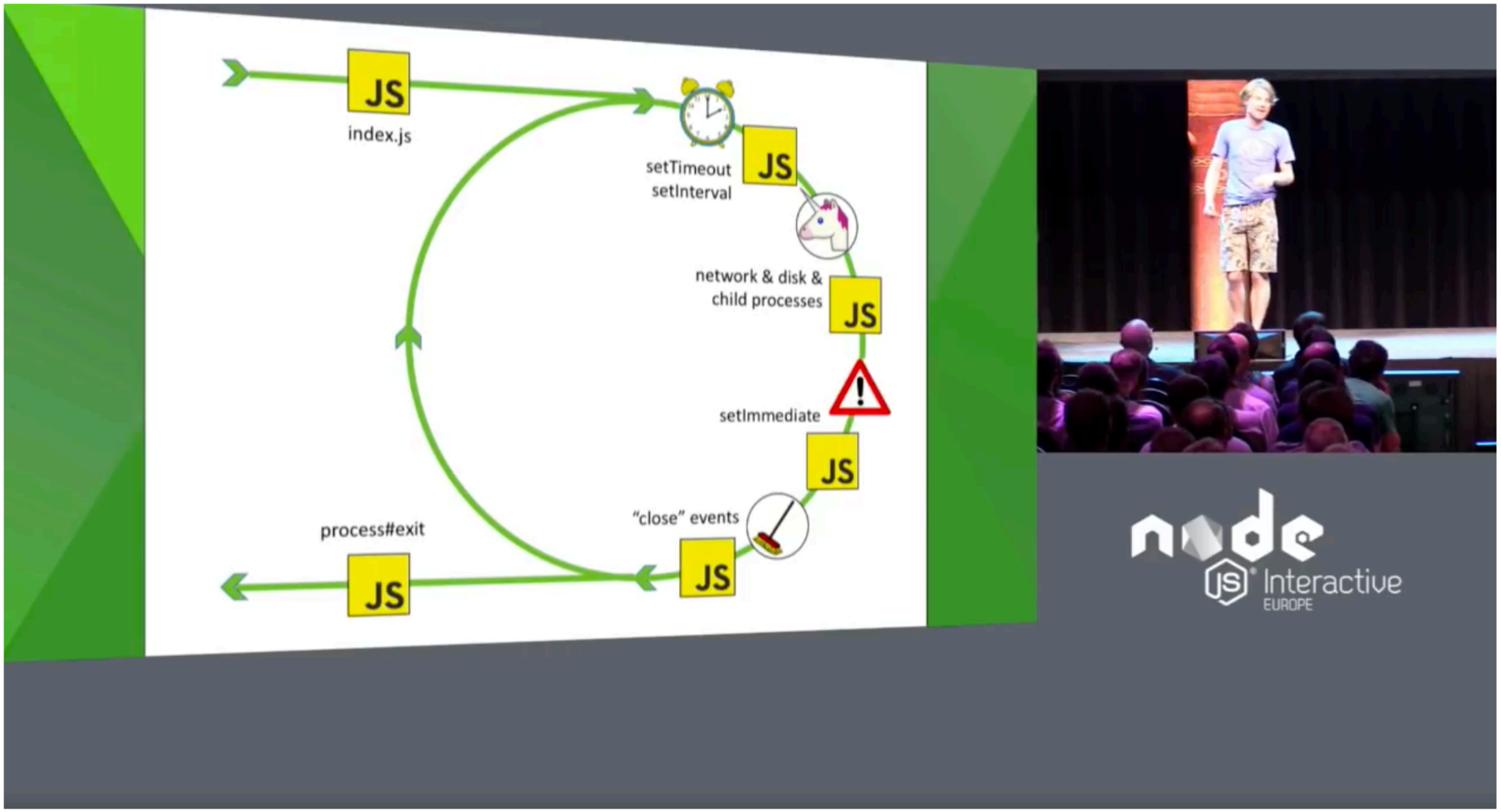


SPIDERMONKEY

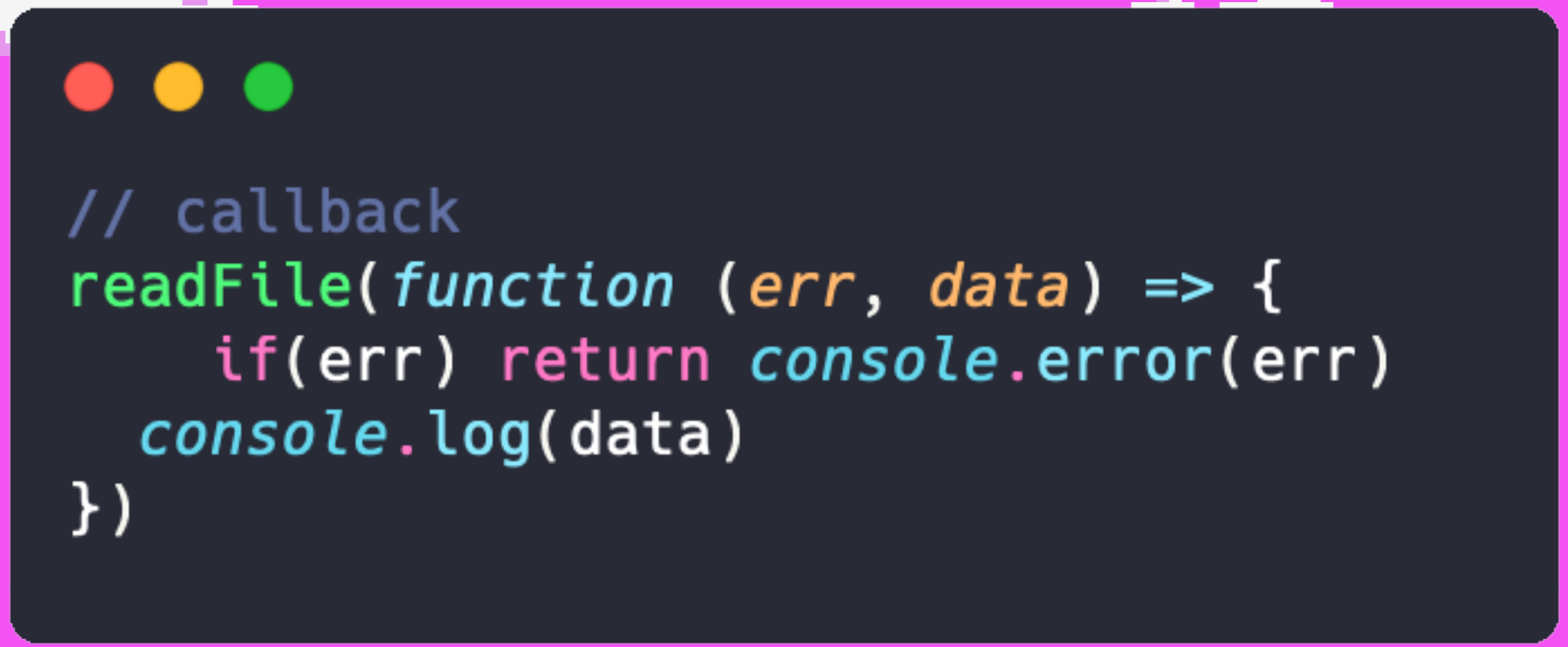


CHAKRA CORE

# libuv




# EVERYTHING YOU NEED TO KNOW ABOUT NODE.JS EVENT LOOP


// callback
readFile(function (err, data) => {
if(err) return console.error(err)
console.log(data)
})

```
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// promise
let promise = readFile()
promise.then(console.log, console.error)
```

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// callback
readFile(function (err, data) => {
    if(err) return console.error(err)
  console.log(data)
})

// promise
let promise = readFile()
promise.then(console.log, console.error)

// await
let data = await readFile()
console.log(contents)
```

# Rust

# What is Rust?

EMPOWERING EVERYONE TO BUILD
RELIABLE AND EFFICIENT SOFTWARE.

# What is Rust?

* SYSTEMS PROGRAMMING LANGUAGE
* STARTED AT MOZILLA (FIREFOX)
* USED BY AMAZON/MICROSOFT/DROPBOX...
* MAIN GOALS: SAFETY, PERFORMANCE
* FEARLESS CONCURRENCY

```
extern crate tokio;

use tokio::prelude::{AsyncRead, Future};

fn main() {
    let task = tokio::fs::File::open("foo.txt")
        .and_then(|mut file| {
            let mut contents = vec![];
            file.read_buf(&mut contents).map(|res| {
                println!("{:?}", res);
            })
        })
        .map_err(|err| eprintln!("IO error: {:?}", err));
    tokio::run(task);
}
```

```
extern crate tokio;

use tokio::prelude::{AsyncRead, Future};

                                                FUTURE
fn main() {
    let task = tokio::fs::File::open("foo.txt")
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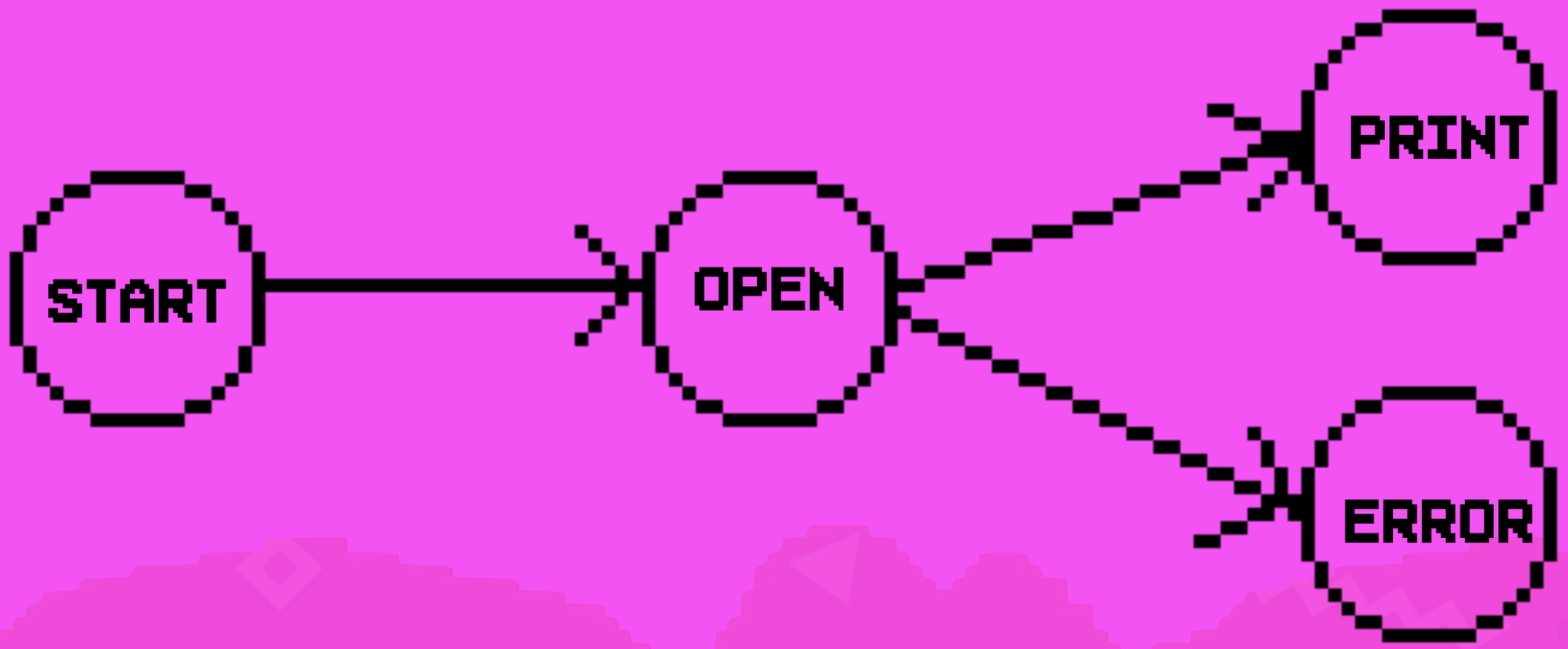
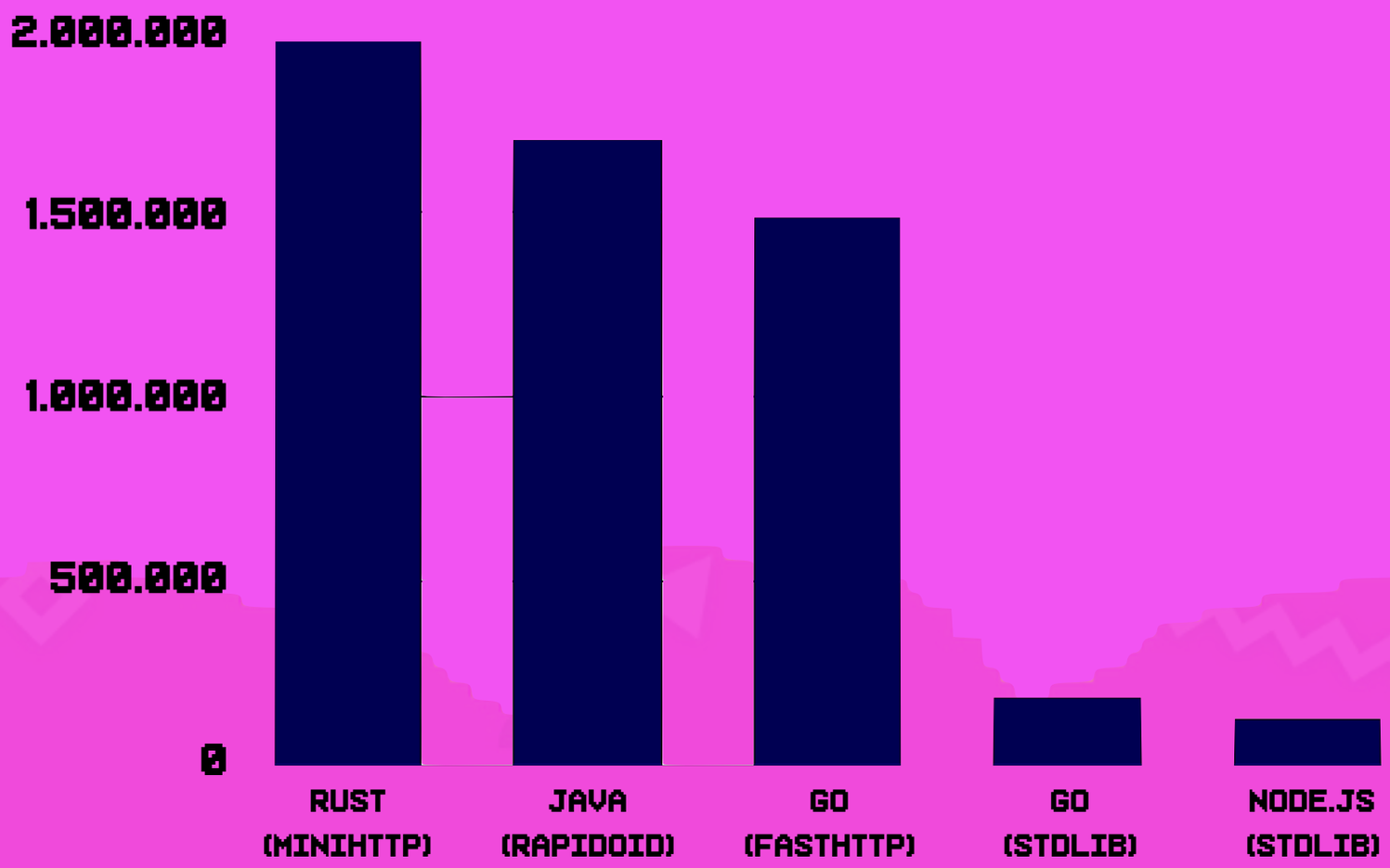
```


START
OPEN
PRINT
ERROR

# requests/s


2.000.000
1.500.000
1.000.000
500.000
0
RUST (MINIHTTP)
JAVA (RAPIDOID)
GO (FASTHTTP)
GO (STDLIB)
NODE.JS (STDLIB)

```rust
let f = file::open("foo.txt").await?;
let mut buffer = Vec::new();
let contents = f.read_to_end(&mut buffer).await?;
println!("{:?}", contents);
```

# Futures in Rust

# Summary

* ASYNCIO IN PYTHON IS BASED ON COROUTINES
* ASYNC IN JAVASCRIPT IS BASED ON CALLBACKS
* RUST'S FUTURES ARE ZERO-COST

# Credits

* PIXEL BACKGROUNDS BY SLANCE.COM
* TRUCK AND ENGINE LOGOS BY PIXELART MAKER
* JAKE ARCHIBALD - IN THE LOOP