멀티 쓰레드

2020.4

동시성, 병렬성

- 프로그램의 부분이 독립적으로 수행 ==> 동시성
- 프로그램의 부분이 동시에 수행 ==> 병렬성
- 동시성이 있는 프로그램이 다중 프로세서 환경에서 병렬적으로 수행이 가능하다.
- 여기서 동시성이라고 하는 말은 병렬성도 포함.

쓰레드

- 다중 스레드는 실행 순서에 대한 보장이 없음
- Race condition => 특정 자원에 순서적 접근이 보장되지 않는다.
- Deadlock => 내가 자원을 쥐고서 상대방의 자원이 해제되길 기다린다.
- 재현이 힘들어 디버깅이 어려운 상황 발생.
- 운영체제의 쓰레드와 프로그래밍 언어가 제공하는 green thread.
- Rust는 green thread를 제공하지 않지만 green thread를 제공하는 라이브러리가 다 수 있음.

Spawn

```rust
use std::thread;
use std::time::Duration;

fn main() {
    thread::spawn(|| {
        for i in 1..10 {
            println!("hi number {} from the spawned thread!", i);
            thread::sleep(Duration::from_millis(1));
        }
    });

    for i in 1..5 {
        println!("hi number {} from the main thread!", i);
        thread::sleep(Duration::from_millis(1));
    }
}
```

```
hi number 1 from the main thread!
hi number 1 from the spawned thread!
hi number 2 from the main thread!
hi number 2 from the spawned thread!
hi number 3 from the main thread!
hi number 3 from the spawned thread!
hi number 4 from the main thread!
hi number 4 from the spawned thread!
hi number 5 from the spawned thread!
```

thread가 모두 실행되지 않고 종료

Join

```
use std::thread;
use std::time::Duration;

fn main() {
    let handle = thread::spawn(ll {
        for i in 1..10 {
            println!("hi number {} from the spawned thread!", i);
            thread::sleep(Duration::from_millis(1));
        }
    });

    for i in 1..5 {
        println!("hi number {} from the main thread!", i);
        thread::sleep(Duration::from_millis(1));
    }

    handle.join().unwrap();
}
```

```
hi number 1 from the main thread!
hi number 2 from the main thread!
hi number 1 from the spawned thread!
hi number 3 from the main thread!
hi number 2 from the spawned thread!
hi number 4 from the main thread!
hi number 3 from the spawned thread!
hi number 4 from the spawned thread!
hi number 5 from the spawned thread!
hi number 6 from the spawned thread!
hi number 7 from the spawned thread!
hi number 8 from the spawned thread!
hi number 9 from the spawned thread!
```

Join 위치

```
use std::thread;
use std::time::Duration;

fn main() {
    let handle = thread::spawn(ll {
        for i in 1..10 {
            println!("hi number {} from the spawned thread!", i);
            thread::sleep(Duration::from_millis(1));
        }
    });

    handle.join().unwrap();

    for i in 1..5 {
        println!("hi number {} from the main thread!", i);
        thread::sleep(Duration::from_millis(1));
    }
}
```

```
hi number 1 from the spawned thread!
hi number 2 from the spawned thread!
hi number 3 from the spawned thread!
hi number 4 from the spawned thread!
hi number 5 from the spawned thread!
hi number 6 from the spawned thread!
hi number 7 from the spawned thread!
hi number 8 from the spawned thread!
hi number 9 from the spawned thread!
hi number 1 from the main thread!
hi number 2 from the main thread!
hi number 3 from the main thread!
hi number 4 from the main thread!
```

Move

```
use std::thread;

fn main() {
    let v = vec![1, 2, 3];

    let handle = thread::spawn(|| {
        println!("Here's a vector: {:?}", v);
    });

    handle.join().unwrap();
}
```

```
error[E0373]: closure may outlive the current function, but it borrows `v`,
which is owned by the current function
 --> src/main.rs:6:32
  |
6 |     let handle = thread::spawn(|| {
  |                                ^^ may outlive borrowed value `v`
7 |         println!("Here's a vector: {:?}", v);
  |                                           - `v` is borrowed here
  |
help: to force the closure to take ownership of `v` (and any other referenced
variables), use the `move` keyword
  |
6 |     let handle = thread::spawn(move || {
  |                                ^^^^^^^
```

Move

```
use std::thread;

fn main() {
    let v = vec![1, 2, 3];

    let handle = thread::spawn(|| {
        println!("Here's a vector: {:?}", v);
    });

    drop(v); // oh no!

    handle.join().unwrap();
}
```

```
use std::thread;

fn main() {
    let v = vec![1, 2, 3];

    let handle = thread::spawn(move || {
        println!("Here's a vector: {:?}", v);
    });

    handle.join().unwrap();
}
```

메시지 패싱

메모리를 공유하는 것으로 통신하지 마세요; 대신, 통신해서 메모리를 공유하세요

```
use std::thread;
use std::sync::mpsc;

fn main() {
    let (tx, rx) = mpsc::channel();

    thread::spawn(move || {
        let val = String::from("hi");
        tx.send(val).unwrap();
    });

    let received = rx.recv().unwrap();
    println!("Got: {}", received);
}
```

메시지의 소유권

```
use std::thread;
use std::sync::mpsc;

fn main() {
    let (tx, rx) = mpsc::channel();

    thread::spawn(move || {
        let val = String::from("hi");
        tx.send(val).unwrap();
        println!("val is {}", val);
    });

    let received = rx.recv().unwrap();
    println!("Got: {}", received);
}
```

```
error[E0382]: use of moved value: `val`
  --> src/main.rs:10:31
   |
9  |         tx.send(val).unwrap();
   |                 --- value moved here
10 |         println!("val is {}", val);
   |                               ^^^ value used here after move
   |
   = note: move occurs because `val` has type `std::string::String`, which does
not implement the `Copy` trait
```

여러 메시지 송수신

```
use std::thread;
use std::sync::mpsc;
use std::time::Duration;

fn main() {
    let (tx, rx) = mpsc::channel();

    thread::spawn(move || {
        let vals = vec![
            String::from("hi"),
            String::from("from"),
            String::from("the"),
            String::from("thread"),
        ];

        for val in vals {
            tx.send(val).unwrap();
            thread::sleep(Duration::from_secs(1));
        }
    });

    for received in rx {
        println!("Got: {}", received);
    }
}
```

```
Got: hi
Got: from
Got: the
Got: thread
```

여러 스레드에서 메시지

```rust
let (tx, rx) = mpsc::channel();

let tx1 = mpsc::Sender::clone(&tx);
thread::spawn(move || {
    let vals = vec![
        String::from("hi"),
        String::from("from"),
        String::from("the"),
        String::from("thread"),
    ];

    for val in vals {
        tx1.send(val).unwrap();
        thread::sleep(Duration::from_secs(1));
    }
});

thread::spawn(move || {
    let vals = vec![
        String::from("more"),
        String::from("messages"),
        String::from("for"),
        String::from("you"),
    ];

    for val in vals {
        tx.send(val).unwrap();
        thread::sleep(Duration::from_secs(1));
    }
});

for received in rx {
    println!("Got: {}", received);
}
```

```
Got: hi
Got: more
Got: from
Got: messages
Got: for
Got: the
Got: thread
Got: you
```

뮤텍스

- 자원의 공유가 가능
- Lock 을 얻어야 하고
- 사용 후 반드시 unlock해줘야 한다.(스코프 벗어나면 자동으로 언락됨)

```
use std::sync::Mutex;

fn main() {
    let m = Mutex::new(5);

    {
        let mut num = m.lock().unwrap();
        *num = 6;
    }

    println!("m = {:?}", m);
}
```

뮤텍스는 스마트 포인터이다.
따라서 Deref, Drop이 특별히 구현되어 있다.

다수의 스레드

```rust
use std::sync::Mutex;
use std::thread;

fn main() {
    let counter = Mutex::new(0);
    let mut handles = vec![];

    for _ in 0..10 {
        let handle = thread::spawn(move || {
            let mut num = counter.lock().unwrap();

            *num += 1;
        });
        handles.push(handle);
    }

    for handle in handles {
        handle.join().unwrap();
    }

    println!("Result: {}", *counter.lock().unwrap());
}
```

```
error[E0382]: capture of moved value: `counter`
  --> src/main.rs:10:27
   |
9  |         let handle = thread::spawn(move || {
   |                                    ------- value moved (into closure) here
10 |             let mut num = counter.lock().unwrap();
   |                           ^^^^^^^ value captured here after move
   |
   = note: move occurs because `counter` has type `std::sync::Mutex<i32>`,
   which does not implement the `Copy` trait

error[E0382]: use of moved value: `counter`
  --> src/main.rs:21:29
   |
9  |         let handle = thread::spawn(move || {
   |                                    ------- value moved (into closure) here
...
21 |     println!("Result: {}", *counter.lock().unwrap());
   |                             ^^^^^^^ value used here after move
   |
   = note: move occurs because `counter` has type `std::sync::Mutex<i32>`,
   which does not implement the `Copy` trait

error: aborting due to 2 previous errors
```

Arc

```
use std::sync::{Mutex, Arc};
use std::thread;

fn main() {
    let counter = Arc::new(Mutex::new(0));
    let mut handles = vec![];

    for _ in 0..10 {
        let counter = Arc::clone(&counter);
        let handle = thread::spawn(move || {
            let mut num = counter.lock().unwrap();

            *num += 1;
        });
        handles.push(handle);
    }

    for handle in handles {
        handle.join().unwrap();
    }

    println!("Result: {}", *counter.lock().unwrap());
}
```

```
Result: 10
```

Sync, Send

- Send : 소유권이 스레드 간에 이동할 수 있다.
- Rc<T>는 Send가 아님. 대부분의 기본타입이 Send이다.
- Send로 구성된 어떤 타입은 자동으로 Send가 된다.
- Sync: 다수의 스레드로부터 안전하게 참조 가능.
- &T가 Send이면 Sync가 된다.
- Send와 Sync는 손수 구현하면 안전하지 않다.

Q & A