Computer Resources

Computation

- CPU

Memory:

- Persistent memory
    - Hard driver or SSD
- Volatile memory
    - RAM

RAM

- Stack
    - Function Arguments
    - Local Variables
    - Known size at compile time
    - size: Dynamic / Fixed upper limit
    - Cleanup: Automatic / When function returns

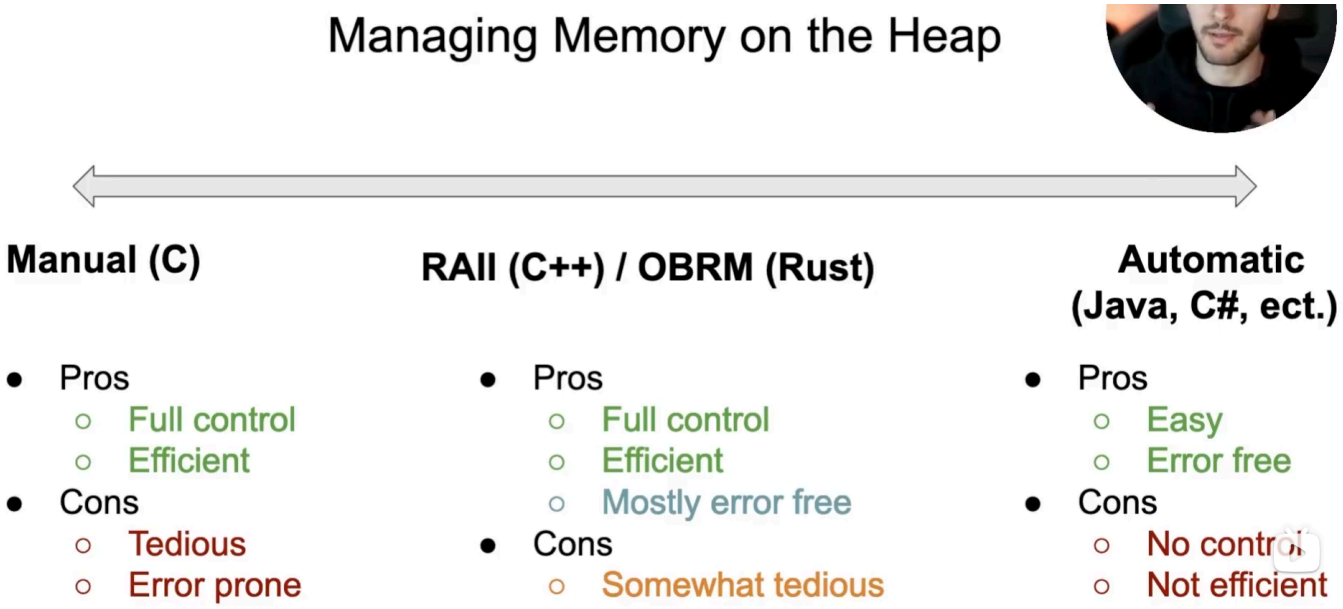
Heap

- Values that live beyond a function's lifetime
- Values accessed by multiple threads
- Large values
- Unknown size at compile time
- Size: Dynamic
- Lifetime: Determined by programmer
- Cleanup: Manual

Static

- Program's binary
- Static variables
- String literals
- Size: fixed
- Lifetime: Lifetime of program
- Cleanup: automatic When program terminates

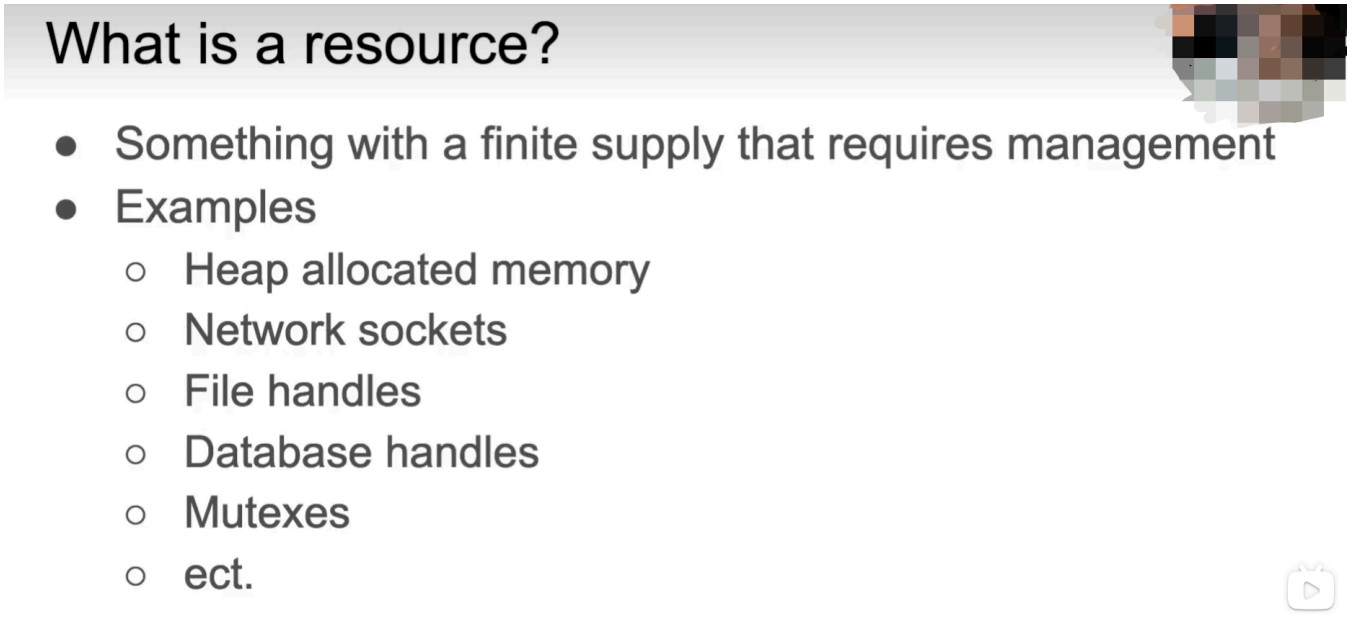
Heap Memory Managing



RAII

> 利用析构函数 + 对象（Wrapper了原始对象）分配到栈上(不使用new)

What is a resource



```
class Car {};

void memory_example()
{
    Car* car = new Car;              // allocate memory on the heap
    function_that_can_throw();       // memory leak if exception is thrown
    if(!should_continue()) return;   // memory leak if early return
    delete car;                      // clean up memory on the heap
}
```

```
void file_example()
{
    ofstream file("example.txt");  // acquire file handle
    function_that_can_throw();     // file is never closed if exception is thrown
    if(!should_continue()) return; // file is never closed if early return
    file.close();                  // close file handle
}
```

在函数的最后，我们关闭文件句柄。

Solution

Use objects (constructors/destructors) to manage resources.

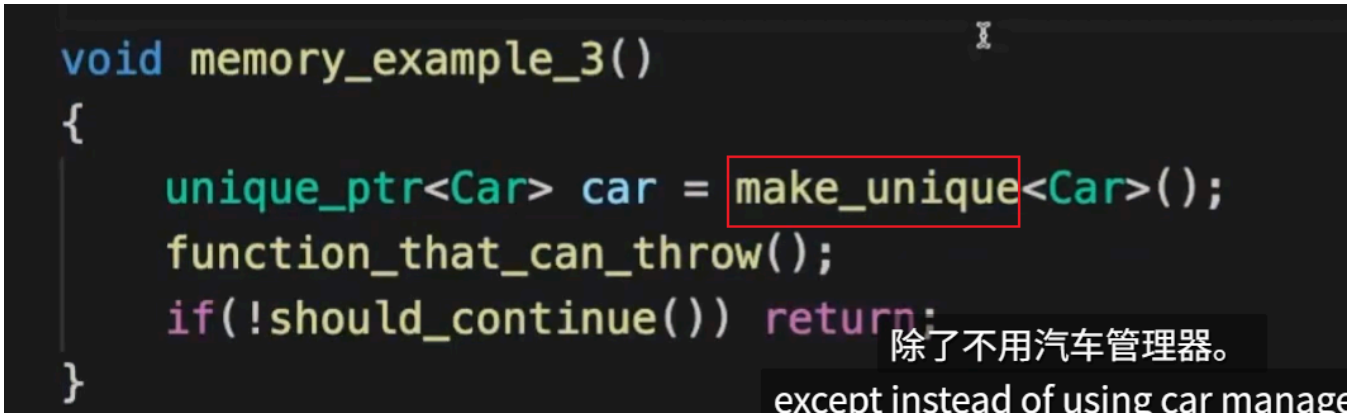
```
class CarManager
{
private:
    Car* p; // pointer to a Car
public:
    CarManager(Car* p) : p(p) {}
    ~CarManager()
    {
        // clean up memory on the heap
        delete p;
    }
};
```

```
void memory_example_2()
{
    CarManager car = CarManager(new Car);
    function_that_can_throw();
    if(!should_continue()) return;
}
```

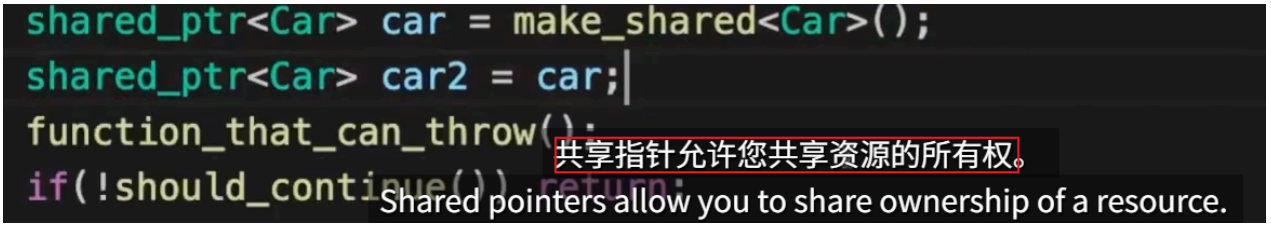
因为car manager是在堆栈上分配的，
Because car manager is allocated on the stack,

```
class File
{
private:
    ofstream file; // file handle
public:
    File(string file_name) {
        file = ofstream(file_name);
    }
    ~File()
    {
        // close file handle
        file.close();
    }
};
```

- only one owner



- shared



Ownership Based Resource Management (OBRM)

Similar to RAII but instead of being a best-practice/pattern it's a built-in language feature.

Ownership rules are checked at compile time

- Each value in Rust has a variable that's called its owner.
- There can only be one owner at a time.
- When the owner goes out of scope, the value will be dropped.

- Rust OBRM VS C++ RAII

> Rust中ownership不仅用于内存管理，而且用于资源管理,如文件句柄、网络socket等

raii.cpp > memory_example()

```cpp
class Car {};

void memory_example()
{
    unique_ptr<Car> car =
        make_unique<Car>();
    function_that_can_throw();
    if(!should_continue()) return;
}

void file_example()
{
    File file = File("example.txt");
    function_that_can_throw();
    if(!should_continue()) return;
}
```

src > obrm.rs > memory_example

```rust
struct Car {}

fn memory_example() {
    let car = Box::new(Car {});
    let my_string = String::from("LGR");
    function_that_can_panic();
    if !should_continue() { return; }
}

fn file_example() {
    let path = Path::new("example.txt");
    let file = File::open(&path).unwrap();
    function_that_can_panic();
    if !should_continue() { return; }
}
```

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```cpp
class Car {};

void memory_example()
{
    unique_ptr<Car> car =
        make_unique<Car>();
    unique_ptr<Car> car2 = move(car);
    function_that_can_throw();
    if(!should_continue()) return;
}

void file_example()
{
    File file = File("example.txt");
    function_that_can_throw();
    if(!should_continue()) return;
}
```

```rust
struct Car {}

fn memory_example() {
    let car = Box::new(Car {});
    let car2 = car;
    let my_string = String::from("LGR");
    function_that_can_panic();
    if !should_continue() { return; }
}

fn file_example() {
    let path = Path::new("example.txt");
    let file = File::open(&path).unwrap();
    function_that_can_panic();
    if !should_continue() { return; }
}
```

注意，使用Rust，我们不会得到任何错误，这是因为移动语义是隐式的。
Notice that with Rust, we don't get any errors, and that's because move semantics are implicit.

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```cpp
class Car {};

void memory_example()
{
    shared_ptr<Car> car =
        make_shared<Car>();
    shared_ptr<Car> car2 = car;
    function_that_can_throw();
    if(!should_continue()) return;
}

void file_example()
{
    File file = File("example.txt");
    function_that_can_throw();
    if(!should_continue()) return;
}
```

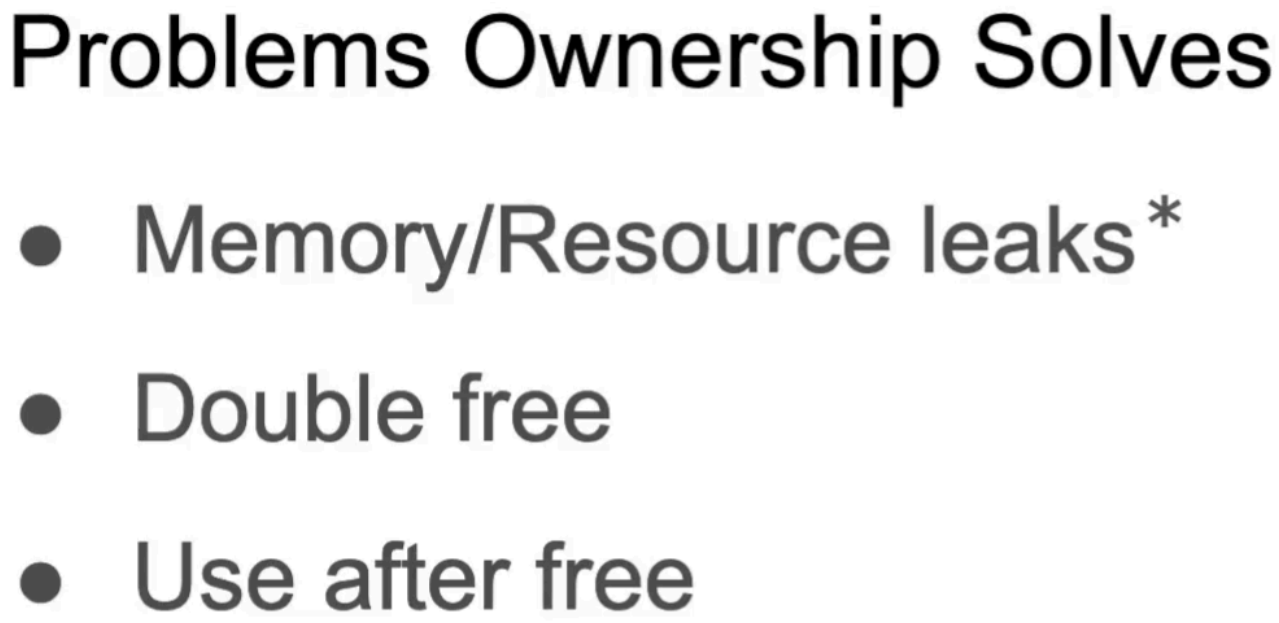
```rust
struct Car {}

fn memory_example() {
    let car = Rc::new(Car {});
    let car2 = car.clone();
    let my_string = String::from("LGR");
    function_that_can_panic();
    if !should_continue() { return; }
}

fn file_example() {
    let path = Path::new("example.txt");
    let file = File::open(&path).unwrap();
    function_that_can_panic();
    if !should_continue() { return; }
}
```

在RC智能指针上调用Clone将产生一个指向相同内存位置的新智能指针。
Calling Clone on an RC SmartPointer will produce a new SmartPointer pointing to the same memory location.

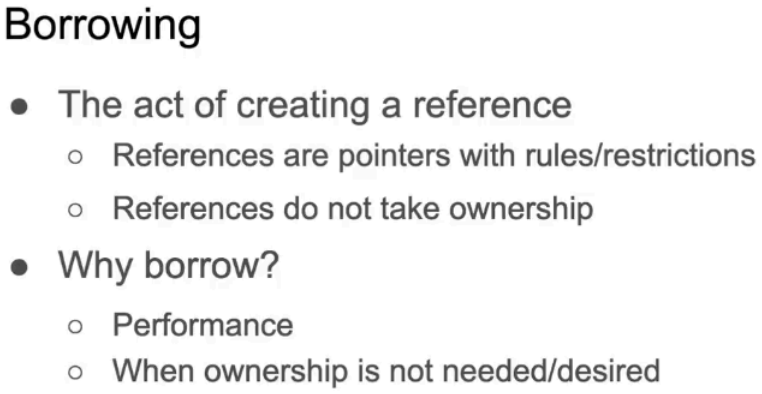
Cons



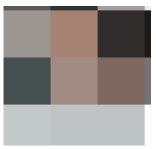
Tips

- primitives that are entirely stored on stack，即primitive 类型的变量赋值给其他变量 或传递到函数中不会发生move，而是clone
- 赋值发生move: 一个变量赋值给另一个会发生所有权转移
- 所有权转移到函数: 将变量传递到函数中同样会发生所有权转移
- 所有权转移出函数: 函数返回值情况， 如函数返回 String

Borrowing



Borrowing Rules



- Rules
  - At any given time, you can have either one mutable reference or any number of immutable references.
  - References must always be valid.
- Problems these rules solve
  - Data races
  - Dangling references