

Programovanie v operačných systémoch

03 - Resources

Jozef Šiška



Department of Applied Informatics
Comenius University in Bratislava

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Resource Management

Error handling

- ▶ acquire
 - ▶ allocate memory, open file, lock mutex
- ▶ release
 - ▶ release memory, close file, unlock mutex
- ▶ leaks (not releasing resources)
- ▶ ownership

Resource management in C, take 0

```
void do_something()
{
    int fd_in, fd_out;
    char *buffer;

    fd_in = open(...);
    fd_out = open(...);

    buffer == malloc(...);

    // do something

    free(buffer);
    close(fd_out);
    close(fd_int);
}
```

Resource management in C, take 1

```
int do_something()
{
    int fd_in, fd_out;
    char *buffer;

    if ((fd_in = open(.....)) == -1)
        return -1;
    if ((fd_out = open(...)) == -1)
        return -1; // !!!

    if ((buffer == malloc(...)) == NULL)
        return -1; // !!!

    // do something

    free(buffer);
    close(fd_out);
    close(fd_int);

    return 0;
}
```

Resource management in C, take 2

```
int do_something()
{
    int fd_in, fd_out;
    char *buffer;

    if ((fd_in = open(.....)) == -1)
        return -1;
    if ((fd_out = open(.....)) == -1)
        close(fd_in);
        return -1;

    if ((buffer == malloc(...)) == NULL)
        close(fd_out);
        close(fd_in);
        return -1;

    // more resources ?!

    free(buffer);
    close(fd_out);
    close(fd_in);

    return 0;
}
```

Resource management in C, take 3



```
int do_something()
{
    int fd_in, fd_out, ret = -1;;
    char *buffer;

    if ((fd_in = open(.....)) != 1) {
        if ((fd_out = open(....)) != -1) {
            if ((buffer == malloc(...)) != NULL) {
                // do something...
                // ret = 0;
                free(buffer);
            }
            close(fd_out);
        }
        close(fd_in);
    }

    return ret;
}
```

—> arrow functions

```
function register()
{
    if (!empty($_POST)) {
        $msg = '';
        if ($_POST['user_name']) {
            if ($_POST['user_password_new']) {
                if ($_POST['user_password_new'] === $_POST['user_password_repeat']) {
                    if (strlen($_POST['user_password_new']) > 5) {
                        if (strlen($_POST['user_name']) < 65 && strlen($_POST['user_name']) > 1) {
                            if (preg_match('/^[a-z\d]{2,64}$/i', $_POST['user_name'])) {
                                $user = read_user($_POST['user_name']);
                                if (!isset($user['user_name'])) {
                                    if ($_POST['user_email']) {
                                        if (strlen($_POST['user_email']) < 65) {
                                            if (filter_var($_POST['user_email'], FILTER_VALIDATE_EMAIL)) {
                                                create_user();
                                                $_SESSION['msg'] = 'You are now registered so please login';
                                                header('Location: ' . $_SERVER['PHP_SELF']);
                                                exit();
                                            } else $msg = 'You must provide a valid email address';
                                        } else $msg = 'Email must be less than 64 characters';
                                    } else $msg = 'Email cannot be empty';
                                } else $msg = 'Username already exists';
                            } else $msg = 'Username must be only a-z, A-Z, 0-9';
                        } else $msg = 'Username must be between 2 and 64 characters';
                    } else $msg = 'Password must be at least 6 characters';
                } else $msg = 'Passwords do not match';
            } else $msg = 'Empty Password';
        } else $msg = 'Empty Username';
        $_SESSION['msg'] = $msg;
    }
    return register_form();
}
```



<https://medium.com/@mena.meseha/how-to-refactor-the-arrow-type-code-8c40c21db85f>

Resource management in C, take 4

```
int do_something()
{
    int fd_in, fd_out, ret = -1;
    char *buffer;

    if ((fd_in = open(.....)) == -1)
        goto err_fd_in;
    if ((fd_out = open(.....)) == -1)
        goto err_fd_out;

    if ((buffer == malloc(...)) == NULL)
        goto err_buffer;

    // do something
    ret = -1;

    free(buffer);
err_fd_buffer:
    close(fd_out);
err_fd_out:
    close(fd_int);
err_fd_in:
    return ret;
}
```

Resource management in C++ (RAII)

```
int doSomething() // returns -1 or throws std::bad_alloc on errors
{
    ifstream inf(...);
    if (!inf.good()) return -1;

    ofstream outf(...);
    if (!outf.good()) return -1; // ifstream destructor releases resource

    Buffer buffer(...); // throws std::bad_alloc when a problem occurs

    // do something

    return 0;
}
```

So... how does this work?

Resource management in C++ (RAII)

```
int doSomething() // returns -1 or throws std::bad_alloc on errors
{
    ifstream inf(...);
    if (!inf.good()) return -1;

    ofstream outf(...);
    if (!outf.good()) return -1; // ifstream destructor releases resource

    Buffer buffer(...); // throws std::bad_alloc when a problem occurs

    // do something

    return 0;
}
```

So... how does this work?

- ▶ RAII – Resource acquisition is initialization (1984)
- ▶ CADRe – Constructor Acquires, Destructor Releases
- ▶ SBRM – Scope-based Resource Management
- ▶ Context managers in other languages

```
Buffer::Buffer(size_t size) { data = new char[size]; }  
Buffer::~~Buffer() { delete[] data; }
```

```
File::File(const char *name, int flags)  
{  
    fd = open(name, flags);  
    if (fd == -1) throw IOError("Error opening file");  
}  
File::~~File() { close(fd); }
```

```
Lock::Lock(Mutex *mutex) { mutex->lock(); }  
Lock::~~Lock() { mutex->unlock(); }
```

Resource management in C++ (RAII)

```
void doSomething() // throws something on errors
{
    File inf(...);
    File outf(...); // throws IOException when open fails?
    Buffer buffer(...);

    // do something
}
```

Resource management in C++ (RAII)

```
void doSomething() // throws something on errors
{
    File inf(...);
    File outf(...); // throws IOException when open fails?
    Buffer buffer(...);

    // do something
}
```

So, why are RAII + exceptions not used all the time...

- ▶ need to go all the way...
- ▶ ... so people consider C++ exceptions problematic
- ▶ interop with c / "bad" libraries (need to wrap everything etc)
- ▶ Note: RAII can be used also without exceptions (with a bit of checking for valid objects)

Exception guarantees

- ▶ none
- ▶ basic: when an exception is thrown (and possibly caught), no resources must be leaked!
- ▶ strong: transactional behaviour: either an operation completes successfully, or no side effects appear at all.
- ▶ nothrow

Other languages – Python

```
def doSomething():  
    try:  
        inFile = open(inFileName)  
        try:  
            outFile = open(outFileName)  
            process(inFile, outFile)  
        finally:  
            close(outFile)  
    finally:  
        close(inFile)
```

Actually wrong ;-)

Other languages – Python

```
def doSomething():  
    inFile = open(inFileName)  
    try:  
        outFile = open(outFileName)  
        try:  
            process(inFile, outFile)  
        finally:  
            close(outFile)  
    finally:  
        close(inFile)
```

Other languages – Python

```
def doSomething():
    inFile = open(inFileName)
    try:
        outFile = open(outFileName)
        try:
            process(inFile, outFile)
        finally:
            close(outFile)
    finally:
        close(inFile)
```

Python 2.5 - context managers

```
def doSomethin():
    with
        lock,
        open(inFileName) as inFile,
        open(outFileName) as outFile:
        return process(inFileName, outFileName)
```

Other languages – Java

```
int doSomething()
{
    FileInputStream inStream = new FileInputStream(inFileName);
    try {
        FileOutputStream outStream = new FileOutputStream(outFileName);
        try {
            process(inStream, outStream);
        } finally {
            outStream.close();
        }
    } finally {
        inStream.close();
    }
}
```

Other languages – Java

```
int doSomething()
{
    FileInputStream inStream = new FileInputStream(inFileName);
    try {
        FileOutputStream outStream = new FileOutputStream(outFileName);
        try {
            process(inStream, outStream);
        } finally {
            outStream.close();
        }
    } finally {
        inStream.close();
    }
}

int doSomething()
{
    try (
        FileInputStream inStream = new FileInputStream(inFileName);
        FileOutputStream outStream = new FileOutputStream(outFileName);
    ) {
        process(inStream, outStream);
    }
}
```

TODO rust, go

<https://doc.rust-lang.org/nomicon/obrm.html>