Swift Sync and Async Error Handling

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Agenda

- Traditional Asynchronous Code
- Problems with Traditional Error Handling
- `Result` vs `throws`
- Future
- Future.map
- Future.andThen
- Making `Result` and `throws` play together

Traditional asynchronous code

Traditional asynchronous code

```
struct User { let avatarURL: NSURL }
func requestUserInfo(userID: String, completion: (User?, NSError?) -> ())
func downloadImage(URL: NSURL, completion: (UIImage?, NSError?) -> ())

func loadAvatar(userID: String, completion: (UIImage?, NSError?) -> ()) {
    requestUserInfo(userID) { user, error in
        if let user = user {
            downloadImage(user.avatarURL) { avatar, error in
                if let avatar = avatar { completion(avatar, nil) }
                else { completion(nil, error!) }
            }
        } else { completion(nil, error!) }
    }
}
```

Traditional asynchronous code

```php
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();
}
```

Traditional asynchronous code

```
func downloadImage(URL: NSURL, completion: (UIImage?, NSError?) -> ())
```

(.Some, .None)

(.None, .Some)

(.Some, .Some)

(.None, .None)

(.Some, .Some)

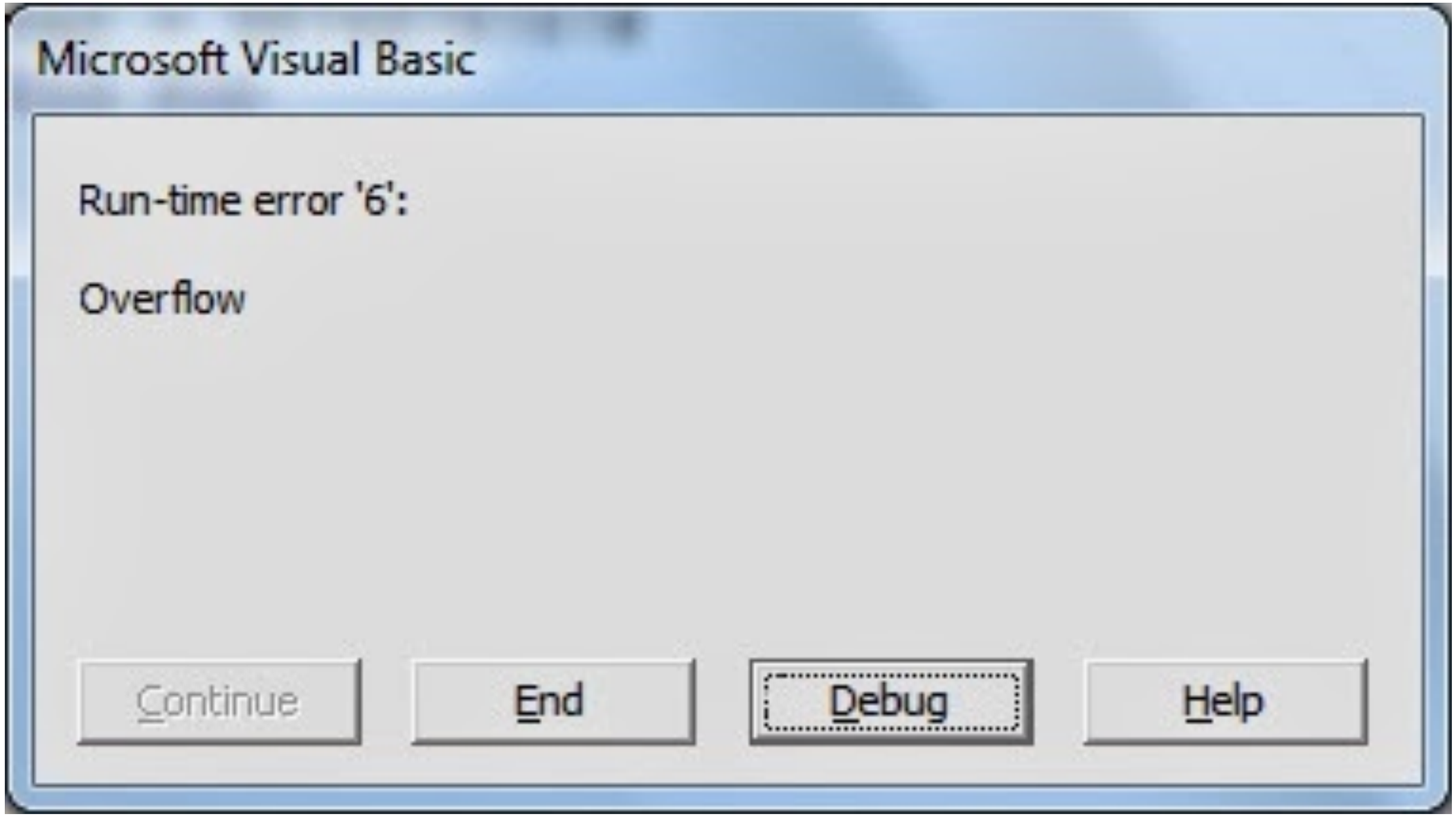
(.None, .None)

Error Handling

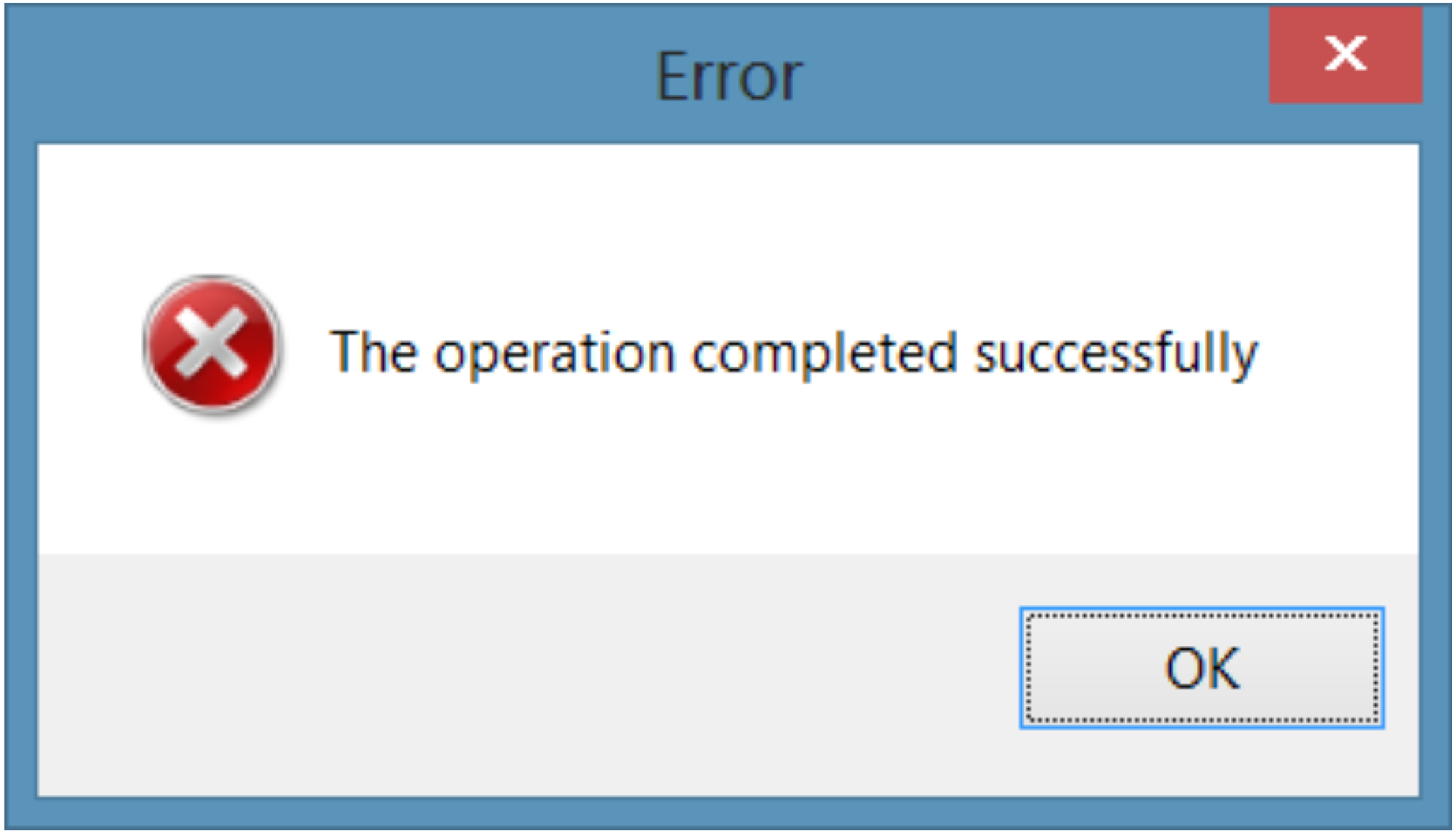
```
func downloadImage(URL: NSURL, completion: (UIImage?, NSError?) -> ())

downloadImage(url) { imageOrNil, errorOrNil in
    if error = errorOrNil {
        // What if image is also not nil??
    }
    else if image = imageOrNil {

    }
}
```

Error Handling

```
var error: NSError?
let string = NSString(contentsOfFile:path encoding:NSUTF8Encoding error:&error)

if string == nil {
    // Oops:
    if error.code == NSFileReadNoSuchFileError {
        // ...
    }
    else if ...
}
```


Microsoft Visual Basic
Run-time error '6':
Overflow
Continue
End
Debug
Help


Microsoft Money
An error has ocurred but the error message cannot be retrieved due to another error.
OK


Error
The operation completed successfully
OK

NSError Alternative

```
protocol ErrorType { }

enum UserInfoErrorDomain: ErrorType {
    case UserDoesNotExist
    case UserRequestFailure(reason: String)
    case NetworkRequestFailure(reason: String)
}

extension NSError: ErrorType { }
```

NSError Alternative

```
enum NoError: ErrorType { }

let error = NoError(?)
```

Result

```
enum Result<T, E: ErrorType> {
    case Success(T)
    case Failure(E)
}
```

`Result` by Rob Rix:

https://github.com/antitypical/Result

Swift's throws

Swift's throws

```
func readFile(path: String) throws -> NSData
```

Swift's throws

```
func readFile(path: String) throws -> NSData
// throws... what exactly?
```

Swift's throws

```
func readFile(path: String) throws -> NSData
```

Functionally equivalent to

```
func readFile(path: String) -> Result<NSData, ErrorType>
```

Swift's throws

```
func readFile(path: String) throws -> NSData

do {
  let contents = try readFile("path/to/my/file")
}
catch(SomeTypeOfError) {
  // How can I know which errors I should match..?
}
catch {
  // catch-all block.
}
```

Swift's throws

```
func readFile(path: String) -> Result<NSData, FoundationError>

let file = readFile("path/to/my/file")

switch file {
  case let .Succcess(value):
    // ...
  case let .Failure(error):
    // This `error` variable has type information!
}
```

Swift's throws

Hopefully in a future beta...

```
func readFile(path: String) throws FileIOError -> NSData
```

Error handling in Asynchronous APIs

Future<T, E>

Futures

- Encapsulate a deferred computation.
- Treat values that incur a delay to be retrieved as if they were regular values.
- Allow us to treat errors as first class citizens.
- Easily composable.

Future

```
struct Future<T, E: ErrorType> {
    typealias ResultType = Result<T, E>
    typealias Completion = ResultType -> ()
    typealias AsyncOperation = Completion -> ()

    private let operation: AsyncOperation
}
```

Future

```
struct Future<T, E: ErrorType> {
    init(operation: AsyncOperation) {
        self.operation = operation
    }

    func start(completion: Completion) {
        self.operation() { result in
            completion(result)
        }
    }
}
```

Future.map(): transforming the computed value

Future.map(): transforming the computed value

```
struct User { let avatarURL: NSURL }

func requestUserInfo(userID: String) -> Future<User, ErrorDomain>


func requestUserAvatarURL(userID: String) -> Future<NSURL, ErrorDomain> {
    return requestUserInfo(userID)
    .map { $0.avatarURL }
}
```

Future.map(): transforming the computed value

```
struct Future<T, E: ErrorType> {
    func map<U>(f: T -> U) -> Future<U, E>
}
```

map() in other types

```
struct Array<T> {
    func map<U>(f: T -> U) -> [U]
}

enum Optional<T> {
    func map<U>(f: T -> U) -> U?
}

struct Future<T, E: ErrorType> {
    func map<U>(f: T -> U) -> Future<U, E>
}
```

Future.map(): transforming the computed value

```
func map<U>(f: T -> U) -> Future<U, E> {
    // Return a new Future w/ a new operation...
    return Future<U, E>(operation: { completion in

    }
}
```

Future.map(): transforming the computed value

```
func map<U>(f: T -> U) -> Future<U, E> {
    return Future<U, E>(operation: { completion in
        // Retrieve the value from self...
        self.start { result in

        }
    }
}
```

Future.map(): transforming the computed value

```
func map<U>(f: T -> U) -> Future<U, E> {
    return Future<U, E>(operation: { completion in
        self.start { result in
            // Consider .Success and .Failure...
            switch result {

            }
        }
    })
}
```

Future.map(): transforming the computed value

```
case let .Success(value):
    // Call completion with the transformed value
    completion(Result.Success(f(value)))
```

Future.map(): transforming the computed value

```
case let .Failure(error):
    // We didn't get a value: no transformation
    completion(Result.Failure(error))
```

Future.map(): transforming the computed value

```
func map<U>(f: T -> U) -> Future<U, E> {
    return Future<U, E>(operation: { completion in
        self.start { result in
            switch result {
                case let .Success(value):
                    completion(Result.Success(f(value)))
                case let .Failure(error):
                    completion(Result.Failure(error))
            }
        }
    })
}
```

Future.andThen(): concatenating async work

Future.andThen(): concatenating async work

```
func requestUserAvatarURL(userID: String) -> Future<NSURL, ErrorDomain>

func downloadImage(URL: NSURL) -> Future<UIImage, ErrorDomain>


func downloadUserAvatar(userID: String) -> Future<UIImage, ErrorDomain> {
    return requestUserAvatarURL(userID)
    .andThen(downloadImage)
}
```

Future.andThen(): concatenating async work

```
struct Future<T, E: ErrorType> {
    func andThen<U>(f: T -> Future<U, E>) -> Future<U, E>
}
```

Future.andThen(): concatenating async work

```
func andThen<U>(f: T -> Future<U, E>) -> Future<U, E> {
    return Future<U, E>(operation: { completion in

    }
}
```

Future.andThen(): concatenating async work

```
func andThen<U>(f: T -> Future<U, E>) -> Future<U, E> {
    return Future<U, E>(operation: { completion in
        self.start { firstFutureResult in

        }
    }
}
```

Future.andThen(): concatenating async work

```
func andThen<U>(f: T -> Future<U, E>) -> Future<U, E> {
    return Future<U, E>(operation: { completion in
        self.start { firstFutureResult in
            switch firstFutureResult {
                case let .Success(value): // ...
                case let .Failure(error): // ...
            }
        }
    }
}
```

Future.andThen(): concatenating async work

```
case let .Success(value):
    let nextFuture = f(value)
```

Future.andThen(): concatenating async work

```
case let .Success(value):
    let nextFuture = f(value)

    nextFuture.start { finalResult in
        completion(finalResult)
    }
```

Future.andThen(): concatenating async work

```
case let .Failure(error):
    completion(Result.Failure(error))
```

Future.andThen(): concatenating async work

```
func andThen<U>(f: T -> Future<U, E>) -> Future<U, E> {
    return Future<U, E>(operation: { completion in
        self.start { firstFutureResult in
            switch firstFutureResult {
                case let .Success(value): f(value).start(completion)
                case let .Failure(error): completion(Result.Failure(error))
            }
        }
    })
}
```

We can go from this...

```
func loadAvatar(userID: String, completion: (UIImage?, NSError?) -> ()) {
    requestUserInfo(userID) { user, error in
        if let user = user {
            downloadImage(user.avatarURL) { avatar, error in
                if let avatar = avatar {
                    completion(avatar, nil)
                } else {
                    completion(nil, error)
                }
            }
        }
        else { completion(nil, error) }
    }
}
```

... To this

```
func requestUserInfo(userID: String) -> Future<User, UserInfoErrorDomain>

func downloadImage(URL: NSURL) -> Future<UIImage, UserInfoErrorDomain>


func loadAvatar(userID: String) -> Future<UIImage, UserInfoErrorDomain> {
    return requestUserInfo(userID)
    .map { $0.avatarURL }
    .andThen(downloadImage)
}
```

Mixing it all up

`Result<T, E>` and `throws`

Result<T, E> and throws

throws => Result

```
extension Result {
  public init(@autoclosure _ f: () throws -> T) {
        do {
            self = .Success(try f())
        } catch {
            self = .Failure(error as! Error)
        }
    }
}
```

Result<T, E> and throws

Result => throws

```
extension Result {
  public func dematerialize() throws -> T {
        switch self {
        case .Success(value):
            return value
        case let .Failure(error):
            throw error
        }
    }
}
```

Result<T, E> and throws

Future => throws

```
let avatarFuture = loadAvatar("4815162342")

avatarFuture.start { result in
  do {
    let avatar = result.materialize()
  }
  catch {
    // handle `error`
  }
}
```

Limitations of Futures

- Only represent computation to retrieve one value.
- Can't encapsulate streams of values.
- Only consumer (pull) driven, not producer (push) driven.

ReactiveCocoa

Signals > Futures

Follow-up Resources

- Playground: https://github.com/JaviSoto/Talks
- ReactiveCocoa: https://github.com/ReactiveCocoa/ReactiveCocoa
- Railway Oriented Programming: http://fsharpforfunandprofit.com/posts/recipe-part2/

Thanks!

Questions?