

COMPOSABLE ERROR HANDLING

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FUNCTIONAL ERROR HANDLING

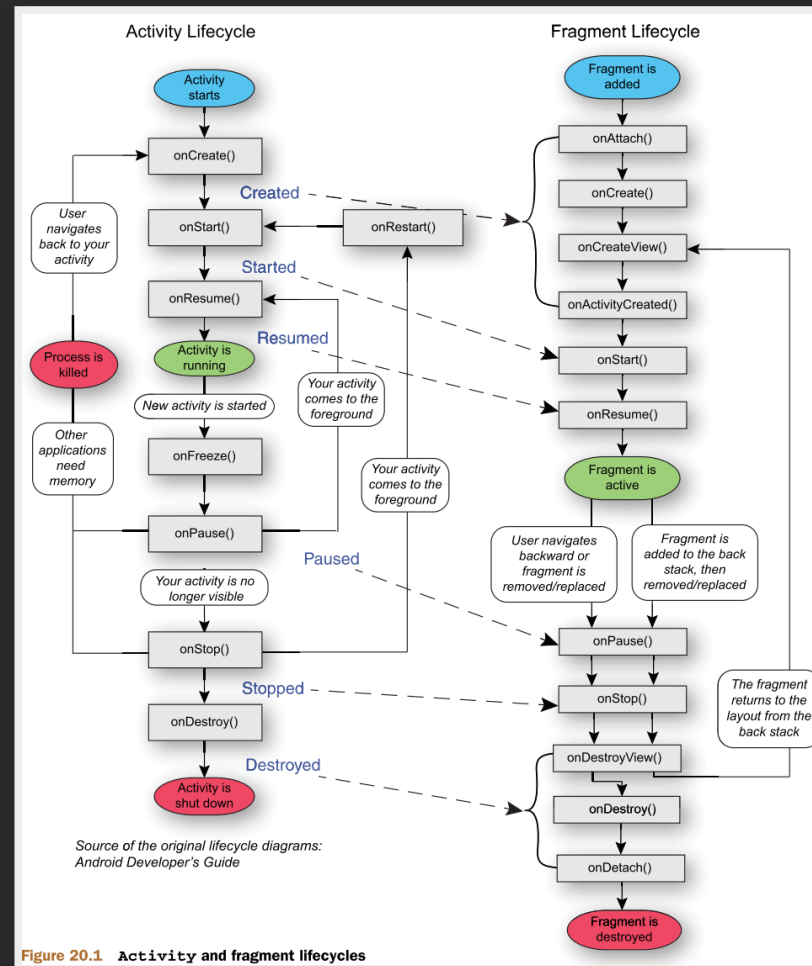
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SOLVING PROBLEMS

As developers we solve complex problems.

ANDROID ACTIVITY LIFECYCLE



SOLVING COMPLEX PROBLEMS

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- Split problem into smaller problems

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- Split problem into smaller problems
- Write code solving the small problems

SOLVING COMPLEX PROBLEMS

- Split problem into smaller problems
- Write code solving the small problems
- Combine the solutions of the small problems

DATA VALIDATION

The problem of user sign up with data:

- Email
- First Name
- Last Name
- Date of Birth

VALIDATION RULES

- Email must contain @
- First Name and Last Name can't be blank. Max length 50 (DB limit).
- Date of Birth must be formatted as YYYY-MM-DD

THE DTO

```
data class UserDto(  
    val email: String?,  
    val firstName: String?,  
    val lastName: String?,  
    val dateOfBirth: String?  
)
```

THE DTO

```
data class UserDto(  
    val email: String?,  
    val firstName: String?,  
    val lastName: String?,  
    val dateOfBirth: String?  
)
```

Postel's law: Be conservative in what you do, be liberal in what you accept from others.

THE DOMAIN

THE DOMAIN

```
data class Email(val email: String) { companion object }
```

THE DOMAIN

```
data class Email(val email: String) { companion object }
```

```
data class String50(val value: String) { companion object }
```

THE DOMAIN

```
data class Email(val email: String) { companion object }
```

```
data class String50(val value: String) { companion object }
```

```
import java.time.LocalDate
```

```
data class User(  
    val email: Email,  
    val firstName: String50,  
    val lastName: String50,  
    val dateOfBirth: LocalDate  
) { companion object }
```


VALIDATING EMAIL

Email must contain @

```
fun validateEmail(email: String?): Boolean =  
    email != null && email.contains('@')
```

VALIDATING FIRST/LAST NAME

First Name and Last Name can't be blank. Max length 50 (DB limit).

```
fun validateName(name: String?): Boolean =  
    !name.isNullOrEmpty() && name.length < 50
```

VALIDATING DOB

Date of Birth must be formatted as YYYY-MM-DD

```
import java.time.LocalDate
import java.time.format.DateTimeParseException

fun validateDateOfBirth(dob: String?): Boolean =
    try {
        LocalDate.parse(dob)
        true
    } catch (e: DateTimeParseException) {
        false
    }
```

VALIDATING USER

```
import java.time.LocalDate
import java.time.format.DateTimeParseException

fun validateUser(
    email: String?,
    firstName: String?,
    lastName: String?,
    dob: String?
): Boolean = validateEmail(email)
    && validateName(firstName)
    && validateName(lastName)
    && validateDateOfBirth(dob)
```

USAGE (A) -> BOOLEAN

```
validateUser("stojan", null, "", "August")  
// false
```

USAGE (A) -> BOOLEAN

```
validateUser("stojan", null, "", "August")  
// false
```

BOOLEANS

- Composes well
- Bad error messages

Boolean -> True | False

EXCEPTIONS

EXCEPTIONS

```
fun validateEmailBool(email: String?): Boolean {  
    require(email != null && email.contains('@'))  
    { "Email must contain @, found: '$email'" }  
    return true  
}
```

IllegalArgumentException if the predicate is false

RETURN VALUE IS ALWAYS TRUE

```
fun validateEmailUnit(email: String?): Unit =  
    require(email != null && email.contains('@'))  
    { "Email must contain @, found: '$email'" }  
  
fun validateNameUnit(name: String?): Unit =  
    require(!name.isNullOrBlank() && name.length < 50)  
    { "Name must be between 1 and 50 chars, found: '$name'" }  
  
fun validateDateOfBirthUnit(dob: String?): Unit {  
    LocalDate.parse(dob)  
}
```

COMPOSING

```
fun validateUserUnit(  
    email: String?,  
    firstName: String?,  
    lastName: String?,  
    dob: String?  
) : Unit {  
    validateEmailUnit(email)  
    validateNameUnit(firstName)  
    validateNameUnit(lastName)  
    validateDateOfBirthUnit(dob)  
}
```

USAGE (A) -> UNIT + EXCEPTION

```
validateUserUnit("stolea@gmail.com", "Stojan", "An", "1995-10-10")
```

USAGE (A) -> UNIT + EXCEPTION

```
validateUserUnit("stolea@gmail.com", "Stojan", "An", "1995-10-10")
```

```
val result = try {  
    validateUserUnit("stojan", null, "", "August")  
    "Valid"  
} catch (e: Exception) {  
    e.message!!  
}  
result  
// Email must contain @, found: 'stojan'
```

We only get the first error!

ACCUMULATE ERRORS

```
fun validateUserAccumulateErrors (
    email: String?,
    firstName: String?,
    lastName: String?,
    dob: String?
): Unit {
    val errors = mutableListOf<String>()

    try {
        validateEmailUnit(email)
    } catch (e: IllegalArgumentException) {
        errors.add(e.message!!)
    }

    // TODO: firstName, lastName, dob
```

Glue code to the MAX!

PROBLEMS WITH EXCEPTIONS

- Boilerplate code
- Throwing Exceptions is expensive on JVM
- Does not fit on a slide

ERRORS AS VALUES

```
typealias ErrorMsg = String
```


ERRORS AS VALUES

```
typealias ErrorMsg = String
```

```
fun validateEmail(email: String?): ErrorMsg? =  
    if (email != null && email.contains('@')) null  
    else "Email must contain @, found: '$email'"
```

ERRORS AS VALUES

```
typealias ErrorMsg = String
```

```
fun validateEmail(email: String?): ErrorMsg? =  
    if (email != null && email.contains('@')) null  
    else "Email must contain @, found: '$email'"
```

```
fun validateName(name: String?): ErrorMsg? =  
    if (!name.isNullOrEmpty() && name.length < 50) null  
    else "Name must be between 1 and 50 chars, found: '$name'"
```

```
fun validateDateOfBirth(dob: String?): ErrorMsg? = TODO()
```

COMPOSING VALUES

```
fun validateUser(  
    email: String?,  
    firstName: String?,  
    lastName: String?,  
    dob: String?  
) : ErrorMsg? {  
    val errorMsg = listOfNotNull(  
        validateEmail(email),  
        validateName(firstName),  
        validateName(lastName),  
        validateDateOfBirth(dob)  
    ).joinToString()  
    return if (errorMsg.isEmpty()) null else errorMsg  
}
```

ERRORMSG

- Composable
- Good error messages
- Developer friendly ?

ERROR PRONE

```
val email: String? = "stolea@gmail.com"  
val emailErr: ErrorMsg? = validateEmail(email)  
if (emailErr == null) {  
    Email(email!!) // <-- Error prone  
}
```

validateEmail already does a null check

SMART CAST

```
fun foo(): String {  
    val result: String? = something()  
  
    if (result  $\neq$  null) {  
        return result  
    }  
}
```

CAN WE DO BETTER

VALRES

```
sealed class ValRes<out E, out A> {  
    data class Valid<A>(val a: A) : ValRes<Nothing, A>()  
    data class Invalid<E>(val e: E) : ValRes<E, Nothing>()  
}
```


VALRES

```
sealed class ValRes<out E, out A> {  
    data class Valid<A>(val a: A) : ValRes<Nothing, A>()  
    data class Invalid<E>(val e: E) : ValRes<E, Nothing>()  
}
```

```
fun <A> valid(a: A): ValRes<Nothing, A> = ValRes.Valid(a)
```

```
fun <E> invalid(e: E): ValRes<E, Nothing> = ValRes.Invalid(e)
```

VALRES IN THE SMALL

```
fun validateEmail(email: String?): ValRes<String, Email> =  
    if (email != null && email.contains('@')) valid(Email(email))  
    else invalid("Email must contain @, found: '$email'")
```

VALRES IN THE SMALL

```
fun validateEmail(email: String?): ValRes<String, Email> =  
    if (email != null && email.contains('@')) valid(Email(email))  
    else invalid("Email must contain @, found: '$email'")
```

```
fun validateName(name: String?): ValRes<String, String50> =  
    if (!name.isNullOrBlank() && name.length < 50) valid(String50  
    else invalid("Name must be between 1 and 50 chars, found: '$n
```

VALRES IN THE SMALL

```
fun validateEmail(email: String?): ValRes<String, Email> =  
    if (email != null && email.contains('@')) valid(Email(email))  
    else invalid("Email must contain @, found: '$email'")
```

```
fun validateName(name: String?): ValRes<String, String50> =  
    if (!name.isNullOrBlank() && name.length < 50) valid(String50  
    else invalid("Name must be between 1 and 50 chars, found: '$n
```

```
fun validateDateOfBirth(dob: String?): ValRes<String, LocalDate>
```

COMBINING VALRES

```
typealias Valid<A> = ValRes.Valid<A>
typealias Invalid<E> = ValRes.Invalid<E>

fun <E, A, B> tupled(
    combine: (E, E) -> E,
    a: ValRes<E, A>,
    b: ValRes<E, B>
): ValRes<E, Pair<A, B>> =
    if (a is Valid && b is Valid) valid(Pair(a.a, b.a))
    else if (a is Invalid && b is Invalid) invalid(combine(a.e, b.e))
    else if (a is Invalid) invalid(a.e)
    else if (b is Invalid) invalid(b.e)
    else throw IllegalStateException("This is impossible")
```

USAGE

```
validateEmail("stolea@gmail.com")  
// Valid(a=Email(email=stolea@gmail.com))
```

USAGE

```
validateEmail("stolea@gmail.com")  
// Valid(a=Email(email=stolea@gmail.com))
```

```
validateEmail("email")  
// Invalid(e=Email must contain @, found: 'email')
```

USAGE

```
validateEmail("stolea@gmail.com")  
// Valid(a=Email(email=stolea@gmail.com))
```

```
validateEmail("email")  
// Invalid(e=Email must contain @, found: 'email')
```

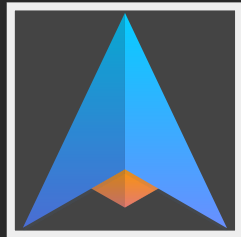
```
tupled(  
  {e1, e2 -> "$e1, $e2"},  
  validateEmail("stojan"),      //invalid  
  validateName(null)           //invalid  
)  
// Invalid(e=Email must contain @, found: 'stojan', Name must be )
```



```
data class Triple<A, B, C>(val a: A, val b: B, val c: C)
```

```
fun <E, A, B, C> tupled(  
    combine: (E, E) -> E,  
    a: ValRes<E, A>,  
    b: ValRes<E, B>,  
    c: ValRes<E, C>  
) : ValRes<E, Triple<A, B, C>> = TODO()
```

ARROW-KT



Functional companion to Kotlin's Standard Library

arrow-kt.io

VALIDATED

```
sealed class Validated<out E, out A> {  
    data class Valid<out A>(val a: A) : Validated<Nothing, A>()  
    data class Invalid<out E>(val e: E) : Validated<E, Nothing>()  
}
```

VALIDATED

```
sealed class Validated<out E, out A> {  
    data class Valid<out A>(val a: A) : Validated<Nothing, A>()  
    data class Invalid<out E>(val e: E) : Validated<E, Nothing>()  
}
```

```
import arrow.core.*
```

```
typealias ValidatedNel<E, A> = Validated<Nel<E>, A>
```

VALIDATIONRESULT

```
typealias ValidationResult<A> = ValidatedNel<String, A>
```

VALIDATIONRESULT

```
typealias ValidationResult<A> = ValidatedNel<String, A>
```

```
fun Email.Companion.create(email: String?): ValidationResult<Email> {  
    if (email != null && email.contains('@')) Email(email).valid()  
    else "Email must contain @, found: '$email'".invalidNel()  
}
```

VALIDATING IN THE SMALL

```
fun String50.Companion.create(name: String?): ValidationResult<St  
    if (!name.isNullOrEmpty() && name.length < 50) String50(name)  
    else "Name must be between 1 and 50 chars, found: '$name'".in
```

VALIDATING IN THE SMALL

```
fun String50.Companion.create(name: String?): ValidationResult<String50> {
    if (!name.isNullOrEmpty() && name.length < 50) String50(name)
    else "Name must be between 1 and 50 chars, found: '$name'".invalid()
}
```

```
fun validateDateOfBirth(dob: String?): ValidationResult<LocalDate> {
    try {
        LocalDate.parse(dob).valid()
    } catch (e: DateTimeParseException) {
        "Date of Birth must be a valid date, found: '$dob'".invalid()
    }
}
```



```
import arrow.core.extensions.nonemptylist.semigroup.semigroup
import arrow.core.extensions.validated.applicative.applicative

fun validateNameAndEmail (
    email: String?,
    firstName: String?
): ValidationResult<Tuple2<Email, String50>> =
    ValidationResult.applicative (Nel.semigroup<String>())
        .tupled(
            Email.create(email),           // ValidationResult<Email>
            String50.create(firstName)    // ValidationResult<String>
        ).fix()
```

APPLICATIVE

Combine values from multiple independent computations that can potentially fail.

`tupled 2-X arguments returns Tuple2-TupleX`

SEMIGROUP

A semigroup for some given type A has a single operation (which we will call `combine`), which takes two values of type A , and returns a value of type A . This operation must be guaranteed to be associative.

```
interface Semigroup<A> {  
    fun combine(a: A, b: A): A  
}
```

VALIDATING NAME AND EMAIL

```
validateNameAndEmail("stolea@gmail.com", "Stojan")  
// Valid(a=Tuple2(a=Email(email=stolea@gmail.com), b=String50(val
```

VALIDATING NAME AND EMAIL

```
validateNameAndEmail("stolea@gmail.com", "Stojan")  
// Valid(a=Tuple2(a=Email(email=stolea@gmail.com), b=String50(val
```

```
validateNameAndEmail("Not an email", "    ")  
// Invalid(e=NonEmptyList(all=[Email must contain @, found: 'Not
```

```
import arrow.core.extensions.nonemptylist.semigroup.semigroup
import arrow.core.extensions.validated.applicative.applicative

fun User.Companion.create(
    email: String?,
    firstName: String?,
    lastName: String?,
    dob: String?
): ValidationResult<User> =
    ValidationResult.applicative(Nel.semigroup<String>())
        .tupled(
            Email.create(email),
            String50.create(firstName),
            String50.create(lastName),
            validateDateOfBirth(dob)
```

CREATE USER (VALID)

```
User.create(  
  email = "stolea@gmail.com",  
  firstName = "Stojan",  
  lastName = "Anastasov",  
  dob = "1991-10-10"  
)  
// Valid(a=User(email=Email(email=stolea@gmail.com), firstName=St
```

CREATE USER (INVALID)

```
User.create(  
    email = "",  
    firstName = " ",  
    lastName = "a",  
    dob = "10.10.1992"  
)  
// Invalid(e=NonEmptyList(all=[Date of Birth must be a valid date
```


EXTRACTING THE VALUE

```
val user = User.create(  
    email = "stolea@gmail.com",  
    firstName = "Stojan",  
    lastName = "Anastasov",  
    dob = "1991-10-10"  
)  
  
user.fold(  
    { e: Nel<String> -> TODO() },  
    { validUser: User -> validUser }  
)  
// User(email=Email(email=stolea@gmail.com), firstName=String50(v
```

BENEFITS OF VALIDATION RESULT

- It composes well
- Good error messages
- Developer friendly
- Composition functions are written and tested

LEARN MORE

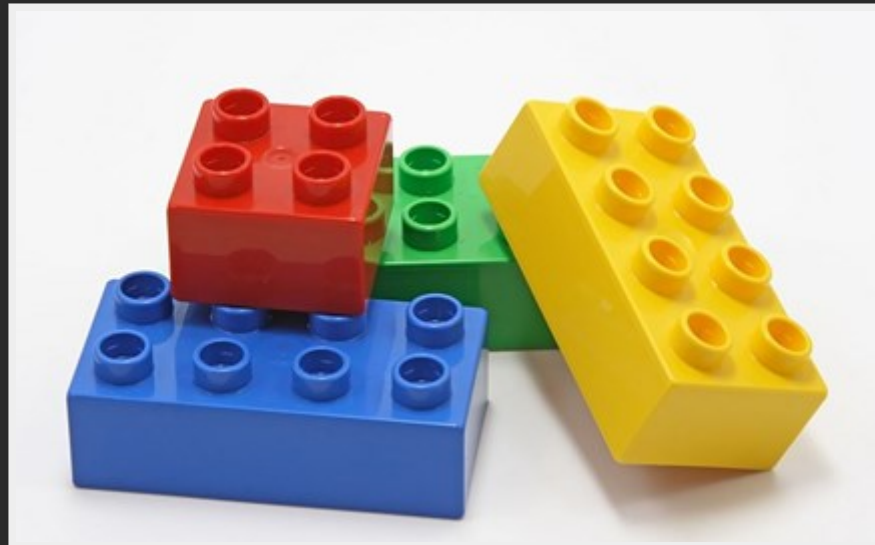
arrow-kt.io

Patterns -> Error Handling

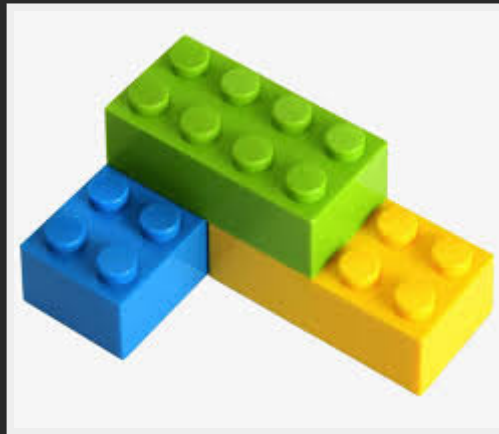
COMPOSITION

How do things compose

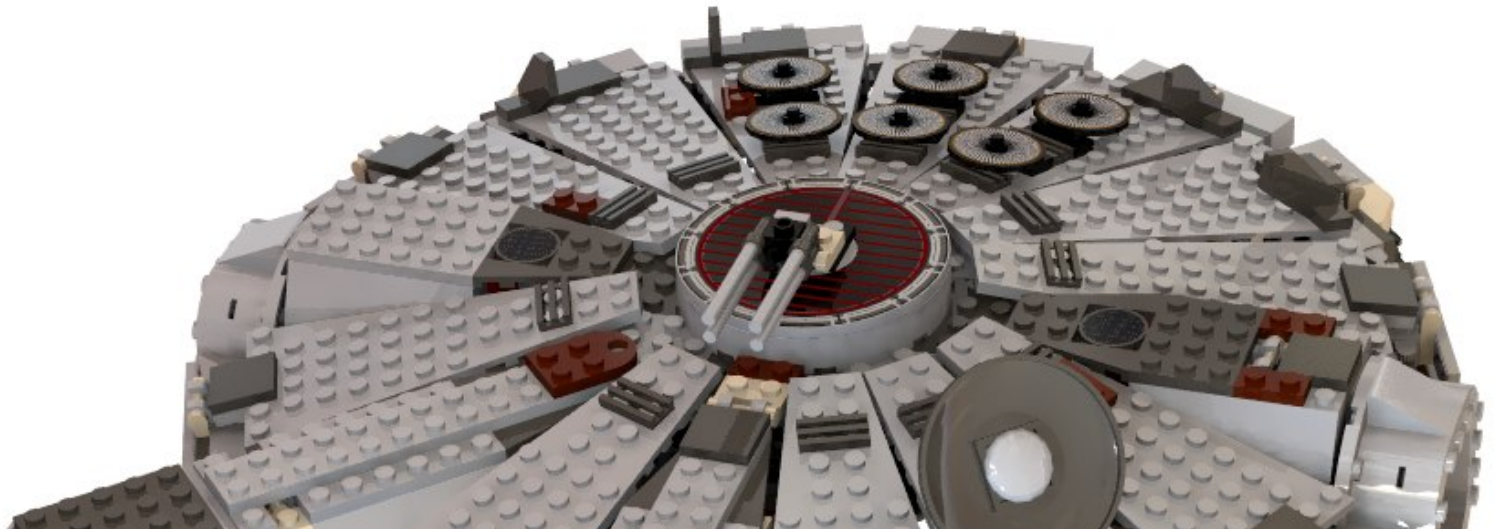
LEGO BLOCK



LEGO COMBINED



LEGO FALCON



COMBINING FUNCTIONS

```
// (String?) -> ValidationResult<Email>  
fun validateEmail(email: String?): ValidationResult<Email> = TODO
```


COMBINING FUNCTIONS

```
// (String?) -> ValidationResult<Email>  
fun validateEmail(email: String?): ValidationResult<Email> = TODO
```

```
// (String?, String?, String?, String?) -> ValidationResult<User>  
fun validateUser(  
    email: String?,  
    firstName: String?,  
    lastName: String?,  
    dob: String?): ValidationResult<User> = TODO()
```

SUMMARY

We can validate data using different technics

- (A) -> Boolean

SUMMARY

We can validate data using different technics

- (A) -> Boolean
- (A) -> Unit + Exceptions

SUMMARY

We can validate data using different technics

- (A) -> Boolean
- (A) -> Unit + Exceptions
- (A) -> ErrorMsg?

SUMMARY

We can validate data using different technics

- (A) -> Boolean
- (A) -> Unit + Exceptions
- (A) -> ErrorMsg?
- (A) -> ValRes

SUMMARY

We can validate data using different technics

- (A) -> Boolean
- (A) -> Unit + Exceptions
- (A) -> ErrorMsg?
- (A) -> ValRes
- (A) -> Validated (arrow-kt)

THANK YOU

QUESTIONS