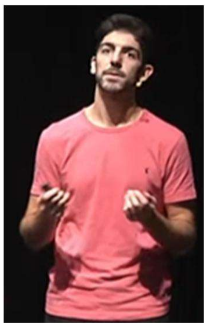
Exception Handling

https://medium.com/androiddevelopers/exceptions-in-coroutines-ce8da1ec060c



Cancellation and Exception Handling

- **Cancellation** is important for avoiding doing more work than needed which can waste memory and battery life.
- **Proper exception handling** is *key to a great user experience*.

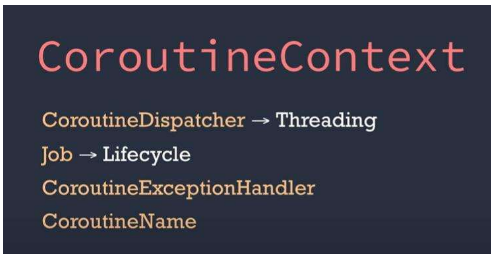
Exception Handling

- Exception and error handling is an integral part of asynchronous programming.
- It's important to know *how errors and exceptions are **propagated*** through the process.

(Review) CoroutineContext

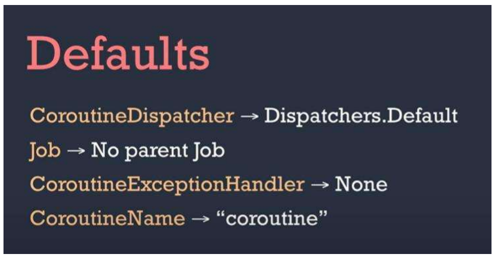
The `CoroutineContext` is a set of elements that define the behavior of a coroutine:

- `Job` — controls the lifecycle of the coroutine.
- `CoroutineDispatcher` — dispatches work to the appropriate thread.
- `CoroutineName` — name of the coroutine, useful for debugging.
- `CoroutineExceptionHandler` — handles uncaught exceptions.



CoroutineContext

CoroutineDispatcher → Threading
Job → Lifecycle
CoroutineExceptionHandler
CoroutineName



Defaults

CoroutineDispatcher → Dispatchers.Default
Job → No parent Job
CoroutineExceptionHandler → None
CoroutineName → "coroutine"

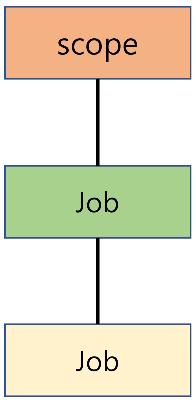
(Review)
What's the CoroutineContext of a new coroutine?

- A ***new instance*** of `Job` will be created, allowing us to control its lifecycle.
- The rest of the elements will be *inherited* from the parent's `CoroutineContext`

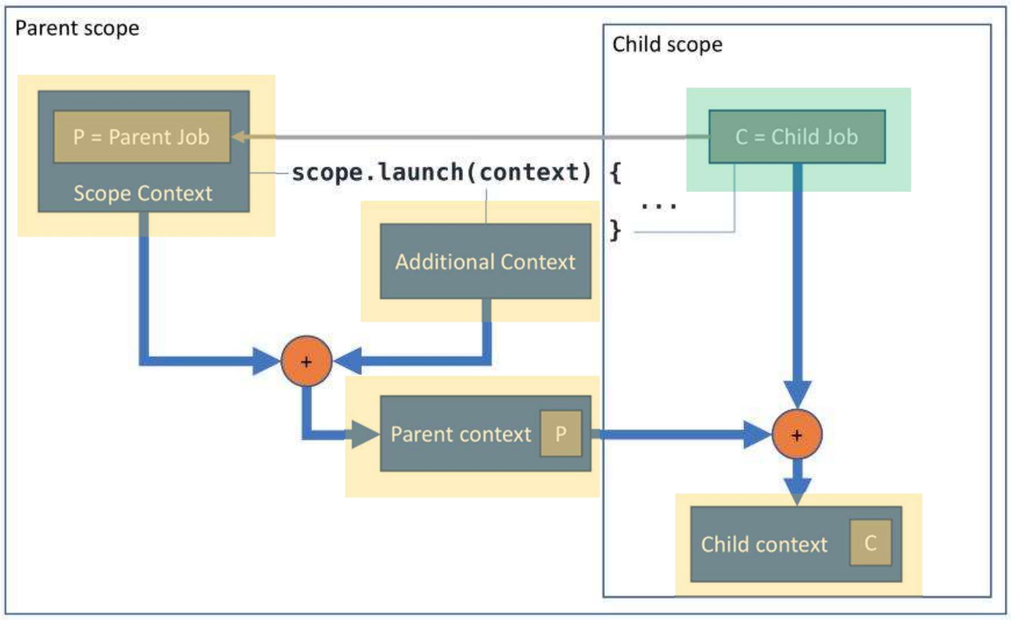
(Review) Task Hierarchy

- Since a `CoroutineScope` can create coroutines and you can create more coroutines inside a coroutine, an implicit task hierarchy is created.

```
val scope = CoroutineScope(Job() + Dispatchers.Main)
val job = scope.launch {
    // New coroutine with CoroutineScope as a parent
    val result = async {
        // New coroutine that has the coroutine
        // started by launch as a parent
    }.await()
}
```

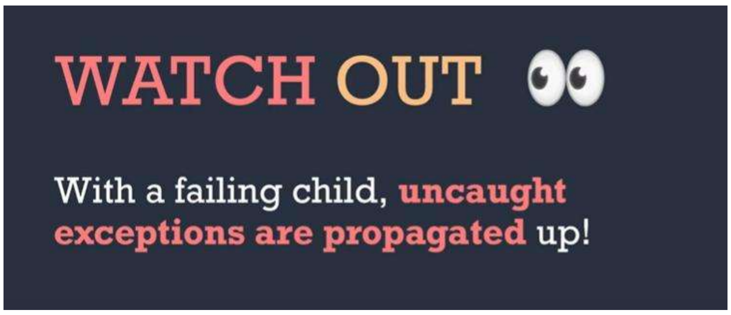


(Review) Parent Scope vs Child Scope



Exception Propagation

- An **uncaught exception**, instead of being re-thrown, is *"**propagated up the job hierarchy**"*.

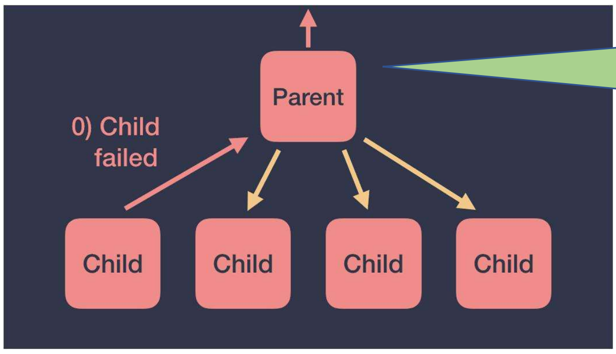


WATCH OUT 👀

With a failing child, **uncaught exceptions are propagated** up!

Exception Propagation

- This exception propagation *leads to the failure of the parent Job and the cancellation of all the Jobs of its children*.
- The exception will reach the root of the hierarchy and all the coroutines that the `CoroutineScope` started will get cancelled too (***default behavior***).



Here, the parent is another coroutine.

*Step 3) is different if parent is either a scope or subscope**

Exception Re-throwing vs. Propagation

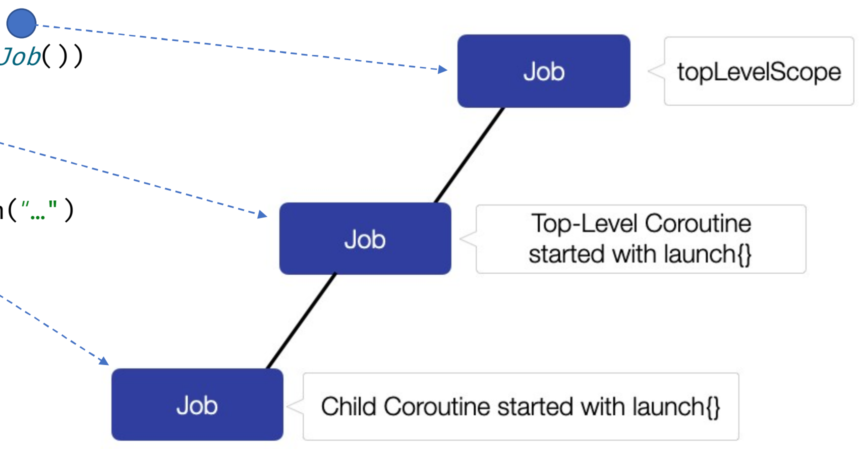
- In Kotlin, functions by default **re-throw** all the exceptions that were not caught inside them.
- Therefore, the exception from the `failingMethod` can be caught in the parent `try–catch` block.

```
fun someMethod() {
    try {
        val failingData = failingMethod()
    } catch (e: Exception) {
        // handle exception
    }
}

fun failingMethod() { throw RuntimeException() }
```

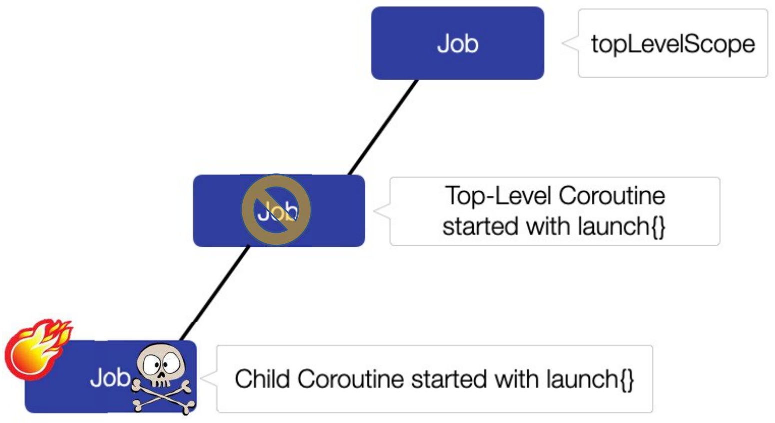
Coroutines Parent-Child Relationship

```
fun main() {
  val scope = CoroutineScope(Job())
  scope.launch {
    try {
      launch {
        throw RuntimeException("…")
      }
    } catch (ex: Exception) {
      // do something …
    }
  }
  Thread.sleep(100)
}
```


Job
topLevelScope
Job
Top-Level Coroutine started with launch{}
Job
Child Coroutine started with launch{}

Exception Propagation up to …

```
fun main() {
  val scope = CoroutineScope(Job())
  scope.launch {
    try {
      launch {
        throw RuntimeException("…")
      }
    } catch (ex: Exception) {
      // do something …
    }
  }
  Thread.sleep(100)
}
```


Job
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Job
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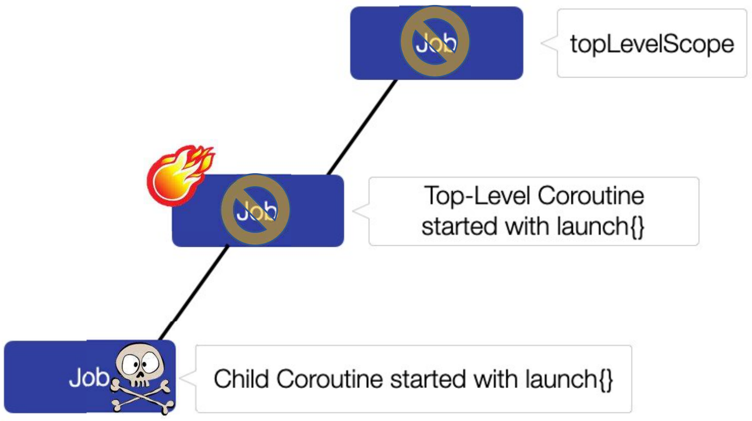
Job
Child Coroutine started with launch{}

Exception Propagation up to …

```
fun main() {
  val scope = CoroutineScope(Job())
  scope.launch {
    try {
      launch {
        throw RuntimeException("…")
      }
    } catch (ex: Exception) {
      // do something …
    }
  }
  Thread.sleep(100)
}
```


Job
topLevelScope
Job
Top-Level Coroutine started with launch{}
Job
Child Coroutine started with launch{}

Exception Re-Thrown vs. Propagation

```
fun main() {
  try {
    failingMethod()
  } catch (ex: Exception) {
    println("Caught: $ex")
  }
}
```

Caught: java.lang.RuntimeException: oops

```
fun main() = runBlocking<Unit> {
  try {
    launch {
      failingMethod()
    }
  } catch (ex: Exception) {
    println("Caught: $ex")
  }            Useless!
}
```

```
Exception in thread "main" java.lang.RuntimeException: oops
  at com.org.androidtestingkt.coroutines. …
```

Exception Propagation: If Root is not a Scope

```
@Test(expected = RuntimeException::class)
fun `Uncaught exceptions propagate`() = runBlocking {
    val job = launch {
        println("1. Exception thrown inside launch")
        throw RuntimeException()
    }
    println("2. Wait for child to finish")
    job.join()
    println("3. Joined failed job: Unreachable code")
}
```

```
2. Wait for child to finish
1. Exception thrown inside launch
```

Exception Propagation: If Root is a Scope

```
@Test
fun `Uncaught exceptions propagate`() = runBlocking {
    val scope = CoroutineScope(Job())
    val job = scope.launch {
        println("1. Exception thrown inside launch")
        // handled by Thread.defaultUncaughtExceptionHandler
        throw RuntimeException()
    }
    println("2. Wait for child to finish")
    job.join()
    println("3. Joined failed job: Now reachable code")
}
```

```
2. Wait for child to finish
1. Exception thrown inside launch
Exception in thread "DefaultDispatcher-worker-1 …
…
3. Joined failed job: Now reachable code
```

Failures in a Scope

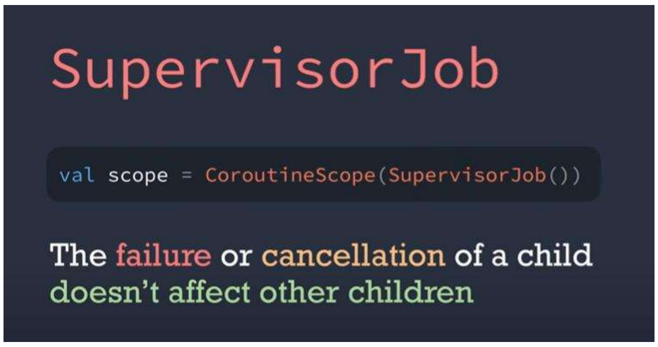
```
child1: java.lang.RuntimeException: oops
child2: kotlinx.coroutines.JobCancellationException: ...
isCancelled = true
```

- The failure of a child cancels the parent and child's other siblings.

```kotlin
val parentJob = launch {
  launch {
    throw RuntimeException("oops")
  }.invokeOnCompletion { ex -> println("child1: $ex") }

  launch {
    delay(100)
  }.invokeOnCompletion { ex -> println("child2: $ex") }
}.apply {
  invokeOnCompletion { println("isCancelled = ${parentJob.isCancelled}") }
}

parentJob.join()
```

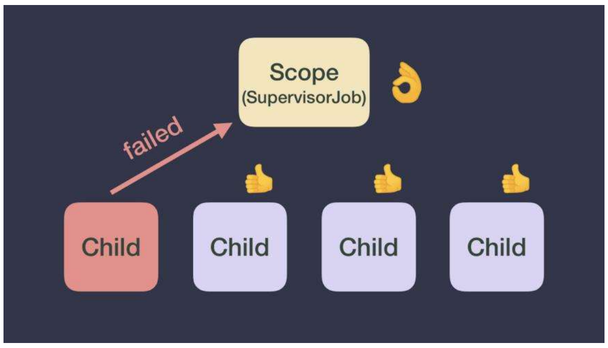
SupervisorJob to the rescue

- *A SupervisorJob won't cancel itself nor the rest of its children*


SupervisorJob

```kotlin
val scope = CoroutineScope(SupervisorJob())
```

The failure or cancellation of a child doesn't affect other children

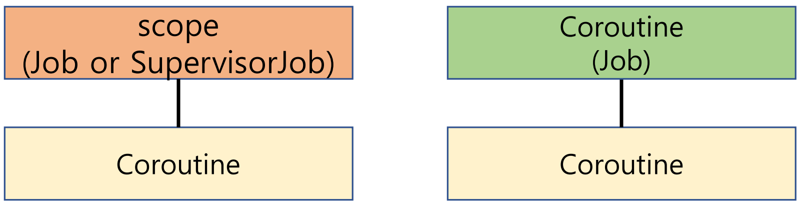


Review of SupervisorJob

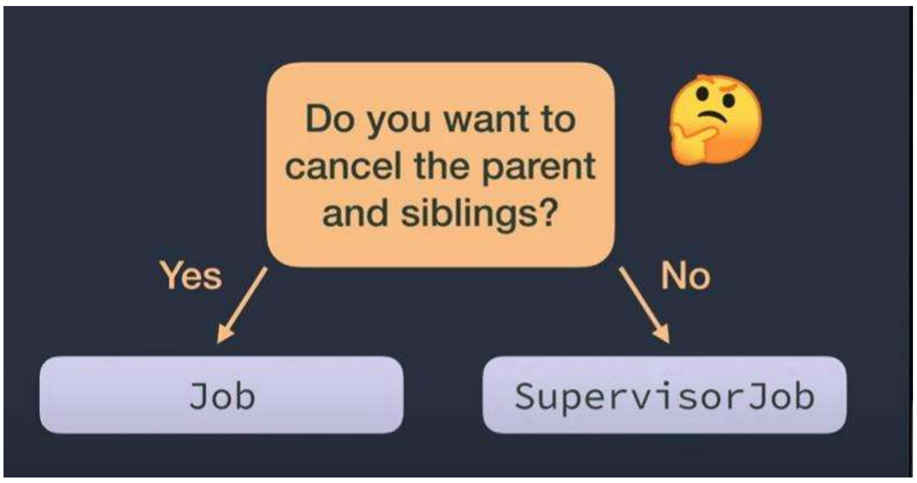
- A `CoroutineScope` can have a `SupervisorJob` that changes how the `CoroutineScope` deals with exceptions.

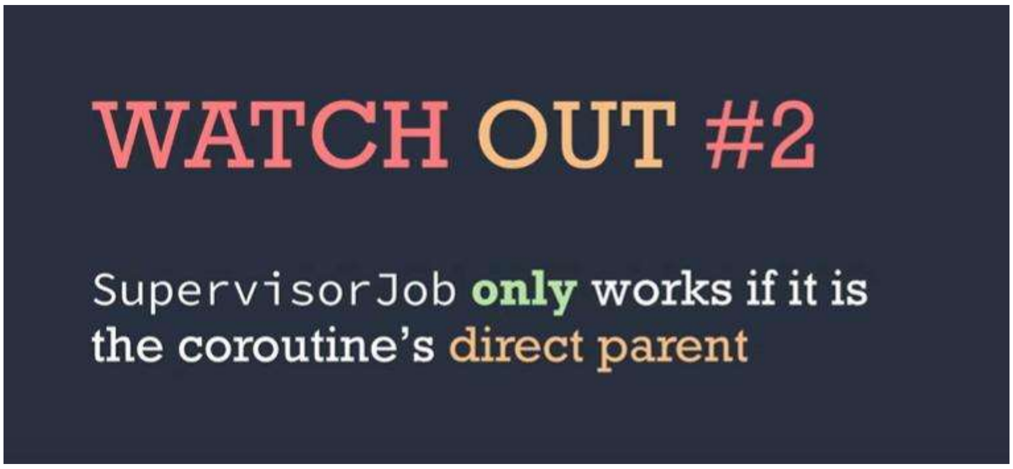
```
val scope = CoroutineScope(SupervisorJob())
```

- However, when the **parent of a coroutine is another coroutine**, the parent `Job` will **always** be of type `Job`.



What to choose?

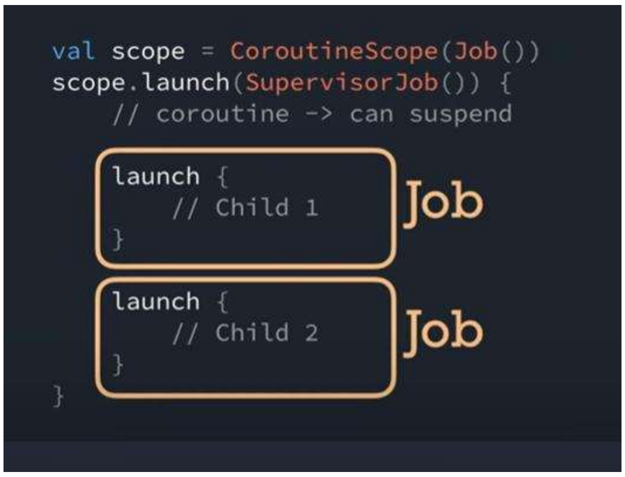



WATCH OUT #2

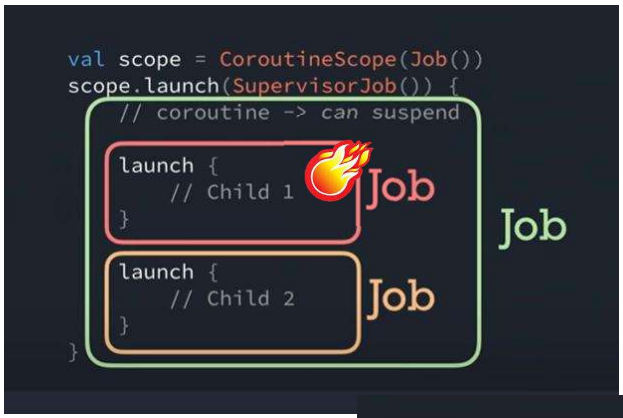
SupervisorJob **only** works if it is the coroutine's direct parent

Watch out quiz! Who's my parent? 🎯

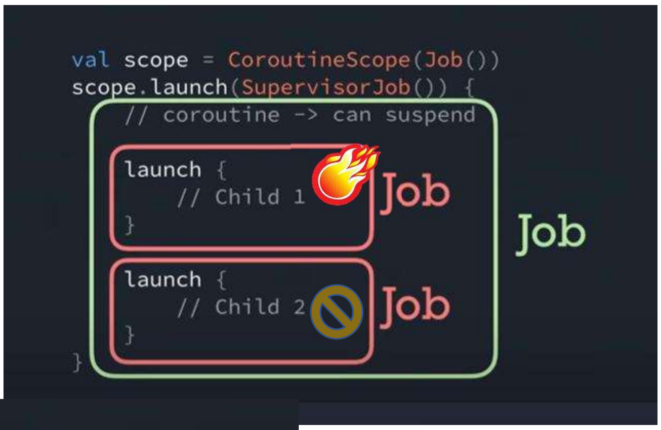
- Given the following snippet of code, can you identify what kind of `Job` "child 1" has as a parent?



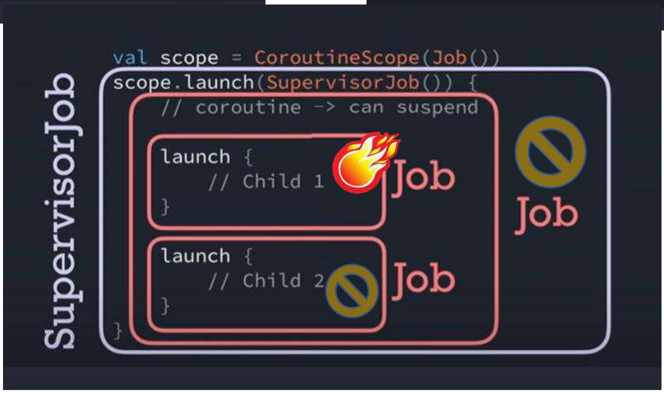
```
val scope = CoroutineScope(Job())
scope.launch(SupervisorJob()) {
    // coroutine -> can suspend
    launch {
        // Child 1
    }
    launch {
        // Child 2
    }
}
```



```
val scope = CoroutineScope(Job())
scope.launch(SupervisorJob()) {
    // coroutine -> can suspend
    launch {
        // Child 1
    }
    launch {
        // Child 2
    }
}
```



```
val scope = CoroutineScope(Job())
scope.launch(SupervisorJob()) {
    // coroutine -> can suspend
    launch {
        // Child 1
    }
    launch {
        // Child 2
    }
}
```



```
val scope = CoroutineScope(Job())
scope.launch(SupervisorJob()) {
    // coroutine -> can suspend
    launch {
        // Child 1
    }
    launch {
        // Child 2
    }
}
```

SupervisorJob protects a failed child's siblings only if it is a failed coroutine's direct parent

- Coroutines that are created as a direct child of either `supervisorScope` or `CoroutineScope(SupervisorJob())` work as expected.
- Passing a `SupervisorJob` as a parameter of a coroutine builder *may* **<u>not</u>** have your desired effect.

Somewhat misleading statement … I think

Remember that a `SupervisorJob` only works when it's part of a scope.

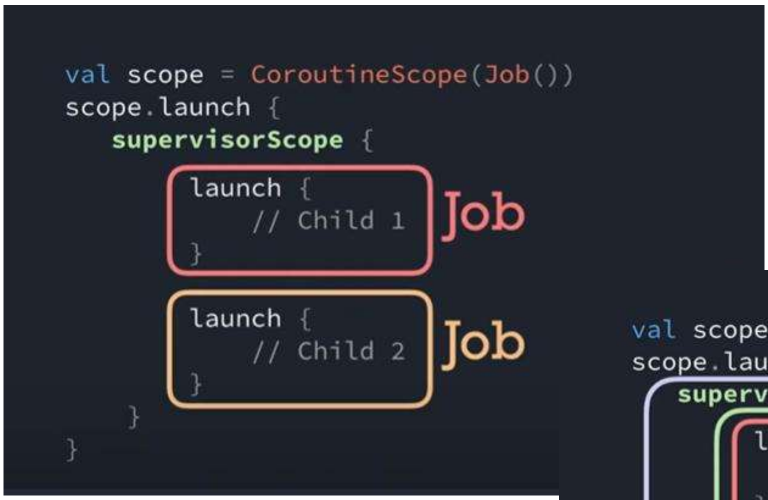
Exception handling Behavior of `SupervisorJob` and top-level Scopes

If any child throws an exception, that `SupervisorJob` won’t either propagate up in the hierarchy or rethrow the exception.

Instead, it delegates the exception to `CoroutineExceptionHandler`, if exists, or `Thread.uncaughtExceptionHandler`.

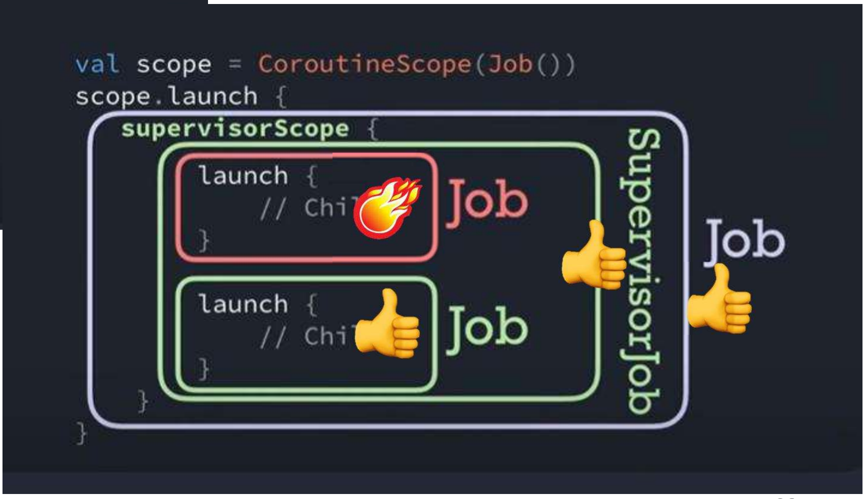
Note also that calling CEH is also true for any top-level scope with any kind of jobs .

> **Note**: Uncaught exceptions will get passed to the thread’s default thread’s exception handler. On JVM it will be just logged to the console, while in Android it will crash the application.

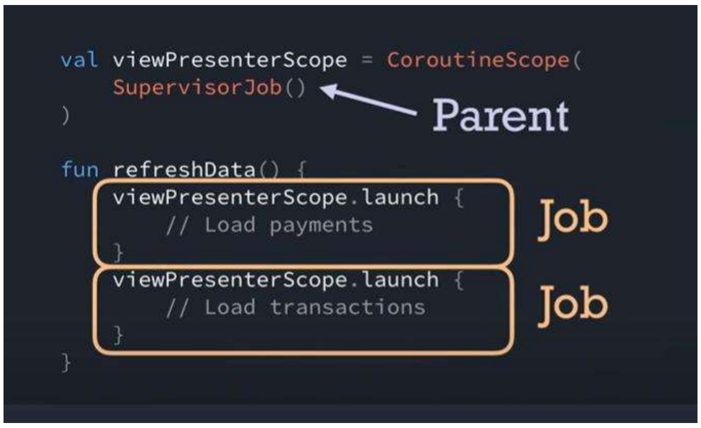


```
val scope = CoroutineScope(Job())
scope.launch {
    supervisorScope {
        launch {
            // Child 1
        }
        launch {
            // Child 2
        }
    }
}
```

Coroutines are created as a direct child of `supervisorScope`

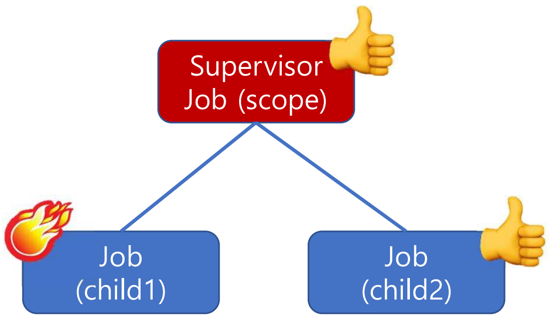


```
val scope = CoroutineScope(Job())
scope.launch {
    supervisorScope {
        launch {
            // Chi
        }
        launch {
            // Chi
        }
    }
}
```

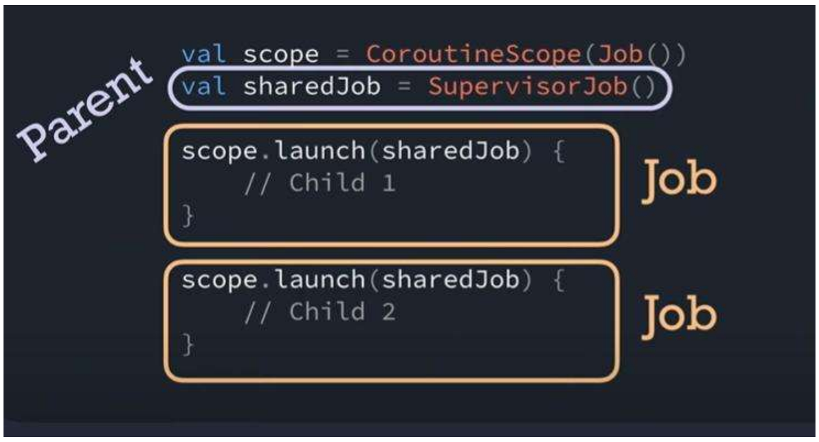


```
val viewPresenterScope = CoroutineScope(
    SupervisorJob()
)

fun refreshData() {
    viewPresenterScope.launch {
        // Load payments
    }
    viewPresenterScope.launch {
        // Load transactions
    }
}
```

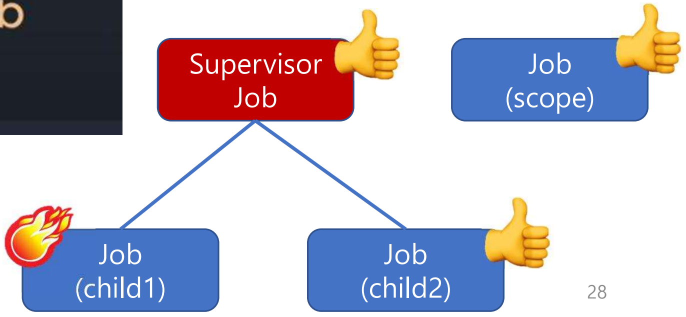
Coroutines are created as a direct child of `CoroutineScope(SupervisorJob())`



Coroutines are created and adopted by `SupervisorJob()`

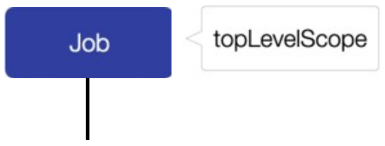


```
val scope = CoroutineScope(Job())
val sharedJob = SupervisorJob()

scope.launch(sharedJob) {
    // Child 1
}

scope.launch(sharedJob) {
    // Child 2
}
```



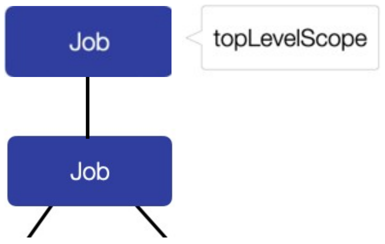
Exception Handling properties of supervisorScope

```
val scope = CoroutineScope(Job())
```



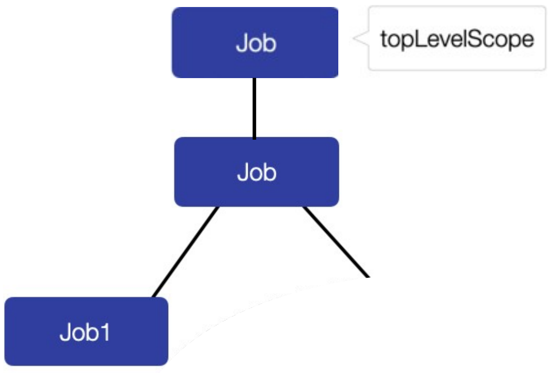
Exception Handling properties of supervisorScope

```
val scope = CoroutineScope(Job())
scope.launch {









}
```



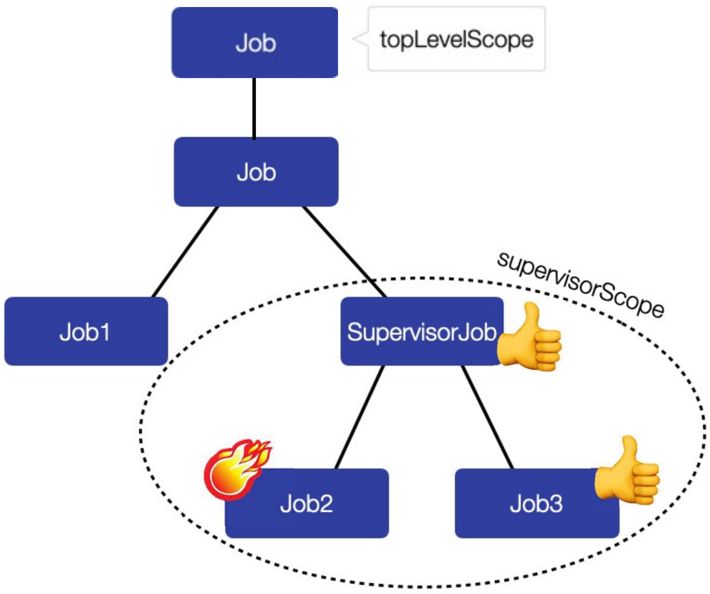
Exception Handling properties of supervisorScope

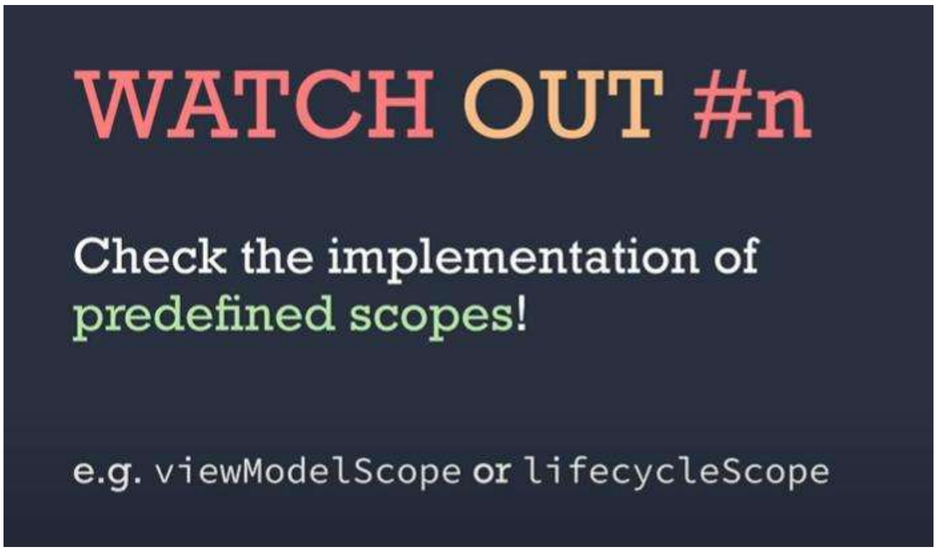
```
val scope = CoroutineScope(Job())
scope.launch {
  val job1 = launch {
    println("starting Coroutine 1")
  }









}
```



Exception Handling properties of supervisorScope

```
val scope = CoroutineScope(Job())
scope.launch {
  val job1 = launch {
    println("starting Coroutine 1")
  }
  supervisorScope {
    val job2 = launch~~(ehandler)~~ {
      throw RuntimeException("oops")
    }
    val job3 = launch {
      println("starting Coroutine 3")
    }
  }
}
```





WATCH OUT #n

Check the implementation of predefined scopes!

e.g. `viewModelScope` or `lifecycleScope`

Dealing with Exceptions

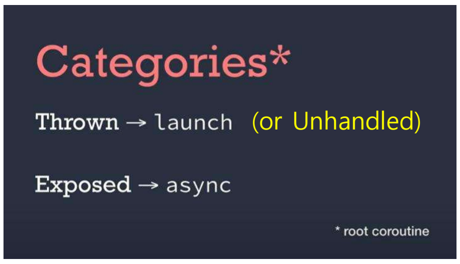
✋ Exceptions

1. try/catch
2. runCatching
3. CoroutineExceptionHandler

- `try`/`catch`
- `runCatching` (which uses try/catch internally)
- `CoroutineExceptionHandler`

Recall that uncaught exceptions will always be propagated by default.
However, different coroutines builders treat exceptions in different ways.

Uncaught Exceptions



Categories*

Thrown → `launch` (or Unhandled)

Exposed → `async`

* root coroutine

Coroutine Builder: launch Behavior

- With `launch`, ***exceptions will be thrown as soon as they happen***. Therefore, you can wrap the code that can throw exceptions inside a `try`/`catch`, like in this example:

inside launch

```
launch {
    try {
        println("1. Exception thrown inside launch")
        throw RuntimeException()
    } catch (ex: Exception) {
        println("Exception ${ex.javaClass.simpleName} caught ...")
    }
}
```

Coroutine Builder: async Behavior

Root coroutines:

Coroutines that are a direct child of a

`coroutineScope` or `supervisorScope`

coroutineScope

Coroutine Builder: async Behavior

- **Root coroutines**: coroutines that are a direct child of a `CoroutineScope` or `supervisorScope`
- When `async` is used as a root coroutine, *exceptions are not thrown automatically, instead, they're thrown when you call `.await()`*.
- To handle exceptions thrown in `async` whenever it's a root coroutine, you can wrap the `.await()` call inside a `try`/`catch`:

```
supervisorScope {
    val deferred = async {
        throw codeThatMayThrowsException()
    }
    try {
        deferred.await()
    } catch (e: Exception) {
        println("Caught ${e.javaClass.simpleName}")
    }
}
```

Watch out!

- Notice that we're using a `supervisorScope` to call `async` and `await`.
- But, a `coroutineScope` automatically rethrows the exception so the catch block ~~won't be called~~: => *will be called, but still exception propagates*

```
coroutineScope {
   try {
      val deferred = async {
         codeThatCanThrowExceptions()
      }
      deferred.await()
   } catch(e: Exception) {
      // Exception thrown in async WILL NOT be caught here
       // but still will be rethrown by the coroutineScope
   }
 }
```

Furthermore, exceptions that happen in coroutines created by other coroutines will always be propagated regardless of the coroutine builder.

```
val scope = CoroutineScope(Job())

scope.launch {
    val deferred = async {
        // If async throws, launch throws
        throw RuntimeException()
    }
}
```

⚠ Exceptions thrown in a coroutineScope builder or in coroutines created by other coroutines won't be caught in a try/catch! `async`: caught but still propagates!

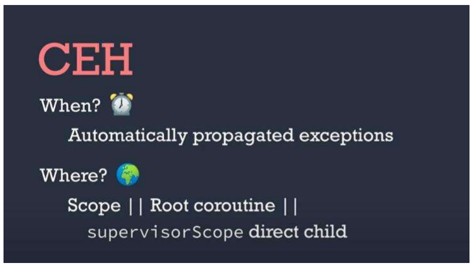
CoroutineExceptionHandler

- The `CoroutineExceptionHandler` is an optional element of a `CoroutineContext` allowing you to handle uncaught exceptions.

```
val handler = CoroutineExceptionHandler {
        context, exception -> println("Caught $exception")
}
```

Exceptions will be caught by the CEH if these requirements are met:

- **When** ⏰: Automatically propagated exceptions
- **Where** 🌍: If handler is in the `CoroutineContext` of a `CoroutineScope` or a root coroutine (direct child of `CoroutineScope` or a `supervisorScope`).

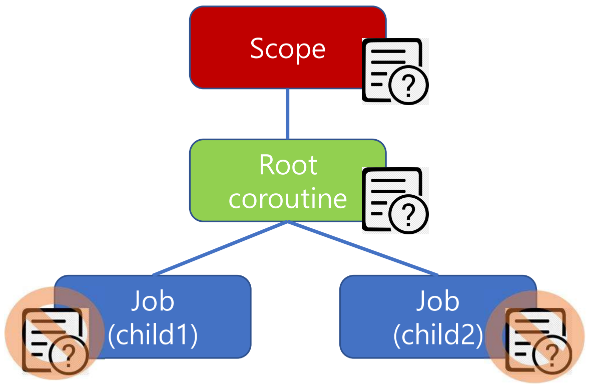

CEH

When? ⏰

Automatically propagated exceptions

Where? 🌍

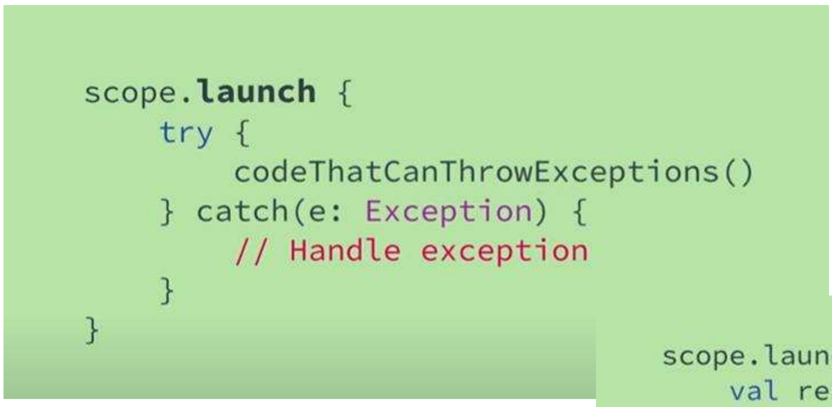
Scope || Root coroutine || `supervisorScope` direct child



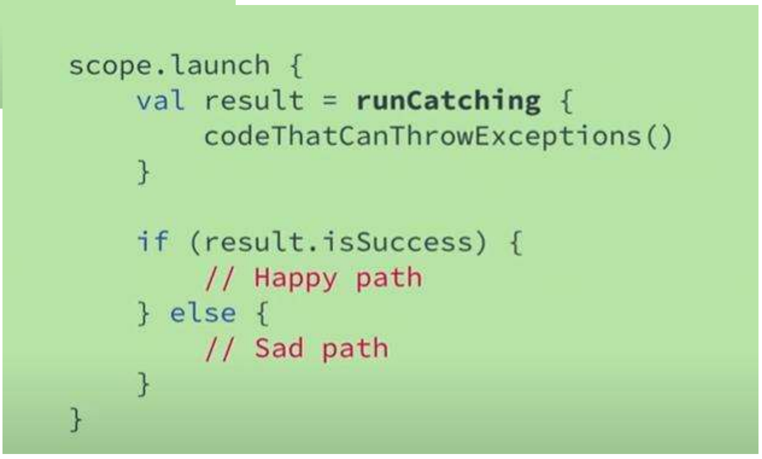
```
val
scope=CoroutineScope(Job() + handler)

scope.launch {
     launch {
          throw Exception("failed")
     }

}
```

```
val
scope = CoroutineScope(Job())

scope.launch(handler) {
     launch {
          throw Exception("failed")
     }

}
```

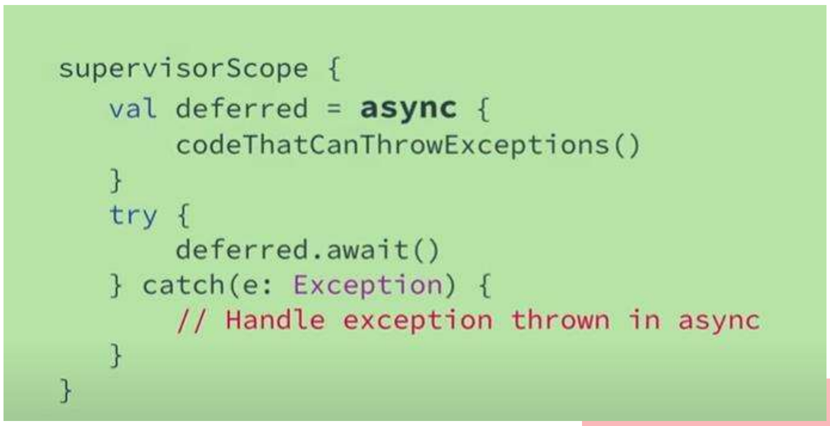
```
supervisorScope {
     launch(handler) {
          throw Exception("failed")
     }

}
```



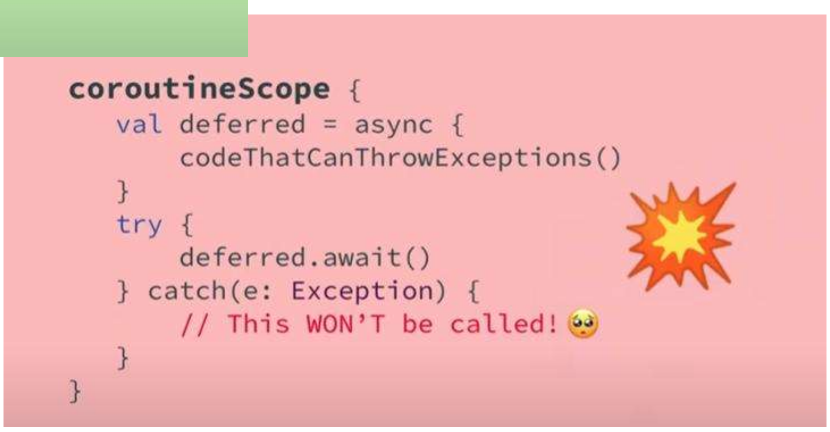
```
scope.launch {
    try {
        codeThatCanThrowExceptions()
    } catch(e: Exception) {
        // Handle exception
    }
}
```



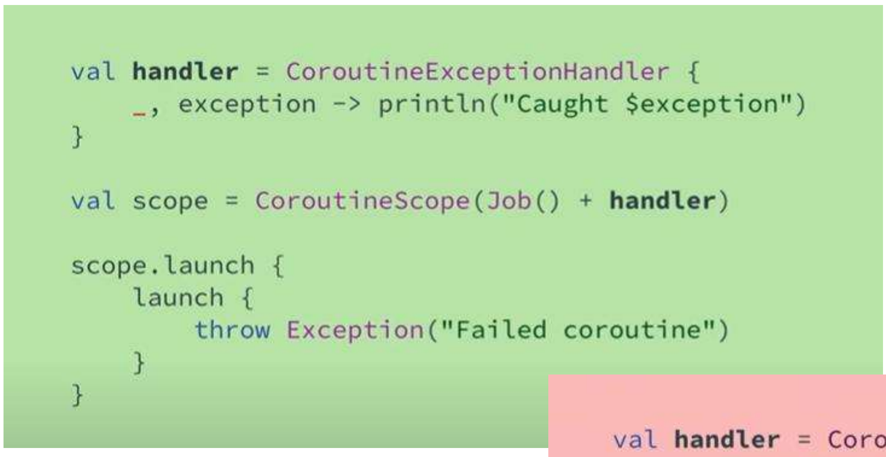
```
scope.launch {
    val result = runCatching {
        codeThatCanThrowExceptions()
    }

    if (result.isSuccess) {
        // Happy path
    } else {
        // Sad path
    }
}
```



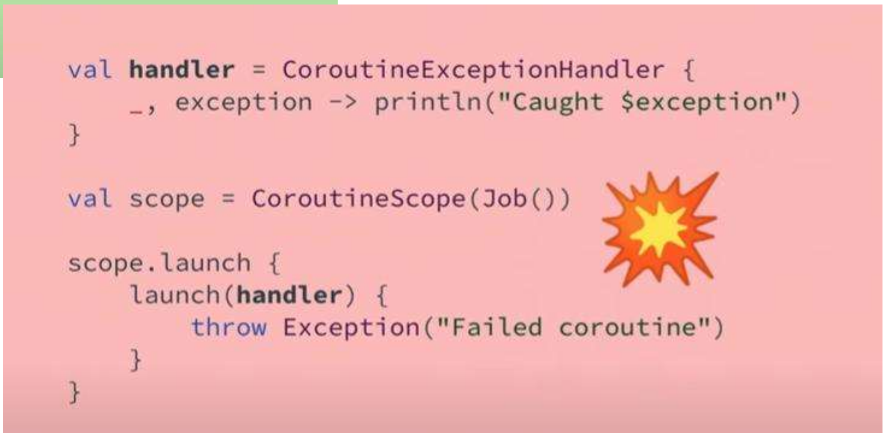
```
supervisorScope {
    val deferred = async {
        codeThatCanThrowExceptions()
    }
    try {
        deferred.await()
    } catch(e: Exception) {
        // Handle exception thrown in async
    }
}
```



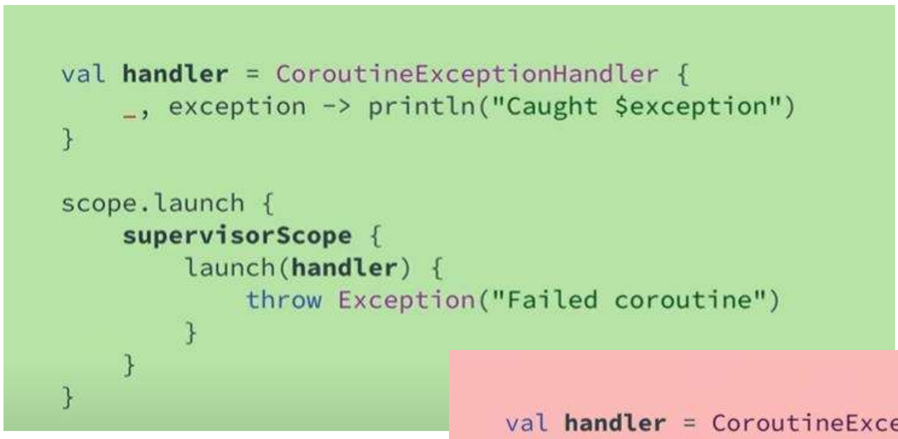
```
coroutineScope {
    val deferred = async {
        codeThatCanThrowExceptions()
    }
    try {
        deferred.await()
    } catch(e: Exception) {
        // This WON'T be called! 🥺
    }
}
```



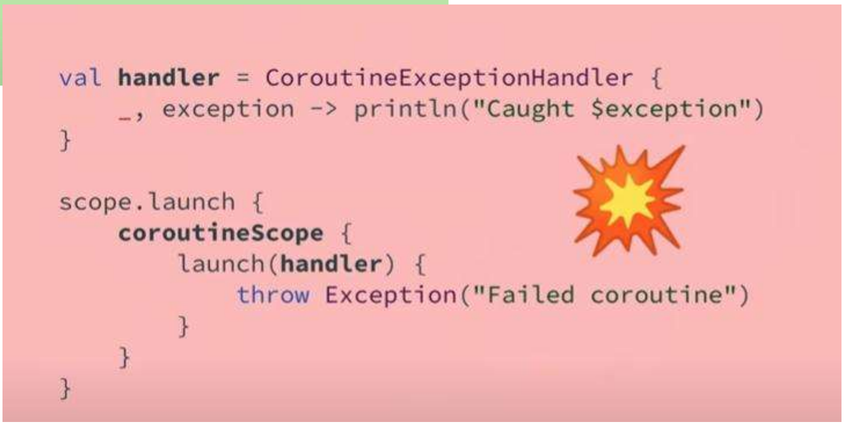
```kotlin
val handler = CoroutineExceptionHandler {
    _, exception -> println("Caught $exception")
}

val scope = CoroutineScope(Job() + handler)

scope.launch {
    launch {
        throw Exception("Failed coroutine")
    }
}
```



```kotlin
val handler = CoroutineExceptionHandler {
    _, exception -> println("Caught $exception")
}

val scope = CoroutineScope(Job())

scope.launch {
    launch(handler) {
        throw Exception("Failed coroutine")
    }
}
```



```kotlin
val handler = CoroutineExceptionHandler {
    _, exception -> println("Caught $exception")
}

scope.launch {
    supervisorScope {
        launch(handler) {
            throw Exception("Failed coroutine")
        }
    }
}
```



```kotlin
val handler = CoroutineExceptionHandler {
    _, exception -> println("Caught $exception")
}

scope.launch {
    coroutineScope {
        launch(handler) {
            throw Exception("Failed coroutine")
        }
    }
}
```

Coroutine builders

coroutineScope

- It **inherits the caller's** CoroutineContext and supports Structured Concurrency.
- It **cancels** all other children if one of them fails.
- Call CEH if exists. Otherwise, **re-throws** them instead of propagating exceptions

supervisorScope

- It **inherits the caller's** CoroutineContext and supports Structured Concurrency.
- It does **not cancel** itself and all other children if one of them fails.
- Call CEH if exists. Otherwise, It propagate exceptions from its children, which eventually fails.
- However, it rethrows its own exception and cancellation.

Summary

- Dealing with exceptions gracefully in your application is important to have a good user experience, even when things don't go as expected.
- Remember to use `SupervisorJob` when you want to avoid propagating cancellation when an exception happens, and `Job` otherwise.
- Uncaught exceptions will be propagated, catch them to provide a great UX!