Lecture #7
Reactive Programming

Mobile Applications 2019-2020

Why Reactive?

- Unless you can model your entire system synchronously ...

Why Reactive?

- Unless you can model your entire system synchronously, a single asynchronous source breaks imperative programming.

Why Reactive?

```
interface UserManager {
    fun getUser(): User
}
```

Why Reactive?

```
interface UserManager {
    fun getUser(): User
    fun setName(name: String)
    fun setAge(age: Int)
}
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Why Reactive?

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interface UserManager {
    fun getUser(): User
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val um: UserManager = UserManagerImpl()
logd(um.getUser())
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val um: UserManager = UserManagerImpl()
logd(um.getUser())


um.setName("John Doe")
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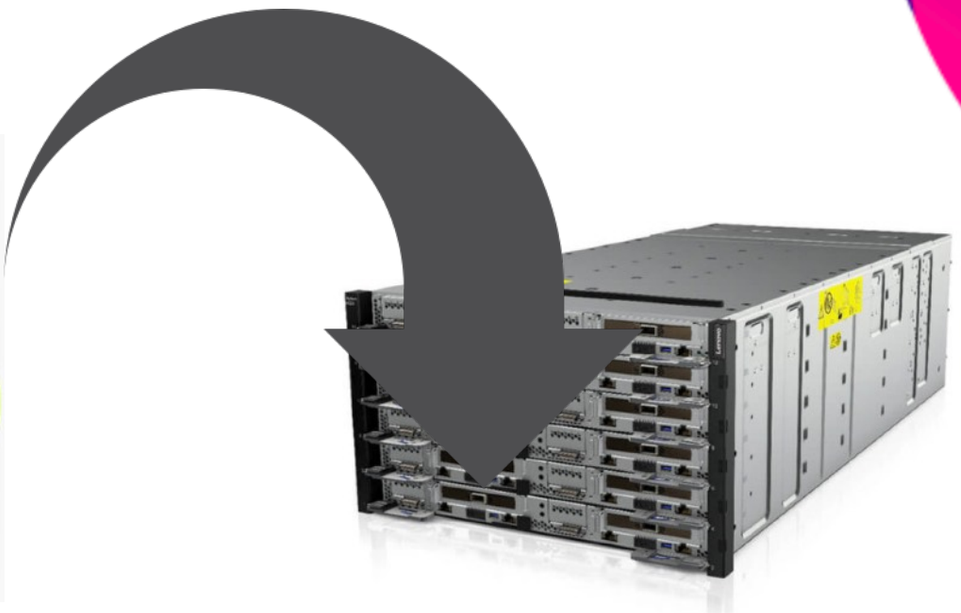

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async

async

Why Reactive?

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um.setName("John Doe")
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```

async

async

Why Reactive?

```
interface UserManagerV2 {
    fun getUser(): User
    fun setName(name: String, callback: Runnable)
    fun setAge(age: Int, callback: Runnable)
}
```

Why Reactive?

```
interface UserManagerV2 {
    fun getUser(): User
    fun setName(name: String, callback: Runnable)
    fun setAge(age: Int, callback: Runnable)
}
```

```
val um: UserManagerV2 = UserManagerV2Impl()
logd(um.getUser())
```

Why Reactive?

```
interface UserManagerV2 {
    fun getUser(): User
    fun setName(name: String, callback: Runnable)
    fun setAge(age: Int, callback: Runnable)
}
```

```
val um: UserManagerV2 = UserManagerV2Impl()
logd(um.getUser())

um.setName("John Doe", Runnable {
    logd(um.getUser())
})
```

Why Reactive?

```
interface UserManagerV2 {
    fun getUser(): User
    fun setName(name: String, callback: Runnable)
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}
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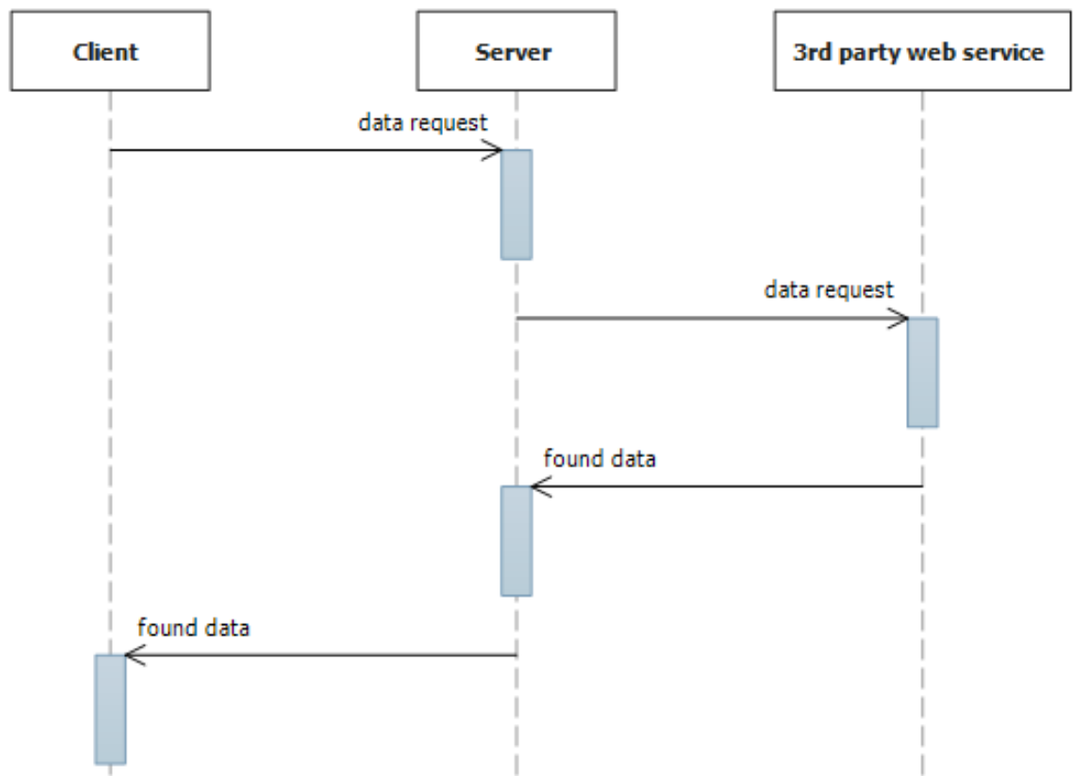

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}
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logd(um.getUser())

um.setName("John Doe", Runnable {
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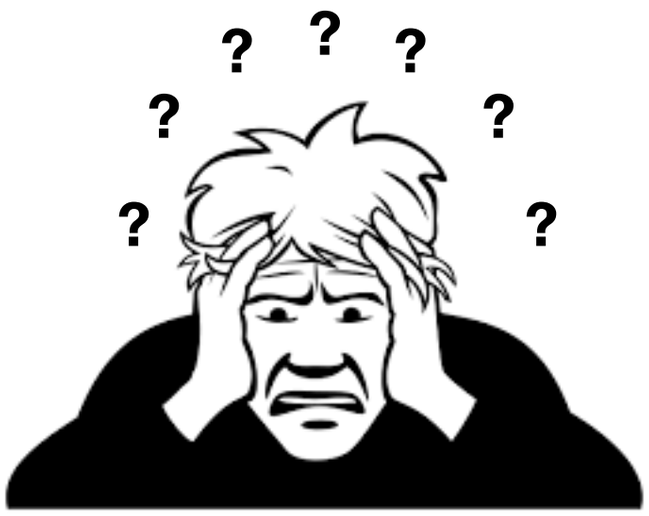

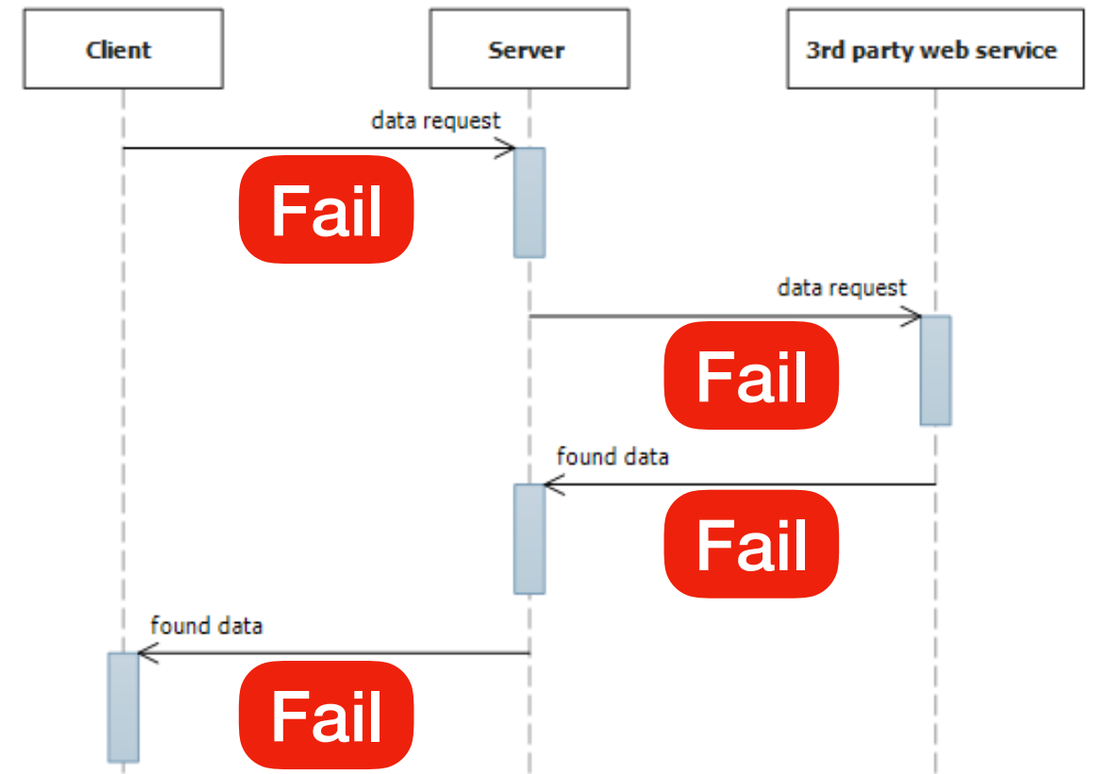

Why Reactive?

```
interface UserManagerV3 {
    fun getUser(): User
    fun setName(name: String, listener: Listener): void
    fun setAge(age: Int, listener: Listener): void

    interface Listener {
        fun success(user: User)
        fun failed(error: UserException)
    }
}
```

Why Reactive?

```
interface UserManagerV3 {
    fun getUser(): User
    fun setName(name: String, listener: Listener): void
    fun setAge(age: Int, listener: Listener): void

    interface Listener {
        fun success(user: User)
        fun failed(error: UserException)
    }
}

val um: UserManagerV3 = UserManagerV3Impl()
logd(um.getUser())

um.setName("John Doe", object : UserManagerV3.Listener {
    override fun success(user: User) {
        logd(user)
    }

    override fun failed(error: UserException) {
        loge("Unable to update the user details", error)
    }
})
```

Why Reactive?

```
val um: UserManagerV3 = UserManagerV3Impl()
logd(um.getUser())

um.setName("John Doe", object : UserManagerV3.Listener {
    override fun success(user: User) {
        logd(user)
    }

    override fun failed(error: UserException) {
        loge("Unable to update the user details", error)
    }
})

um.setAge(42, object : UserManagerV3.Listener {
    override fun success(user: User) {
        logd(user)
    }

    override fun failed(error: UserException) {
        loge("Unable to update the user details", error)
    }
})
```

Why Reactive?

```
um.setName("John Doe", object : UserManagerV3.Listener {
    override fun success(user: User) {
        um.setAge(42, object : UserManagerV3.Listener {
            override fun success(user: User) {
                logd(user)
            }

            override fun failed(error: UserException) {
                loge("Unable to update the user details", error)
            }
        })
    }

    override fun failed(error: UserException) {
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})
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Why Reactive?

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um.setName("John Doe", object : UserManager.Listener {
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            }

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        })
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Why Reactive?

```
class UserActivity : AppCompatActivity() {
    val um: UserManager = UserManagerImpl()

    override fun onCreate(savedInstanceState: Bundle?) {
        super.onCreate(savedInstanceState)
        setContentView(R.layout.activity_user)
        um.setName("John Doe", object : UserManager.Listener {
            override fun success(user: User) {
                um.setAge(42, object : UserManager.Listener {
                    override fun success(user: User) {
                        logd(user)
                    }

                    override fun failed(error: UserException) {
                        loge("Unable to update the user details", error)
                    }
                })
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            override fun failed(error: UserException) {
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        um.setName("John Doe", object : UserManager.Listener {
            override fun success(user: User) {
                um.setAge(42, object : UserManager.Listener {
                    override fun success(user: User) {
                        textView.text = user.name
                        logd(user)
                    }
                    override fun failed(error: UserException) {
                        loge("Unable to update the user details", error)
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        um.setName("John Doe", object : UserManager.Listener {
            override fun success(user: User) {
                um.setAge(42, object : UserManager.Listener {
                    override fun success(user: User) {
                        if (!isDestroyed) {
                            textView.text = user.name
                        }
                        logd(user)
                    }
                    override fun failed(error: UserException) {
                        loge("Unable to update the user details", error)
                    }
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                })
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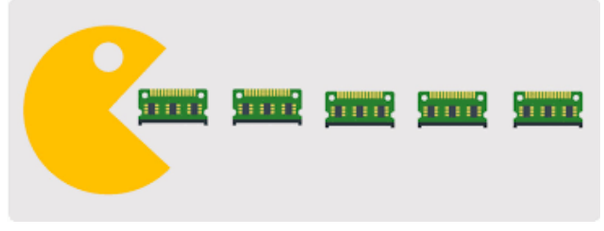
        })
    }
}
```



“A small leak will sink a great ship.”
Benjamin Franklin

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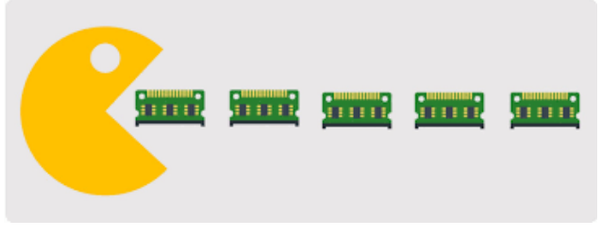

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https://github.com/square/leakcanary

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                            textView.text = user.name
                        }
                        logd(user)
                    }
                    override fun failed(error: UserException) {
                        loge("Unable to update the user details", error)
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                })
            }
            override fun failed(error: UserException) {
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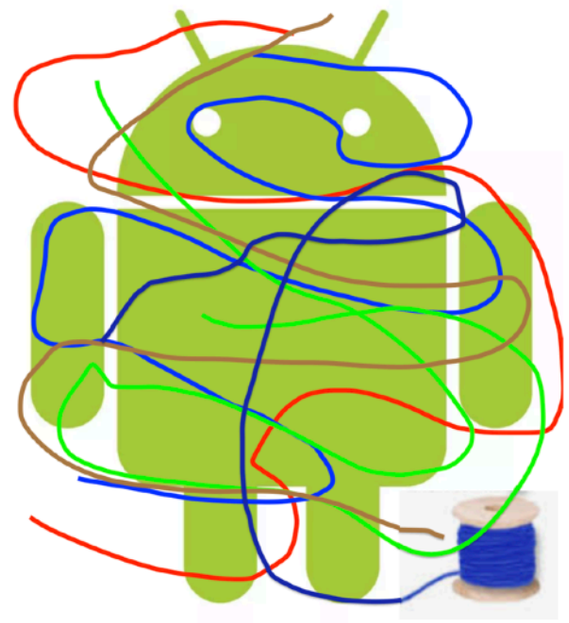
    }
}
```



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                    override fun success(user: User) {
                        if (!isDestroyed) {
                            textView.text = user.name
                        }
                        logd(user)
                    }
                    override fun failed(error: UserException) {
                        loge("Unable to update the user details", error)
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                })
            }
            override fun failed(error: UserException) {
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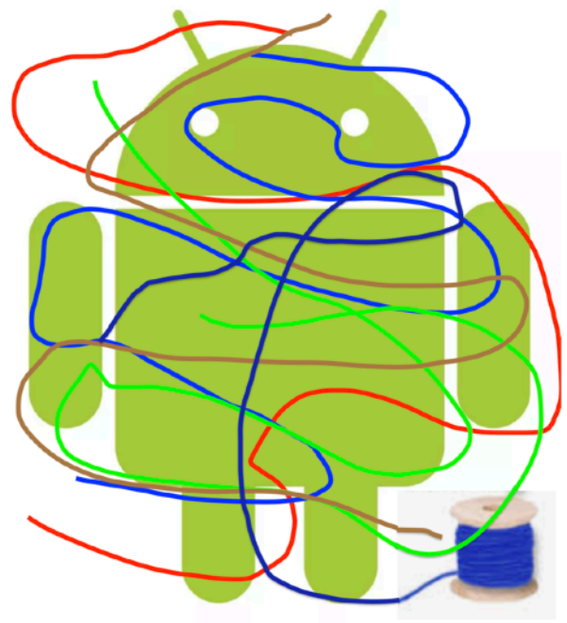
        })
    }
}
```



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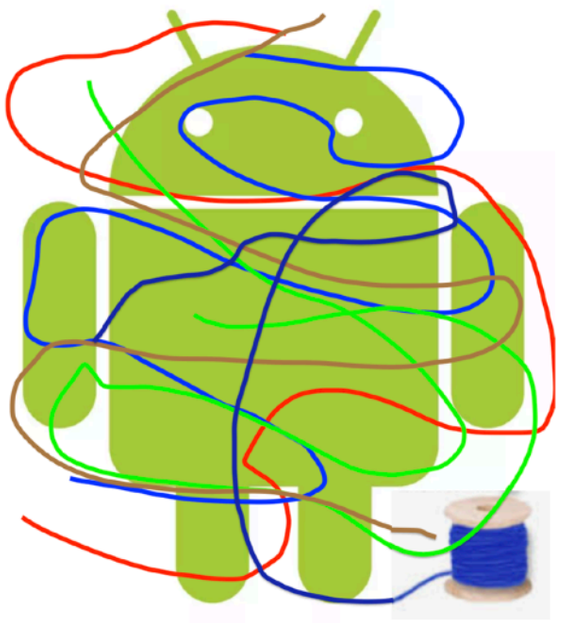
    val um: UserManager = UserManagerImpl()
    override fun onCreate(savedInstanceState: Bundle?) {
        super.onCreate(savedInstanceState)
        setContentView(R.layout.activity_user)
        um.setName("John Doe", object : UserManager.Listener {
            override fun success(user: User) {
                um.setAge(42, object : UserManager.Listener {
                    override fun success(user: User) {
                        runOnUiThread {
                            if (!isDestroyed) {
                                textView.text = user.name
                            }
                        }
                    }
                    override fun failed(error: UserException) {
                        loge("Unable to update the user details", error)
                    }
                })
            }
            //...
        })
    }
}
```



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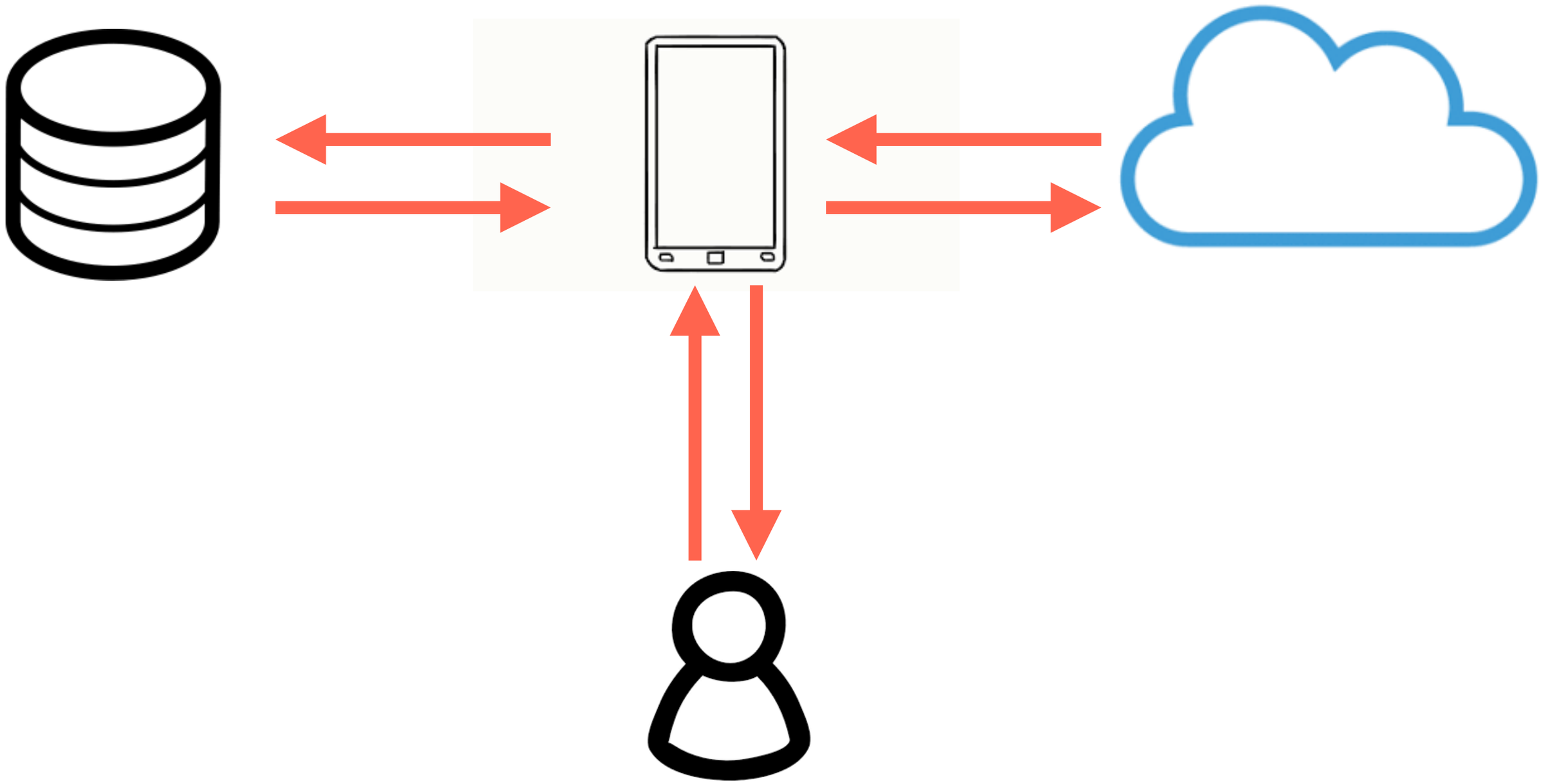

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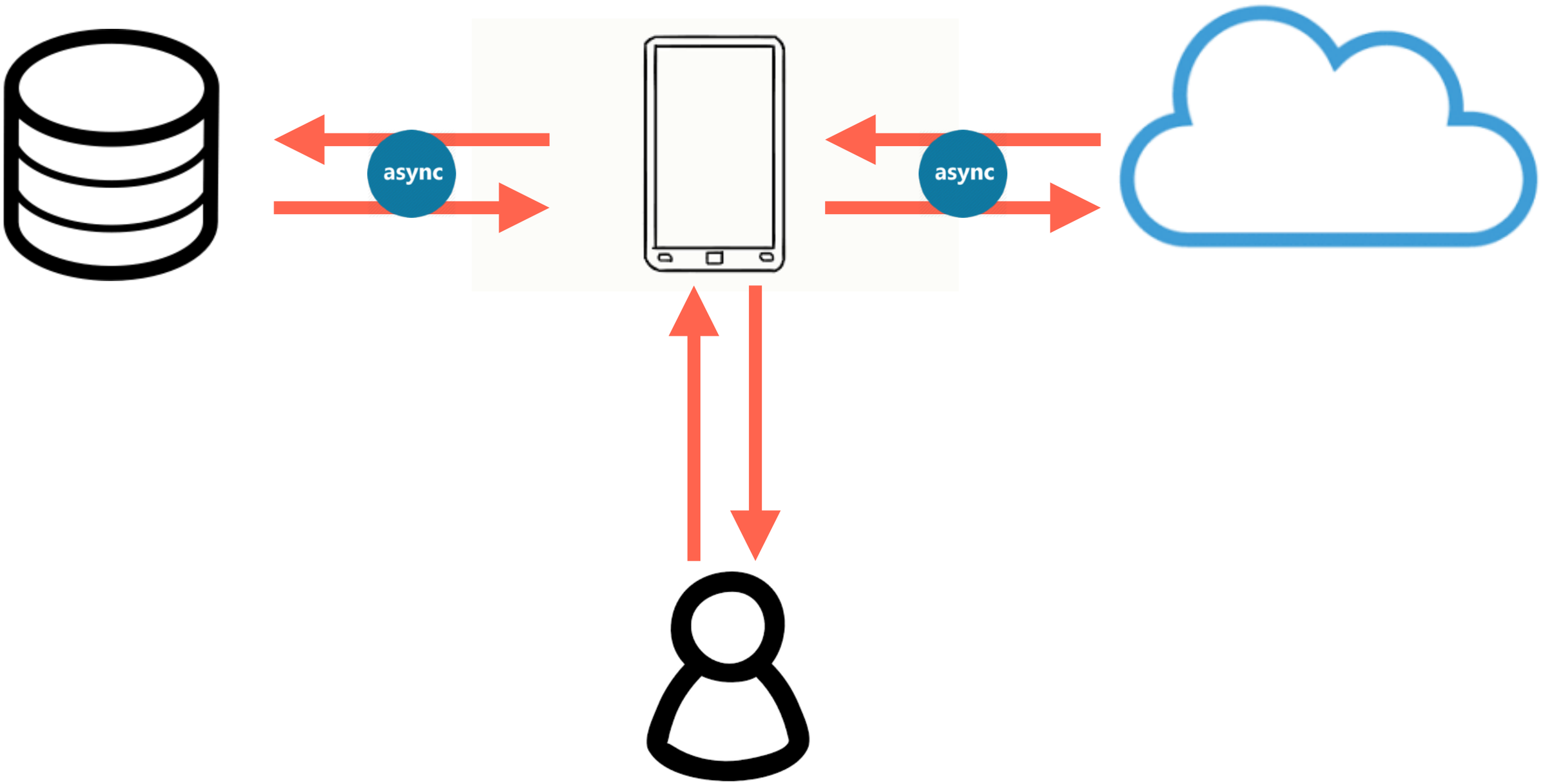

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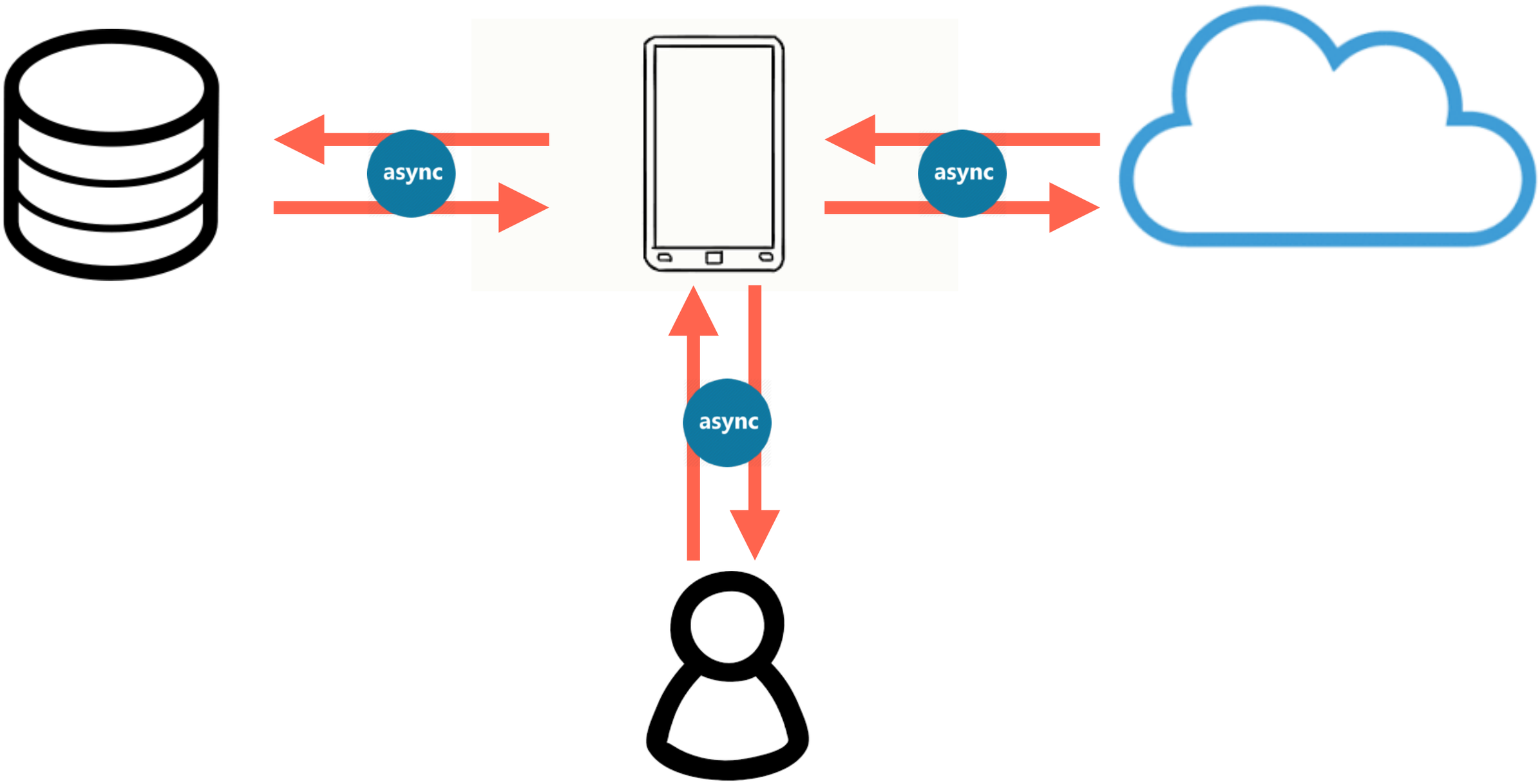

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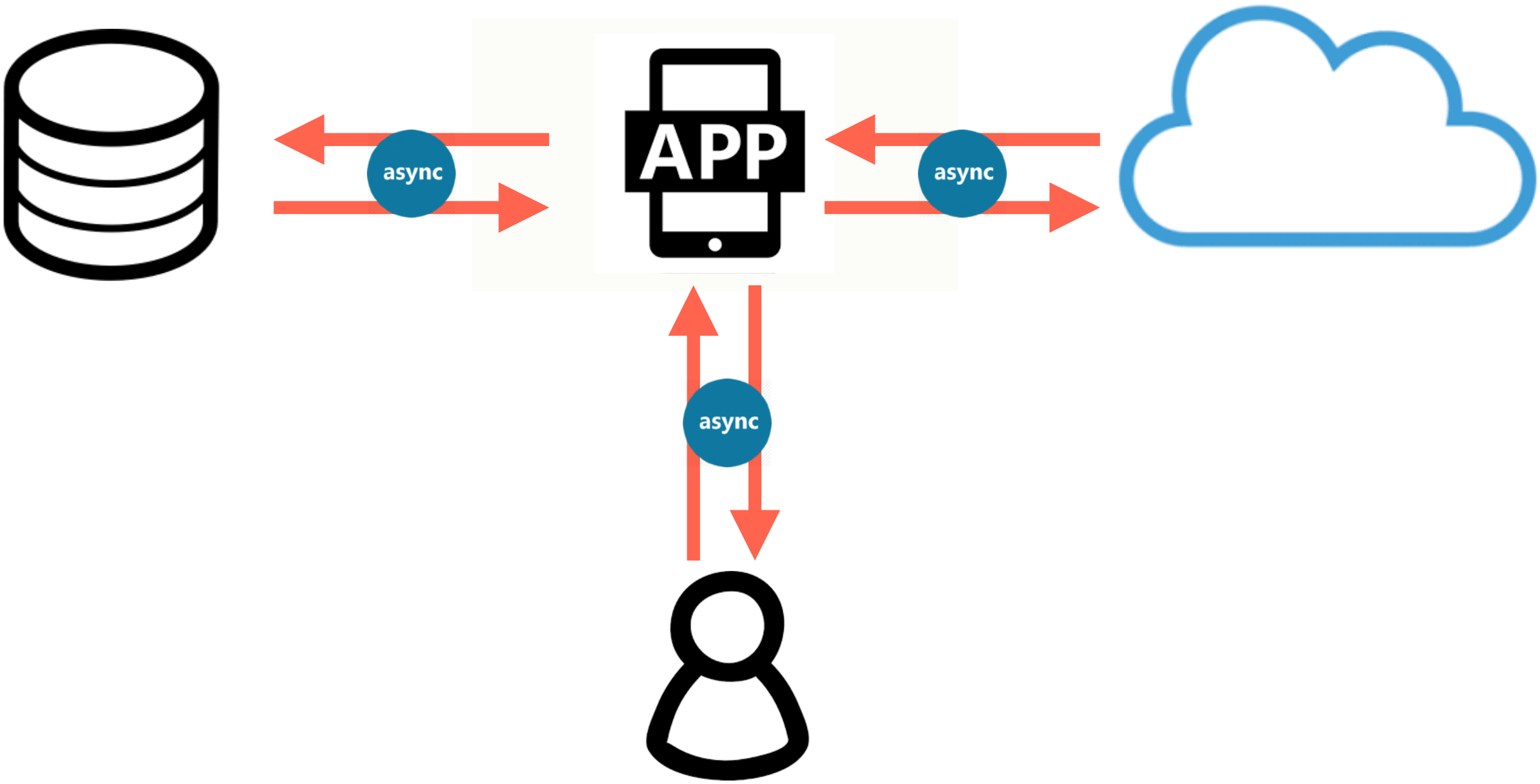

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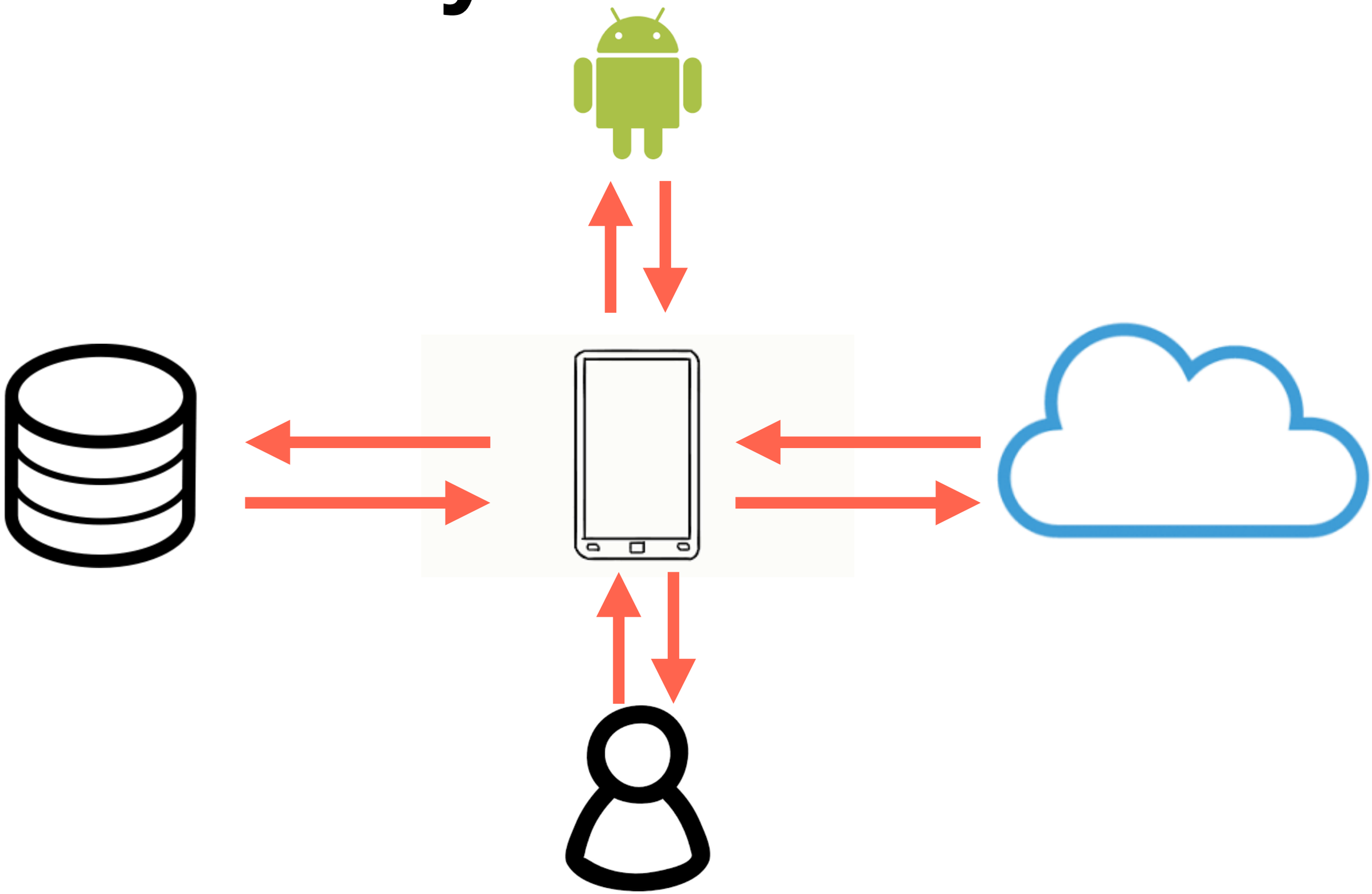

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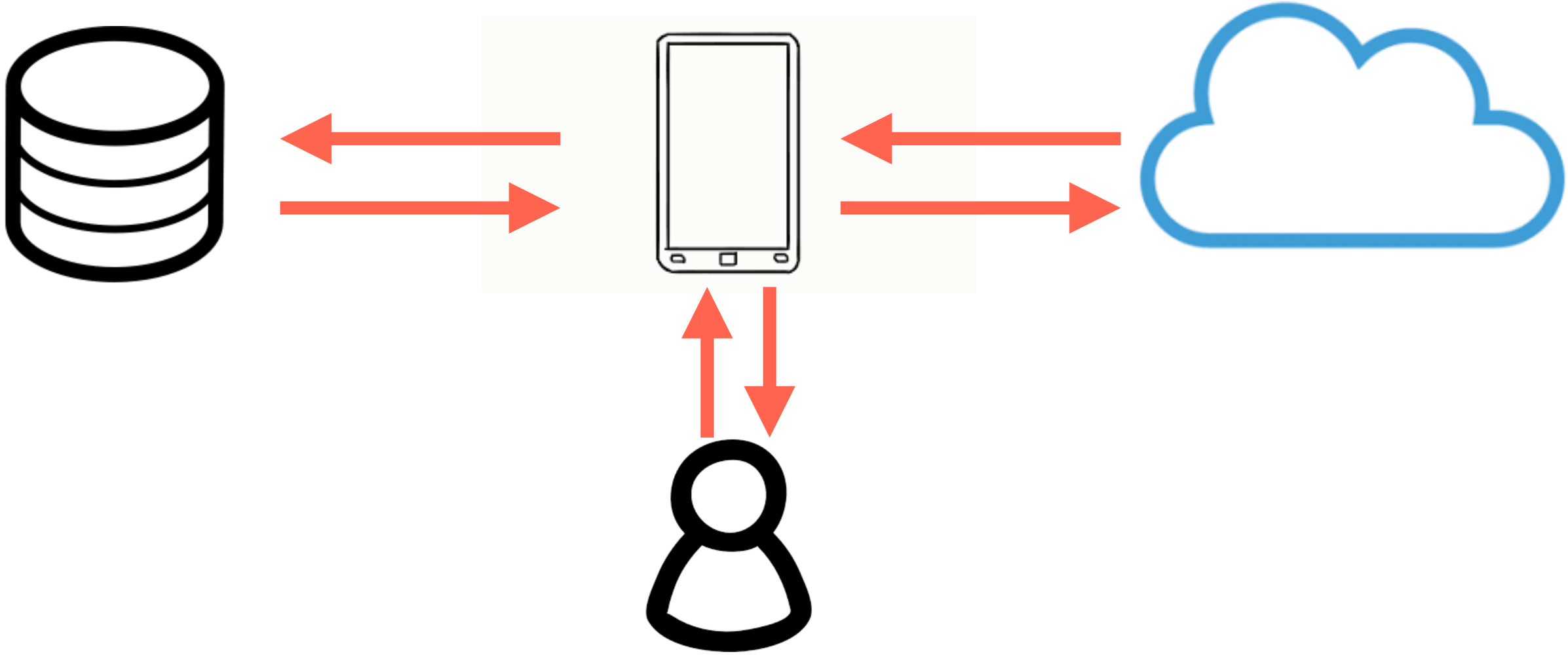

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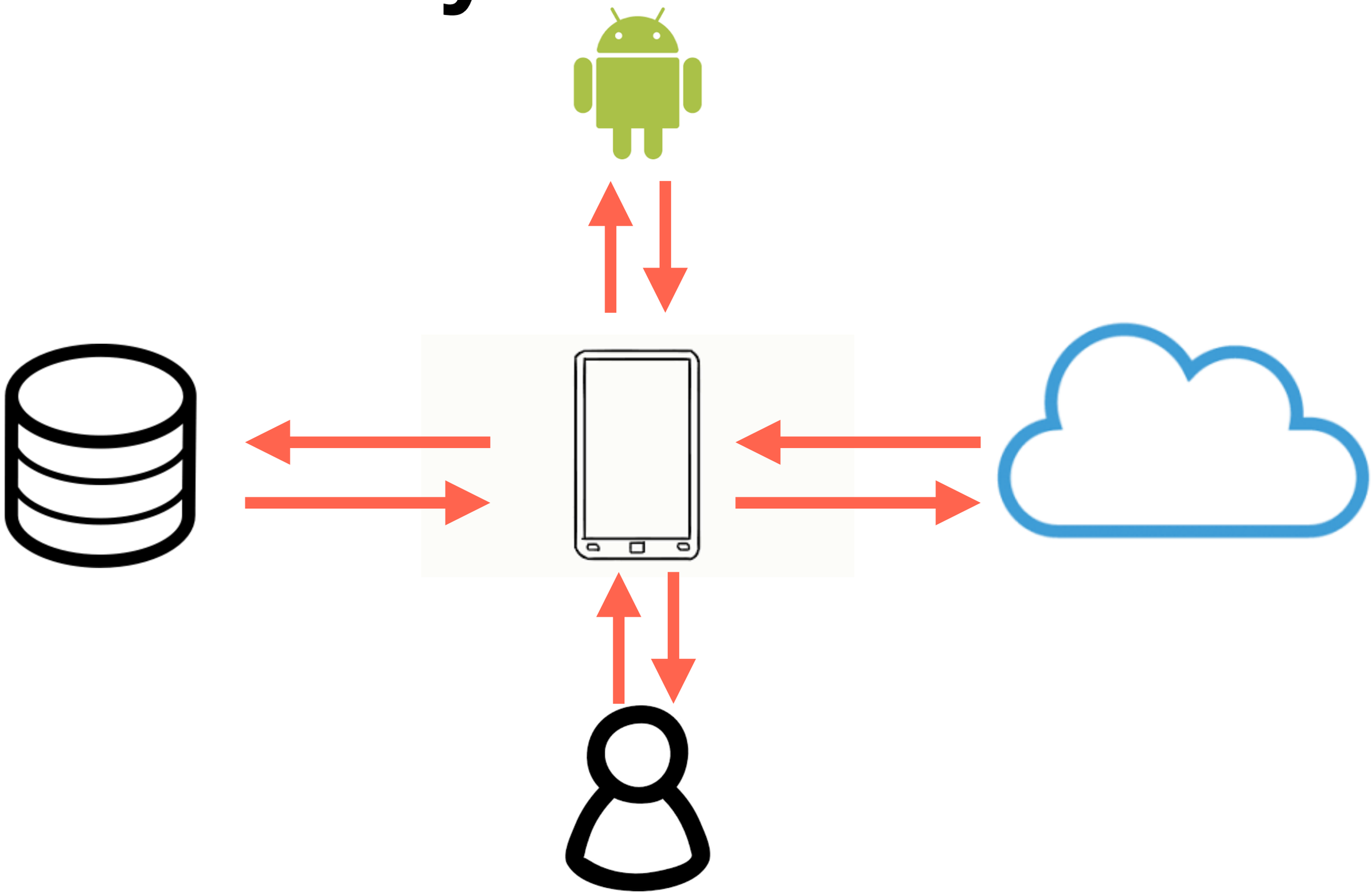

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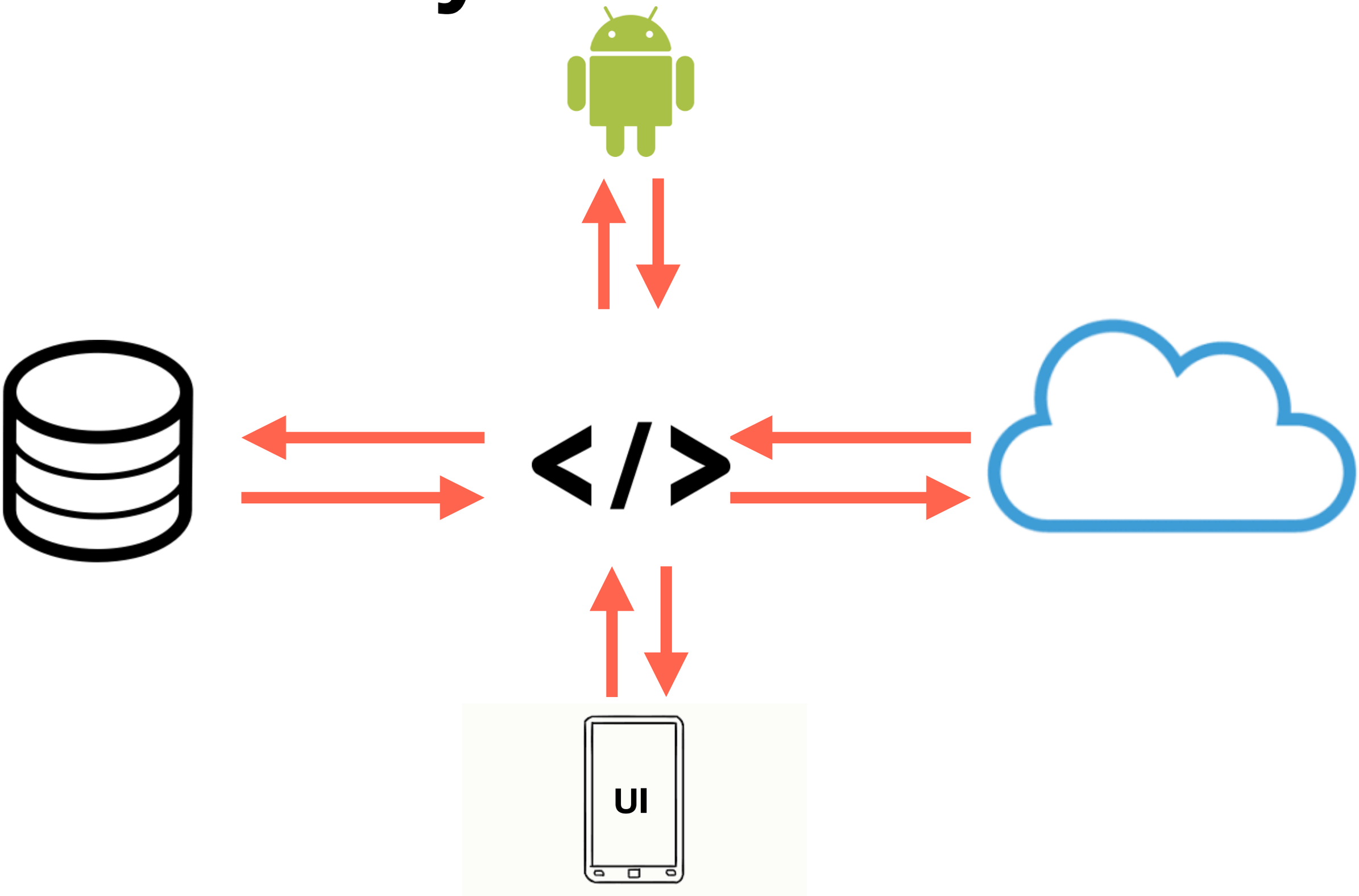

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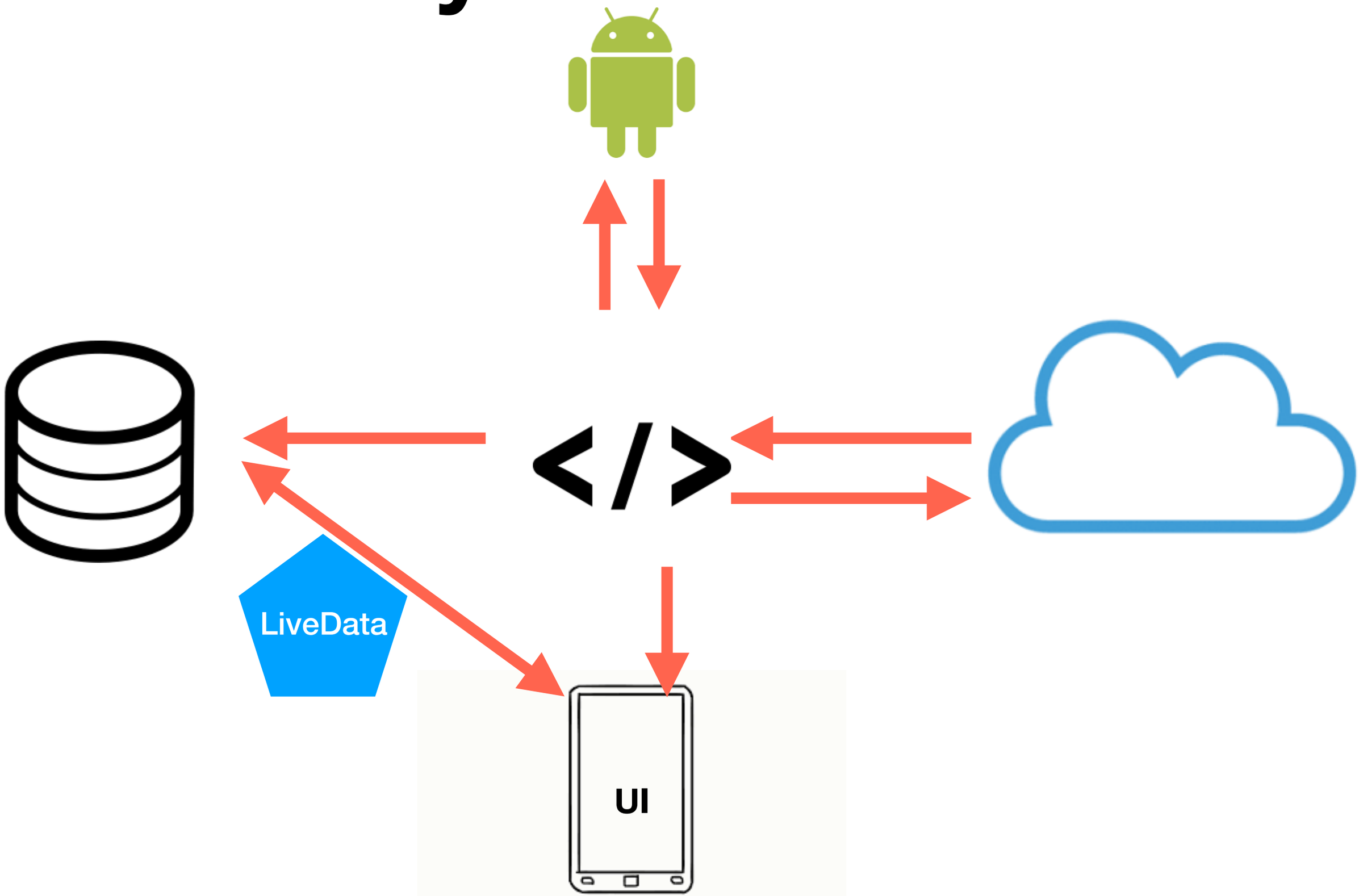

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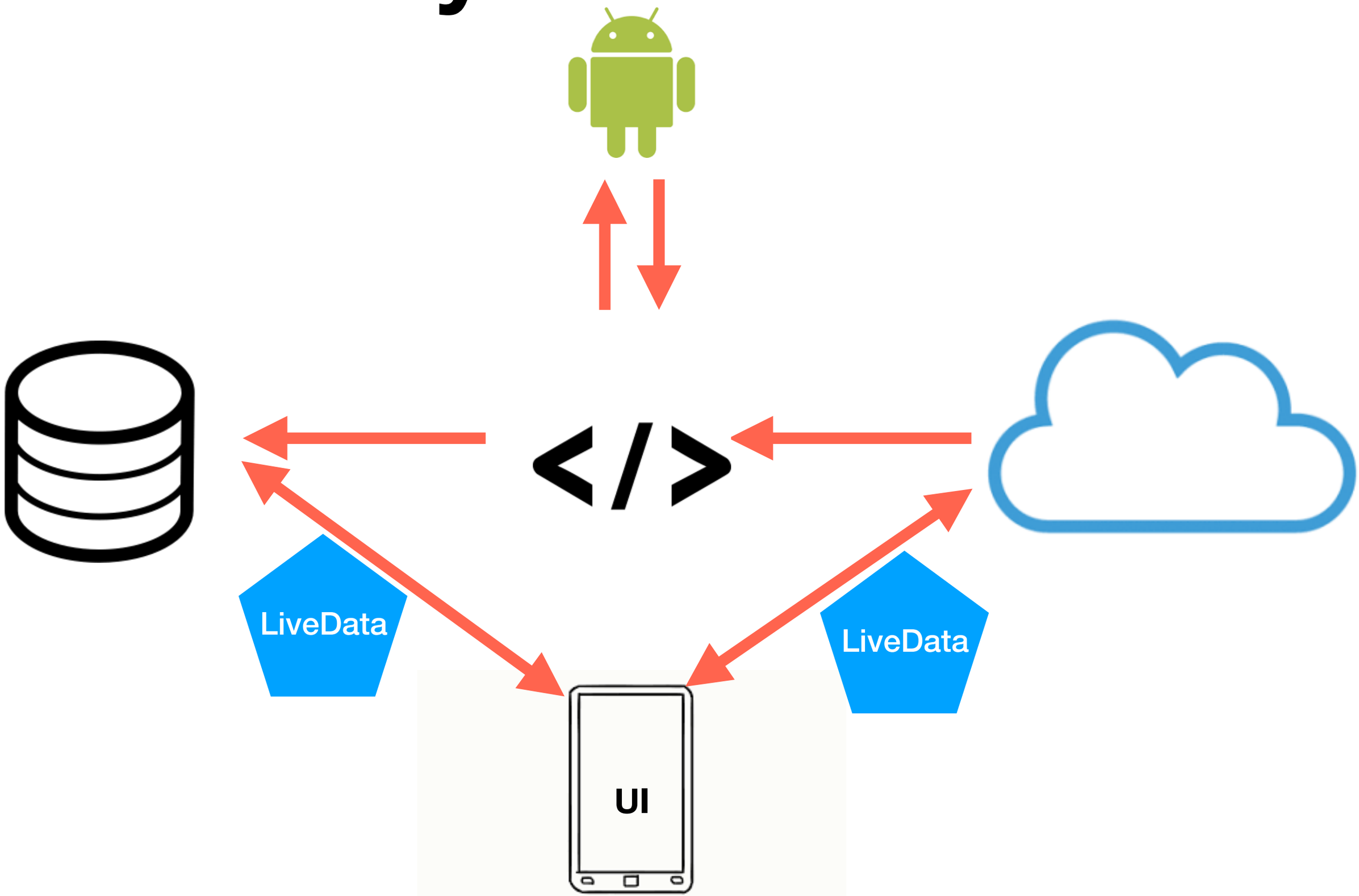

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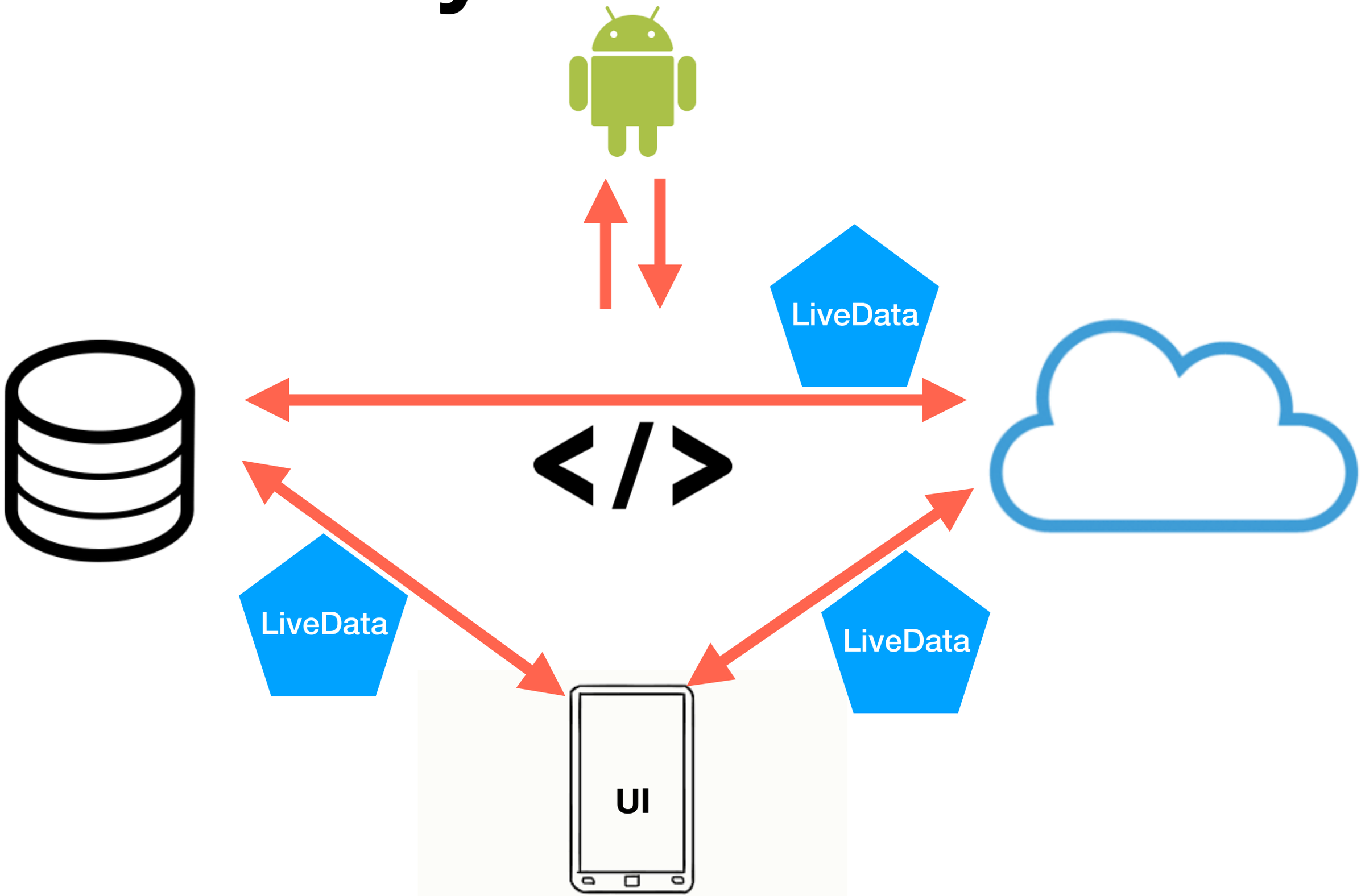

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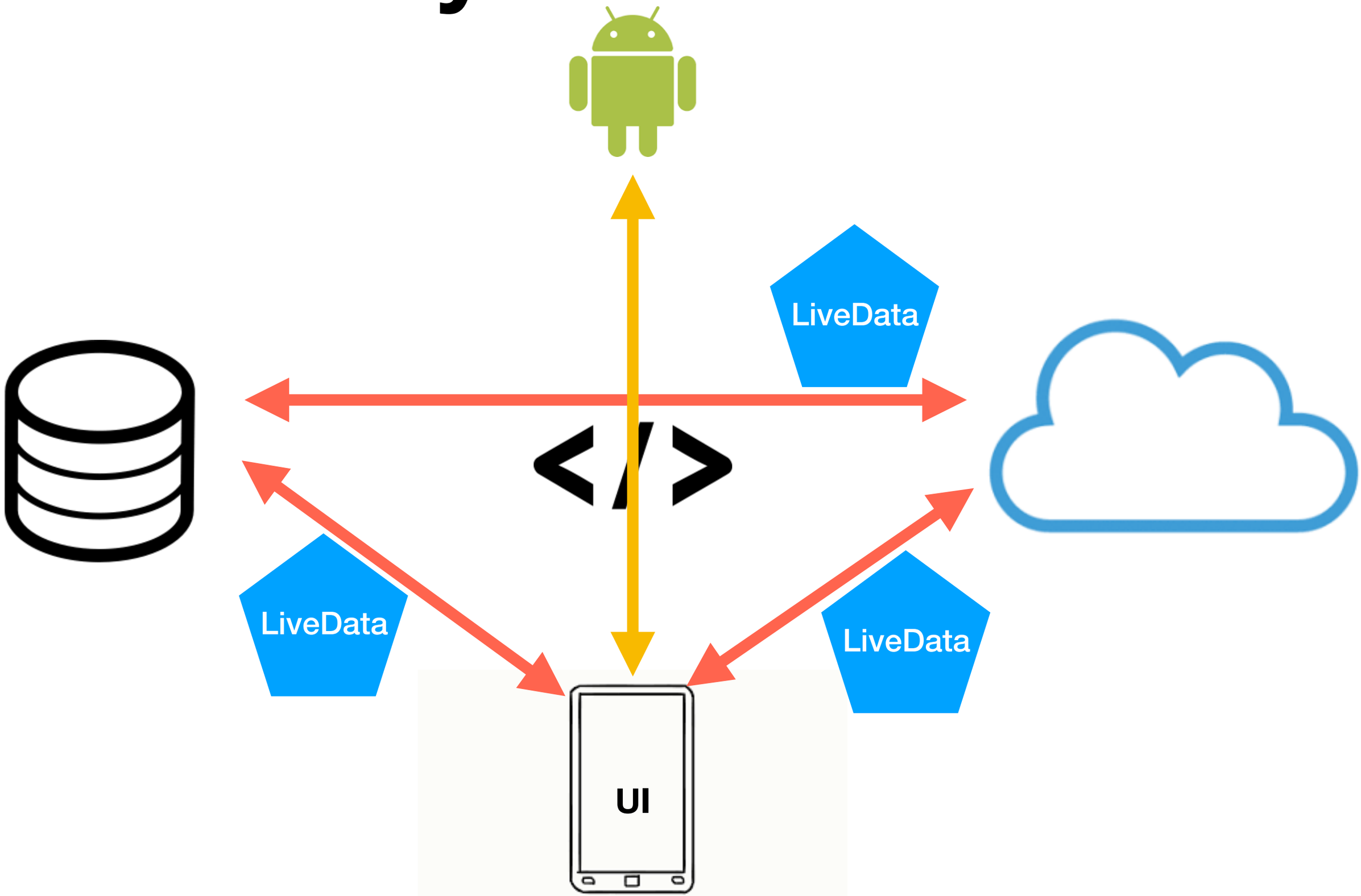

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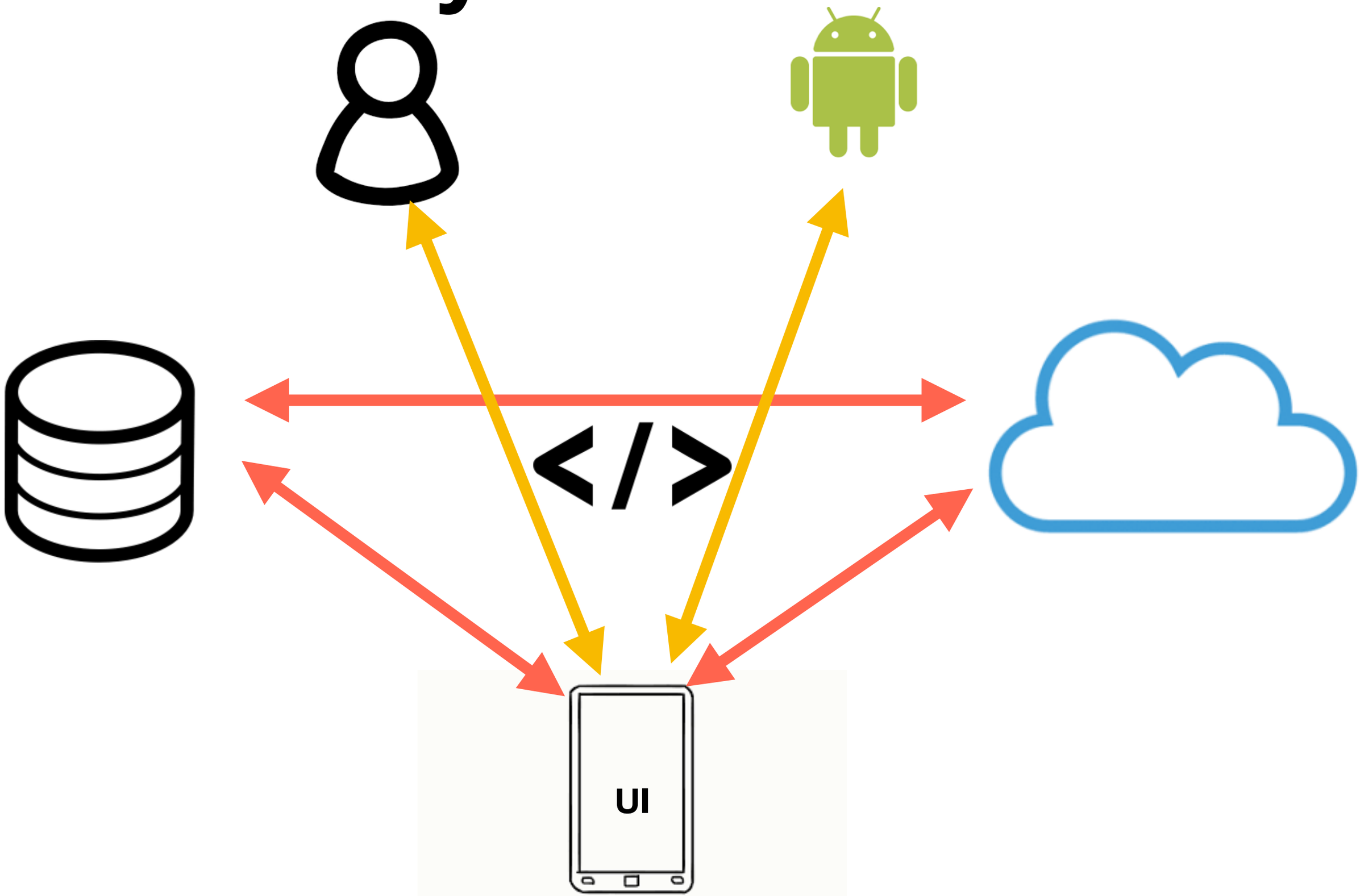


Rx{Java|Kotlin|Swift|Dart}

- A set of classes for representing sources of data.
- A set of classes for listening to data sources.
- A set of methods for modifying and composing the data.

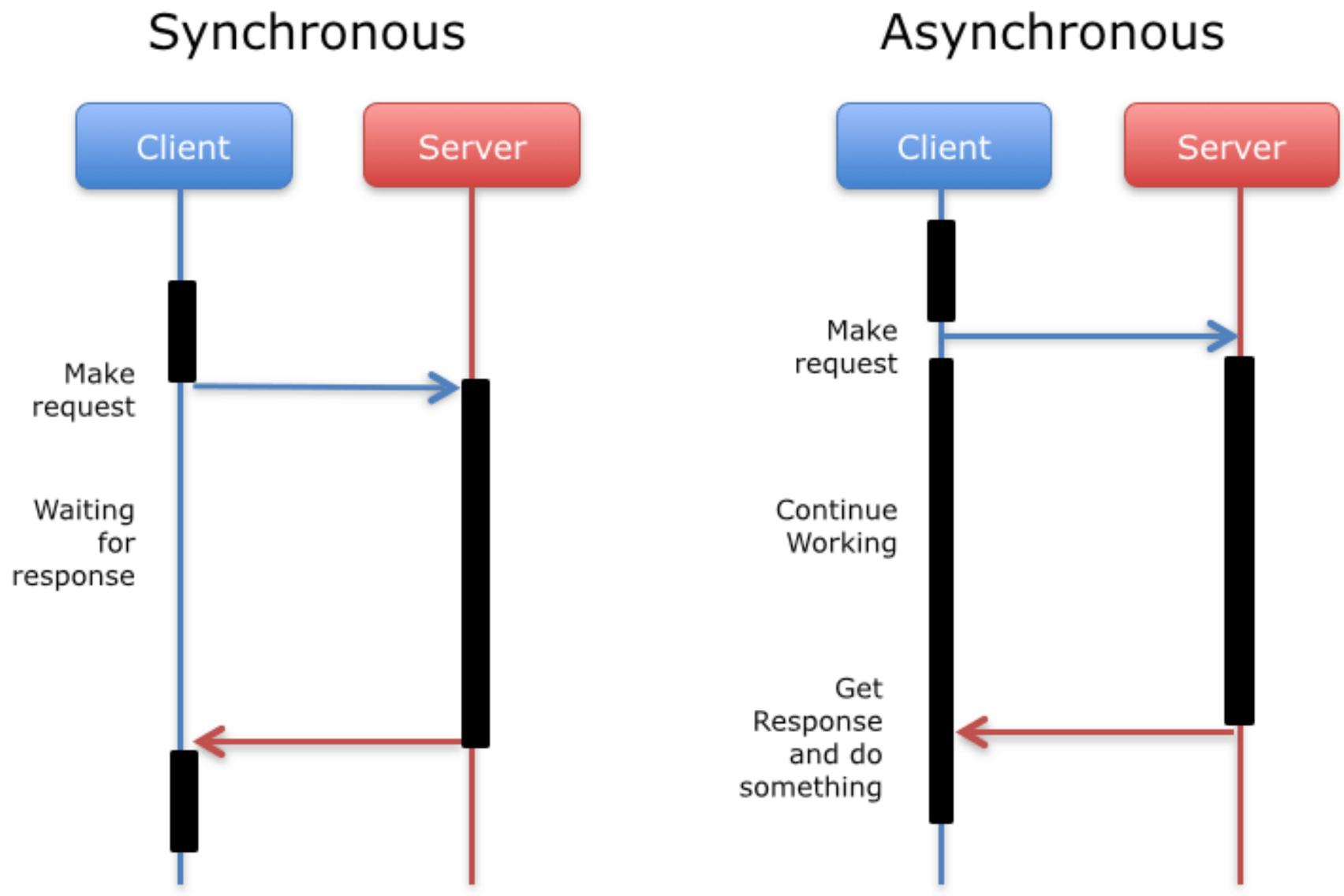
http://reactivex.io/

Sources

Sources

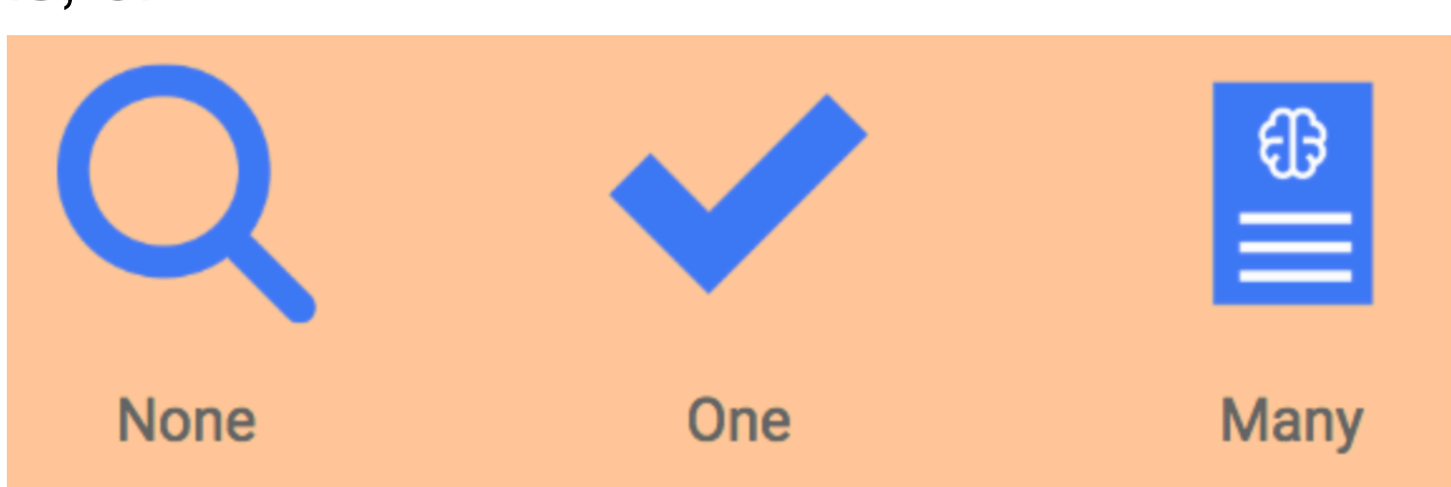
Sources

- Synchronous or asynchronous.



Sources

- Synchronous or asynchronous.
- Single item, many items, or empty.



Sources

- Synchronous or asynchronous.
- Single item, many items, or empty.
- Terminates with an error or succeeds to completion.

Sources

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- May never terminate!

Sources

- Synchronous or asynchronous.
- Single item, many items, or empty.
- Terminates with an error or succeeds to completion.
- May never terminate!
- Just an implementation of the Observer pattern.

Sources

- Observable<T>
- Flowable<T>

Sources

- Observable<T>
  - Emits 0 to N items.
  - Terminates with complete or error.
- Flowable<T>
  - Emits 0 to N items.
  - Terminates with complete or error.

Sources

- Observable<T>
  - Emits 0 to N items.
  - Terminates with complete or error.
  - Does not have backpressure.
- Flowable<T>
  - Emits 0 to N items.
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Sources

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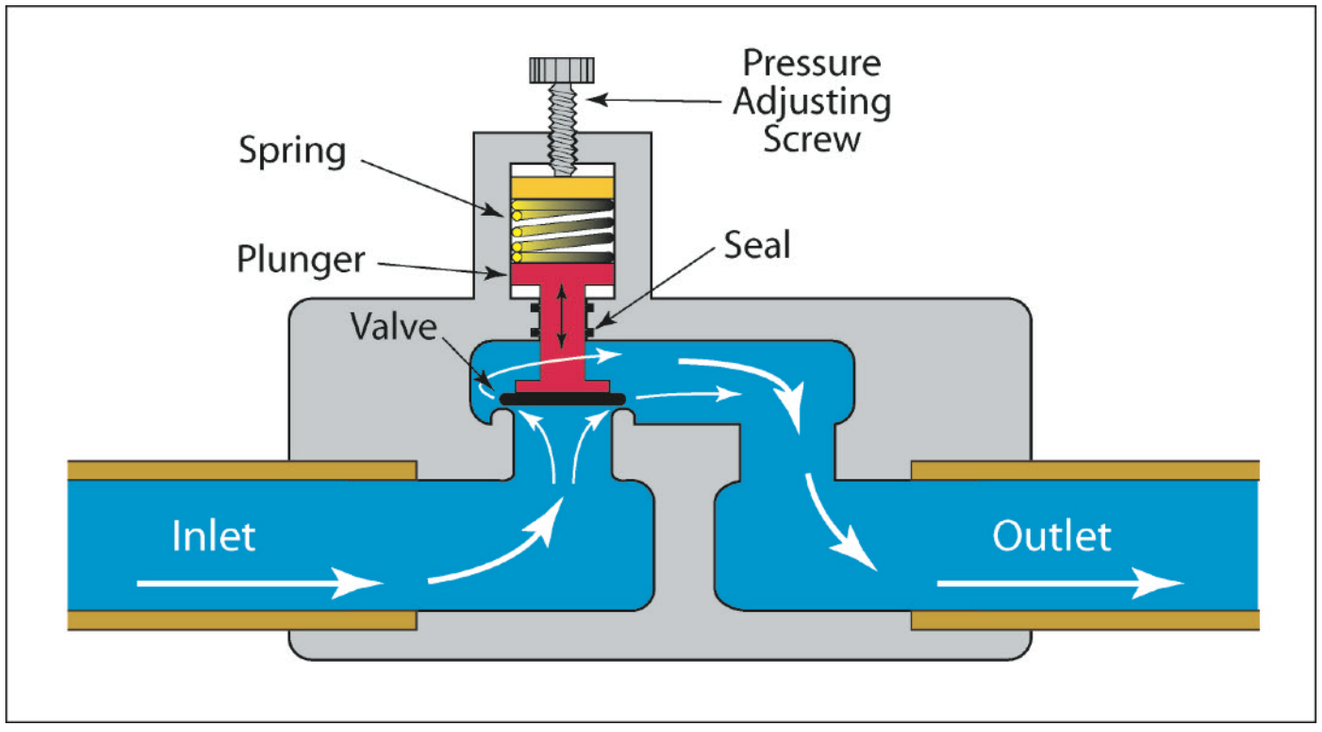
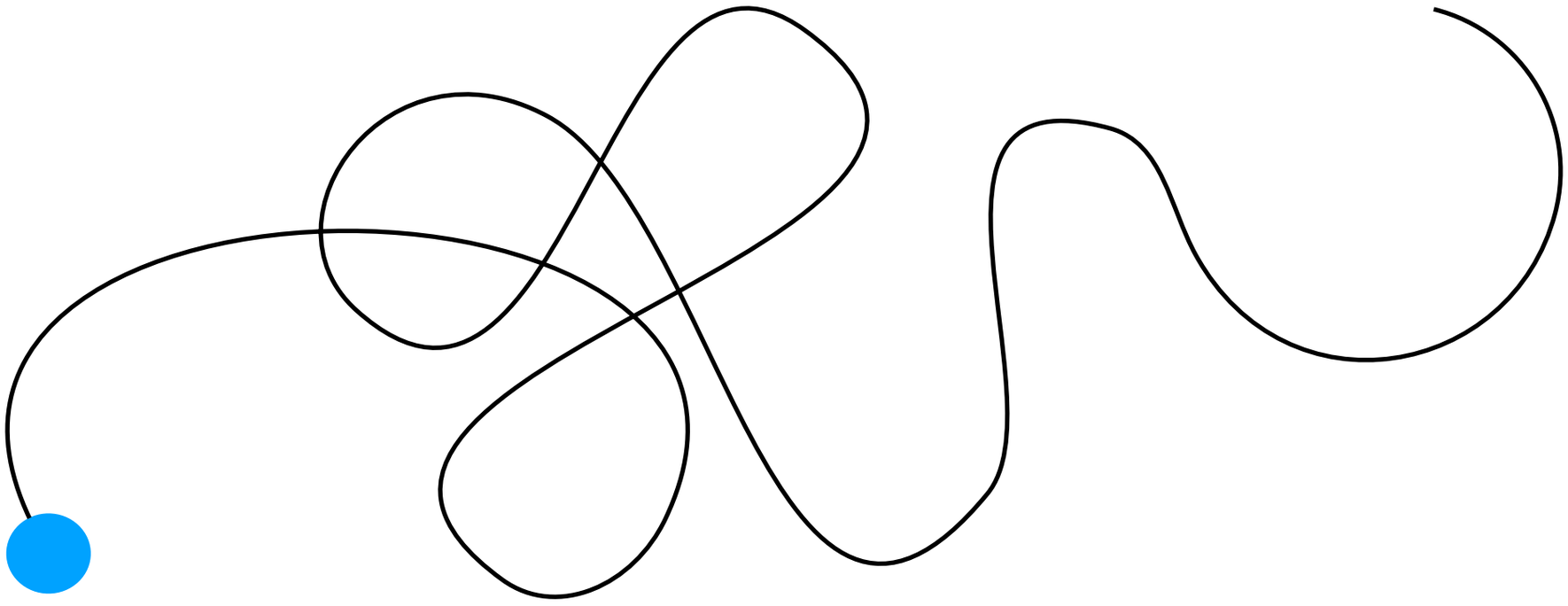


Flowable vs. Observable

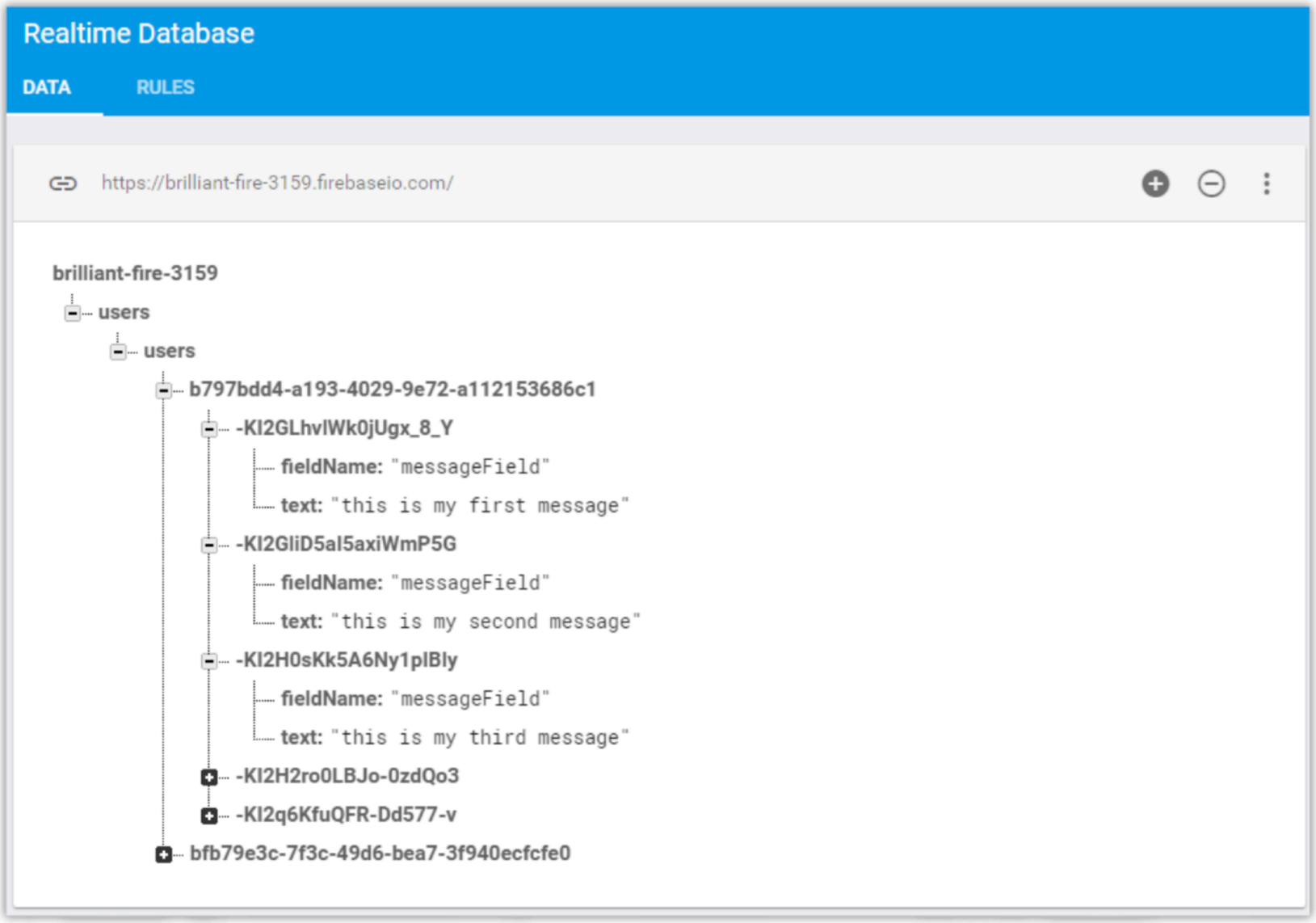
```
val events: Observable<MotionEvent> = RxView.touches(paintView);
```



Flowable vs. Observable

```
val events: Observable<MotionEvent> = RxView.touches(paintView);

val users: Observable<User> = db.query("select * from ...");
```



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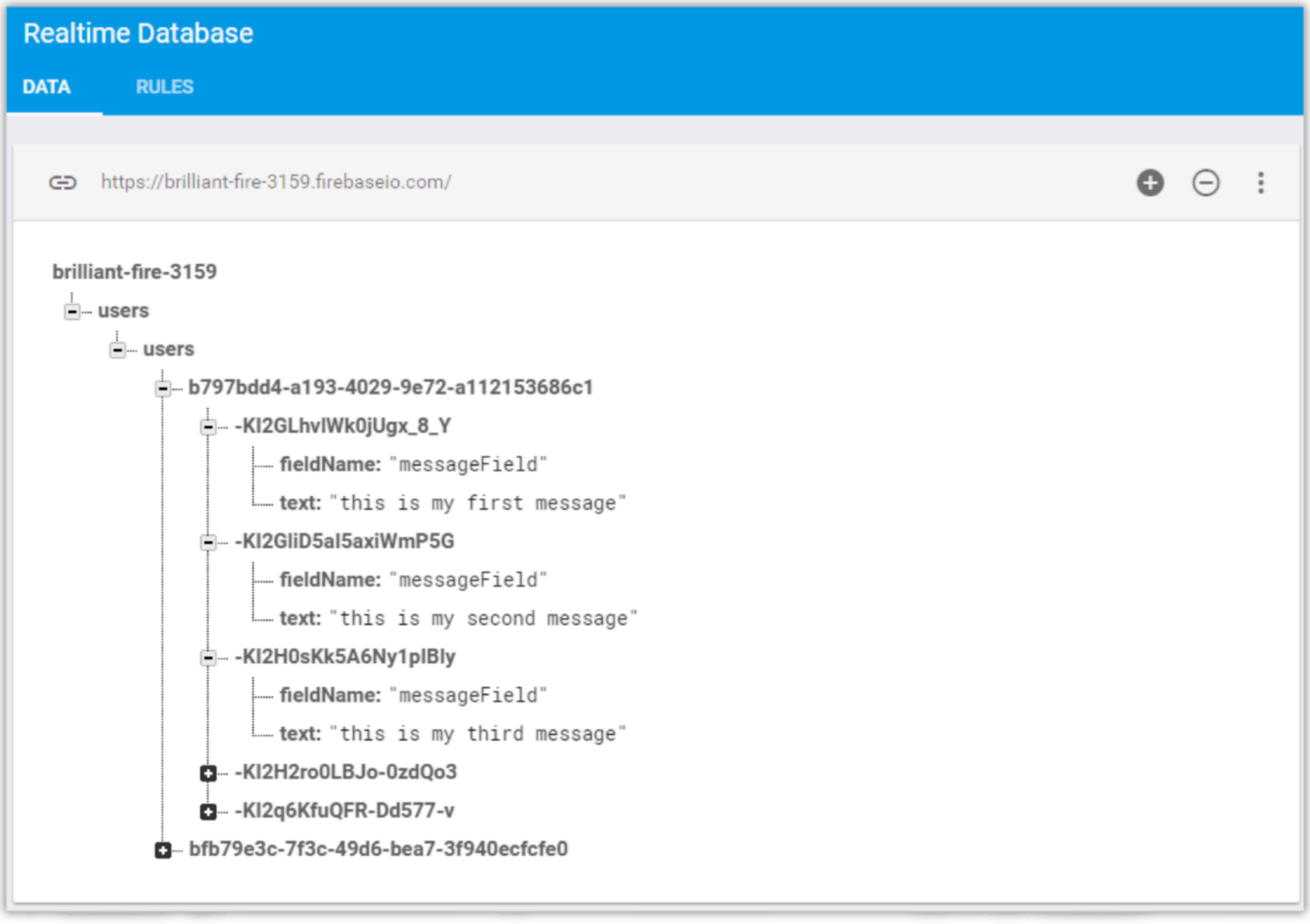

Flowable vs. Observable

Observable<MotionEvent>

```
interface Observer<T>{
    fun onNext(t: T)
    fun onComplete()
    fun onError(t: Throwable)
    fun onSubscribe(d: Disposable)
}
```

Flowable<User>

```
interface Subscriber<T>{
    fun onNext(t: T)
    fun onComplete()
    fun onError(t: Throwable)
    fun onSubscribe(s: Subscription)
}
```

Flowable vs. Observable

Observable<MotionEvent>

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Flowable vs. Observable

Observable<MotionEvent>

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Flowable vs. Observable

Observable<MotionEvent>

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    fun onError(t: Throwable)
    fun onSubscribe(d: Disposable)
}


interface Disposable{
    fun dispose()
}
```

Flowable<User>

```
interface Subscriber<T>{
    fun onNext(t: T)
    fun onComplete()
    fun onError(t: Throwable)
    fun onSubscribe(s: Subscription)
}

interface Subscription{
    fun cancel()
    fun request(r: Long)
}
```

Sources

```
interface UserManager {
    fun getUser(): User
    fun setName(name: String)
    fun setAge(age: Int)
}
```

Sources

```
interface UserManager {
    fun getUser(): Observable<User>
    fun setName(name: String)
    fun setAge(age: Int)
}
```

Specialized Sources

Specialized Sources

- Encoding subsets of Observable into the type system:

Specialized Sources

- Encoding subsets of Observable into the type system:
  - Single
    - Either succeeds with an item or an error.
    - No backpressure support.

Specialized Sources

- Encoding subsets of Observable into the type system:
  - Single
    - Either succeeds with an item or an error.
    - No backpressure support.
  - Completable
    - Either completes or errors. Has no items!
    - No backpressure support.

Specialized Sources

- Encoding subsets of Observable into the type system:
  - Single
    - Either succeeds with an item or an error.
    - No backpressure support.
- Completable
  - Either completes or errors. Has no items!
  - No backpressure support.
- Maybe
  - Either succeeds with an item, completes with no items, or error.
  - No backpressure support.

Specialized Sources

- Encoding subsets of Observable into the type system:
  - Single 

    - Either succeeds with an item or an error.
    - No backpressure support.
- Completable
    - Either completes or errors. Has no items!
    - No backpressure support.
- Maybe
    - Either succeeds with an item, completes with no items, or error.
    - No backpressure support.

Specialized Sources

- Encoding subsets of Observable into the type system:
  - Single **scalar**
    - Either succeeds with an item or an error.
    - No backpressure support.
- Completable **Runnable**
  - Either completes or errors. Has no items!
  - No backpressure support.
- Maybe
  - Either succeeds with an item, completes with no items, or error.
  - No backpressure support.

Specialized Sources

- Encoding subsets of Observable into the type system:
  - Single `scalar`
    - Either succeeds with an item or an error.
    - No backpressure support.
- Completable `Runnable`
  - Either completes or errors. Has no items!
  - No backpressure support.
- Maybe `Optional`
  - Either succeeds with an item, completes with no items, or error.
  - No backpressure support.

Sources

```
interface UserManager {
    fun getUser(): Observable<User>
    fun setName(name: String)
    fun setAge(age: Int)
}
```

Sources

```
interface UserManager {
    fun getUser(): Observable<User>
    fun setName(name: String): Completable
    fun setAge(age: Int): Completable
}
```

Creating Sources

```
Flowable.just("Hello")
Flowable.just("Hello", "World")

Observable.just("Hello")
Observable.just("Hello", "World")

Maybe.just("Hello")

Single.just("Hello")
```

Creating Sources

```
Flowable.just("Hello")
Flowable.just("Hello", "World")

Observable.just("Hello")
Observable.just("Hello", "World")
```

```
Maybe.just("Hello")

Single.just("Hello")

val array = arrayListOf("Hello", "World")
val list = array.toList()

Flowable.fromArray(array)
Flowable.fromIterable(list)

Observable.fromArray(array)
Observable.fromIterable(list)
```

Creating Sources

```
Flowable.just("Hello")
Flowable.just("Hello", "World")

Observable.just("Hello")
Observable.just("Hello", "World")

Maybe.just("Hello")

Single.just("Hello")
```

```
val array = arrayListOf("Hello", "World")
val list = array.toList()

Flowable.fromArray(array)
Flowable.fromIterable(list)

Observable.fromArray(array)
Observable.fromIterable(list)

Observable.fromCallable {
    setName()
}
```

Creating Sources

```
val url = "https://example.com"

val request = Request.Builder().url(url).build()
val client = OkHttpClient()

Observable.fromCallable {
    client.newCall(request).execute()
}
```

Create Sources

```
Observable.create(ObservableOnSubscribe<String> {
    it.onNext("Hello")
    it.onComplete()
})
```

Create Sources

```
Observable.create(ObservableOnSubscribe<String> {
    it.onNext("Hello")
    it.onComplete()
})


Observable.create(ObservableOnSubscribe<String>(
   function = fun(it: ObservableEmitter<String>) {
    it.onNext("Hello")
    it.onComplete()
}))
```

Create Sources

```
Observable.create<String> {
    it.onNext("Hello")
    it.onComplete()
}
```

```
Observable.create(ObservableOnSubscribe<String> {
    it.onNext("Hello")
    it.onComplete()
})
```

```
Observable.create(ObservableOnSubscribe<String>(
   function = fun(it: ObservableEmitter<String>) {
    it.onNext("Hello")
    it.onComplete()
}))
```

Create Sources

```
Observable.create<String> {
    it.onNext("Hello")
    it.onNext("World")
    it.onComplete()
}
```

Create Sources

```
Observable.create<View> {
    it.setCancellable { textView.setOnClickListener(null) }
    textView.setOnClickListener { v -> it.onNext(v) }
}
```

Create Sources

```
Observable.create<View> {
    it.setCancellable { textView.setOnClickListener(null) }
    textView.setOnClickListener { v -> it.onNext(v) }
}
```

```
val request = Request.Builder().url(url).build()
val client = OkHttpClient()

Observable.create<String> {
    val call = client.newCall(request)
    it.setCancellable { call.cancel() }
    call.enqueue(object : Callback {
        override fun onFailure(call: Call, e: IOException) {
            it.onError(e)
        }

        override fun onResponse(call: Call, response: Response) {
            it.onNext(response.body().toString())
            it.onComplete()
        }
    })
}
```

Observing Sources

Observable<MotionEvent>

```
interface Observer<T>{
    fun onNext(t: T)
    fun onComplete()
    fun onError(t: Throwable)
    fun onSubscribe(d: Disposable)
}


interface Disposable{
    fun dispose()
}
```

Flowable<User>

```
interface Subscriber<T>{
    fun onNext(t: T)
    fun onComplete()
    fun onError(t: Throwable)
    fun onSubscribe(s: Subscription)
}


interface Subscription{
    fun cancel()
    fun request(r: Long)
}
```

Observing Sources

Observing Sources

```
val observable: Observable<String> = Observable.just("Hello")

observable.subscribe(object: DisposableObserver<String>(){
    override fun onComplete() {
        //...
    }

    override fun onNext(t: String) {
        //...
    }

    override fun onError(e: Throwable) {
        //...
    }
})
```

Observing Sources

```
val observable: Observable<String> = Observable.just("Hello")

observable.subscribe(object: DisposableObserver<String>(){
    override fun onComplete() {
        //...
    }

    override fun onNext(t: String) {
        //...
    }

    override fun onError(e: Throwable) {
        //...
    }
})
```

How to we dispose?

Observing Sources

```
val observable: Observable<String> = Observable.just("Hello")

val observer = object : DisposableObserver<String>() {
    override fun onComplete() {
        //...
    }

    override fun onNext(t: String) {
        //...
    }

    override fun onError(e: Throwable) {
        //...
    }
}
observable.subscribe(observer)

observer.dispose()
```

Observing Sources

```
val observable: Observable<String> = Observable.just("Hello")

val disposable = observable.subscribeWith(object : DisposableObserver<String>() {
    override fun onComplete() {
        //...
    }

    override fun onNext(t: String) {
        //...
    }

    override fun onError(e: Throwable) {
        //...
    }
})

disposable.dispose()
```

Rx{Java|Kotlin|Swift|Dart}

- **A set of classes for representing sources of data.**

- **A set of classes for listening to data sources.**

- A set of methods for modifying and composing the data.

Rx{Java|Kotlin|Swift|Dart}

- A set of classes for representing sources of data.
- A set of classes for listening to data sources.
- **A set of methods for modifying and composing the data.**

Operators

- Manipulate or combine data in some way.
- Manipulate threading in some way.
- Manipulate emissions in some way.

Operators

```
val greeting = "Hello"
val yelling = greeting.toUpperCase()
```

Operators

```
val greeting = Observable.just("Hello")
val yelling = greeting.toUpperCase()
```

Operators

```
val greeting = Observable.just("Hello")
val yelling = greeting.map { it.toUpperCase() }
```

Operators

```
class UserActivity : AppCompatActivity() {
    val um: UserManager = UserManagerImpl()
    override fun onCreate(savedInstanceState: Bundle?) {
        super.onCreate(savedInstanceState)
        setContentView(R.layout.activity_user)
        um.setName("John Doe", object : UserManager.Listener {
            override fun success(user: User) {
                um.setAge(42, object : UserManager.Listener {
                    override fun success(user: User) {
                        runOnUiThread {
                            if (!isDestroyed) {
                                textView.text = user.name
                            }
                        }
                    }
                    override fun failed(error: UserException) {
                        loge("Unable to update the user details", error)
                    }
                })
            }
            //...
        })
    }
}
```

Operators

```
class UserActivity : AppCompatActivity() {
    val um: UserManager = UserManagerImpl()
    override fun onCreate(savedInstanceState: Bundle?) {
        super.onCreate(savedInstanceState)
        setContentView(R.layout.activity_user)
        um.setName("John Doe", object : UserManager.Listener {
            override fun success(user: User) {
                um.setAge(42, object : UserManager.Listener {
                    override fun success(user: User) {
                        runOnUiThread {
                            if (!isDestroyed) {
                                textView.text = user.name
                            }
                        }
                    }
                    override fun failed(error: UserException) {
                      loge("Unable to update the user details", error)
                    }
                })
            }
            //...
        })
    }
}
```

Operators

```
val user: Observable<User> = um.getUser()
val mainThreadUser = user.observeOn(AndroidSchedulers.mainThread())
```

Operators

```
val user: Observable<User> = um.getUser()
val mainThreadUser = user.observeOn(AndroidSchedulers.mainThread())
```

```
val url = "https://example.com"

val request = Request.Builder().url(url).build()
val client = OkHttpClient()

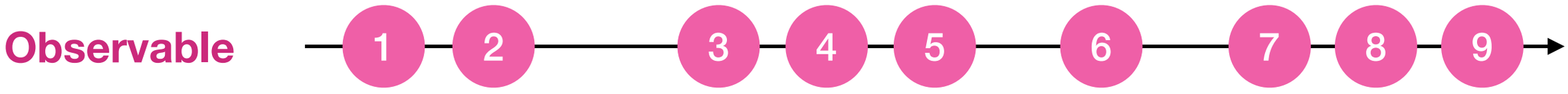
val reponse = Observable.fromCallable { client.newCall(request).execute() }
    .subscribeOn(Schedulers.io()).map { it.body()?.string() }
    .flatMap { Observable.fromArray(it.split(" ")) }
    .observeOn(AndroidSchedulers.mainThread())
```

Operators

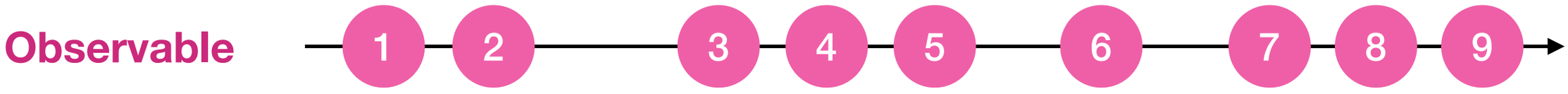
Observable 

Observable 

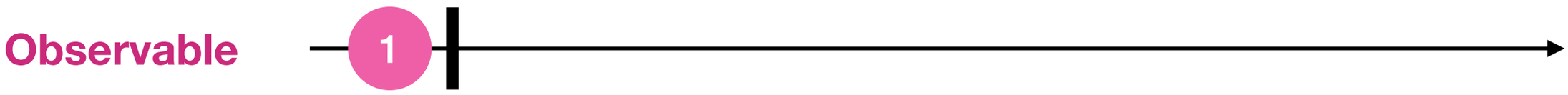
Operators



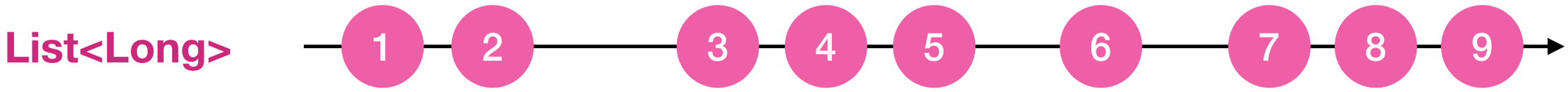
Operators



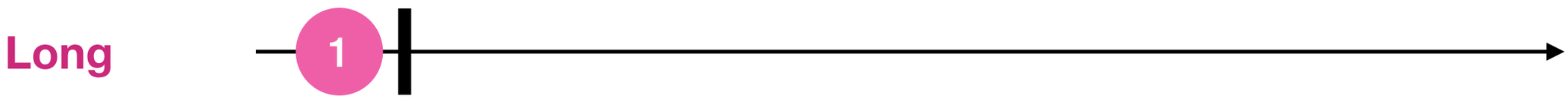
first()



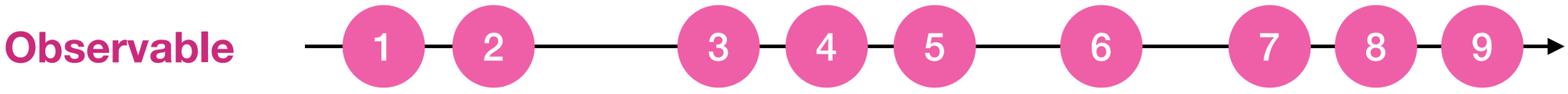
Operators



get(0)



Operators



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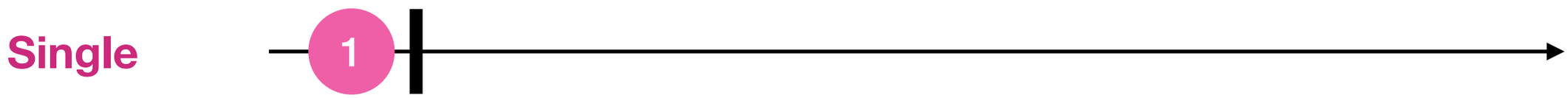
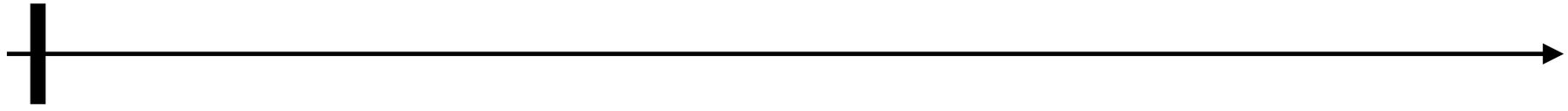


Operators

Observable

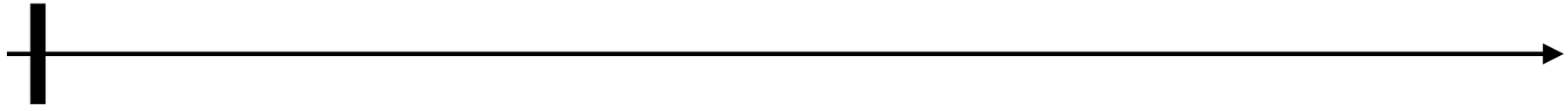


first()

Single

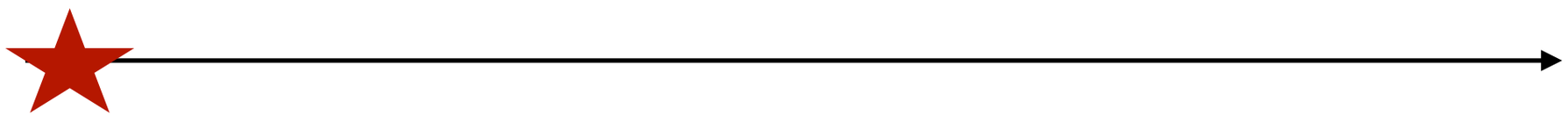
Operators

Observable



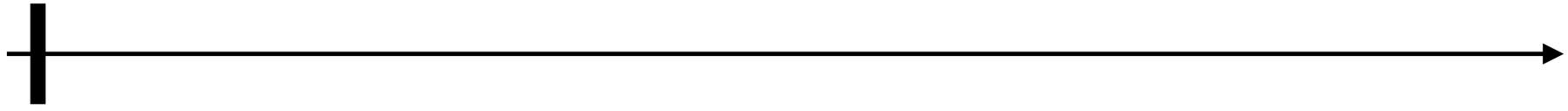
first()

Single



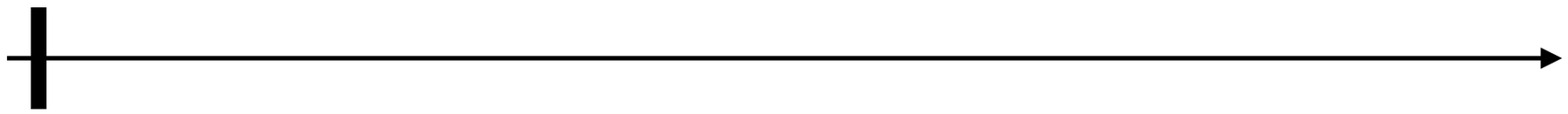
Operators

Observable

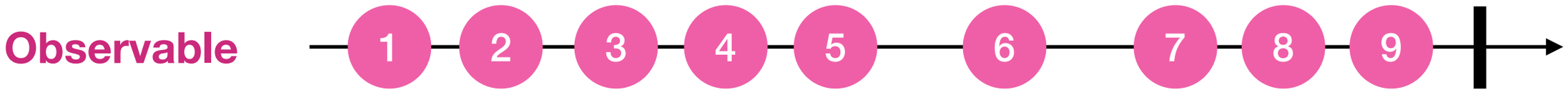


firstElement()

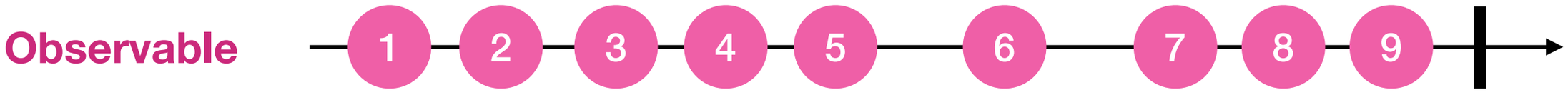
Maybe



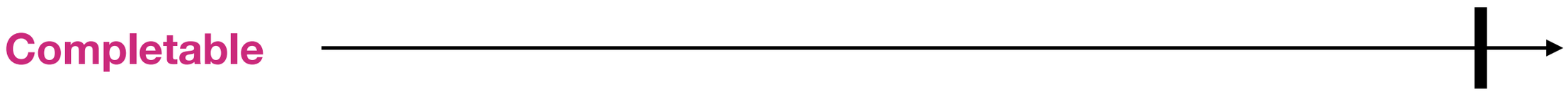
Operators



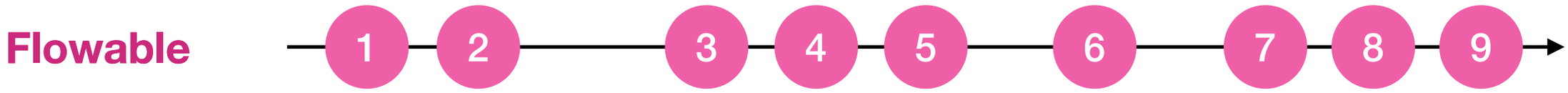
Operators



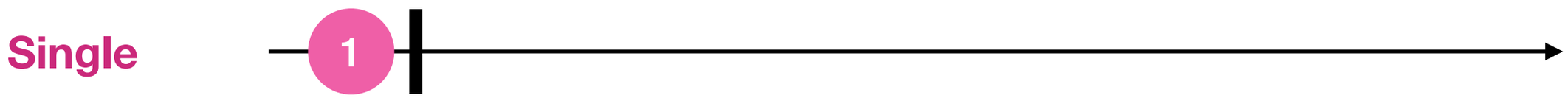
ignoreElements()



Operators

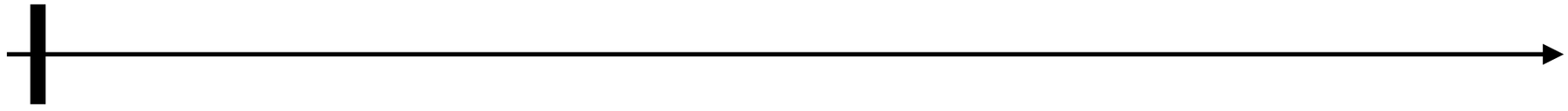


first()



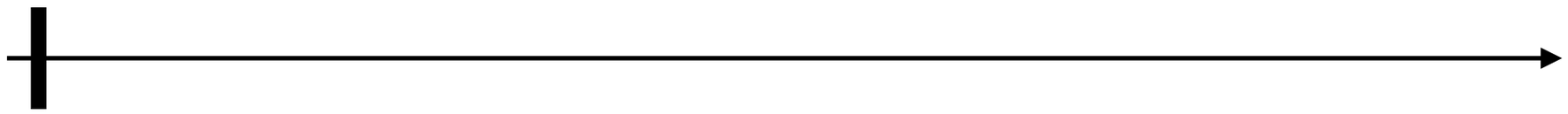
Operators

Flowable

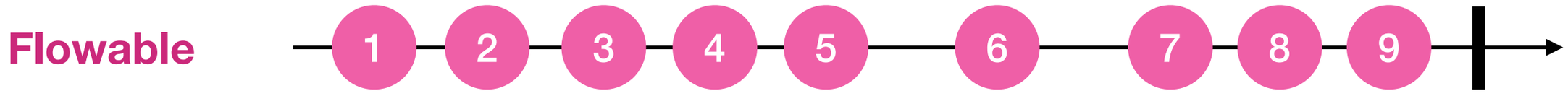


firstElement()

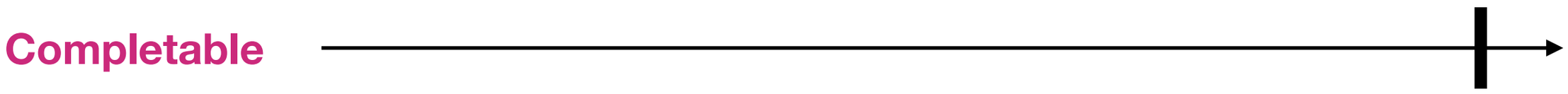
Maybe



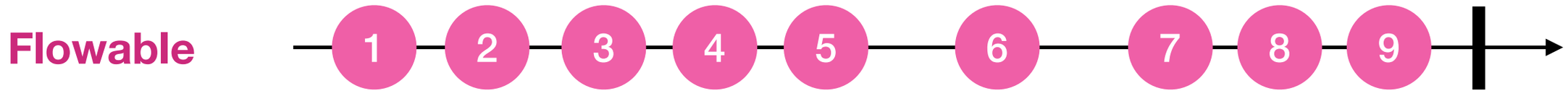
Operators



ignoreElements()



Operators



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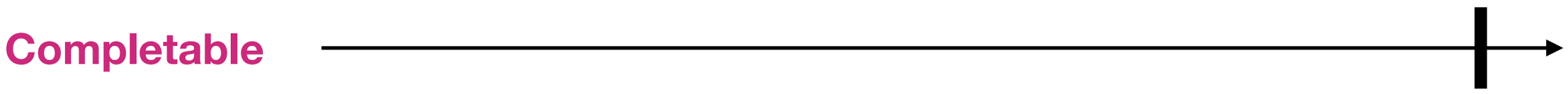


http://reactivex.io/documentation/operators.html

Being Reactive

```
um.getUser()
        .observeOn(AndroidSchedulers.mainThread())
        .subscribeWith(object: DisposableObserver<User>(){
            override fun onNext(user: User) {
            }

            override fun onError(e: Throwable) {
            }

            override fun onComplete() {
            }
    })
```

Being Reactive

```
um.getUser()
        .observeOn(AndroidSchedulers.mainThread())
        .subscribeWith(object: DisposableObserver<User>(){
            override fun onNext(user: User) {
                textView.text = user.toString()
            }

            override fun onError(e: Throwable) {
            }

            override fun onComplete() {
            }
    })
```

Being Reactive

```
// onCreate
val disposables = CompositeDisposable()
disposables.add(um.getUser()
    .observeOn(AndroidSchedulers.mainThread())
    .subscribeWith(object: DisposableObserver<User>(){
        override fun onNext(user: User) {
            textView.text = user.toString()
        }

        override fun onError(e: Throwable) {
        }

        override fun onComplete() {
        }
    }))

// onDestroy
disposable.dispose()
```

DEMO

Dependencies

```
dependencies {
    implementation 'io.reactivex.rxjava2:rxkotlin:2.2.0'
    implementation 'io.reactivex.rxjava2:rxandroid:2.0.1'
}
```

Options

Options

- Callbacks

```
describe('.totalValue', function(){
  it('should calculate the total value of items in a space', function(done){
  var table = new Item('table', 'dining room','07/23/2014', '1','3000');
  var chair = new Item('chair', 'living room','07/23/2014', '3','300');
  var couch = new Item('couch', 'living room','07/23/2014', '2','1100');
  var chair2 = new Item('chair', 'dining room','07/23/2014', '4','500');
  var bed = new Item('bed', 'bed room','07/23/2014', '1','2000');

  table.save(function(){
    chair.save(function(){
      couch.save(function(){
        chair2.save(function(){
          bed.save(function(){
            Item.totalValue({room: 'dining room'}, function(totalValue){
              expect(totalValue).to.equal(5000);
              done();
              });
            });
          });
        });
      });
    });
  });
});
```

Options

- Callbacks
- Futures

What's the Future

- `Callable` – `Runnable` on steroids

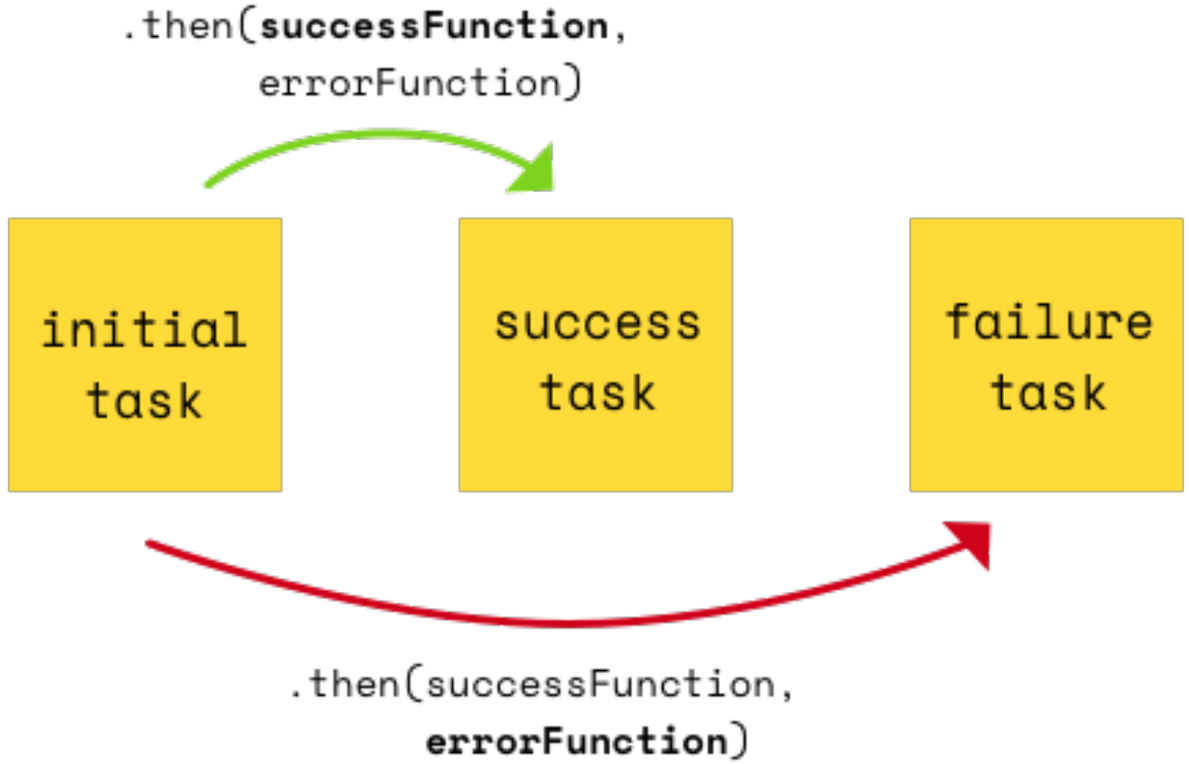
```
Callable<V> {
  V call() throws Exception;
}
```

- `Future` – result of an asynchronous computation

```
Future<V> {
  V get();
  boolean cancel();
  boolean isCancelled();
  boolean isDone();
}
```

Options

- Callbacks
- Futures
- Promises

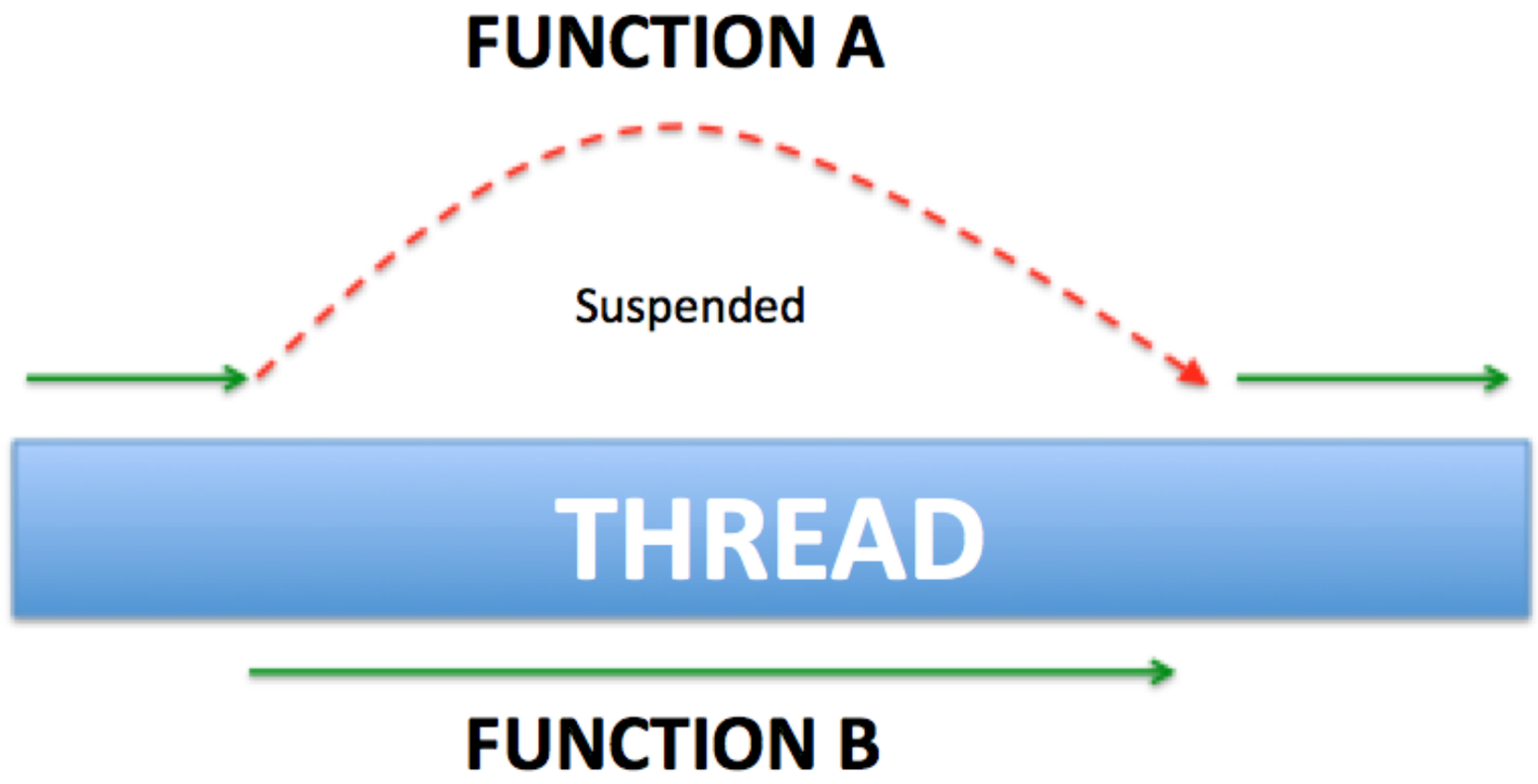


Options

- Callbacks
- Futures
- Promises
- Rx

Options

- Callbacks
- Futures
- Promises
- Rx
- Coroutines



https://kotlinlang.org/docs/reference/coroutines-overview.html

Coroutines

```
fun requestToken(): Token {
    // make a token request and waits
    return token
}

fun createPost(token: Token, item: Item): Post {
    logd("Posting an $item using $token")
    //sends the item to the server and waits
    return post
}

fun processPost(post: Post) {
    // processing the post
    logd("Processing a $post")
}

fun postItem(item: Item) {
    val token = requestToken()
    val post = createPost(token, item)
    processPost(post)
}
```

Coroutines

```
fun requestToken(): Token {
    // make a token request
    // block the thread while waiting for result
    return token
}

fun createPost(token: Token, item: Item): Post {
    logd("Posting an $item using $token")
    //sends the item to the server and waits
    return post
}

fun processPost(post: Post) {
    // processing the post
    logd("Processing a $post")
}

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    val token = requestToken()
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Coroutines

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suspend fun postItem(item: Item) {
    val token = requestToken()
    val post = createPost(token, item)
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}
```

Bonuses

Regular loops:

```
for ((token, item) in list) {
    createPost(token, item)
}
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Regular loops:

```
for ((token, item) in list) {
    createPost(token, item)
}
```

Regular exception handling:

```
try {
    createPost(token, item)
} catch (e: BadTokenException) {
    // ...
}
```

Bonuses

Regular loops:

```
for ((token, item) in list) {
    createPost(token, item)
}
```

Regular exception handling:

```
try {
    createPost(token, item)
} catch (e: BadTokenException) {
    // ...
}
```

Regular higher-order function:

```
file.readLines().forEach { line ->
    createPost(token, line.toItem())
}
```

Bonuses

Regular loops:

```
for ((token, item) in list) {
    createPost(token, item)
}
```

Regular exception handling:

```
try {
    createPost(token, item)
} catch (e: BadTokenException) {
    // ...
}
```

Regular higher-order function:

```
file.readLines().forEach { line ->
    createPost(token, line.toItem())
}
```

Any of: forEach, let, apply, repeat, filter, map, use, etc.

Builders

```
suspend fun requestToken(): Token {
    // make a token request and suspends
    return token
}

suspend fun createPost(token: Token, item: Item): Post {
    logd("Posting an $item using $token")
    //sends the item to the server and waits
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fun processPost(post: Post) {
    // processing the post
    logd("Processing a $post")
}

fun postItem(item: Item) {
    val token = requestToken()
    val post = createPost(token, item)
    processPost(post)
}
```

Suspend function 'requestToken' should be called only from a coroutine or another suspend function

Builders

```
suspend fun requestToken(): Token {
    // make a token request and suspends
    return token
}

suspend fun createPost(token: Token, item: Item): Post {
    logd("Posting an $item using $token")
    //sends the item to the server and waits
    return post
}

fun processPost(post: Post) {
    // processing the post
    logd("Processing a $post")
}

fun postItem(item: Item) {
    GlobalScope.launch {
        val token = requestToken()
        val post = createPost(token, item)
        processPost(post)
    }
}
```

Builders

```
suspend fun requestToken(): Token {
    // make a token request and suspends
    return token
}

suspend fun createPost(token: Token, item: Item): Post {
    logd("Posting an $item using $token")
    //sends the item to the server and waits
    return post
}

fun processPost(post: Post) {
    // processing the post
    logd("Processing a $post")
}

fun postItem(item: Item) {
    GlobalScope.launch(Dispatchers.Main) {
      val token = requestToken()
      val post = createPost(token, item)
      processPost(post)
    }
}
```

Builders

```
public fun CoroutineScope.launch(
    context: CoroutineContext = EmptyCoroutineContext,
    start: CoroutineStart = CoroutineStart.DEFAULT,
    block: suspend CoroutineScope.() -> Unit
): Job {
    val newContext = newCoroutineContext(context)
    val coroutine = if (start.isLazy)
        LazyStandaloneCoroutine(newContext, block) else
        StandaloneCoroutine(newContext, active = true)
    coroutine.start(start, coroutine, block)
    return coroutine
}
```

Dependencies

```
dependencies {
  implementation 'org.jetbrains.kotlinx:kotlinx-coroutines-core:1.3.2'
  implementation “org.jetbrains.kotlinx:kotlinx-coroutines-android:1.3.0"
}
```

Usage

```
class MyViewModel : ViewModel() {
  private val _result = MutableLiveData<String>()
  val result: LiveData<String> = _result

  init {
    viewModelScope.launch {
      val computationalResult = doComputation()
      _result.value = computationalResult
    }
  }
}
```

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  init {
    viewModelScope.launch {
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Usage

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class MyViewModel : ViewModel() {
  private val _result = MutableLiveData<String>()
  val result: LiveData<String> = _result

  init {
    viewModelScope.launch {
      val computationalResult = doComputation()
      _result.value = computationalResult
    }
  }
}
```

```
implementation "androidx.lifecycle:lifecycle-viewmodel-ktx:2.2.0-rc01"
```

Usage

```
class MyNewViewModel : ViewModel() {
  val result = liveData {
    emit(doComputation())
  }
}
```

Usage

```
class MyNewViewModel : ViewModel() {
  val result = liveData {
    emit(doComputation())
  }
}
```

Usage

```
class MyNewViewModel : ViewModel() {
  val result = liveData {
    emit(doComputation())
  }
}
```

```
implementation "androidx.lifecycle:lifecycle-livedata-ktx:2.2.0-rc01"
```

Flow

```
suspend fun foo(): List<Int> {
    delay(1000) // pretend we are doing something asynchronous here
    return listOf(1, 2, 3)
}

fun main() = runBlocking<Unit> {
    foo().forEach { value -> println(value) }
}
```

Flow

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suspend fun foo(): List<Int> {
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    return listOf(1, 2, 3)
}

fun main() = runBlocking<Unit> {
    foo().forEach { value -> println(value) }
}
```

```
Output:

1
2
3
```

Flow

```
fun foo(): Flow<Int> = flow { // flow builder
    for (i in 1..3) {
        delay(100) // pretend we are doing something useful here
        emit(i) // emit next value
    }
}
fun main() = runBlocking<Unit> {
    // Launch a concurrent coroutine to check if the main thread is blocked
    launch {
        for (k in 1..3) {
            println("I'm not blocked $k")
            delay(100)
        }
    }
    // Collect the flow
    foo().collect { value -> println(value) }
}
```

Flow

```
fun foo(): Flow<Int> = flow { // flow builder
    for (i in 1..3) {
        delay(100) // pretend we are doing something useful here
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            println("I'm not blocked $k")
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        }
    }
    // Collect the flow
    foo().collect { value -> println(value) }
}
```

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fun foo(): Flow<Int> = flow { // flow builder
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        emit(i) // emit next value
    }
}
fun main() = runBlocking<Unit> {
    // Launch a concurrent coroutine to check if the main thread is blocked
    launch {
        for (k in 1..3) {
            println("I'm not blocked $k")
            delay(100)
        }
    }
    // Collect the flow
    foo().collect { value -> println(value) }
}
```

```
Output:

I'm not blocked 1
1
I'm not blocked 2
2
I'm not blocked 3
3
```

Flows are cold

```
fun foo(): Flow<Int> = flow {
    println("Flow started")
    for (i in 1..3) {
        delay(100)
        emit(i)
    }
}
fun main() = runBlocking<Unit> {
    println("Calling foo...")
    val flow = foo()
    println("Calling collect...")
    flow.collect { value -> println(value) }
    println("Calling collect again...")
    flow.collect { value -> println(value) }
}
```

Flows are cold

```
fun foo(): Flow<Int> = flow {
    println("Flow started")
    for (i in 1..3) {
        delay(100)
        emit(i)
    }
}
fun main() = runBlocking<Unit> {
    println("Calling foo...")
    val flow = foo()
    println("Calling collect...")
    flow.collect { value -> println(value) }
    println("Calling collect again...")
    flow.collect { value -> println(value) }
}
```

```
Output:

Calling foo...
Calling collect...
Flow started
1
2
3
Calling collect again...
Flow started
1
2
3
```

Flow Cancellation

```
fun fooCancellation(): Flow<Int> = flow {
  for (i in 1..3) {
    delay(100)
    println("Emitting $i")
    emit(i)
  }
}

fun main() = runBlocking<Unit> {
  withTimeoutOrNull(250) { // Timeout after 250ms
    fooCancellation().collect { value -> println(value) }
  }
  println("Done")
}
```

Flow Cancellation

```
fun fooCancellation(): Flow<Int> = flow {
  for (i in 1..3) {
    delay(100)
    println("Emitting $i")
    emit(i)
  }
}

fun main() = runBlocking<Unit> {
  withTimeoutOrNull(250) { // Timeout after 250ms
    fooCancellation().collect { value -> println(value) }
  }
  println("Done")
}
```

```
Output:

Emitting 1
1
Emitting 2
2
Done
```

Flow Operators

```
suspend fun performRequest(request: Int): String {
    delay(1000) // imitate long-running asynchronous work
    return "response $request"
}

fun main() = runBlocking<Unit> {
    (1..3).asFlow() // a flow of requests
        .map { request -> performRequest(request) }
        .collect { response -> println(response) }
}
```

Flow Operators

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suspend fun performRequest(request: Int): String {
    delay(1000) // imitate long-running asynchronous work
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}

fun main() = runBlocking<Unit> {
    (1..3).asFlow() // a flow of requests
        .map { request -> performRequest(request) }
        .collect { response -> println(response) }
}
```

Output:

```
response 1
response 2
response 3
```

Transform Operator

```
suspend fun performRequest(request: Int): String {
    delay(1000) // imitate long-running asynchronous work
    return "response $request"
}
(1..3).asFlow() // a flow of requests
    .transform { request ->
        emit("Making request $request")
        emit(performRequest(request))
    }
    .collect { response -> println(response) }
```

Transform Operator

```
suspend fun performRequest(request: Int): String {
    delay(1000) // imitate long-running asynchronous work
    return "response $request"
}
(1..3).asFlow() // a flow of requests
    .transform { request ->
        emit("Making request $request")
        emit(performRequest(request))
    }
    .collect { response -> println(response) }
```

Output:

```
Making request 1
response 1
Making request 2
response 2
Making request 3
response 3
```

Size-limiting Operators

```
fun numbers(): Flow<Int> = flow {
  try {
    emit(1)
    emit(2)
    println("This line will not execute")
    emit(3)
  } finally {
    println("Finally in numbers")
  }
}
@ExperimentalCoroutinesApi
fun main() = runBlocking<Unit> {
  numbers()
    .take(2) // take only the first two
    .collect { value -> println(value) }
}
```

Size-limiting Operators

```
fun numbers(): Flow<Int> = flow {
  try {
    emit(1)
    emit(2)
    println("This line will not execute")
    emit(3)
  } finally {
    println("Finally in numbers")
  }
}
@ExperimentalCoroutinesApi
fun main() = runBlocking<Unit> {
  numbers()
    .take(2) // take only the first two
    .collect { value -> println(value) }
}
```

```
Output:

1
2
Finally in numbers
```

DEMO

Terminal Flow Operators

```
@ExperimentalCoroutinesApi
fun main() = runBlocking<Unit> {
  val sum = (1..5).asFlow()
    .map { it * it } // squares of numbers from 1 to 5
    .reduce { a, b -> a + b } // sum them (terminal operator)
  println(sum)
}
```

DEMO

Terminal Flow Operators

```
@ExperimentalCoroutinesApi
fun main() = runBlocking<Unit> {
  val sum = (1..5).asFlow()
    .map { it * it } // squares of numbers from 1 to 5
    .reduce { a, b -> a + b } // sum them (terminal operator)
  println(sum)
}
```

```
Output: 55
```

DEMO

Terminal Flow Operators

```
@ExperimentalCoroutinesApi
fun main() = runBlocking<Unit> {
  val sum = (1..5).asFlow()
    .map { it * it } // squares of numbers from 1 to 5
    .reduce { a, b -> a + b } // sum them (terminal operator)
  println(sum)
}
```

```
Output: 55
```

kotlinlang.org/docs/reference/coroutines/flow.html

Lecture outcomes

- Understand the reactive programming (rx) concepts.
- Use rx to re-write the application logic.
- Design a real time application logic against a real time backend.
- Understand coroutines and flow.