App Frameworks

#WWDC16

# CloudKit Best Practices

Session 231

Dave Browning CloudKit Engineer
Nihar Sharma CloudKit Engineer

## What We'll Cover

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How Apple uses CloudKit

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Using the CKOperation API

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Modeling your data

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How Apple uses CloudKit

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Modeling your data

Handling errors

## Quick Refresher

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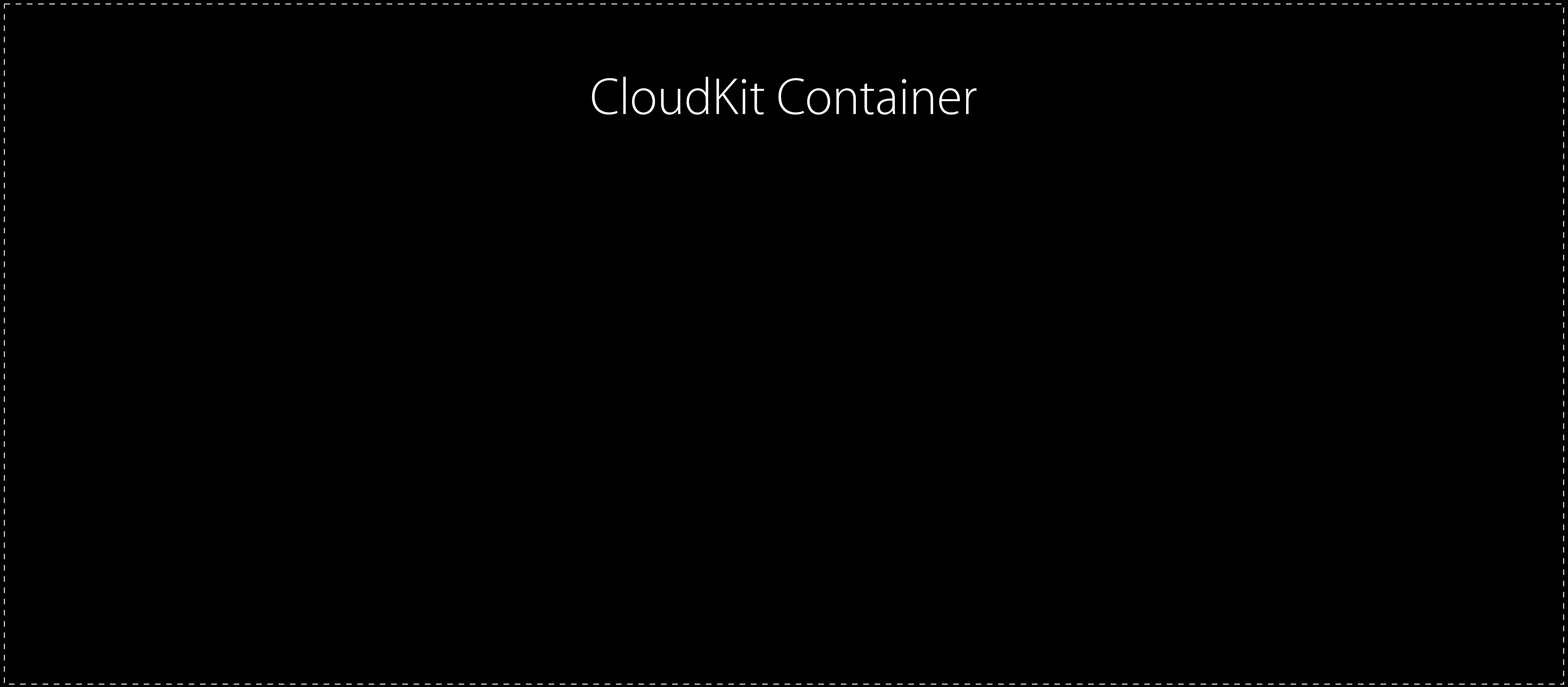

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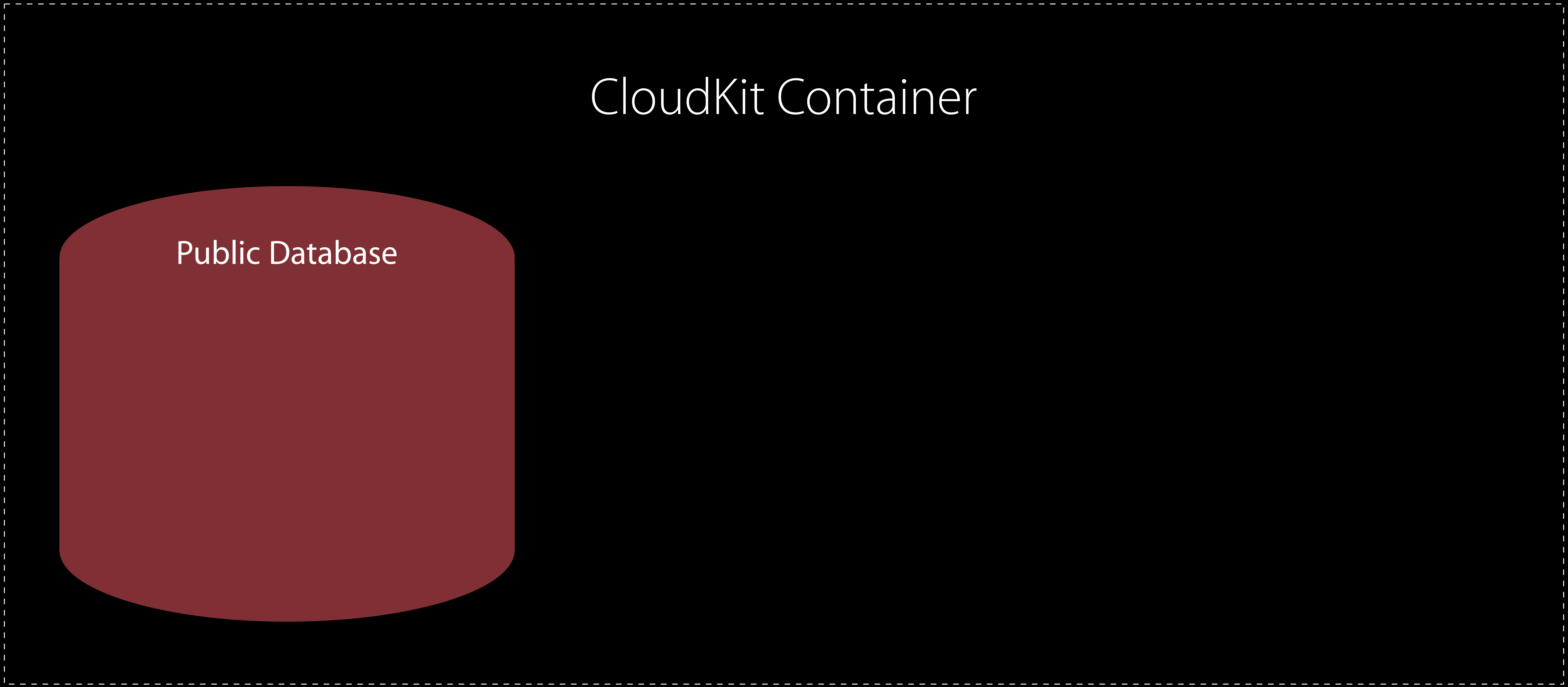

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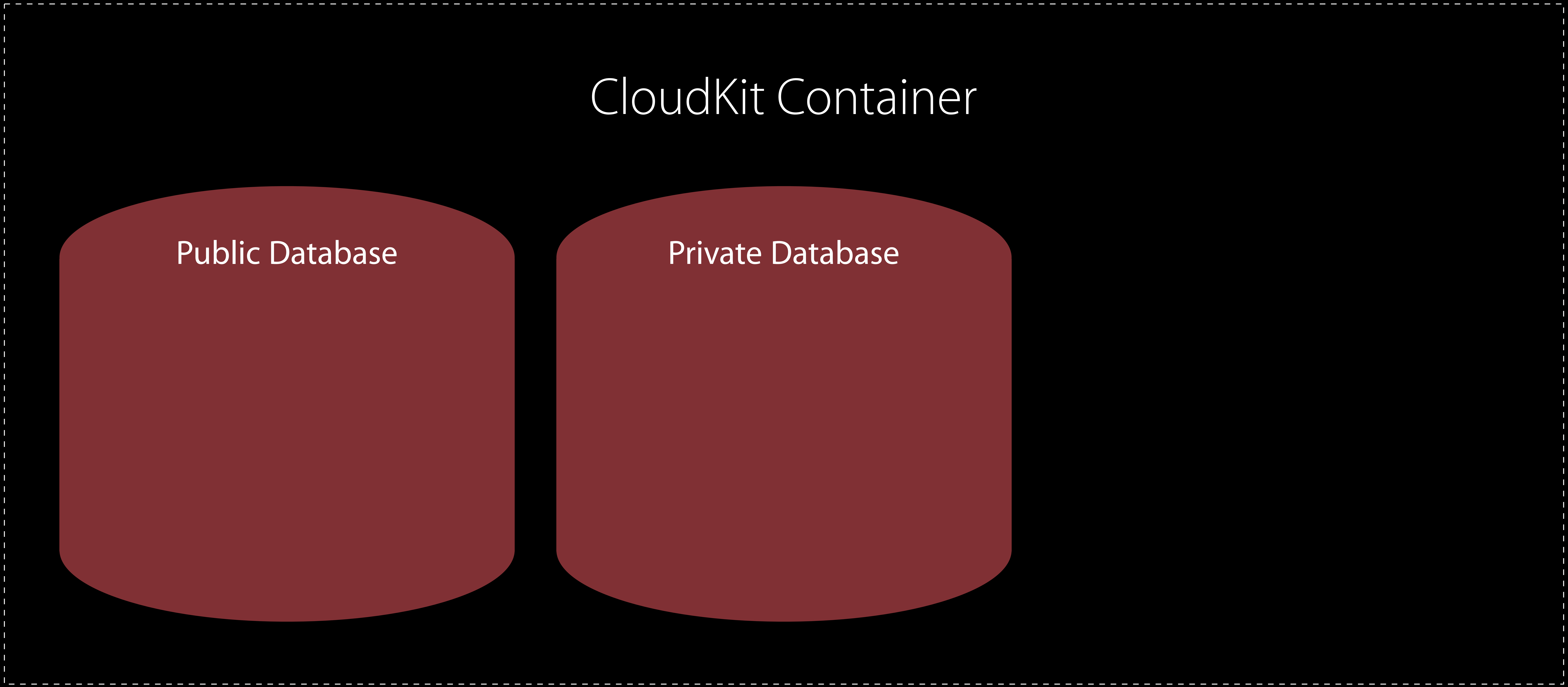

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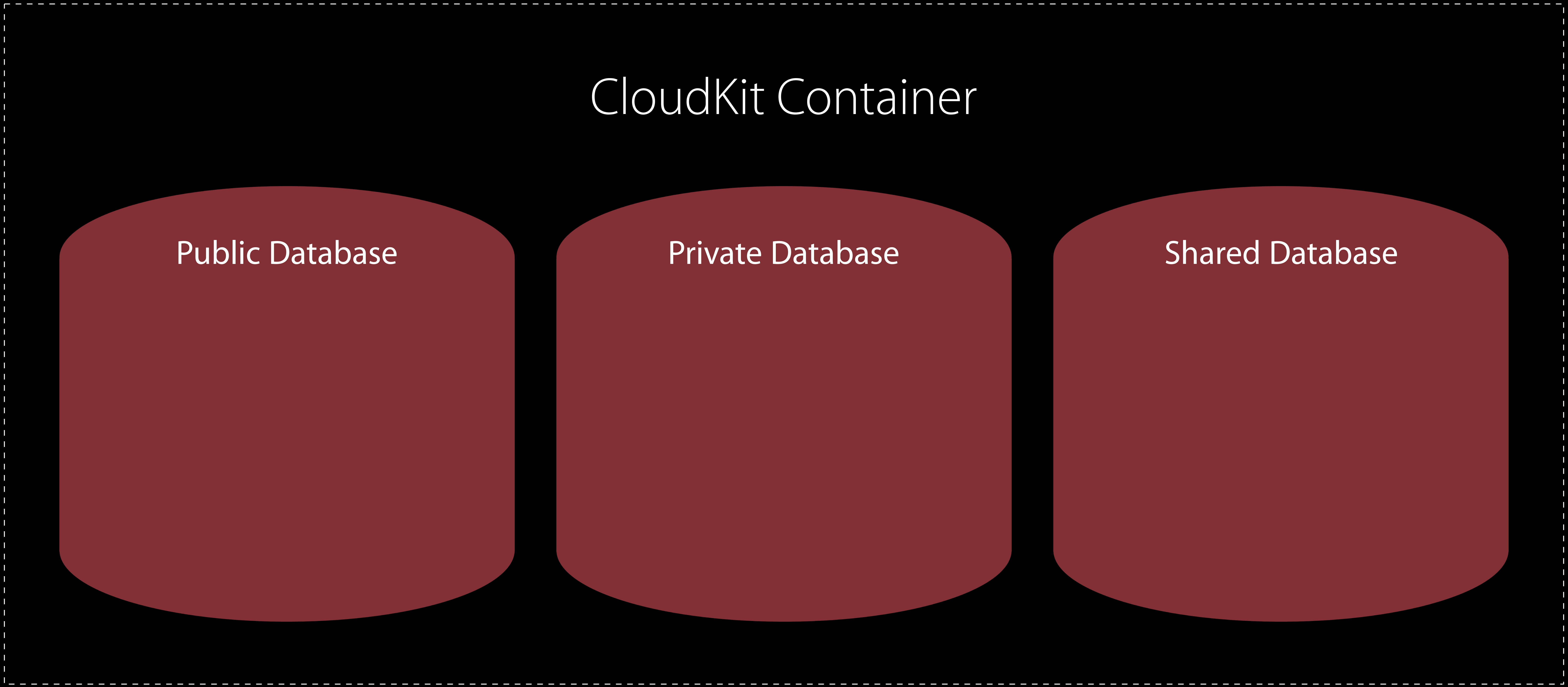

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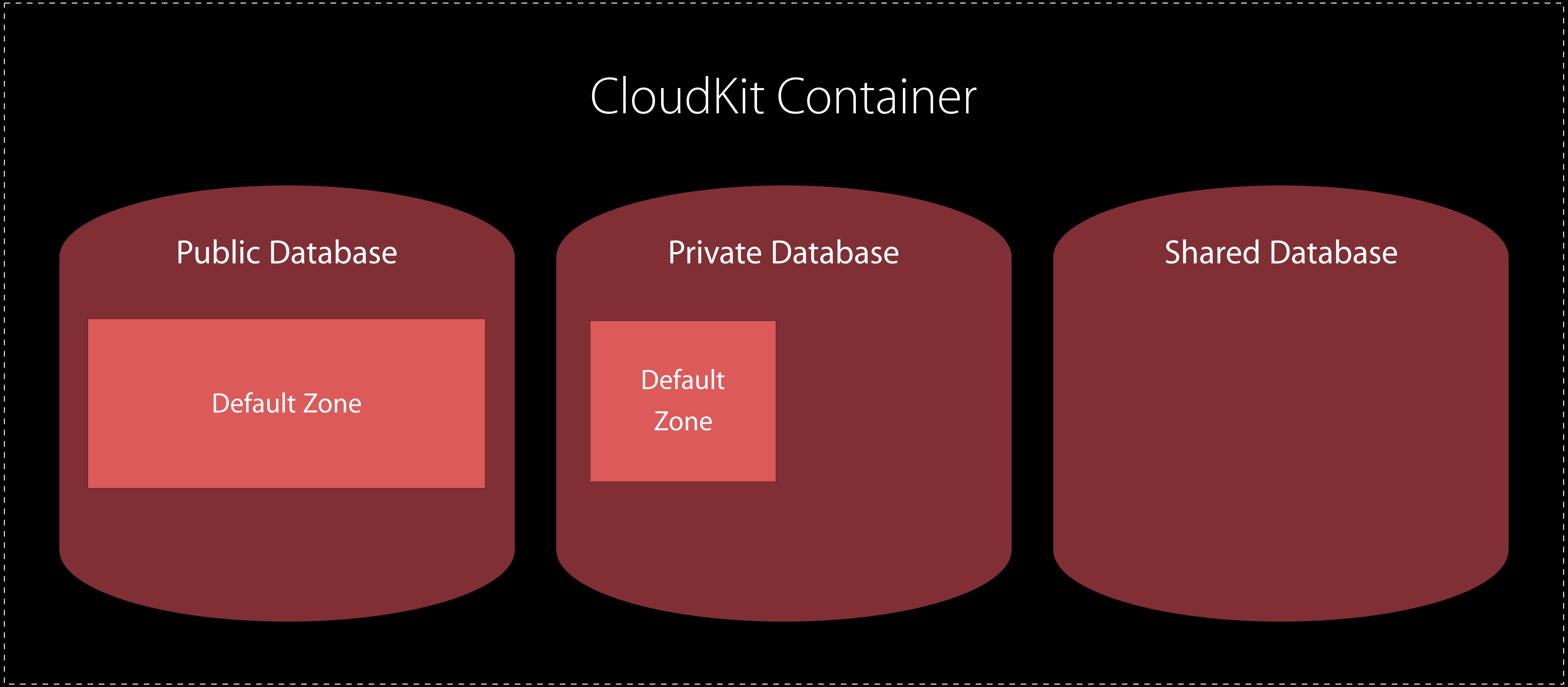

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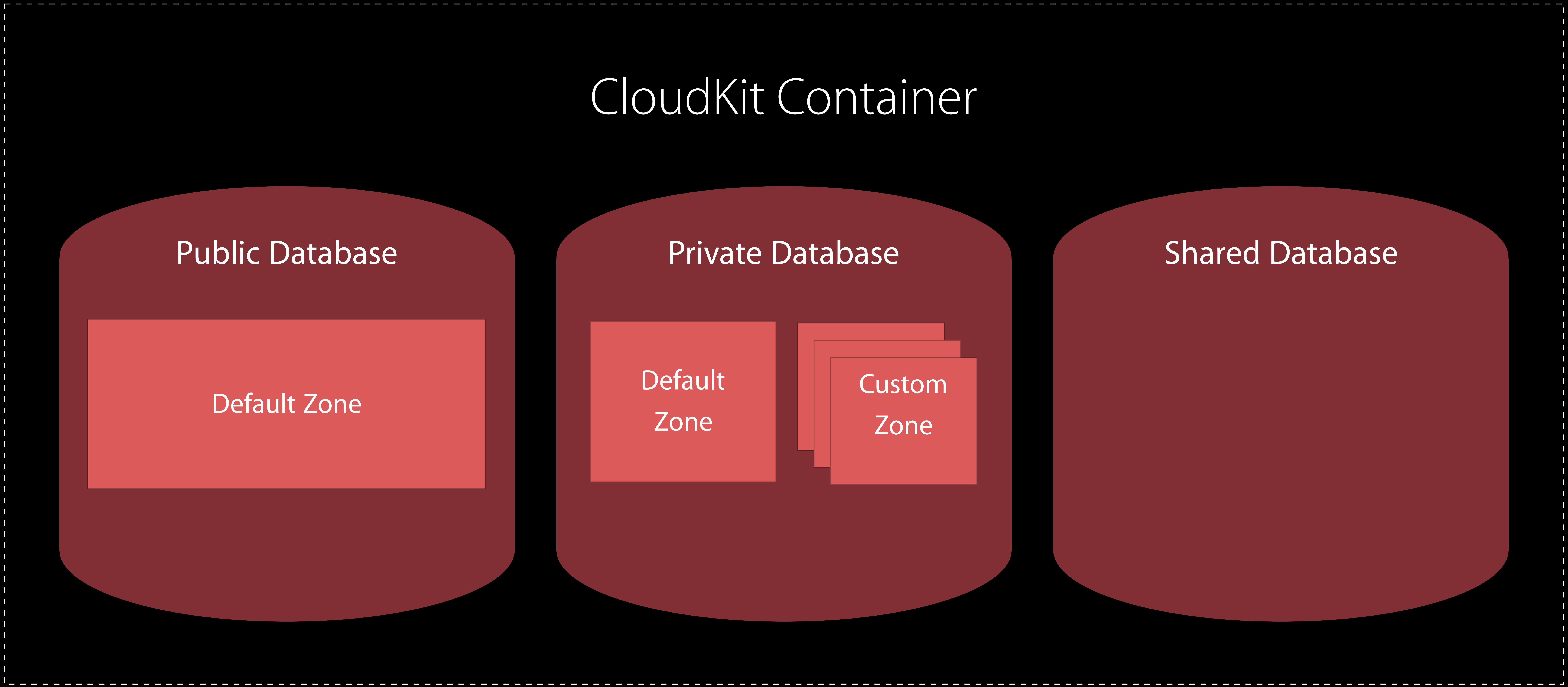

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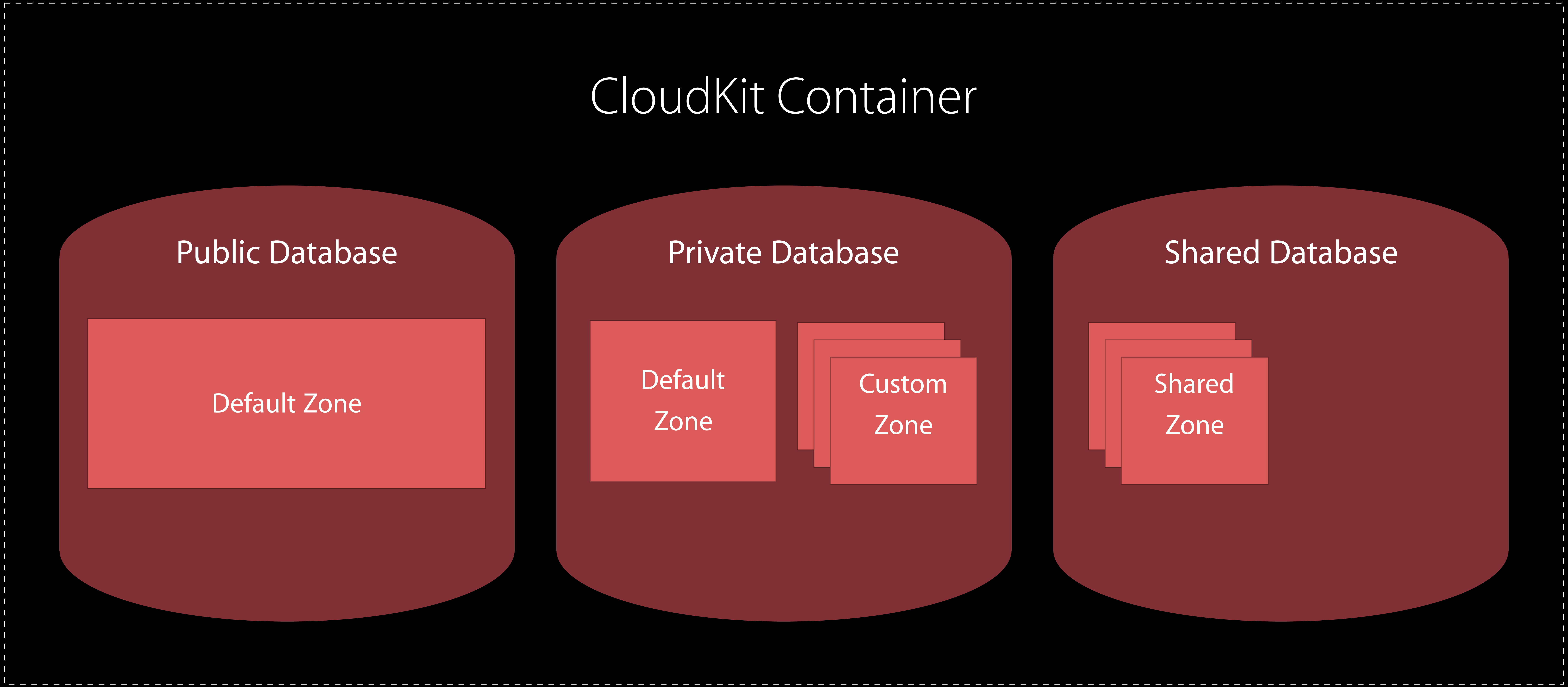

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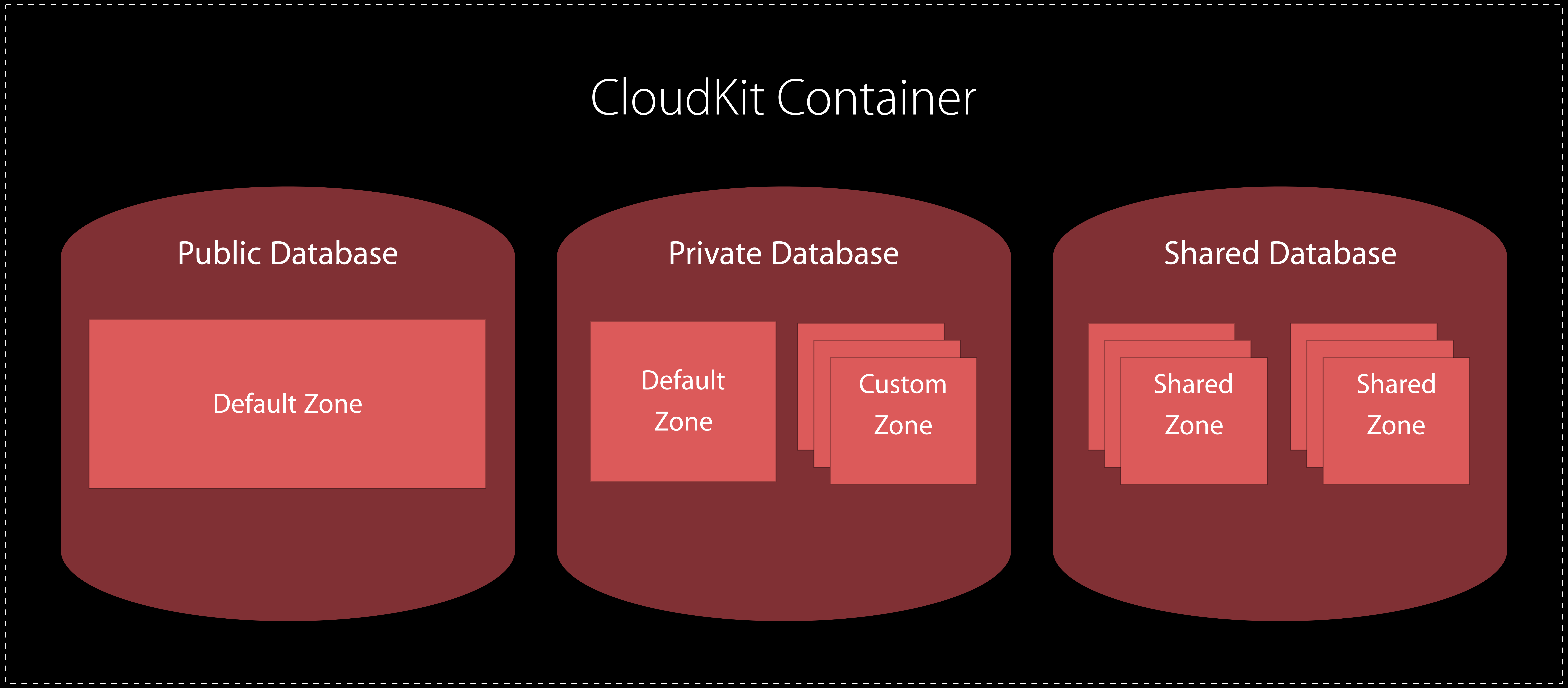

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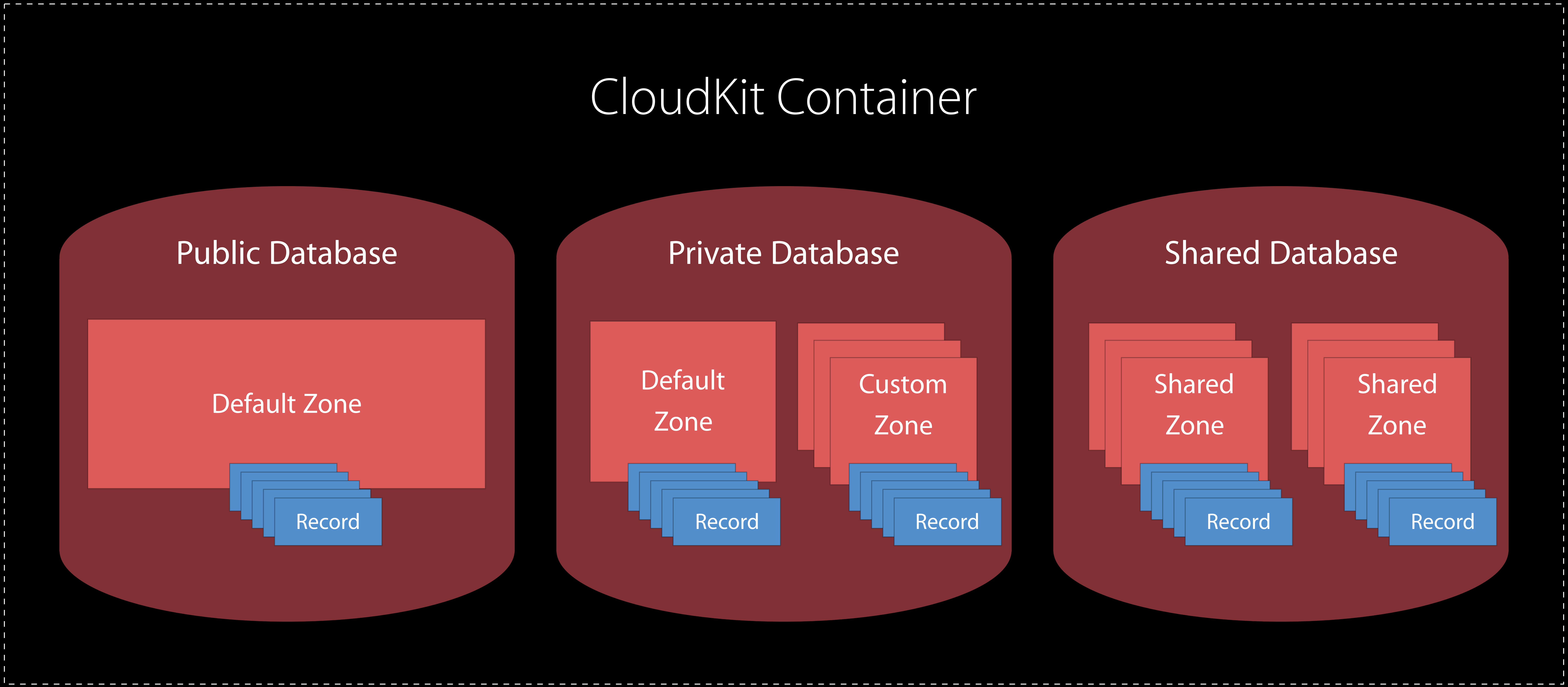

✓ Focus on building your app

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- ✓ Automatic authentication

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- ✓ Automatic authentication
- ✓ Same data across all devices

# The Use Case

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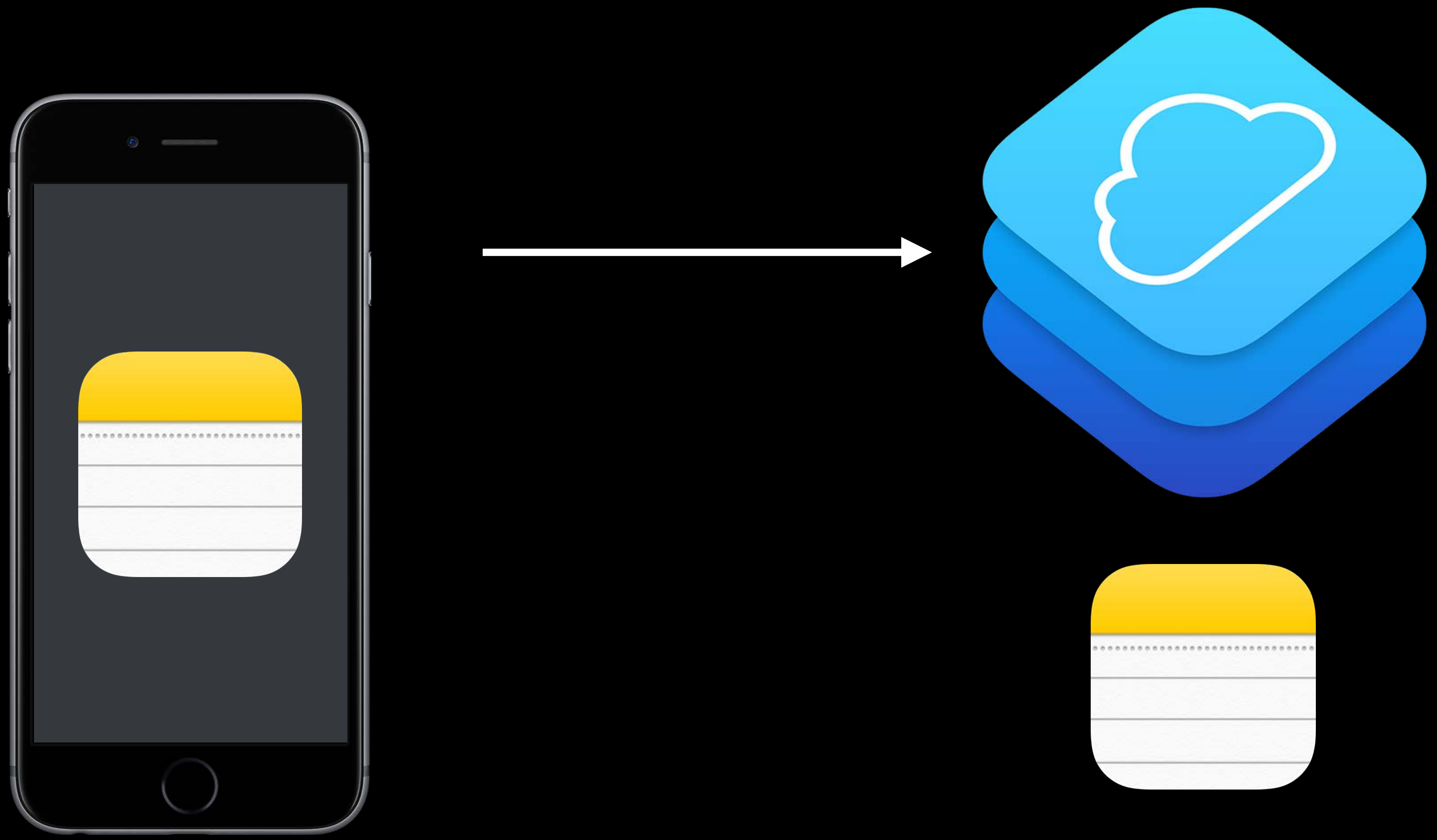

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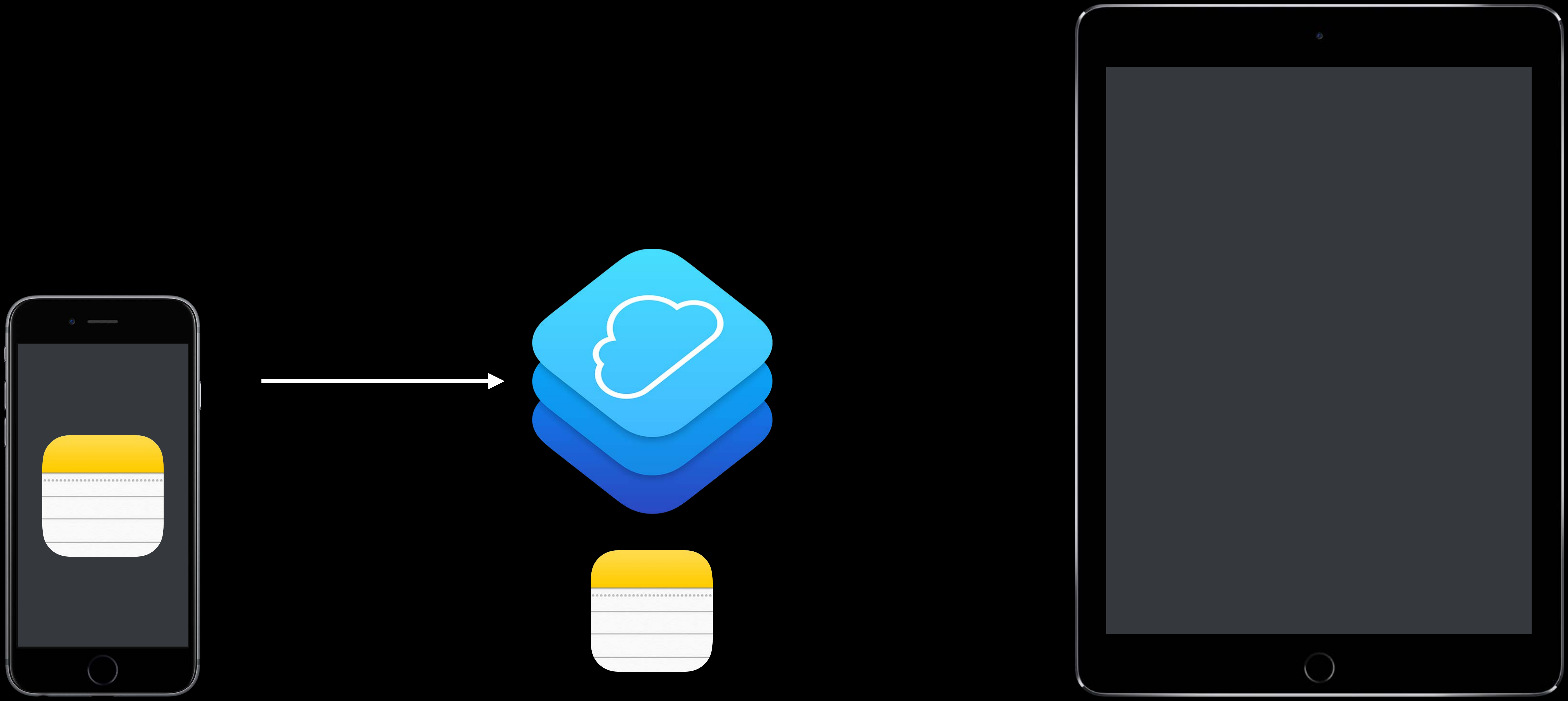

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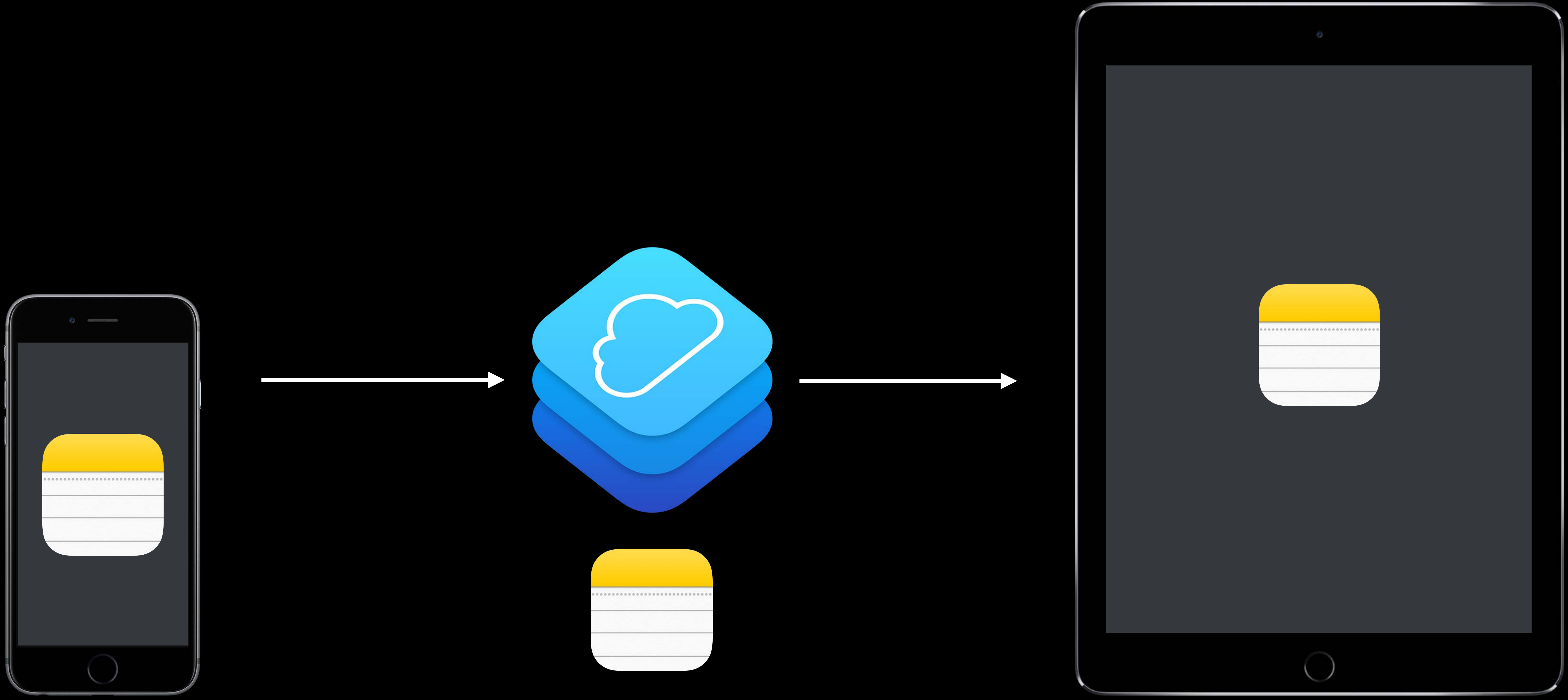

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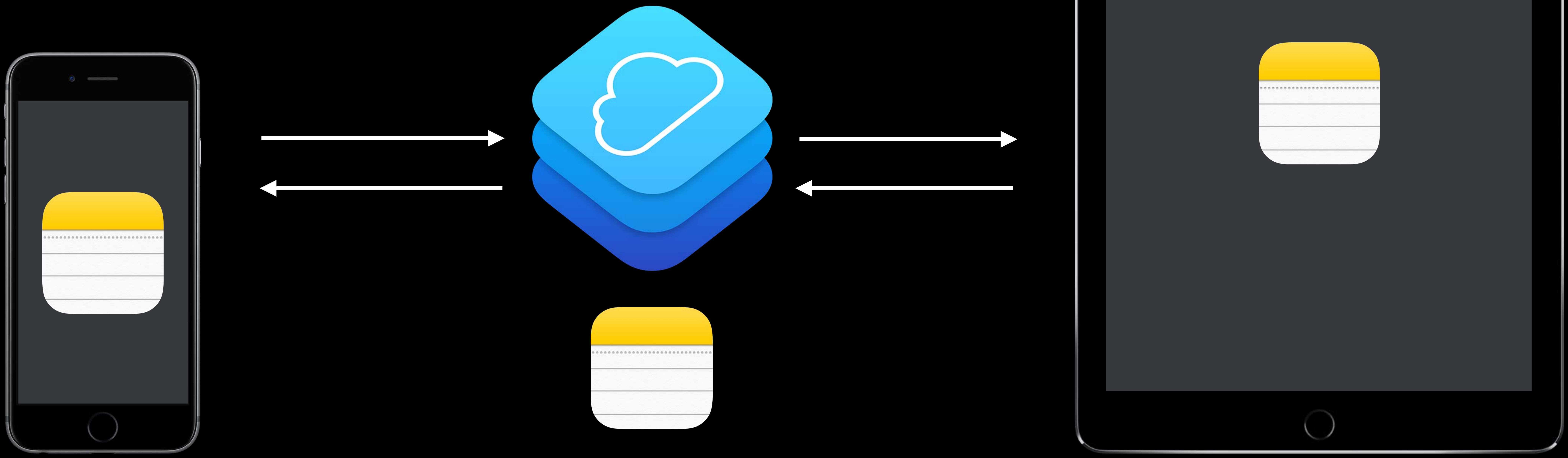

✓ iCloud is the source of truth

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- ✓ Devices have a local cache

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- ✓ Devices have a local cache
- ✓ CloudKit is the glue

## How Does It Work?

## On app launch

On app launch

Fetch changes

## On app launch

- Fetch changes
- Subscribe to future changes

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On push from CloudKit

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## Subscribe to Changes

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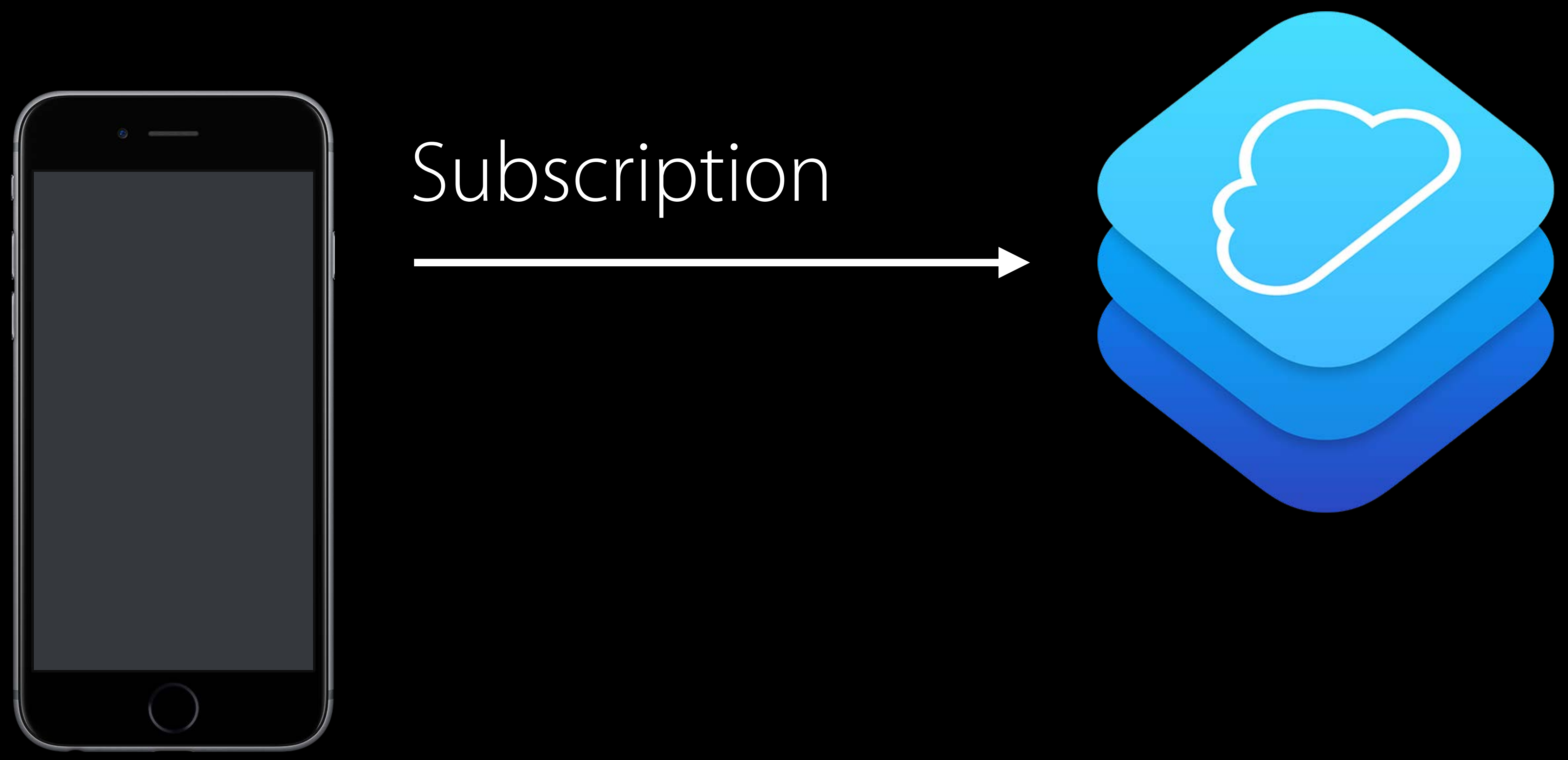

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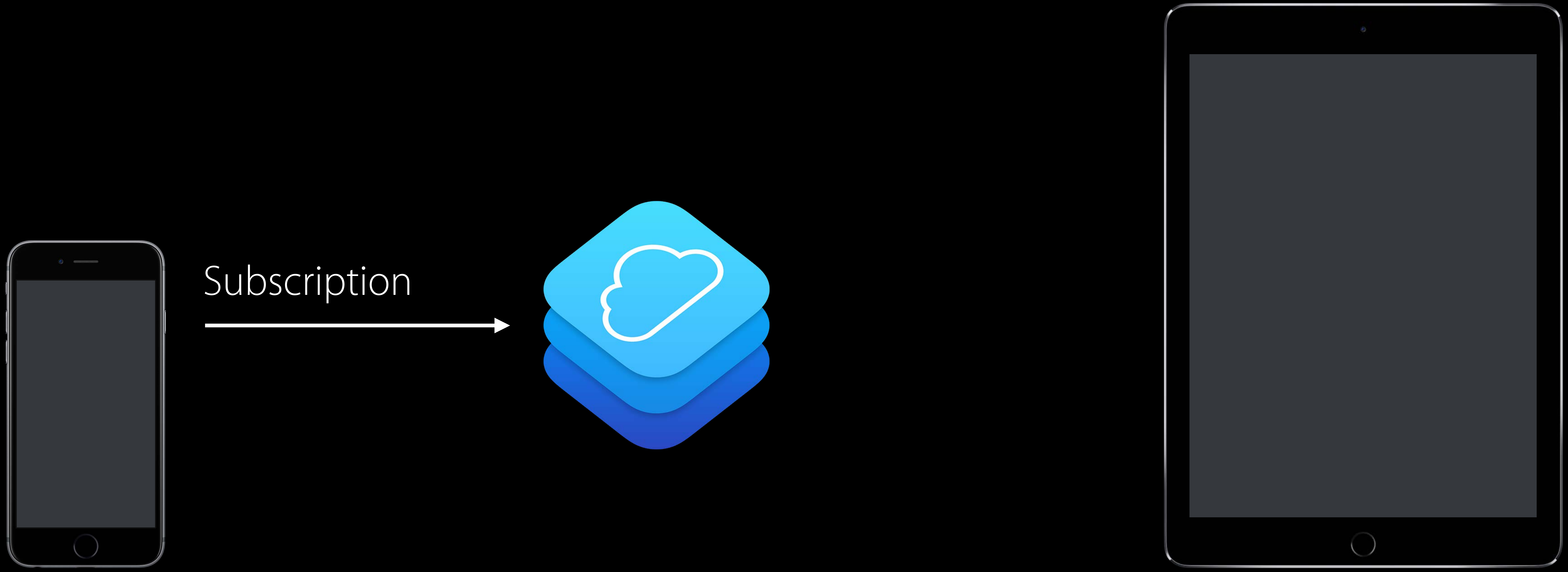

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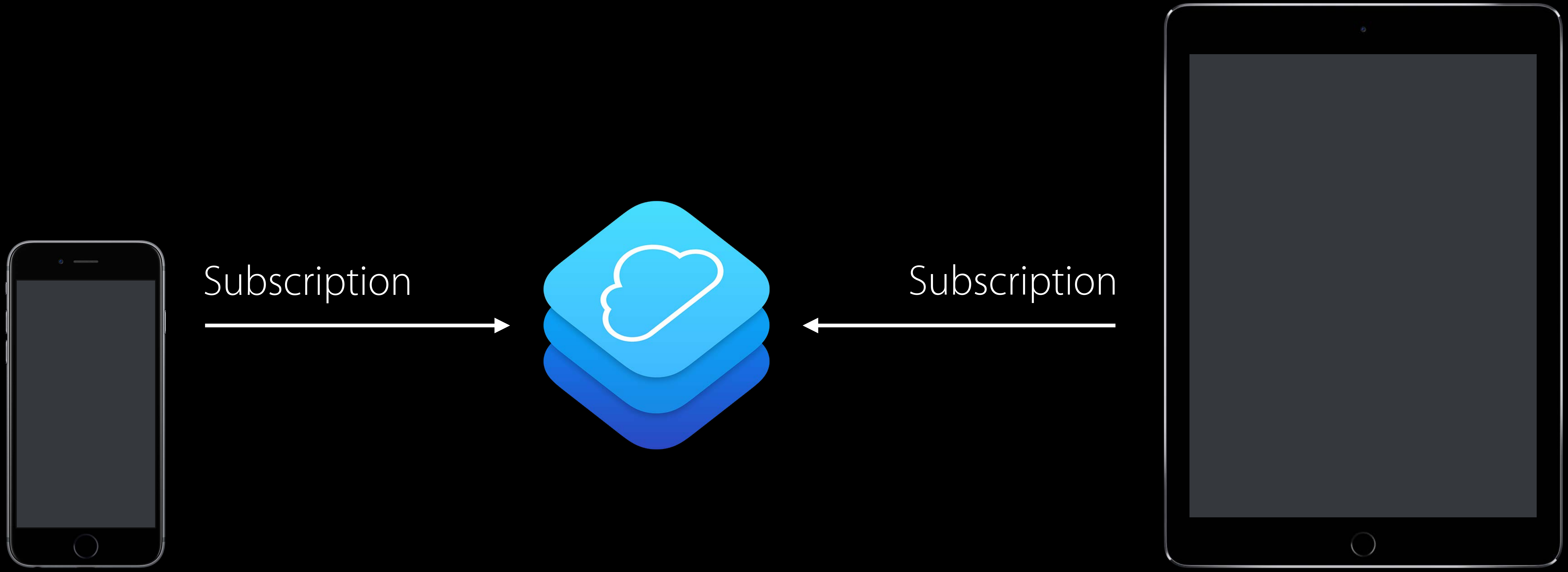

## Listen for Pushes

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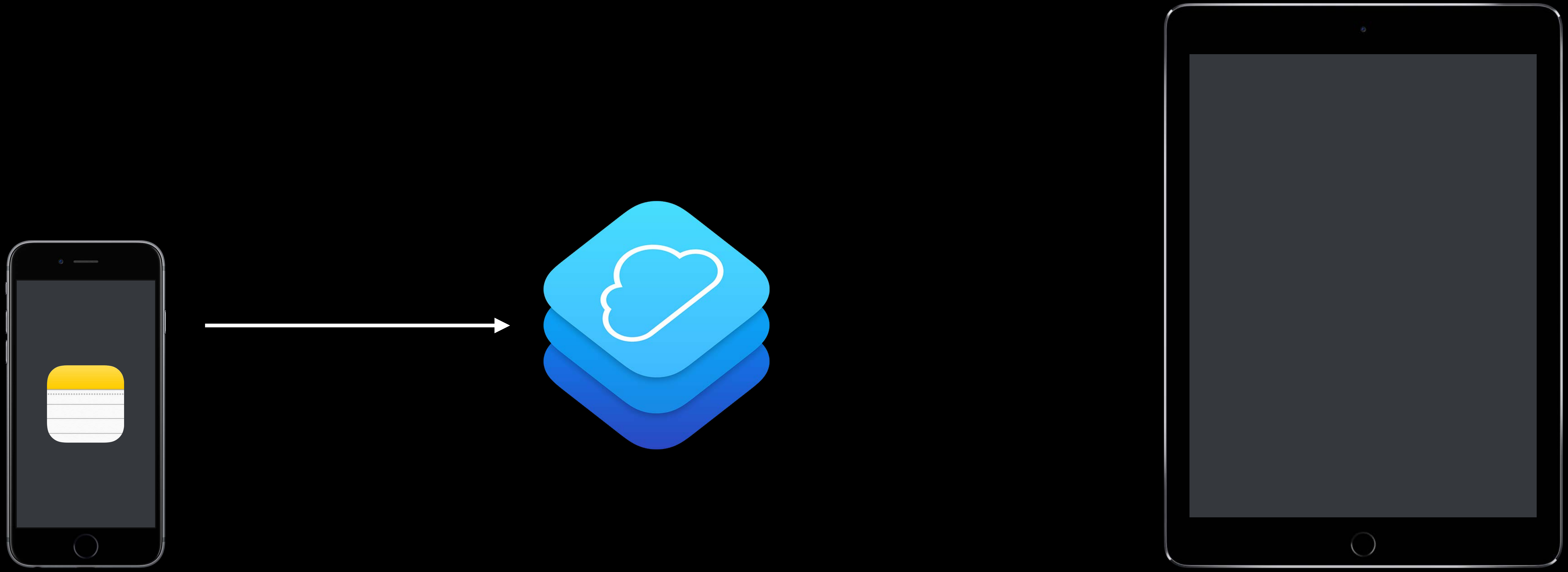

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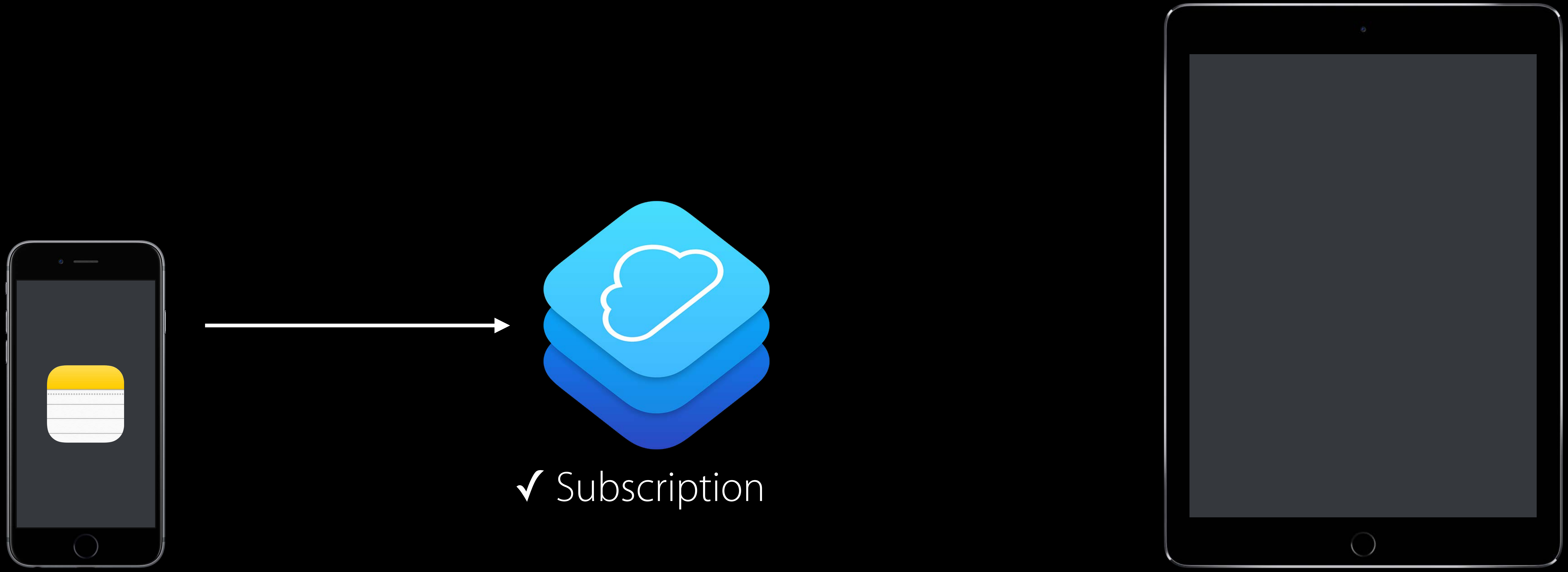

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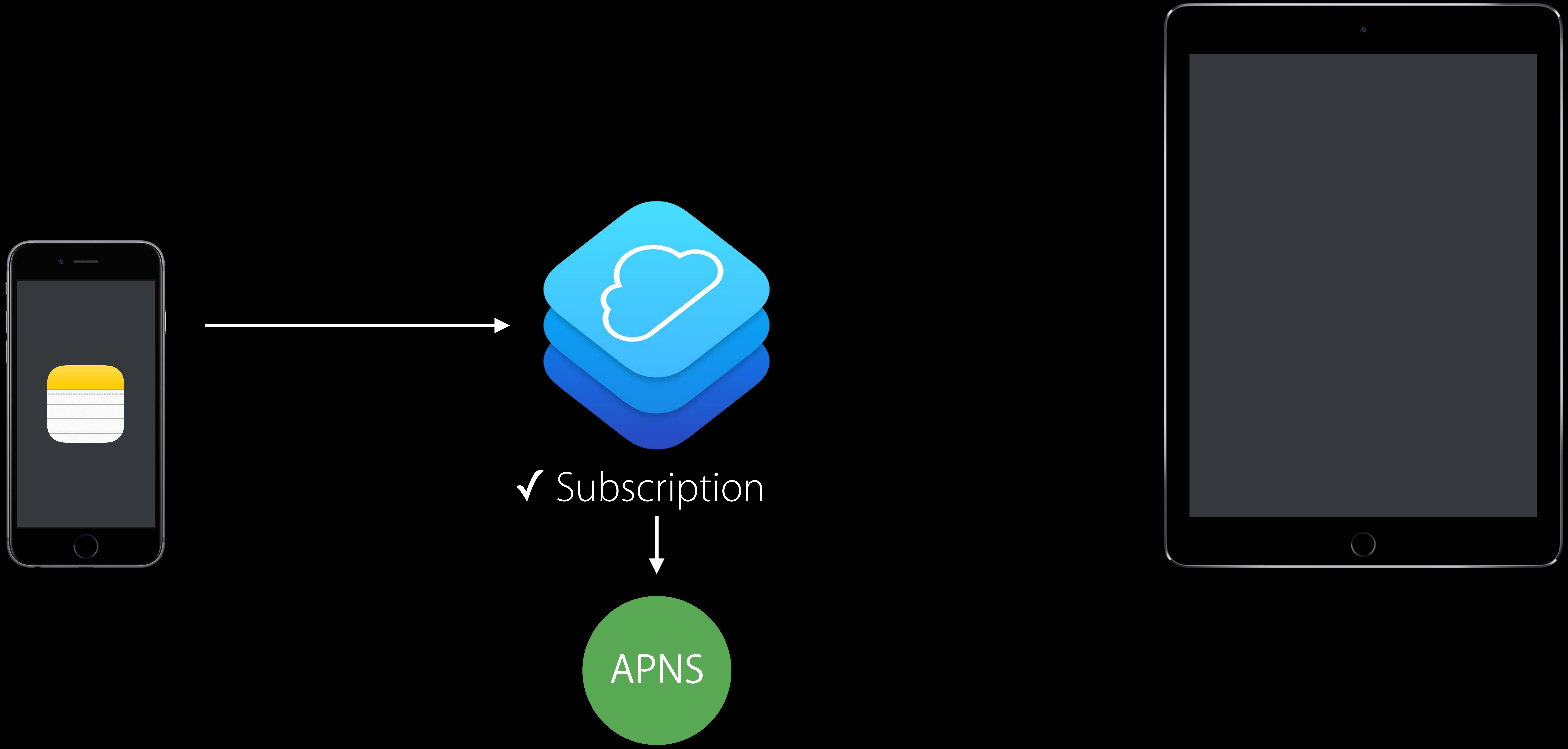

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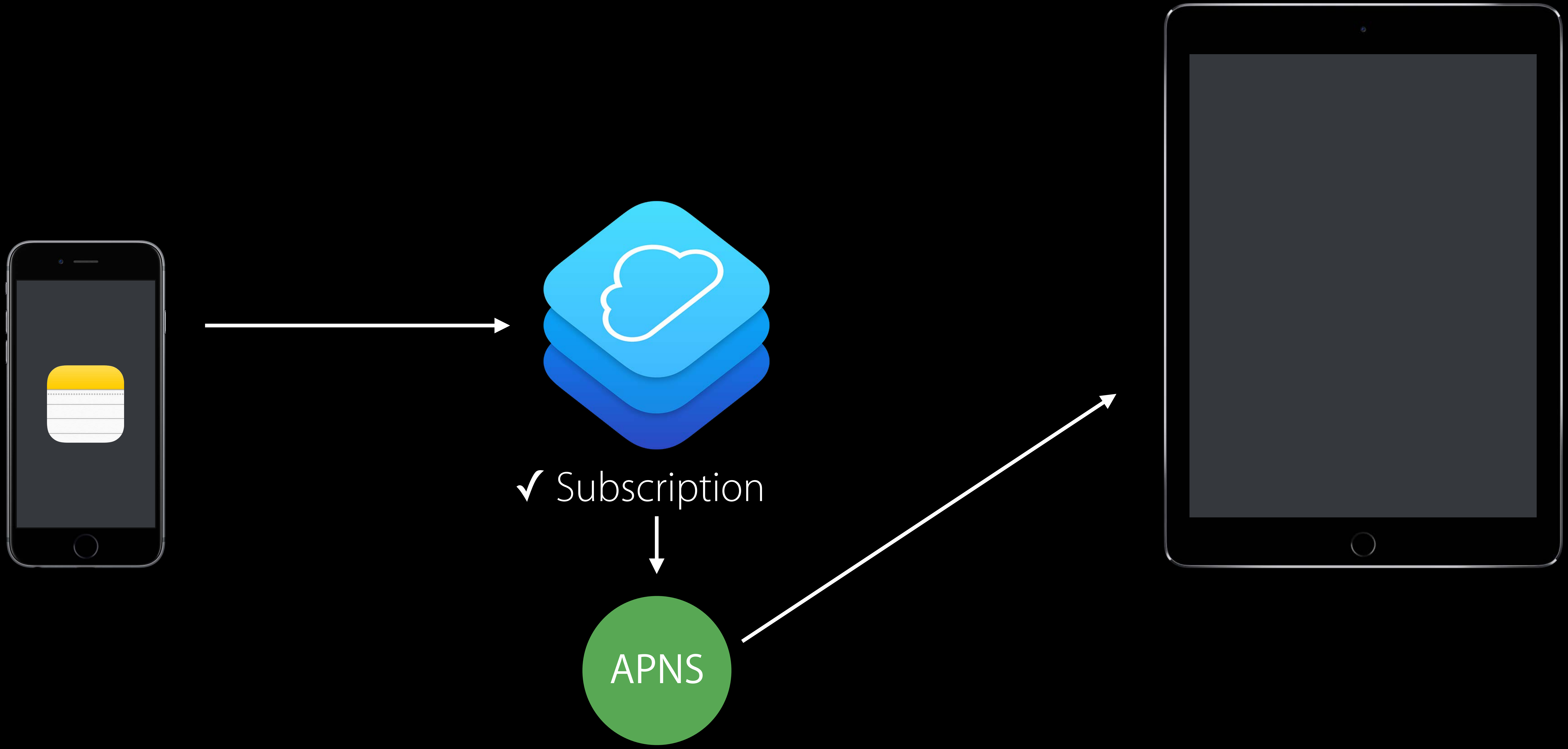

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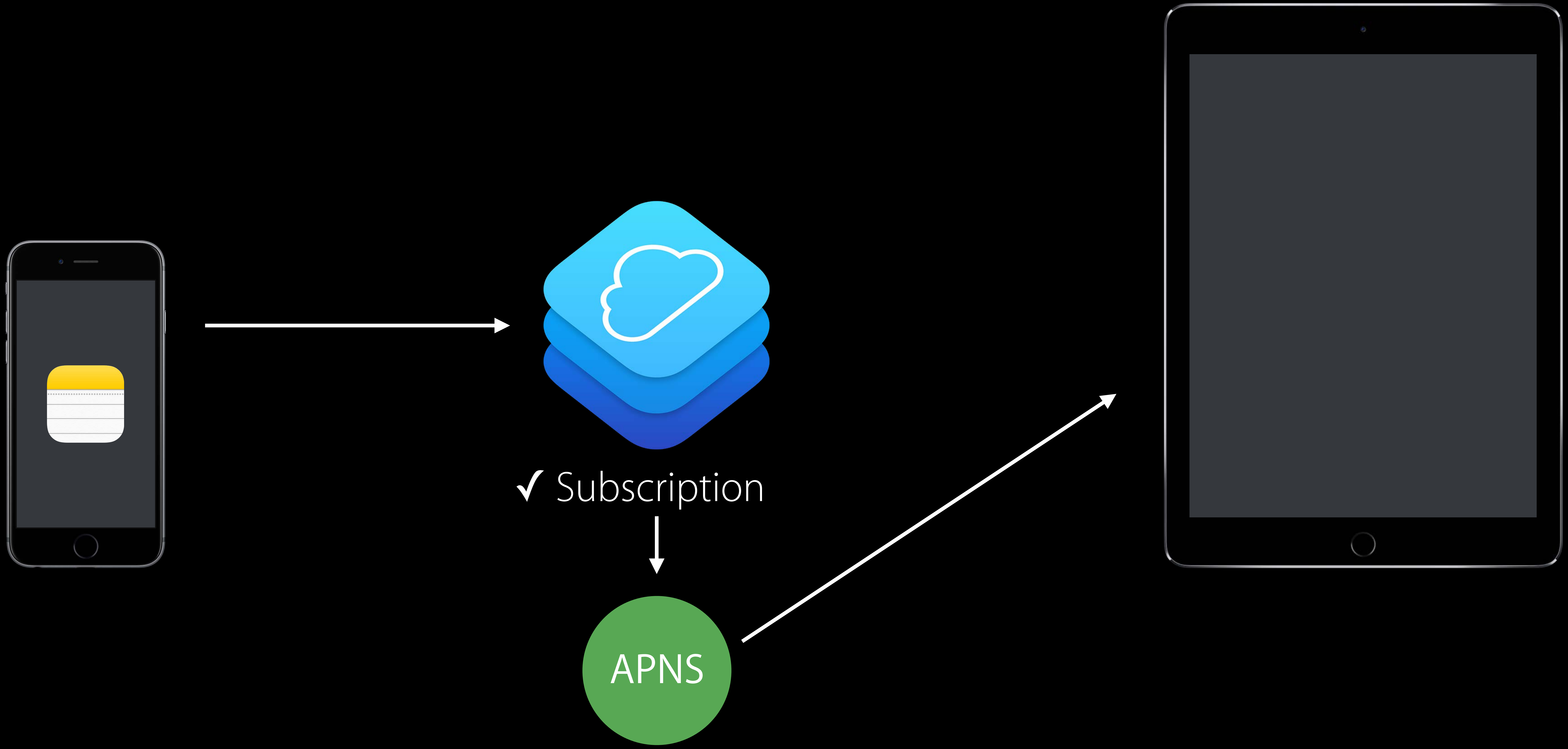

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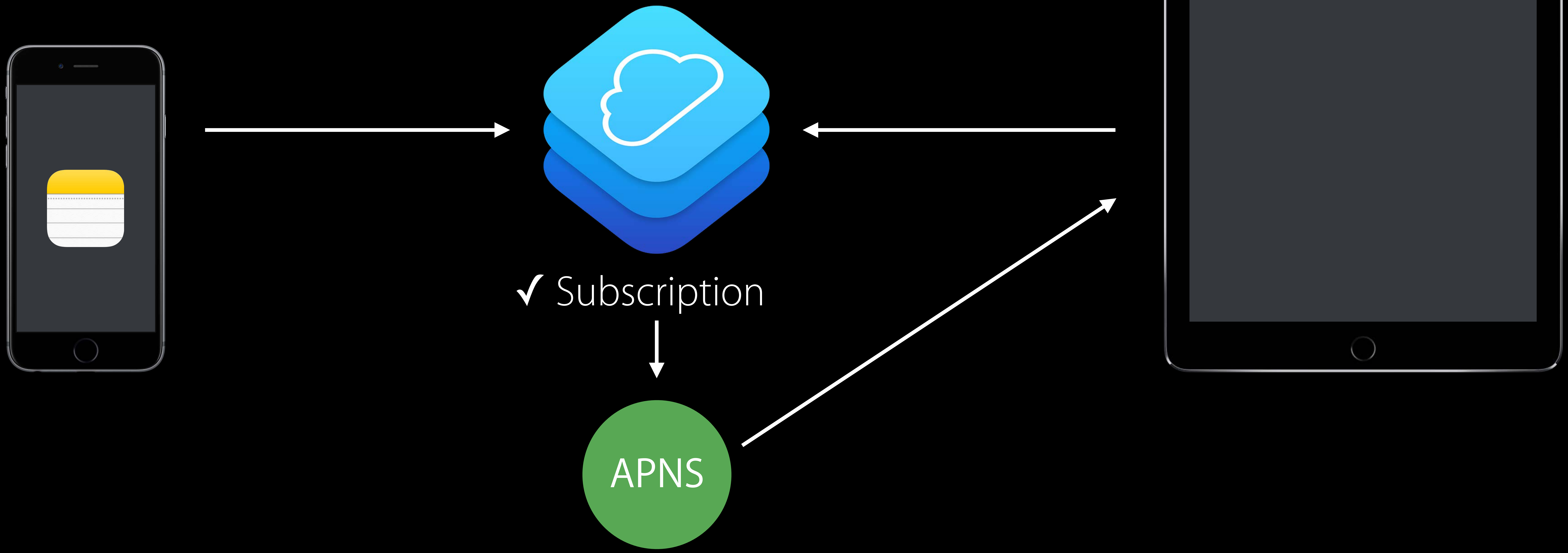

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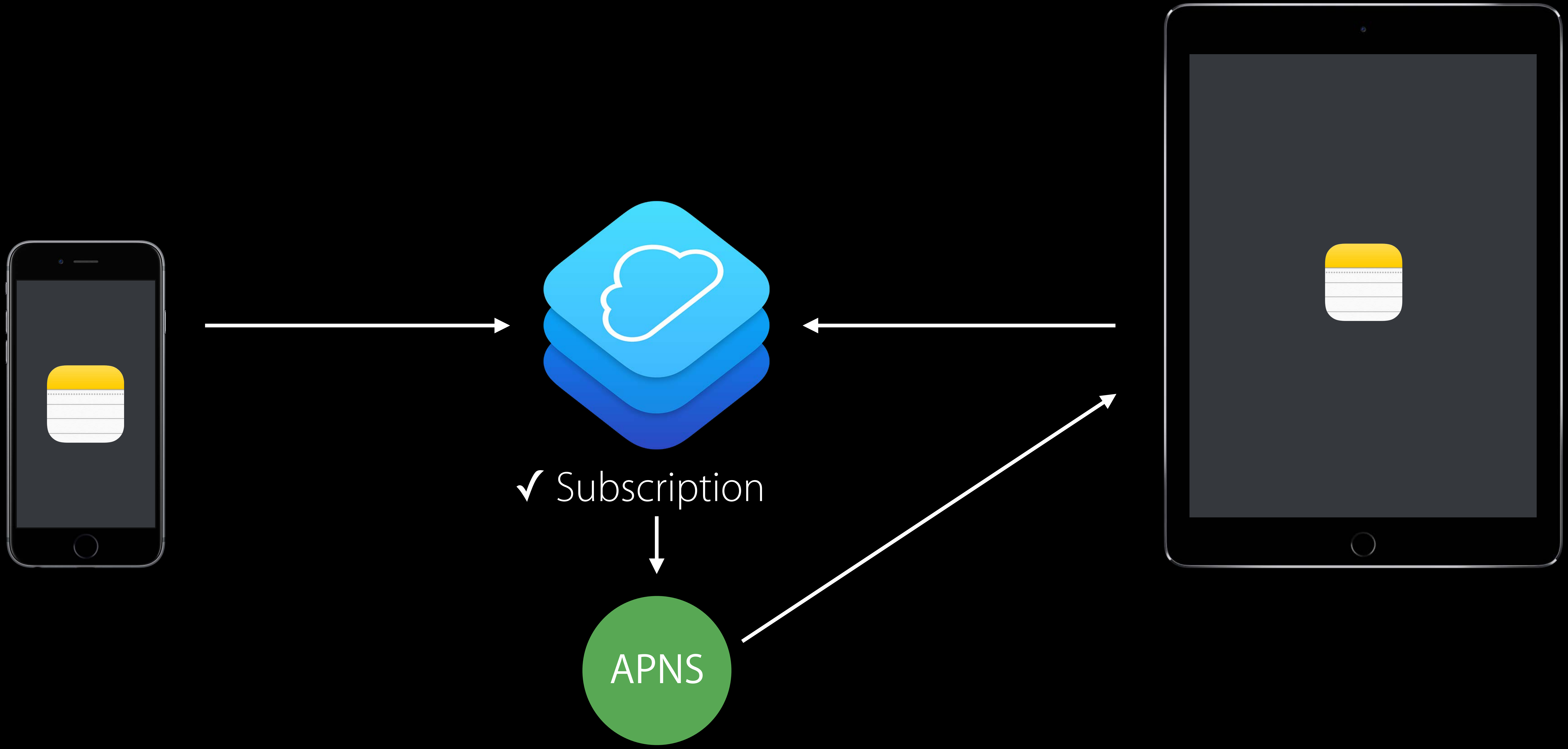

## Let’s Build It

## Subscribe to Changes

```
// Subscribe to changes

if (subscriptionIslocallyCached) { return }

let subscription = CKDatabaseSubscription(subscriptionID: "shared-changes")

let notificationInfo = CKNotificationInfo()
notificationInfo.shouldSendContentAvailable = true
subscription.notificationInfo = notificationInfo

let operation = CKModifySubscriptionsOperation(
   subscriptionsToSave: [subscription], subscriptionIDsToDelete: [])
operation.modifySubscriptionsCompletionBlock = { …
   if error != nil { } // Handle the error
   else { self.subscriptionIslocallyCached = true }
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operation.qualityOfService = .utility
self.sharedDB.add(operation)
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## Push Config

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// Silent push

let notificationInfo = CKNotificationInfo()

// Set only this property
notificationInfo.shouldSendContentAvailable = true

// The device does NOT need to prompt for user acceptance!

// Register for notifications via:
application.registerForRemoteNotifications(…)
```

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// UI push

let notificationInfo = CKNotificationInfo()

// Set any one of these three properties
notificationInfo.shouldBadge = true
notificationInfo.alertBody = NSLocalizedString("alertBody")
notificationInfo.soundName = "default"

// The device needs to prompt for user acceptance via:
application.registerUserNotificationSettings(…)

// Register for notifications via:
application.registerForRemoteNotifications(…)
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## Fine Print

Pushes can be coalesced depending on the conditions of the device

(e.g., airplane mode, poor network, low battery)

## Fine Print

CloudKit lets you ask for only what has changed!

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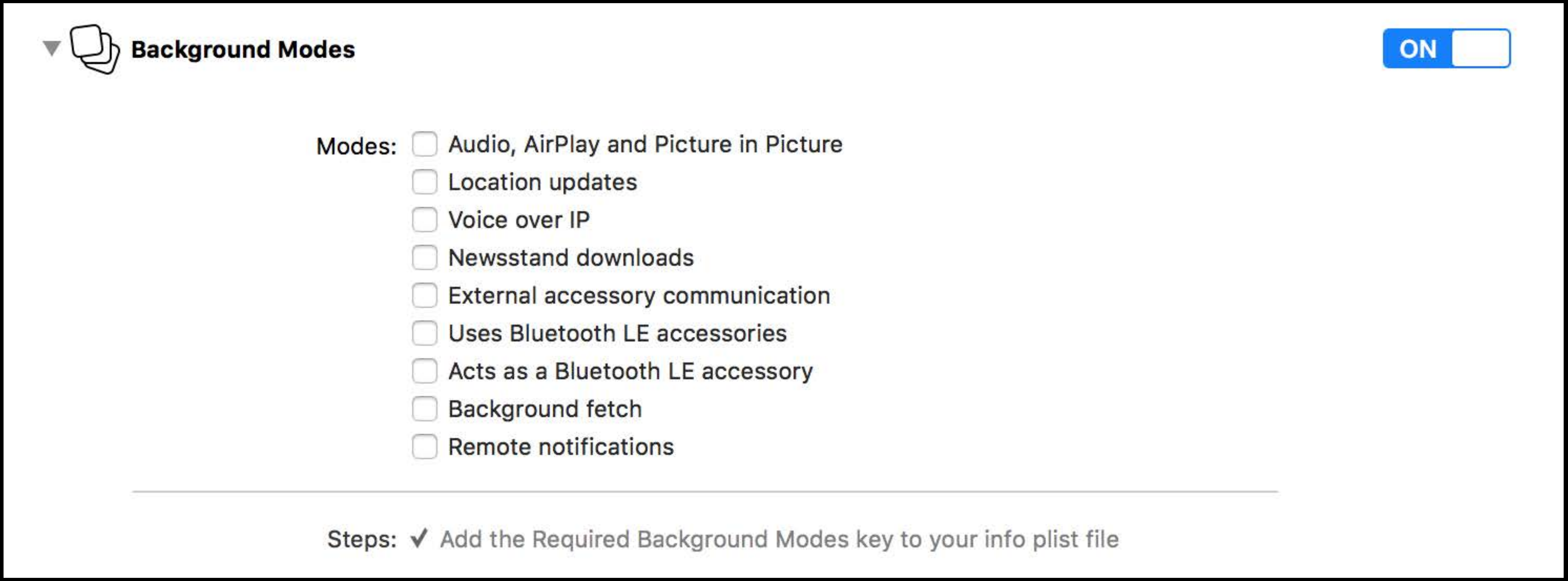
✓ Subscribed to changes

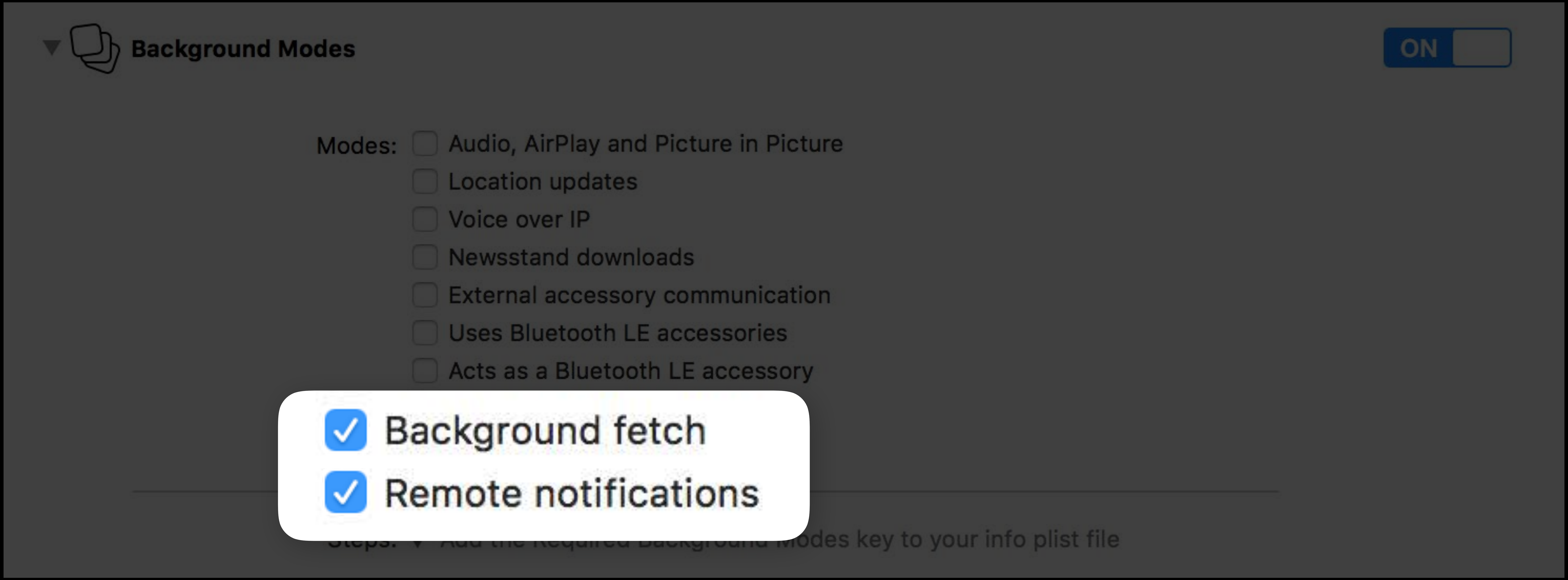
## Listen for Pushes


Background Modes

ON

Modes:
- [ ] Audio, AirPlay and Picture in Picture
- [ ] Location updates
- [ ] Voice over IP
- [ ] Newsstand downloads
- [ ] External accessory communication
- [ ] Uses Bluetooth LE accessories
- [ ] Acts as a Bluetooth LE accessory
- [ ] Background fetch
- [ ] Remote notifications

Steps: ✓ Add the Required Background Modes key to your info plist file



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Steps: ✓ Add the Required Background Modes key to your info plist file

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// Listen for pushes

func application(_ application: UIApplication,
   didReceiveRemoteNotification userInfo: [NSObject : AnyObject],
   fetchCompletionHandler completionHandler: (UIBackgroundFetchResult) -> Void) {

   let dict = userInfo as! [String: NSObject]
   let notification = CKNotification(fromRemoteNotificationDictionary: dict)

   if (notification.subscriptionID == "shared-changes") {
      fetchSharedChanges {
         completionHandler(UIBackgroundFetchResult.newData)
      }
   }
}
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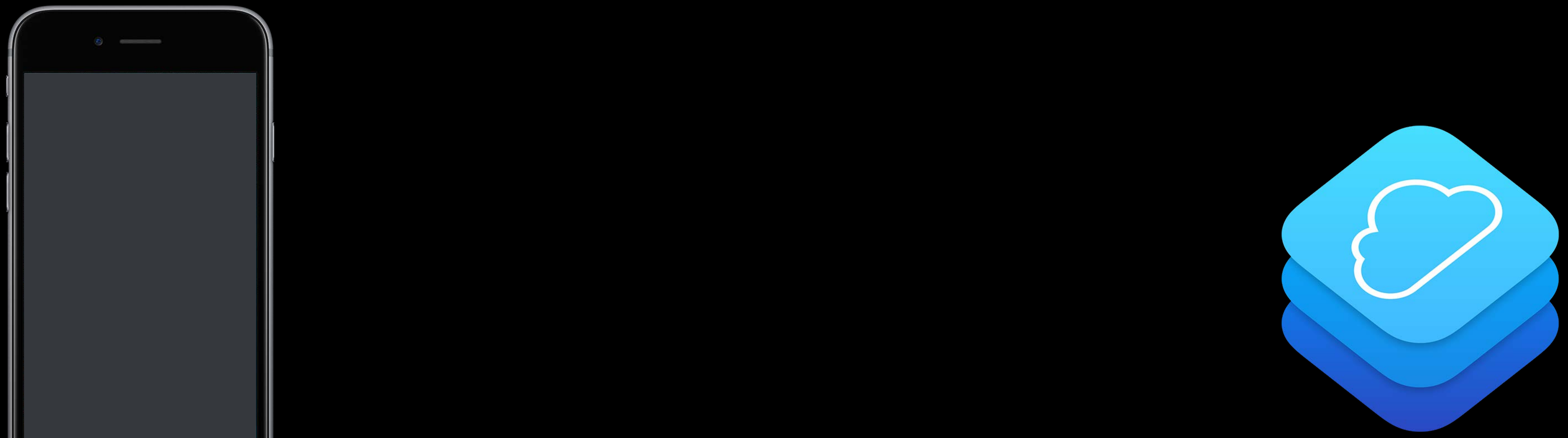
✓ Listening for pushes

## Some Time Later, We Get a Push…

## Fetch New Changes

## Fetching Changes



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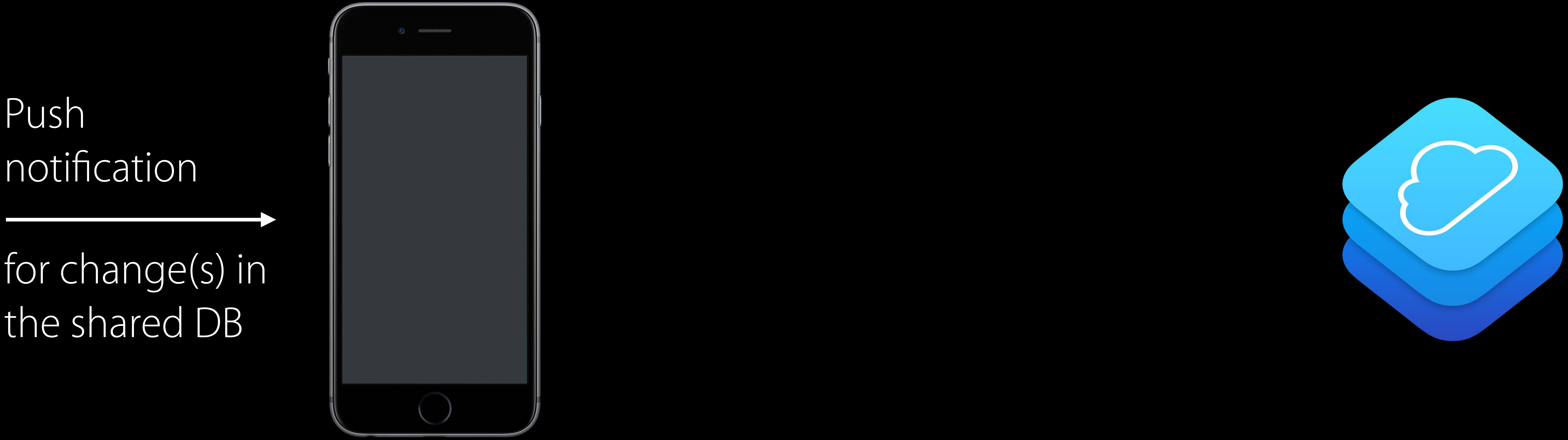

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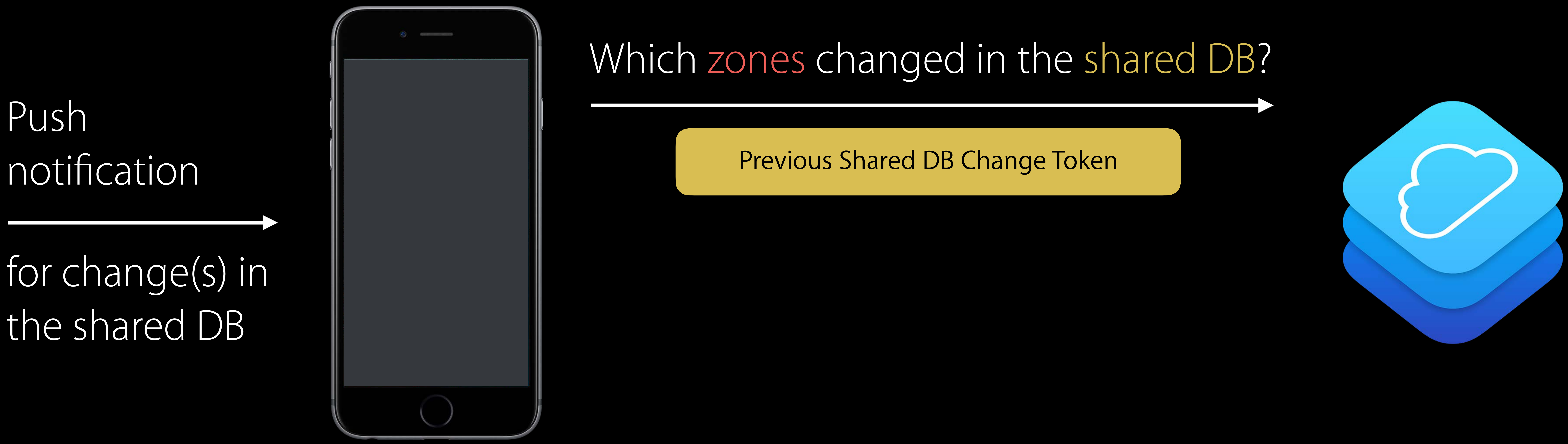
Push notification
for change(s) in the shared DB
Which zones changed in the shared DB?
Previous Shared DB Change Token

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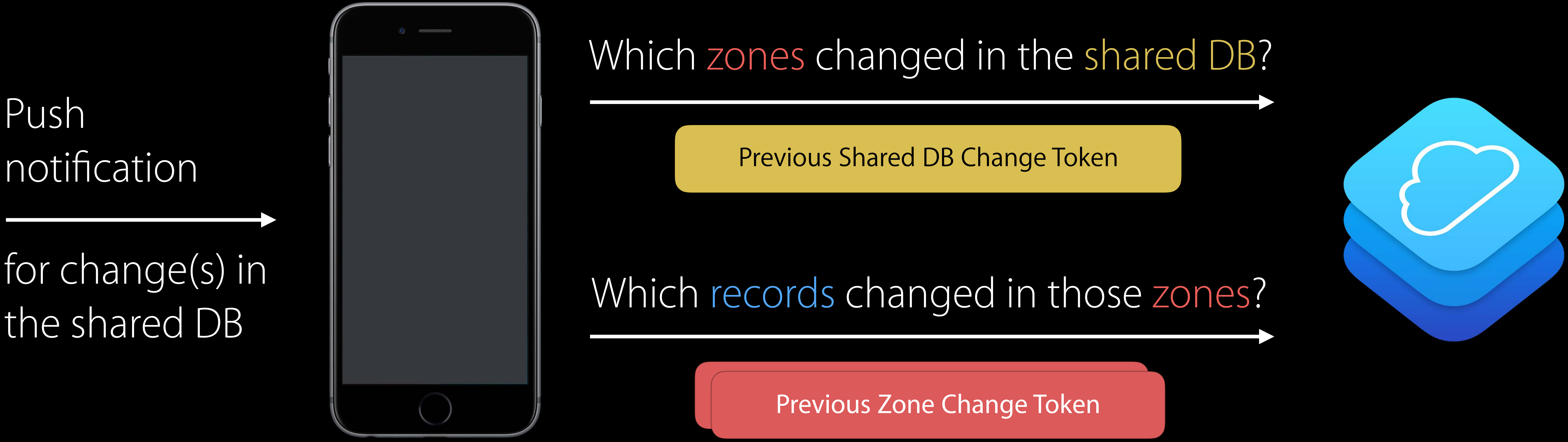
Push notification
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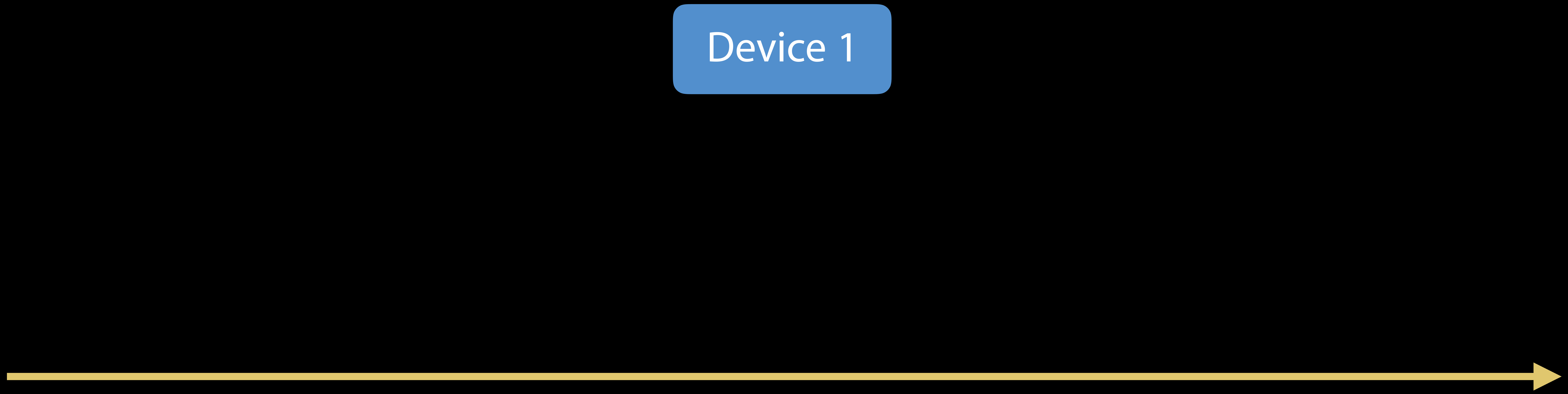
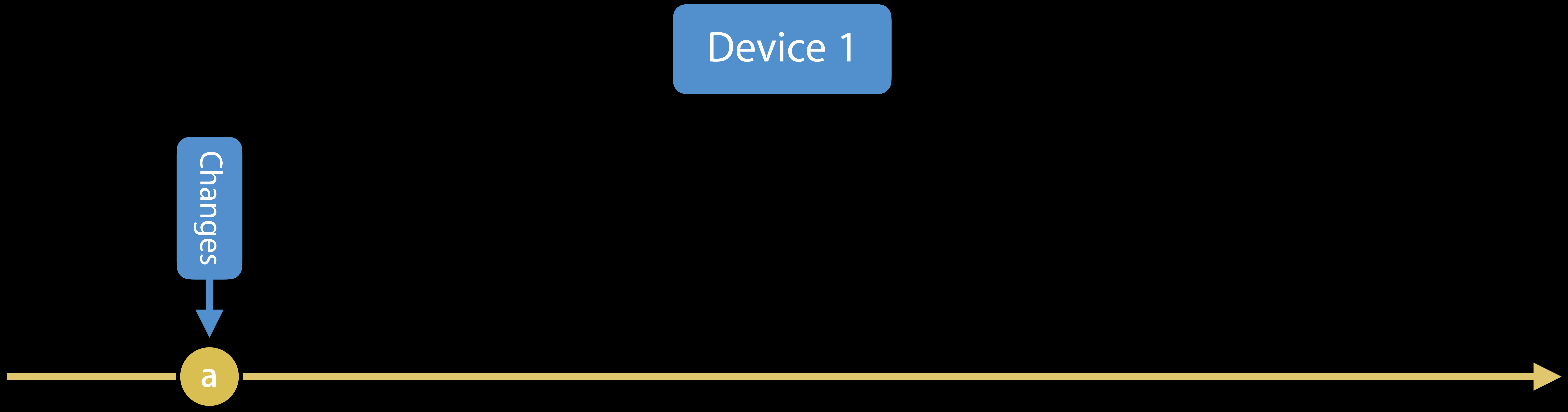
Which records changed in those zones?
Previous Zone Change Token


Device 1


Device 1
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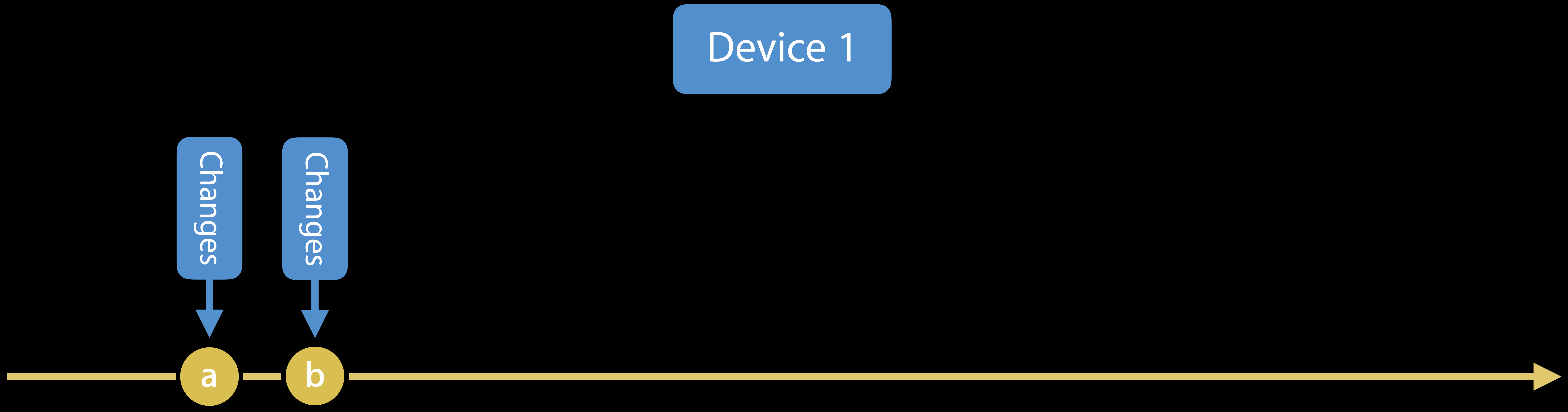
a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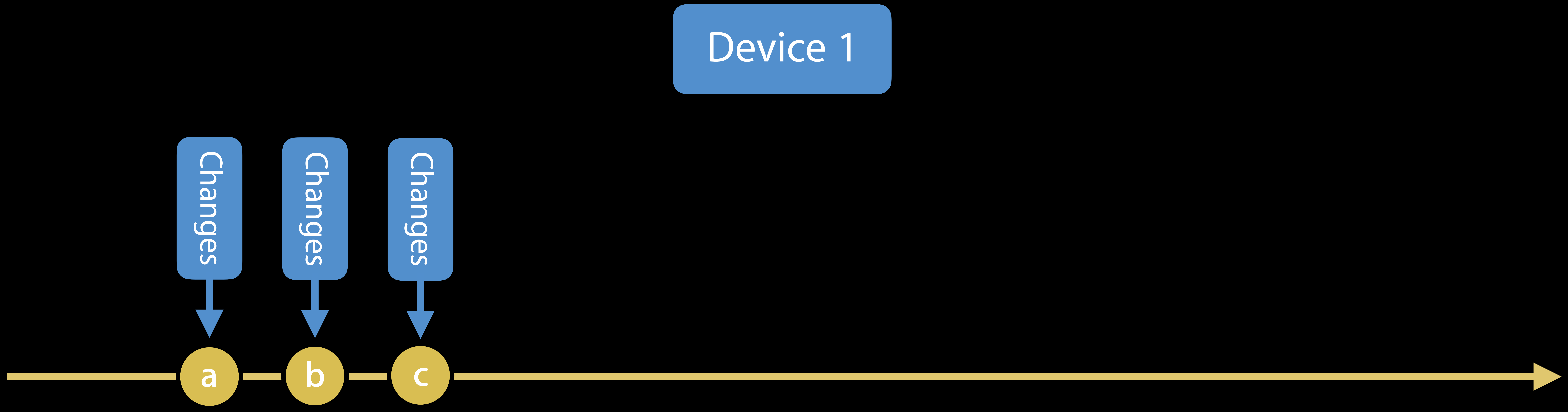
Device 1
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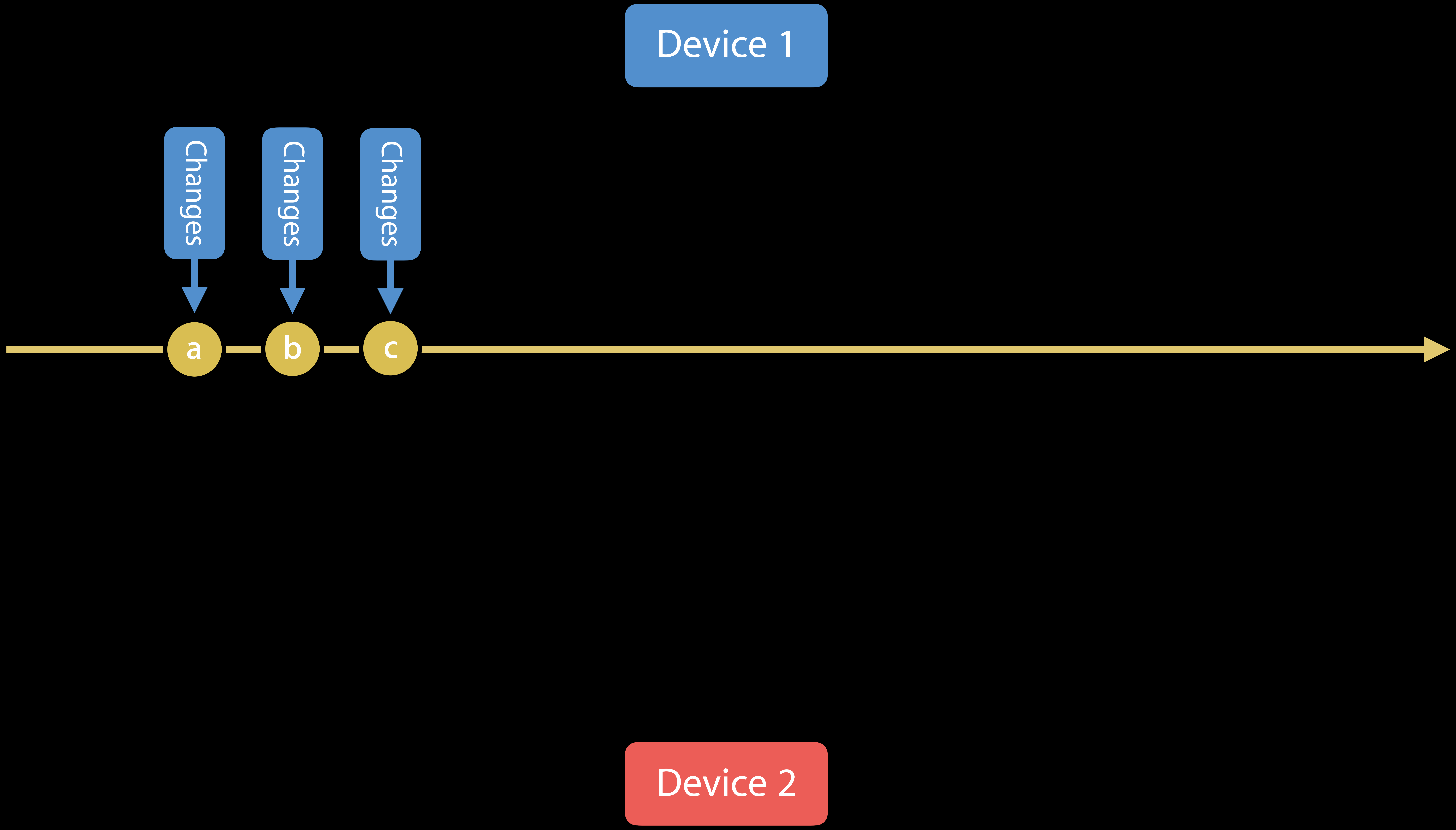
c


Device 1
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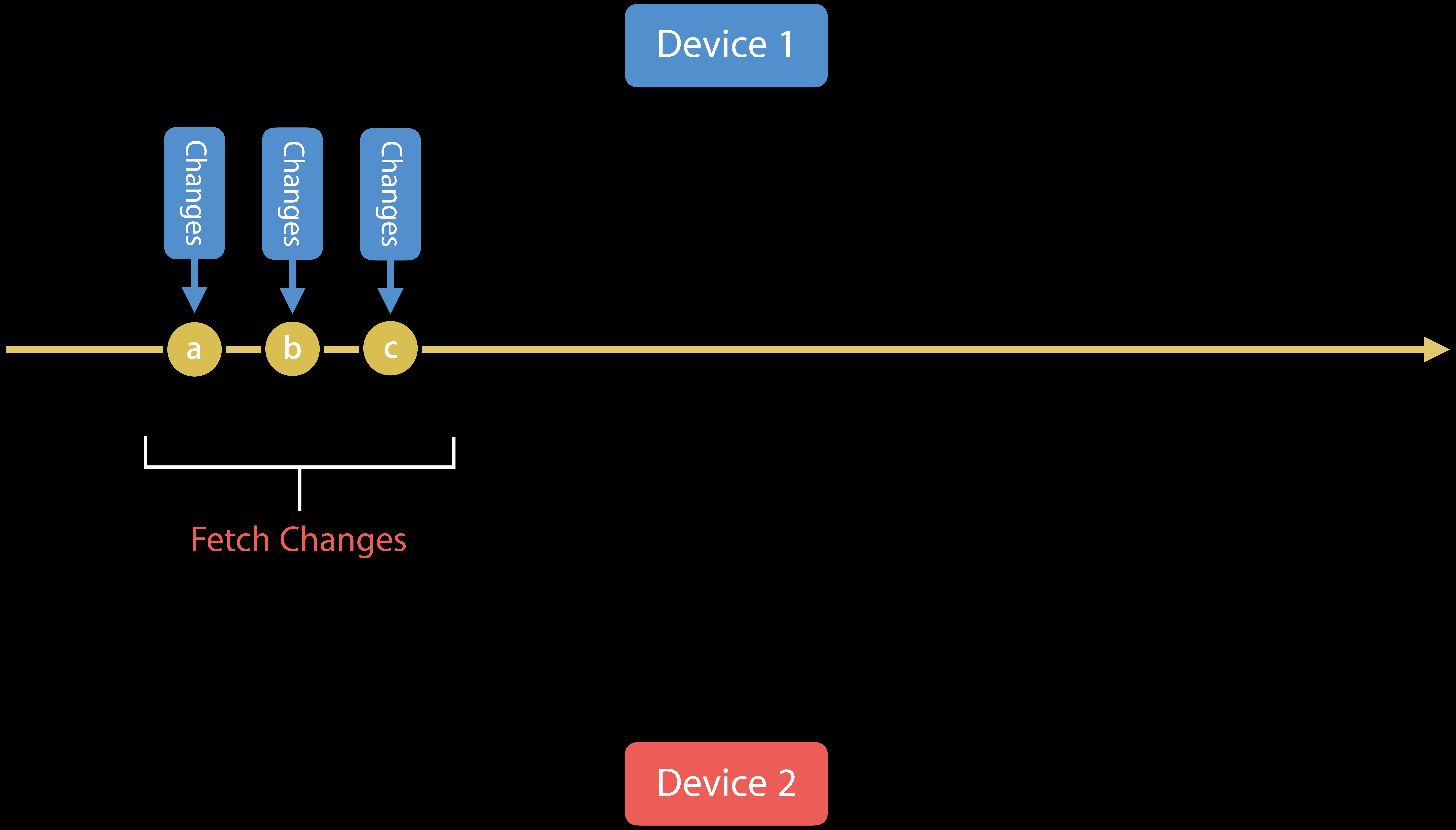
Device 2


Device 1
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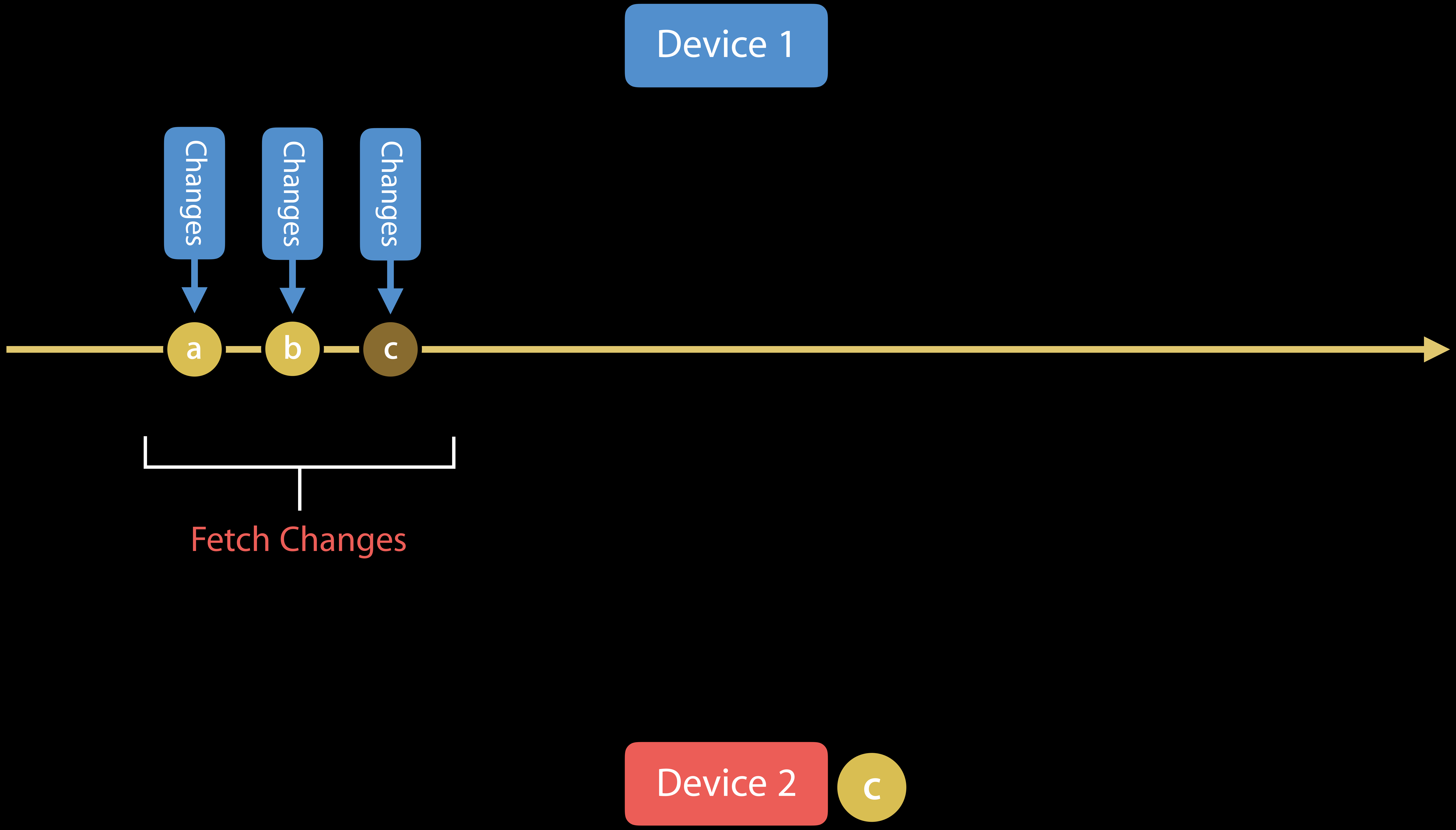
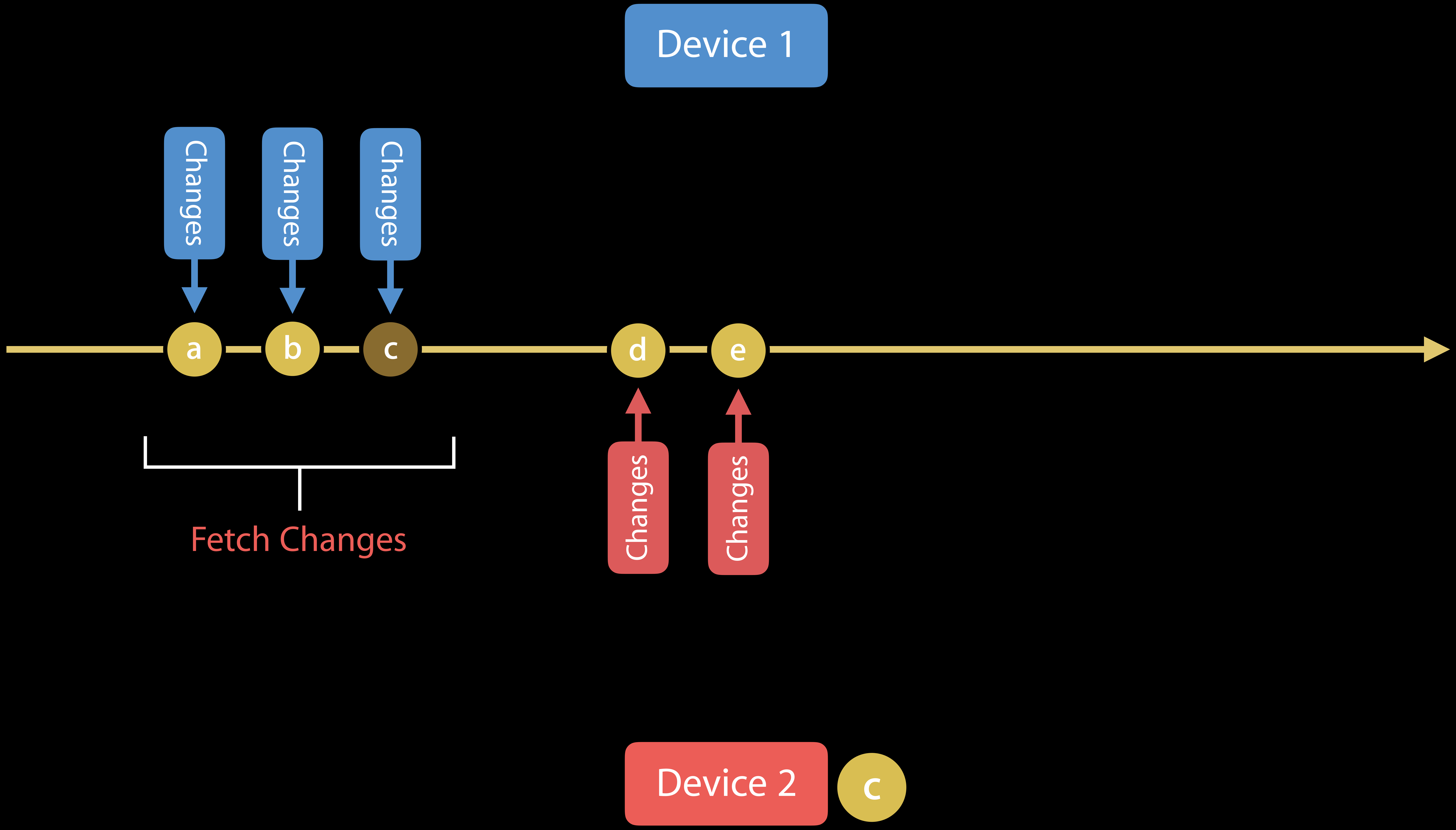
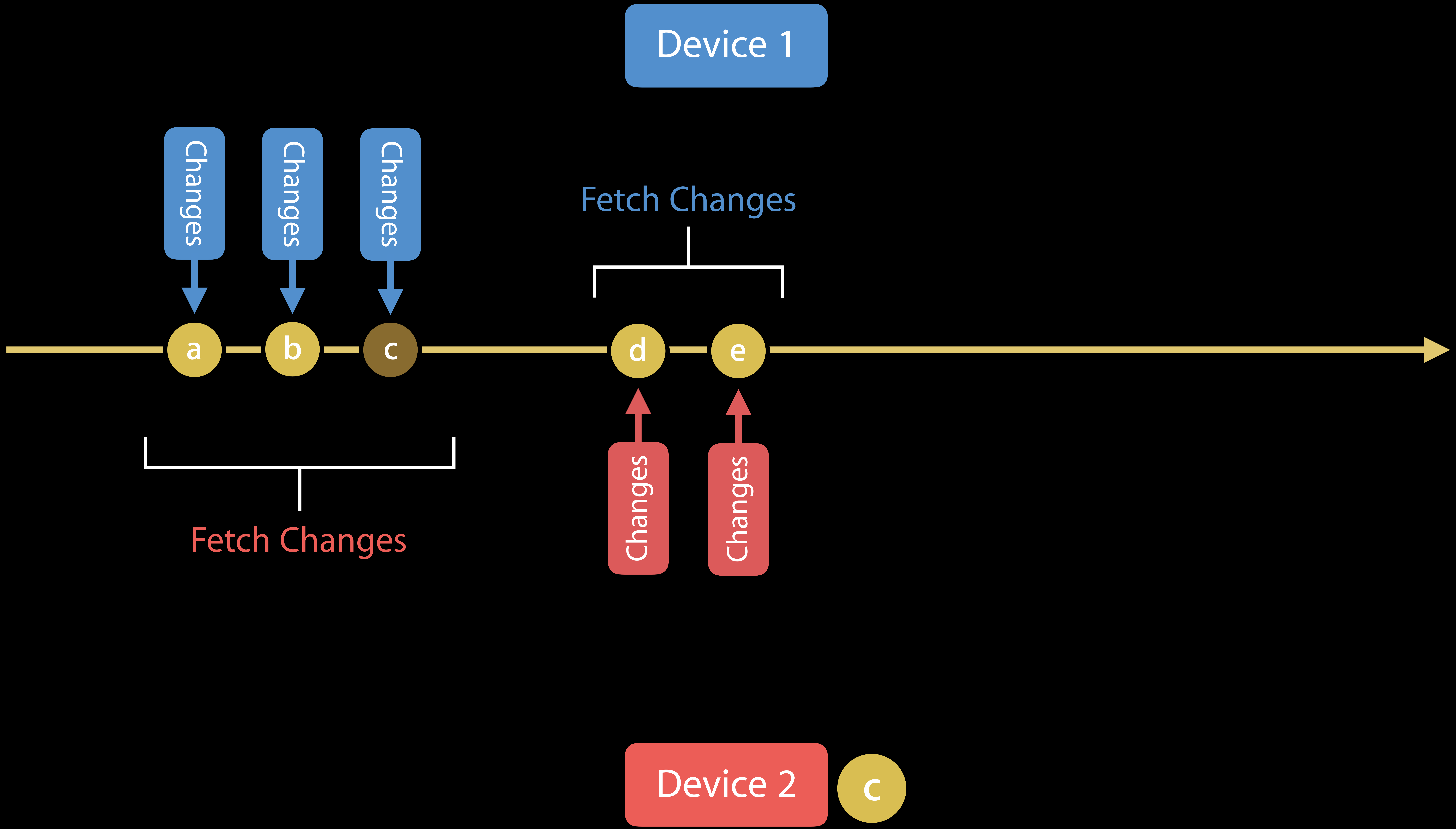
Fetch Changes
Device 2


Device 1
Changes
Changes
Changes
a
b
c
Fetch Changes
Device 2
c


Device 1
Changes
Changes
Changes
a
b
c
d
e
Fetch Changes
Changes
Changes
Device 2
c


Device 1
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Fetch Changes
a
b
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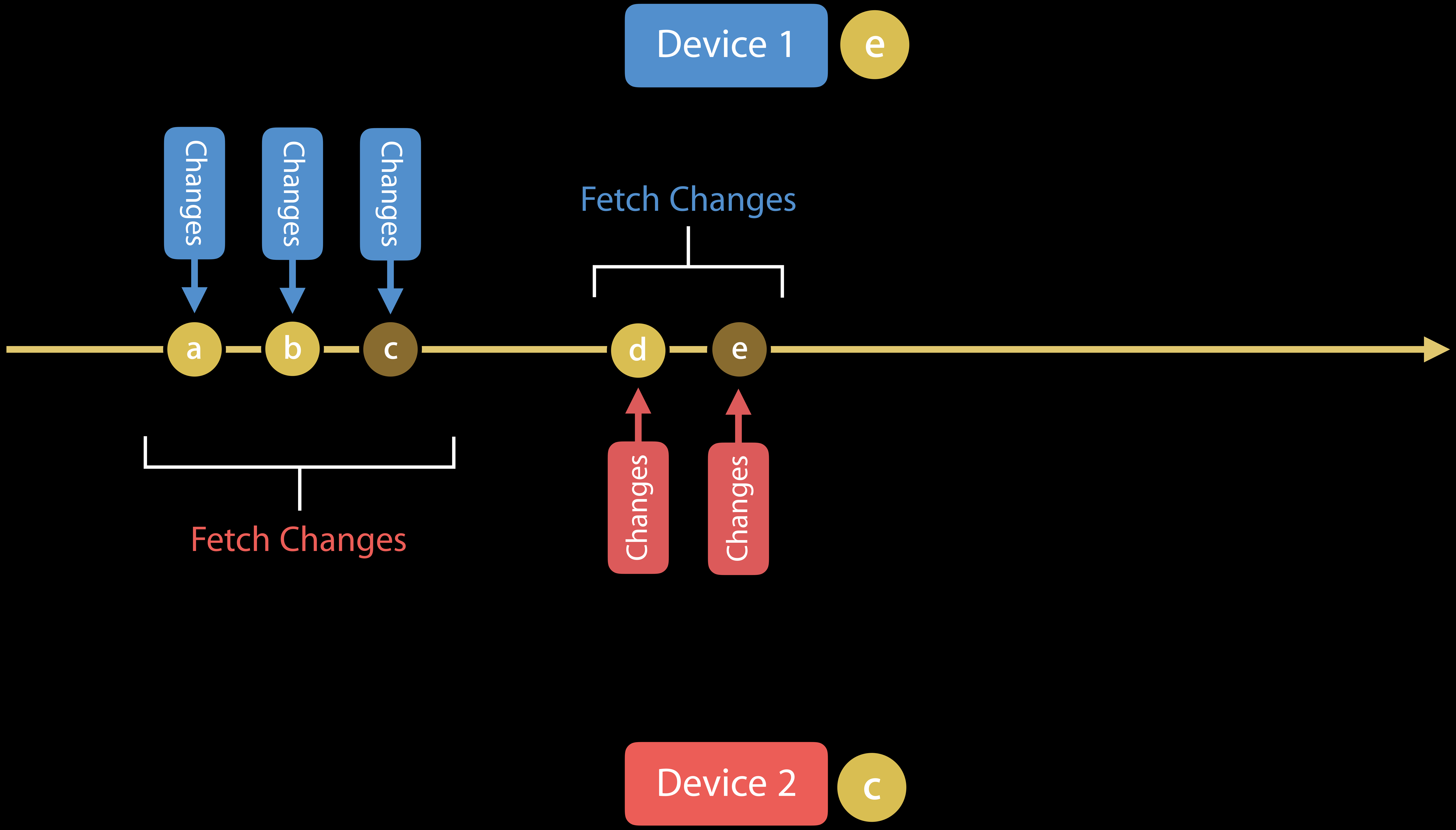
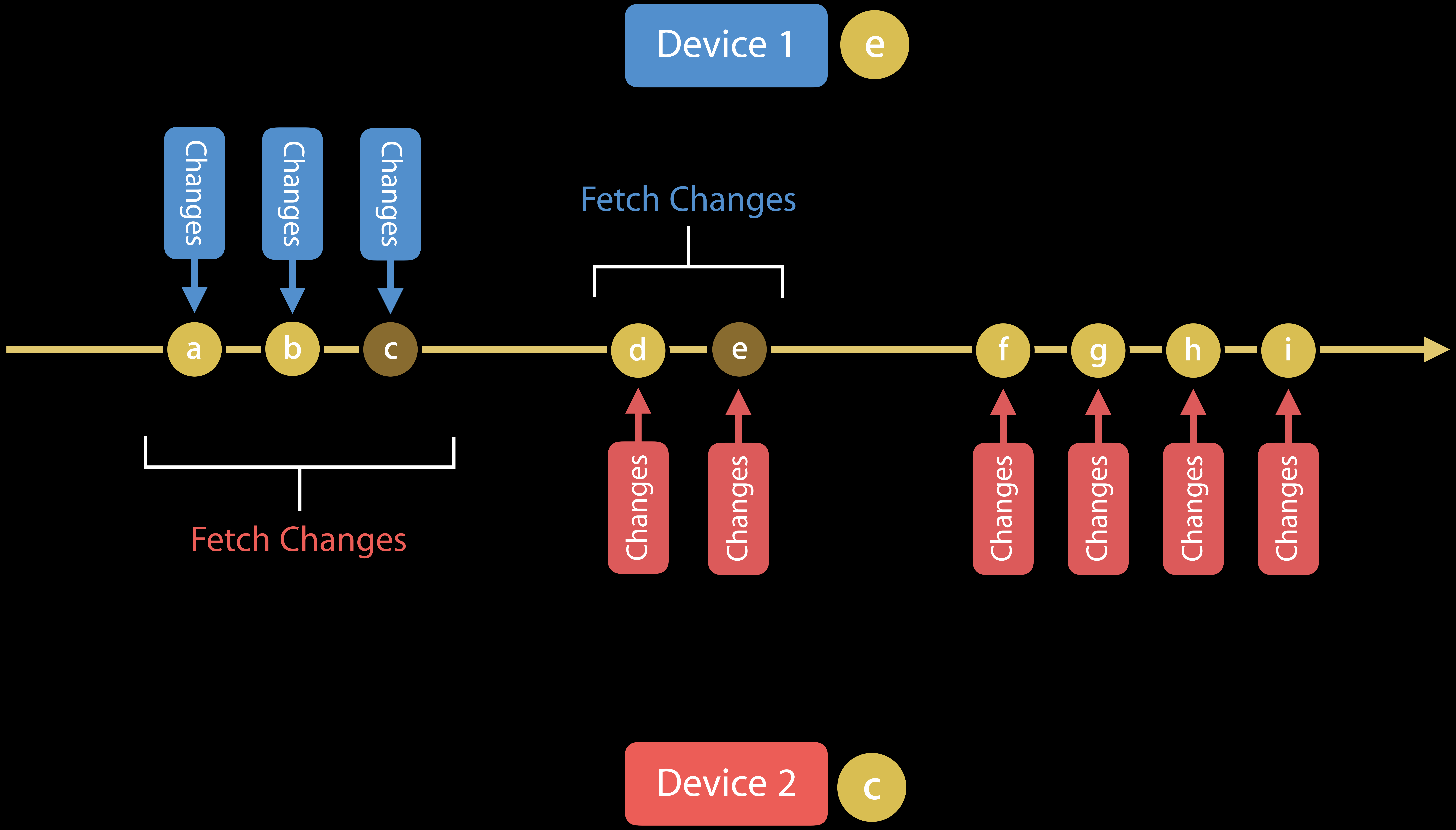
Fetch Changes
Changes
Changes
Device 2
c


Device 1
e
Changes
Changes
Changes
Fetch Changes
a
b
c
d
e
Fetch Changes
Changes
Changes
Device 2
c


Device 1
e
Changes
Changes
Changes
Fetch Changes
a
b
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e
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g
h
i
Fetch Changes
Changes
Changes
Changes
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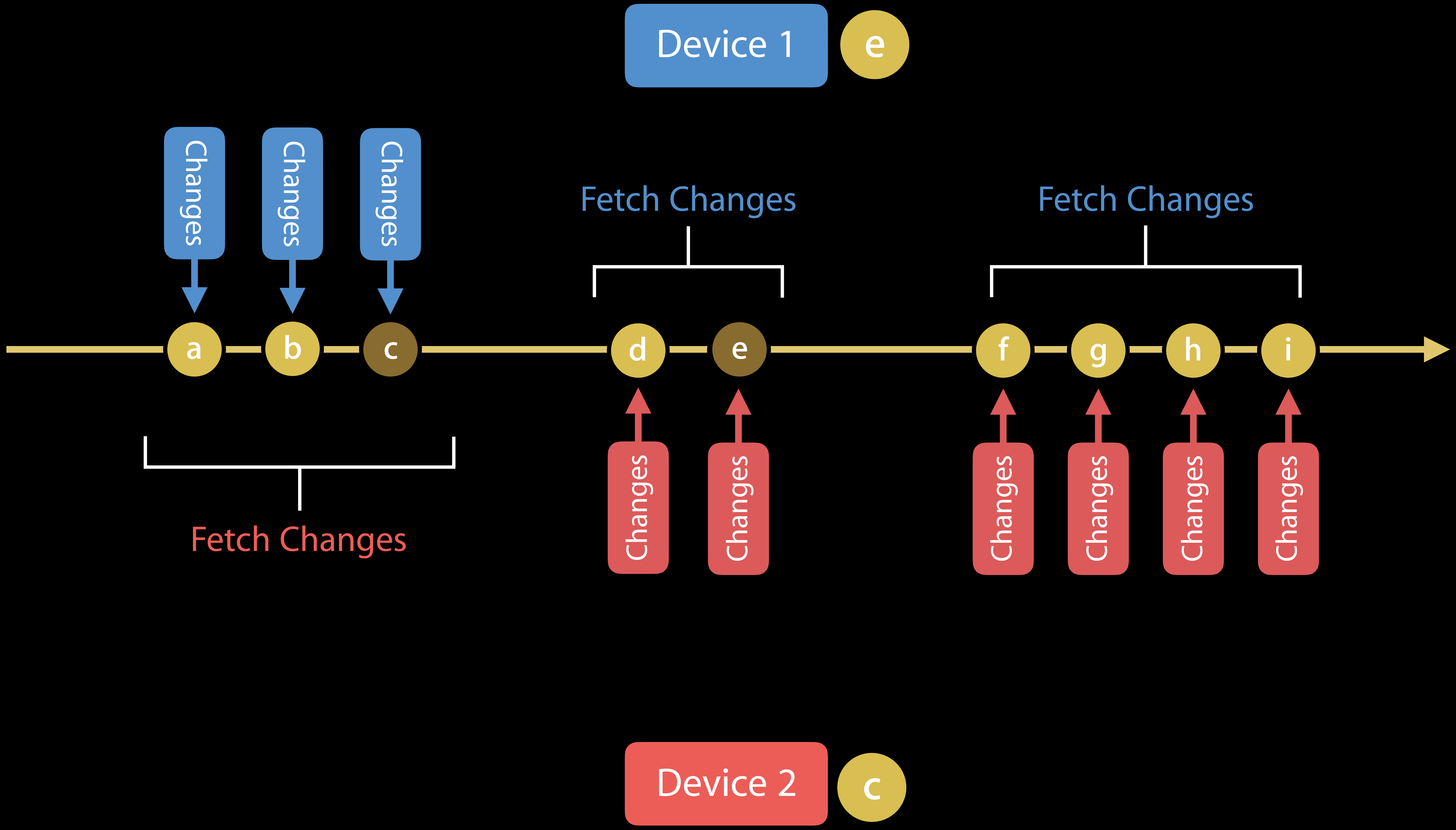
Changes
Changes
Device 2
c


Device 1
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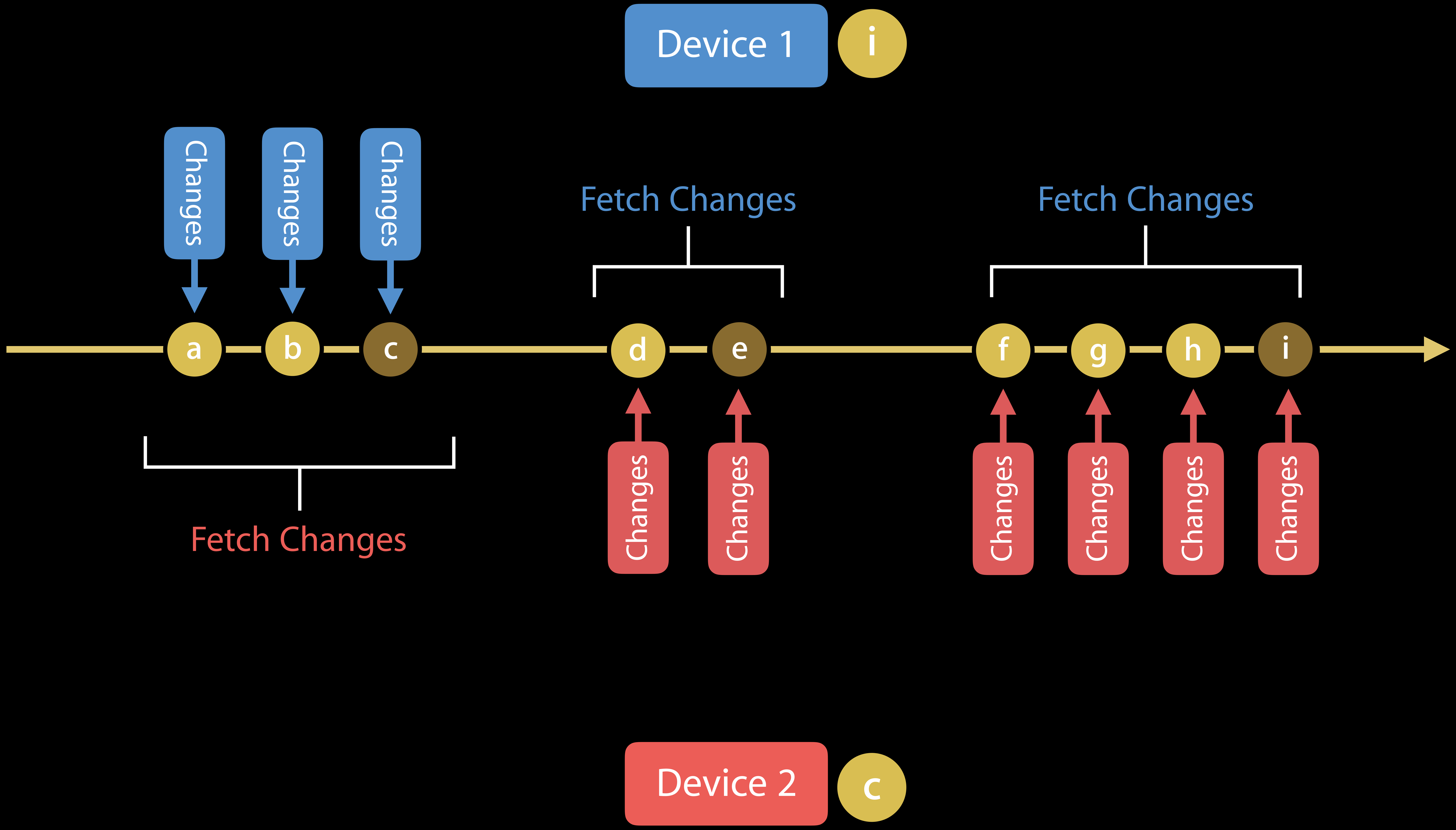
Device 2
c


Device 1
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Fetch Changes
Fetch Changes
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Fetch Changes
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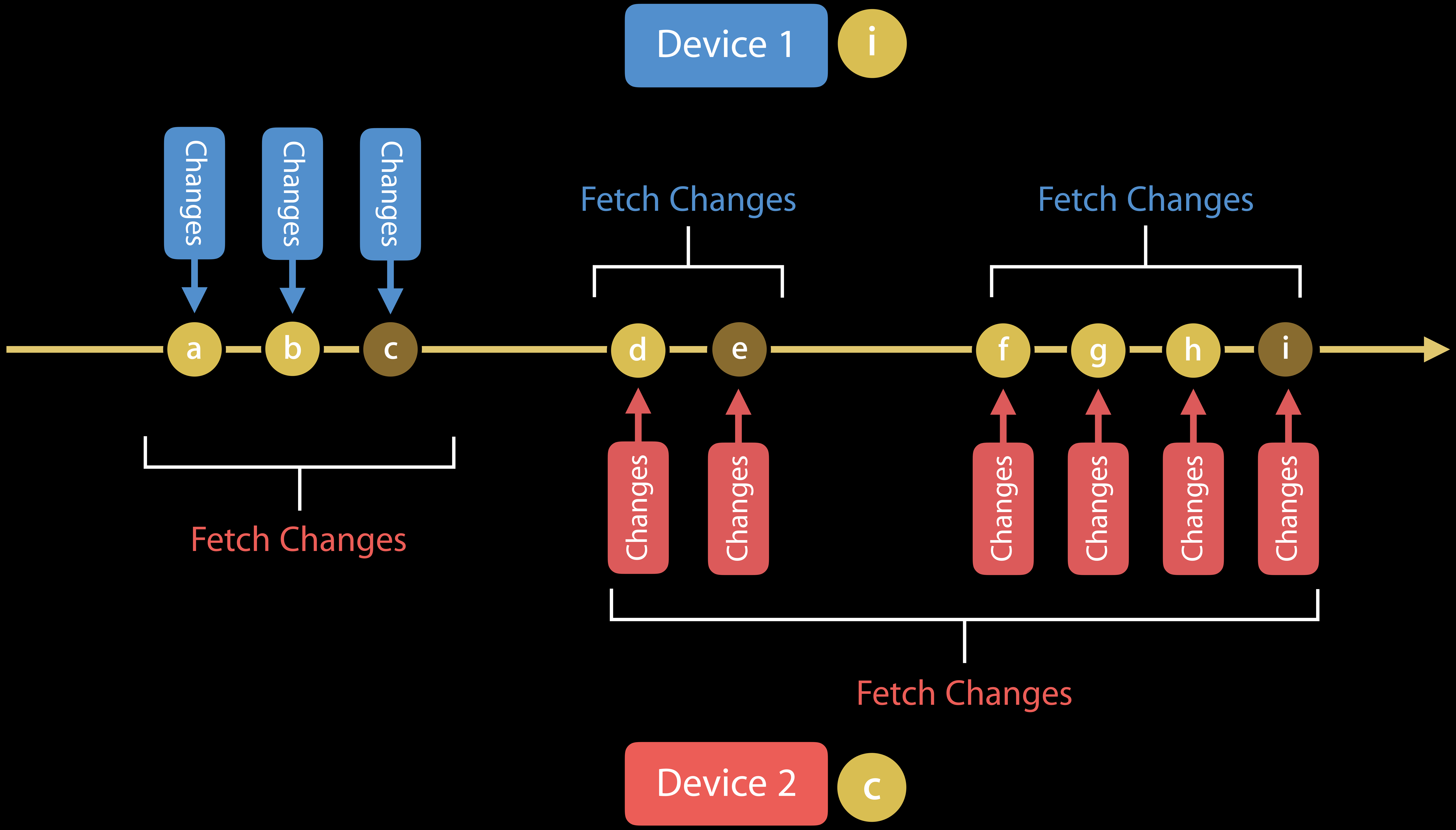
Changes
Changes
Changes
Device 2
c


Device 1
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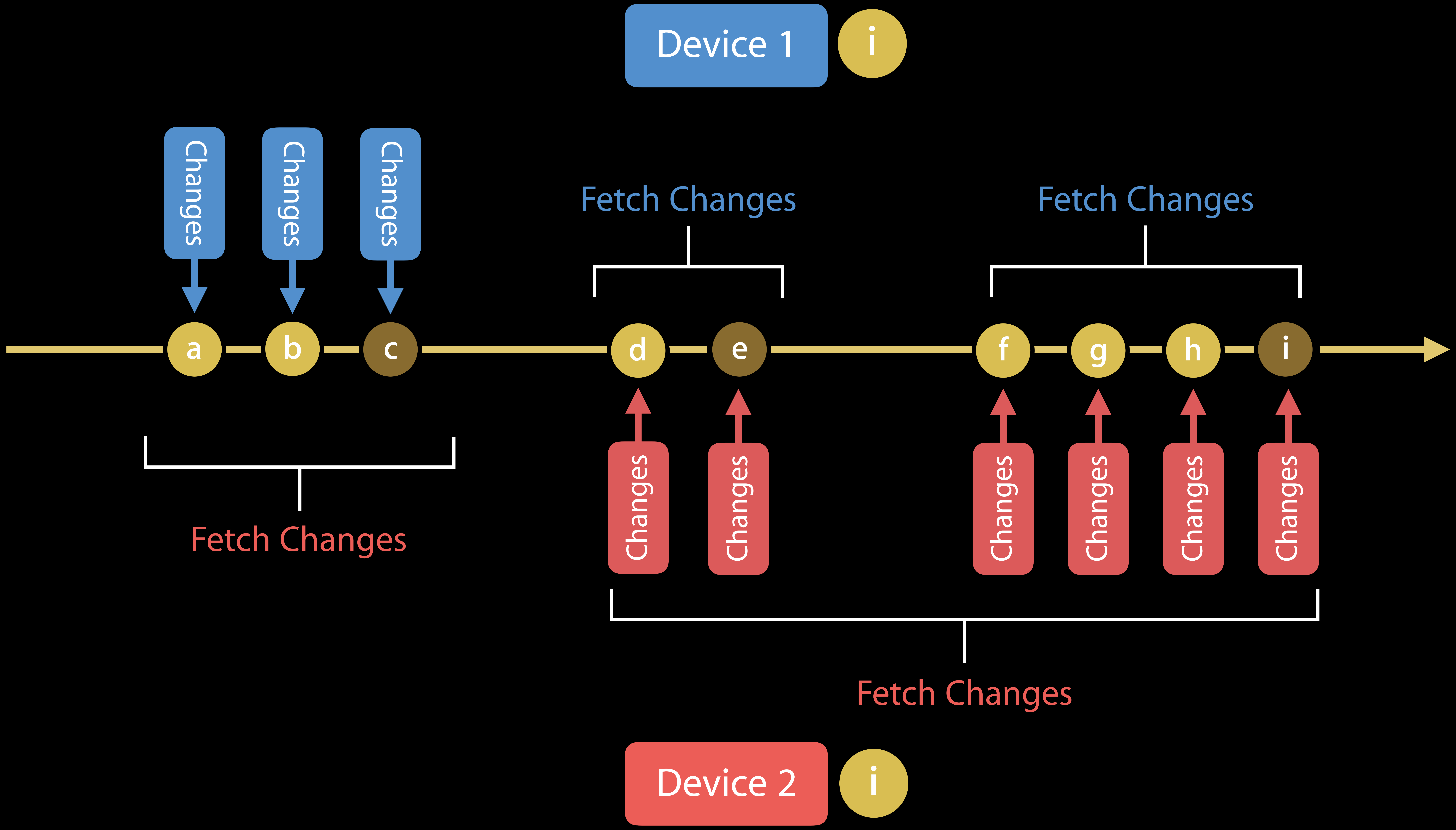
Changes
Fetch Changes
Device 2
c


Device 1
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Fetch Changes
Fetch Changes
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h
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Device 2
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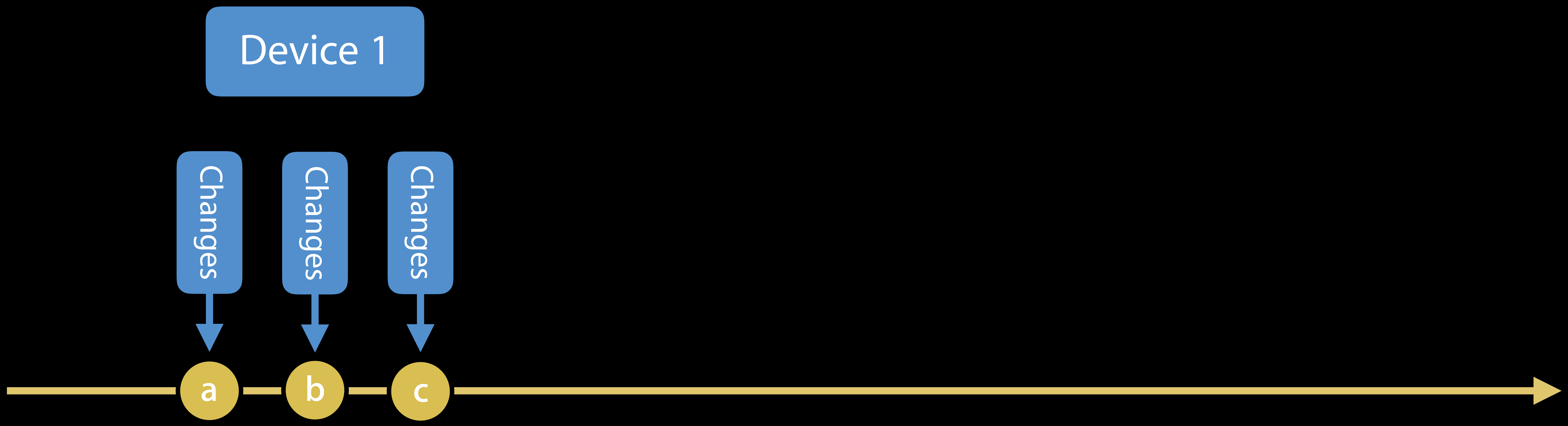
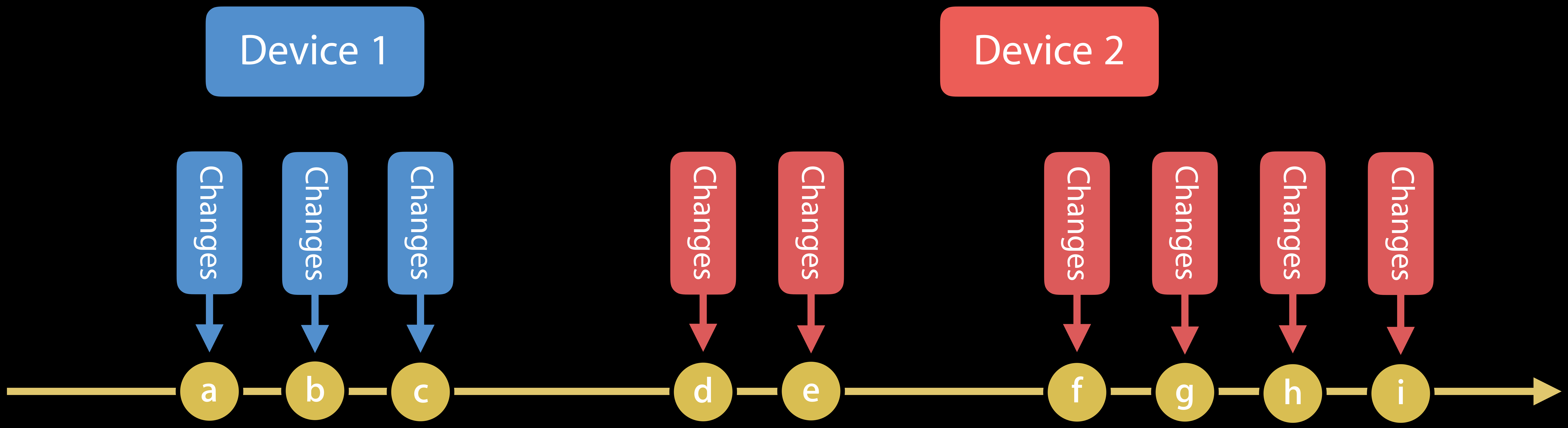

Device 1
Changes
Changes
Changes
a
b
c


Device 1
Device 2
Changes
Changes
Changes
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Changes
Changes
Changes
a
b
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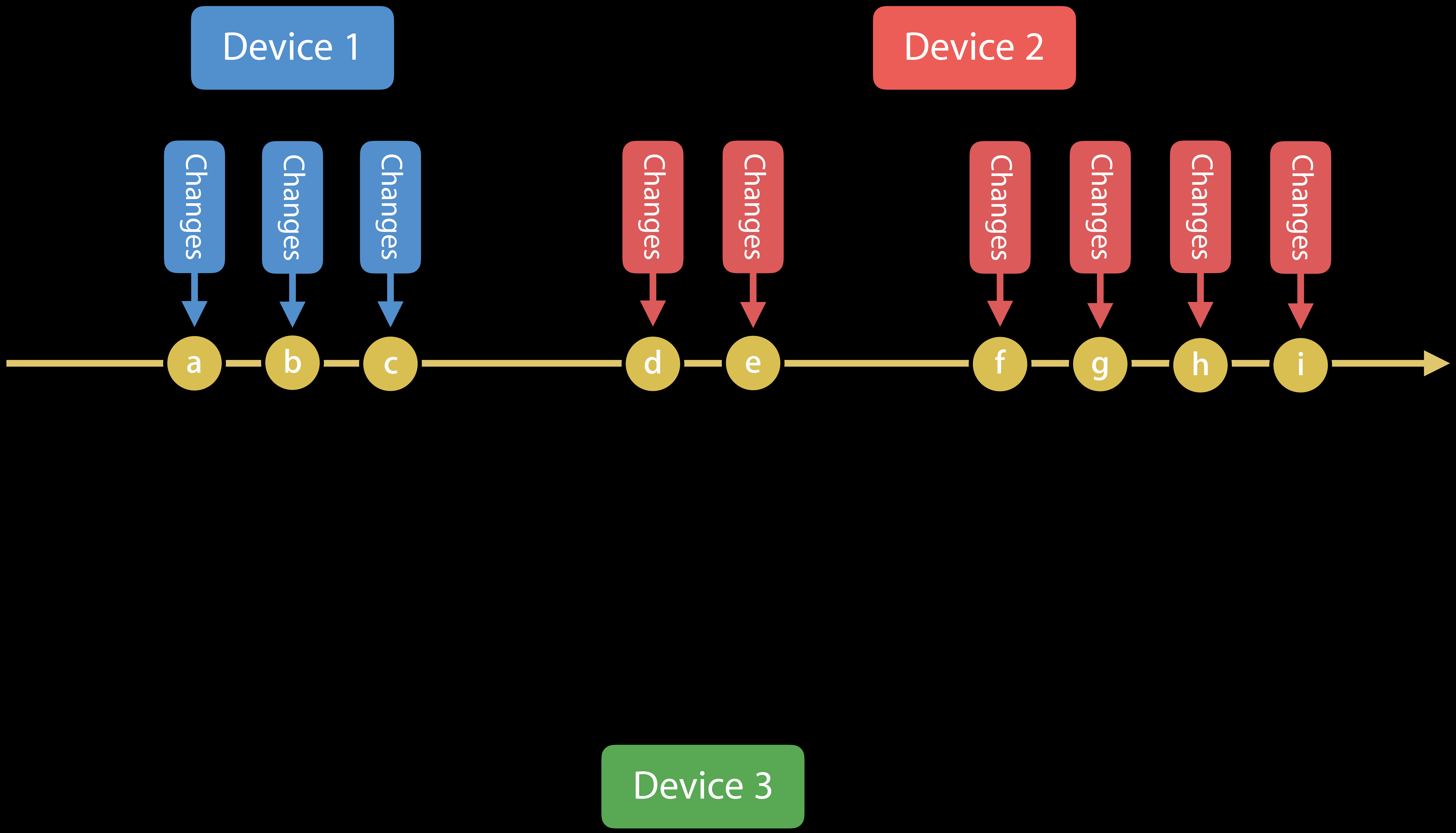
f
g
h
i


Device 1
Device 2
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Changes
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Changes
Changes
a
b
c
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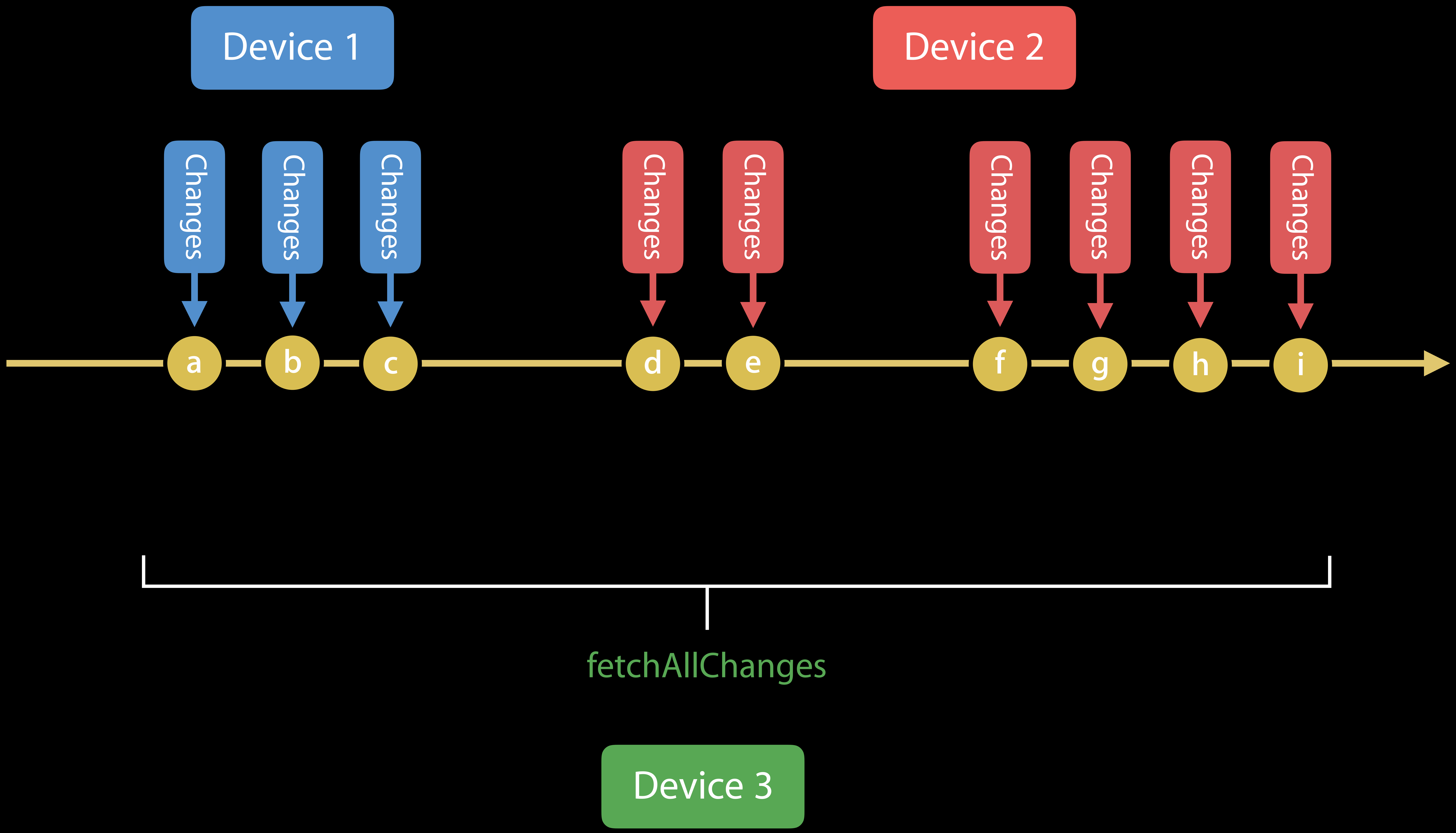
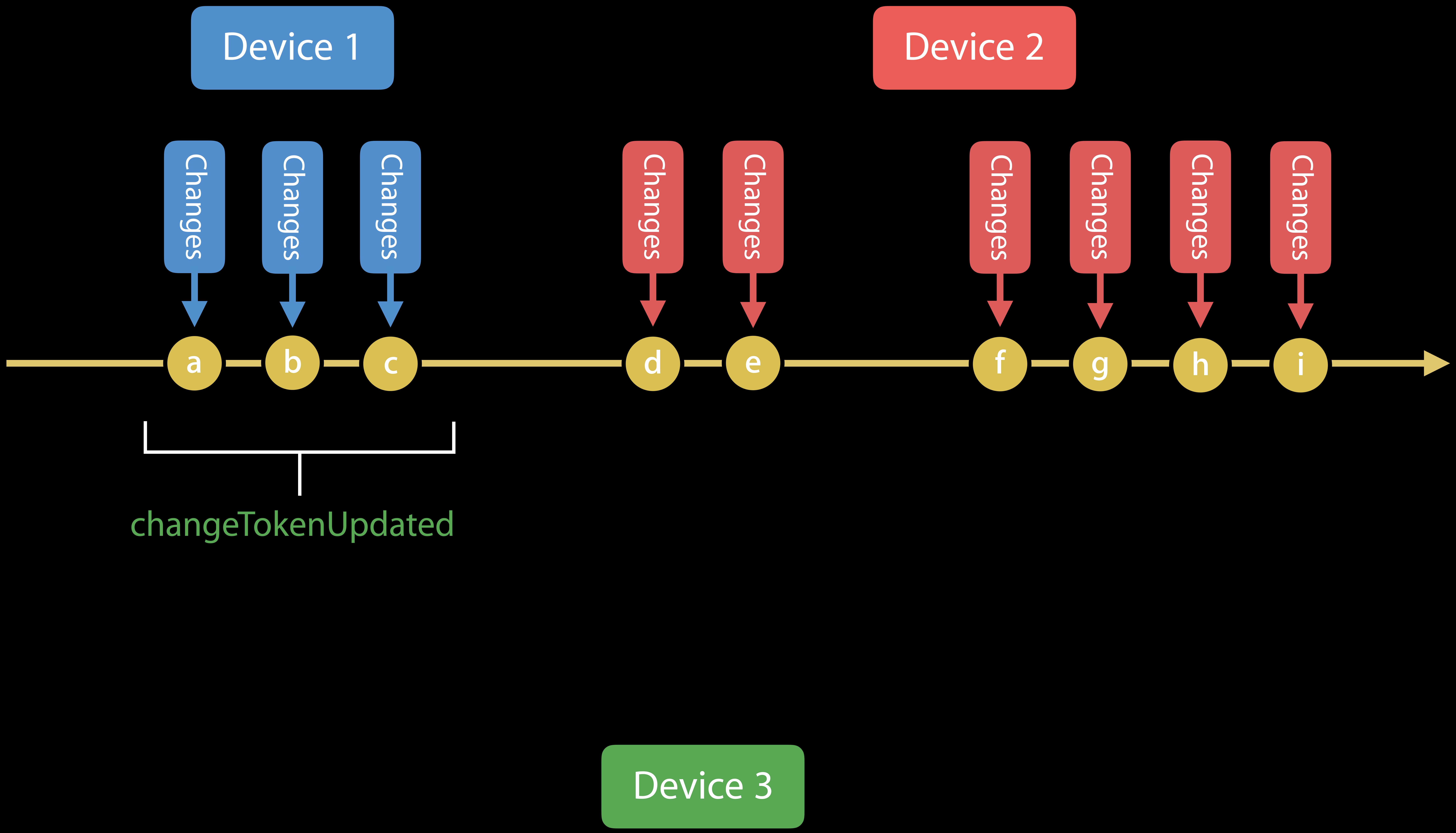
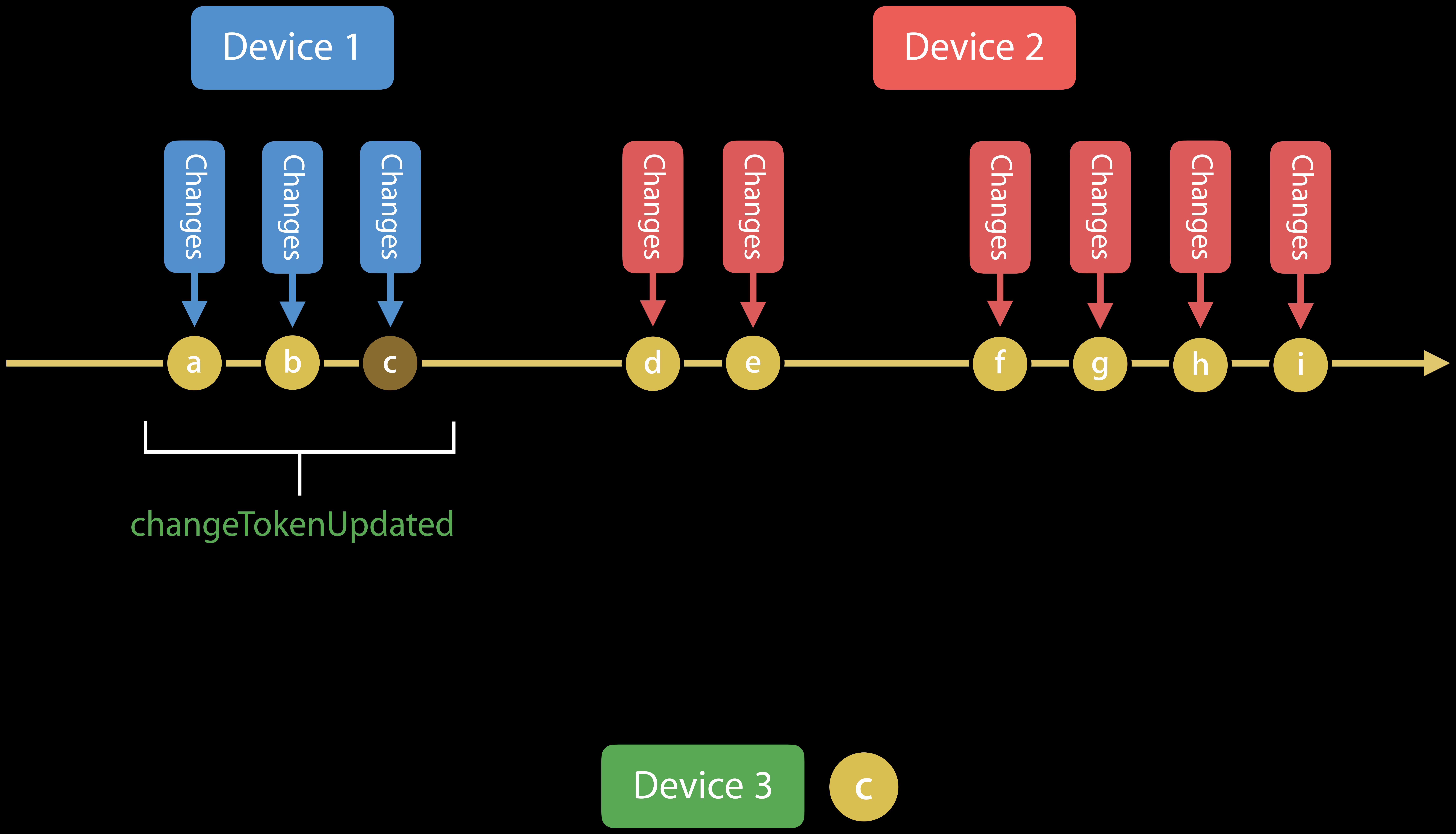
g
h
i
Device 3


Device 1
Device 2
Changes
Changes
Changes
Changes
Changes
Changes
Changes
Changes
Changes
a
b
c
d
e
f
g
h
i
fetchAllChanges
Device 3


Device 1
Device 2
Changes
Changes
Changes
Changes
Changes
Changes
Changes
Changes
Changes
a
b
c
d
e
f
g
h
i
changeTokenUpdated
Device 3


Device 1
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Changes
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Changes
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Changes
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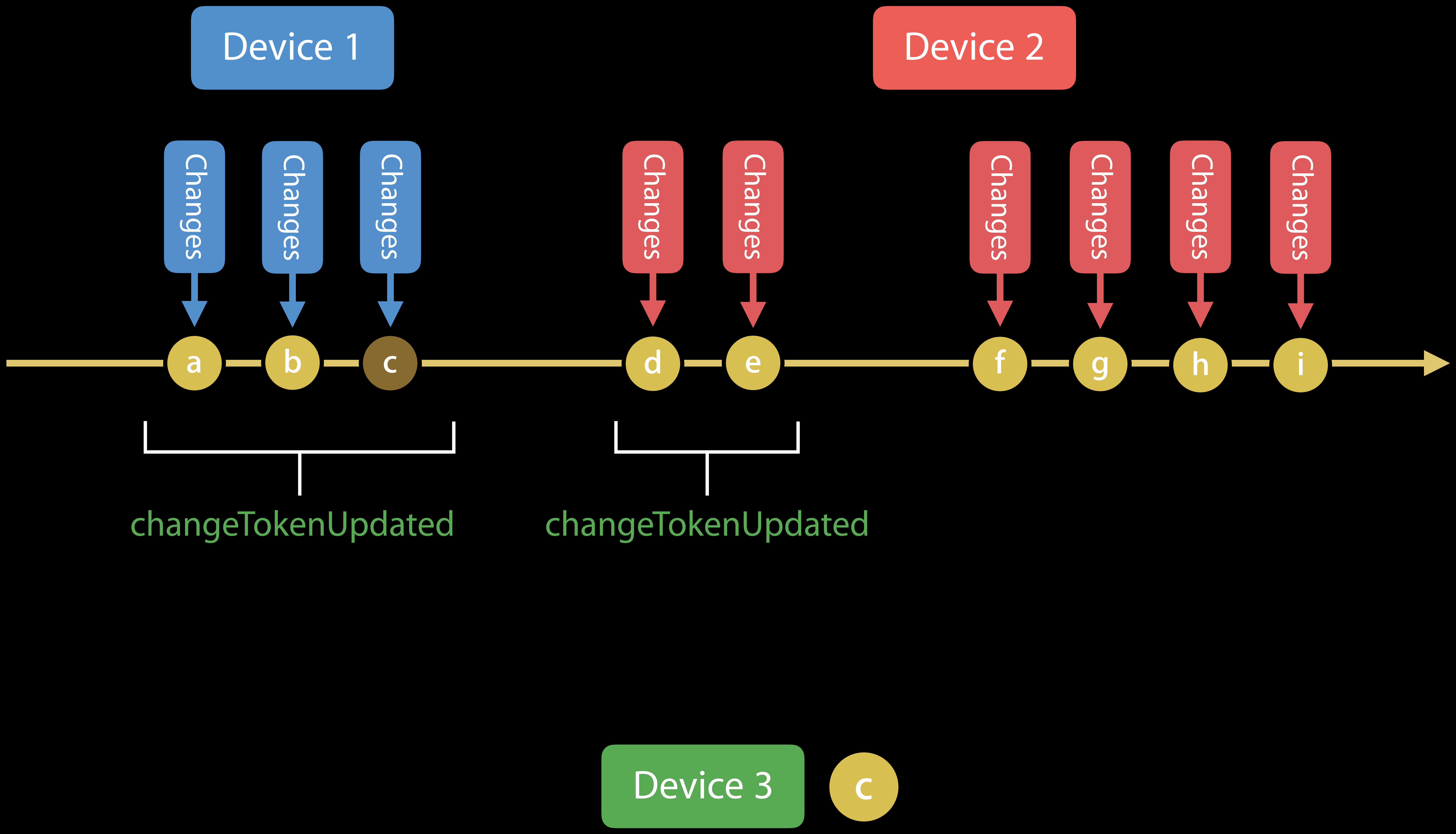
i
changeTokenUpdated
Device 3
c


Device 1
Device 2
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Changes
Changes
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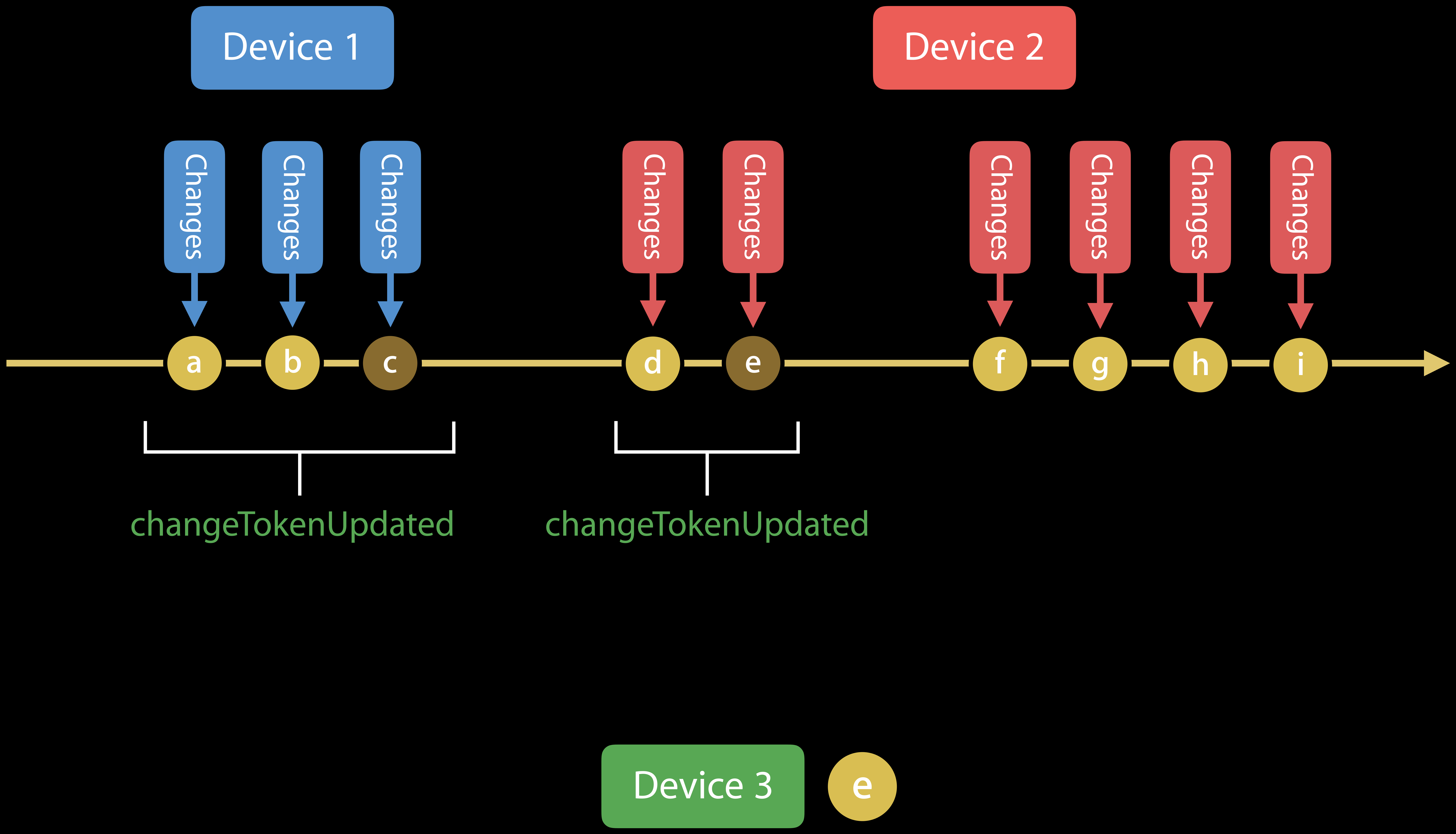
g
h
i
changeTokenUpdated
changeTokenUpdated
Device 3
c


Device 1
Device 2
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Changes
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Changes
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Changes
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Changes
Changes
a
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f
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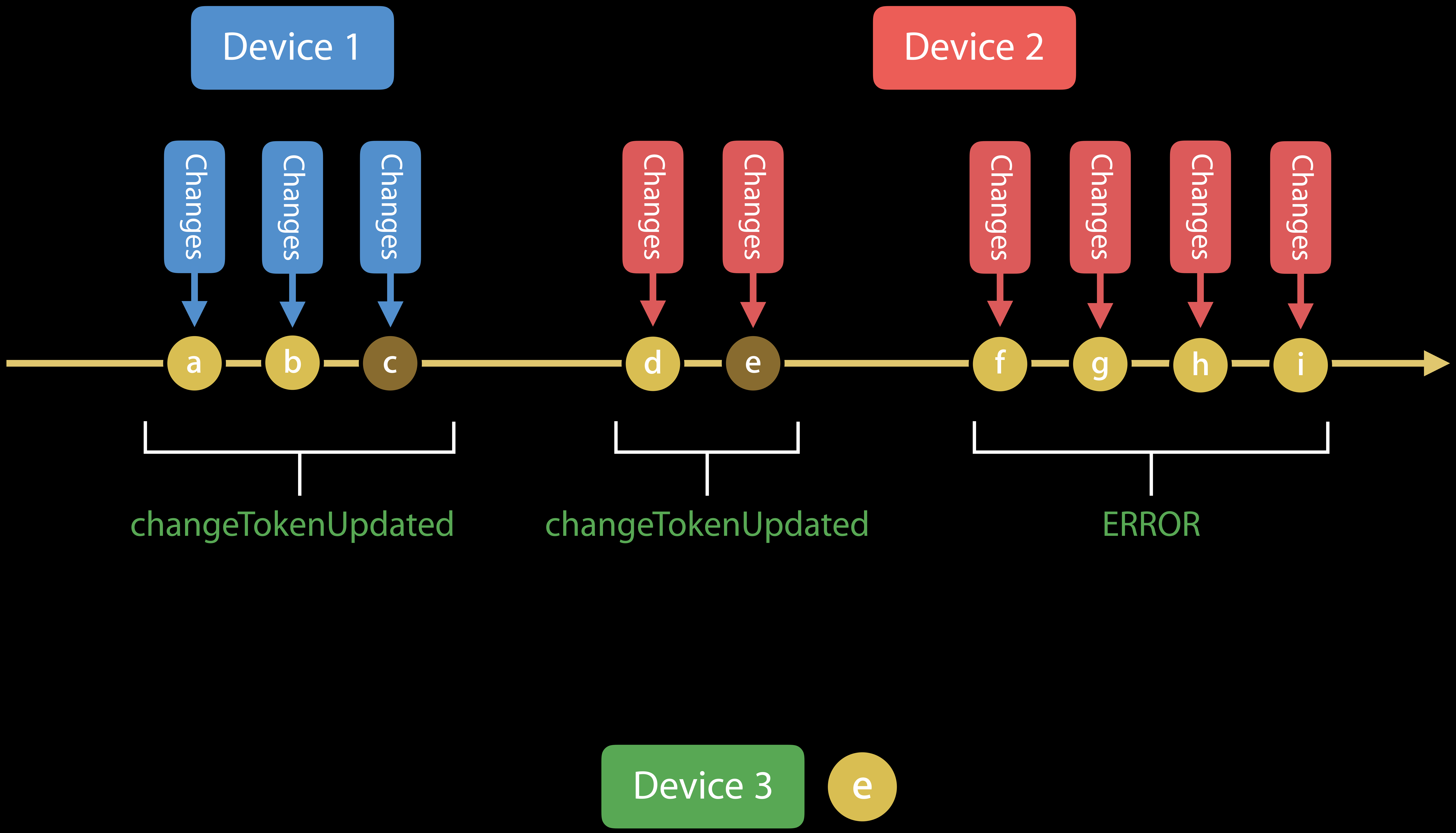
h
i
changeTokenUpdated
changeTokenUpdated
Device 3
e


Device 1
Device 2
Changes
Changes
Changes
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Changes
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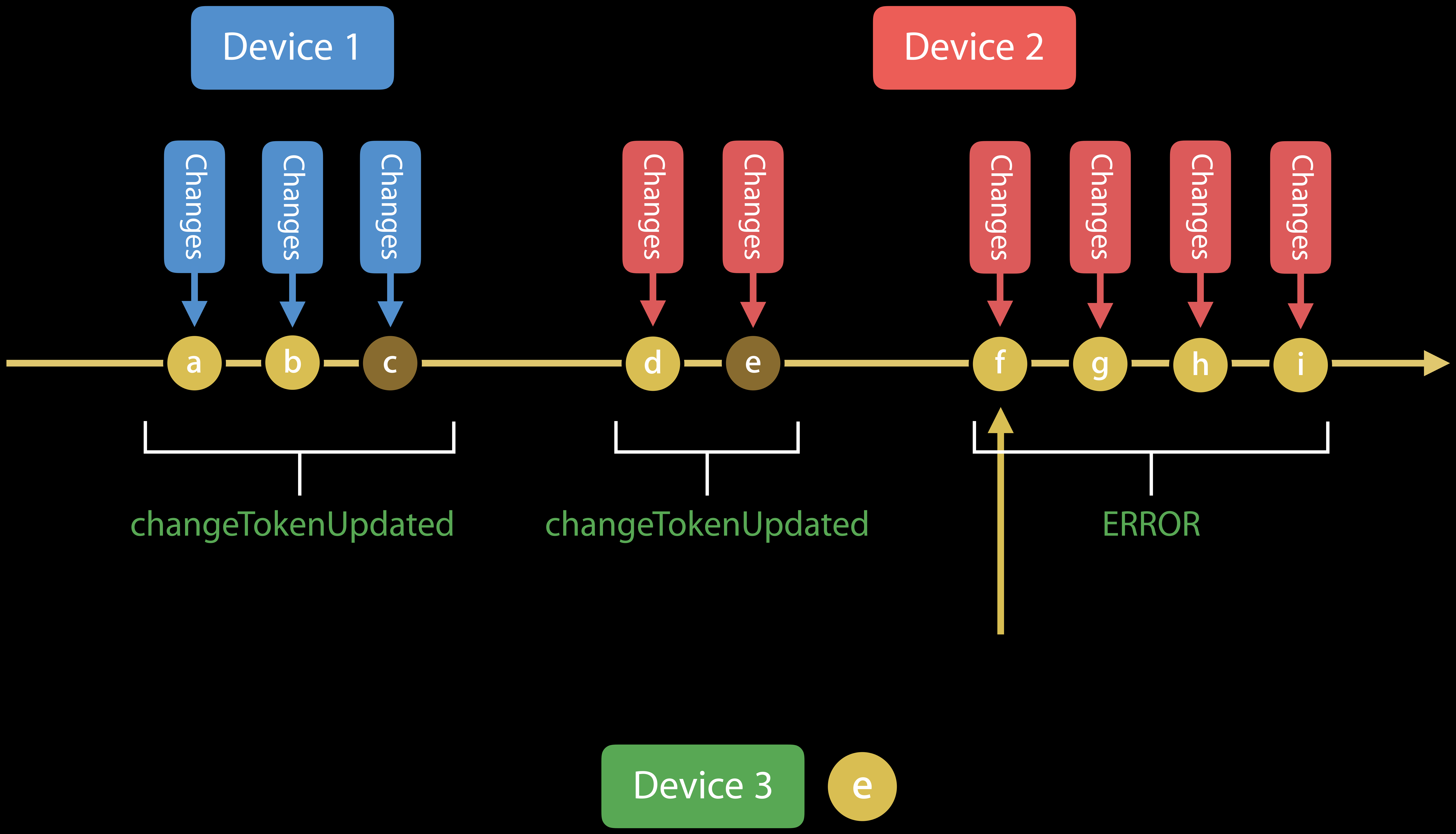
Changes
Changes
Changes
a
b
c
d
e
f
g
h
i
changeTokenUpdated
changeTokenUpdated
ERROR
Device 3
e


Device 1
Device 2
Changes
Changes
Changes
Changes
Changes
Changes
Changes
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b
c
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f
g
h
i
changeTokenUpdated
changeTokenUpdated
ERROR
Device 3
e

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## Recap

# Recap

✓ Subscribing to changes

## Recap

- ✓ Subscribing to changes
- ✓ Listening for pushes

## Recap

- ✓ Subscribing to changes
- ✓ Listening for pushes
- ✓ Fetching exactly what changed

# CloudKit Best Practices

Nihar Sharma CloudKit Engineer

## Best Practices

## Best Practices

Automatic authentication

## Best Practices

Automatic authentication

CKOperation API

## Best Practices

Automatic authentication

CKOperation API

Data modeling

## Best Practices

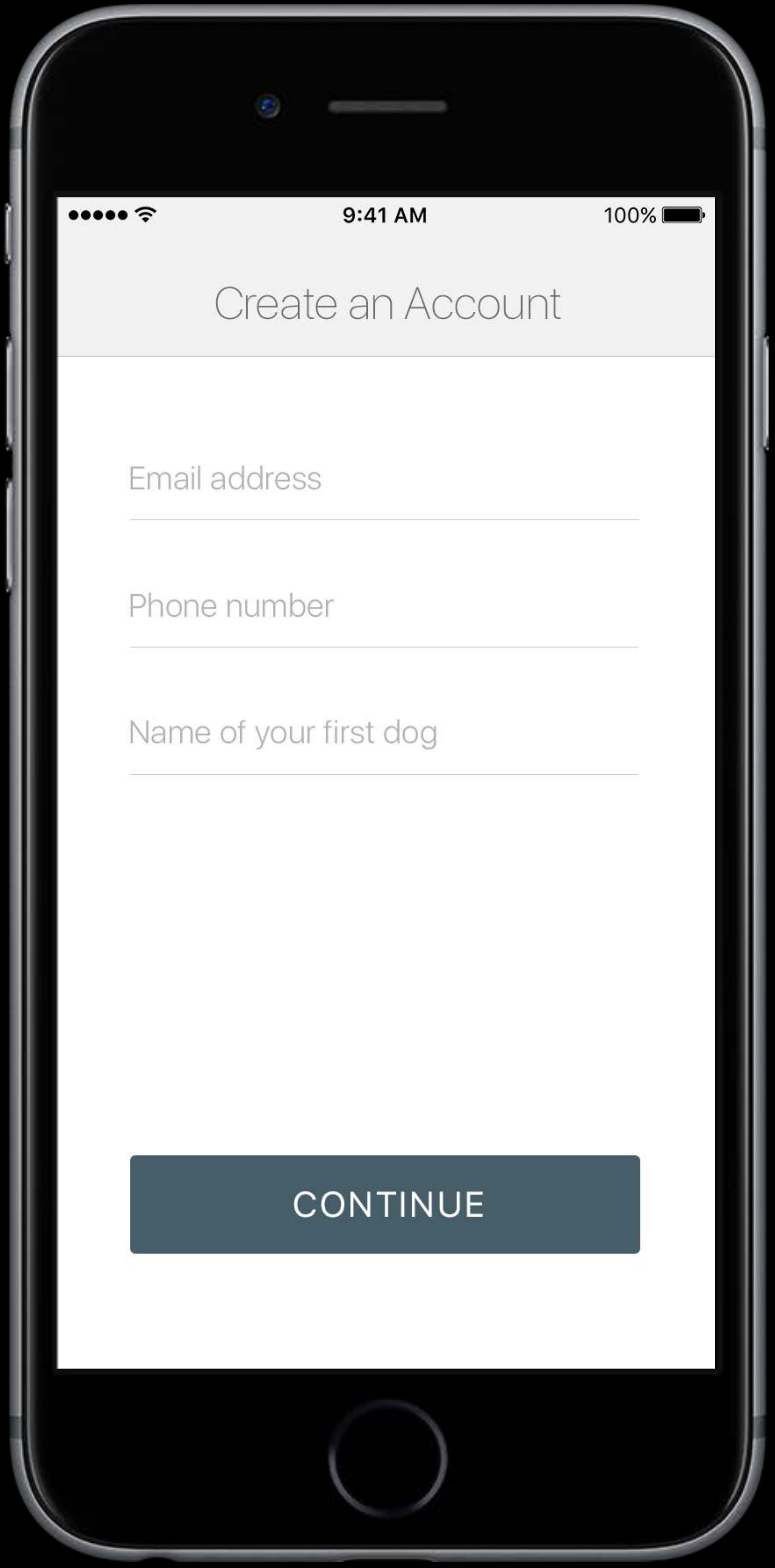
Automatic authentication

CKOperation API

Data modeling

Error handling

## Automatic Authentication


9:41 AM
100%
Create an Account
Email address
Phone number
Name of your first dog
CONTINUE

## Automatic Authentication

## Automatic Authentication

✓

CloudKit user record

## Automatic Authentication

CloudKit user record

Unique per CloudKit container

## Automatic Authentication

CloudKit user record

Unique per CloudKit container

Stable identifier

## Automatic Authentication

CloudKit user record

Unique per CloudKit container

Stable identifier

```
class CKContainer {
   public func fetchUserRecordID(completionHandler: (CKRecordID?, NSError?) -> Void)
}
```

## CKOperation

## CKOperation vs. Convenience API

## CKOperation vs. Convenience API

All convenience APIs have a `CKOperation` counterpart

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Works on batches of items

# CKOperation vs. Convenience API

All convenience APIs have a `CKOperation` counterpart

Works on batches of items

```
class CKDatabase {
    public func fetch(withRecordID recordID: CKRecordID,
        completionHandler: (CKRecord?, NSError?) -> Void)

    public func save(_ record: CKRecord,
        completionHandler: (CKRecord?, NSError?) -> Void)
}
```

# CKOperation vs. Convenience API

All convenience APIs have a `CKOperation` counterpart

Works on batches of items

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class CKDatabase {
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}
```

```
CKFetchRecordsOperation
CKModifyRecordsOperation
```

## CKOperation

## CKOperation

```
class CKOperation : Operation
```

# CKOperation

```
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```

- Set up dependencies

# CKOperation

```
class CKOperation : Operation
```

- Set up dependencies
- Quality of service and queue priorities

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- Configurability

# CKOperation

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```

- Configurability
- Resource optimization

## CKOperation

```
class CKOperation : Operation
```

- Configurability
- Resource optimization
- Lifetime management

# CKOperation

Configurability

# CKOperation

## Configurability

Cellular access

## CKOperation

### Configurability

Cellular access

Fetch partial records

## CKOperation

### Configurability

Cellular access

Fetch partial records

Limit number of results

## CKOperation

### Configurability

Cellular access

Fetch partial records

Limit number of results

Progress reporting

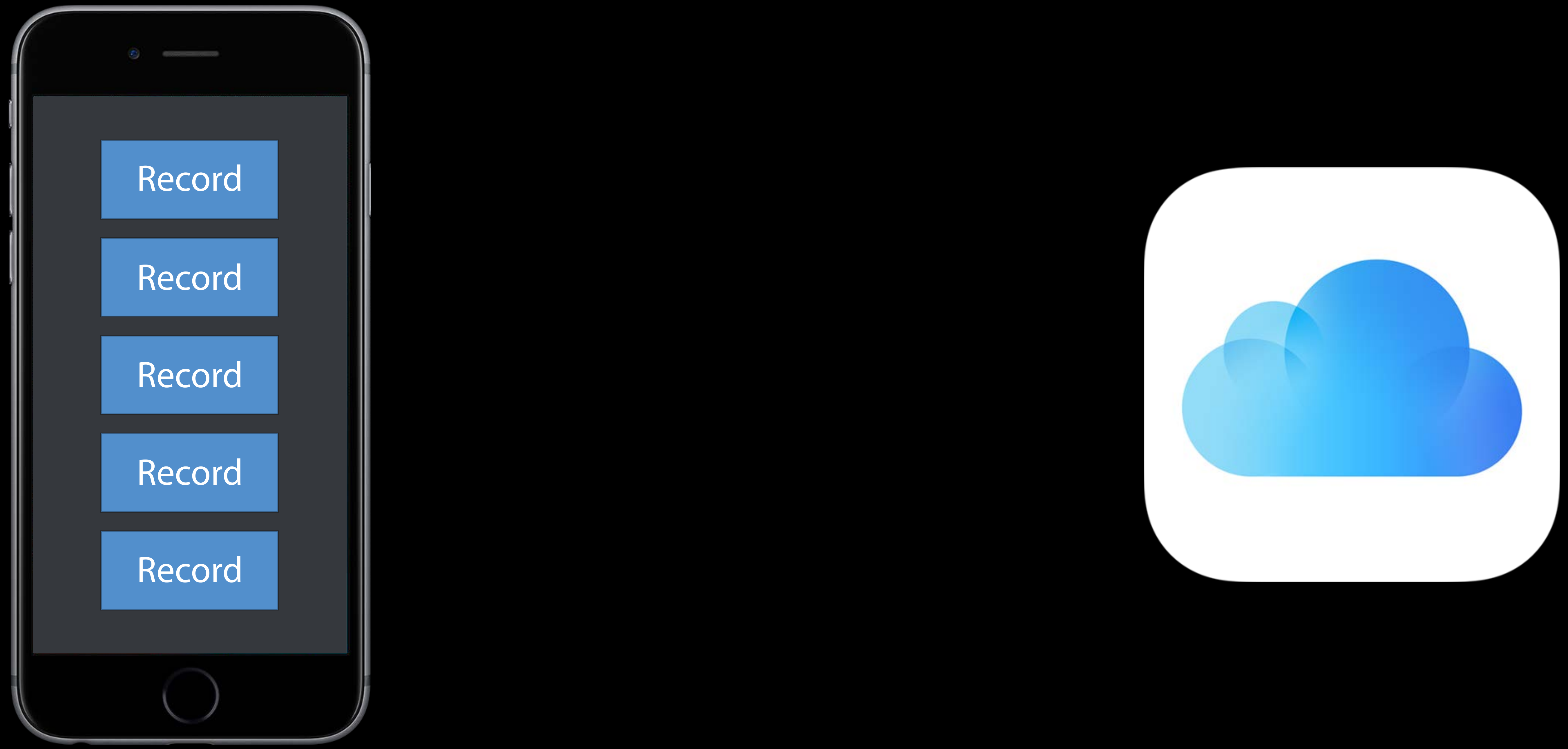
## CKOperation

Resource optimization

# CKOperation

## Resource optimization

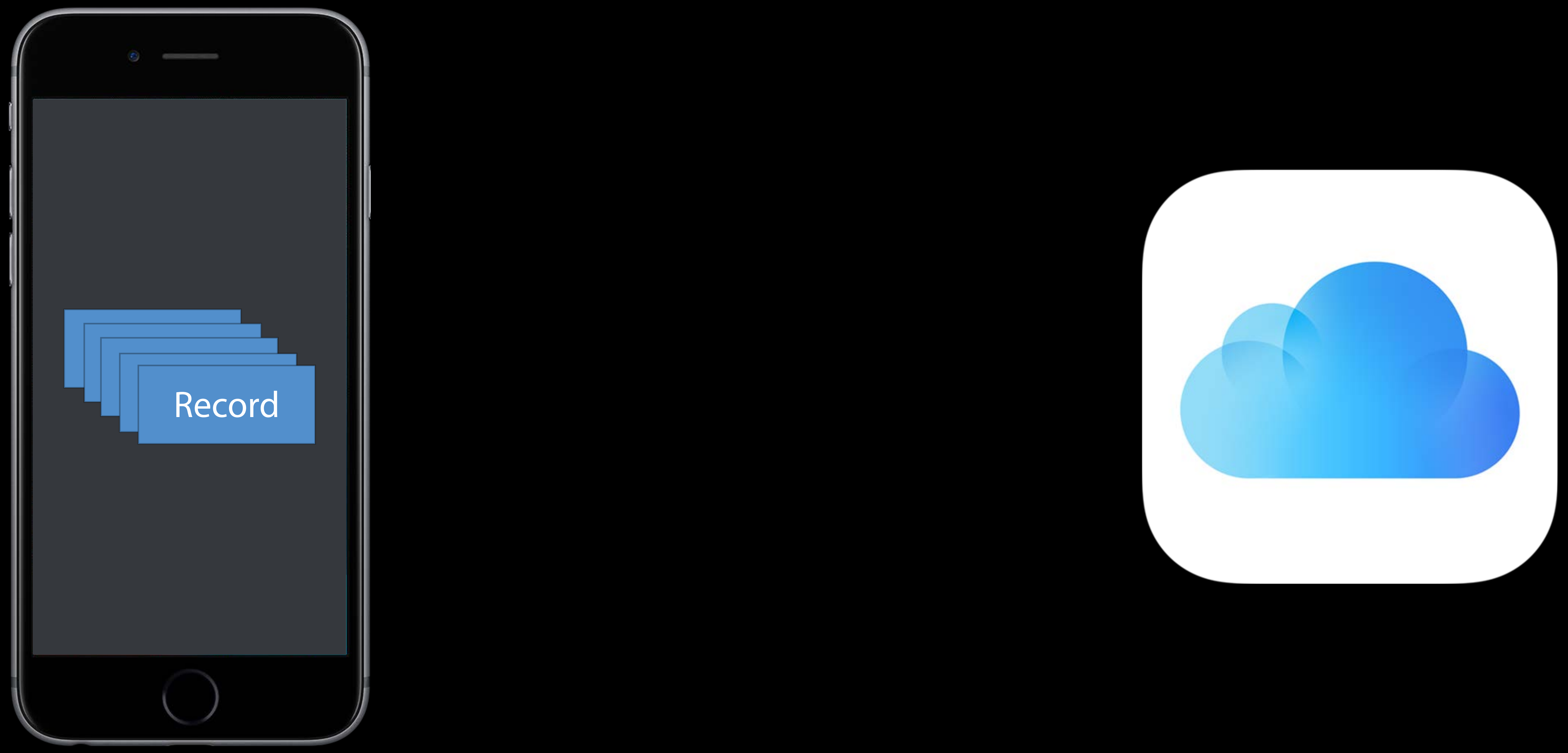
Minimize network requests



# CKOperation

## Resource optimization

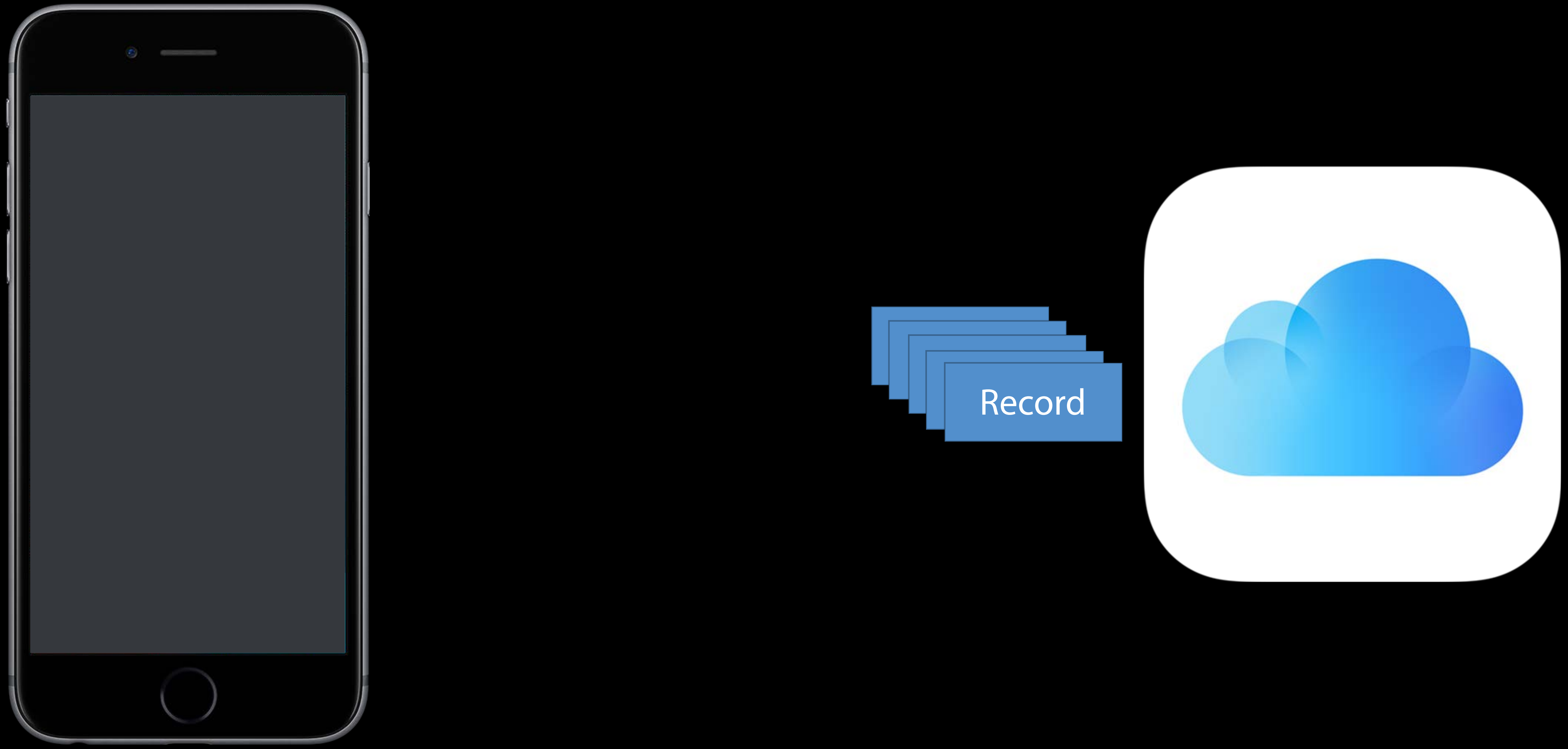
Minimize network requests



## CKOperation

### Resource optimization

Minimize network requests

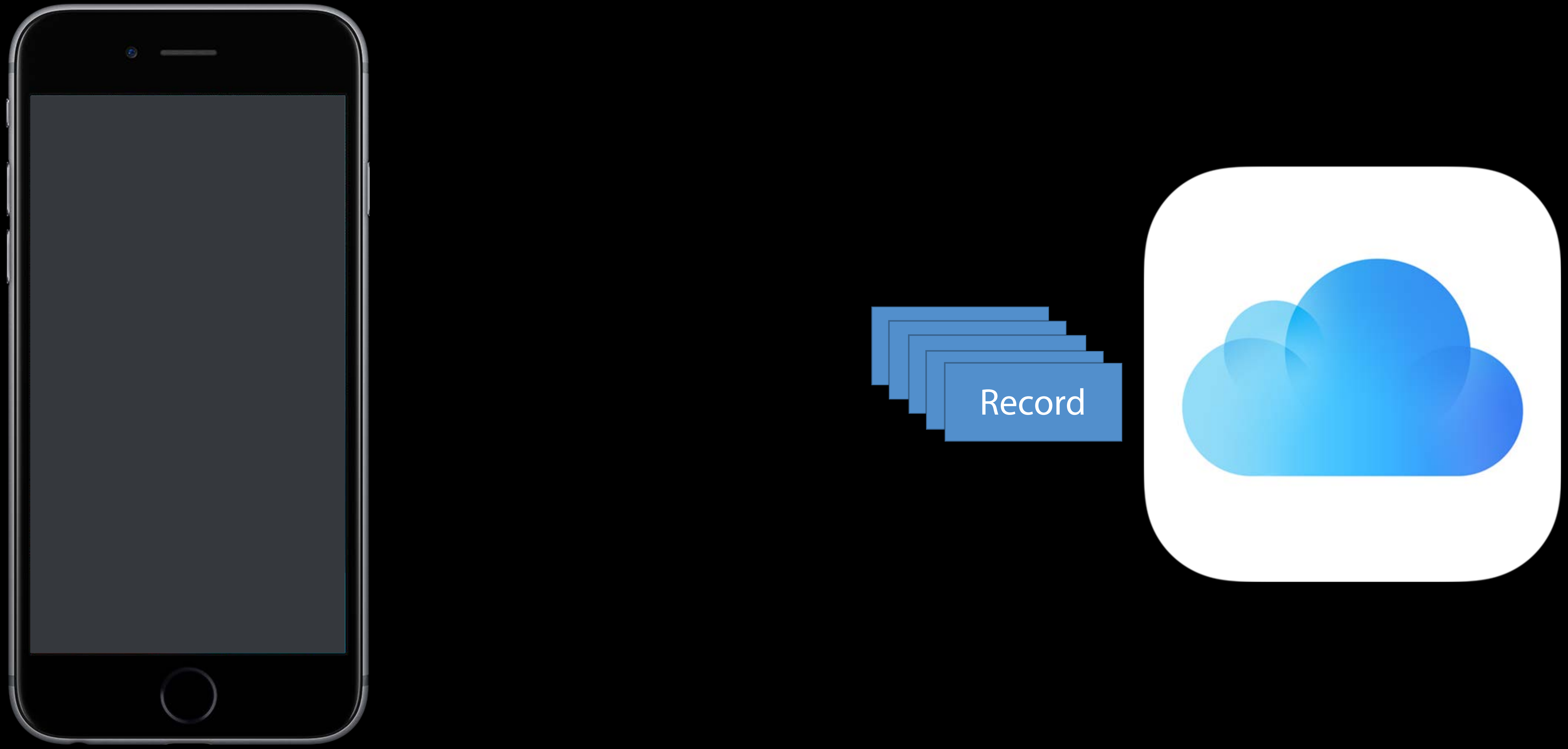


# CKOperation

## Resource optimization

Minimize network requests

System resources



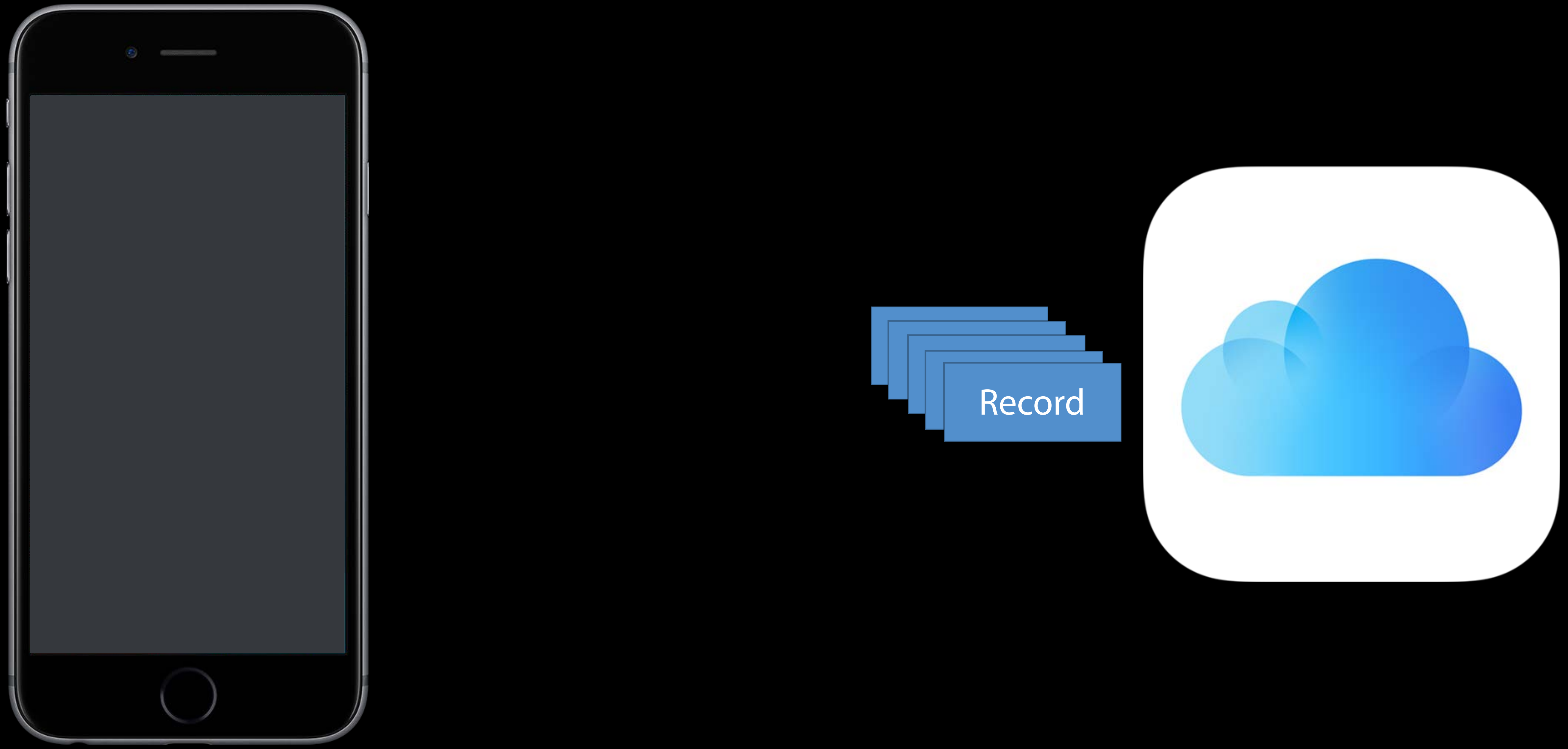
# CKOperation

## Resource optimization

Minimize network requests

System resources

Request quota



## CKOperation

Resource optimization

# CKOperation

## Resource optimization

Discretionary behavior opt-in

# CKOperation

## Resource optimization

Discretionary behavior opt-in

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public enum QualityOfService : Int {
    case userInteractive
    case userInitiated
    case utility
    case background
    case `default`
}
```

# CKOperation

## Resource optimization

✓

Discretionary behavior opt-in

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# CKOperation

## Quality of Service

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# CKOperation

## Quality of Service

Network failures are retried

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    case utility
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}
```

# CKOperation

## Quality of Service

Network failures are retried

7-day resource timeout

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    case userInitiated
    case utility
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```

## CKOperation

Lifetime management

# CKOperation

## Lifetime management

App suspension or force quit

## CKOperation

### Lifetime management

App suspension or force quit

User-initiated or long-running updates

## CKOperation

### Lifetime management

App suspension or force quit

User-initiated or long-running updates

Long-lived operations

## CKOperation

Lifetime management

NEW

App suspension or force quit

User-initiated or long-running updates

Long-lived operations

## CKOperation

Lifetime management

NEW

App suspension or force quit

User-initiated or long-running updates

Long-lived operations

```
public class CKOperation : Operation {
    public var operationID: String { get }
    public var isLongLived: Bool
}
```

## Long-Lived Operations

How to use them

## Long-Lived Operations

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Issuing Long-Lived Operations

- Initialize a CKOperation
- Set the isLongLived flag
- Set callbacks on the operation
- Run the operation

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Resuming Long-Lived Operations

- Fetch the long-lived operation from CKContainer
- Set callbacks on operation
- Run the operation

## Long-Lived Operations

### How to use them

NEW ish

Issuing Long-Lived Operations

- Initialize a CKOperation
- Set the isLongLived flag
- Set callbacks on the operation
- Run the operation

Resuming Long-Lived Operations

- Fetch the long-lived operation from CKContainer
- Set callbacks on operation
- Run the operation

## Long-Lived Operations

### Create and run the operation

NEW ish

```
let myOp = CKFetchRecordsOperation(recordIDs: [myRecordID])

myOp.isLongLived = true
let myOpID = myOp.operationID

// Set callbacks
myOp.fetchRecordsCompletionBlock = {(records, error) in ... }

// Resume the operation
CKContainer.default().privateCloudDatabase.add(myOp)
```

## Long-Lived Operations

### Create and run the operation

NEW ish

```
let myOp = CKFetchRecordsOperation(recordIDs: [myRecordID])

myOp.isLongLived = true
let myOpID = myOp.operationID

// Set callbacks
myOp.fetchRecordsCompletionBlock = {(records, error) in ... }

// Resume the operation
CKContainer.default().privateCloudDatabase.add(myOp)
```

# Long-Lived Operations

## Resume the operation

NEW ish

```
CKContainer.default().fetchLongLivedOperation(withID: myOpID) {
    (longLivedOp: CKOperation?, error: NSError?) in

    let myFetchRecordsOp = longLivedOp as! CKFetchRecordsOperation

    // Set callbacks
    myFetchRecordsOp.fetchRecordsCompletionBlock = {(records, error) in ... }

    // Resume the operation
    CKContainer.default().privateCloudDatabase.add(myFetchRecordsOp)
}
```

# Long-Lived Operations

## Resume the operation

NEW ish

```
CKContainer.default().fetchLongLivedOperation(withID: myOpID) {
    (longLivedOp: CKOperation?, error: NSError?) in

    let myFetchRecordsOp = longLivedOp as! CKFetchRecordsOperation

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    myFetchRecordsOp.fetchRecordsCompletionBlock = {(records, error) in ... }

    // Resume the operation
    CKContainer.default().privateCloudDatabase.add(myFetchRecordsOp)
}
```

## Long-Lived Operations

Resume the operation

NEW ish

```
CKContainer.default().fetchLongLivedOperation(withID: myOpID) {
    (longLivedOp: CKOperation?, error: NSError?) in

    let myFetchRecordsOp = longLivedOp as! CKFetchRecordsOperation

    // Set callbacks
    myFetchRecordsOp.fetchRecordsCompletionBlock = {(records, error) in ... }

    // Resume the operation
    CKContainer.default().privateCloudDatabase.add(myFetchRecordsOp)
}
```

## Long-Lived Operations

### Notes

NEW ish

Operations are cleaned up

## Long-Lived Operations

### Notes

NEW ish

Operations are cleaned up

- Once their completion block is called

## Long-Lived Operations

### Notes

NEW ish

Operations are cleaned up

- Once their completion block is called
- 24 hours after they complete

## Data Modeling

## Data Modeling

# Data Modeling

Schema redundancies

## Data Modeling

Schema redundancies

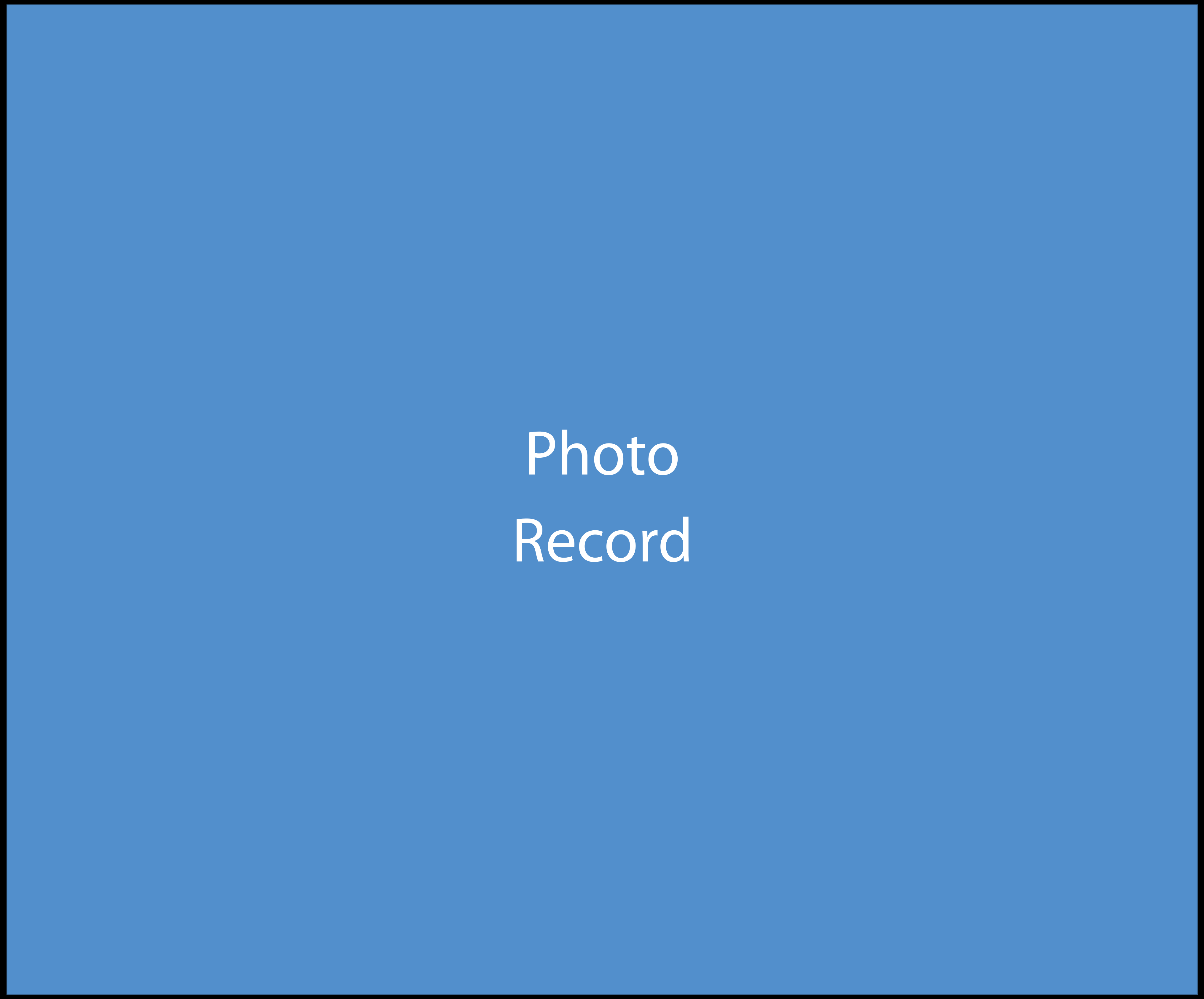
CKReferences

## Data Modeling

- Schema redundancies
- CKReferences
- Parent references

## Schema Redundancies

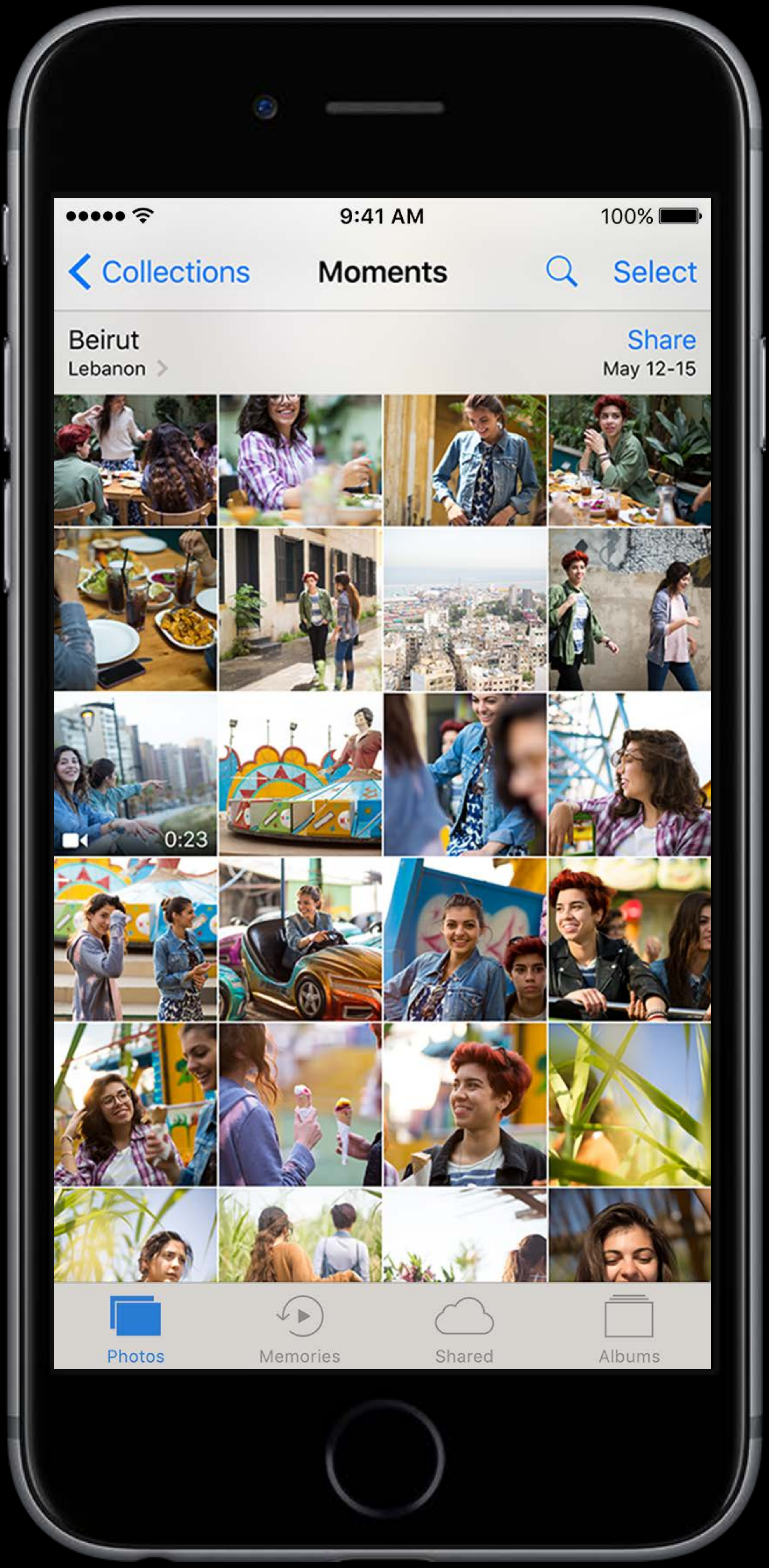
## Schema Redundancies



## Schema Redundancies

## Schema Redundancies

“Photo” =



9:41 AM
100%
Collections
Moments
Select
Beirut
Lebanon
Share
May 12-15
0:23
Photos
Memories
Shared
Albums

# Schema Redundancies

“Photo” =

## Schema Redundancies

“Photo” =

## Schema Redundancies

“Photo” =

“thumbnail1024” =

## Schema Redundancies

Optimized download

## Schema Redundancies

Optimized download

```
let myOp = CKQueryOperation(query: myQuery)
myOp.desiredKeys = ["thumbnail1024"]
myOp.resultsLimit = 10
myOp.sortDescriptors = […]
…
CKContainer.default().privateCloudDatabase.add(myOp)
```

## Schema Redundancies

Optimized download

## Schema Redundancies

Optimized download

✓ Fetch only what’s needed

## Schema Redundancies

### Optimized download

- ✓ Fetch only what’s needed
- ✓ CKFetchRecordZoneChangesOperation, CKFetchRecordsOperation

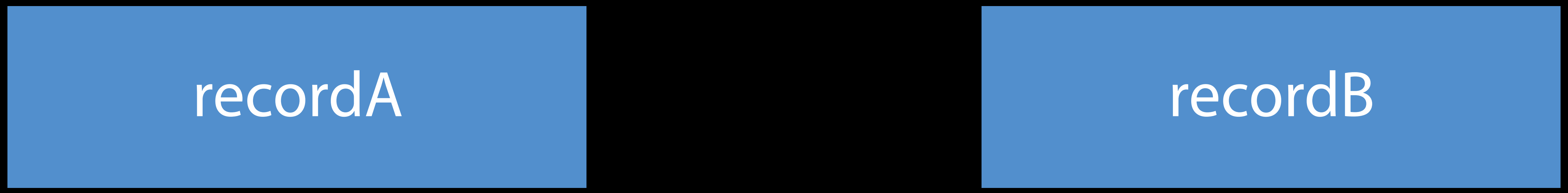
## Schema Redundancies

Optimized download

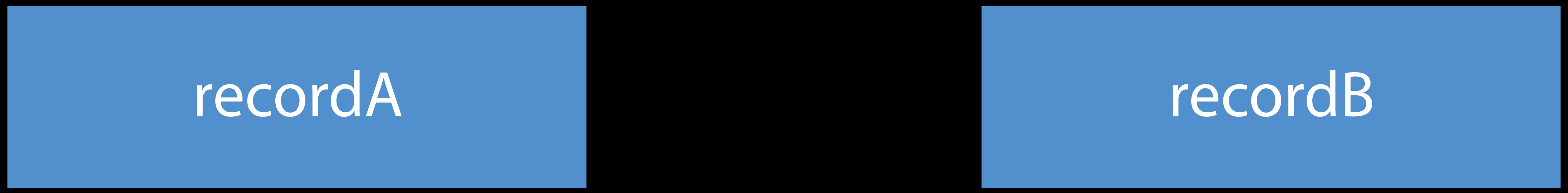
- ✓ Fetch only what's needed
- ✓ CKFetchRecordZoneChangesOperation, CKFetchRecordsOperation
- ✓ Dynamic UI

## CKReferences

## CKReferences

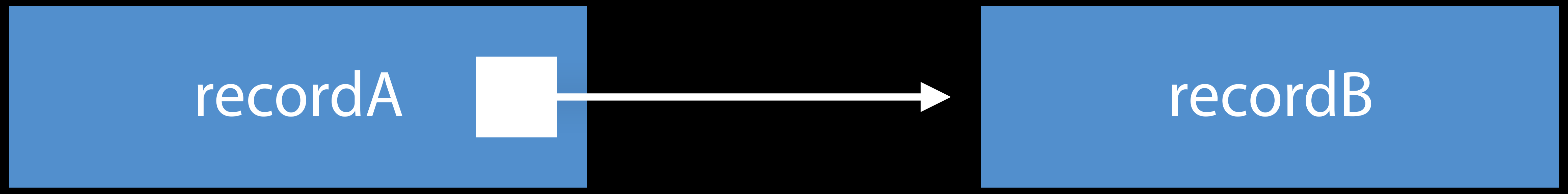


## CKReferences



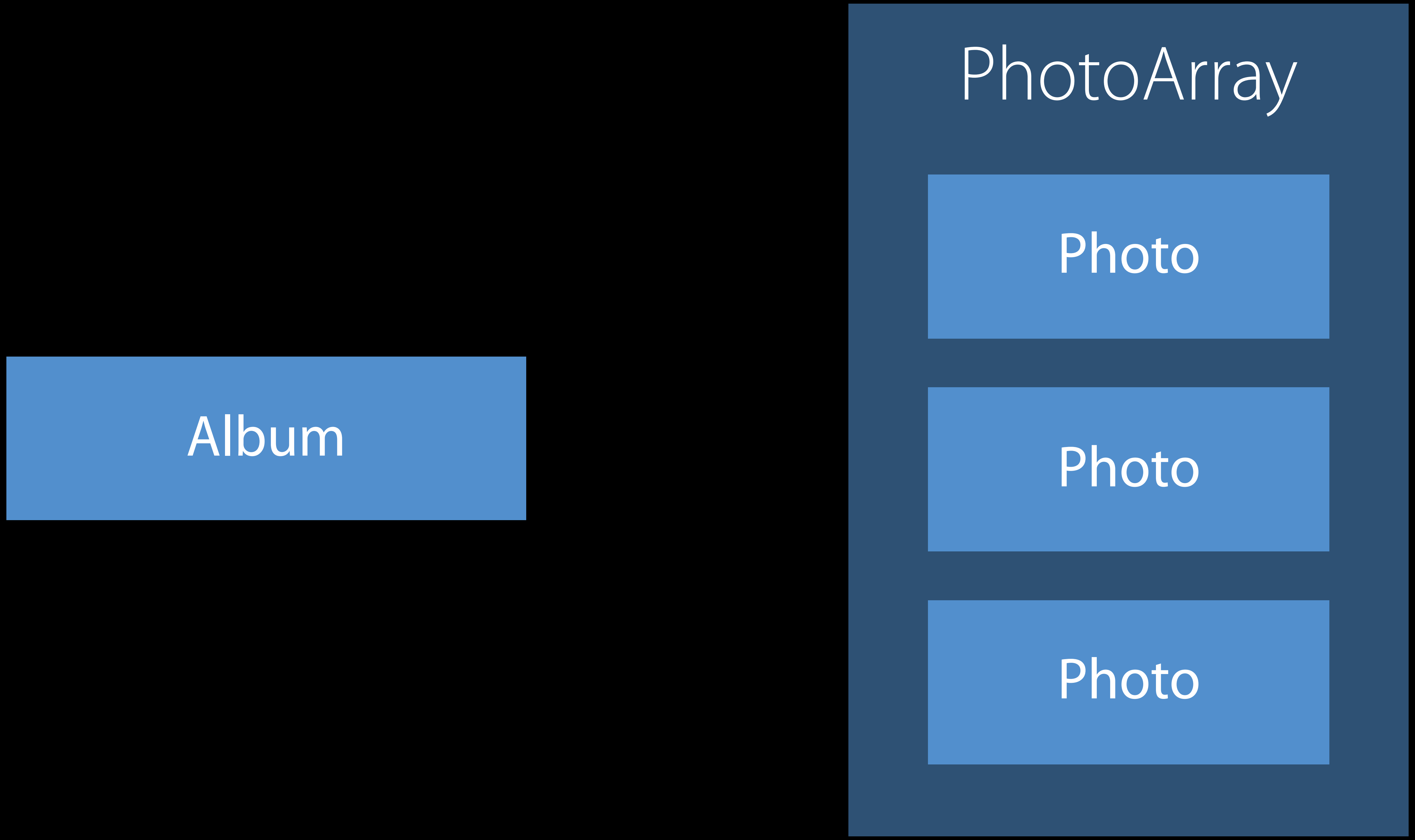
```
recordA["MyReference"] = CKReference(record: recordB, action: .None)
```

## CKReferences

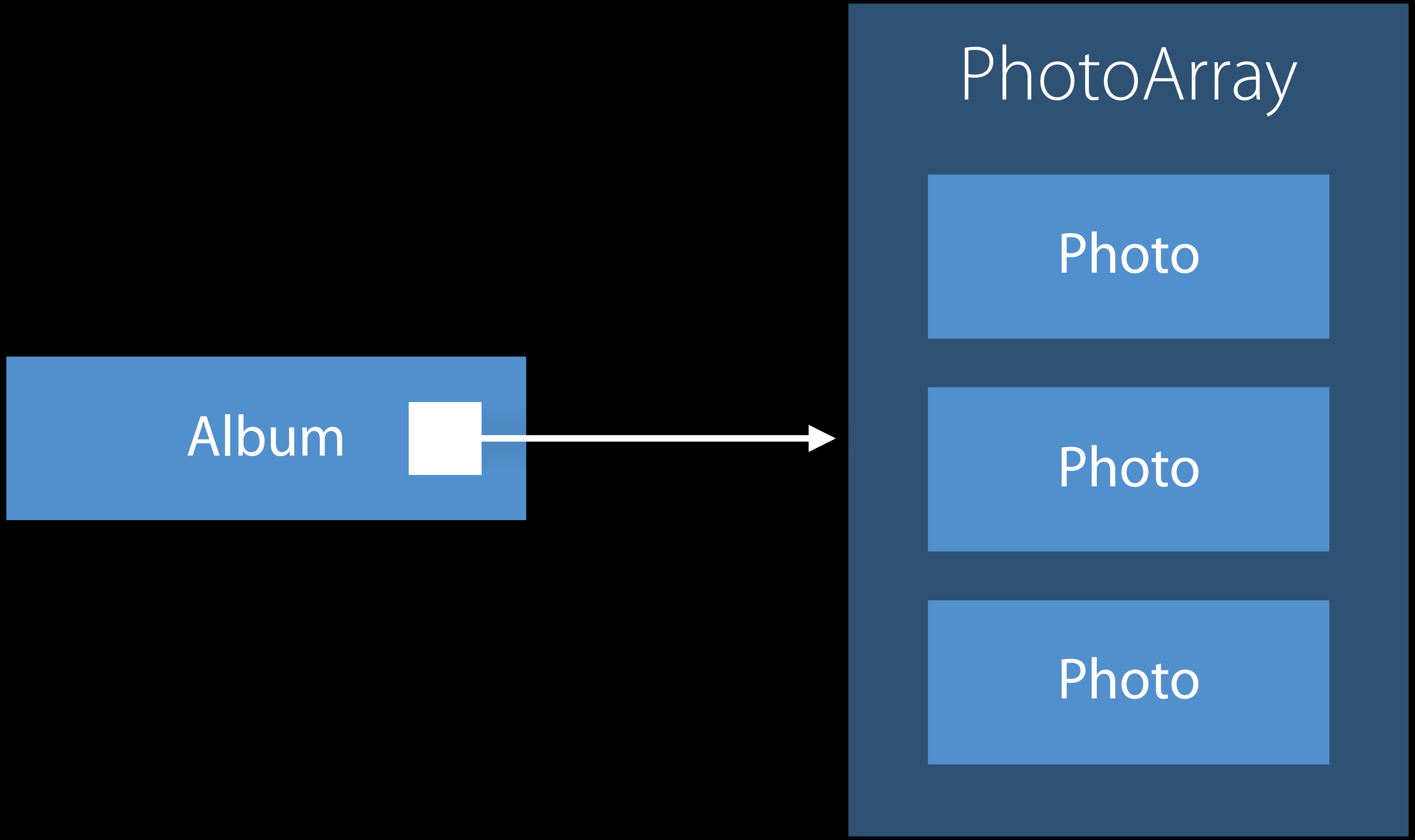


```
recordA["MyReference"] = CKReference(record: recordB, action: .None)
```

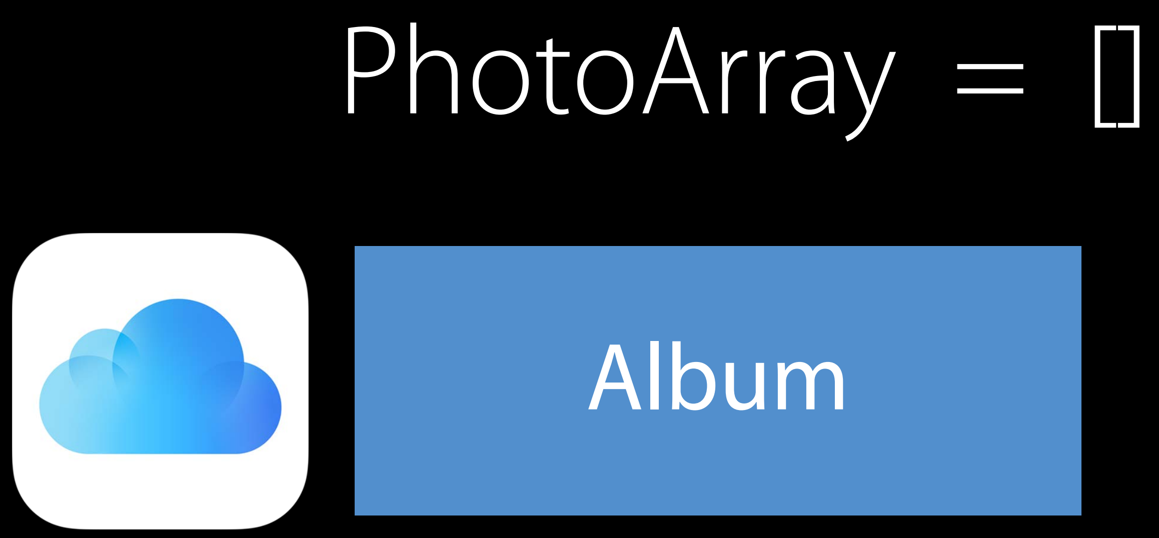
# CKReferences



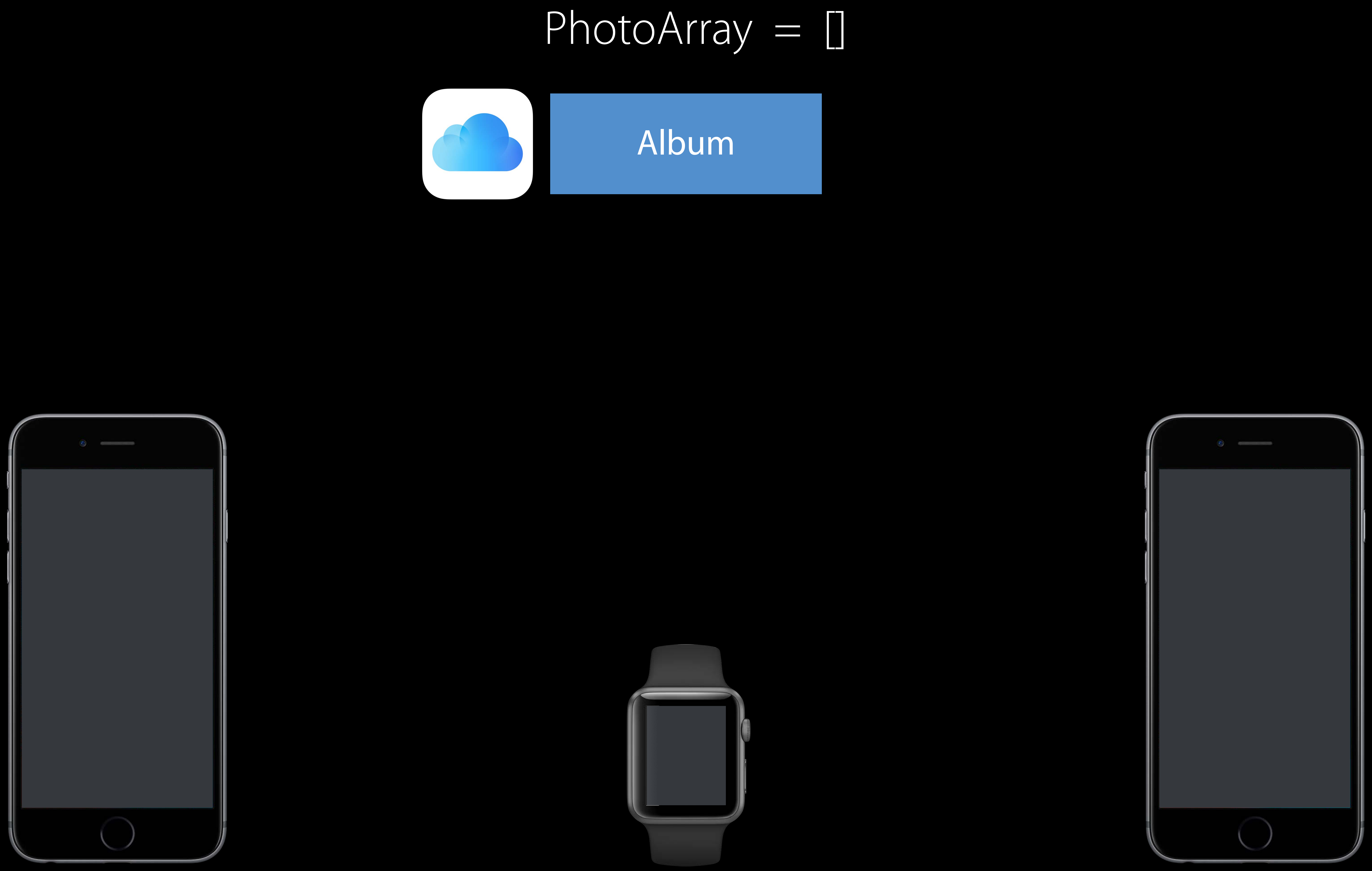
# CKReferences



# CKReferences

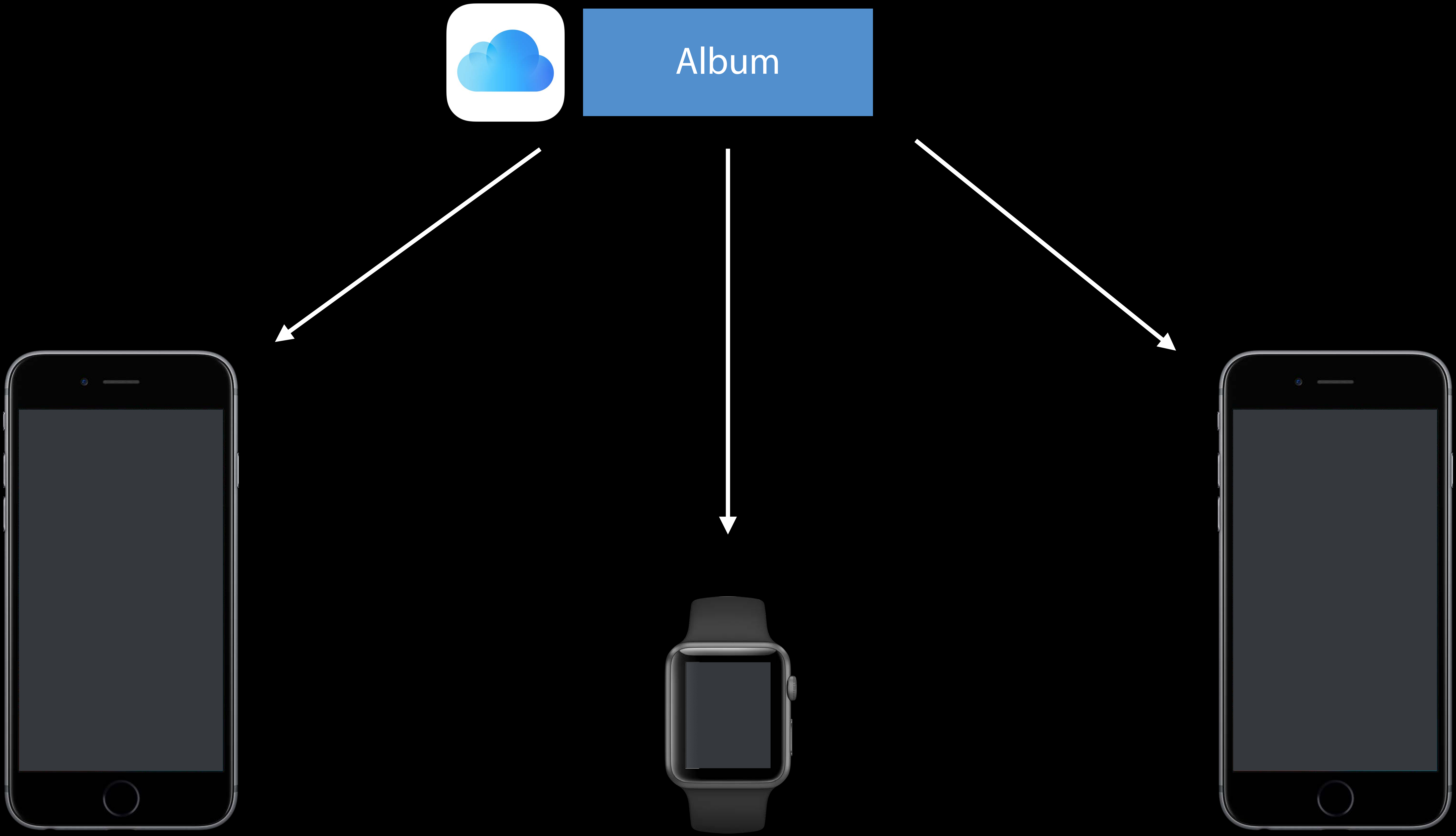


# CKReferences



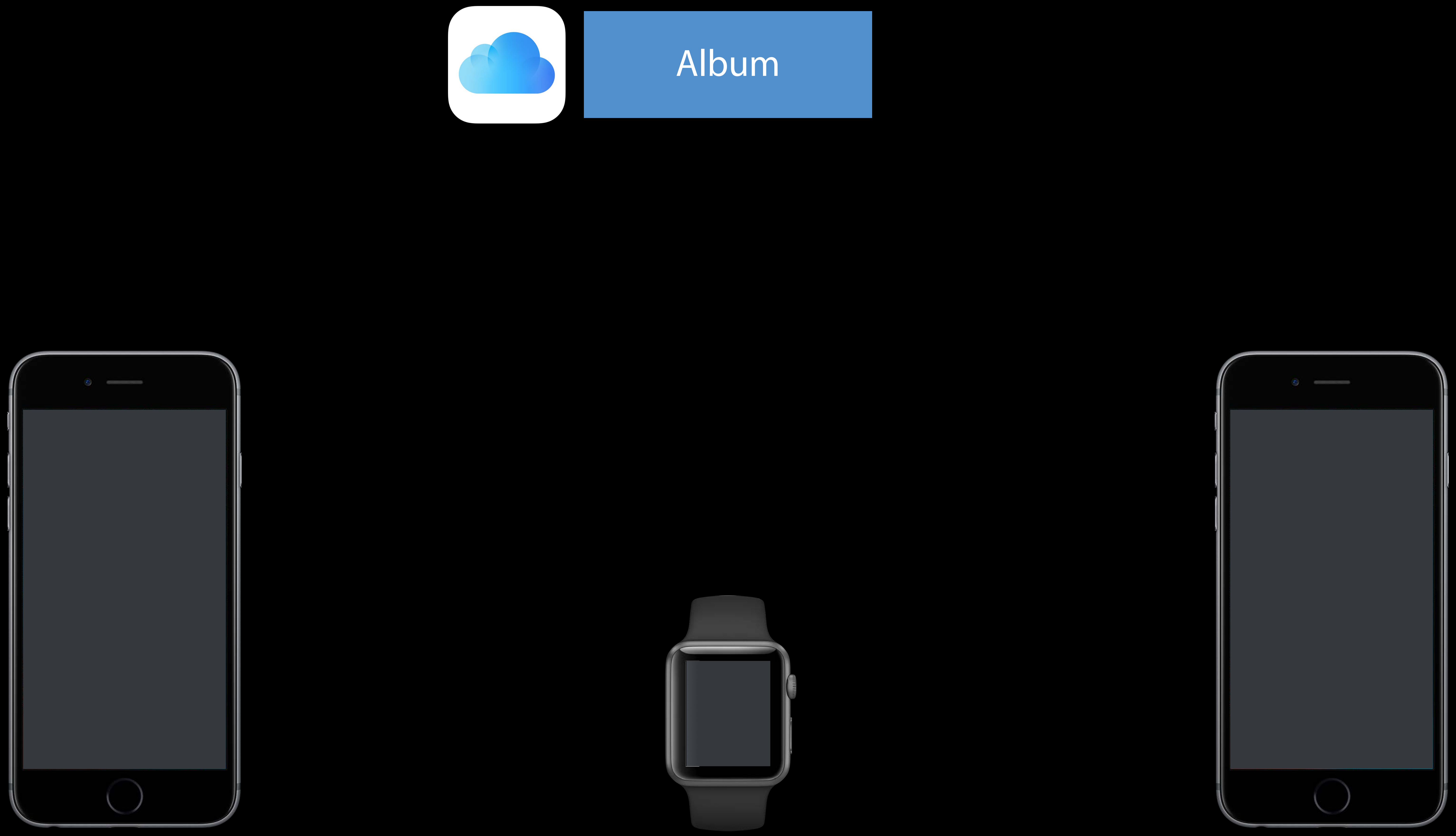
# CKReferences

PhotoArray = []

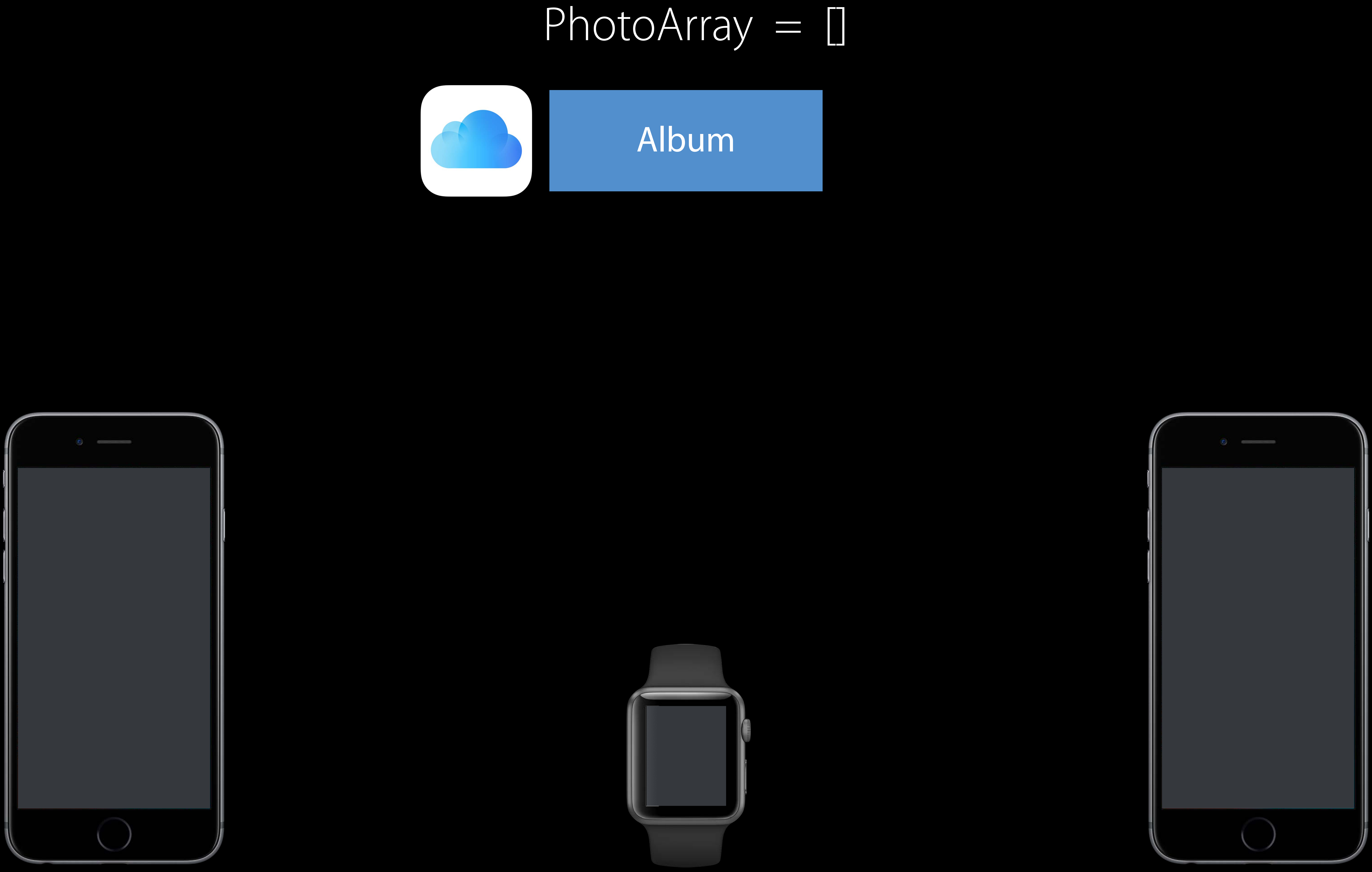


# CKReferences

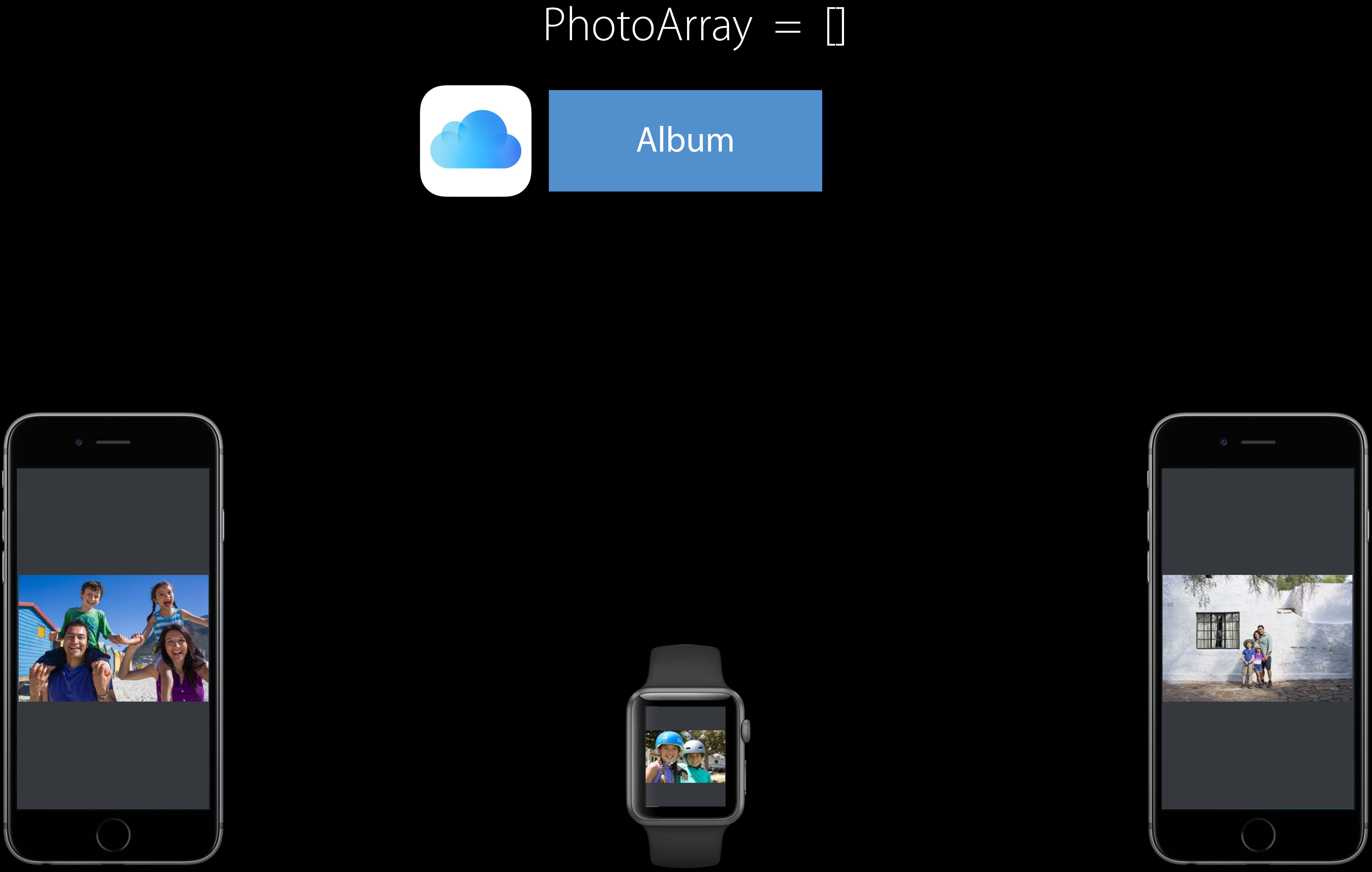
PhotoArray = []



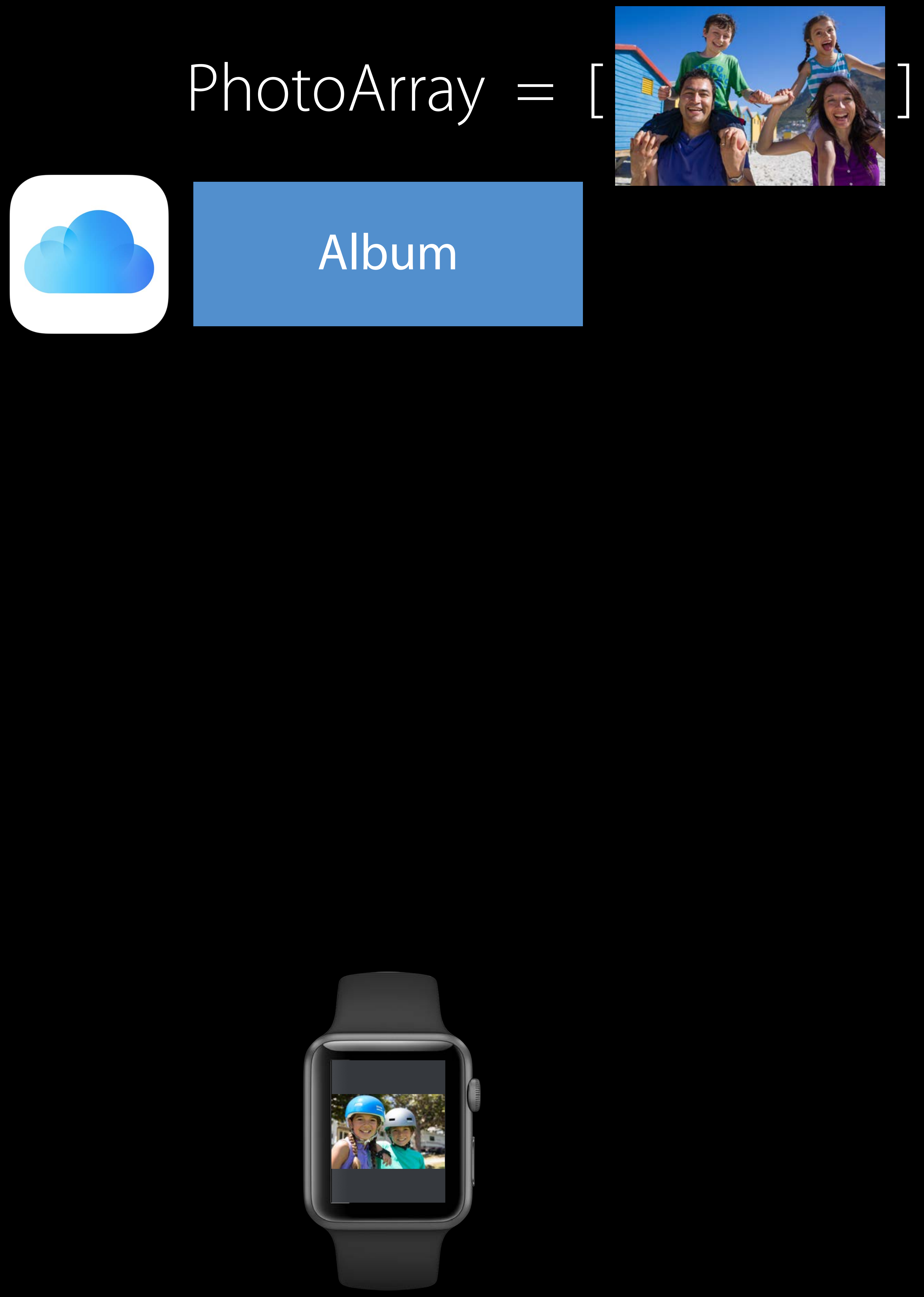
# CKReferences



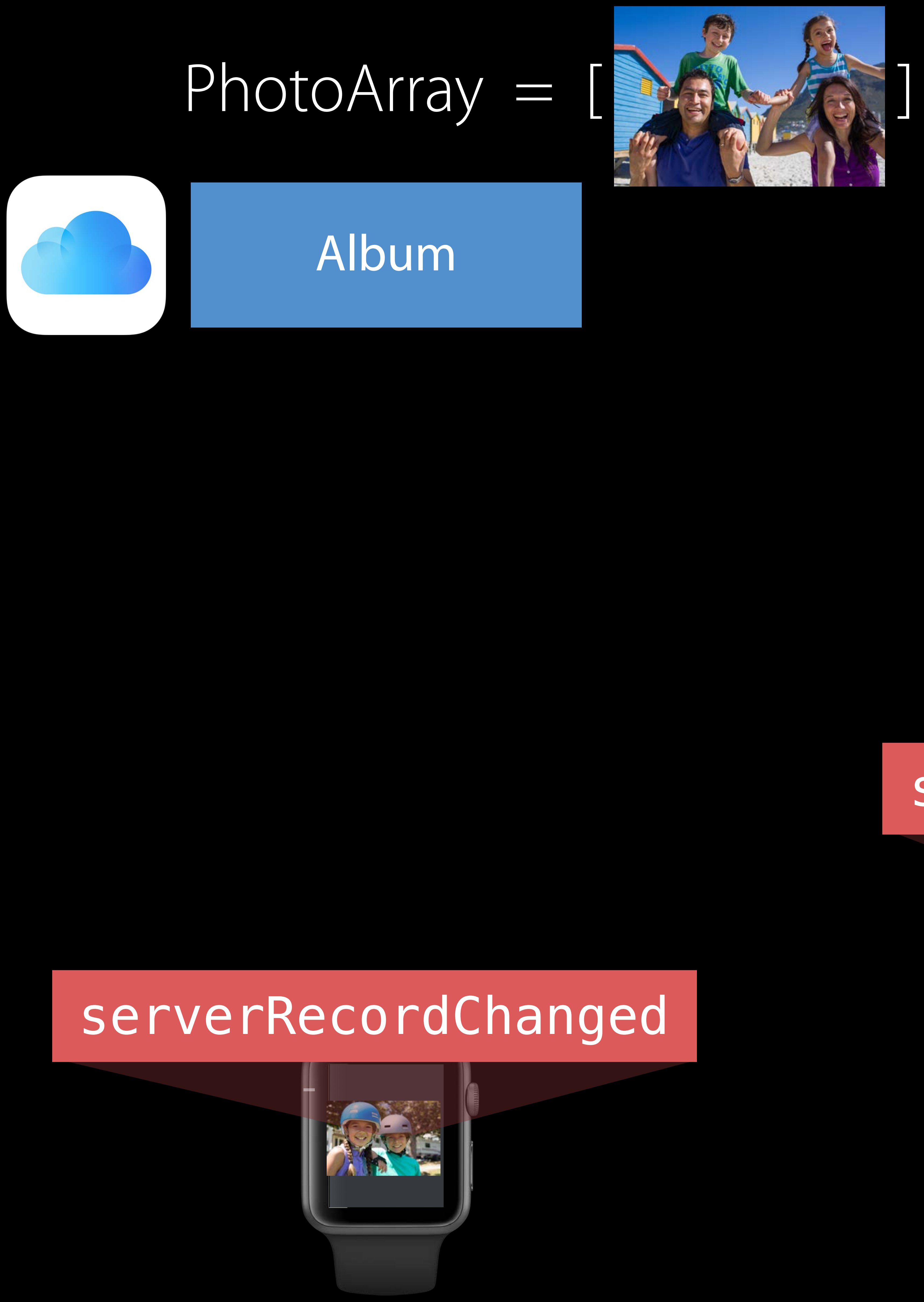
# CKReferences



# CKReferences

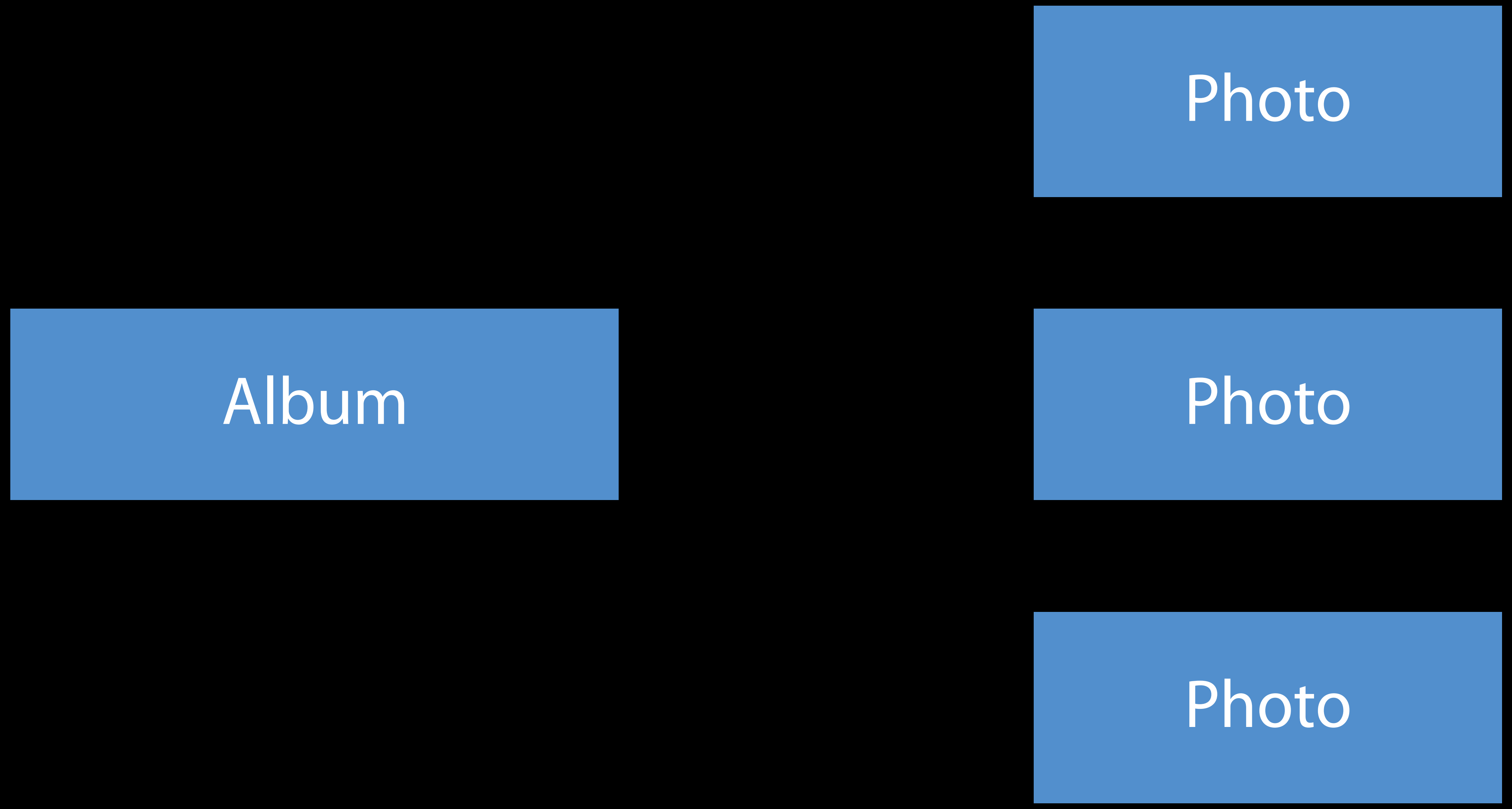


# CKReferences



## CKReferences

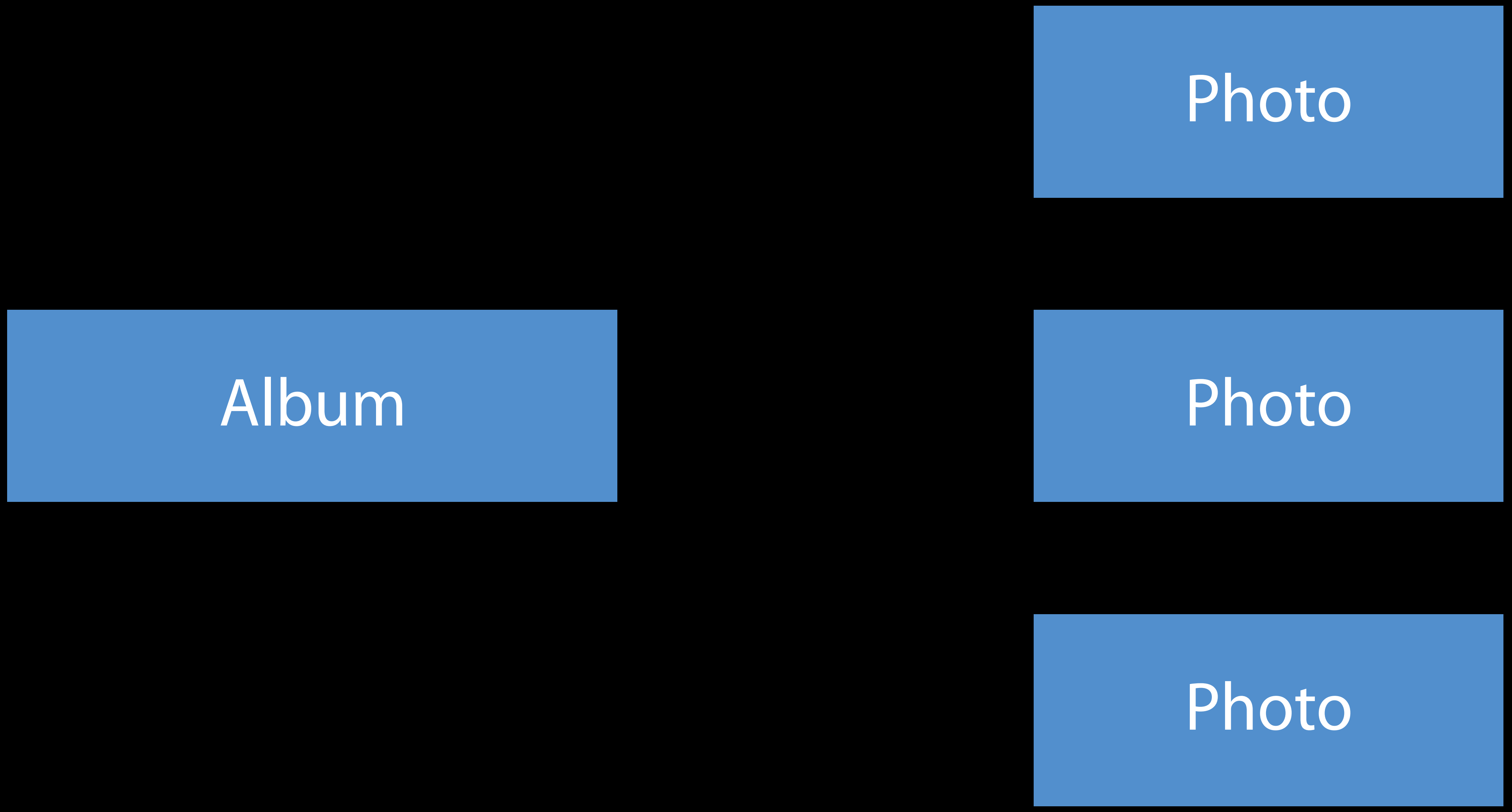
Frequent writes



# CKReferences

## Frequent writes

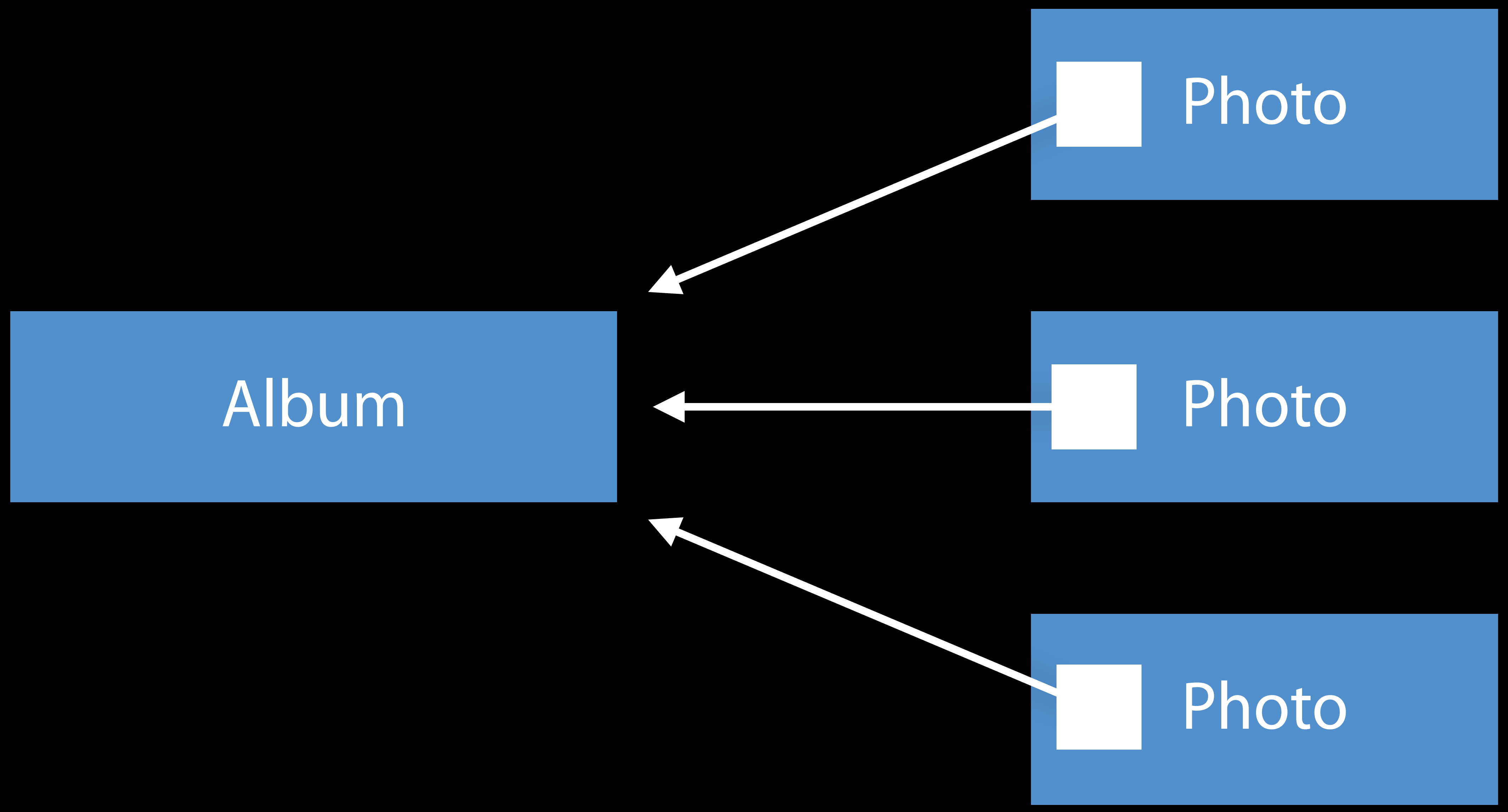
✓ Back pointers



## CKReferences

Frequent writes

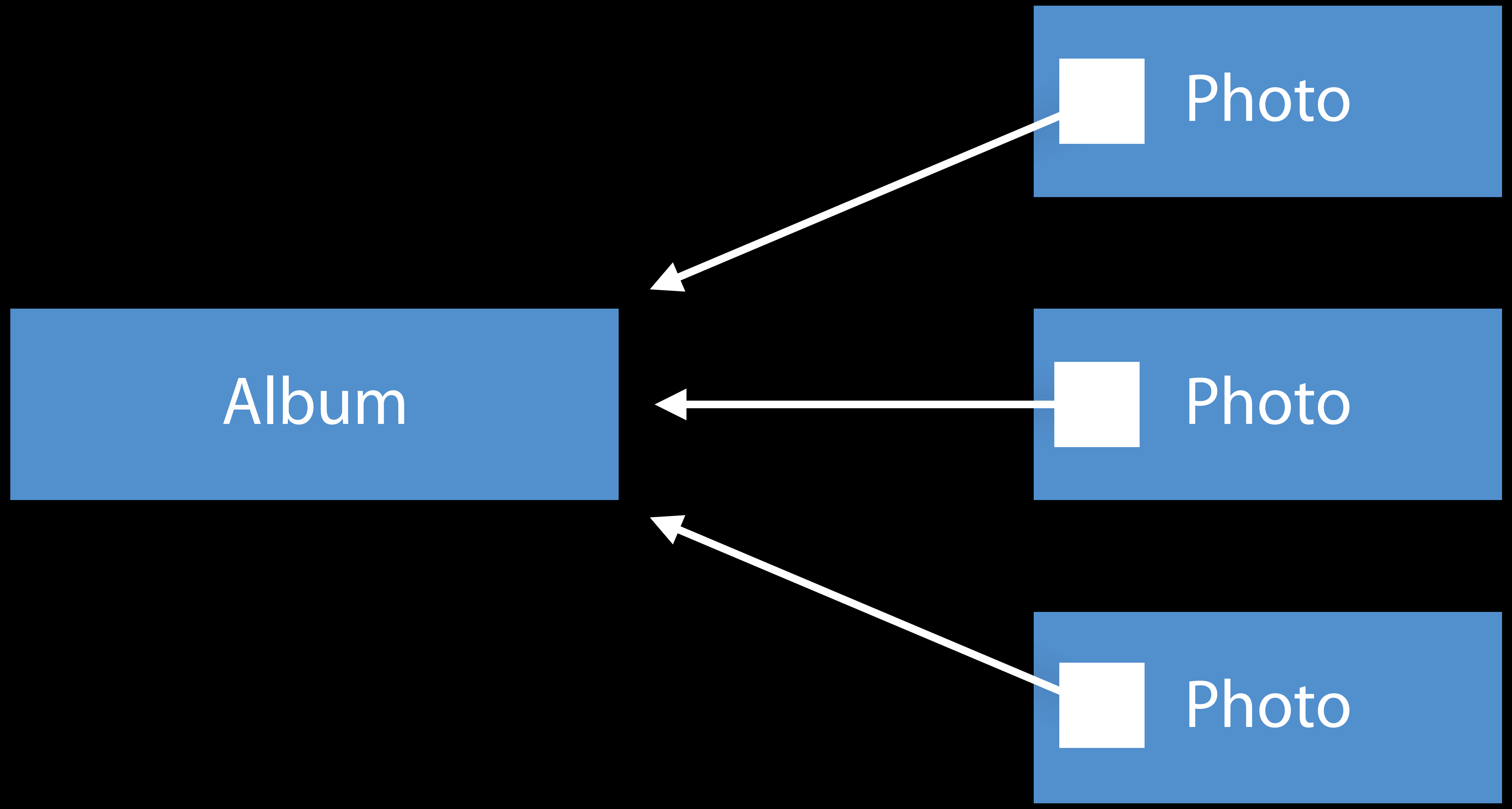
✓ Back pointers



# CKReferences

## Frequent writes

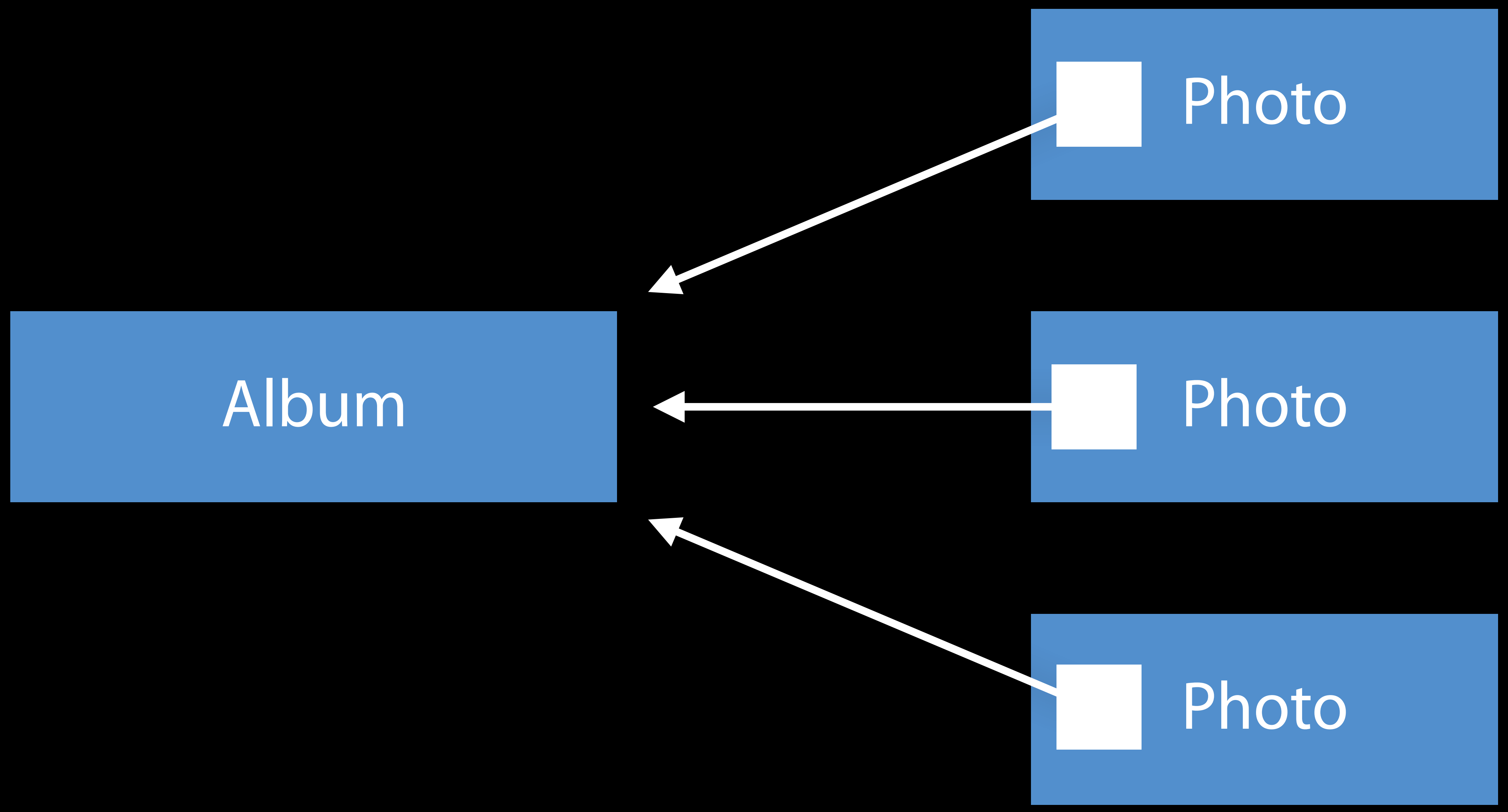
- ✓ Back pointers
- ✓ Reduce update contention



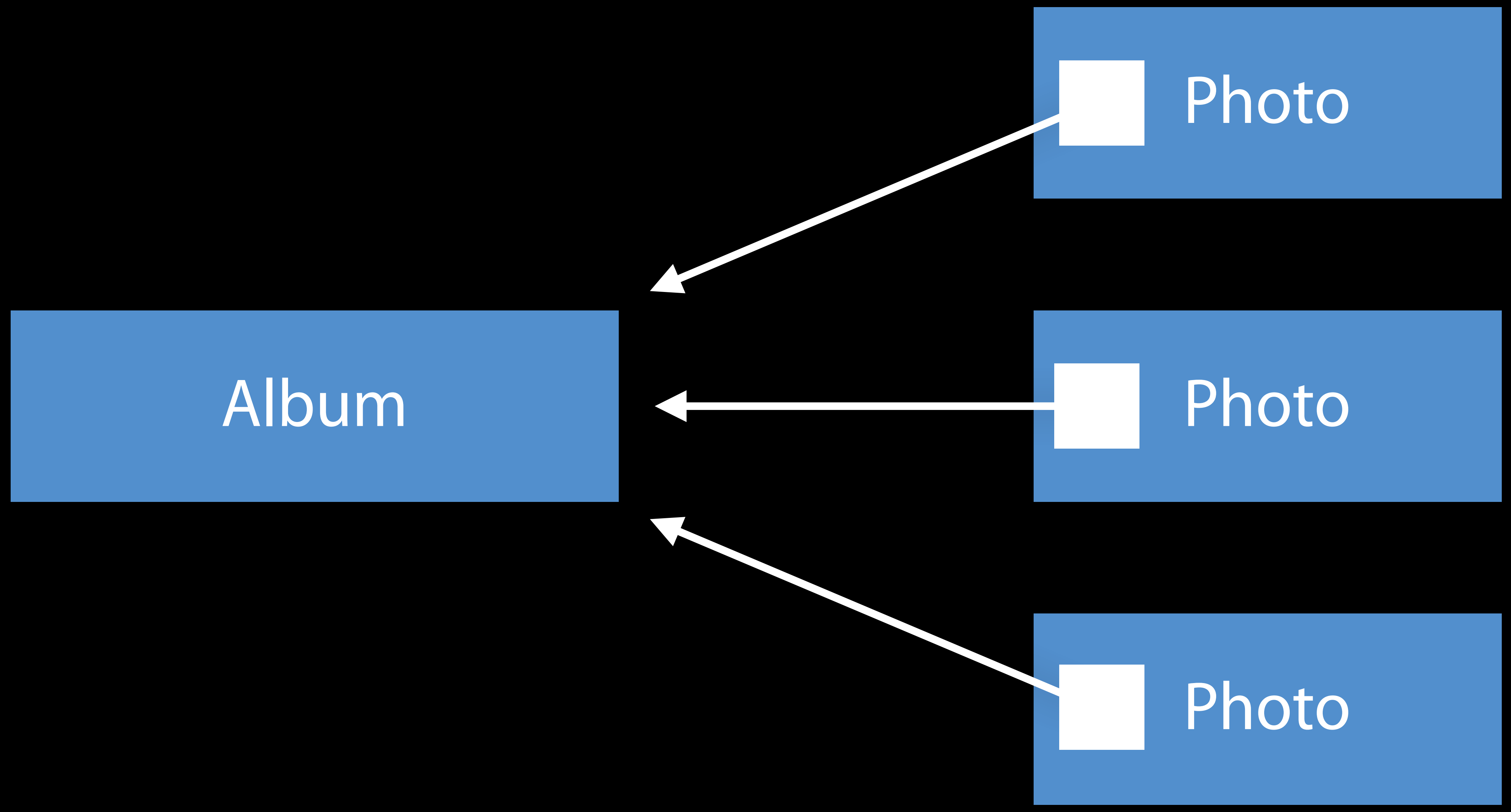
# CKReferences

## Frequent writes

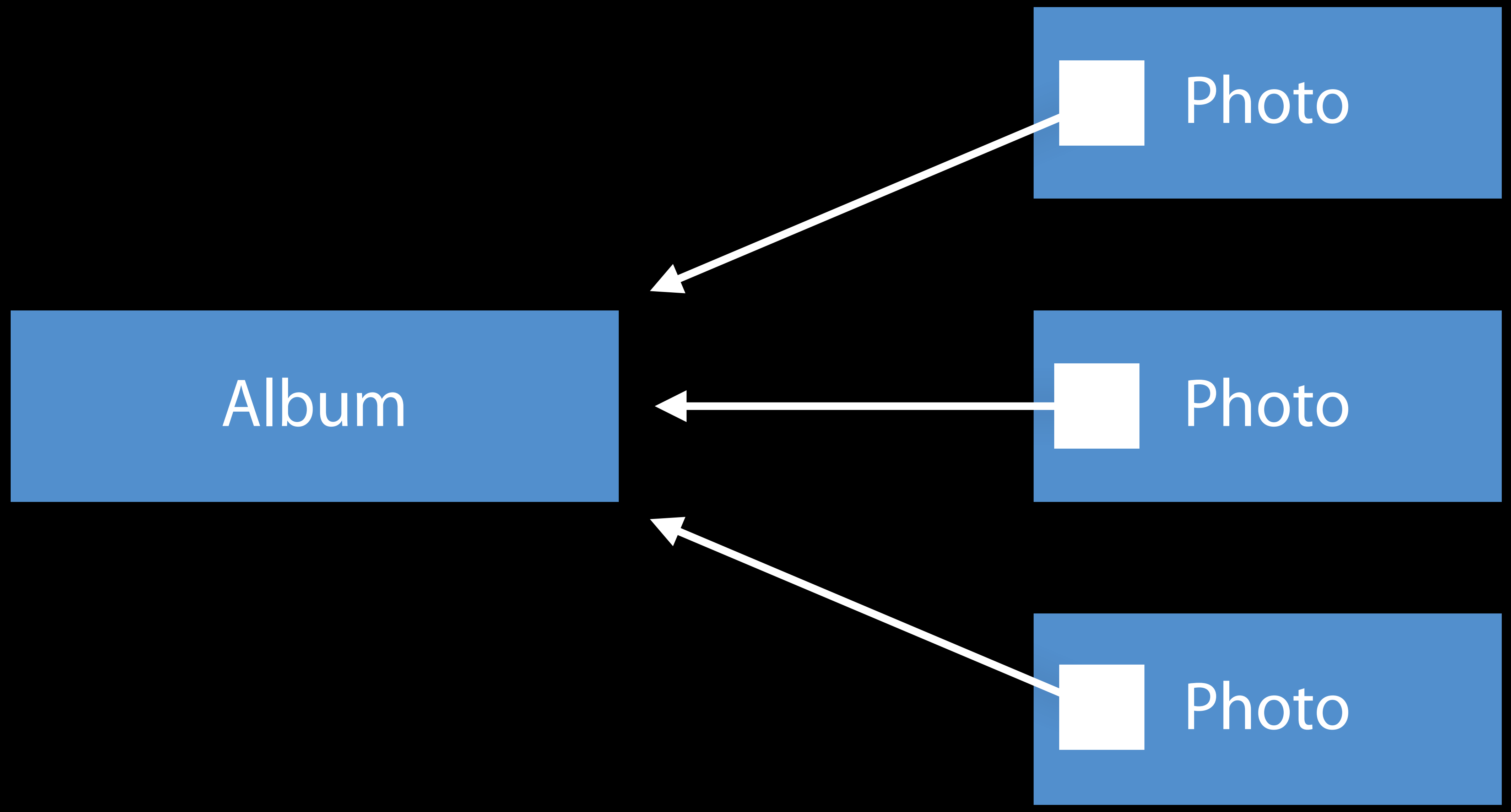
- ✓ Back pointers
- ✓ Reduce update contention
- ✓ Query for children



# CKReferences



# CKReferences



```
// Query to find all Photos in an Album
let query = CKQuery(recordType: "Photo",
   predicate: Predicate(format: "AlbumReference == %@", argumentArray: [albumRecord.recordID]))
```

## CKReferences

Parent references

## CKReferences

### Parent references

```
public class CKRecord : NSObject, NSSecureCoding, NSCopying {
   @NSCopying
   public var parent: CKReference?
}
```

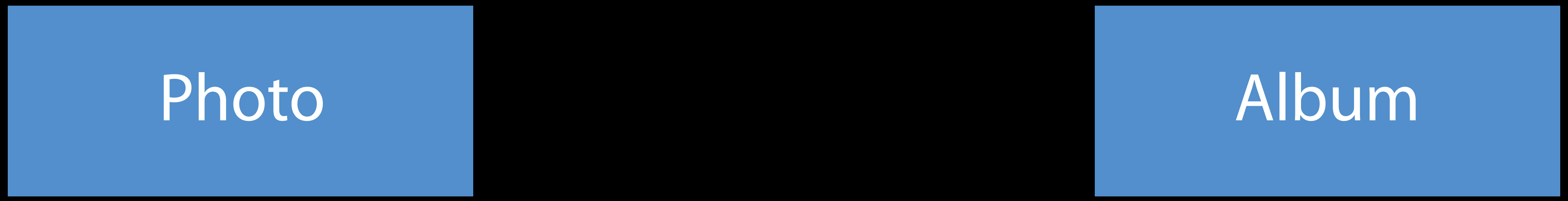
# CKReferences

## Parent references

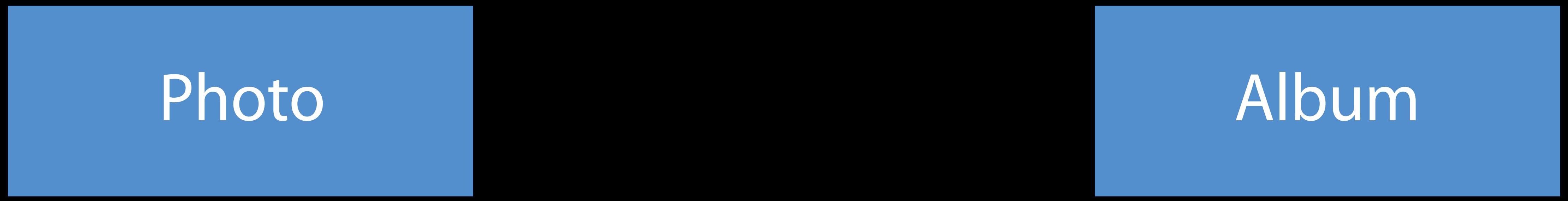
```
public class CKRecord : NSObject, NSSecureCoding, NSCopying {
   @NSCopying
   public var parent: CKReference?
}
```

Set parent references if your app supports sharing

# CKReferences

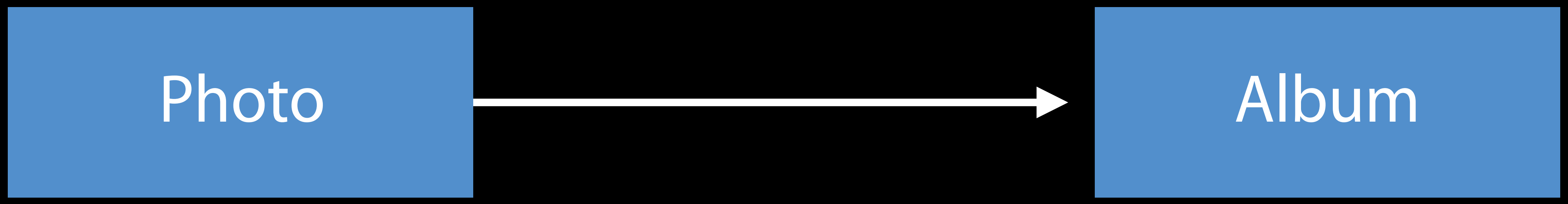


# CKReferences



```
let photoRecord = CKRecord(recordType: "Photo")
…
photoRecord.setParent(albumRecordID)
```

# CKReferences

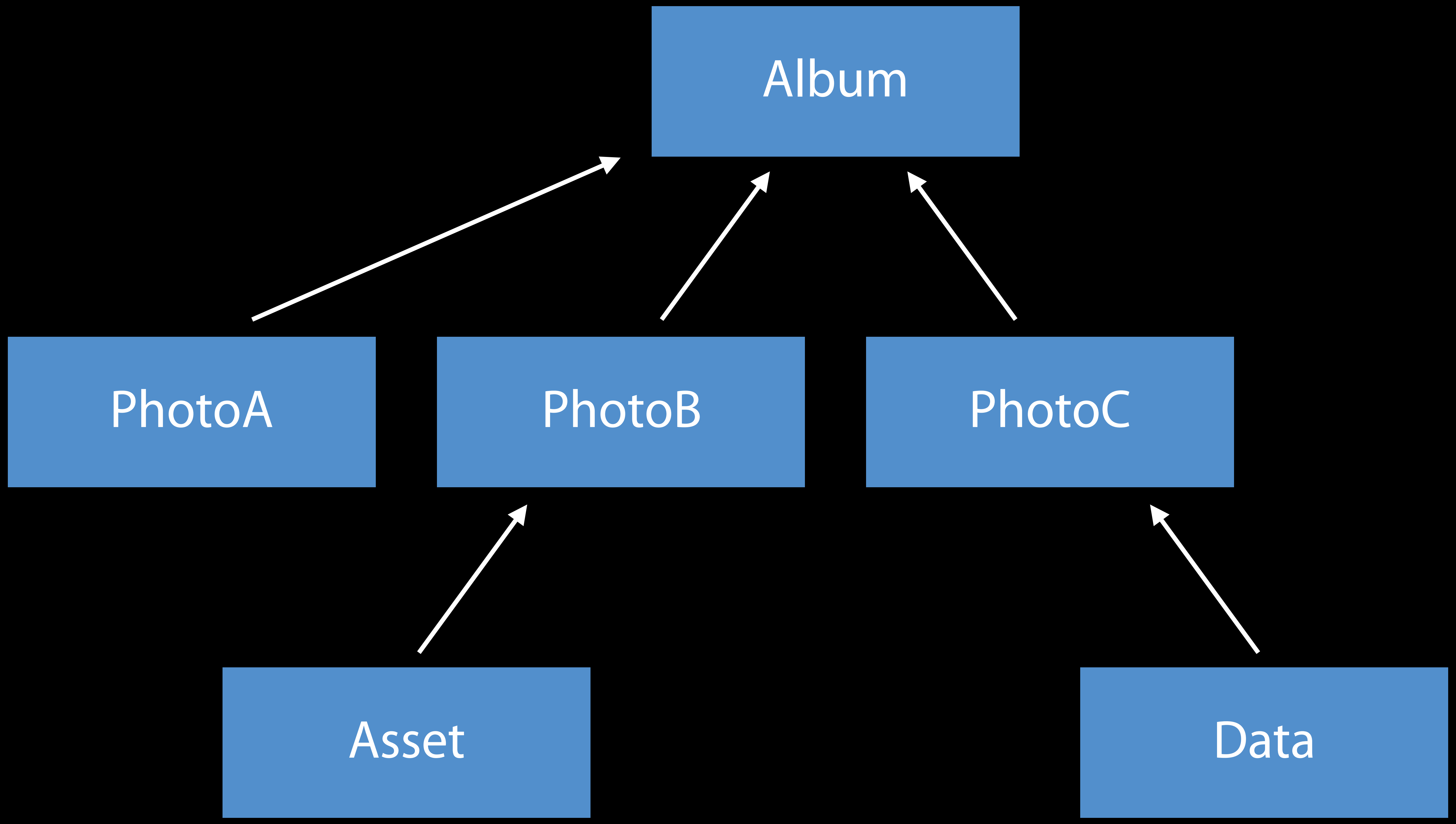


```
let photoRecord = CKRecord(recordType: "Photo")
…
photoRecord.setParent(albumRecordID)
```

# CKReferences

## Parent references

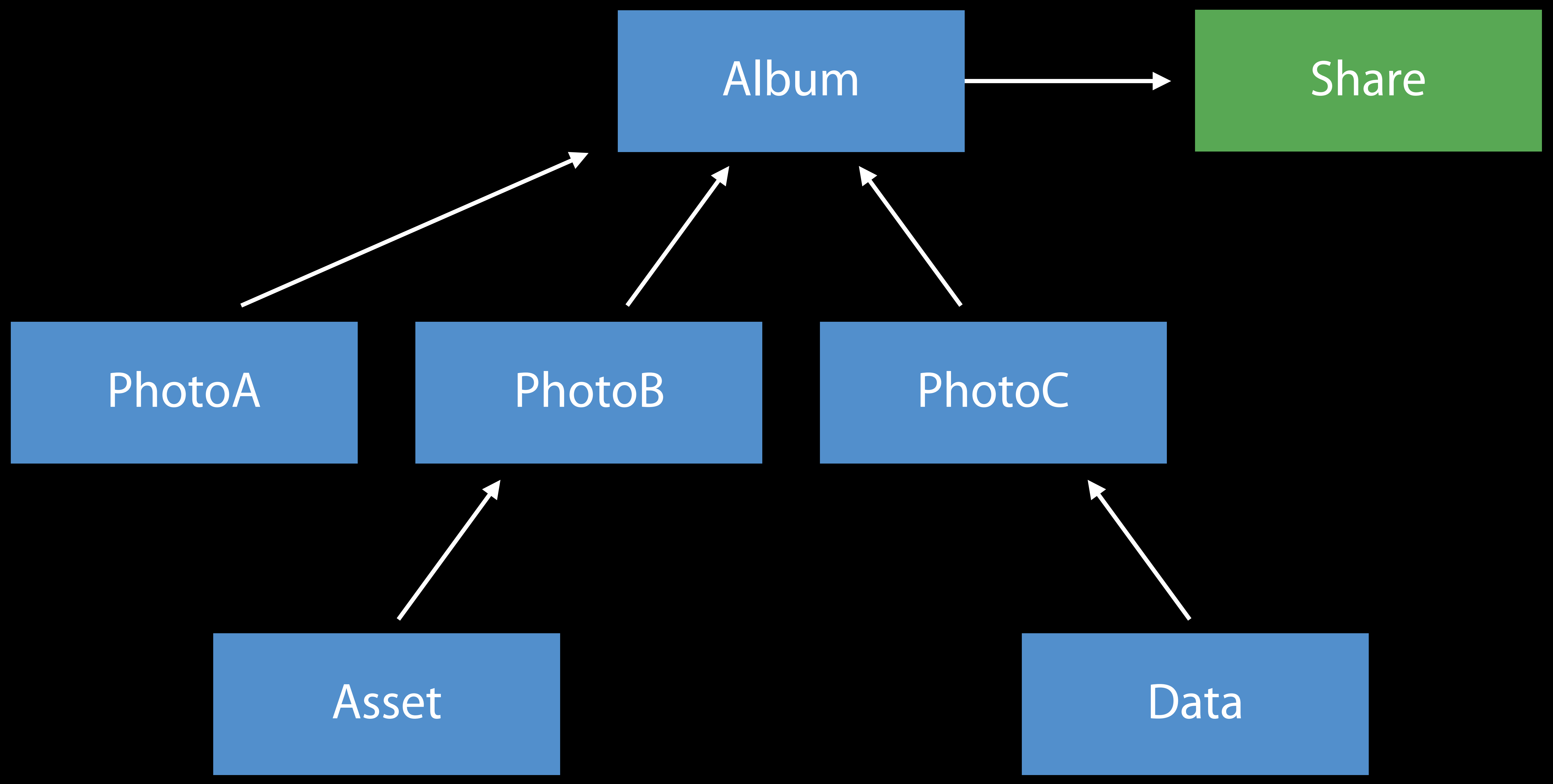
Set parent references if your app supports sharing



# CKReferences

## Parent references

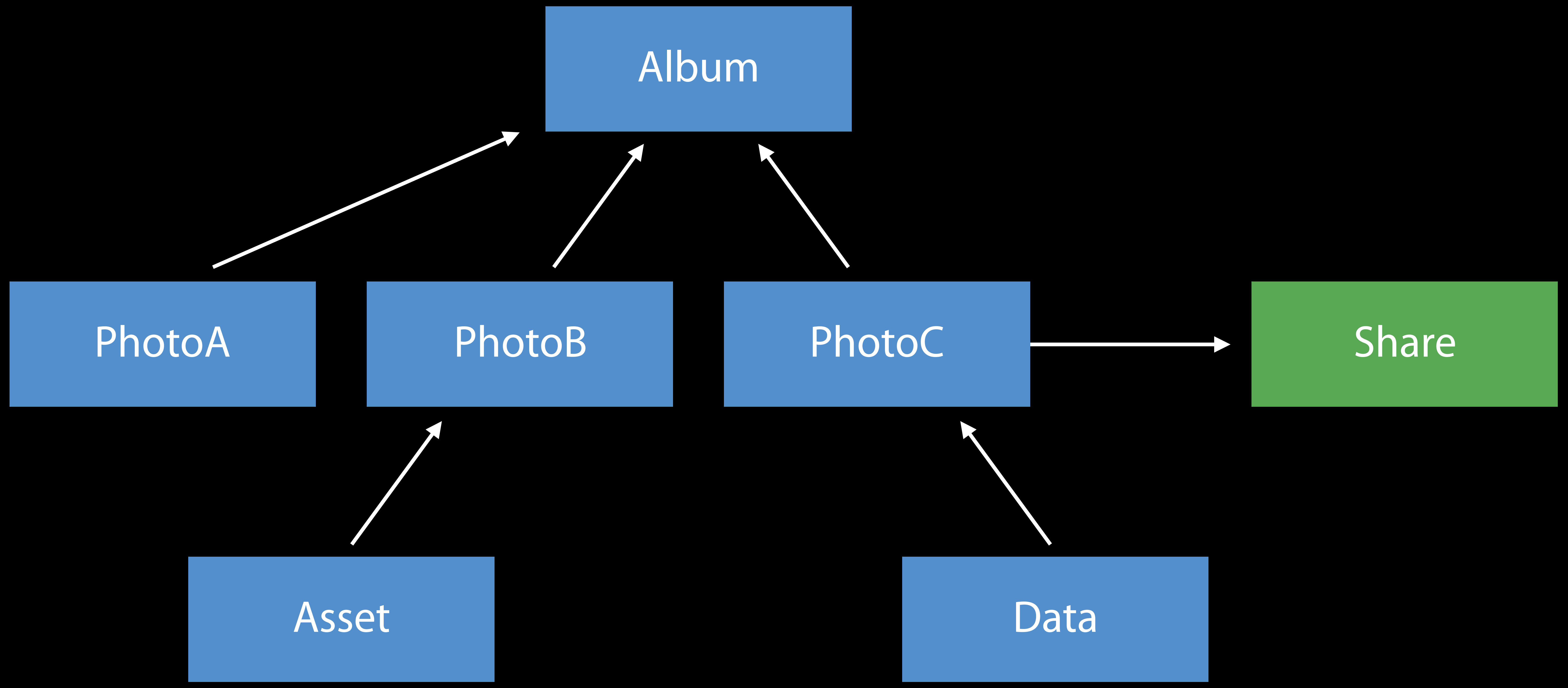
Set parent references if your app supports sharing



# CKReferences

## Parent references

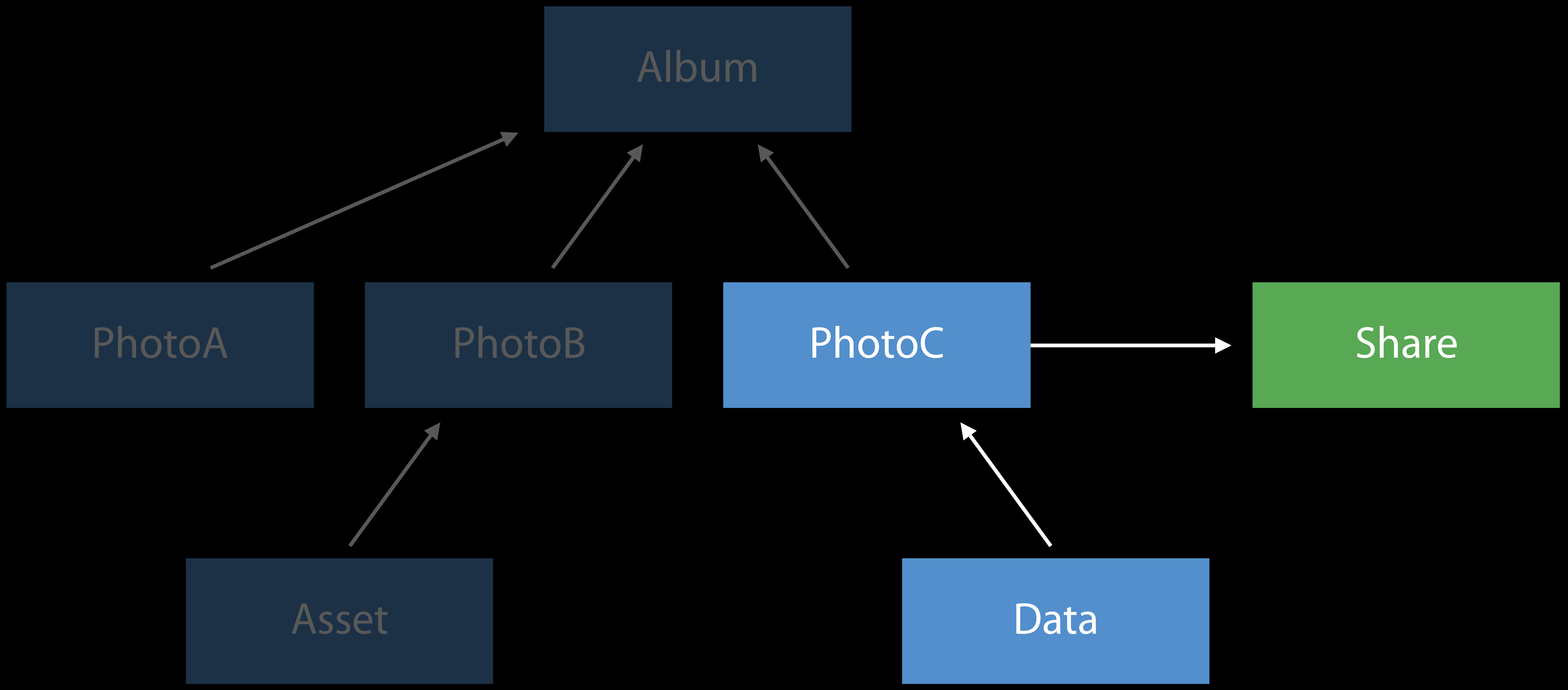
Set parent references if your app supports sharing



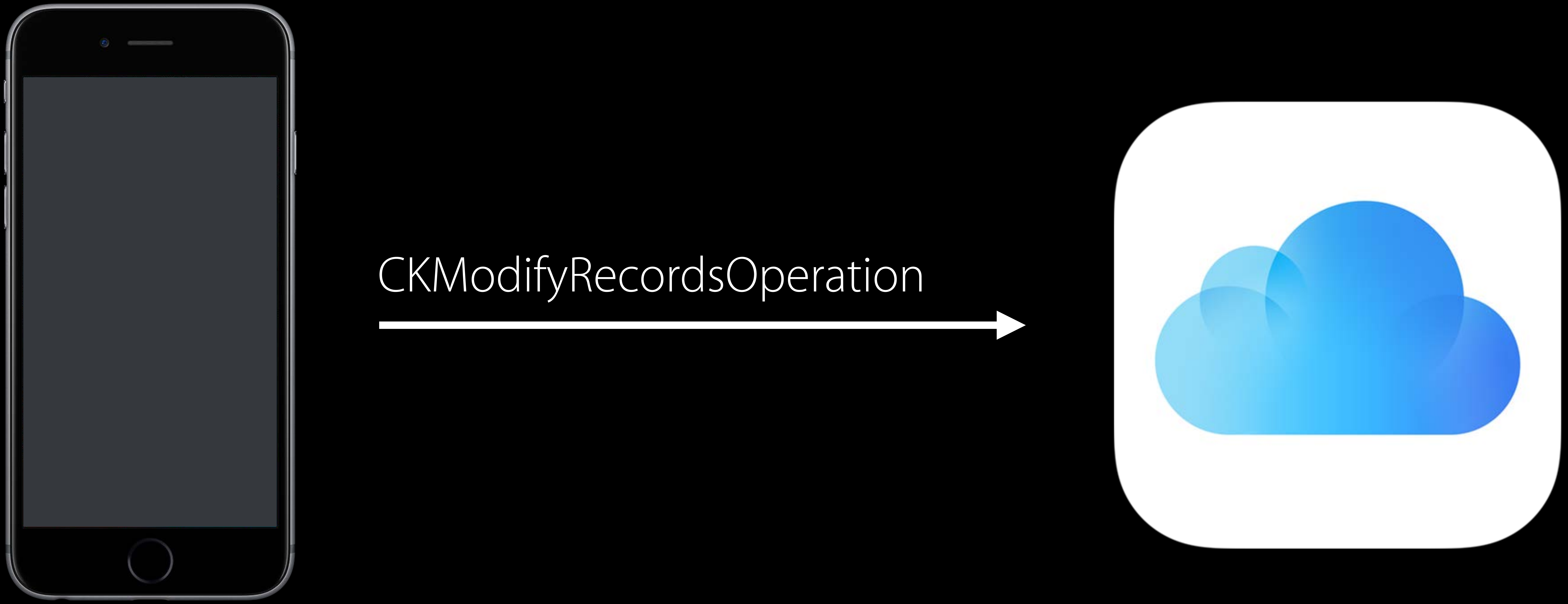
# CKReferences

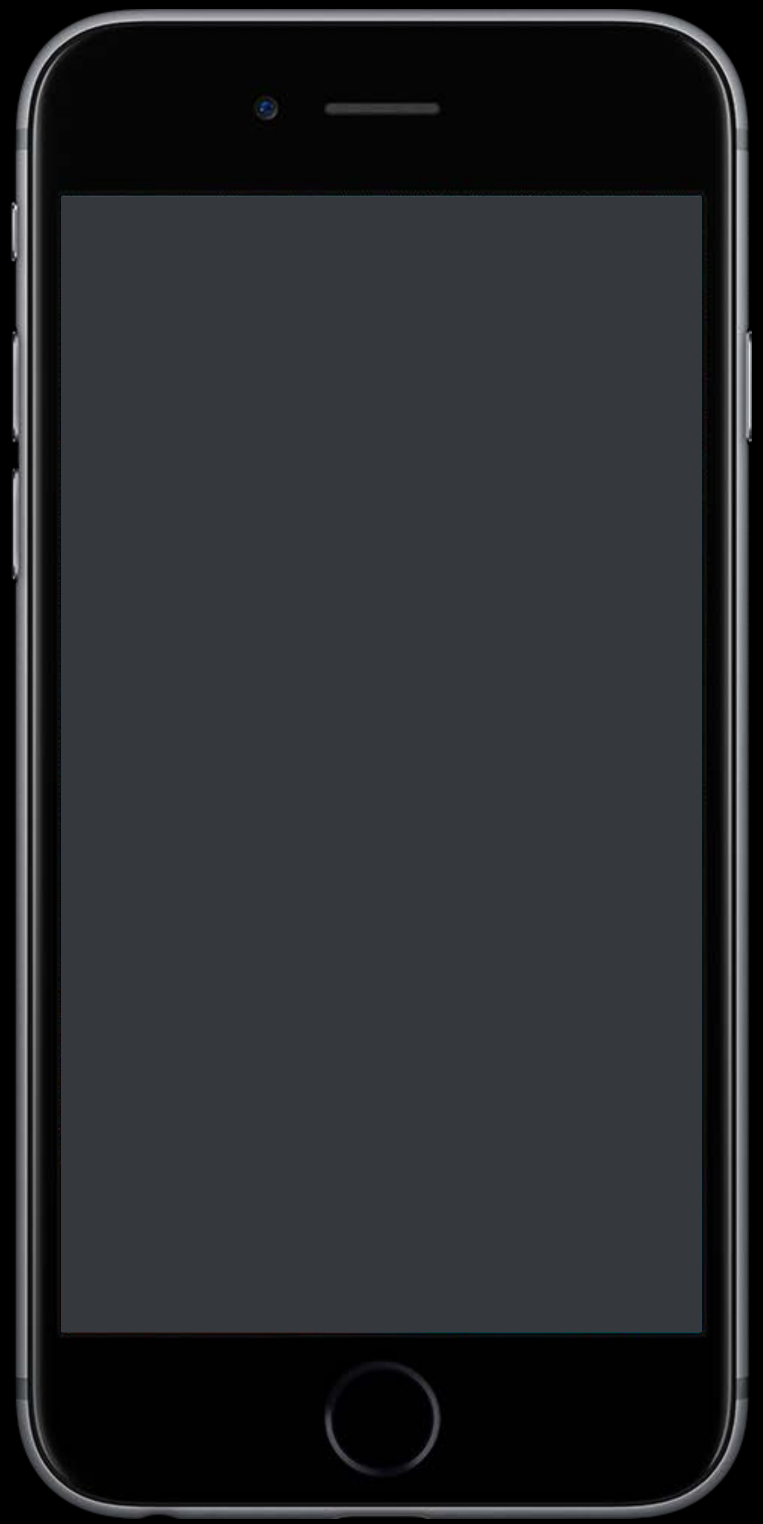
## Parent references

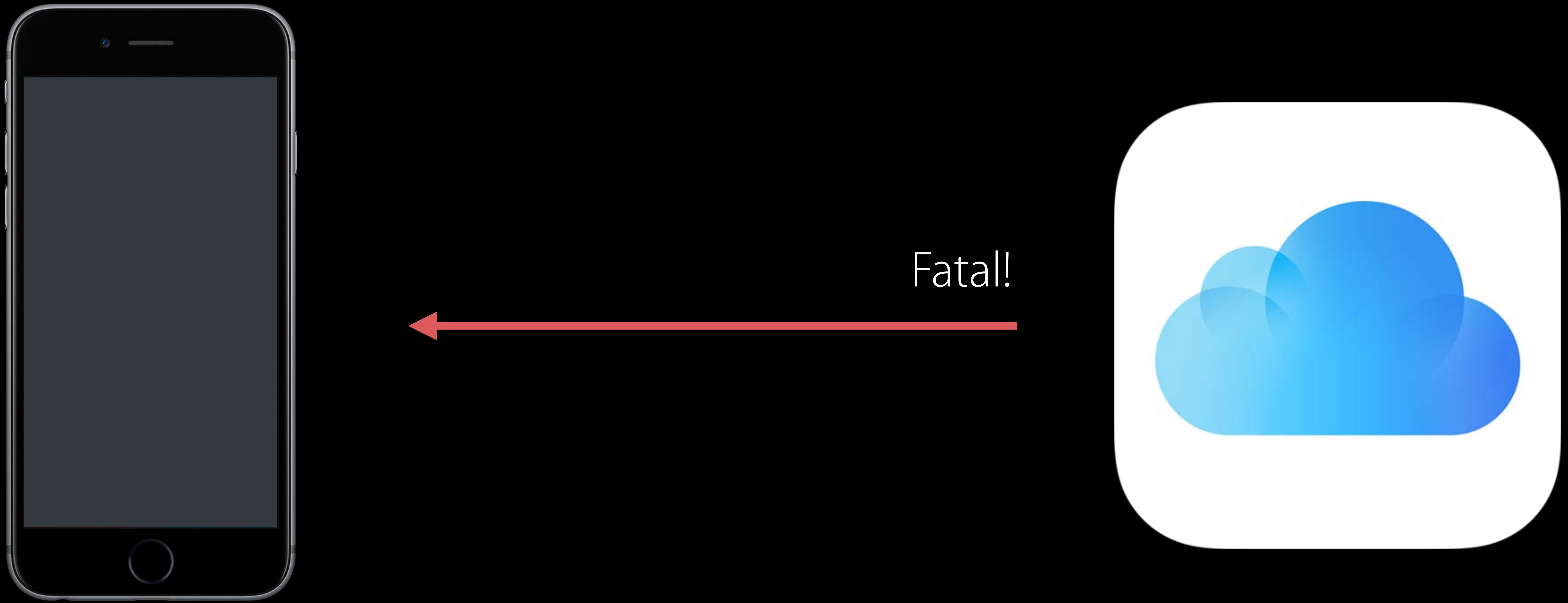
Set parent references if your app supports sharing

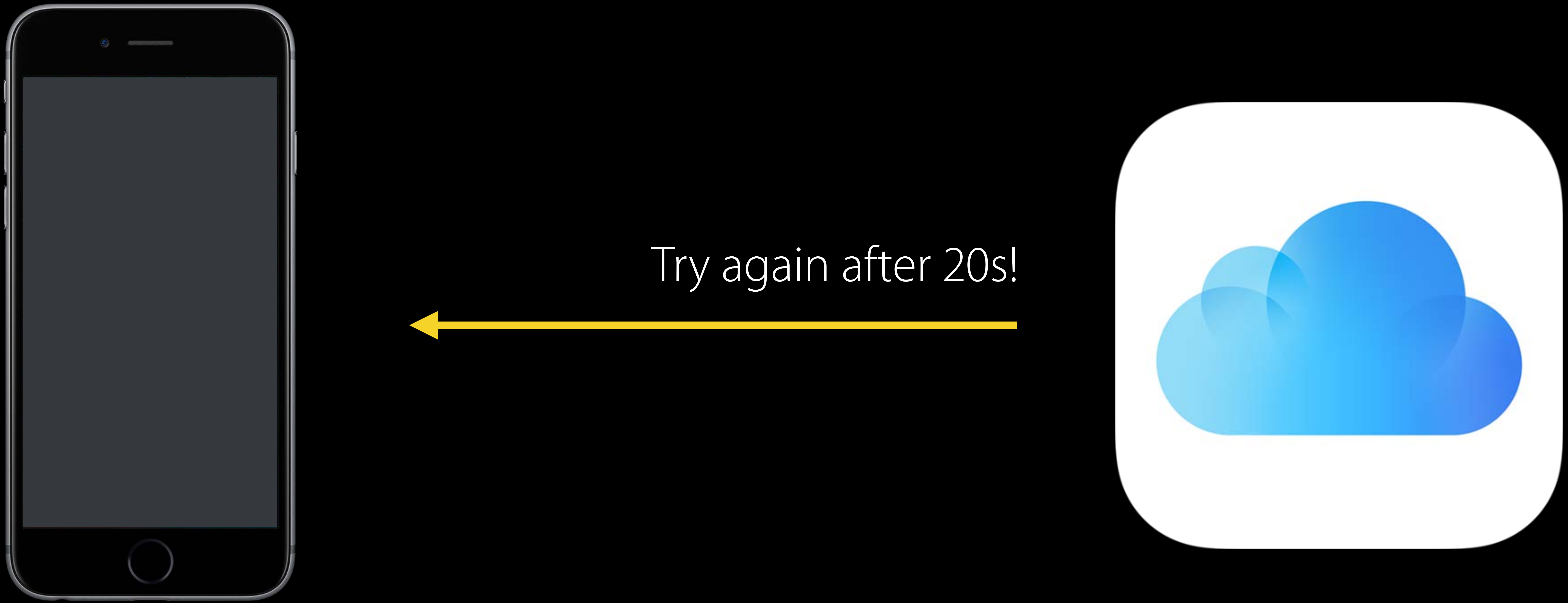


## Error Handling


CKModifyRecordsOperation




Fatal!


Try again after 20s!

## Error Handling

Fatal errors

# Error Handling

## Fatal errors

```
public enum CKErrorCode : Int {
```

## Error Handling

### Fatal errors

```
public enum CKErrorCode : Int {
    case internalError
```

## Error Handling

### Fatal errors

```
public enum CKErrorCode : Int {
    case internalError
    case serverRejectedRequest
```

## Error Handling

### Fatal errors

```
public enum CKErrorCode : Int {
    case internalError
    case serverRejectedRequest
    case invalidArguments
```

## Error Handling

### Fatal errors

```
public enum CKErrorCode : Int {
    case internalError
    case serverRejectedRequest
    case invalidArguments
    case permissionFailure
```

## Error Handling

### Fatal errors

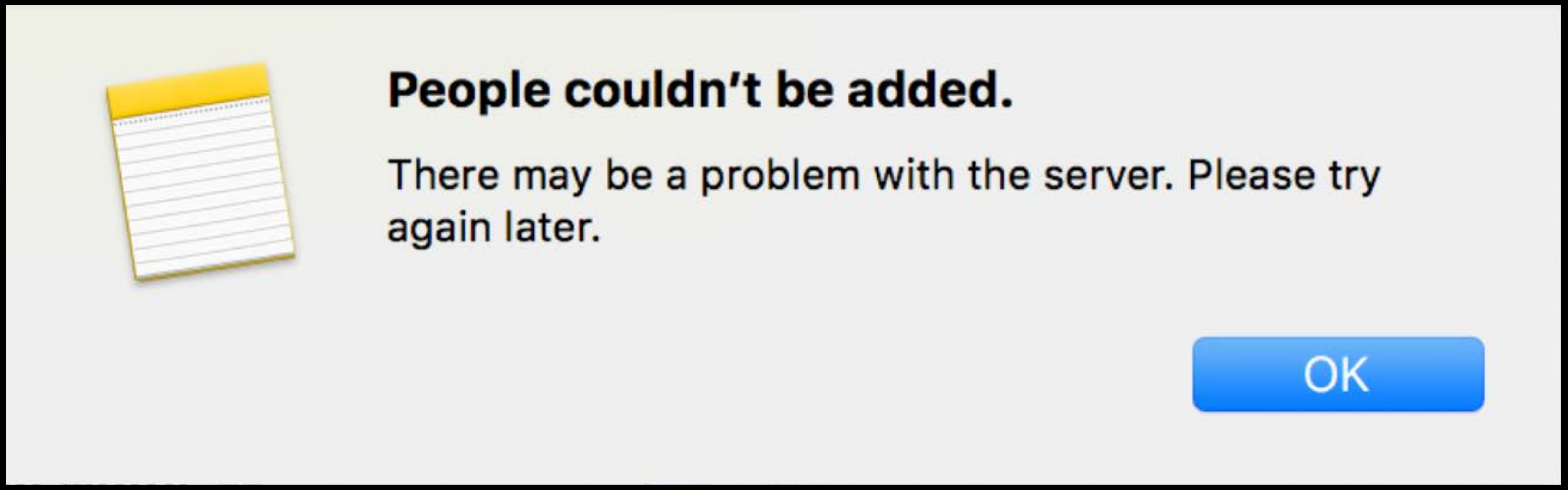
```
public enum CKErrorCode : Int {
    case internalError
    case serverRejectedRequest
    case invalidArguments
    case permissionFailure
}
```

## Error Handling

### Fatal errors

```
public enum CKErrorCode : Int {
    case internalError
    case serverRejectedRequest
    case invalidArguments
    case permissionFailure
}
```

Operations should not be retried



**People couldn't be added.**

There may be a problem with the server. Please try again later.

## Error Handling

Retry case

# Error Handling

Retry case

```
public enum CKErrorCode : Int {
```

# Error Handling

## Retry case

```
public enum CKErrorCode : Int {
    case zoneBusy
```

## Error Handling

Retry case

```
public enum CKErrorCode : Int {
    case zoneBusy
    case serviceUnavailable
```

## Error Handling

### Retry case

```
public enum CKErrorCode : Int {
    case zoneBusy
    case serviceUnavailable
    case requestRateLimited
```

## Error Handling

### Retry case

```
public enum CKErrorCode : Int {
    case zoneBusy
    case serviceUnavailable
    case requestRateLimited
}
```

## Error Handling

### Retry case

```
public enum CKErrorCode : Int {
    case zoneBusy
    case serviceUnavailable
    case requestRateLimited
}
```

Implement application-level retry using `CKErrorRetryAfterKey`

```swift
// Using CKErrorRetryAfterKey

var error = ... // Error from the previous CKOperation

if let retryAfter = error.userInfo[CKErrorRetryAfterKey] as? Double {
    let delayTime = DispatchTime.now() + retryAfter
    DispatchQueue.main.after(when: delayTime) {
        // Initialize CKOperation for a retry
    }
}
```

## Error Handling

Unavailable states

## Error Handling

### Unavailable states

Device offline

## Error Handling

### Unavailable states

Device offline

## Error Handling

Unavailable states

Device offline

`networkUnavailable`

# Error Handling

## Unavailable states

Device offline

`networkUnavailable`

- Monitor network reachability

## Error Handling

### Unavailable states

Device offline

`networkUnavailable`

- Monitor network reachability
- `SCNetworkReachability`

## Error Handling

### Unavailable states

Device offline

`networkUnavailable`

- Monitor network reachability
- `SCNetworkReachability`
- Save changes to your local cache

## Error Handling

### Unavailable states

Account unavailable

`notAuthenticated`

## Error Handling

### Unavailable states

Account unavailable

`notAuthenticated`

```
public static let CKAccountChanged: NSNotification.Name

class CKContainer {
    public func accountStatus(completionHandler: (CKAccountStatus, NSError?) -> Void)
}
```

## Summary

## Summary

Subscribing and fetch changes to efficiently stay up to date

## Summary

Subscribing and fetch changes to efficiently stay up to date

Batch updates with CKOperation

## Summary

Subscribing and fetch changes to efficiently stay up to date

Batch updates with CKOperation

Schema design

## Summary

Subscribing and fetch changes to efficiently stay up to date

Batch updates with CKOperation

Schema design

Error handling

## Related Sessions

| | | |
|---|---|---|
| What's New with CloudKit | Presidio | Thursday 3:00PM |

## Labs

| | | |
|---|---|---|
| CloudKit and iCloud Lab | Frameworks Lab B | Friday 12:00PM |

## More Information

https://developer.apple.com/wwdc16/231

WWDC16