What's New in Core Bluetooth

Session 712

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Duy Phan, Bluetooth Engineer

Introduction

Enhanced reliability

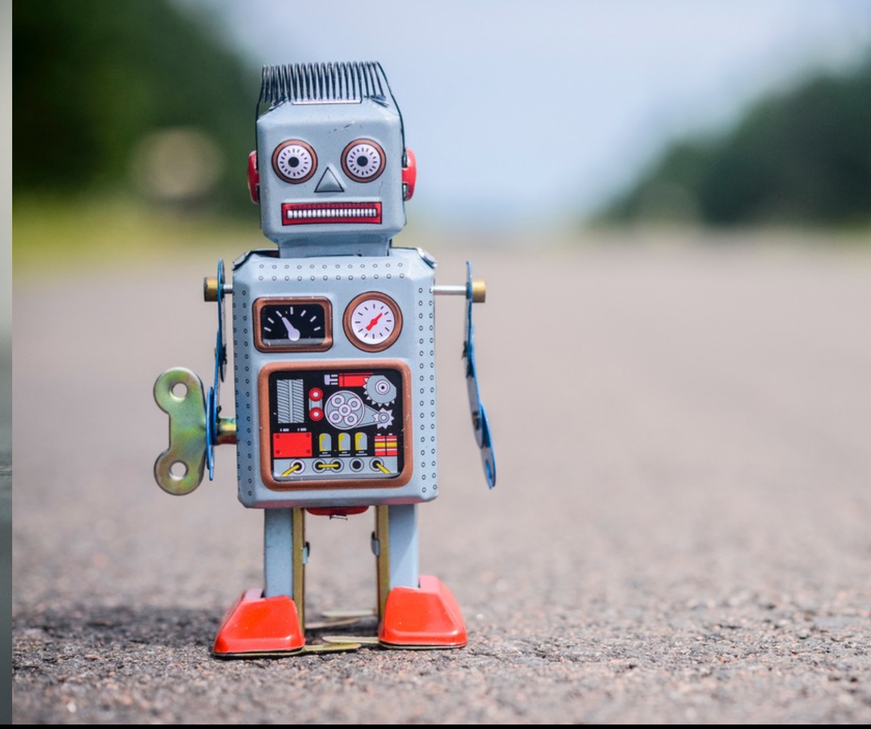
Platform support

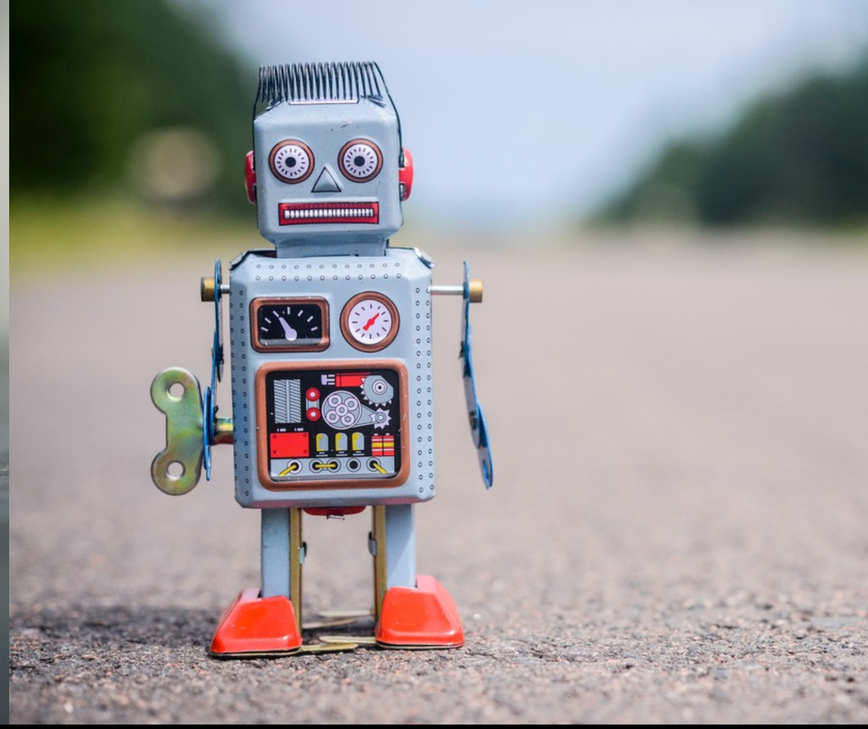
L2CAP channels

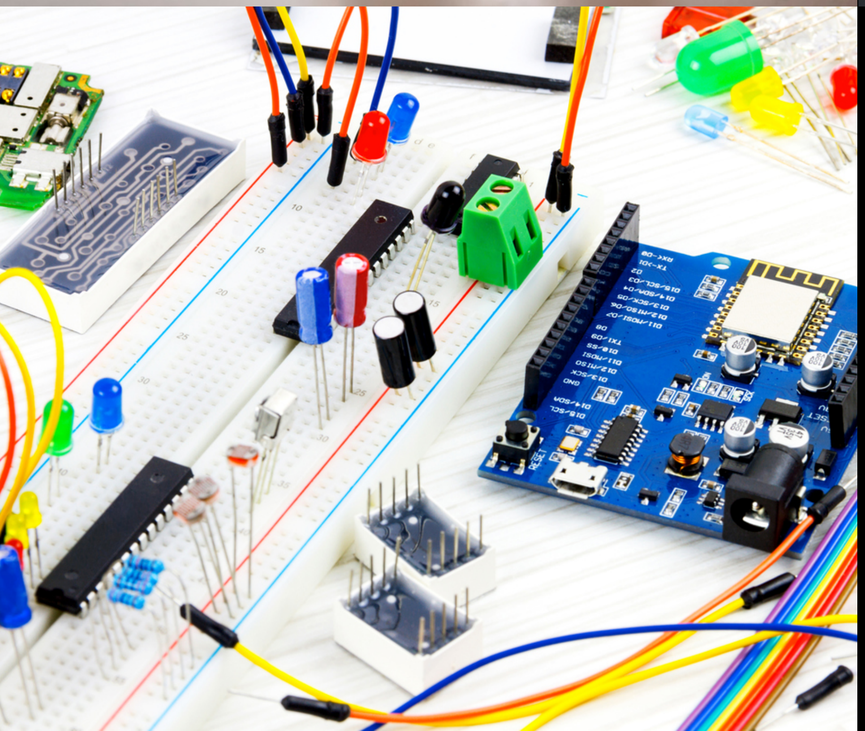
Best practices

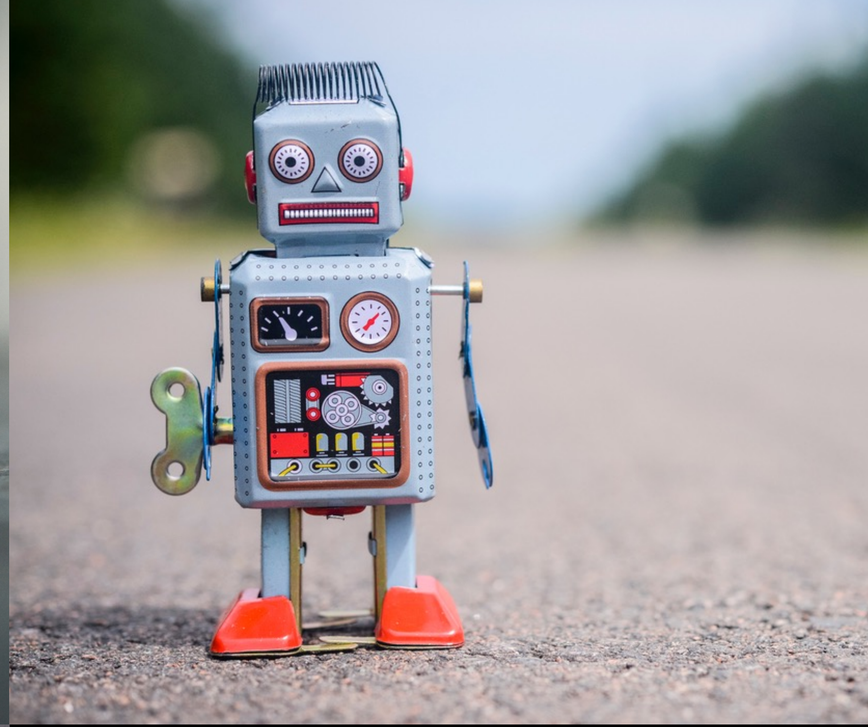
Getting the most out of Core Bluetooth

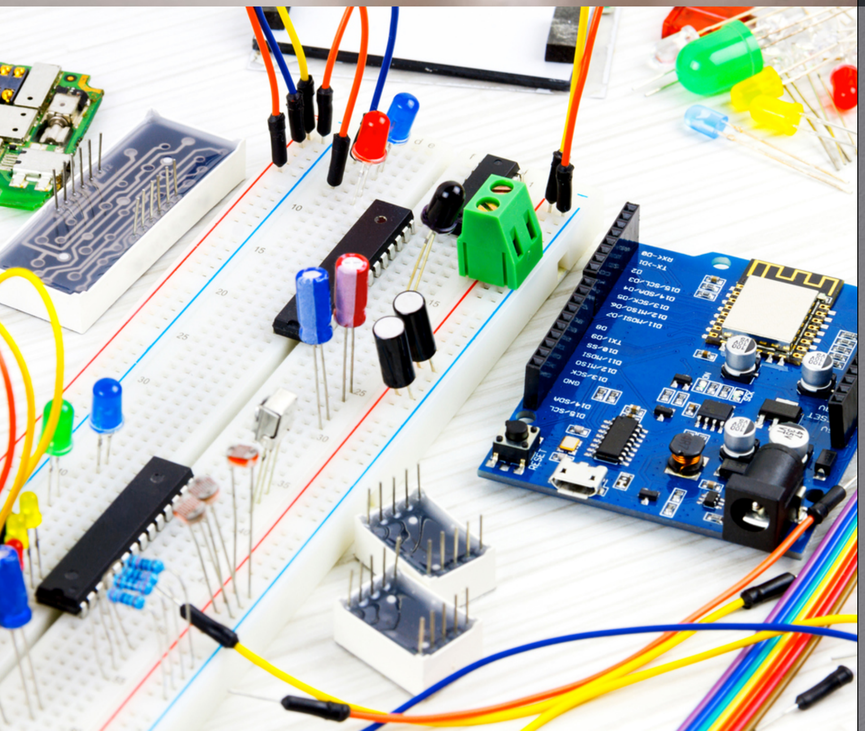
Introduction

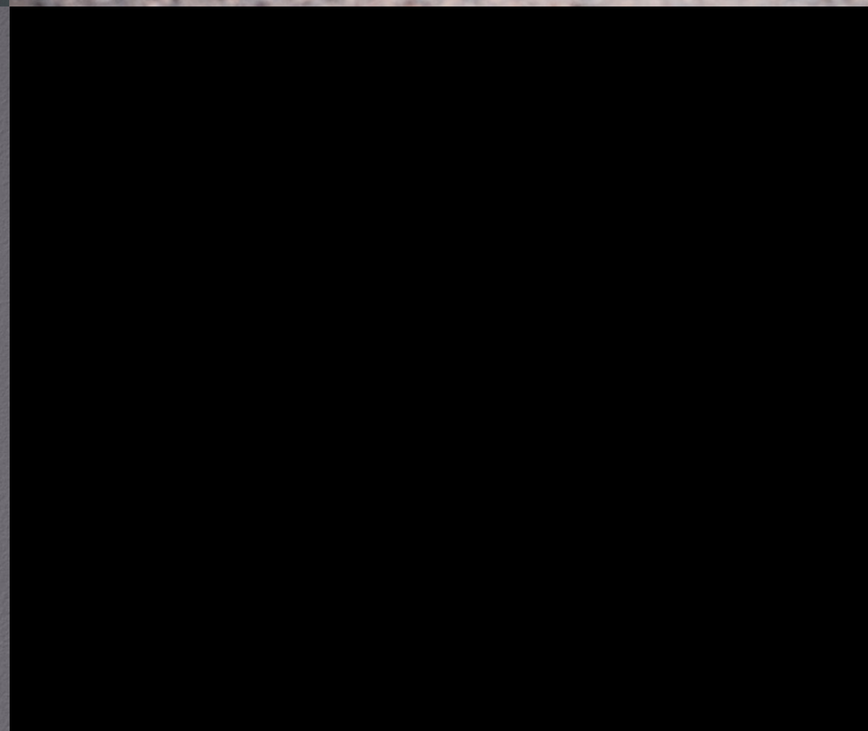


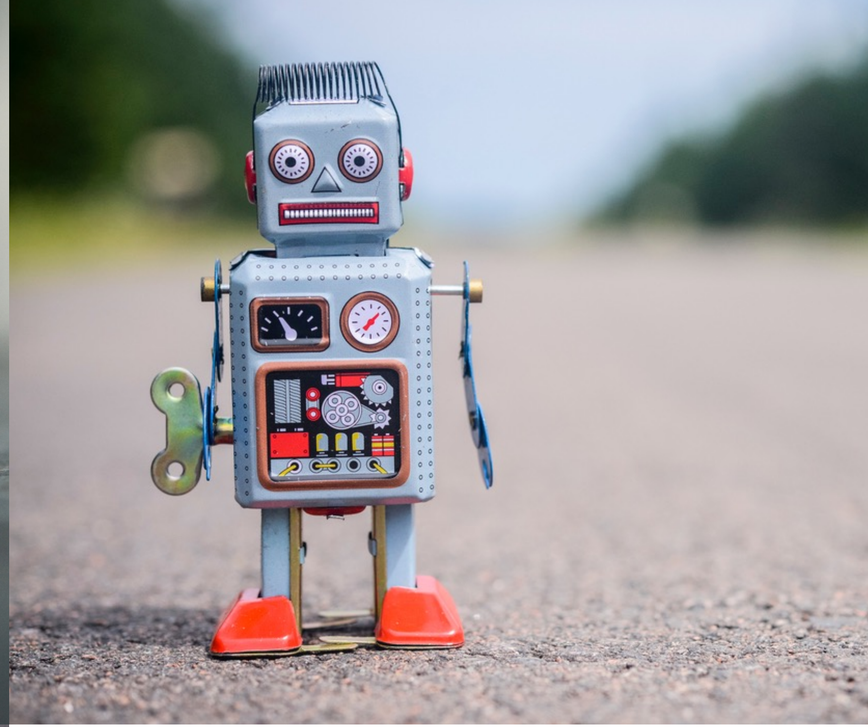


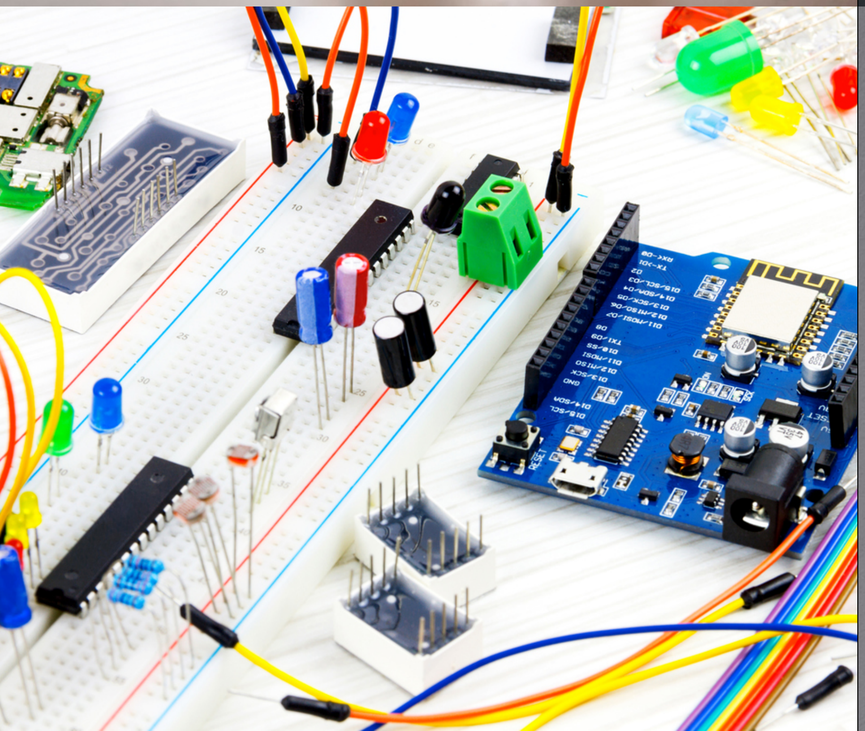













Thank you!

Built-in Profiles

Apple Notification Center Service

Apple Media Service

MIDI over Bluetooth Low Energy

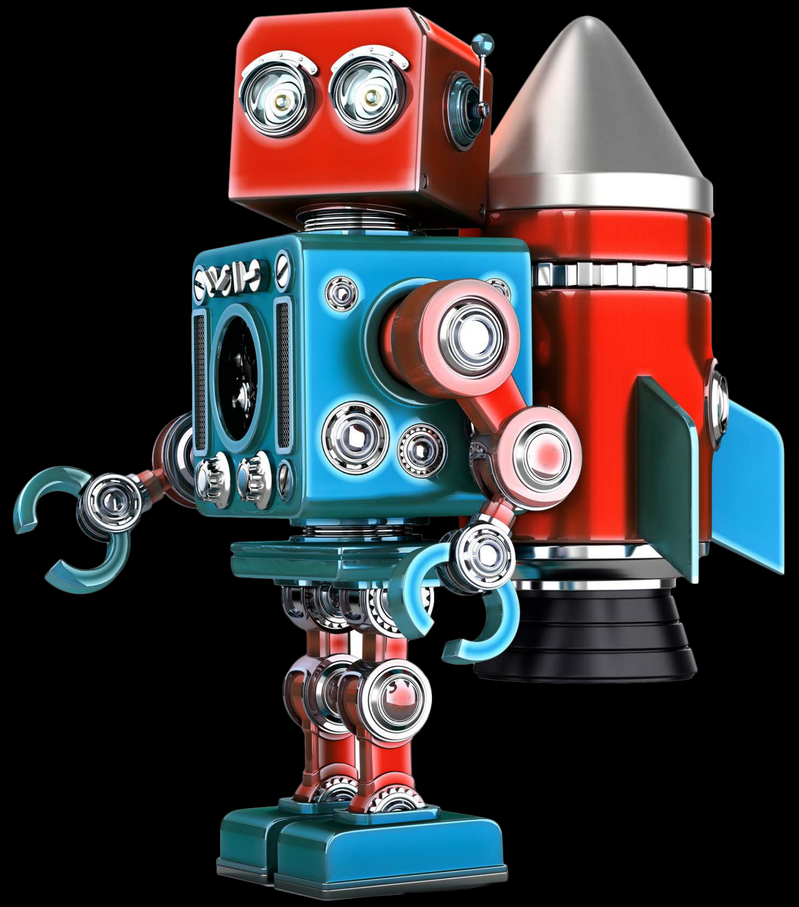
iBeacon

Current Time Service

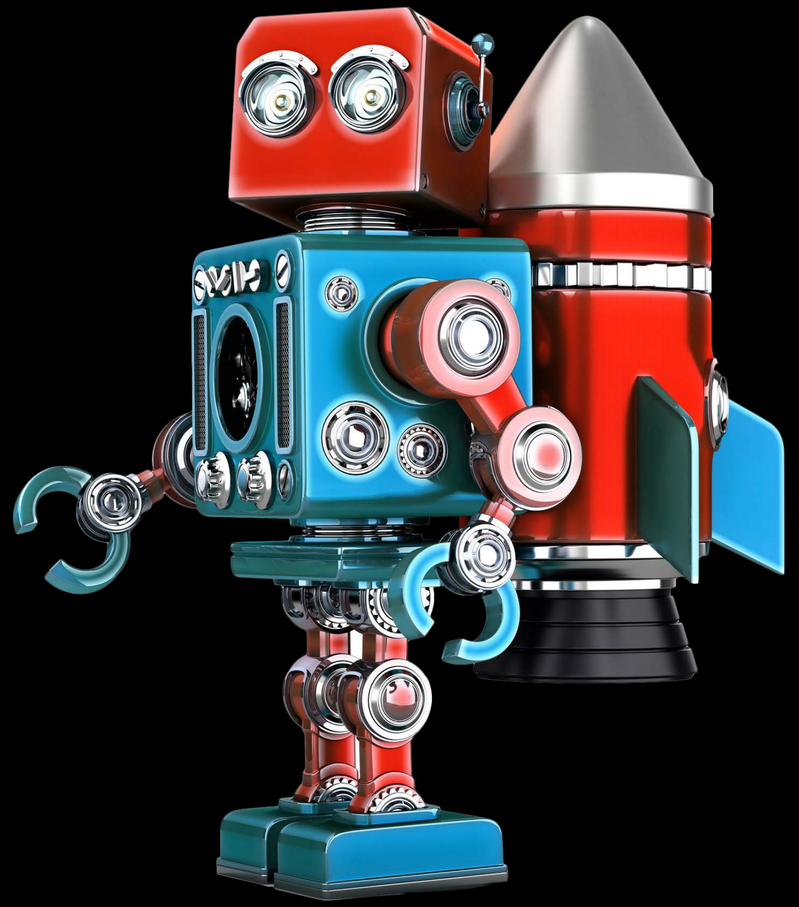
HID Over GATT

Centrals and Peripherals

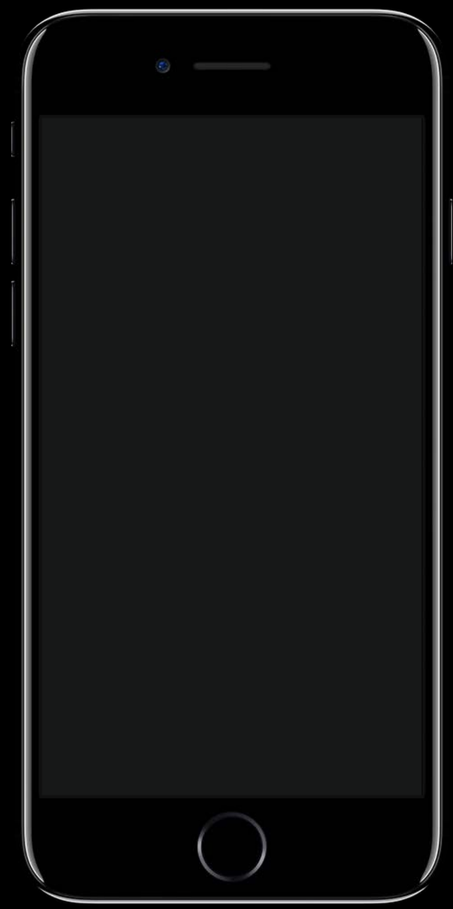
Centrals and Peripherals

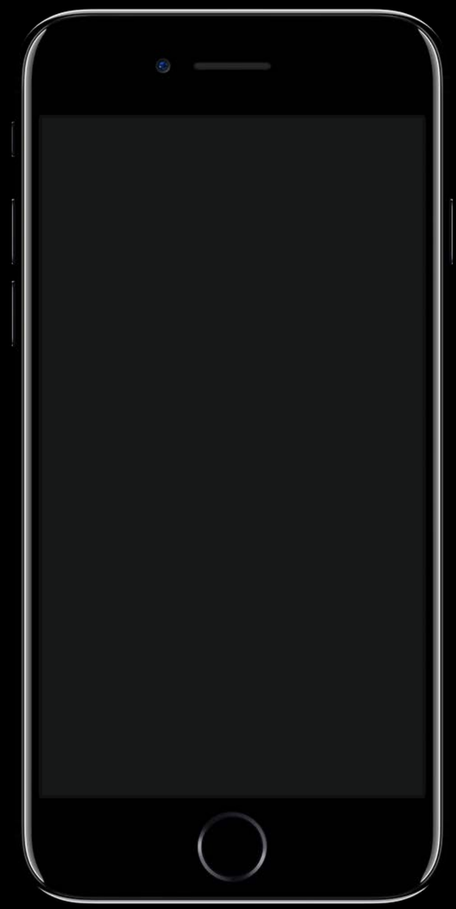


Centrals and Peripherals

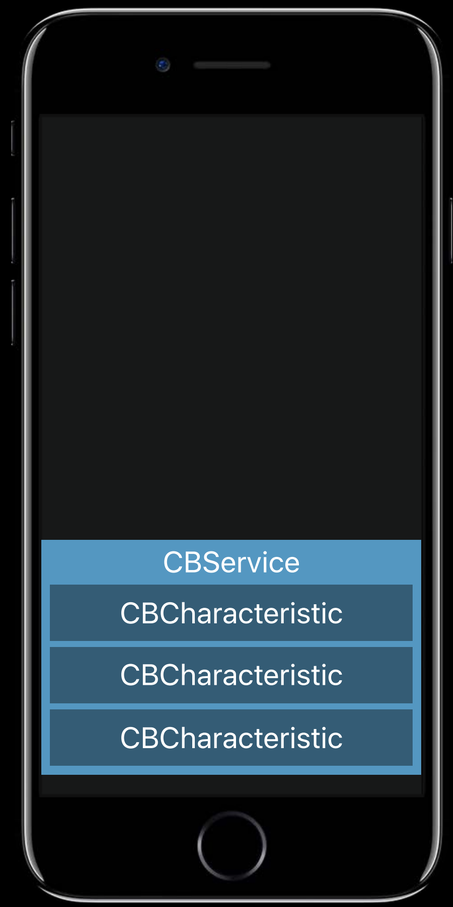


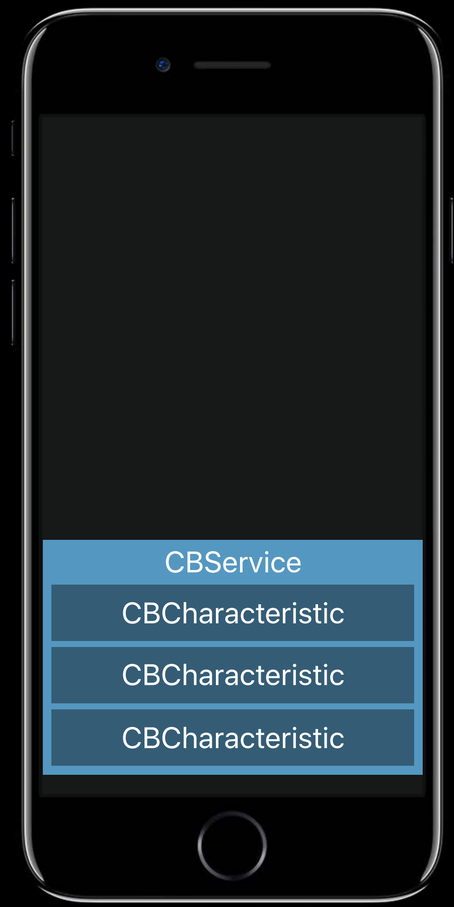
Centrals and Peripherals



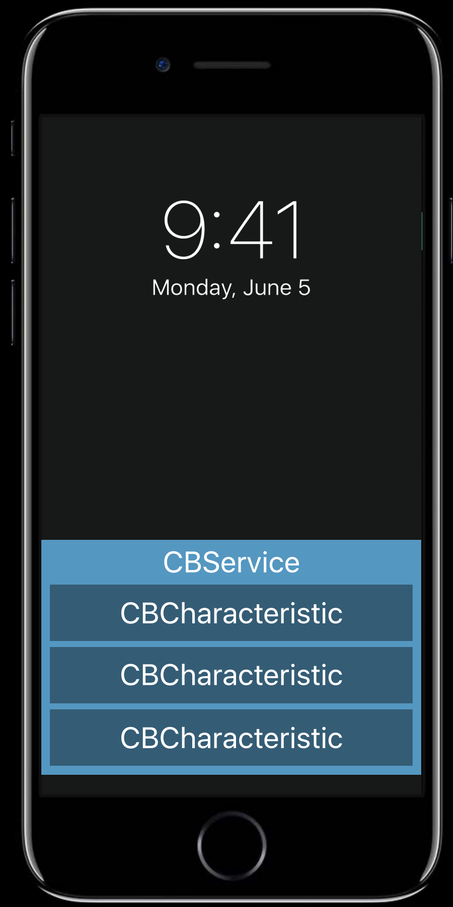


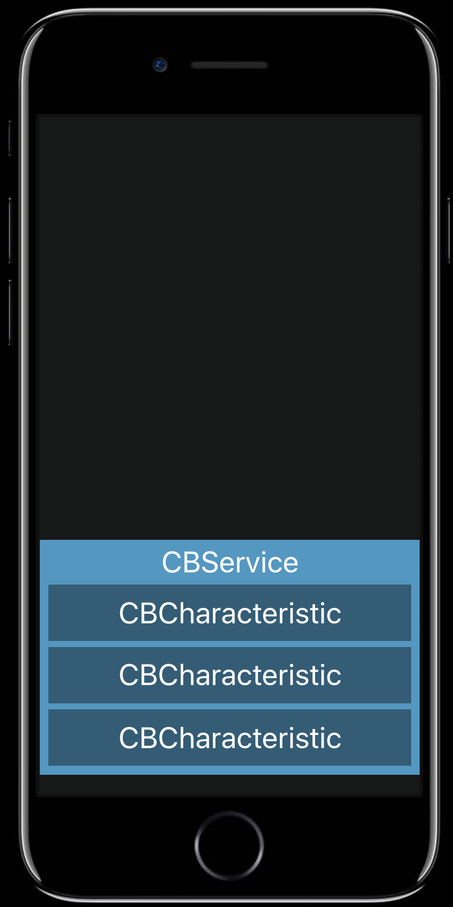
GATT Database





GATT Database





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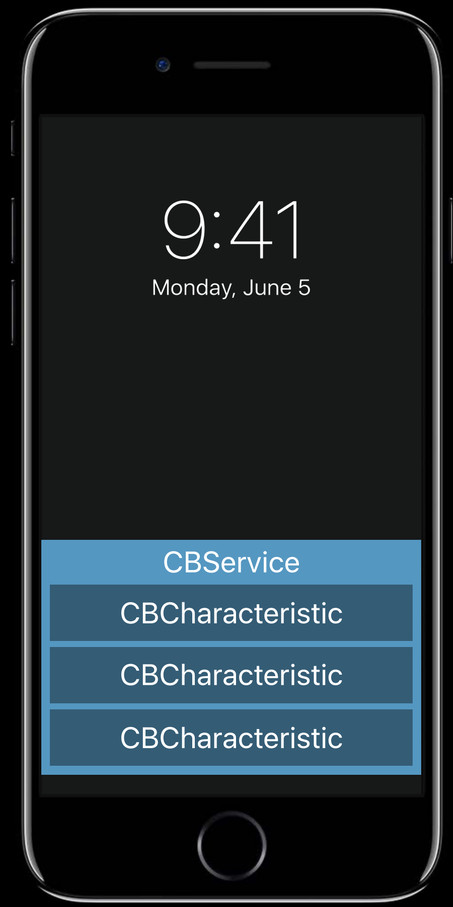
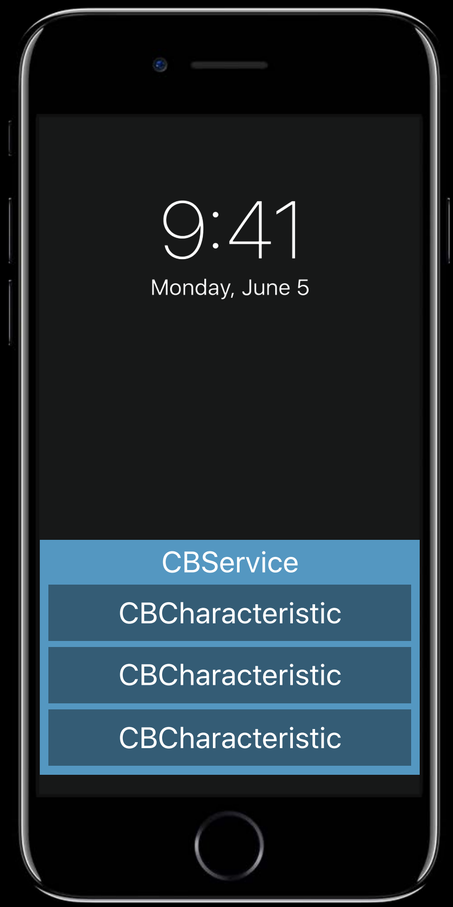




Reading Characteristics as a Central

Services can be read from a connected Central

- Retrieve by identifier
- Retrieve connected devices

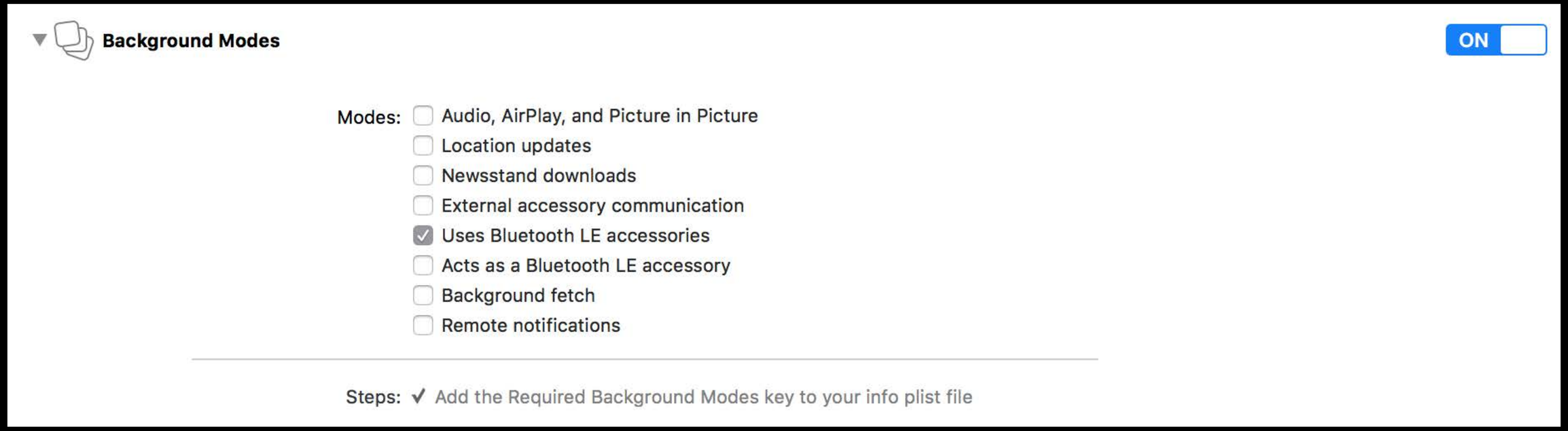
```
open class CBCentralManager : CBManager {
    open func retrievePeripherals(withIdentifiers identifiers: [UUID]) -> [CBPeripheral]
    open func retrieveConnectedPeripherals(withServices serviceUUIDs: [CBUUID]) ->
[CBPeripheral]
}
```

Enhanced Reliability

Summary

Backgrounded Apps

iOS Apps can continue using Core Bluetooth in the background



Backgrounded Apps

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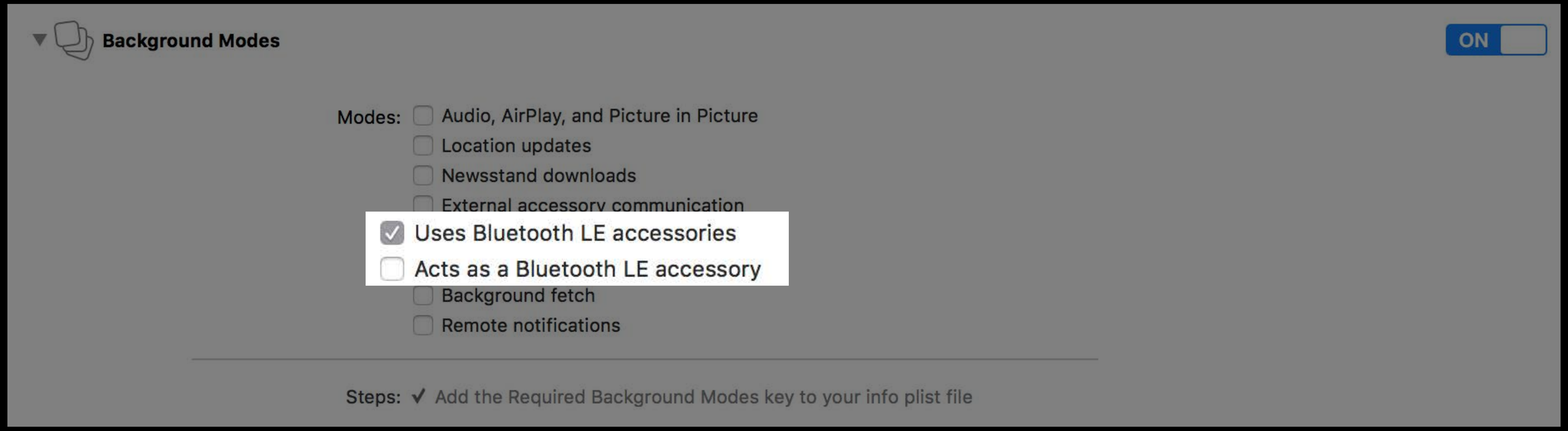

CBCentralManager restoration

Central operations can continue when your app is not running

- Scan for new devices with services
- Connect to an already known device

```
public let CBCentralManagerOptionRestoreIdentifierKey: String

/*
 *  @seealso                CBCentralManagerRestoredStatePeripheralsKey;
 *  @seealso                CBCentralManagerRestoredStateScanServicesKey;
 *  @seealso                CBCentralManagerRestoredStateScanOptionsKey;
 *
 */
optional public func centralManager(_ central: CBCentralManager, willRestoreState dict:
[String: Any])
```

CBPeripheralManager Restoration

Peripheral operations can continue when your app is not running

- Publish local services
- Advertise service UUID

```
public let CBPeripheralManagerOptionRestoreIdentifierKey: String

/*
 *  @seealso            CBPeripheralManagerRestoredStateServicesKey;
 *  @seealso            CBPeripheralManagerRestoredStateAdvertisementDataKey;
 *
 */
optional public func peripheralManager(_ peripheral: CBPeripheralManager,
                                       willRestoreState dict: [String: Any])
```

State Preservation and Restoration

NEW

State Preservation and Restoration

NEW

Works across device reboot or Bluetooth system events

State Preservation and Restoration

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Works across device reboot or Bluetooth system events

- Try to ask for as few system resources as possible

State Preservation and Restoration

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- Background activities will be stopped if

State Preservation and Restoration

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Works across device reboot or Bluetooth system events

- Try to ask for as few system resources as possible
- Background activities will be stopped if
  - User force quits the app

State Preservation and Restoration

NEW

Works across device reboot or Bluetooth system events

- Try to ask for as few system resources as possible
- Background activities will be stopped if
  - User force quits the app
  - User disables Bluetooth

Write Without Response

NEW

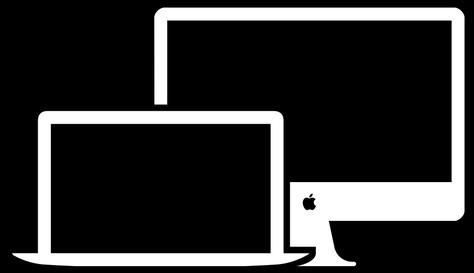
Write Without Response would be dropped due to memory pressure

New property will tell your app if more data can be sent

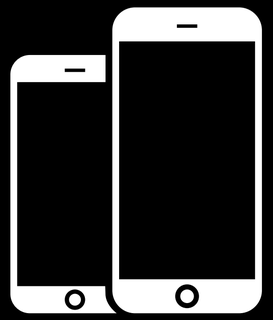
```
open class CBPeripheral: CBPeer {
     open var canSendWriteWithoutResponse: Bool { get }
}

public protocol CBPeripheralDelegate: NSObjectProtocol {
    optional public func peripheralIsReady(toSendWriteWithoutResponse peripheral:
CBPeripheral)
}
```

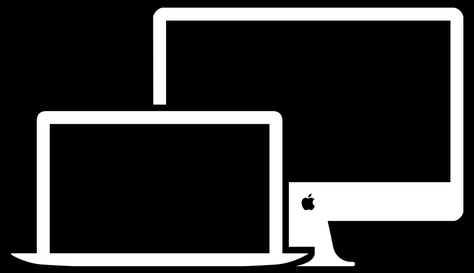
Platform Support



macOS 10.7



iOS 5



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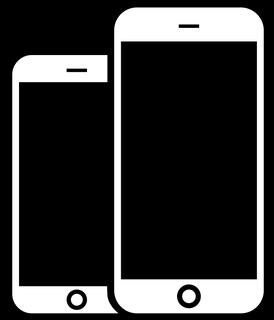
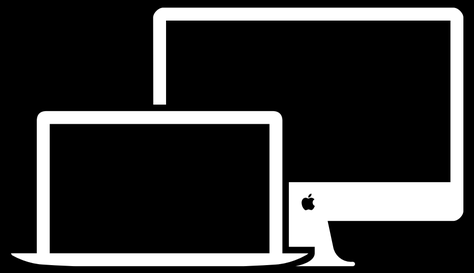


iOS 5

tvOS 9



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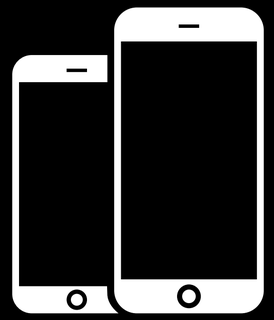

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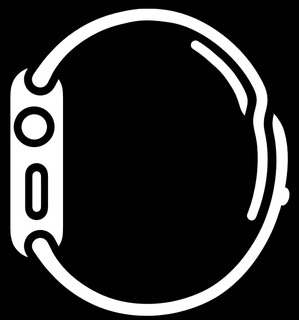


watchOS 4

iOS + macOS

iOS
macOS

iOS + macOS

Foreground and background apps

iOS
macOS

iOS + macOS

Foreground and background apps

Central and Peripheral

iOS
macOS

iOS + macOS

Foreground and background apps

Central and Peripheral

15 ms minimum connection interval

iOS
macOS

iOS + macOS

Foreground and background apps

Central and Peripheral

15 ms minimum connection interval

State Preservation and Restoration on iOS

iOS
macOS

tvOS

tvOS

tvOS

Foreground app only

tvOS

Foreground app only

Central role only

tvOS

Foreground app only

Central role only

Limited to 2 simultaneous connections

tvOS

Foreground app only

Central role only

Limited to 2 simultaneous connections

30 ms minimum connection interval

tvOS

tvOS

Foreground app only

Central role only

Limited to 2 simultaneous connections

30 ms minimum connection interval

Peripherals disconnected when app is moved to the background

watchOS

NEW

watchOS

watchOS

NEW

Access dictated by system runtime policies

watchOS

watchOS

NEW

Access dictated by system runtime policies

Central role only

watchOS

watchOS

NEW

Access dictated by system runtime policies

Central role only

Limited to 2 simultaneous connections

watchOS

watchOS

NEW

Access dictated by system runtime policies

Central role only

Limited to 2 simultaneous connections

30 ms minimum connection interval

watchOS

watchOS

NEW

Access dictated by system runtime policies

Central role only

Limited to 2 simultaneous connections

30 ms minimum connection interval

Peripherals disconnected when app is suspended

watchOS

watchOS

NEW

Access dictated by system runtime policies

Central role only

Limited to 2 simultaneous connections

30 ms minimum connection interval

Peripherals disconnected when app is suspended

Supported on Apple Watch Series 2

watchOS

NEW

L2CAP Channels

L2CAP Connection Oriented Channels

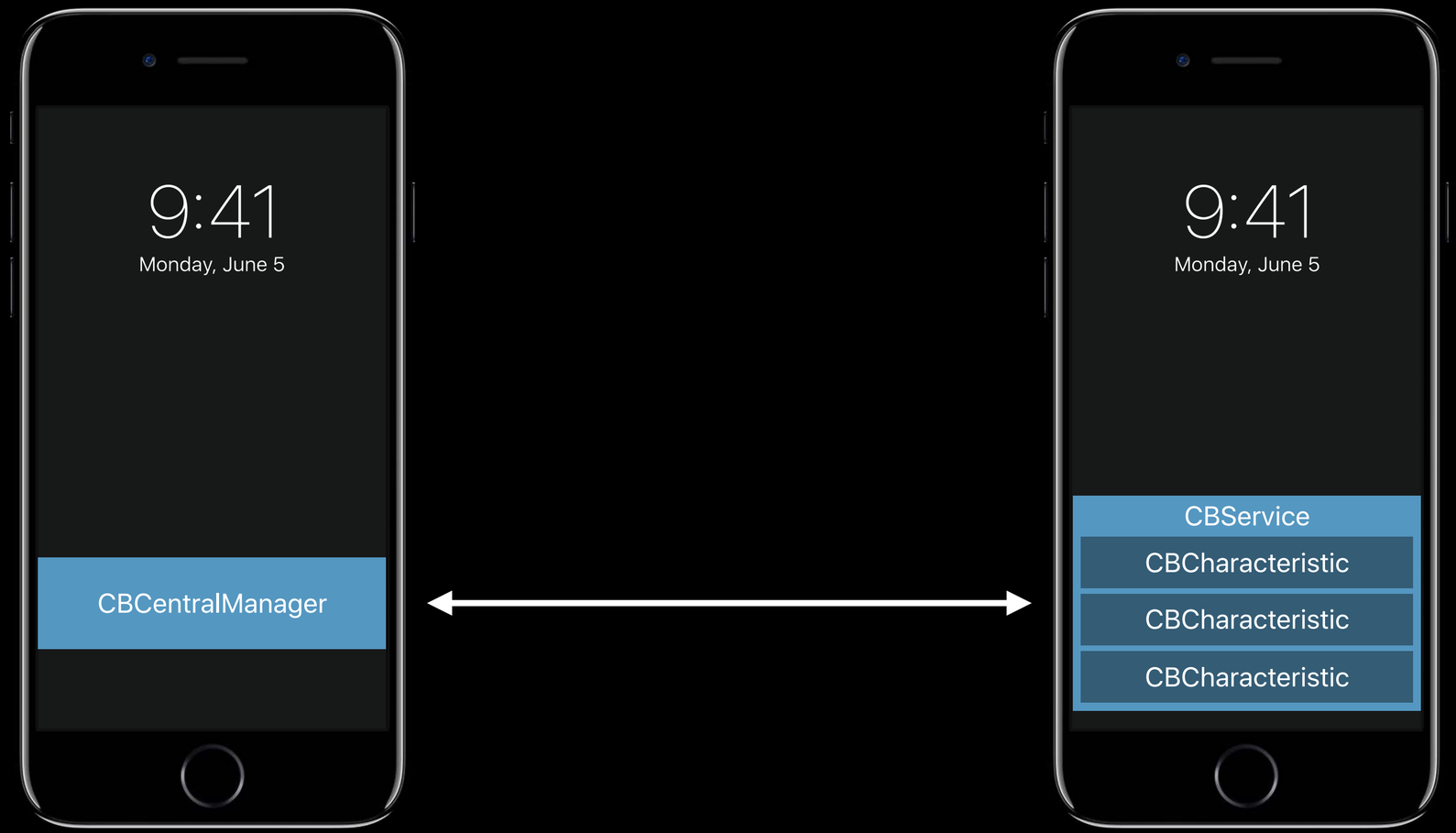
Bluetooth SIG Protocol underlying all communication

Logical Link Control and Adaptation Protocol

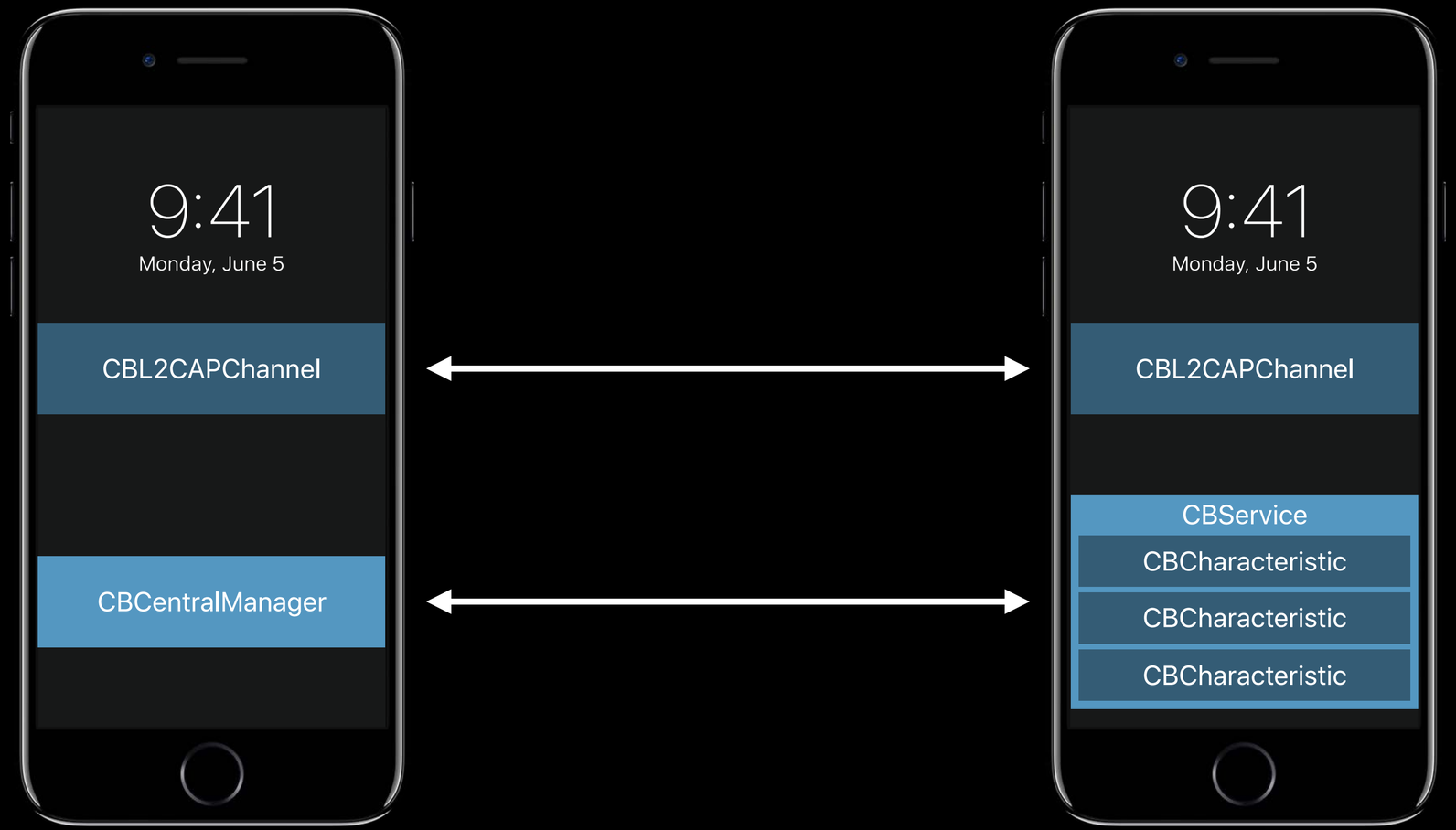
Stream between two devices

Introduced for LE in Bluetooth Core Spec 4.1

L2CAP Channels



L2CAP Channels



Central Side L2CAP

Open an L2CAP Channel on an existing CBPeripheral connection

```
open class CBPeripheral: CBPeer {
     open func openL2CAPChannel(_ PSM: CBL2CAPPSM)
}

public protocol CBPeripheralDelegate: NSObjectProtocol {
    optional public func peripheral(_ peripheral: CBPeripheral,
                                    didOpen channel: CBL2CAPChannel?, error: Error?)
}
```

PSM

SIG Specified PSM for standardized profiles

Locally assigned PSM for dynamic services

```
/*!
 *  @const CBUUIDL2CAppSMCharacteristicString
 *  @discussion The PSM (a little endian uint16_t) of an L2CAP Channel associated with the
GATT service
 *              containing this characteristic.  Servers can publish this characteristic with
the UUID
 *              ABDD3056-28FA-441D-A470-55A75A52553A
 */
public let CBUUIDL2CAppSMCharacteristicString: String
```

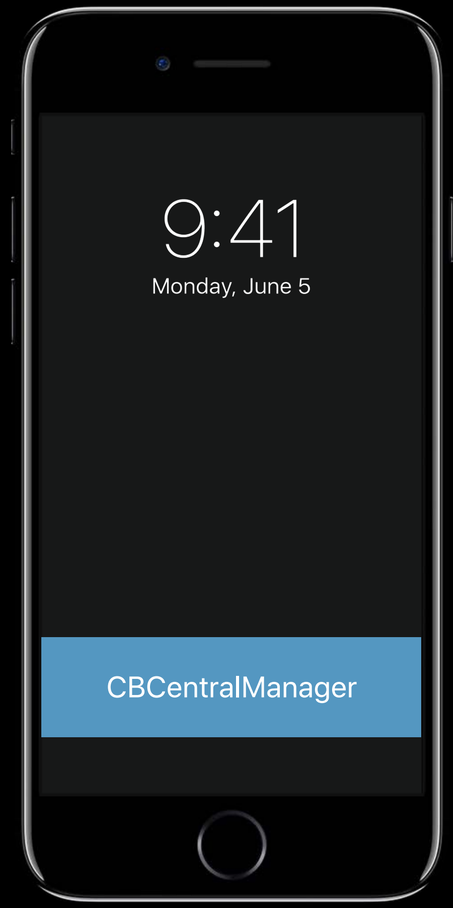
Peripheral Side L2CAP

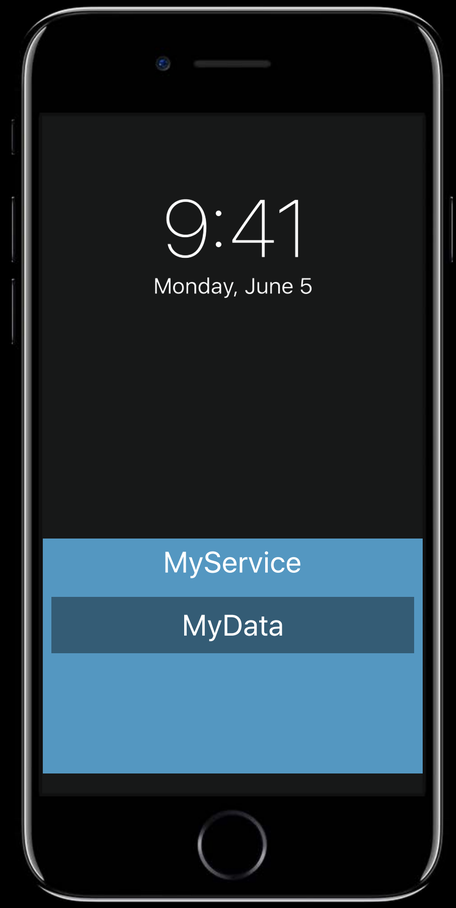
Listen for incoming L2CAP Channels

```
open class CBPeripheralManager : CBManager {
    open func publishL2CAPChannel(withEncryption encryptionRequired: Bool)
    open func unpublishL2CAPChannel(_ PSM: CBL2CAPPSM)
}

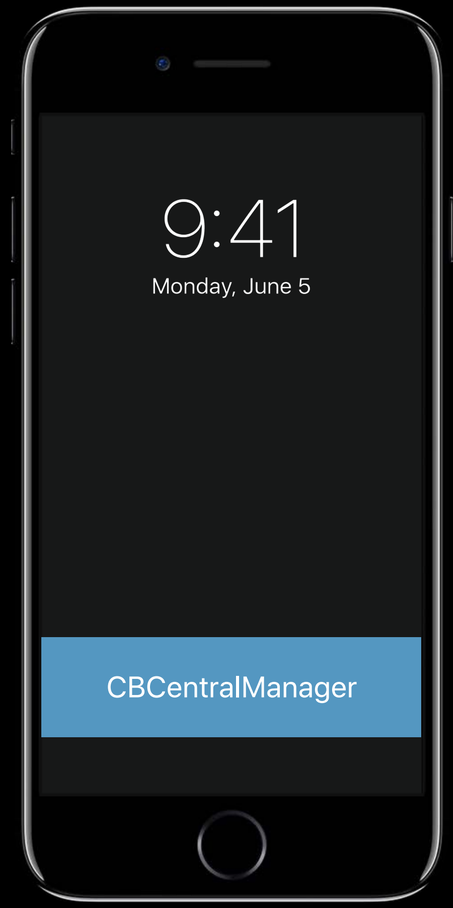
public protocol CBPeripheralManagerDelegate : NSObjectProtocol {
    optional public func peripheralManager(_ peripheral: CBPeripheralManager,
                                           didPublishL2CAPChannel PSM: CBL2CAPPSM,
                                           error: Error?)
}
```

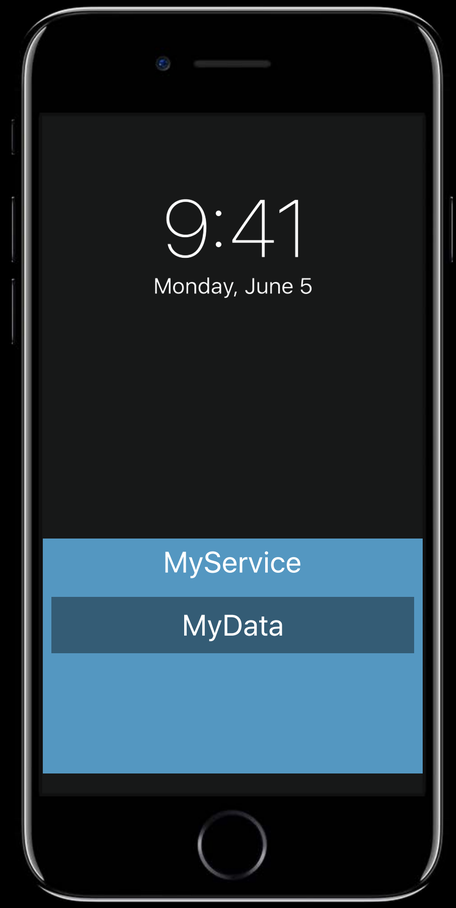
Opening an L2CAP Channel





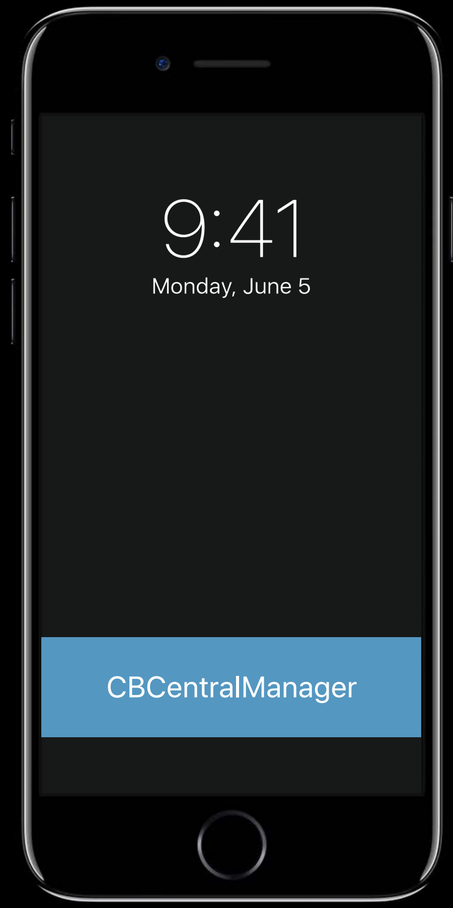
Opening an L2CAP Channel

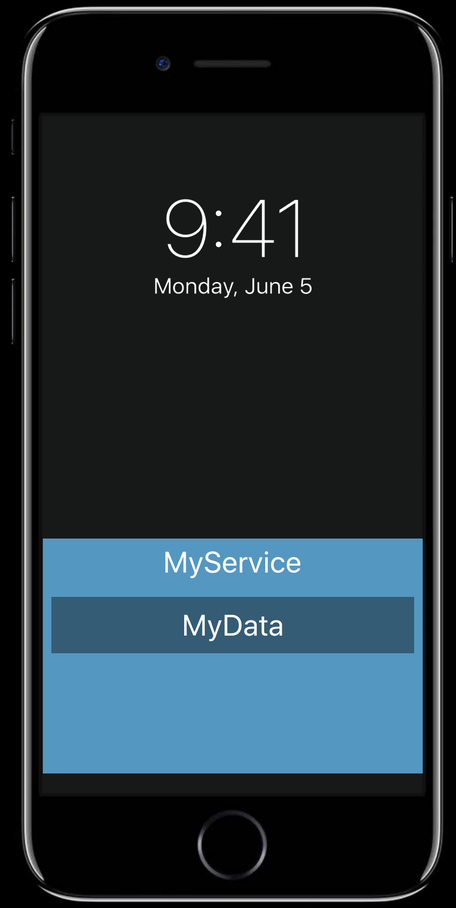





```
peripheral.publishL2CAPChannel(withEncryption: true)
```

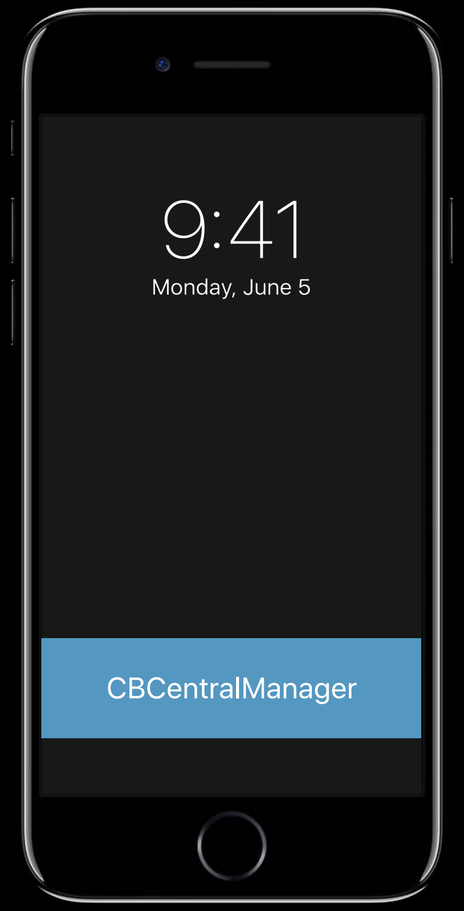
Opening an L2CAP Channel

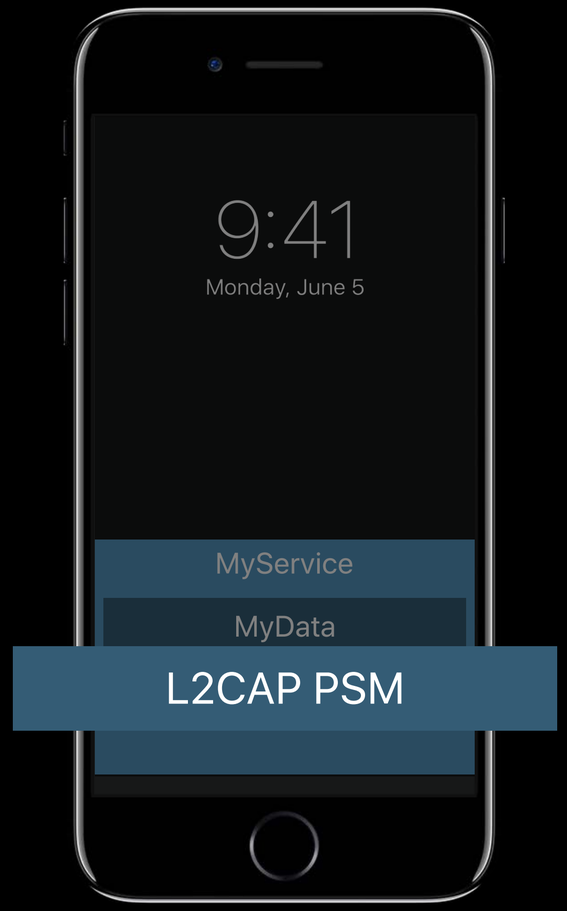





```
optional public func peripheralManager(_ peripheral: CBPeripheralManager,
didPublishL2CAPChannel PSM: CBL2CAPPSM, error: Error?)
```

Opening an L2CAP Channel



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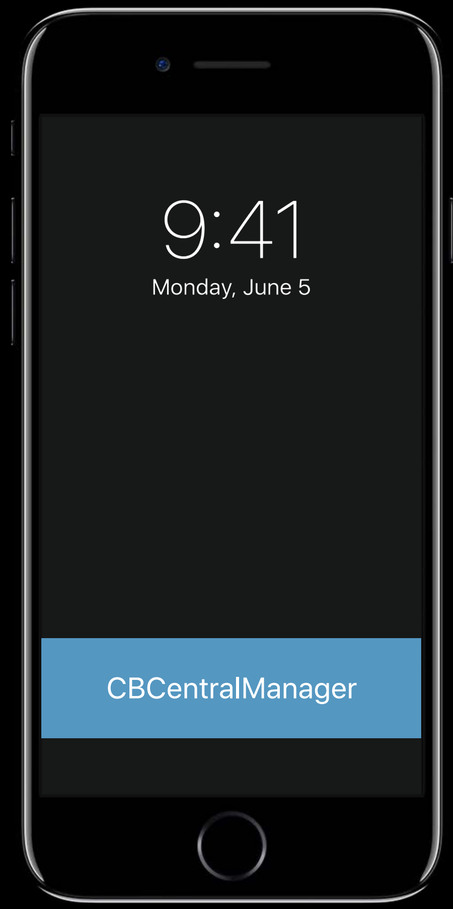
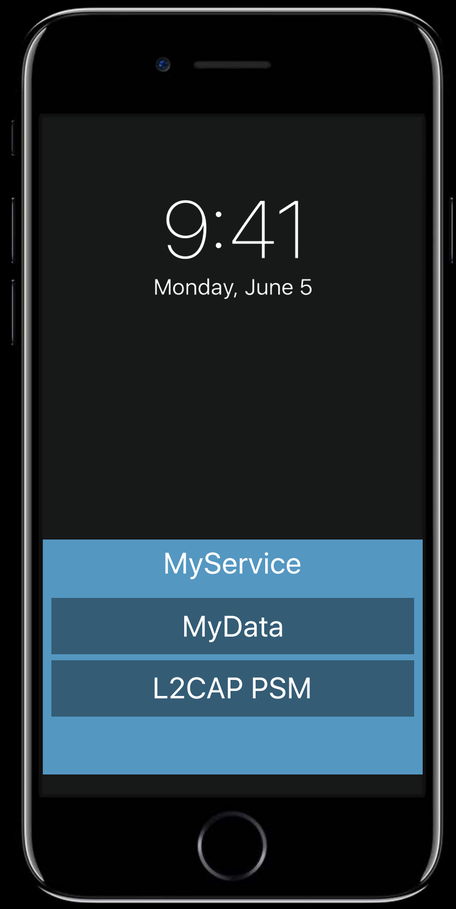
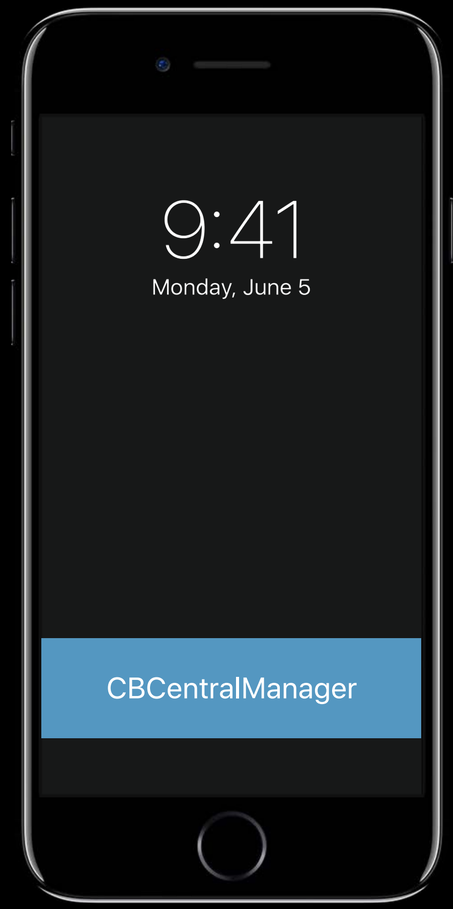
```

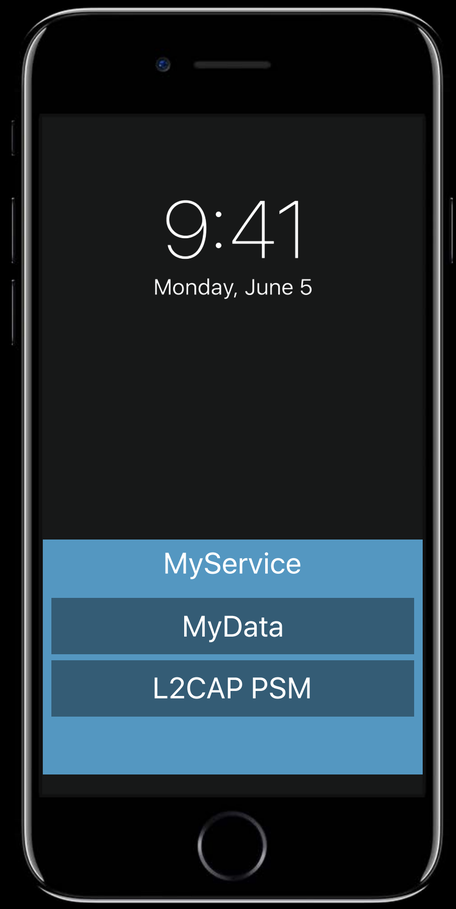
Opening an L2CAP Channel





Opening an L2CAP Channel





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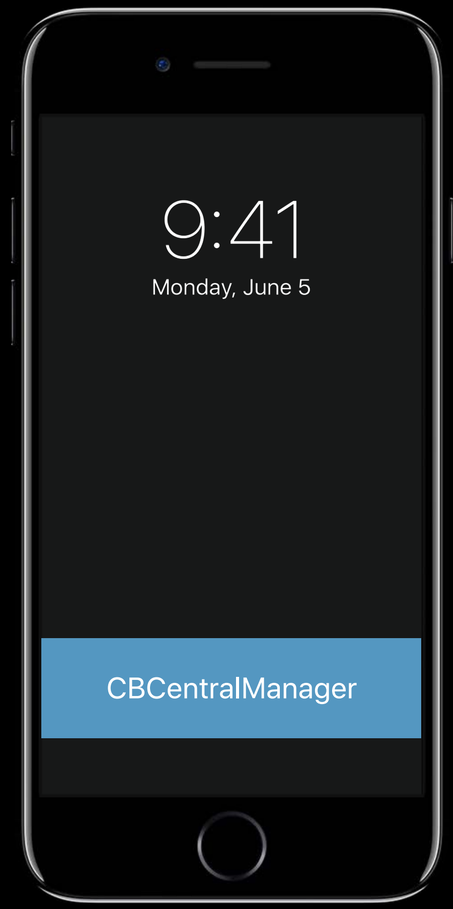
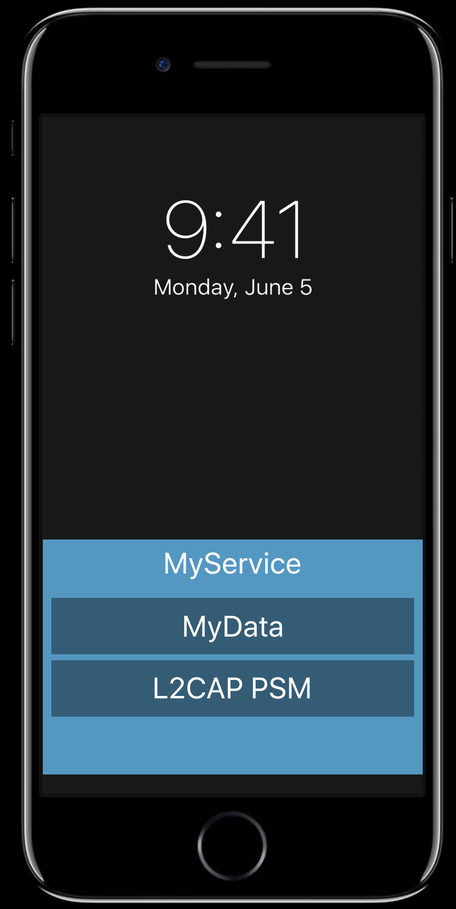
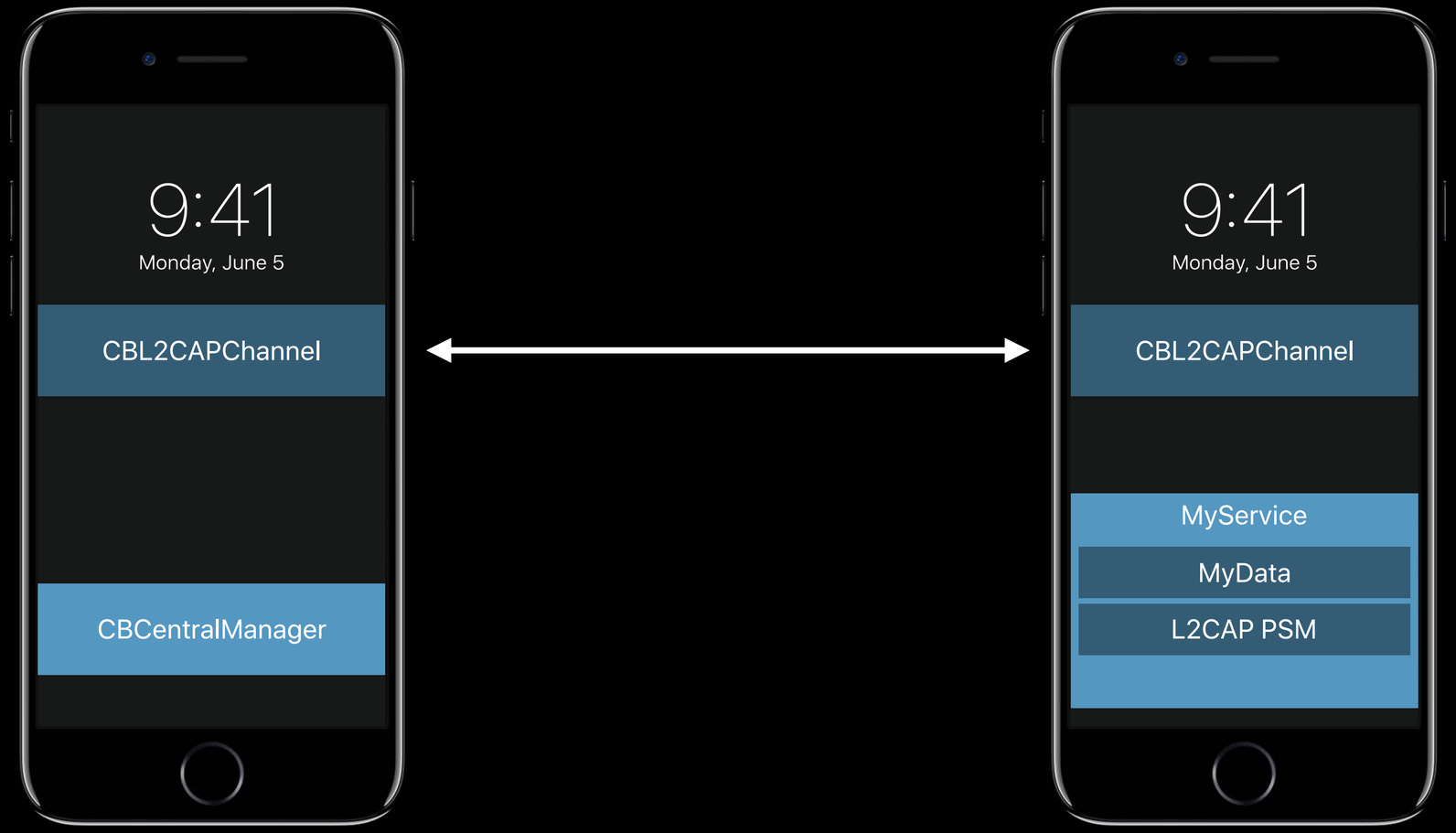





```
peripheral.openL2CAPChannel(PSM)
```

Opening an L2CAP Channel




```
optional public func peripheralManager(_ peripheral: CBPeripheralManager, didOpen channel:
CBL2CAPChannel?, error: Error?)
```

```
@available(macOS 10.13, iOS 11.0, *)
open class CBL2CAPChannel: NSObject {

    open var peer: CBPeer! { get }

    open var inputStream: InputStream! { get }

    open var outputStream: OutputStream! { get }

    open var psm: CBL2CAPPSM { get }

}
```

Stream Events

Stream events are delivered through NSStream

```
public protocol StreamDelegate: NSObjectProtocol {
    optional public func stream(_ aStream: Stream, handle eventCode: Stream.Event)
}

public struct Stream.Event: OptionSet {
    public static var openCompleted: Stream.Event { get }
    public static var hasBytesAvailable: Stream.Event { get }
    public static var hasSpaceAvailable: Stream.Event { get }
    public static var errorOccurred: Stream.Event { get }
    public static var endEncountered: Stream.Event { get }
}
```

Closing Channels

Channels may be closed due to

- Link loss
- Central close
- Peripheral unpublished
- Peripheral object is released

When Should L2CAP Be Used?

Use GATT where it makes sense

Lowest overhead

Best performance

Best for large data transfers

Great for stream protocols

Best Practices

Follow the Bluetooth Accessory Design Guidelines for Apple Products

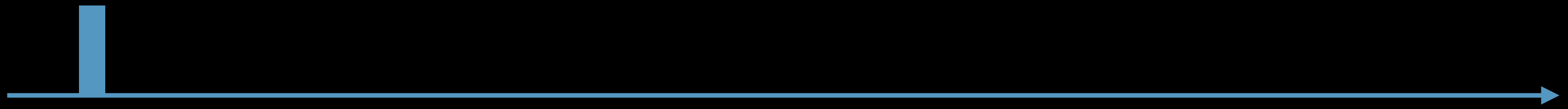
Use Existing Profiles and Services

Why does it take so long to connect?

Time to Discover

Peripheral

Advertisement

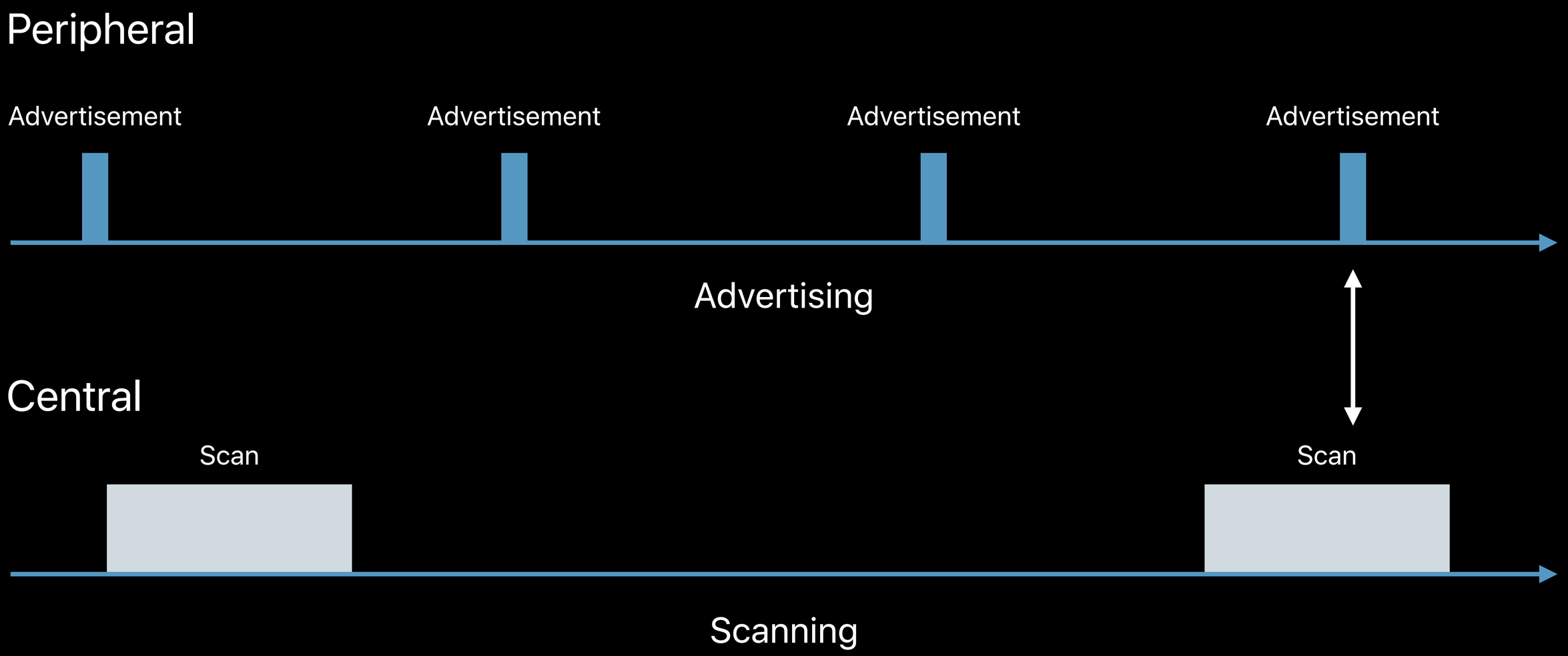


Advertising

Central

Scanning

Time to Discover



Connection Speed

Use the shortest advertising interval possible

Optimize for when users are trying to use your accessory

See the Bluetooth Accessory Design Guidelines for power-efficient advertising intervals

Reconnecting devices

No need to scan for a peripheral for reconnect

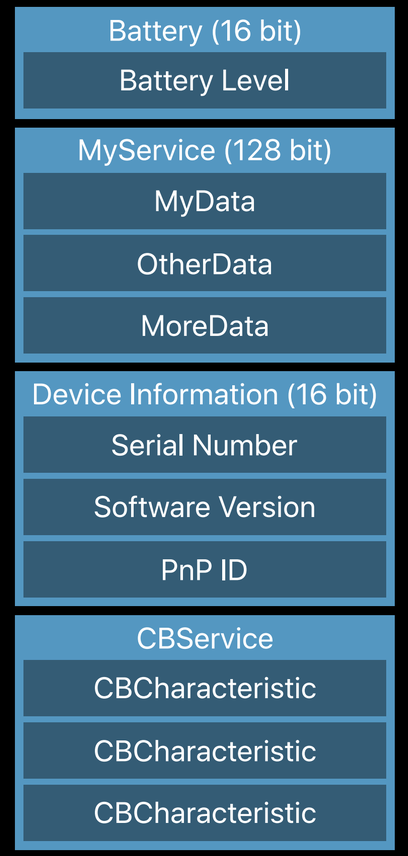
Retrieve the peripheral and directly connect

```
let identifier = UUID()

let peripherals = central.retrievePeripherals(withIdentifiers: [ identifier ])

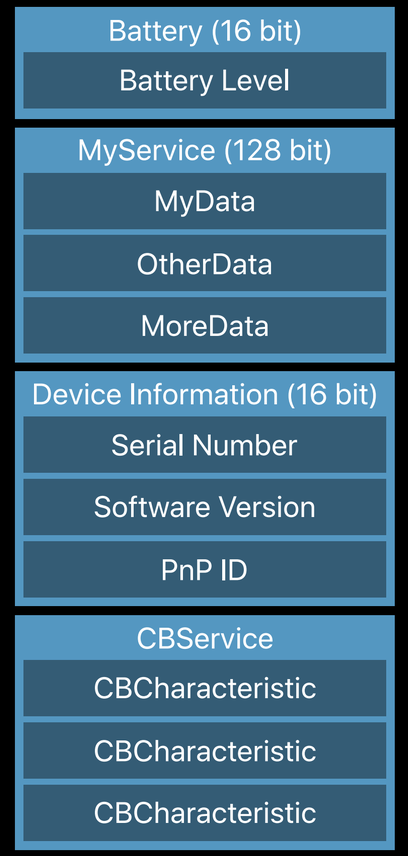
central.connect(peripherals[0])
```

Service Discovery Speed



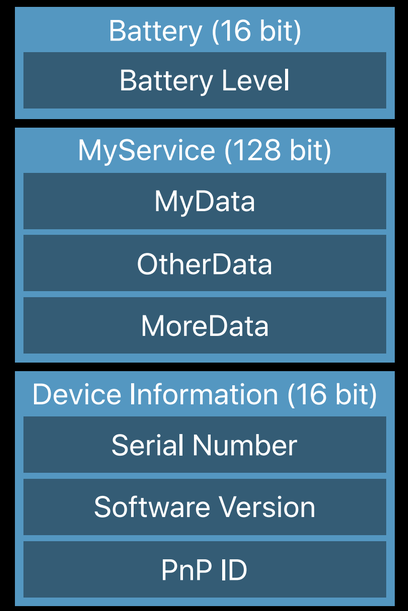
Service Discovery Speed

Use as few services/characteristics as possible



Service Discovery Speed

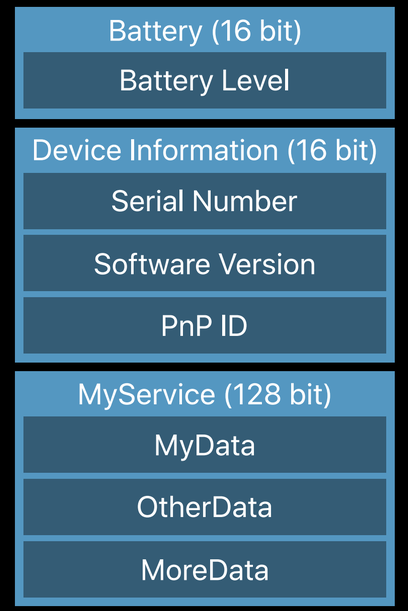
Use as few services/characteristics as possible



Service Discovery Speed

Use as few services/characteristics as possible

Group services by UUID size

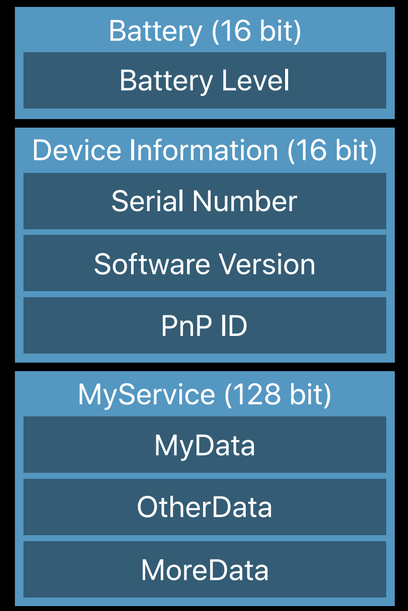


Service Discovery Speed

Use as few services/characteristics as possible

Group services by UUID size

Support GATT Caching



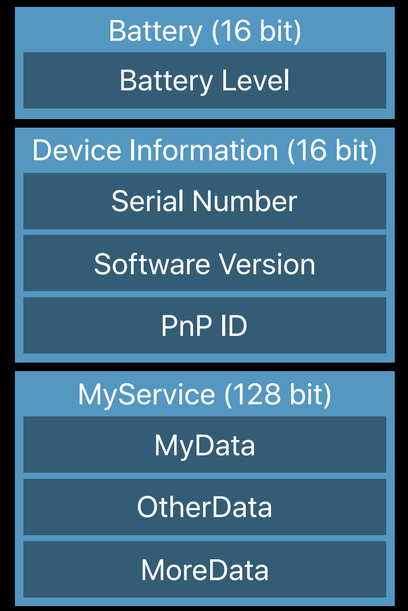
Service Discovery Speed

Use as few services/characteristics as possible

Group services by UUID size

Support GATT Caching

Use “Service Changed”



New Accessory Recommendations

Use the newest chipset / Bluetooth standard available

4.2 and 5.0 are backward compatible

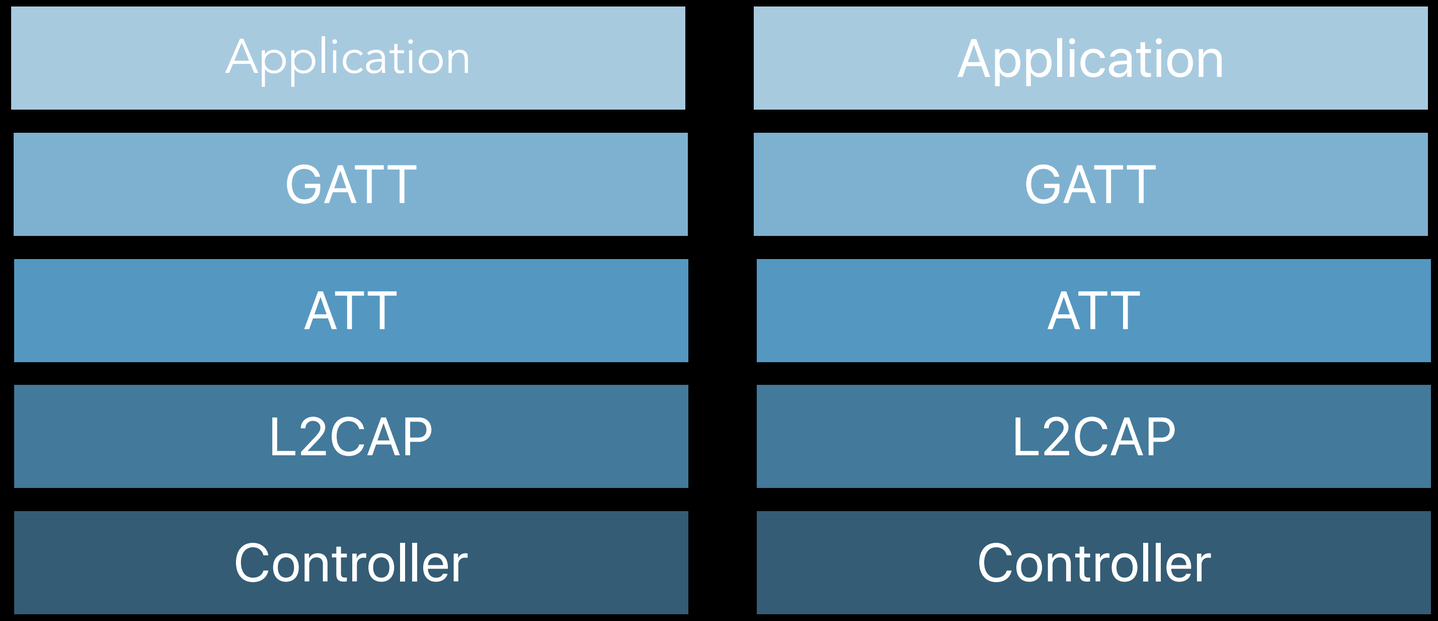
Follow these best practices

Getting the Most out of Core Bluetooth

Duy Phan, Bluetooth Engineer

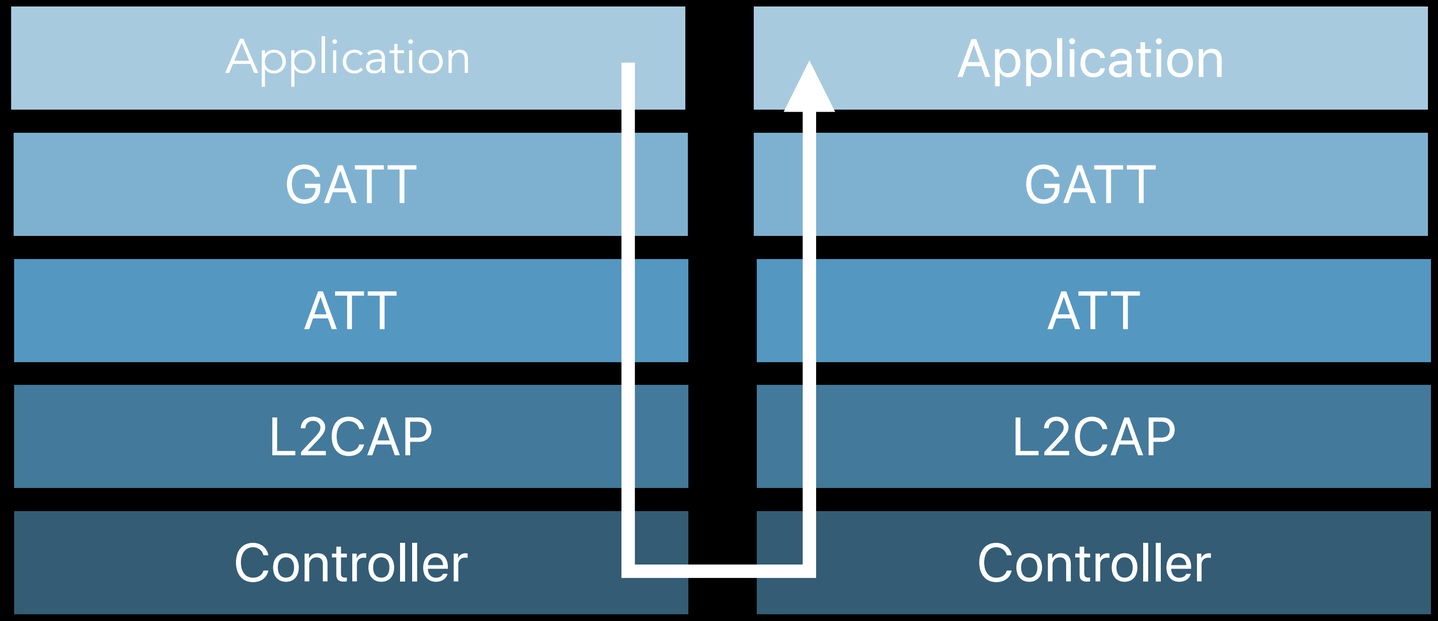
1MB = 3,240 seconds
2.5 kbps

Protocol Overhead



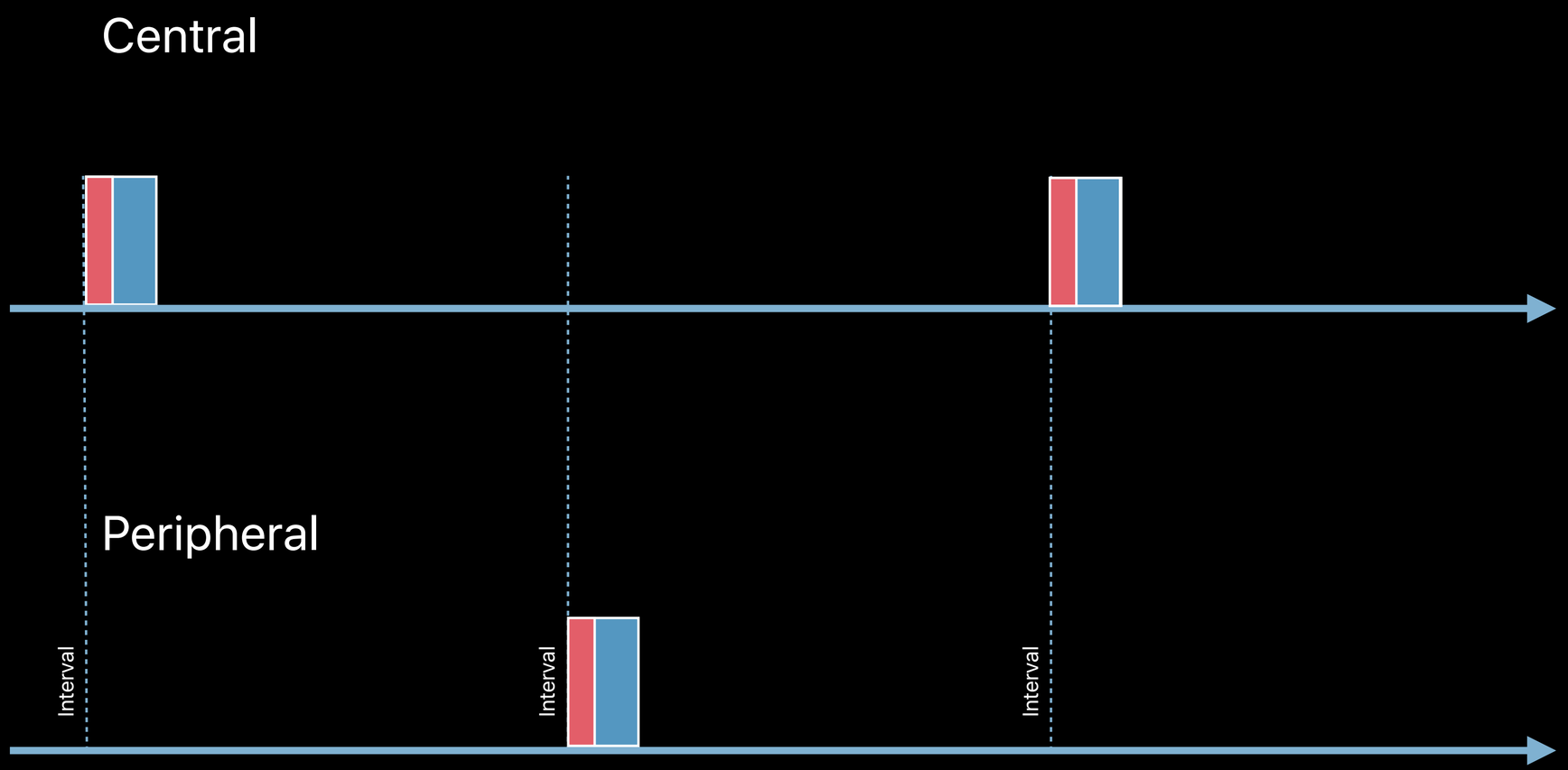
Packet

Protocol Overhead

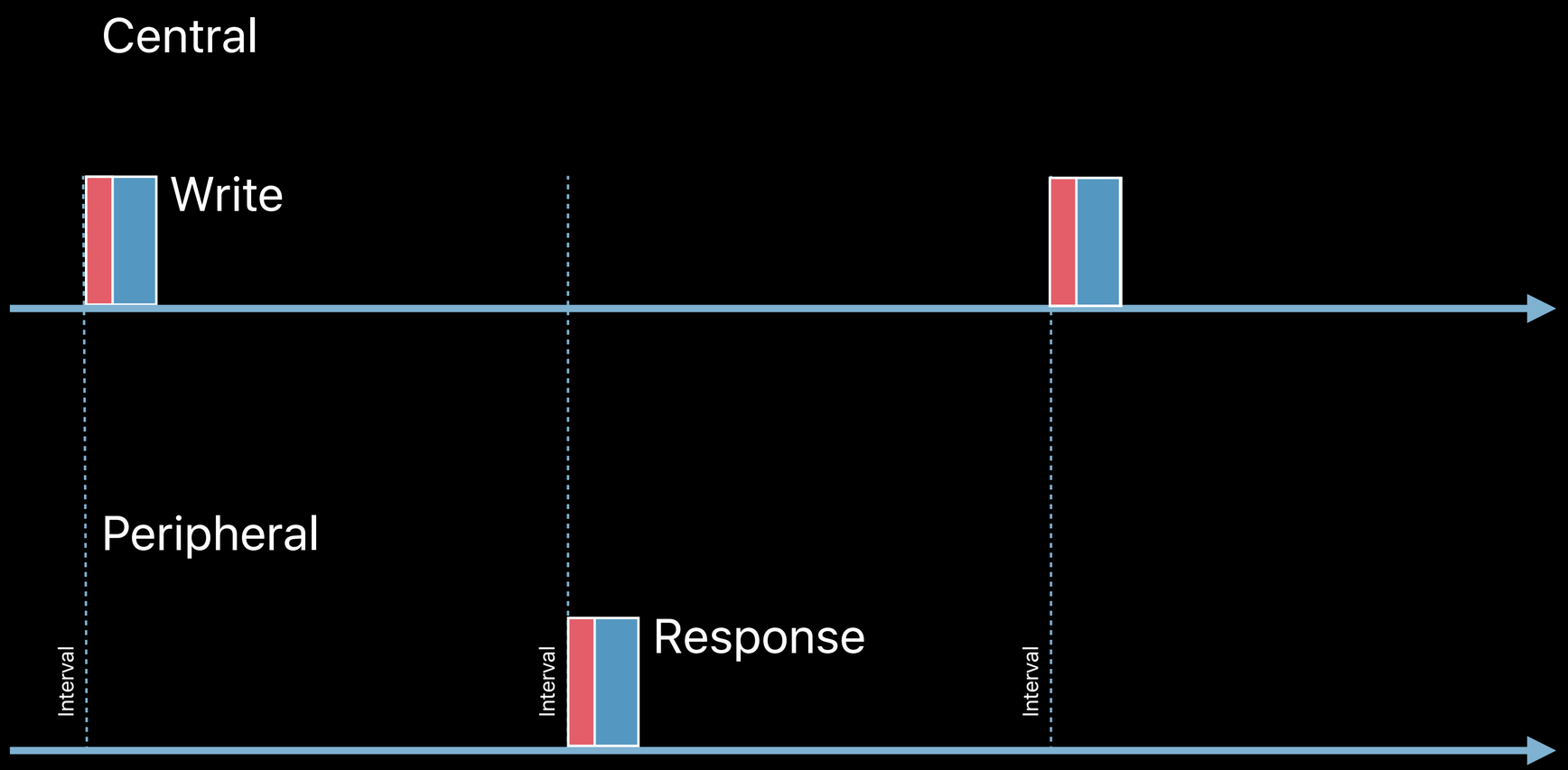


Packet

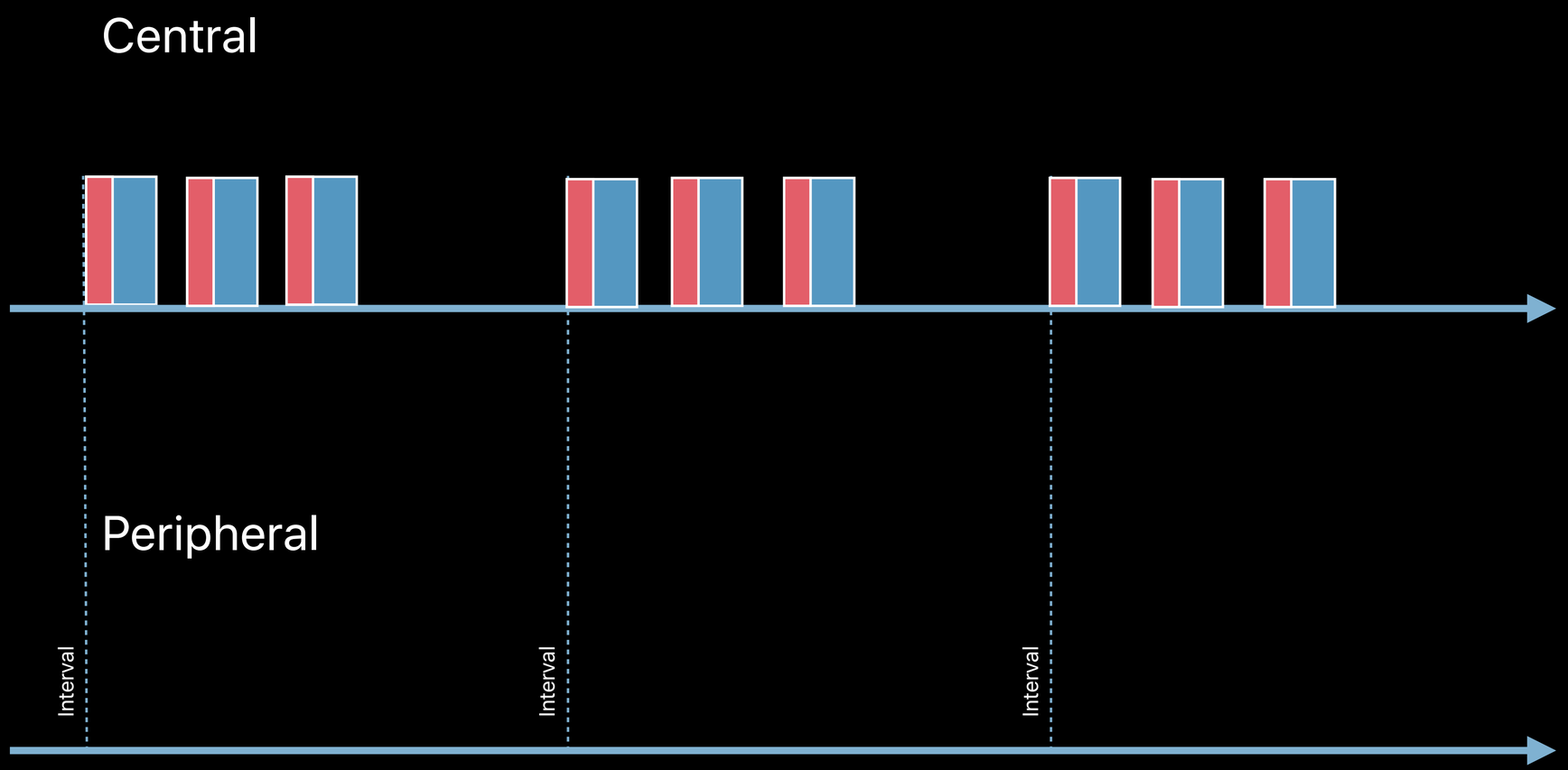
Write With Response



Write With Response



Write With Response



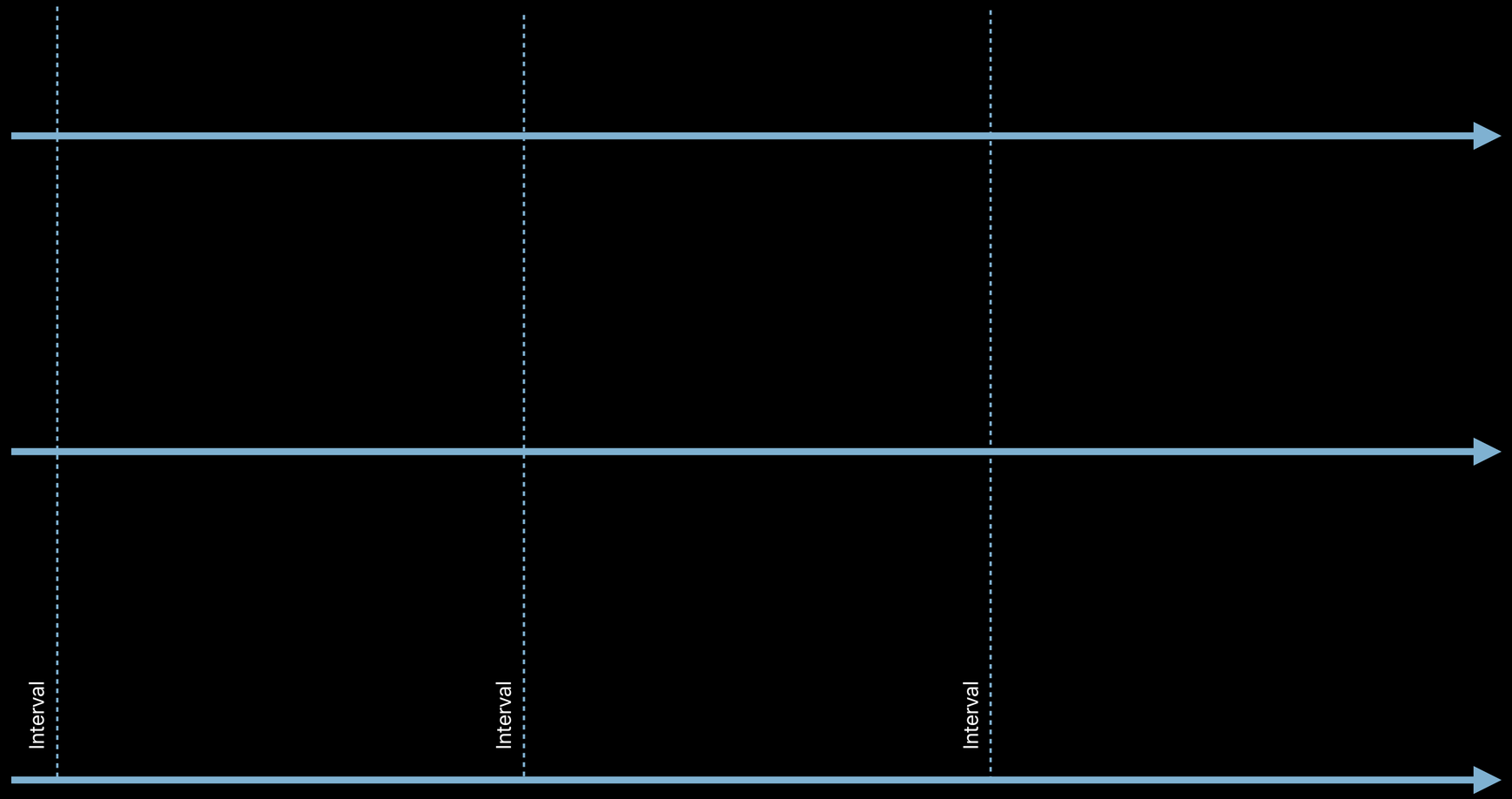
Write Without Response

Reliable with Core Bluetooth flow control

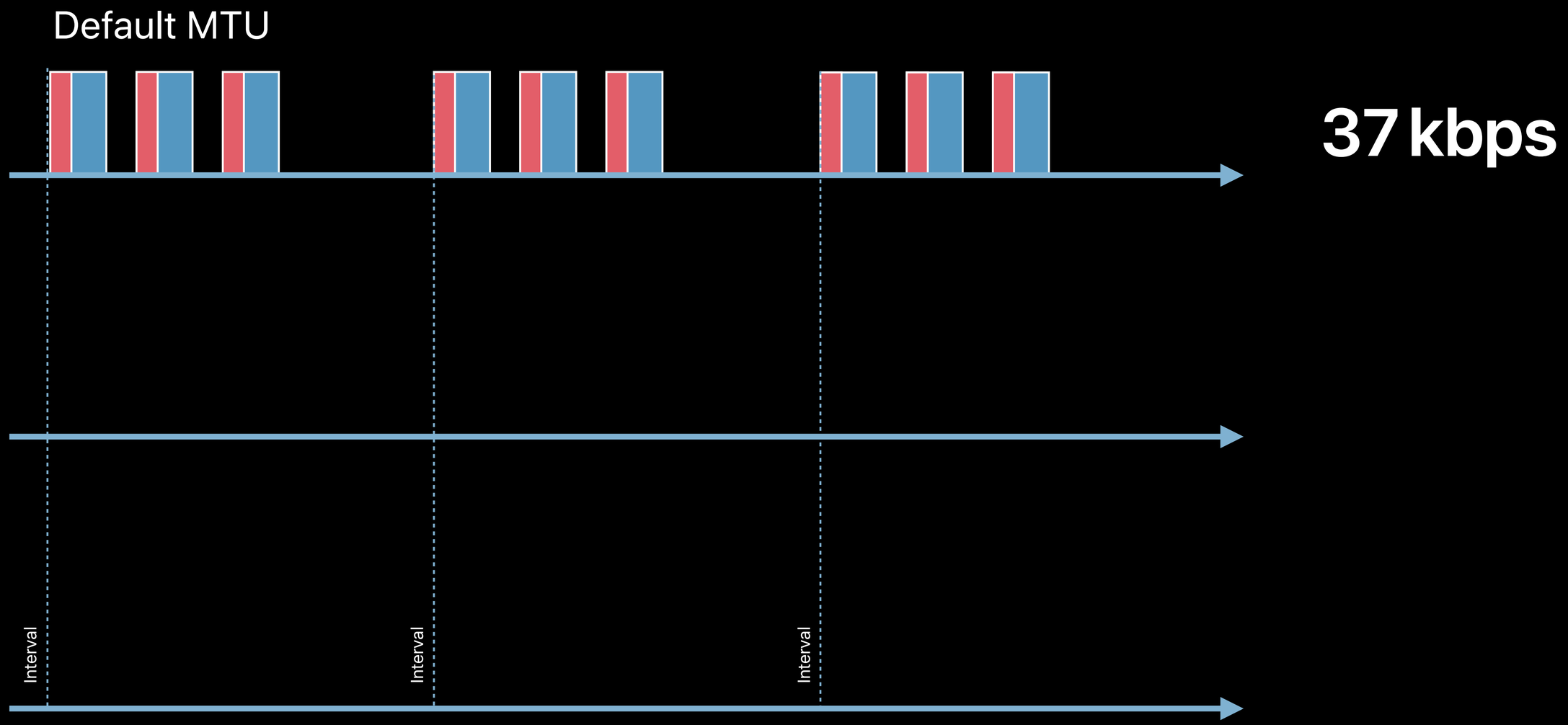
Use all available connection events to transmit

Takes advantage of larger Connection Event Length

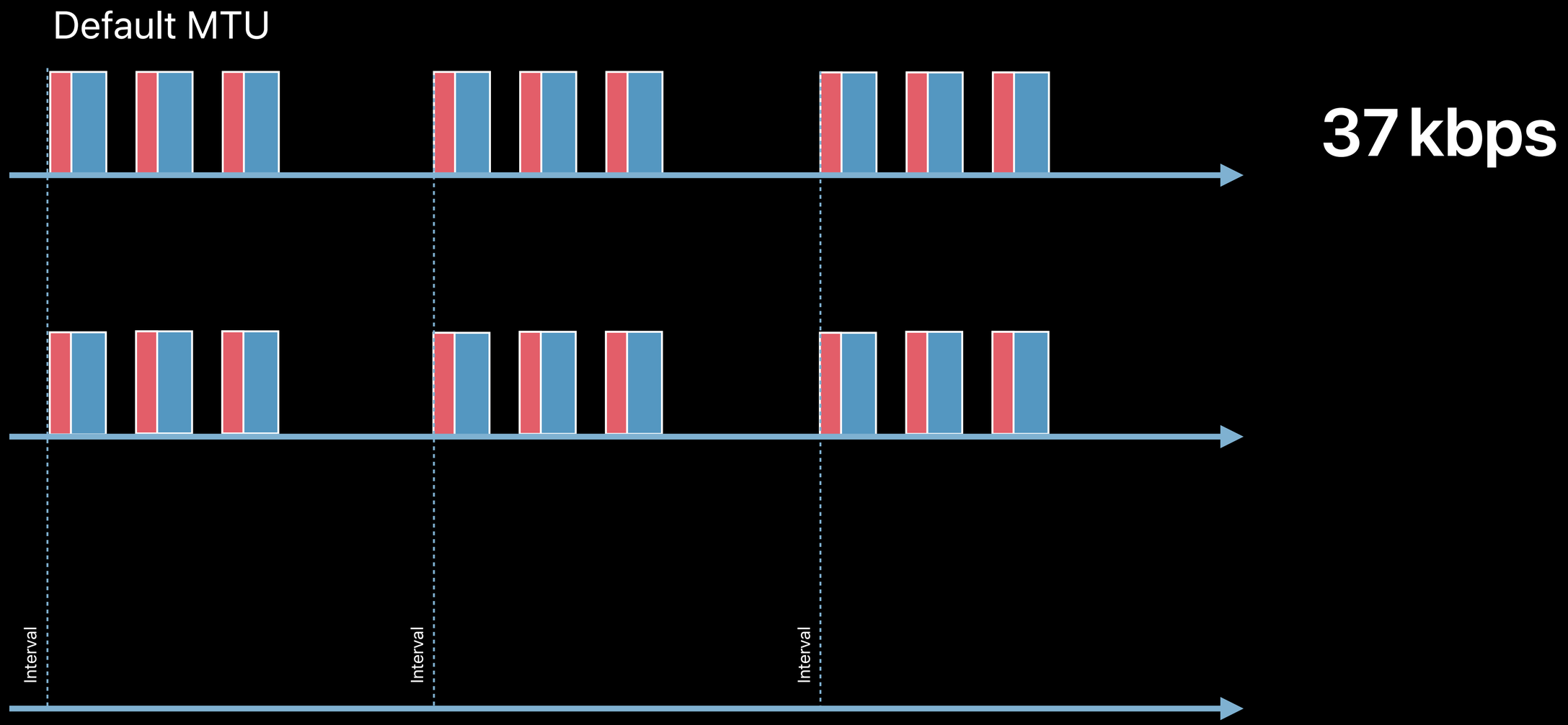
Write Without Response



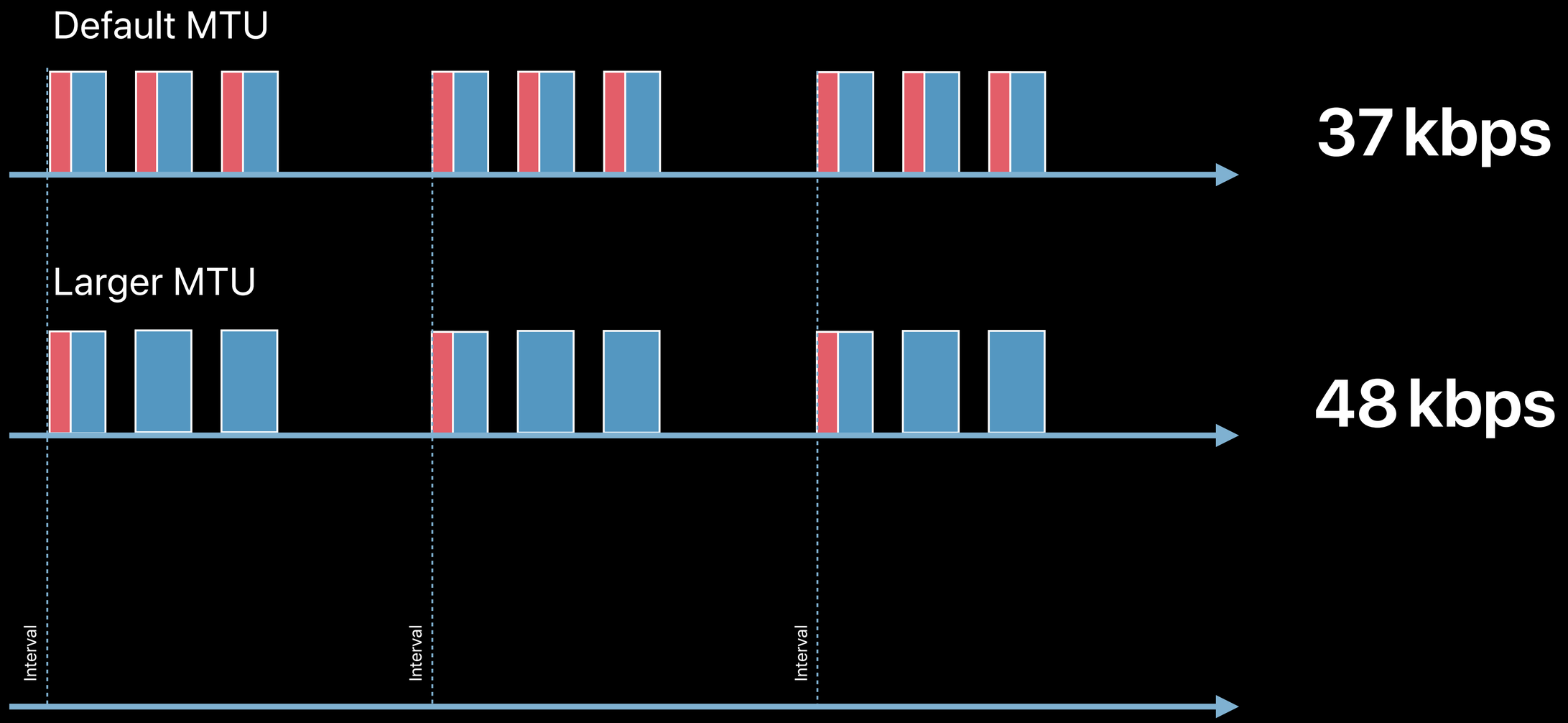
Write Without Response



Write Without Response



Write Without Response



Fitting your data

Apple devices determine the optimal MTU

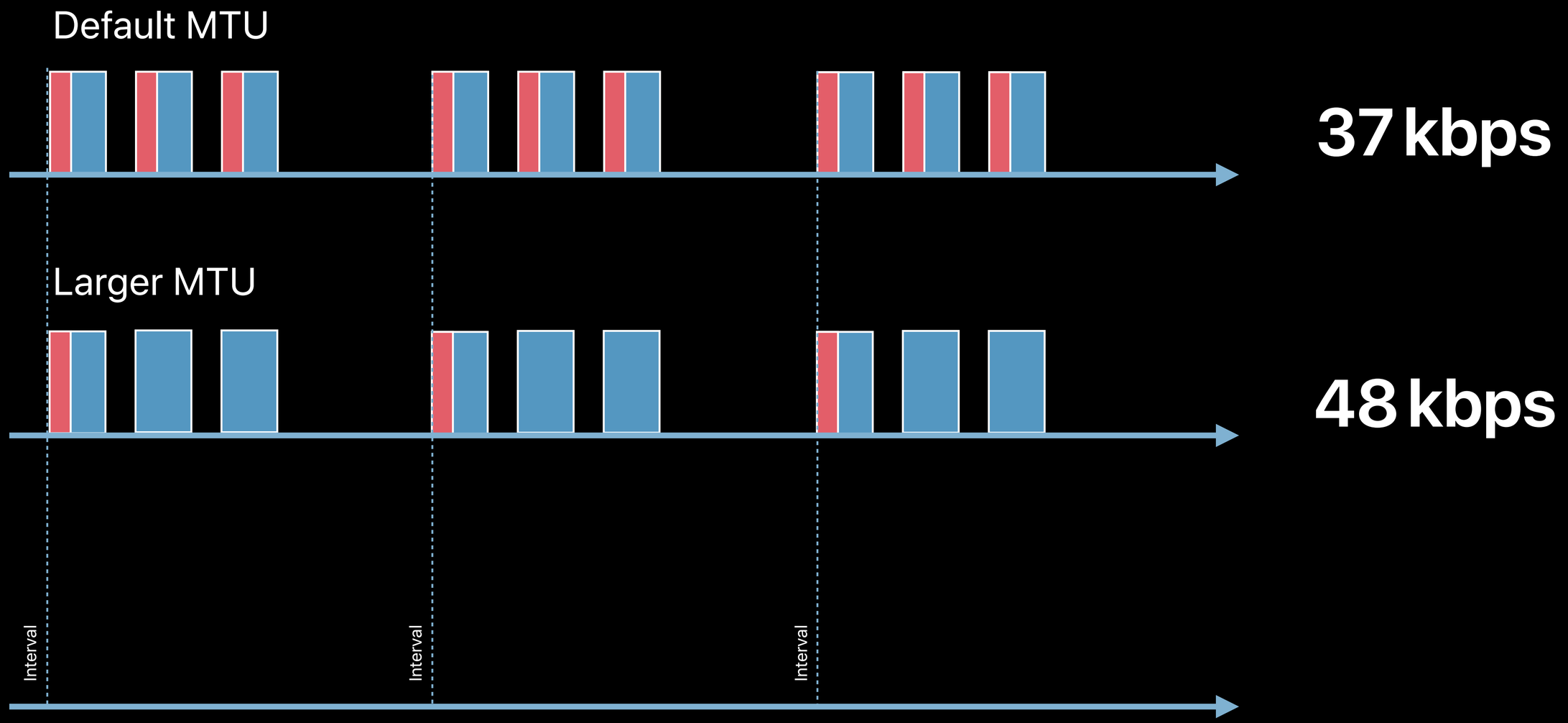
Accessories should support a large MTU

Use large attributes aligned to MTU

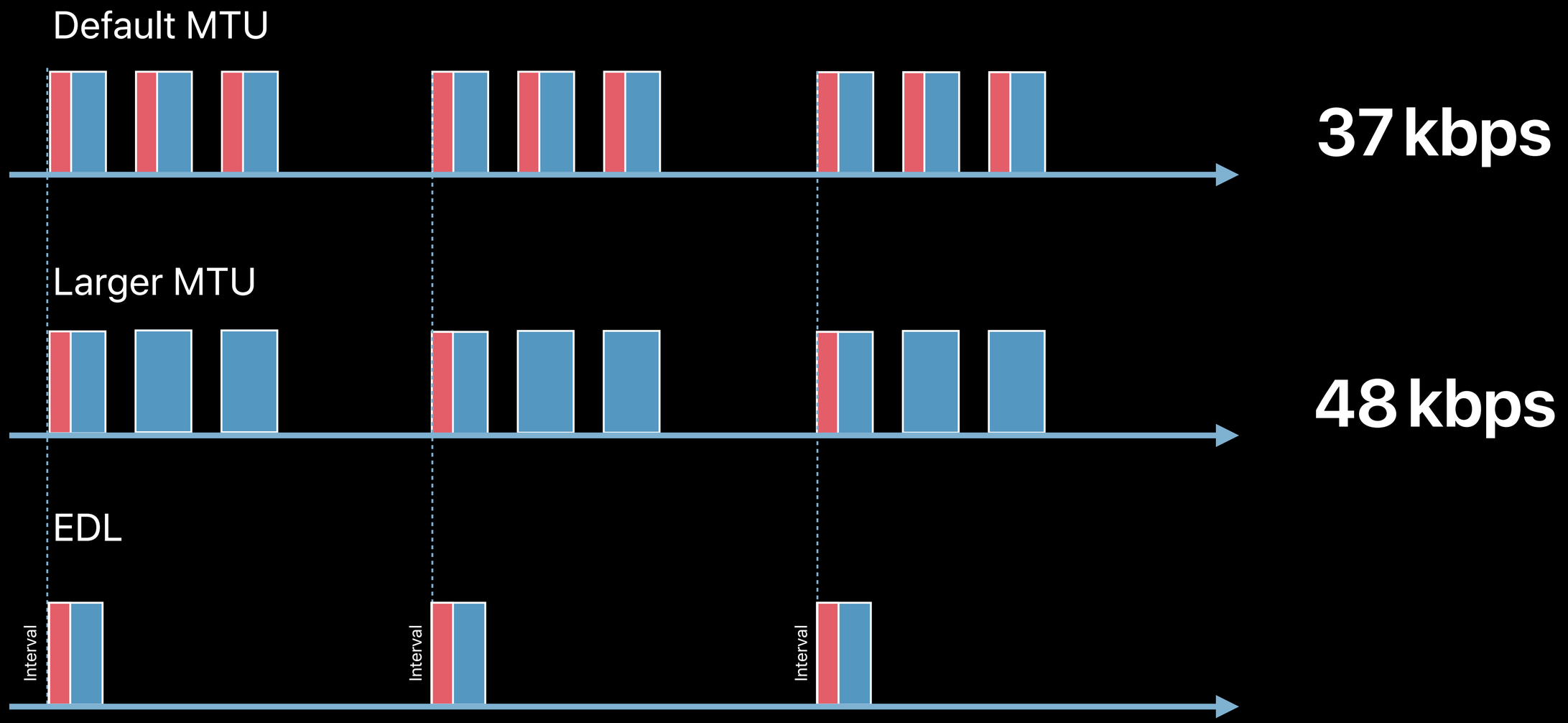
```
open class CBPeripheral: CBPeer {
    open func maximumWriteValueLength(for type: CBCharacteristicWriteType) -> Int
}

open class CBCentral: CBPeer {
    open var maximumUpdateValueLength: Int { get }
}
```

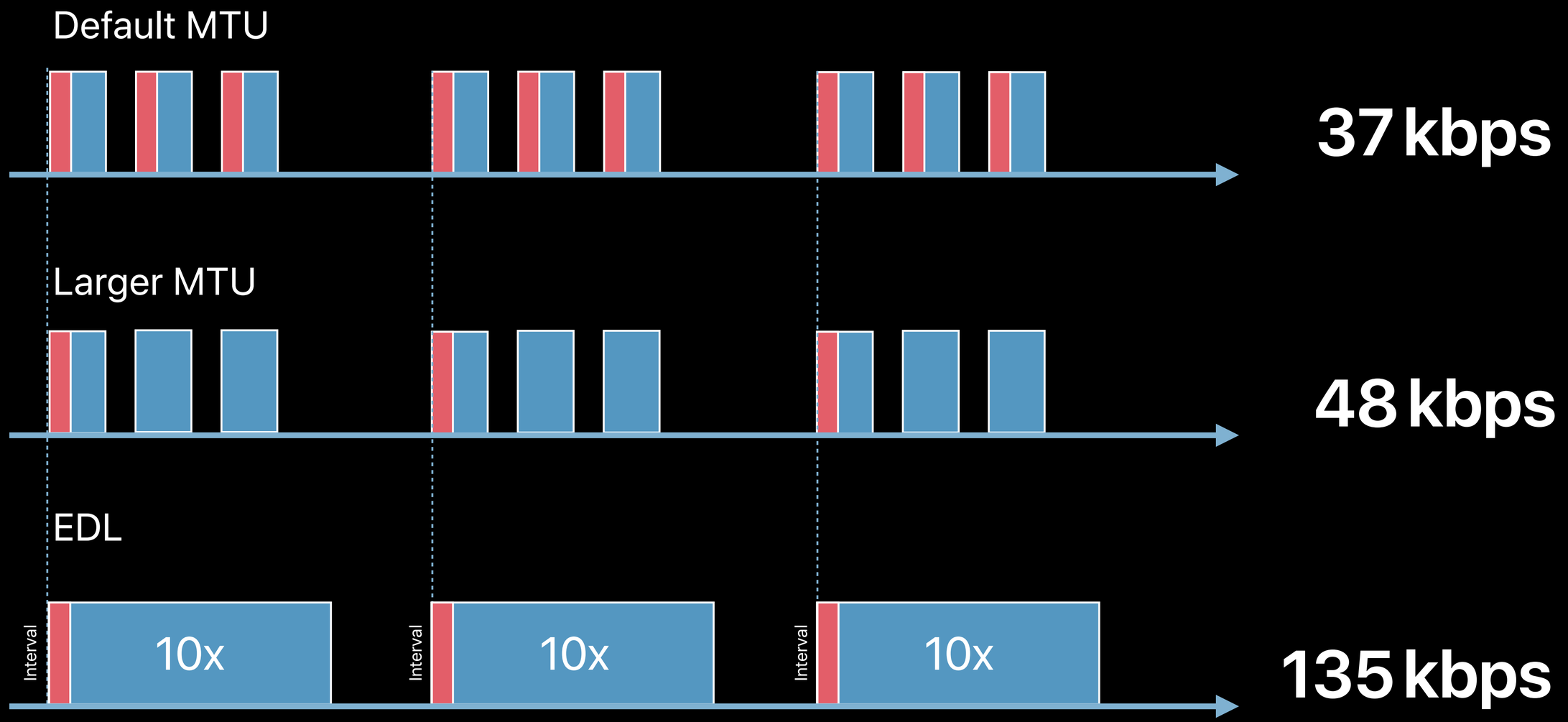
Write Without Response



Write Without Response



Write Without Response



Extended Data Length

New Feature in Bluetooth 4.2

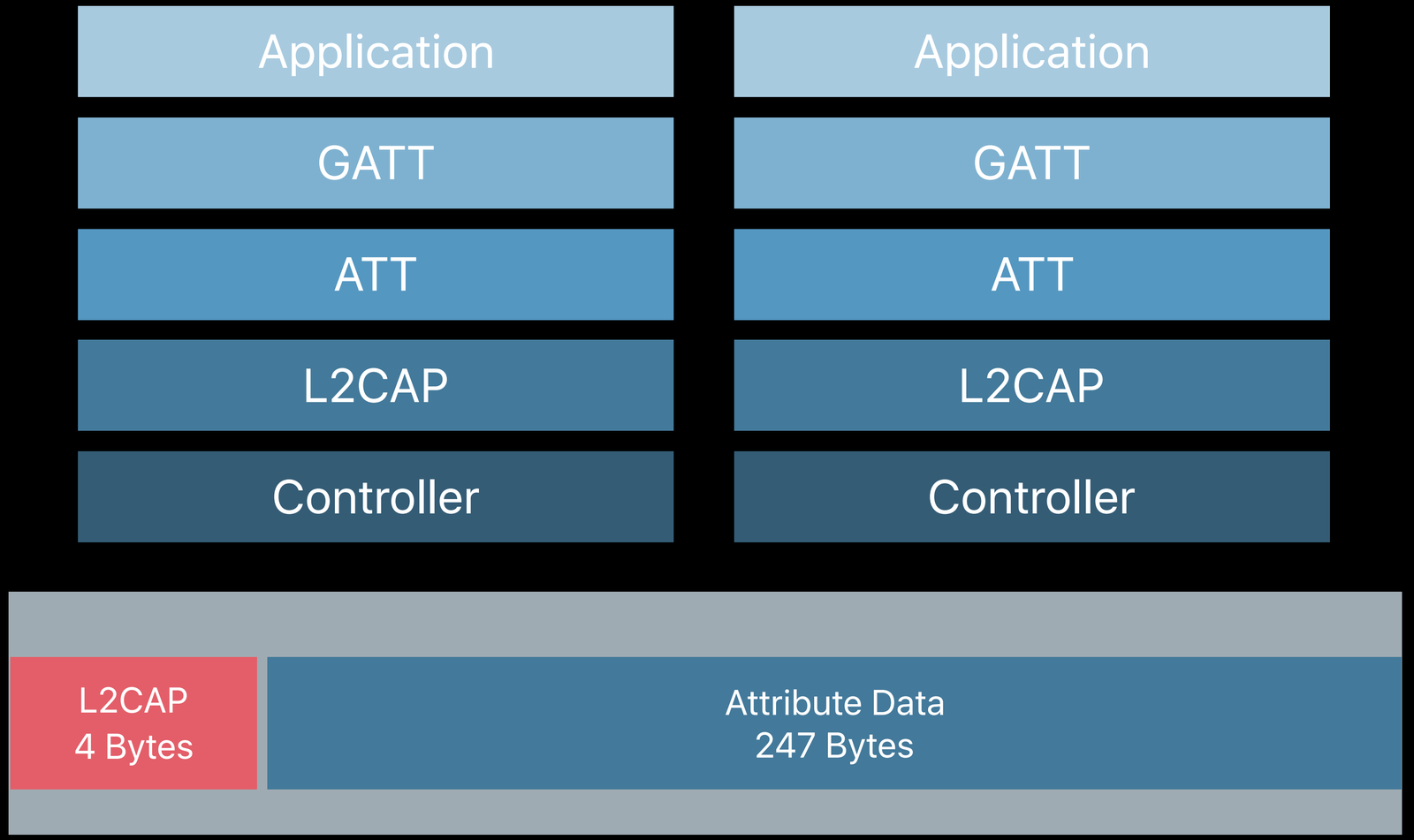
Much larger packets (251 vs 27 bytes)

Transparent to the application

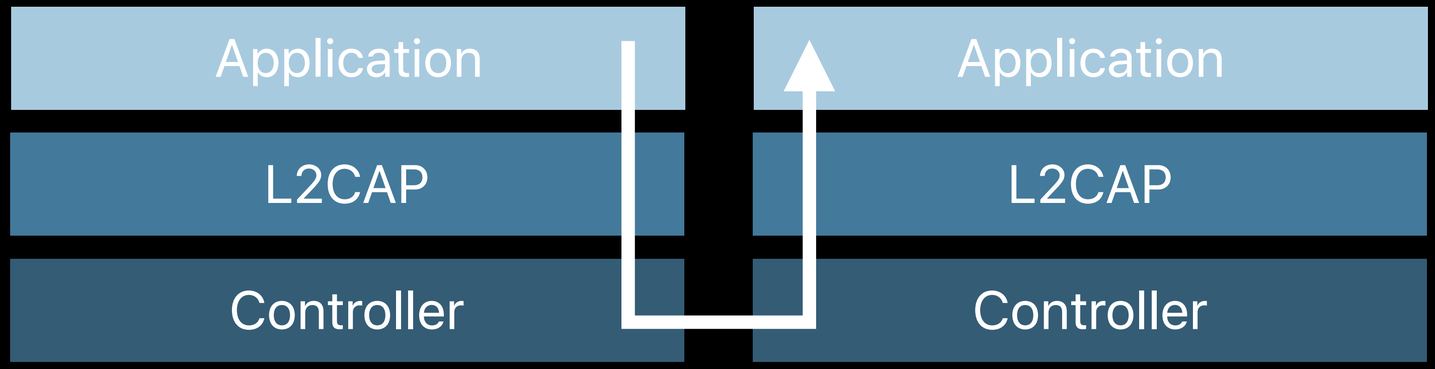
4x throughput with the same radio time

Available on iPhone 7 and Apple Watch Series 2

L2CAP Connection Oriented Channels



L2CAP Connection Oriented Channels

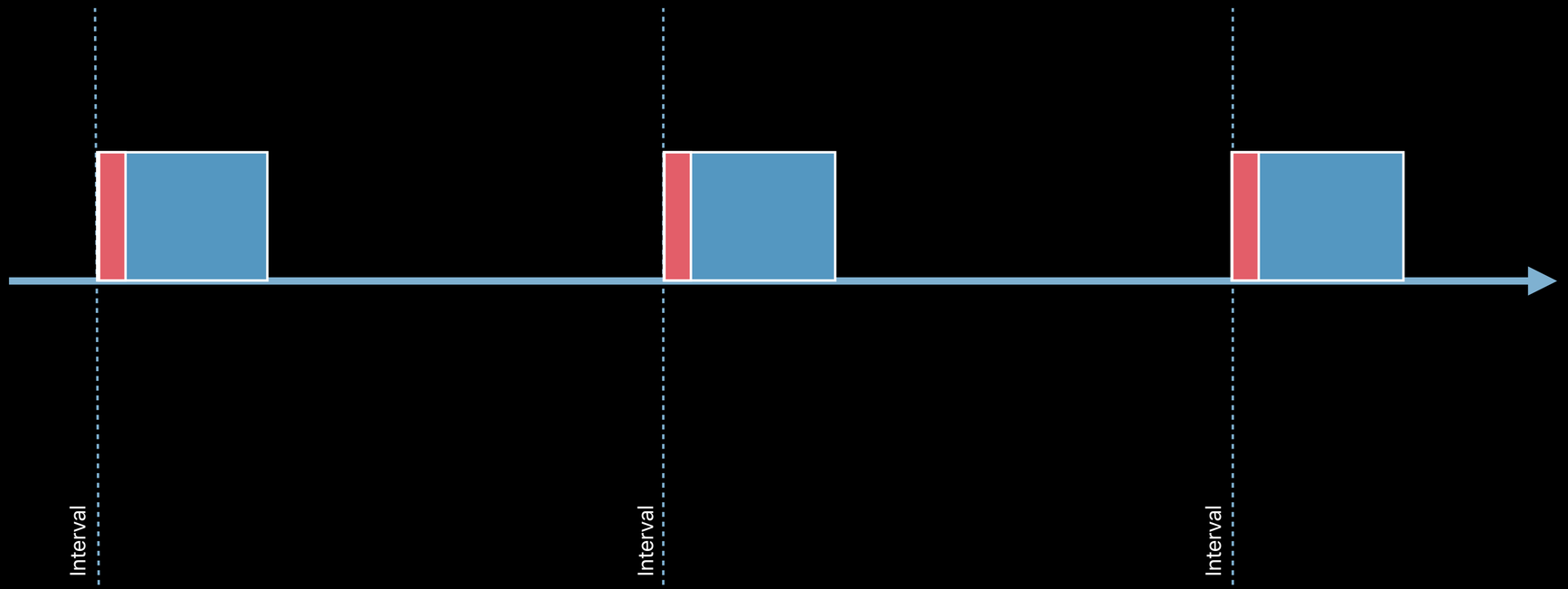


197 kbps

Packet

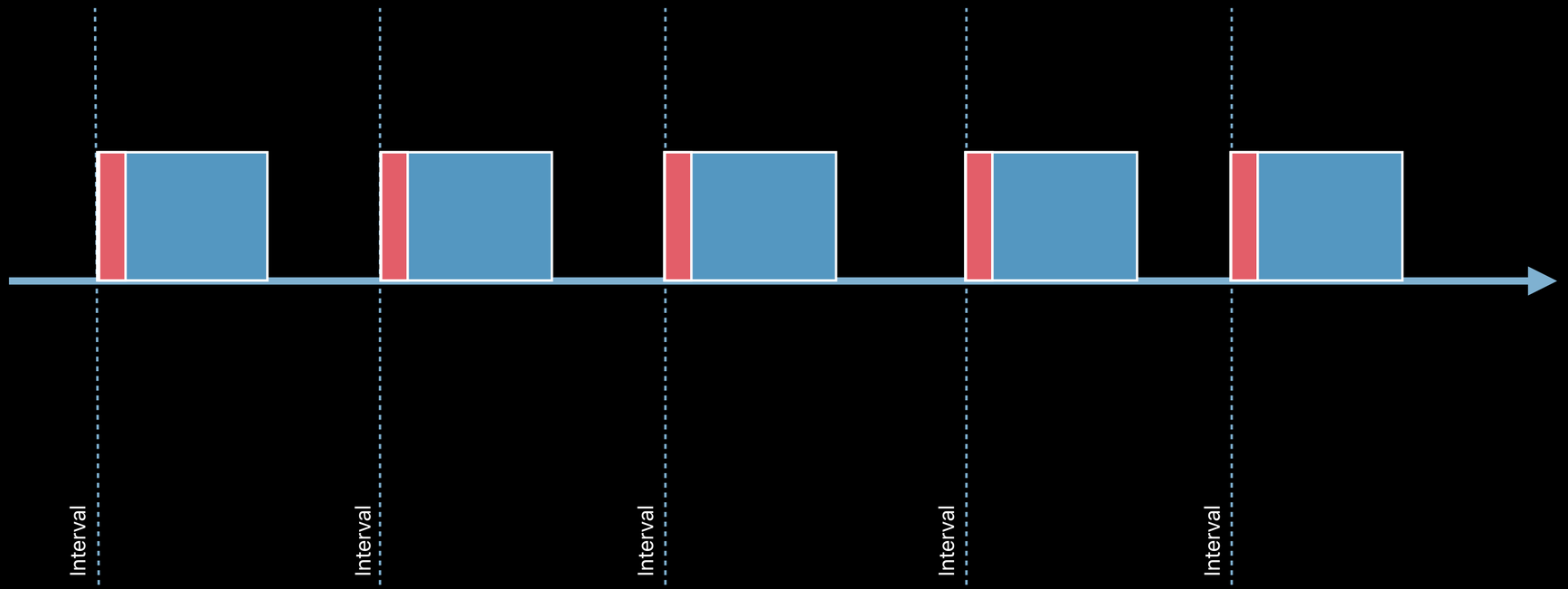
Faster Connection Interval

L2CAP + EDL



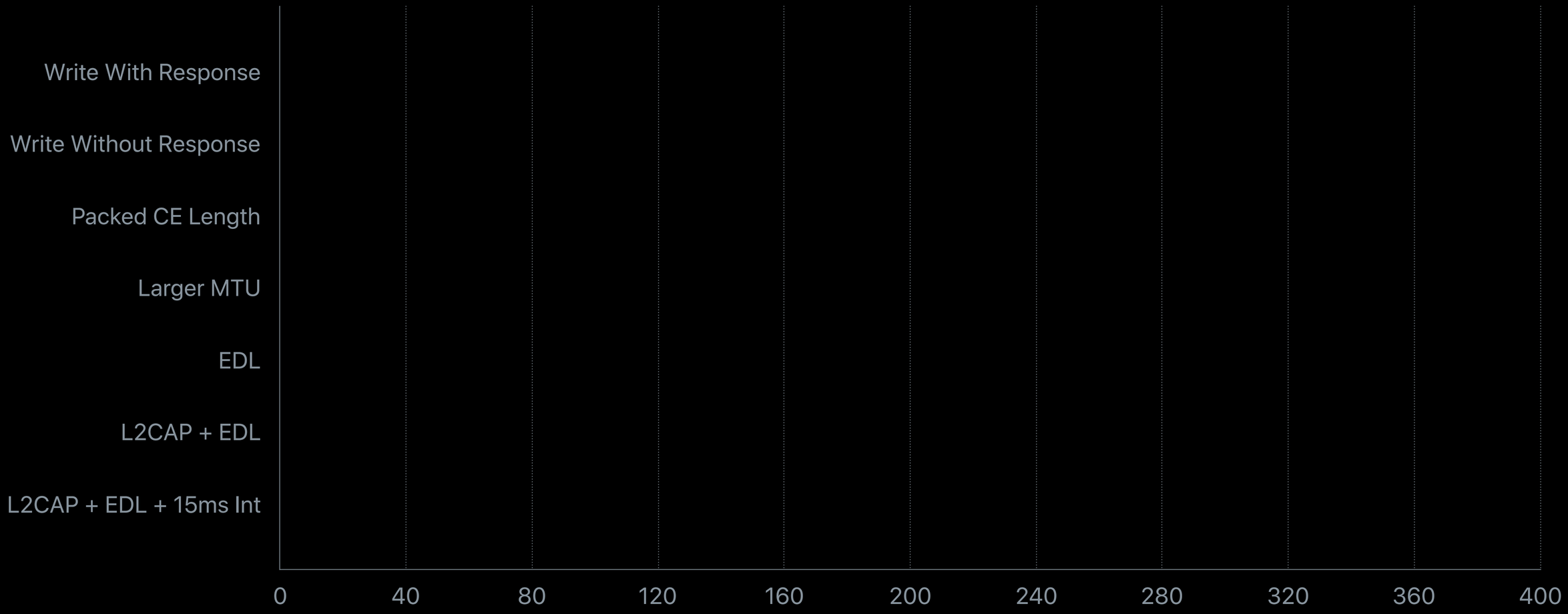
Faster Connection Interval

L2CAP + EDL



394 kbps

Throughput (kbps)



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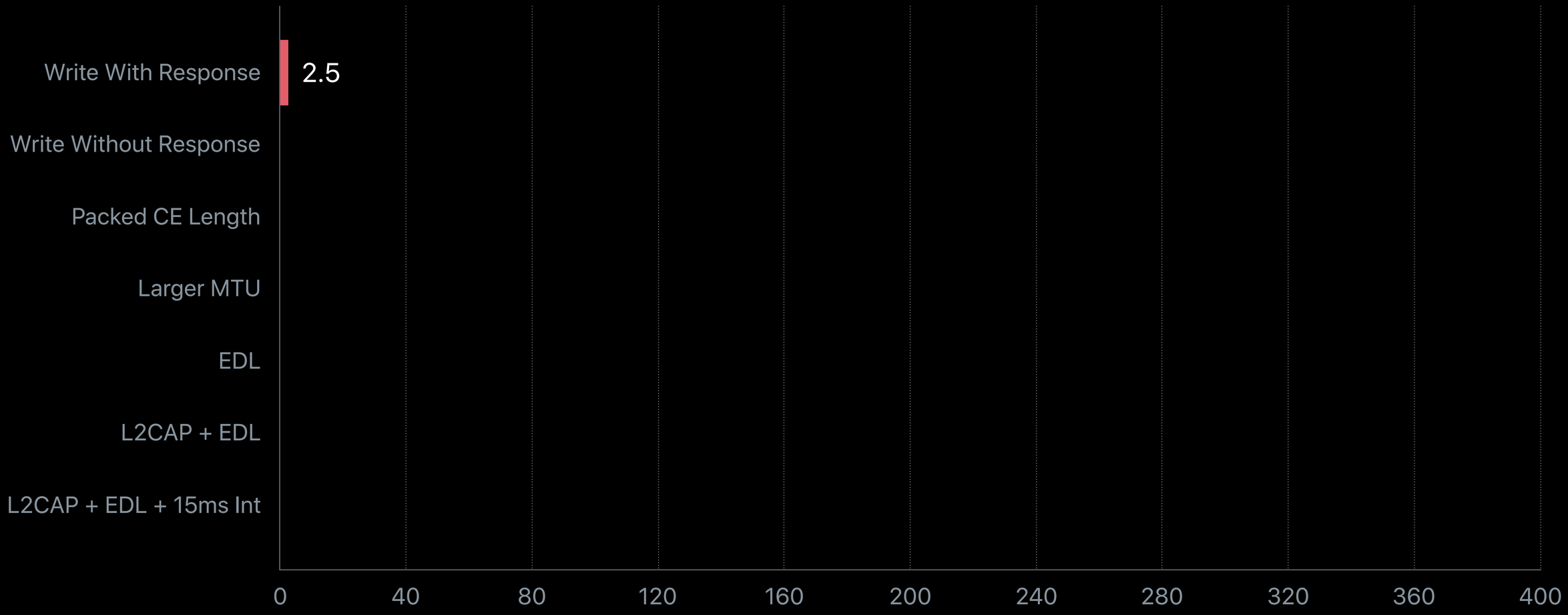

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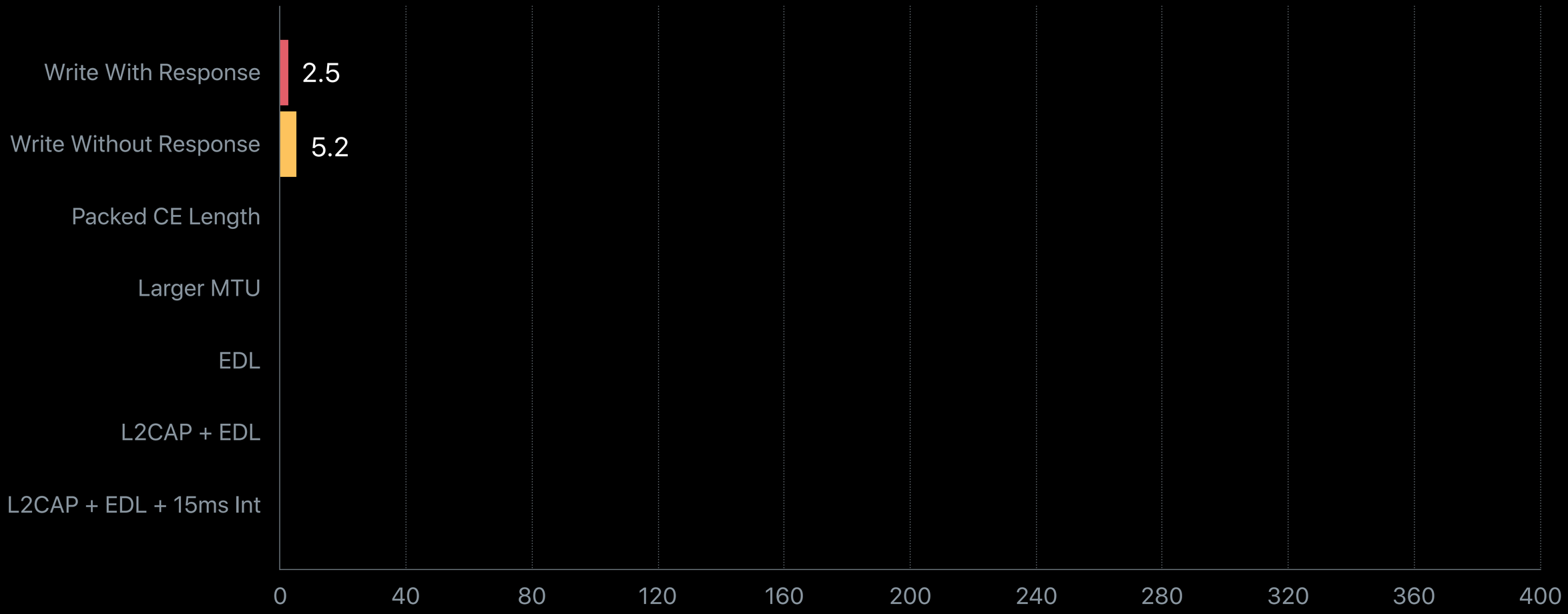
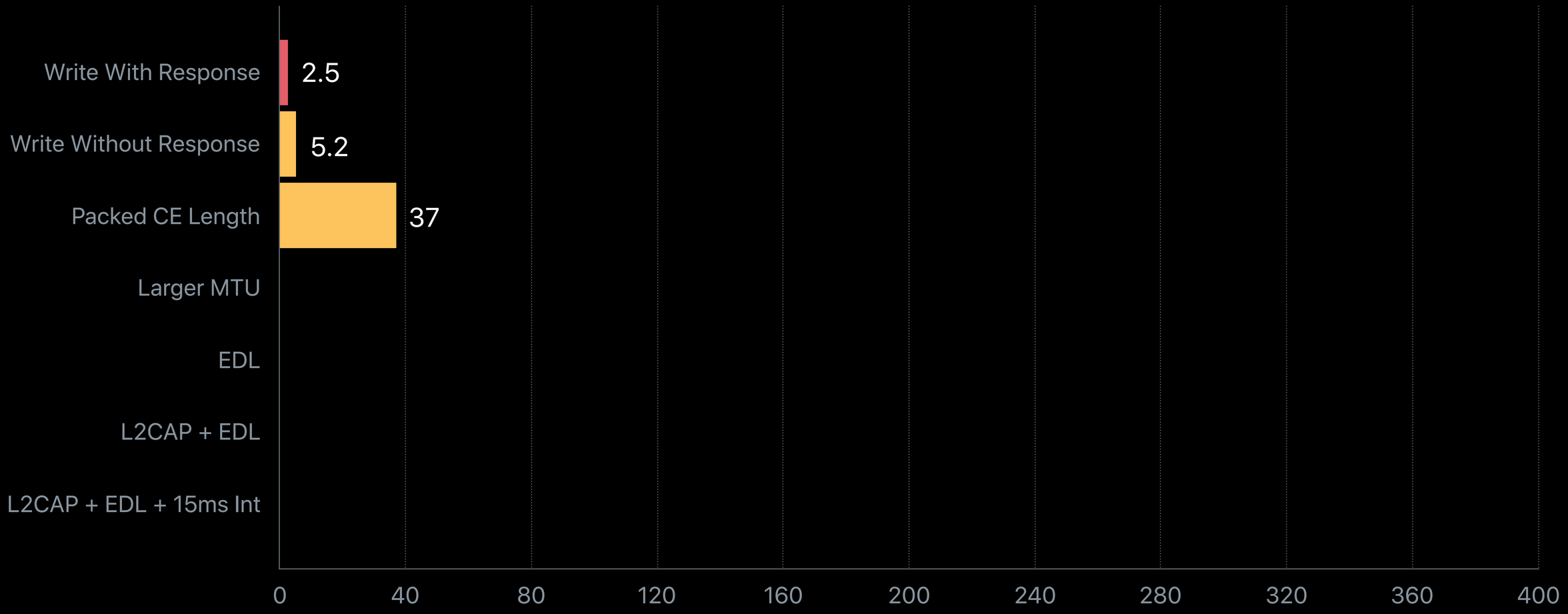
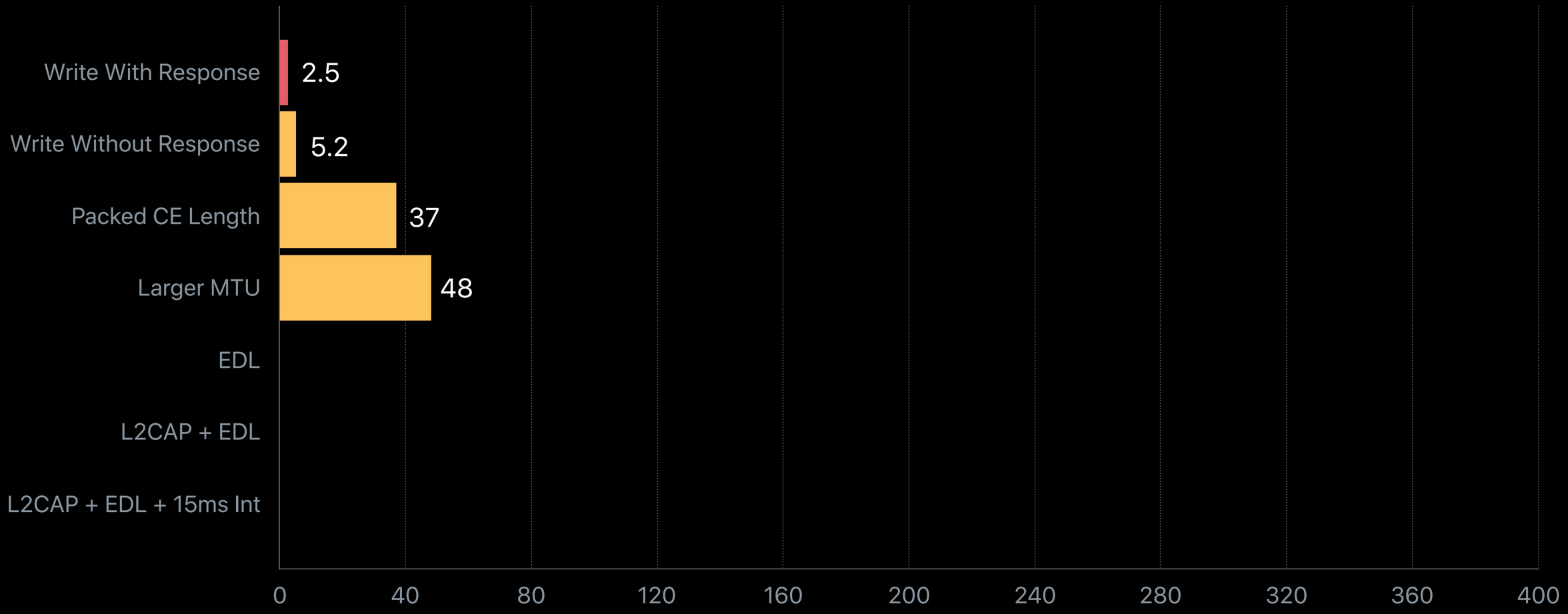


Throughput (kbps)



Throughput (kbps)



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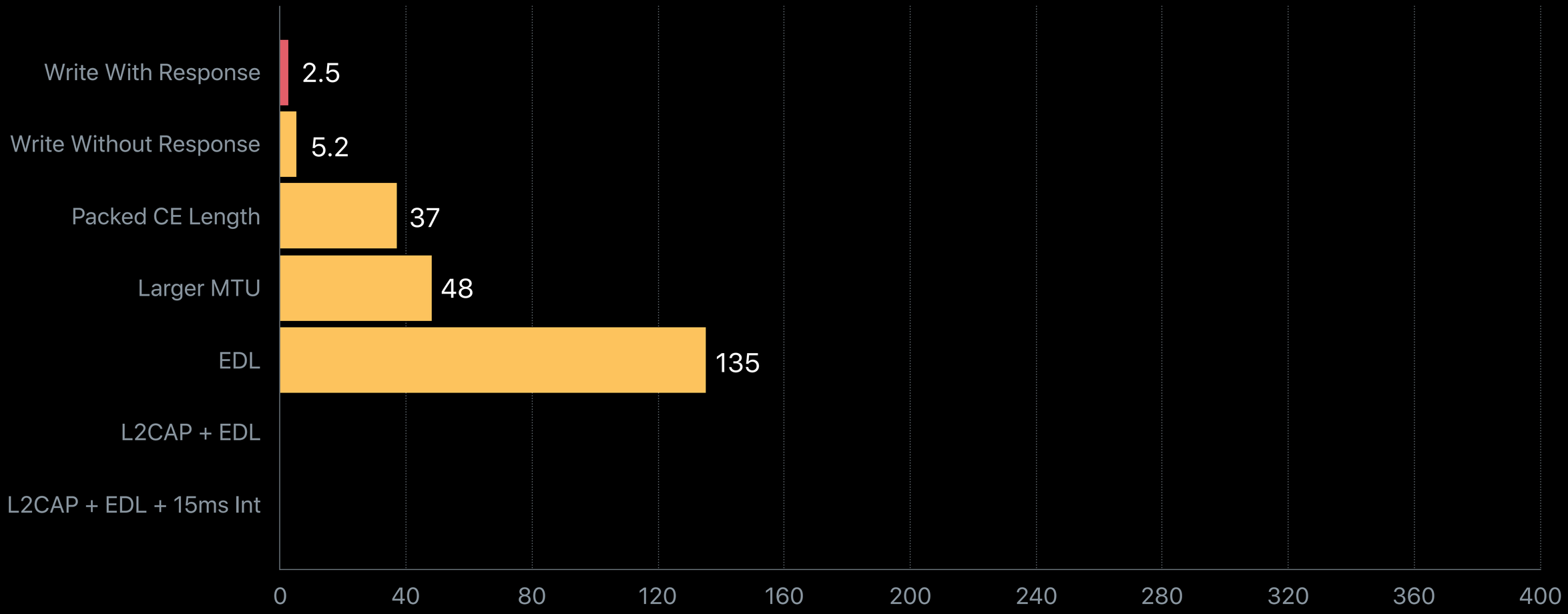

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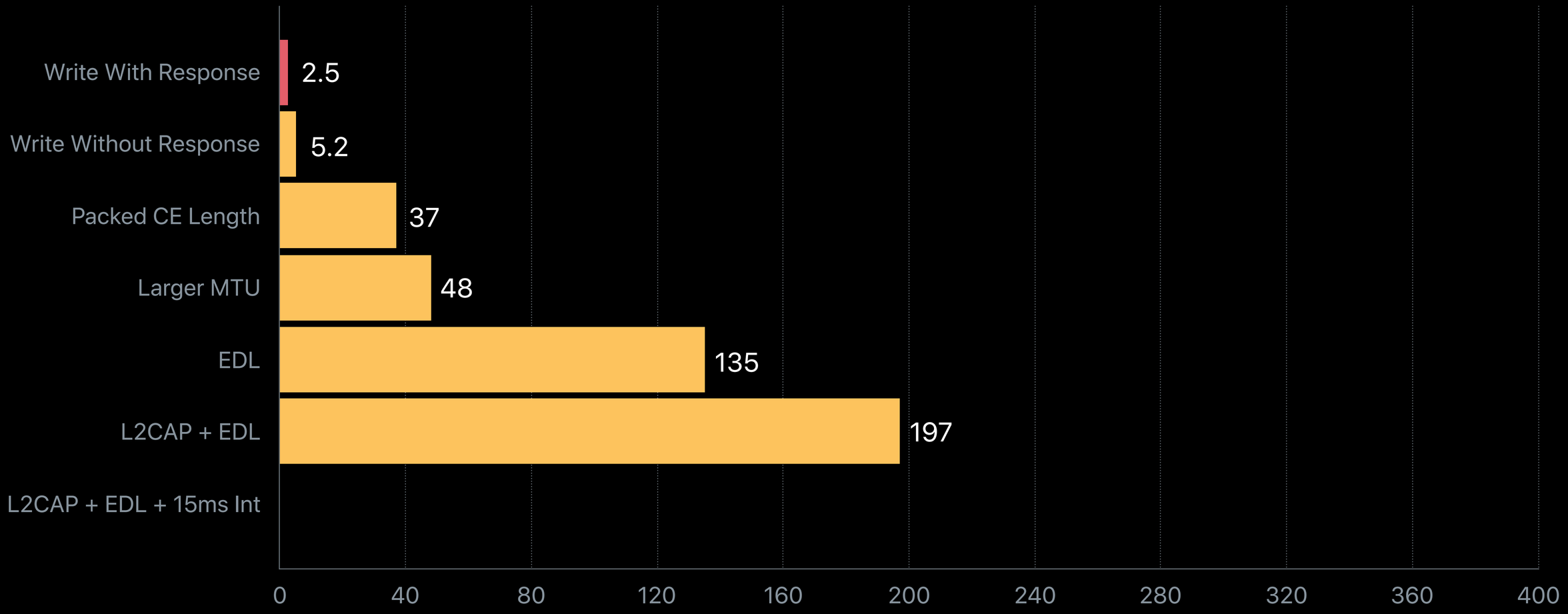

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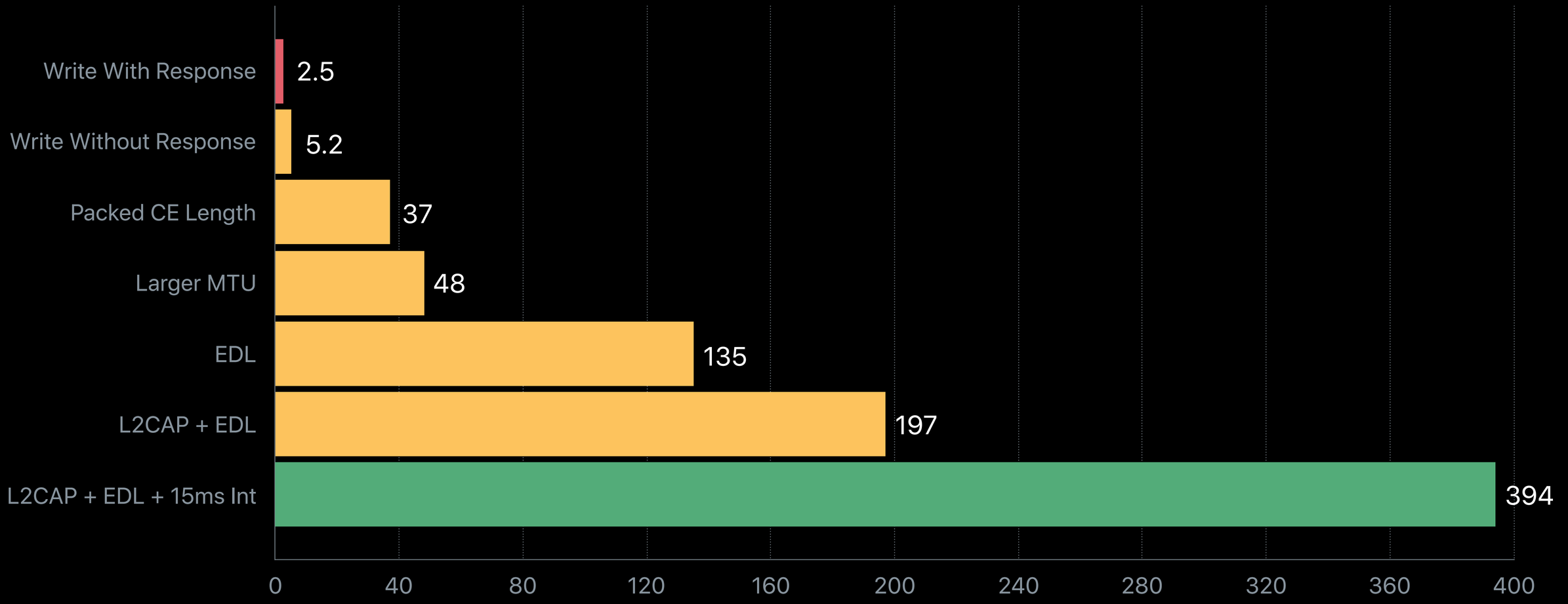

Summary

Request a shorter Connection Interval

Take advantage of GATT optimizations

Use L2CAP Channel for large transfers and stream protocols

Update your hardware (4.2 EDL, 5.0) for best performance and battery life

Wrap Up

Craig Dooley, Bluetooth Engineer

Key Takeaways

Check out State Restoration

Expand your app to tvOS and watchOS

Use L2CAP for stream protocols or large data transfers

Use the newest Bluetooth chipset available

Follow the Bluetooth Accessory Design Guidelines

More Information

https://developer.apple.com/wwdc17/712

Related Sessions

Core Bluetooth 101	WWDC 2012
Core Bluetooth	WWDC 2013

Labs

Bluetooth Lab	Technology Lab J	Thur 12:00PM–2:00PM
Bluetooth Lab	Technology Lab J	Fri 12:00PM–2:00PM


WWDC17