Developing Wireless CarPlay Systems

Session 717

Tanya Kancheva, CarPlay Engineering

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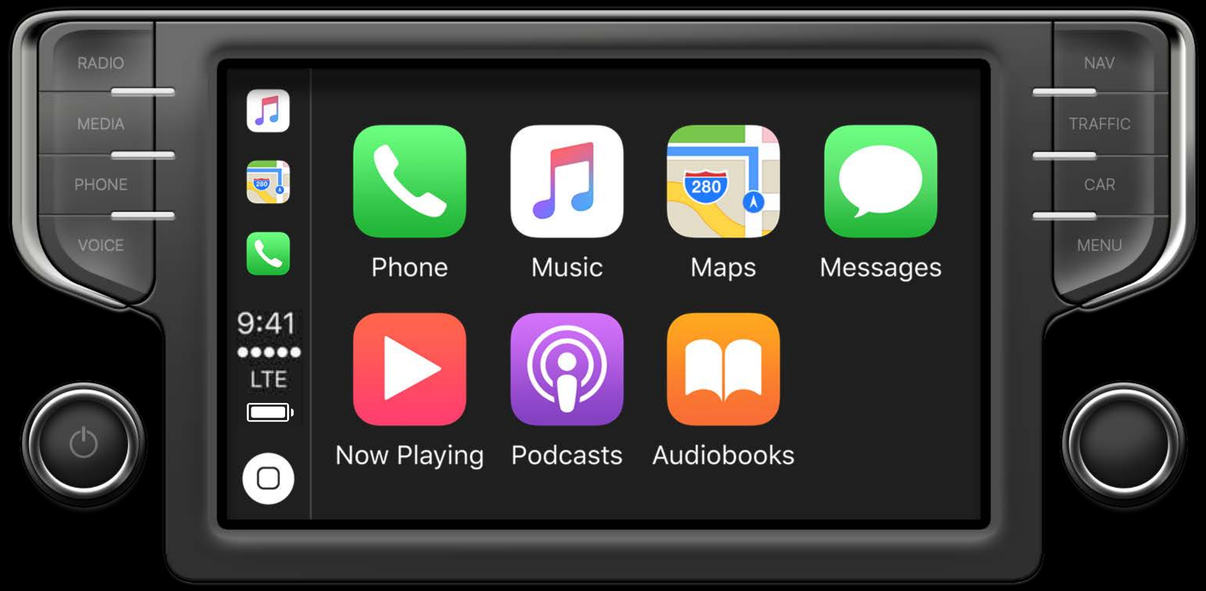
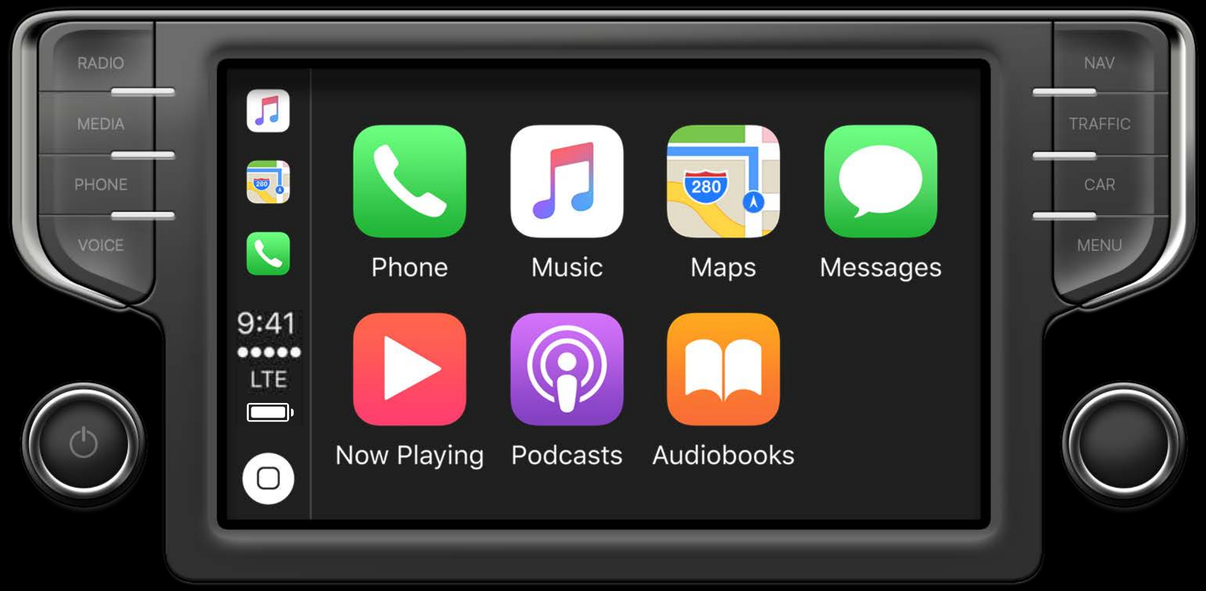
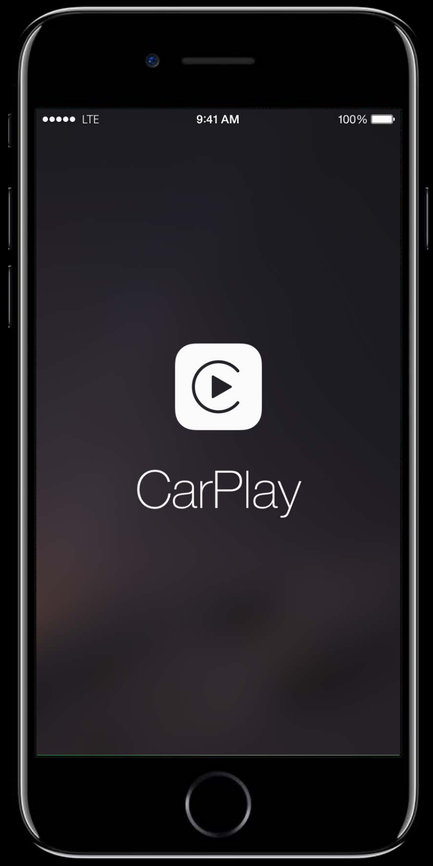
Wireless CarPlay



Wireless CarPlay





Using Wireless CarPlay

Getting Started

Getting Started

Pair by plugging in

Getting Started

Pair by plugging in

Pair without plugging in

Pair by Plugging In

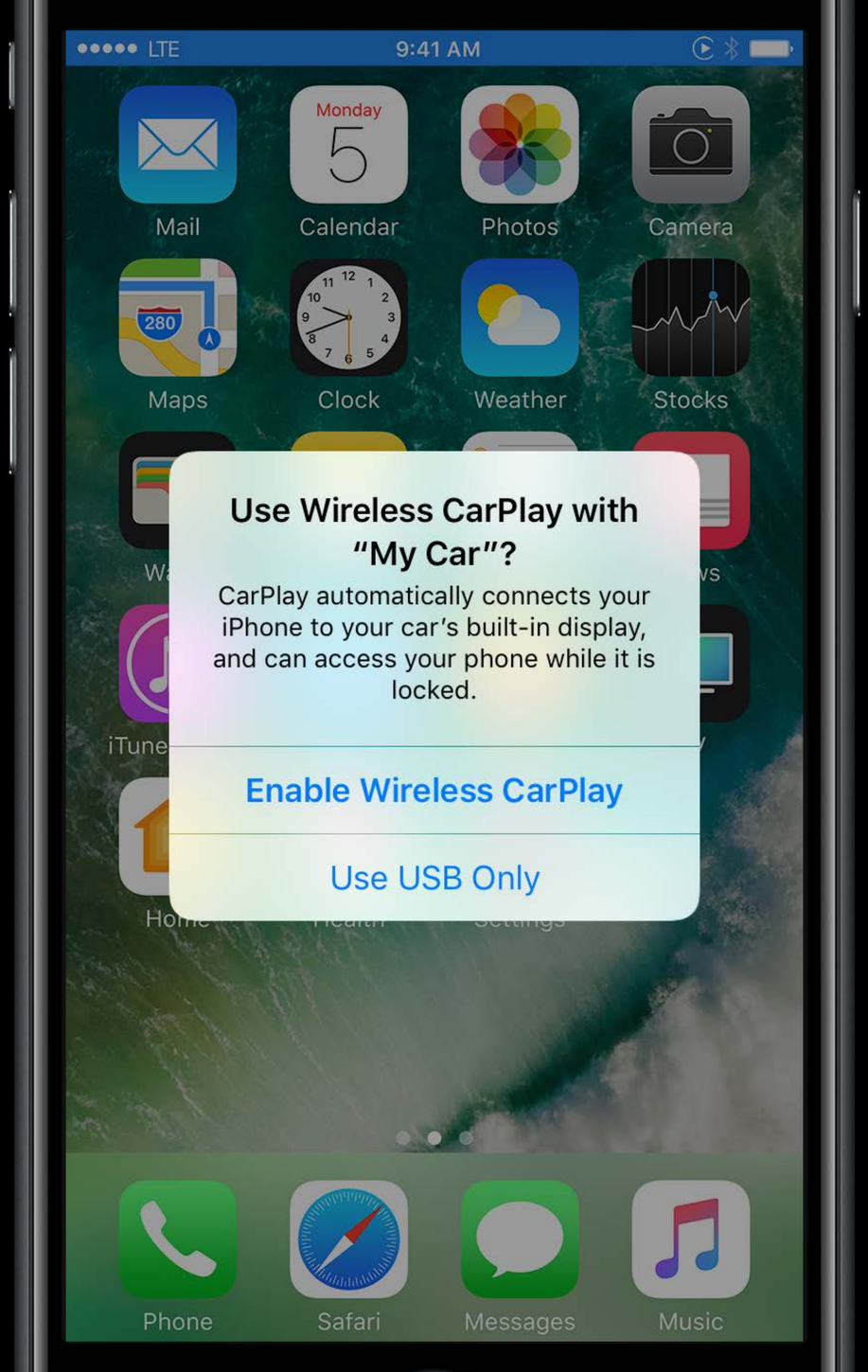
Steps

Plug in

CarPlay starts

Enable wireless CarPlay

CarPlay Starts


LTE
9:41 AM
Monday
5
Mail
Calendar
Photos
Camera
Maps
Clock
Weather
Stocks
Use Wireless CarPlay with "My Car"?
CarPlay automatically connects your iPhone to your car's built-in display, and can access your phone while it is locked.
Enable Wireless CarPlay
Use USB Only
Phone
Safari
Messages
Music

Pairing Complete

Pairing Complete

CarPlay will work wirelessly the next time the user enters the car

Pairing Complete

CarPlay will work wirelessly the next time the user enters the car

Additional confirmation not required on the car’s display

Pair Without Plugging In

Steps

Start CarPlay setup

Select device to pair

CarPlay starts

Start CarPlay Setup

Start CarPlay Setup

Press and hold the voice control button on the steering wheel

Start CarPlay Setup

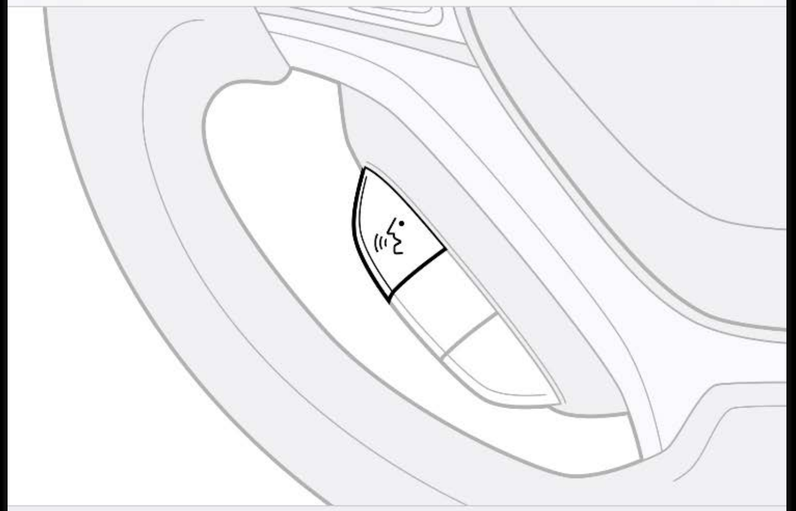
Press and hold the voice control button on the steering wheel

Use the car’s native UI

- Add a CarPlay device
- Add a Bluetooth device

LTE 9:41 AM 100%

General CarPlay

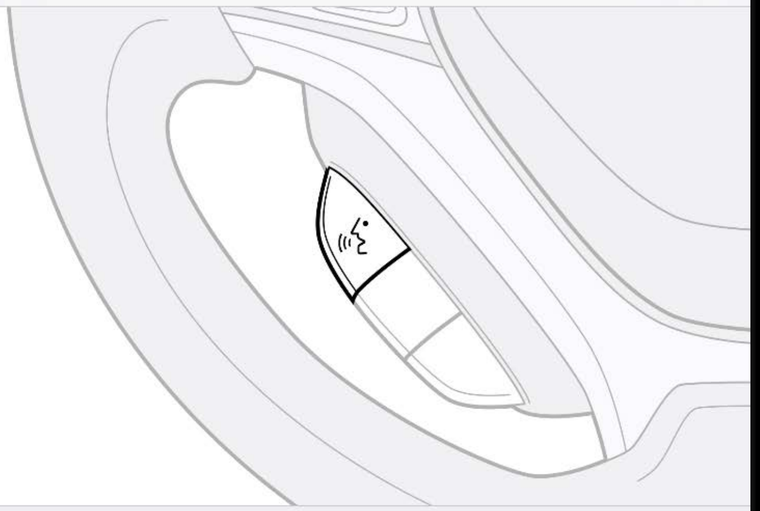


If your car supports wireless CarPlay, press and hold the voice control button on your steering wheel to start CarPlay setup.

AVAILABLE CARS

LTE 9:41 AM 100%

General CarPlay



If your car supports wireless CarPlay, press and hold the voice control button on your steering wheel to start CarPlay setup.

AVAILABLE CARS

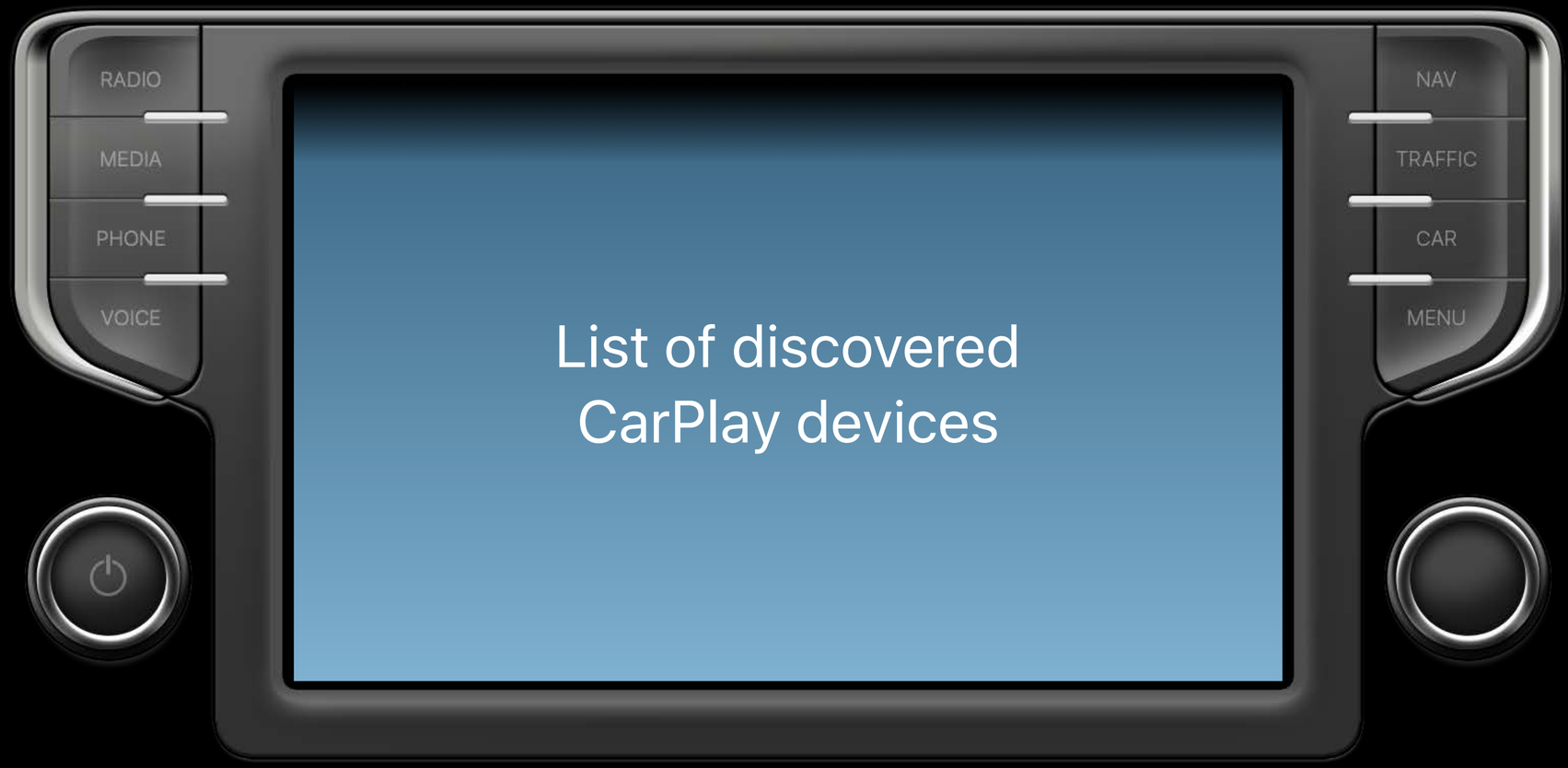
My Car

Select Device to Pair

Selection initiated from iPhone

Select Device to Pair

Selection initiated from the car via CarPlay menu



Select Device to Pair

Selection initiated from the car via Bluetooth menu

Select Device to Pair

Selection initiated from the car via Bluetooth menu

CarPlay Starts

CarPlay Starts

Reconnecting

Reconnecting

CarPlay starts automatically

Reconnecting

CarPlay starts automatically

Last user mode

Handling Multiple Devices

Handling Multiple Devices

Multiple devices

- Wireless devices
- Wired and wireless devices

Handling Multiple Devices

Multiple devices

- Wireless devices
- Wired and wireless devices

Allow the user to choose the active CarPlay device

Choosing the Active CarPlay Device

Choosing the Active CarPlay Device

Show all CarPlay devices

Choosing the Active CarPlay Device

Show all CarPlay devices

Indicate active CarPlay device

Choosing the Active CarPlay Device

Show all CarPlay devices

Indicate active CarPlay device

Don’t show USB or Wi-Fi symbols

Notifications when Devices are Connected

Show when first iPhone is connected, and CarPlay won’t be visible

Show when a second iPhone is connected over USB

Do not show when wireless devices join the network

Developing Wireless CarPlay Systems

Developing Wireless CarPlay Systems

Hardware requirements

Setup and pairing

Reconnecting

Wireless considerations

Developing Wireless CarPlay Systems

Hardware requirements

Setup and pairing

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Wireless considerations

Hardware Requirements

Bluetooth

Wi-Fi

Location

Bluetooth

Used for discovery and reconnection only

Support for communication protocols (SDP, iAP2), 2.1 + EDR

Bluetooth Extended Inquiry Response (EIR)

Wi-Fi

Used for video, audio, and CarPlay protocol, including iAP2

Wi-Fi Alliance certified access point

5 GHz, 802.11ac recommended

Apple Device Information Element

Interworking Information Element

Location

Required because iPhone could be in pocket or bag

GNSS receiver

Speed sensor

Dead reckoning

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Head Unit Components for CarPlay Setup

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Boot Sequence After Head Unit Reset

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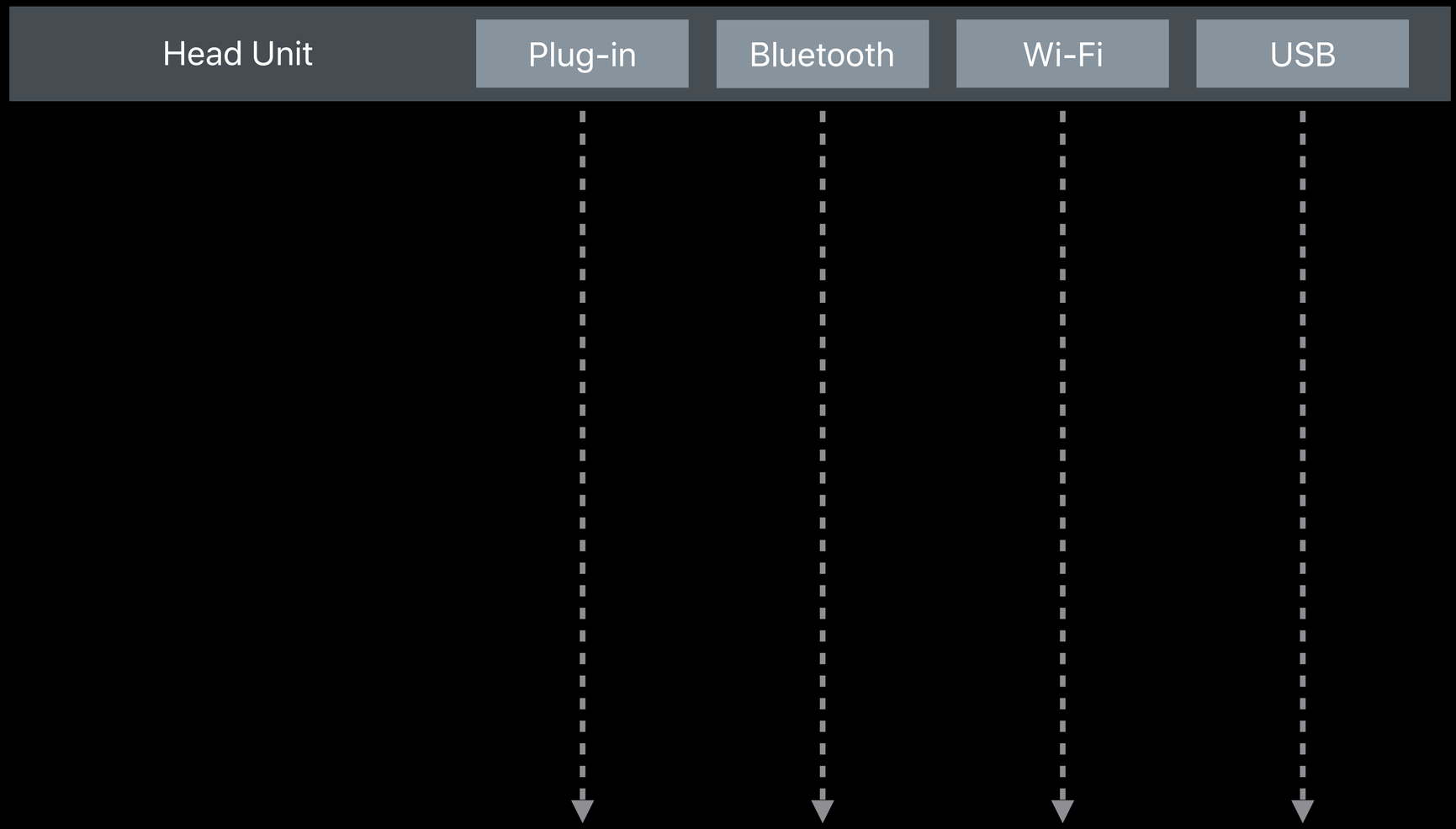

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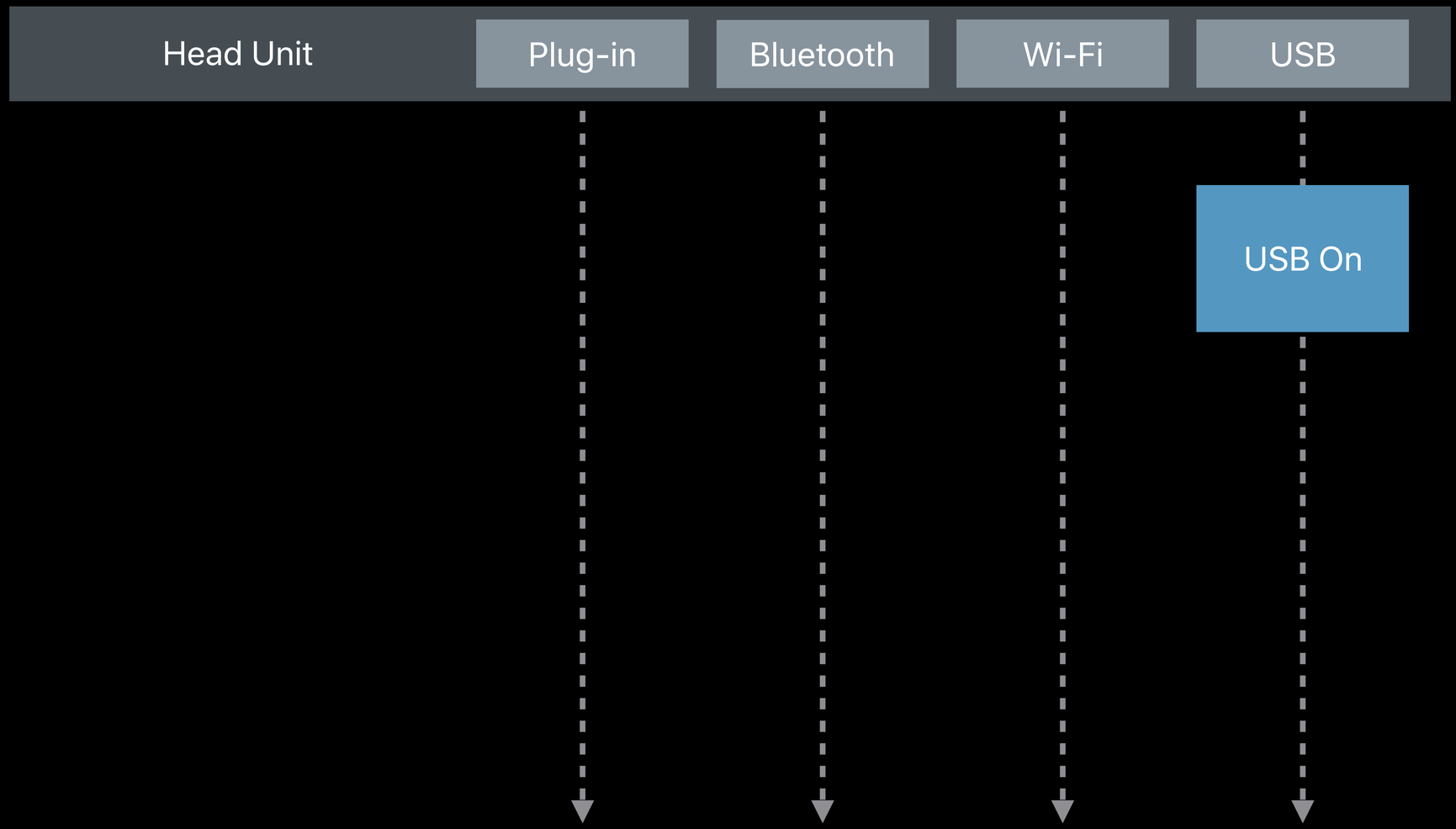

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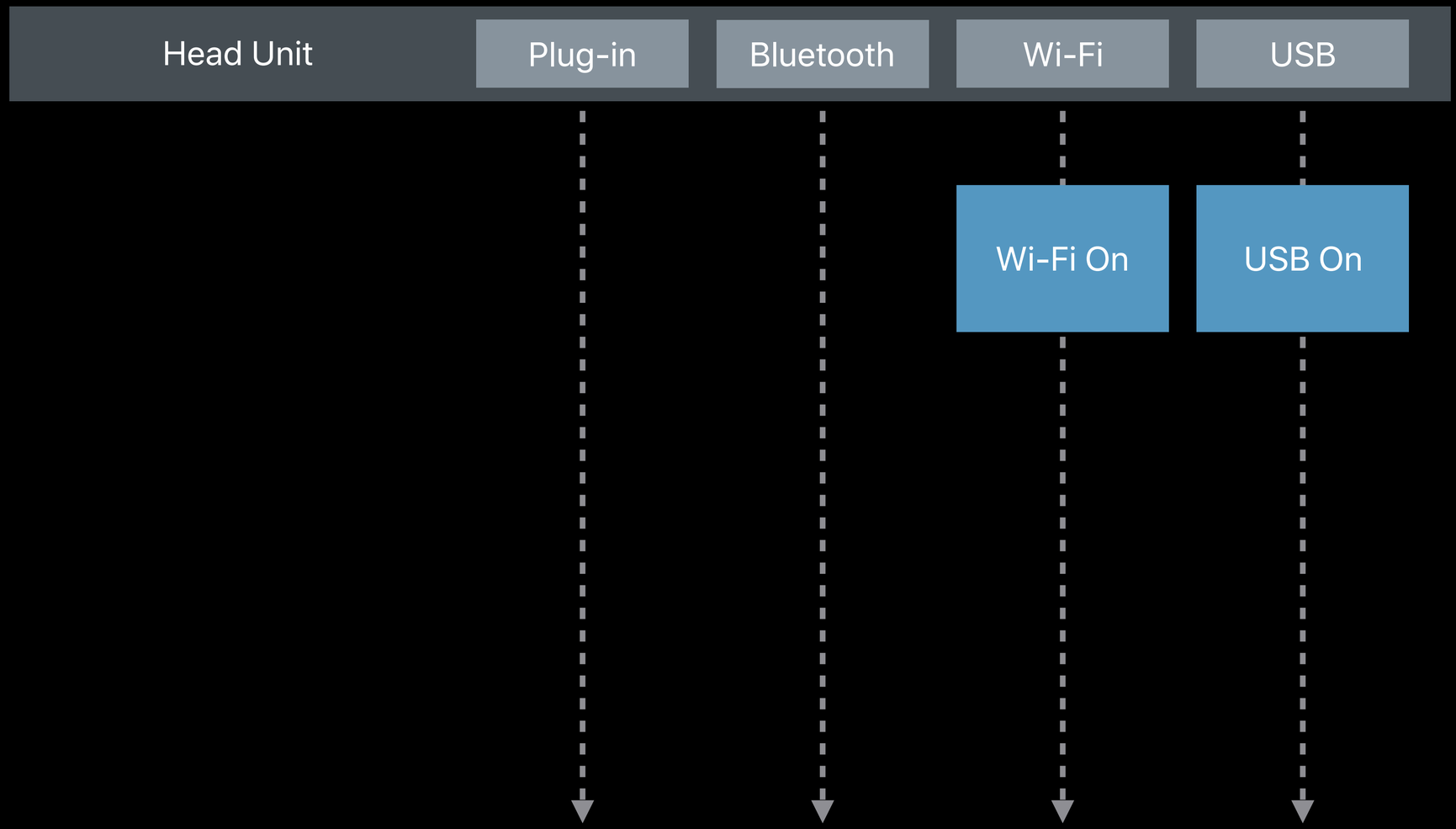

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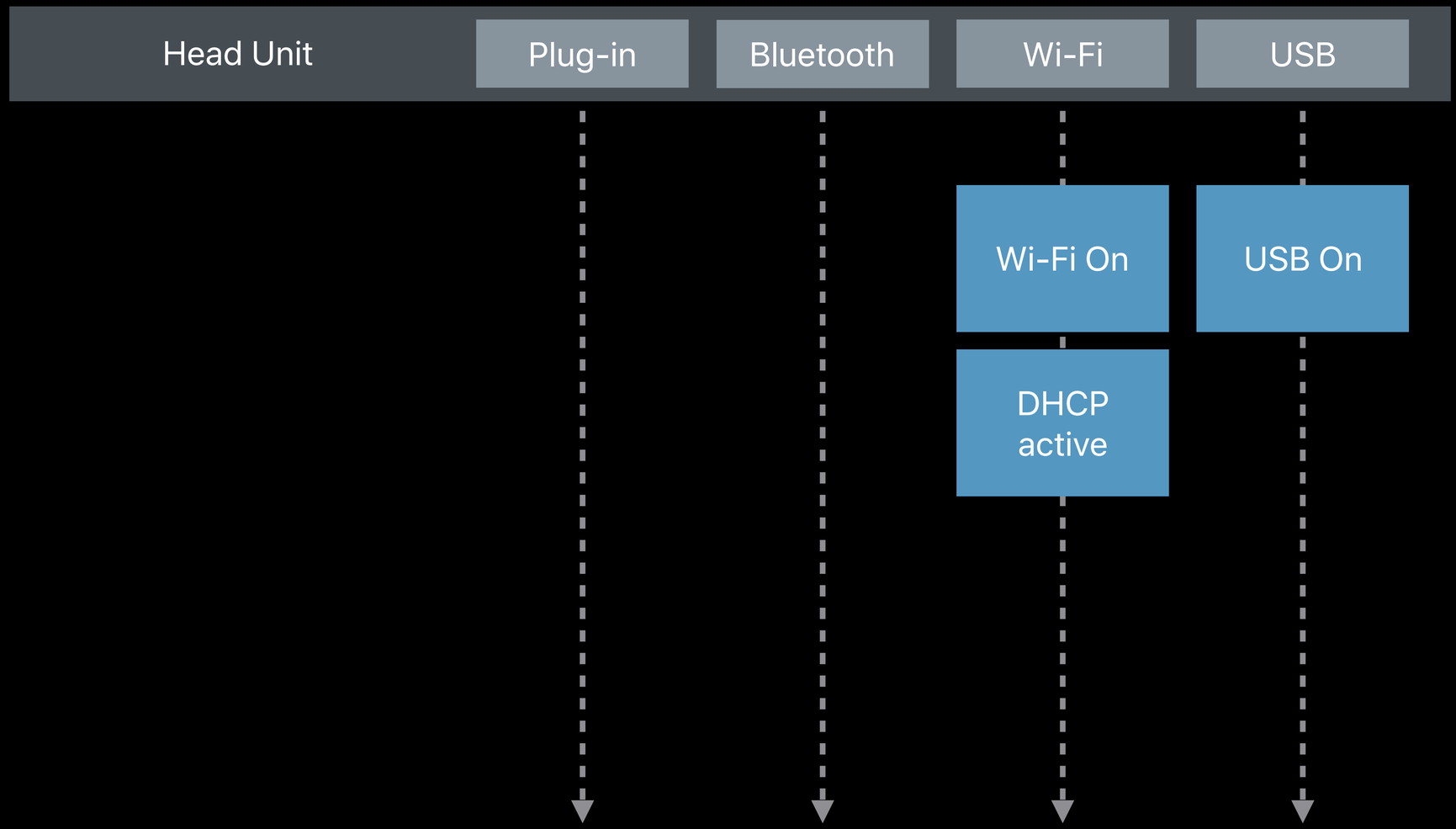

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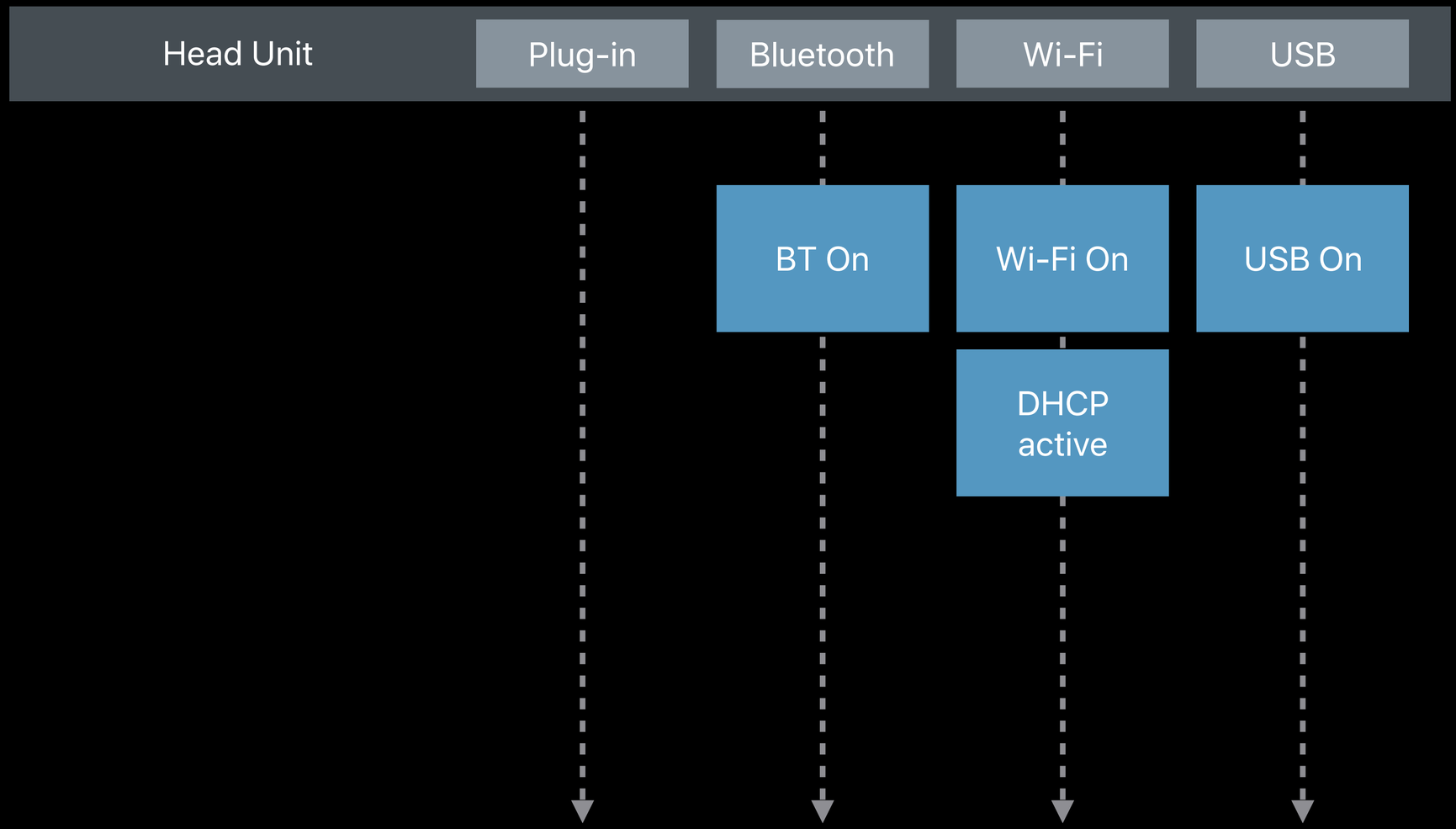

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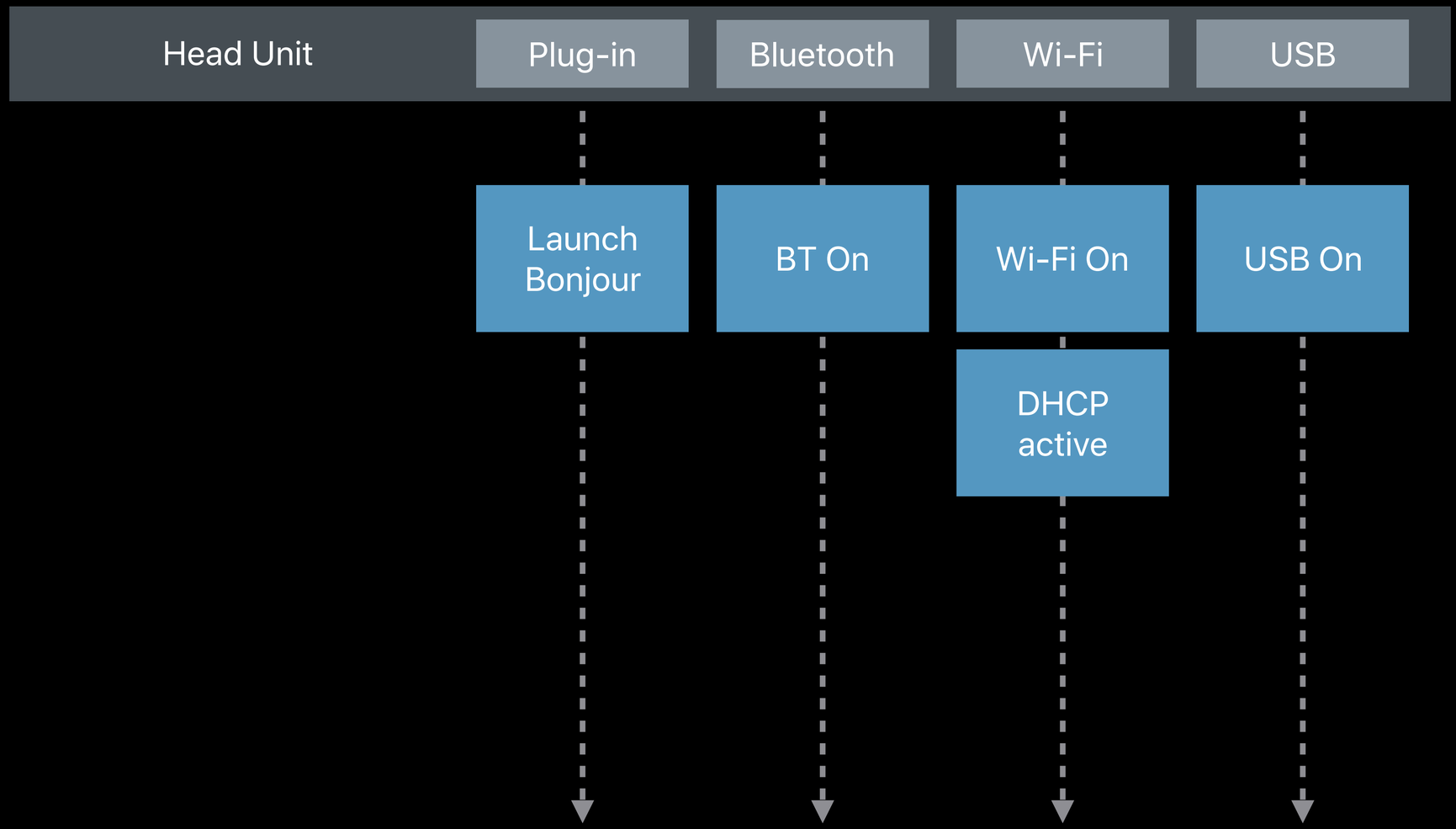

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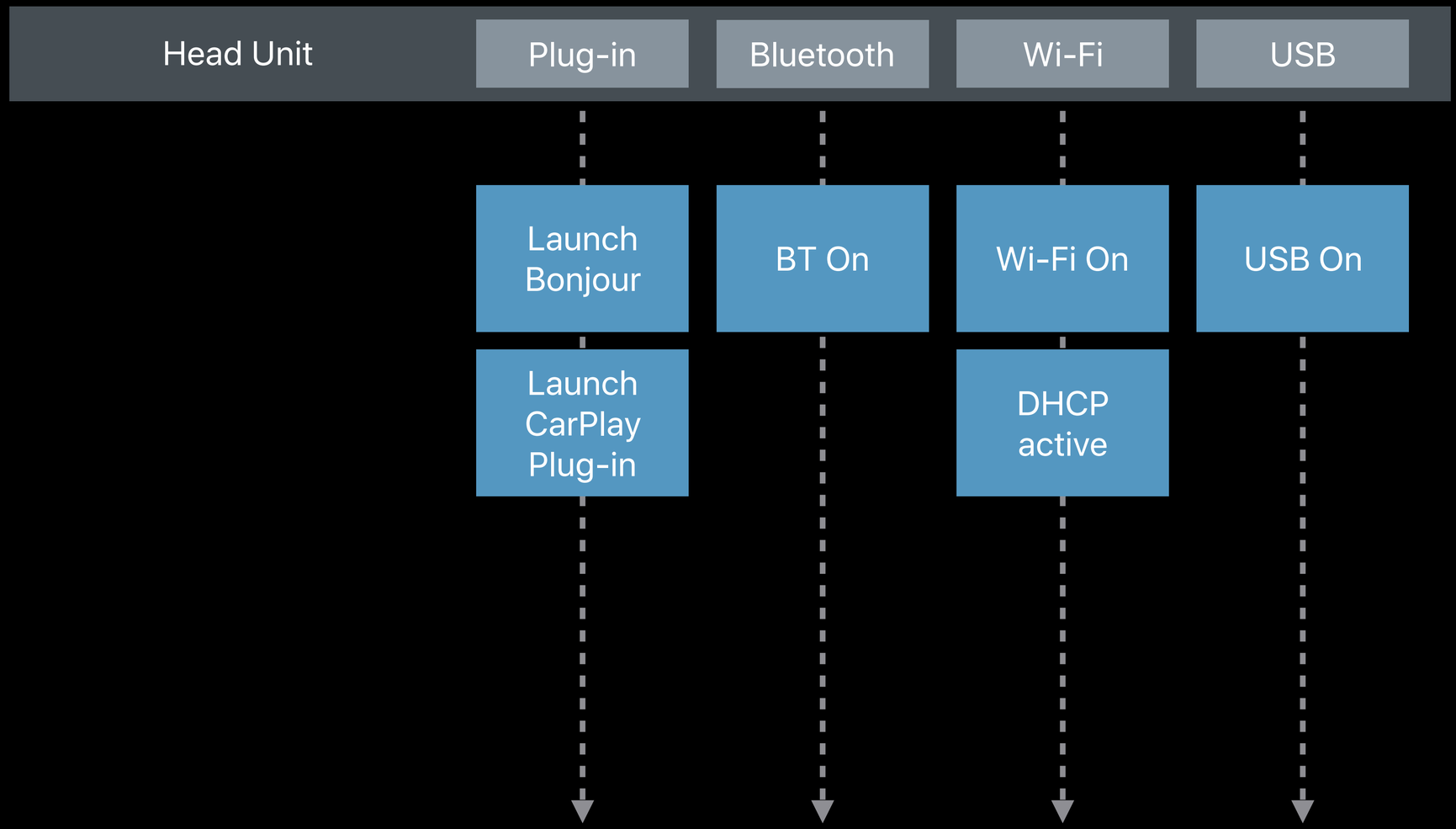

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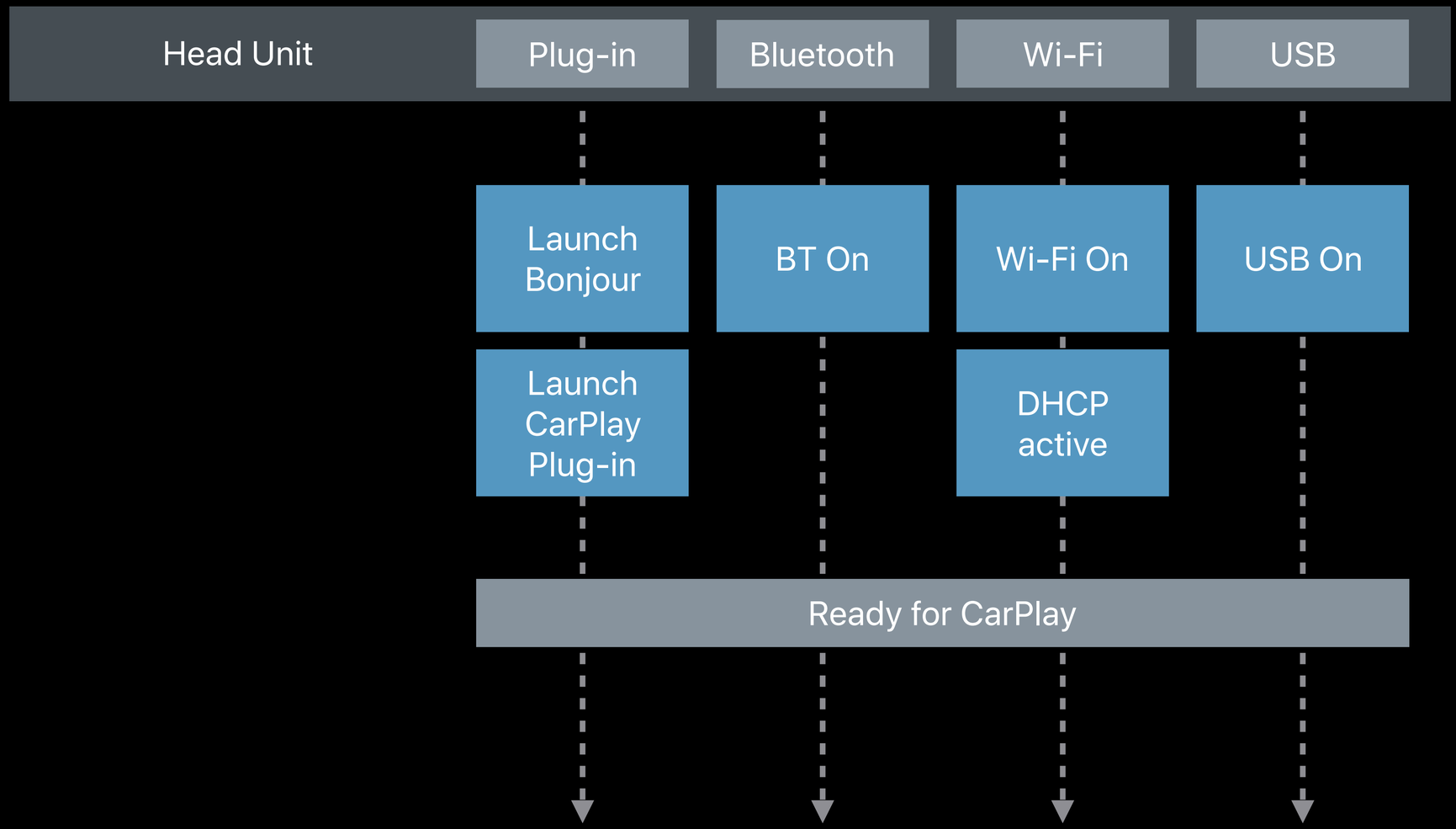


Getting Started

Getting Started

Pair by plugging in

Getting Started

Pair by plugging in

- Out-of-band pairing over USB

Getting Started

Pair by plugging in

- Out-of-band pairing over USB

Pair without plugging in

Getting Started

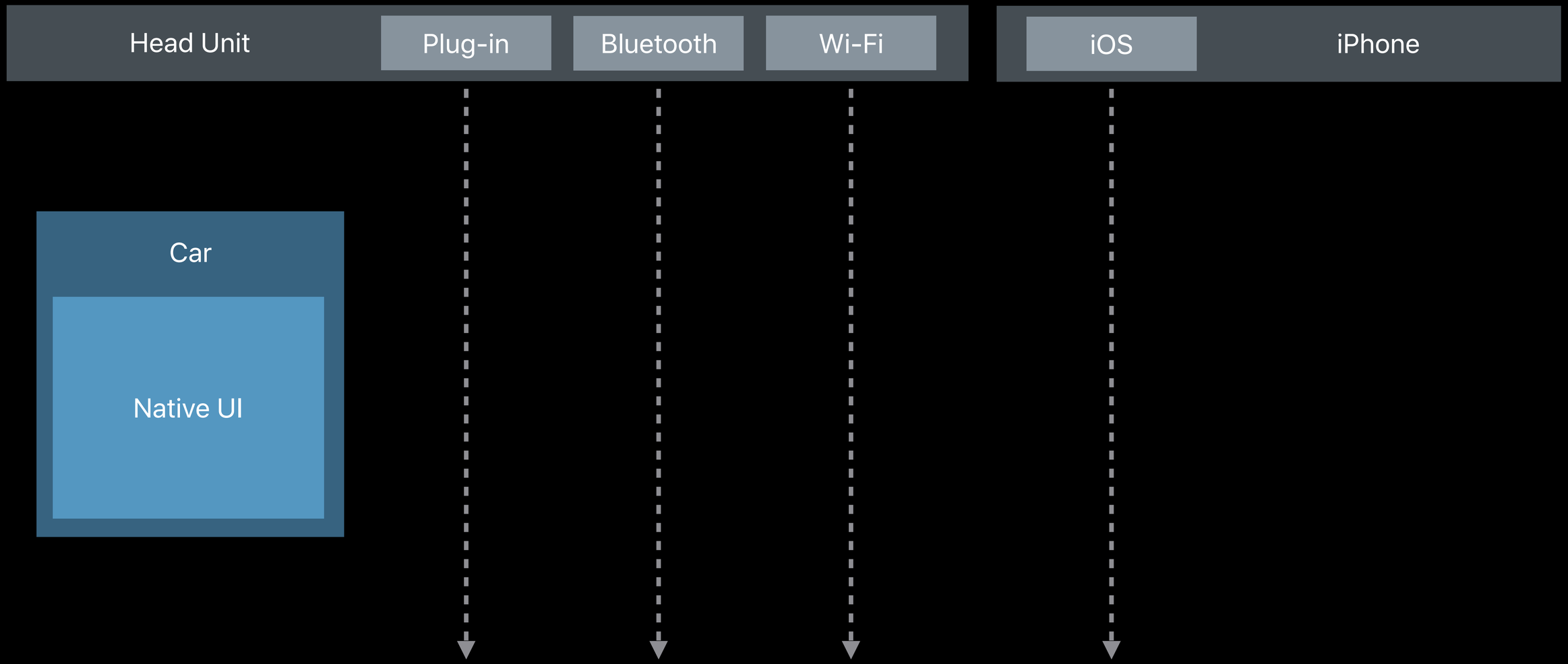
Pair by plugging in

- Out-of-band pairing over USB

Pair without plugging in

- Bluetooth pairing

Out-of-Band Pairing over USB



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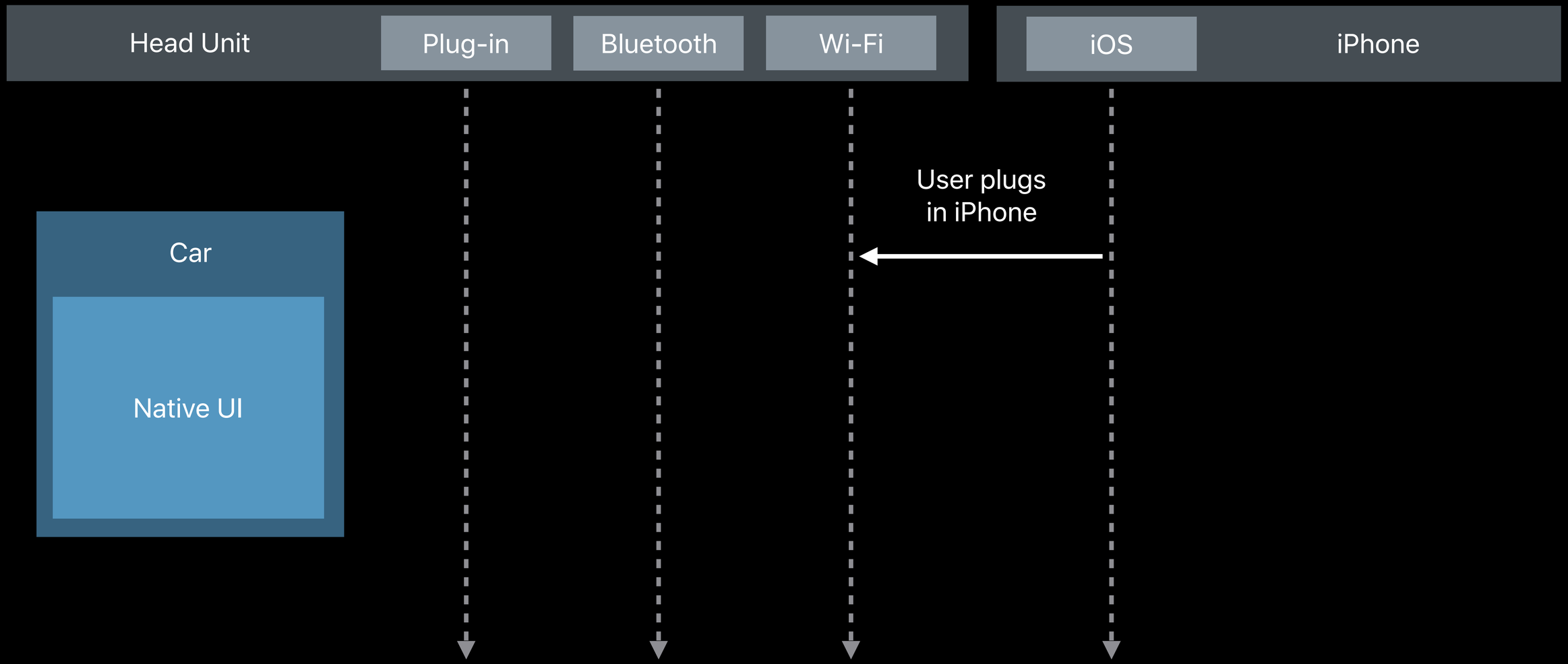

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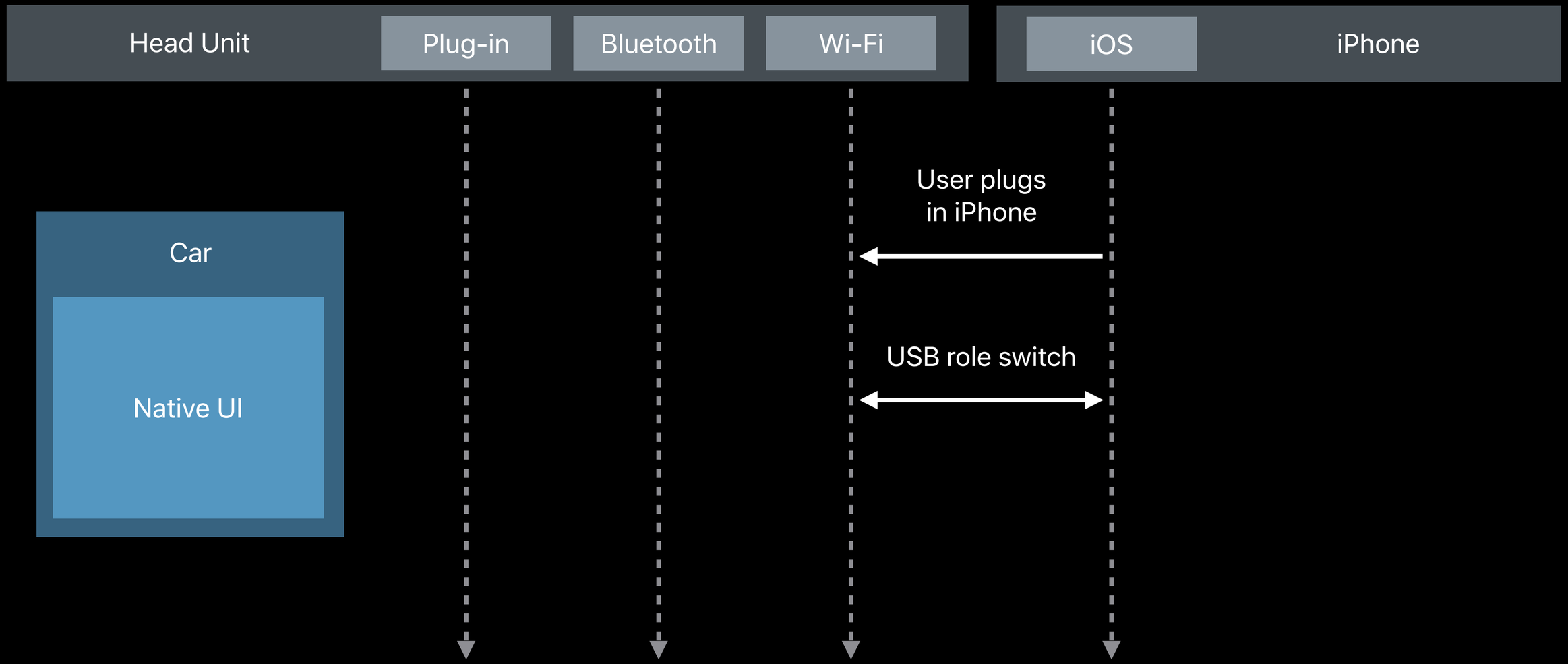

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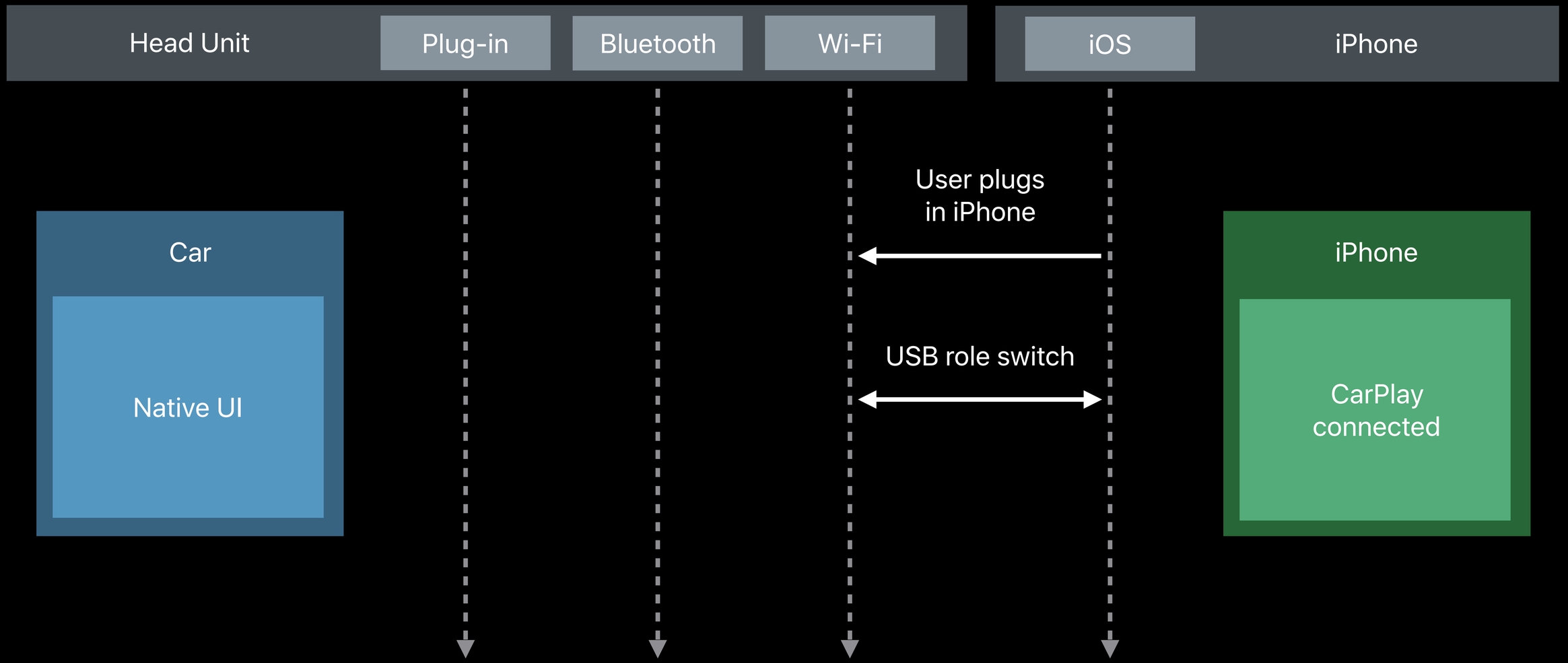

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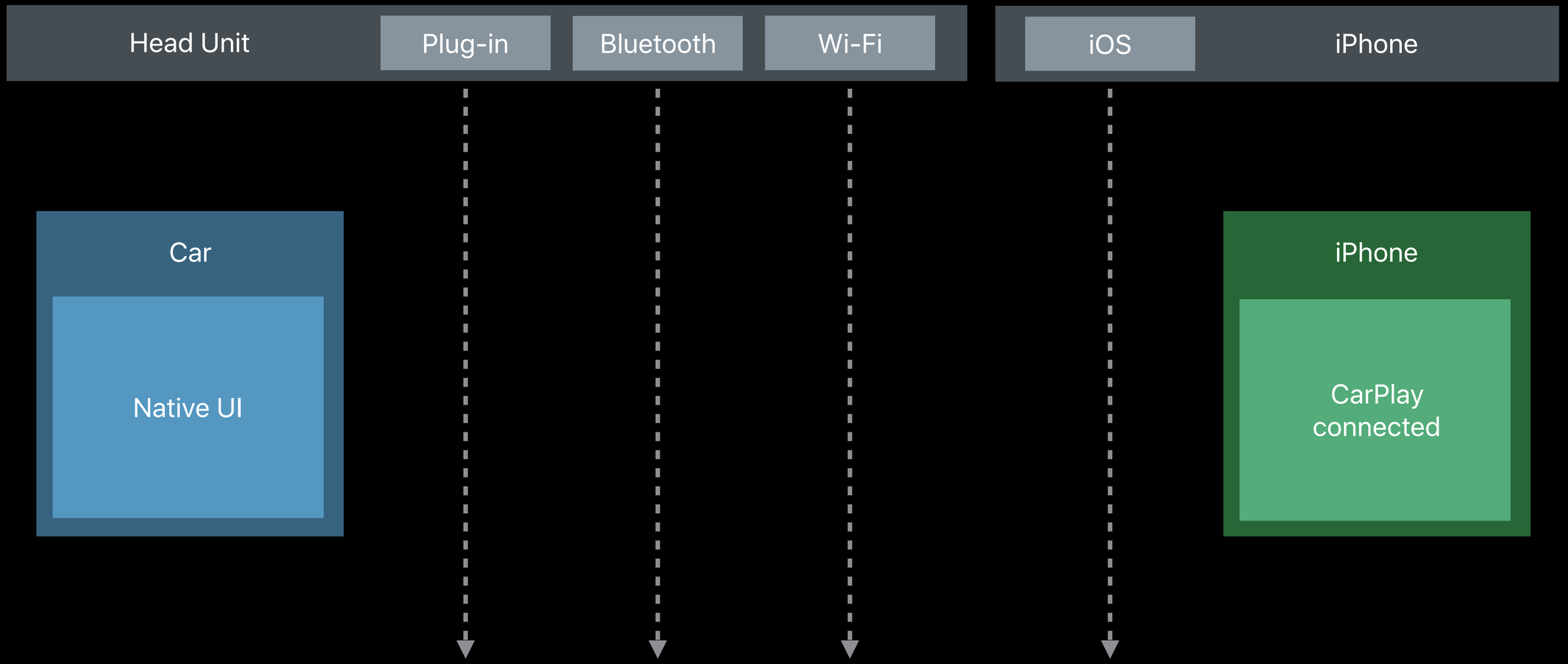

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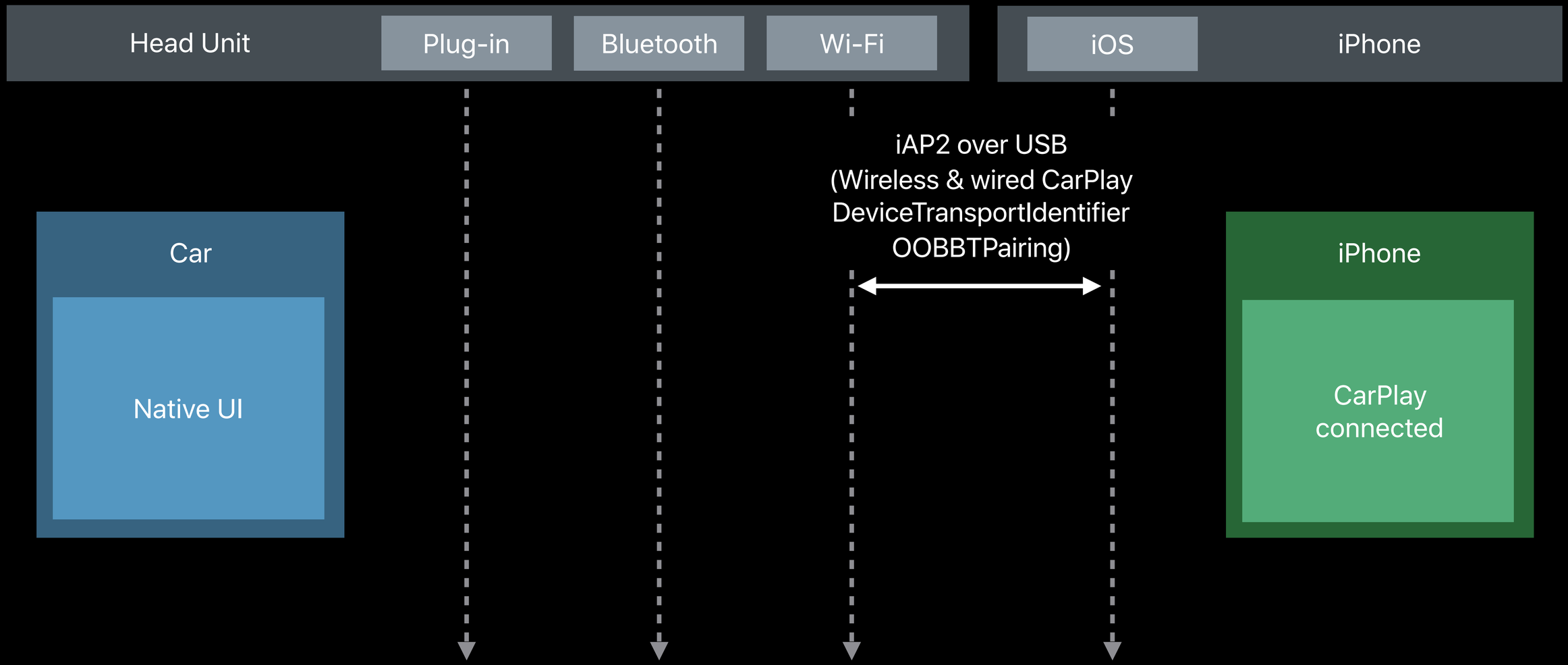

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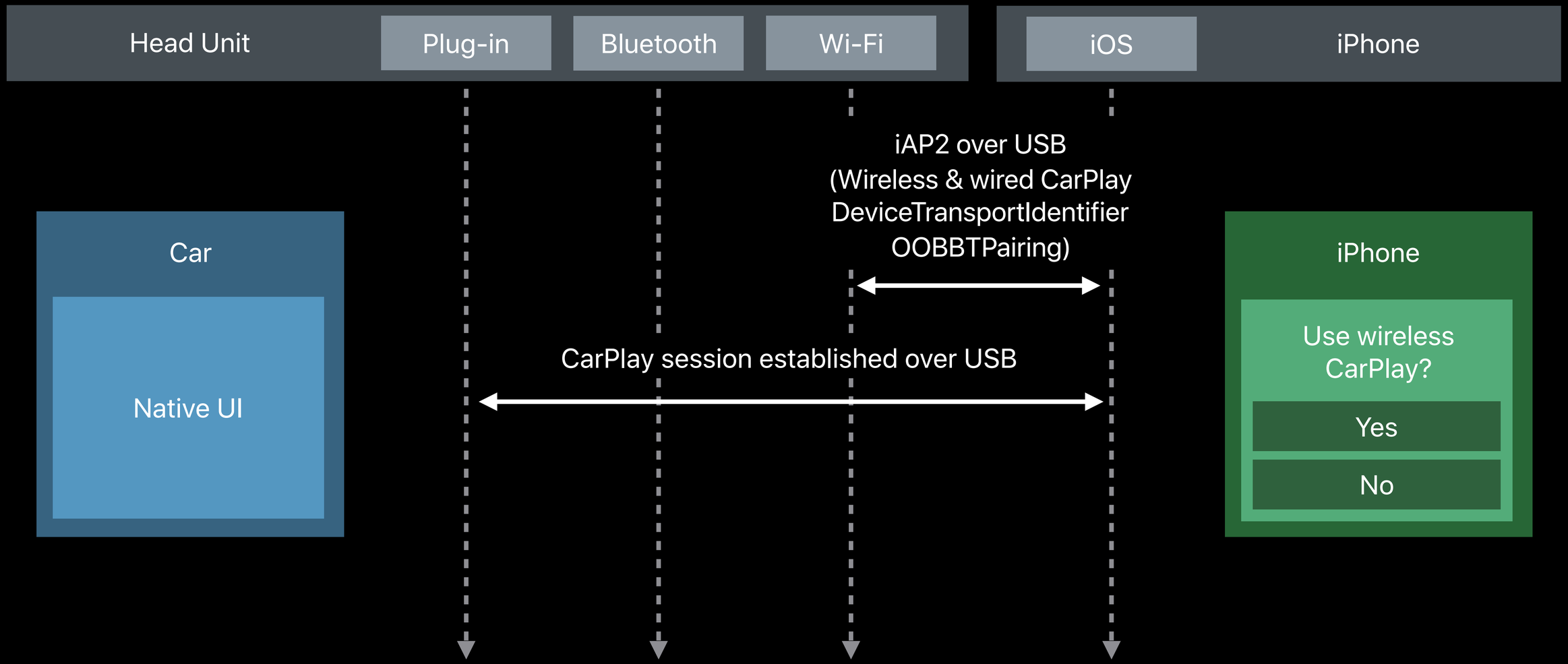

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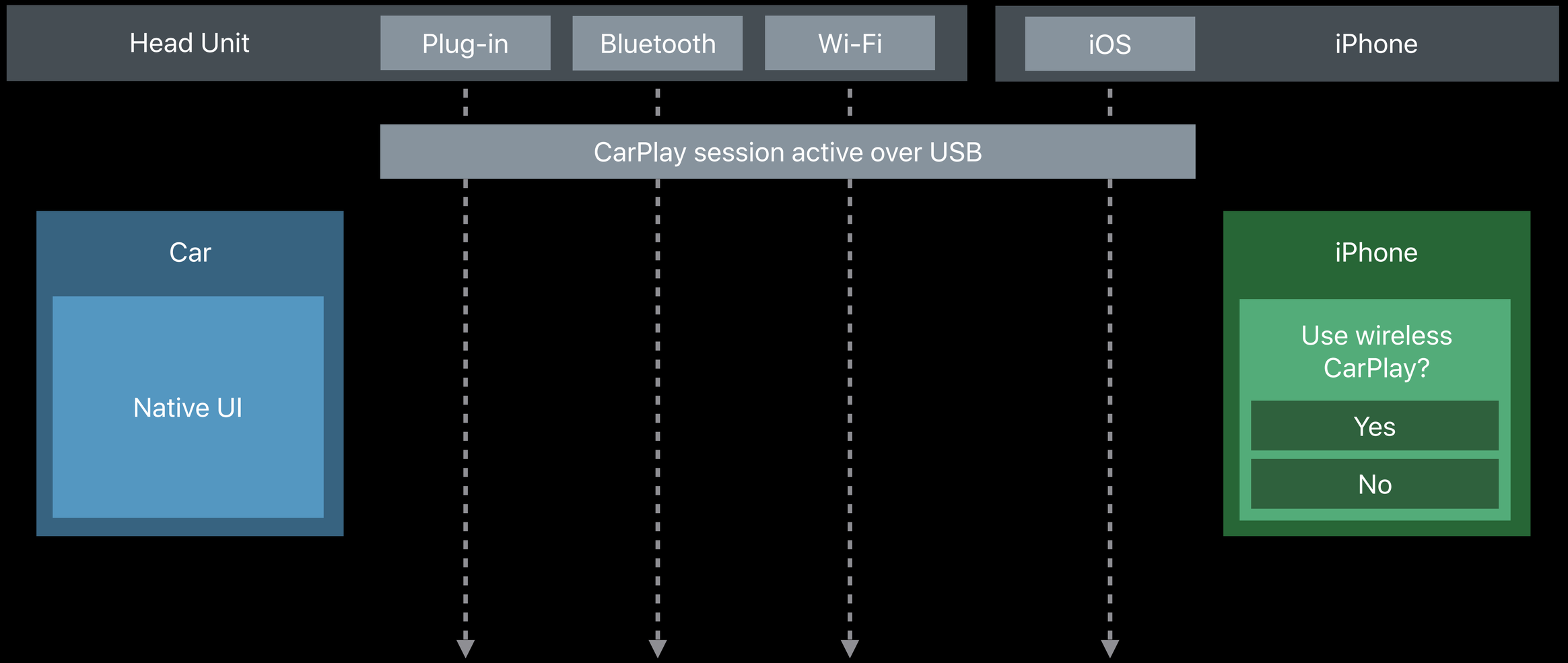

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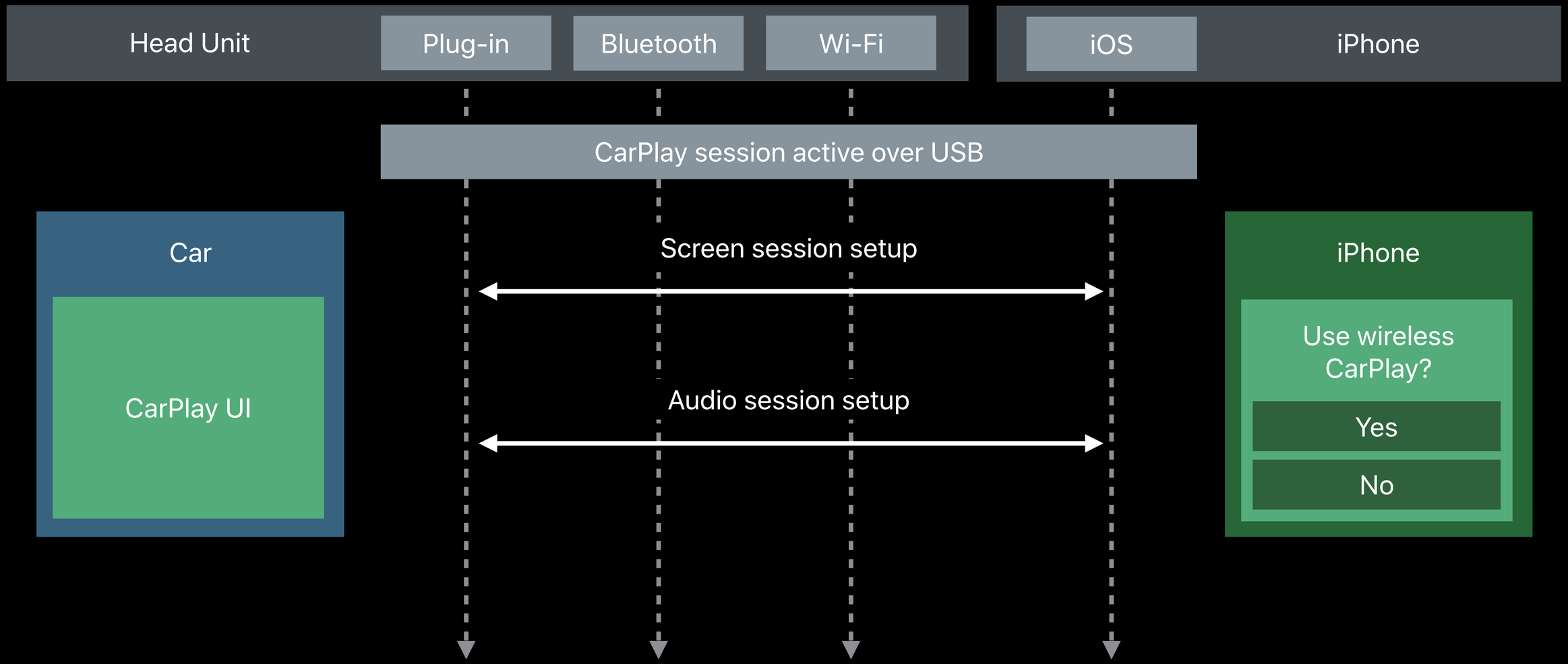

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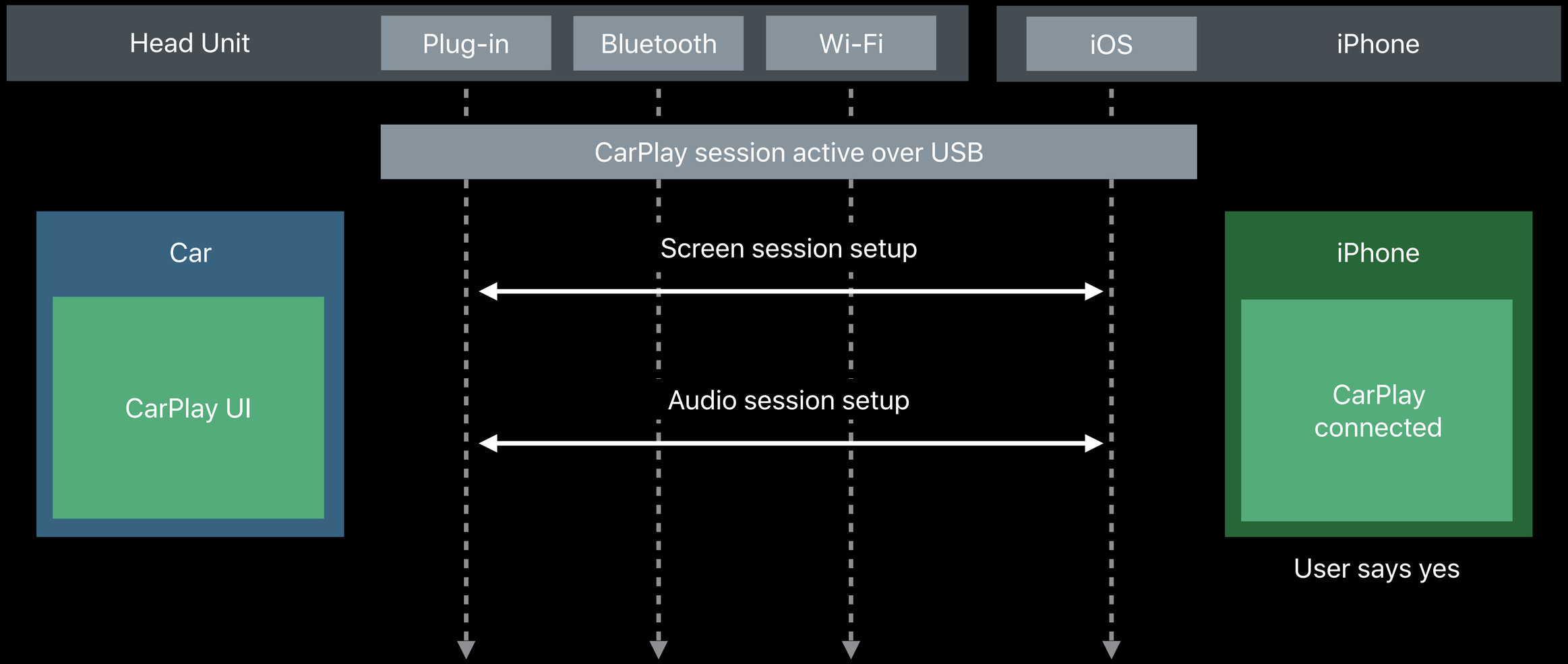

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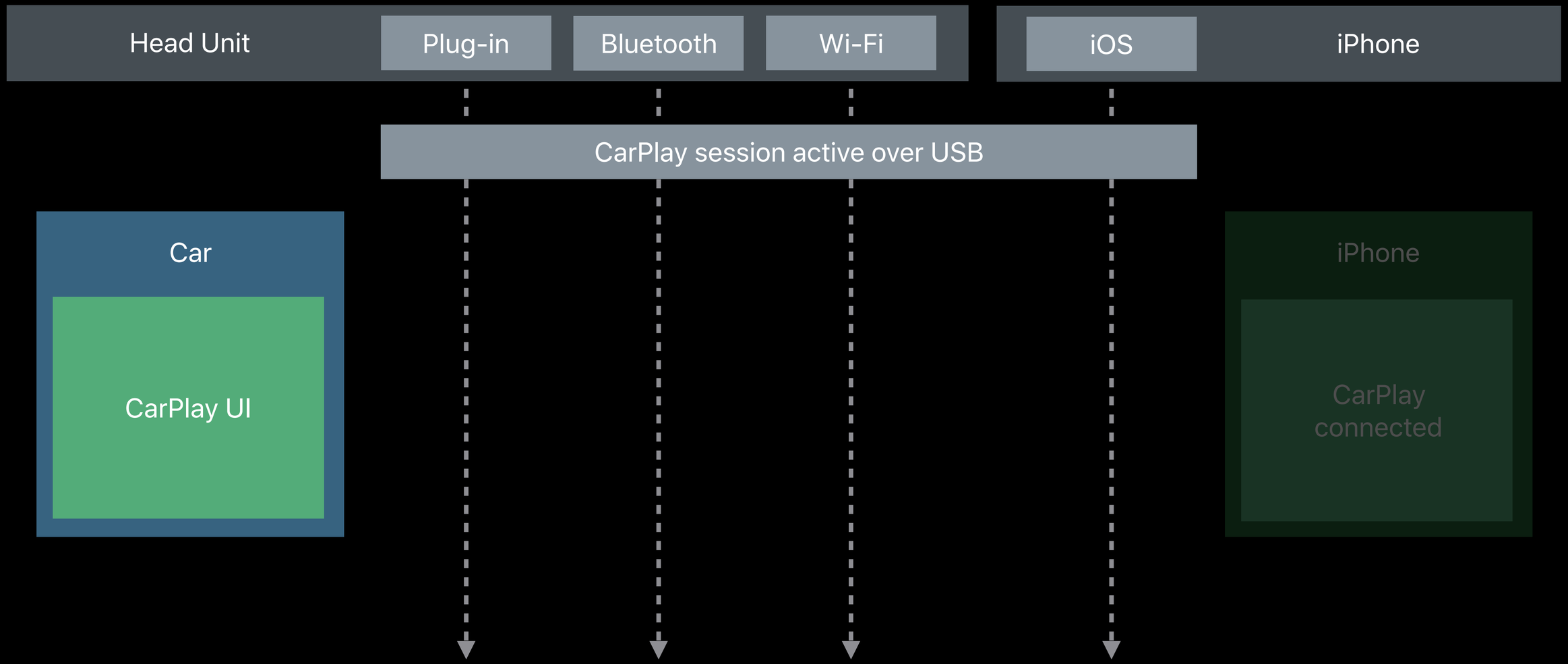

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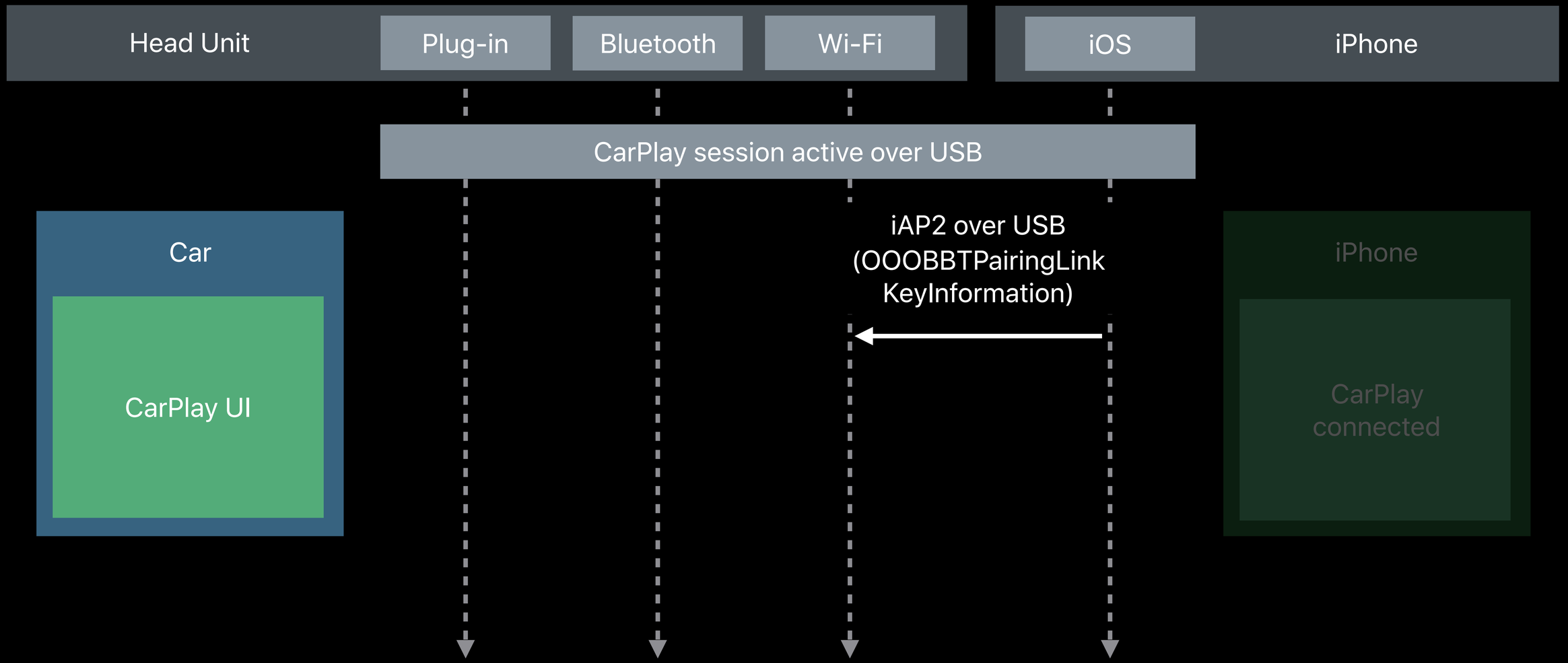

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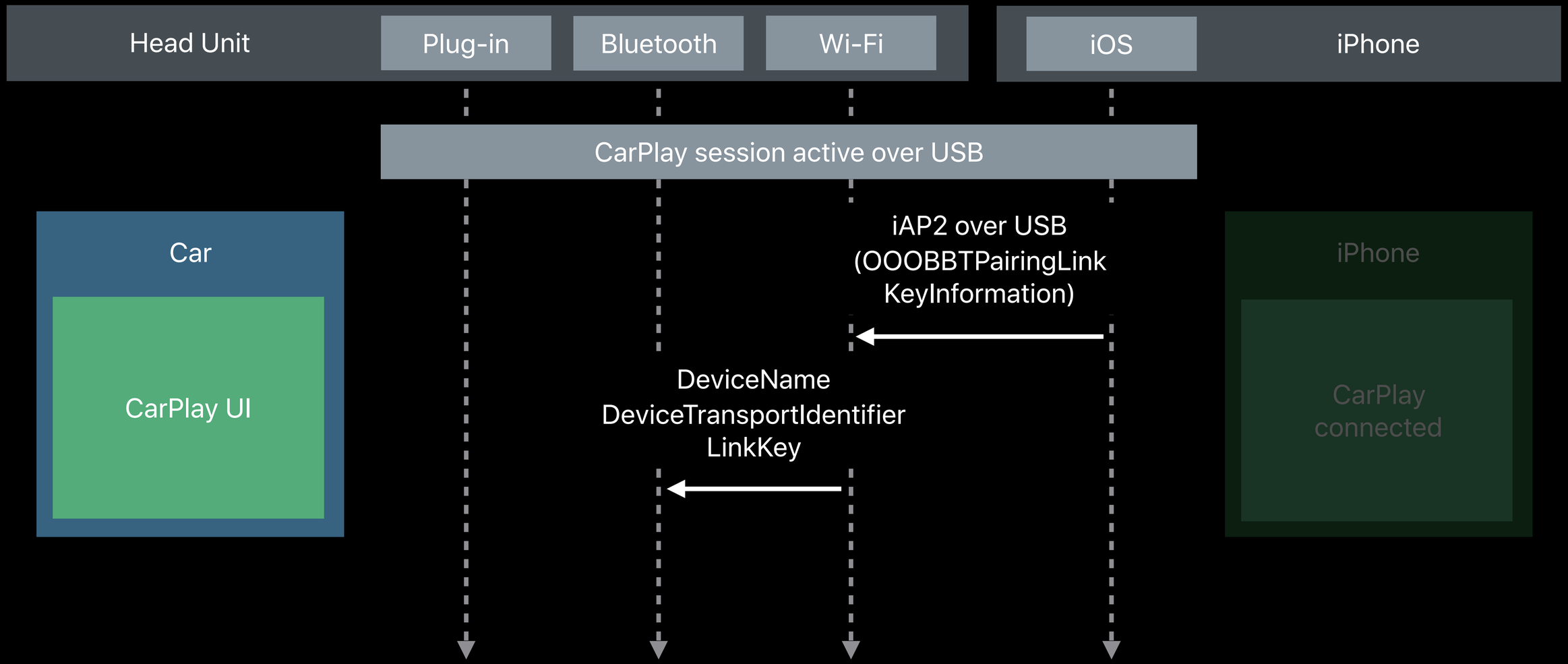

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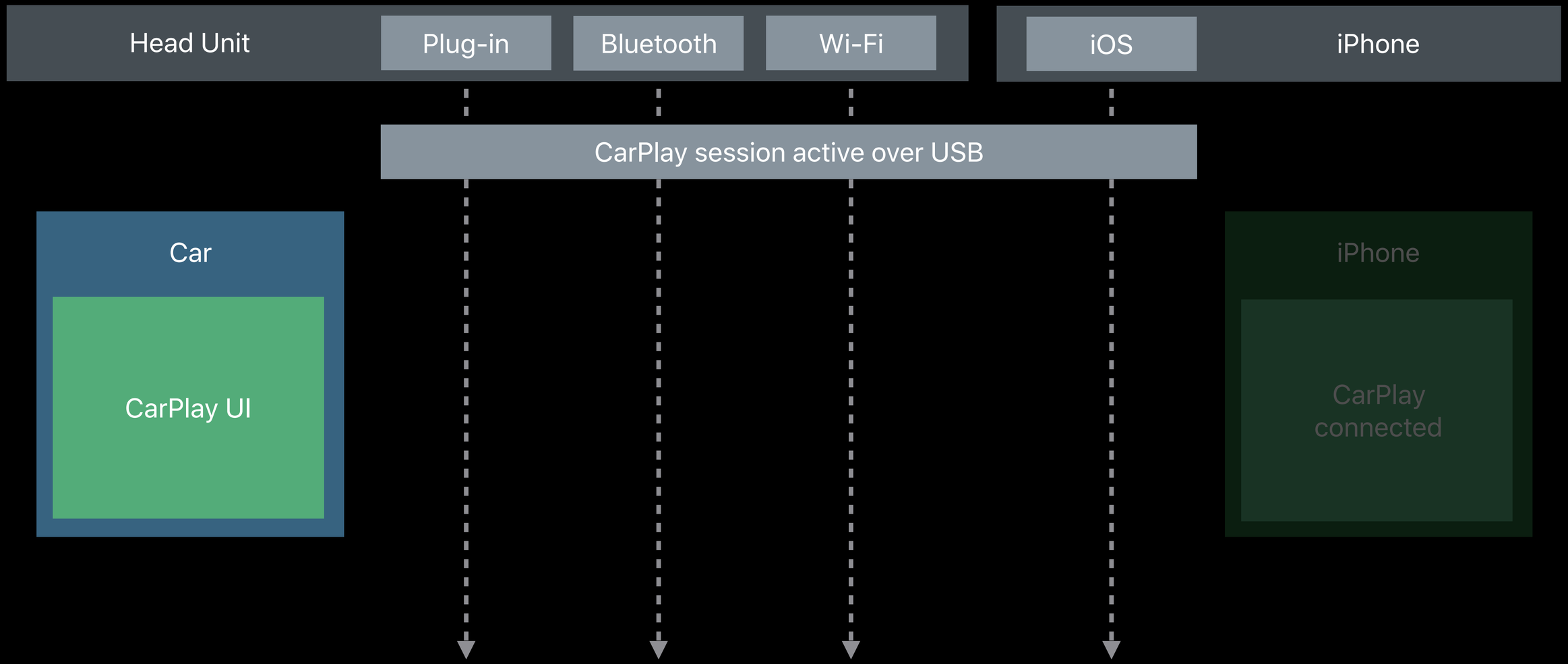

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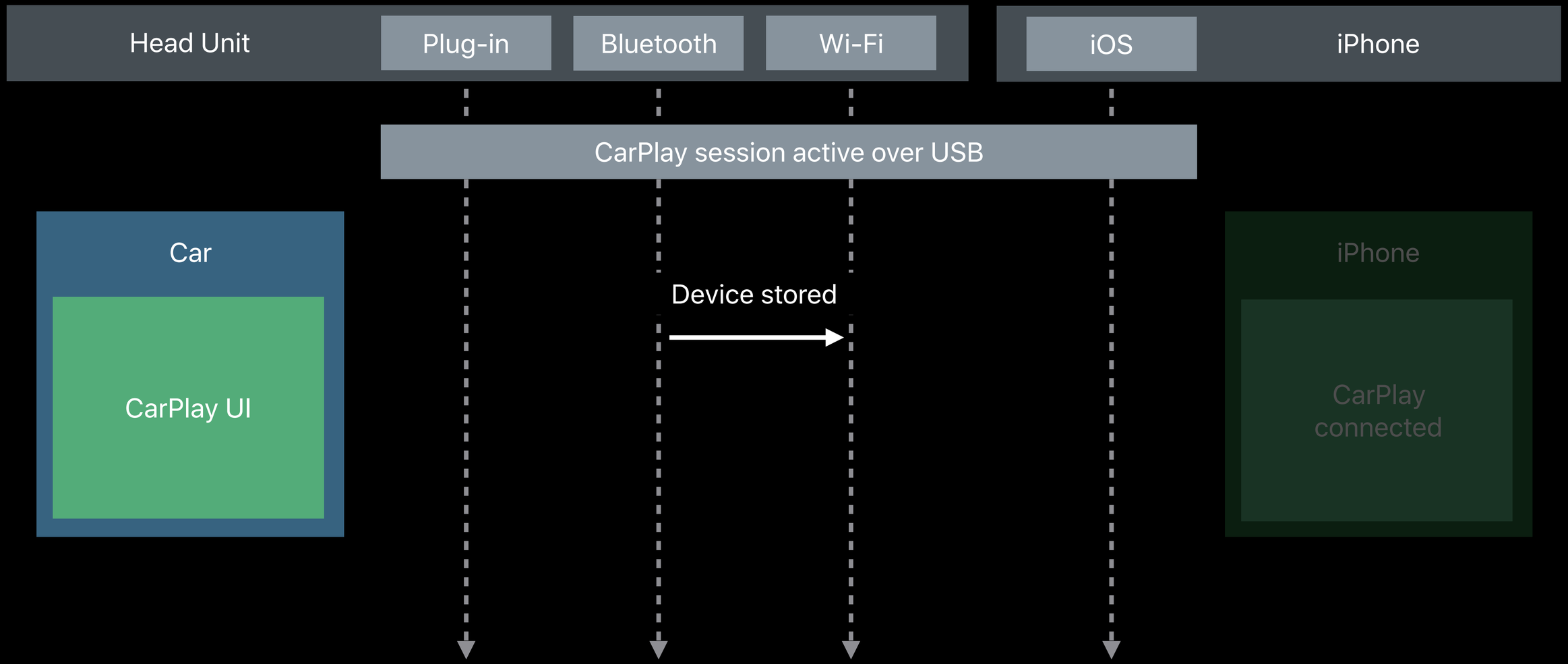

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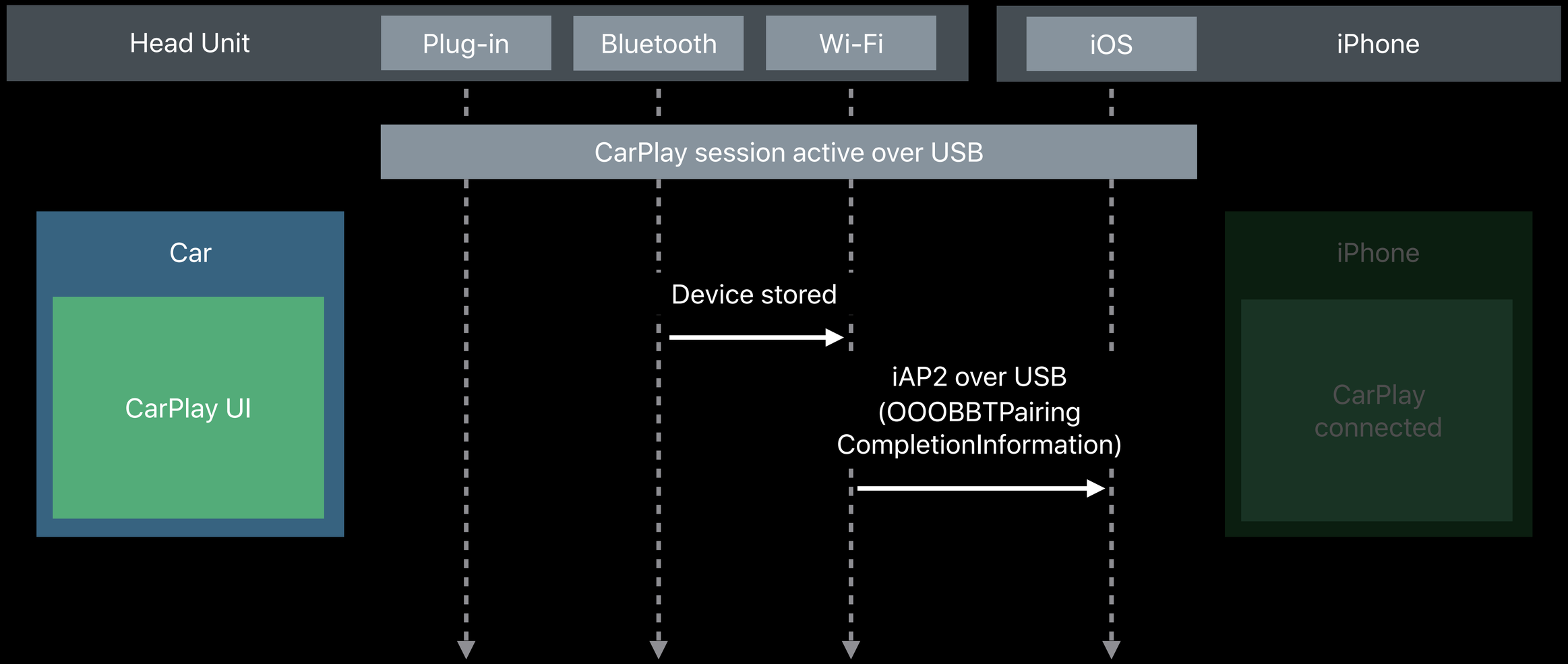


Out-of-Band Pairing over USB

Out-of-Band Pairing over USB

CarPlay session stays over USB

Out-of-Band Pairing over USB

CarPlay session stays over USB

No Bluetooth communication between head unit and iPhone

Out-of-Band Pairing over USB

CarPlay session stays over USB

No Bluetooth communication between head unit and iPhone

Store paired device as last connected device or preferred device

Out-of-Band Pairing over USB

CarPlay session stays over USB

No Bluetooth communication between head unit and iPhone

Store paired device as last connected device or preferred device

After ignition cycle, Bluetooth reconnection starts wireless CarPlay

Out-of-Band Pairing over USB

CarPlay session stays over USB

No Bluetooth communication between head unit and iPhone

Store paired device as last connected device or preferred device

After ignition cycle, Bluetooth reconnection starts wireless CarPlay

- Wireless CarPlay not started if iPhone is simply unplugged

Bluetooth Pairing

Bluetooth Pairing

Press and hold the voice control button on the steering wheel

Bluetooth Pairing

Press and hold the voice control button on the steering wheel

Use the car’s native UI

Bluetooth Pairing

Press and hold the voice control button on the steering wheel

Use the car’s native UI

- Add a CarPlay device

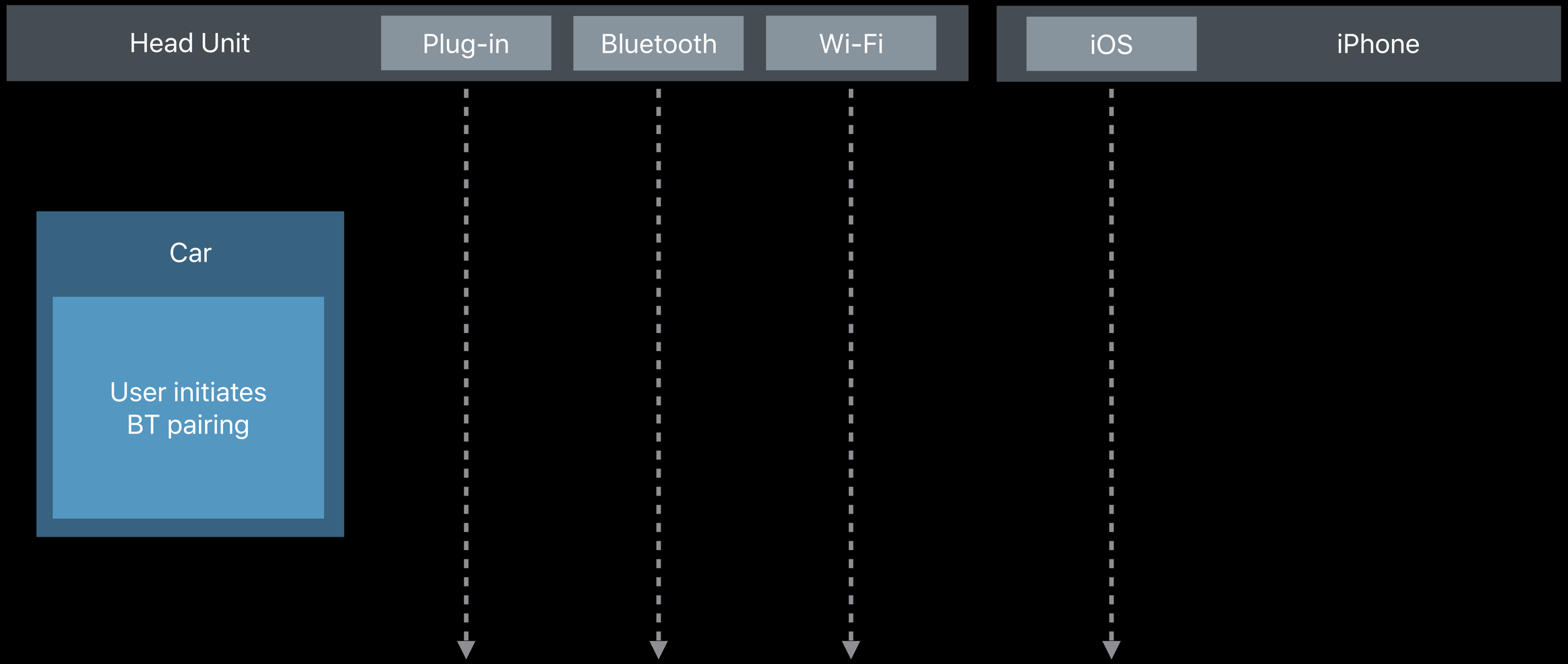
Bluetooth Pairing

Press and hold the voice control button on the steering wheel

Use the car’s native UI

- Add a CarPlay device
- Add a Bluetooth device

Discovering CarPlay Devices over Bluetooth



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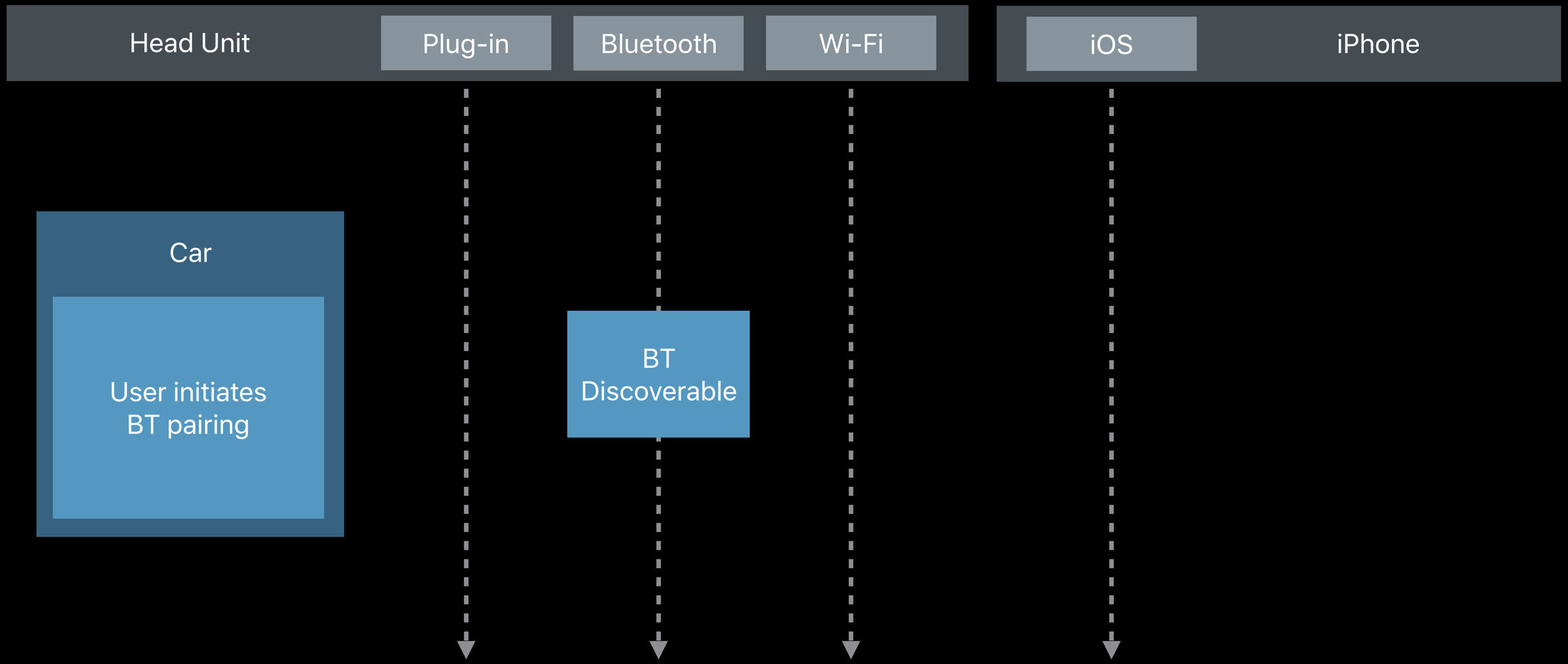

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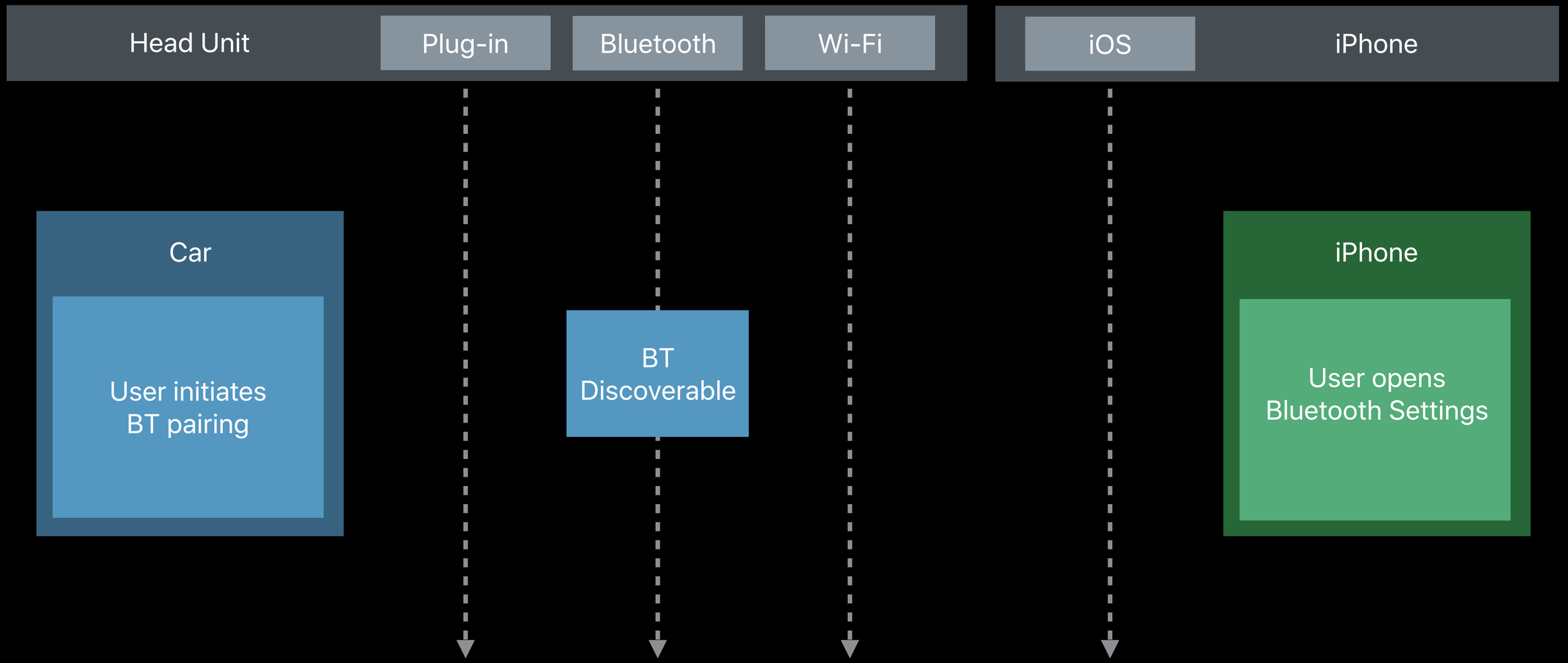

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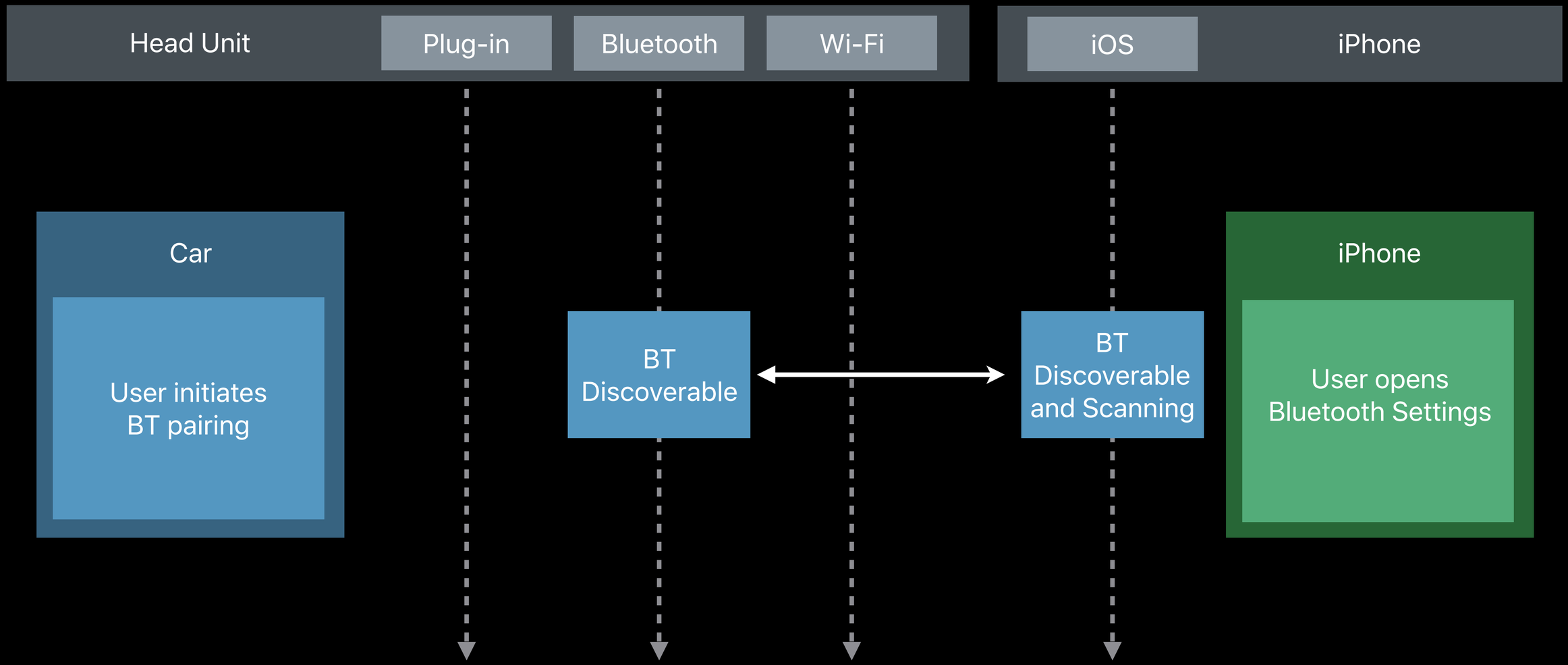
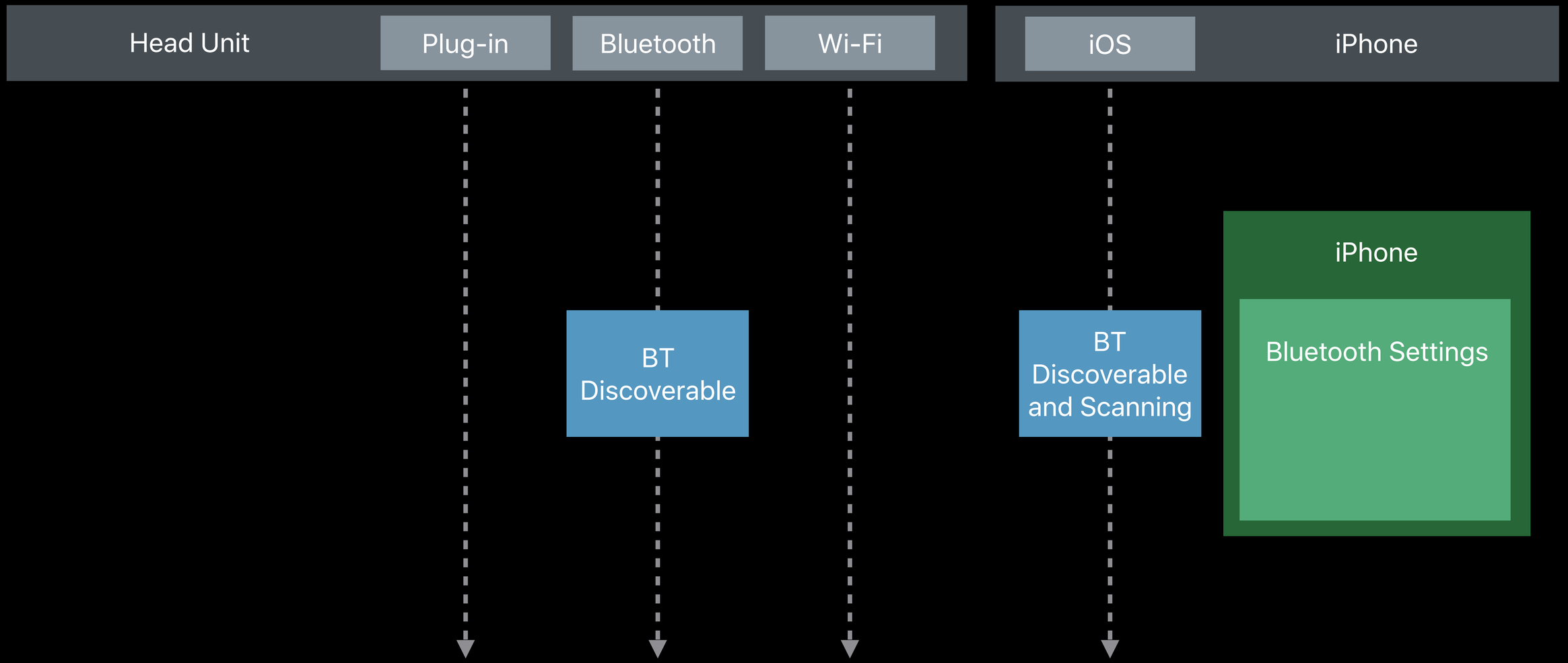


Option 1) Selecting a Car to Pair to from iOS



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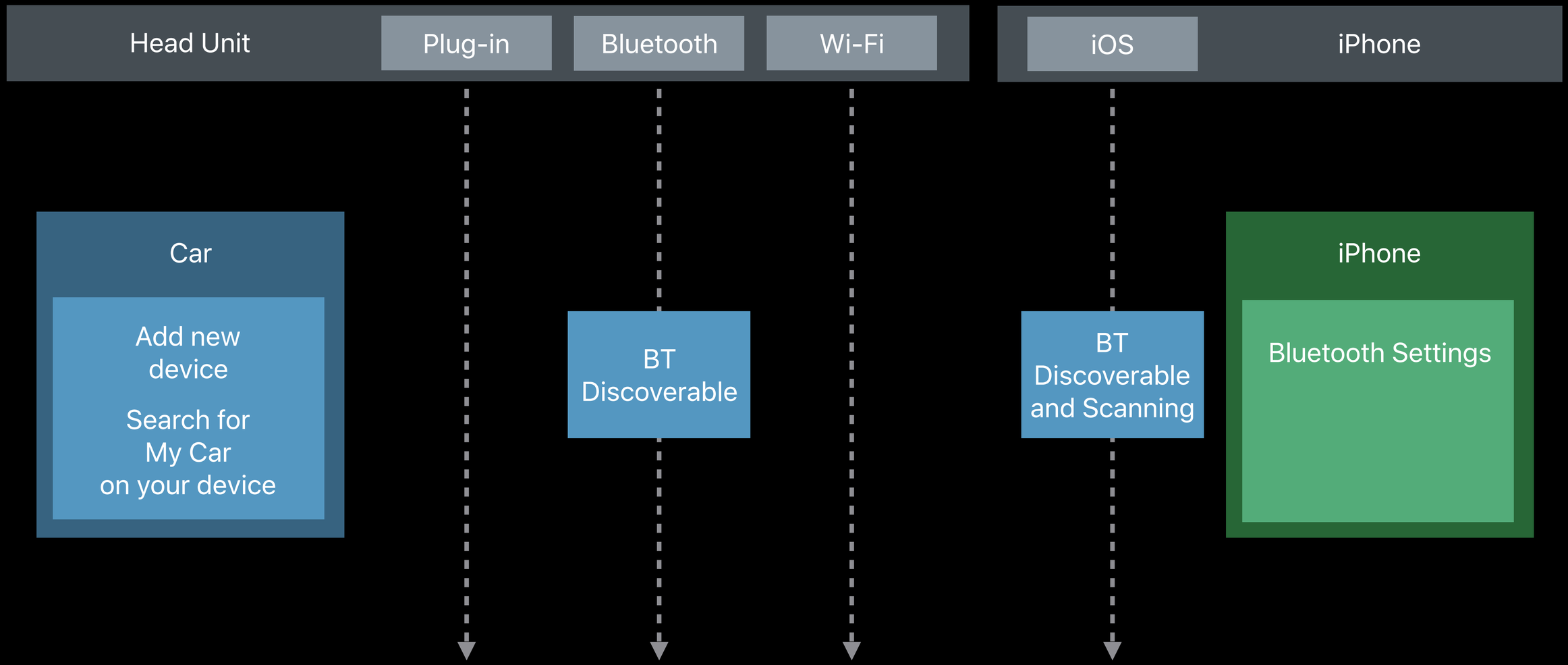
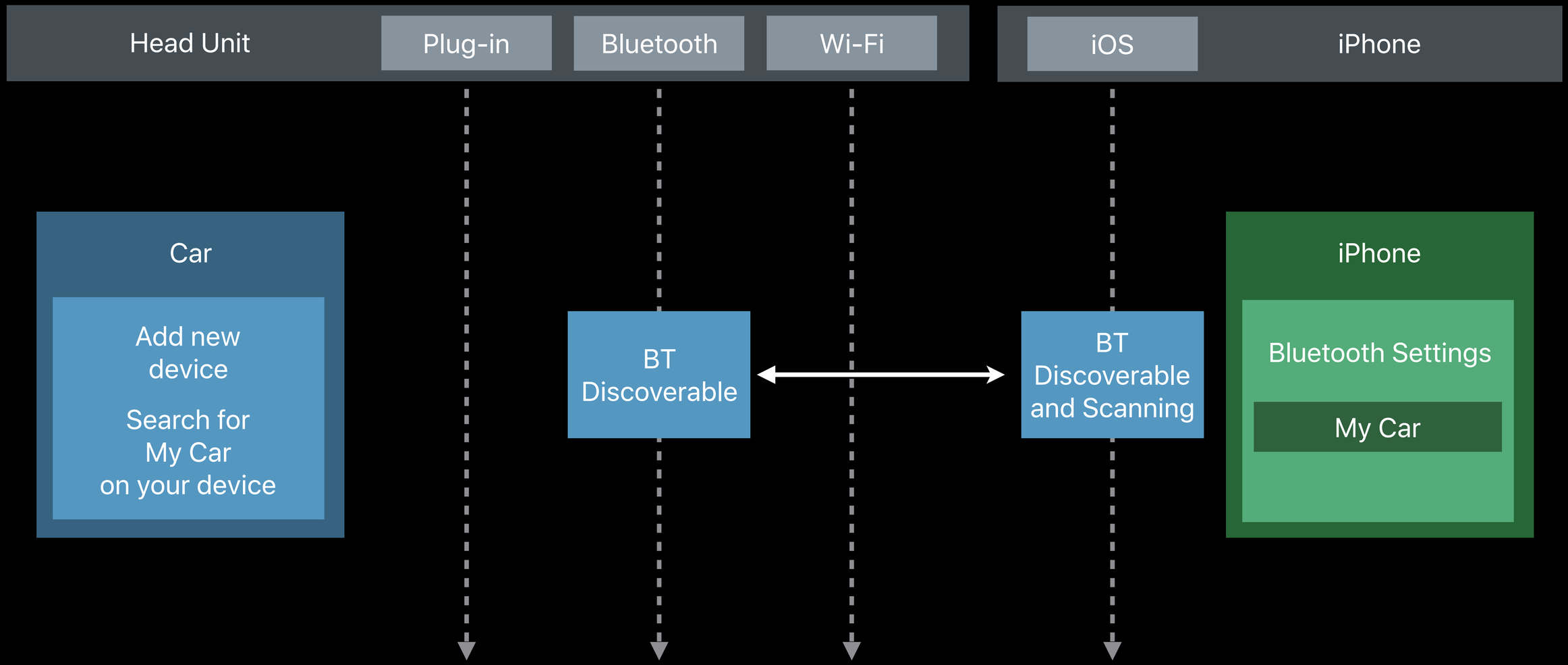


Option 1) Selecting a Car to Pair to from iOS



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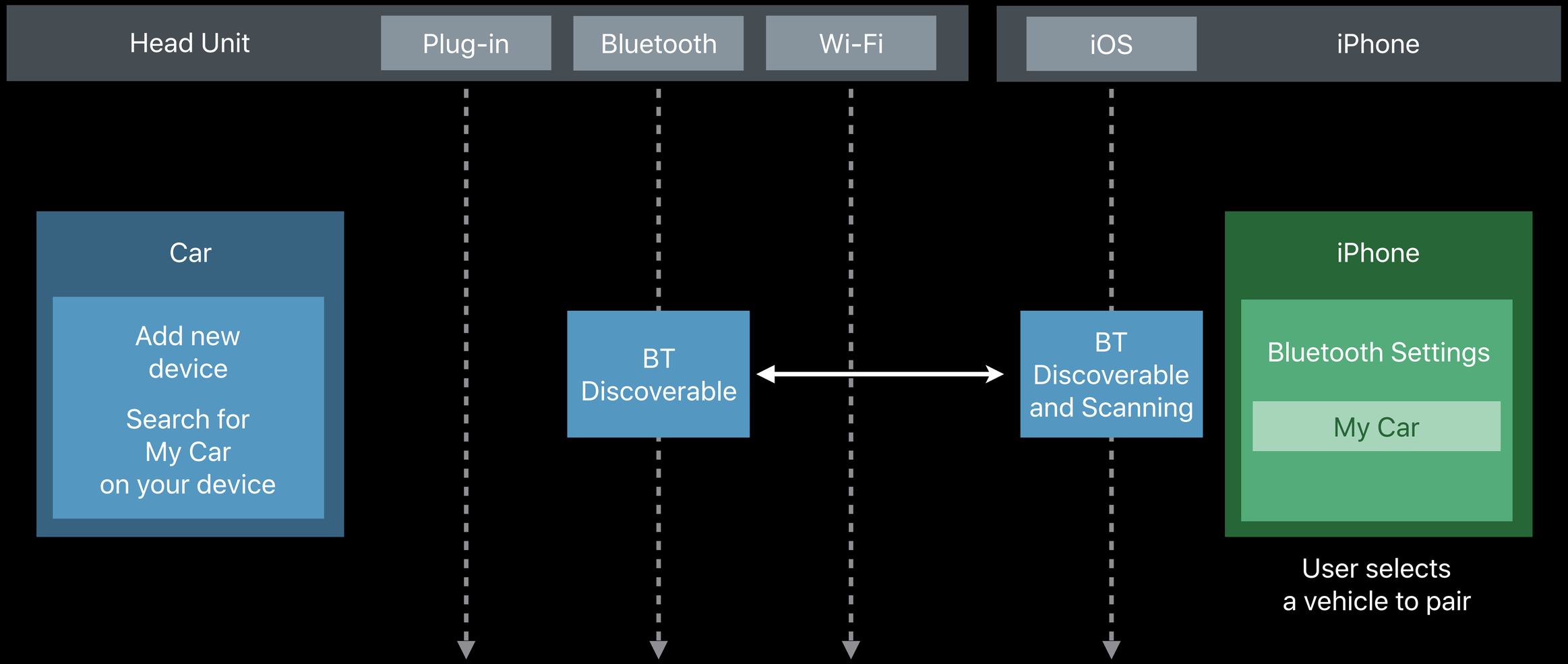
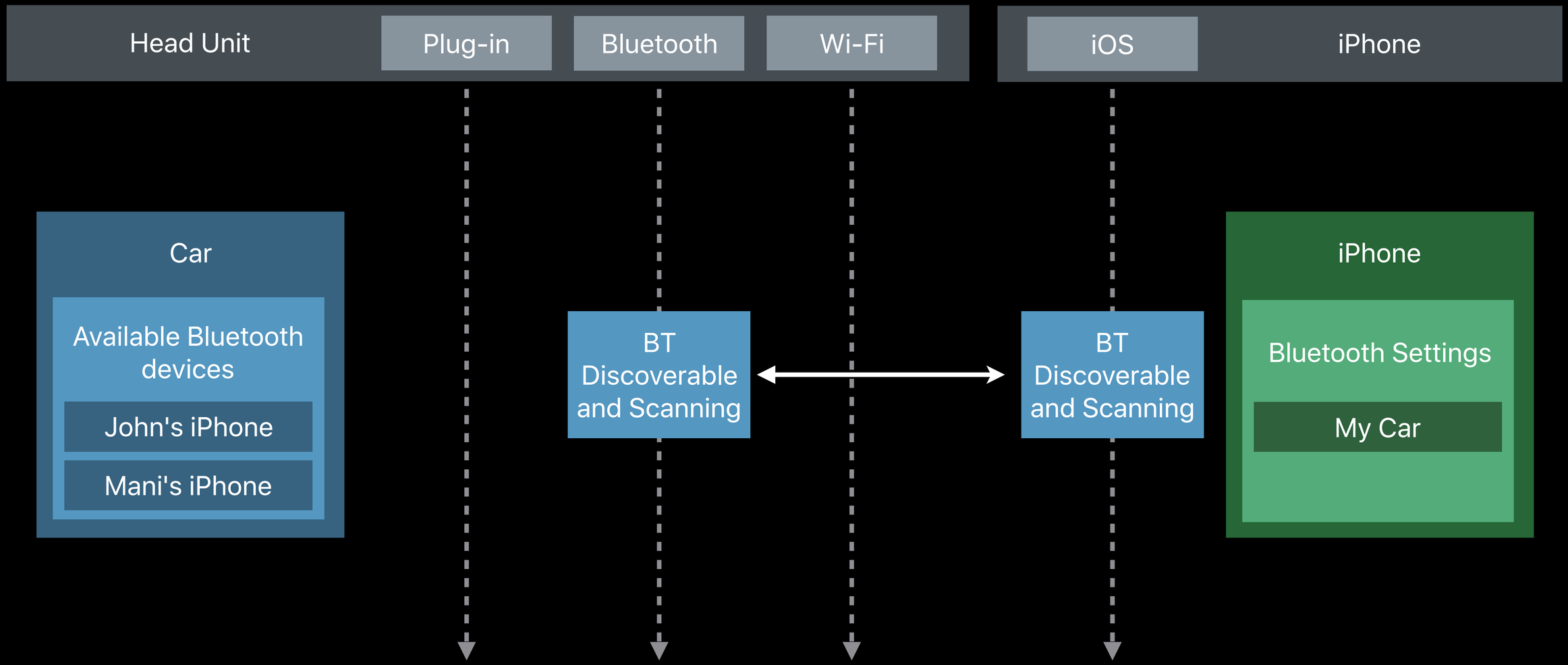


Option 2) Discovery Through Existing BT Menus



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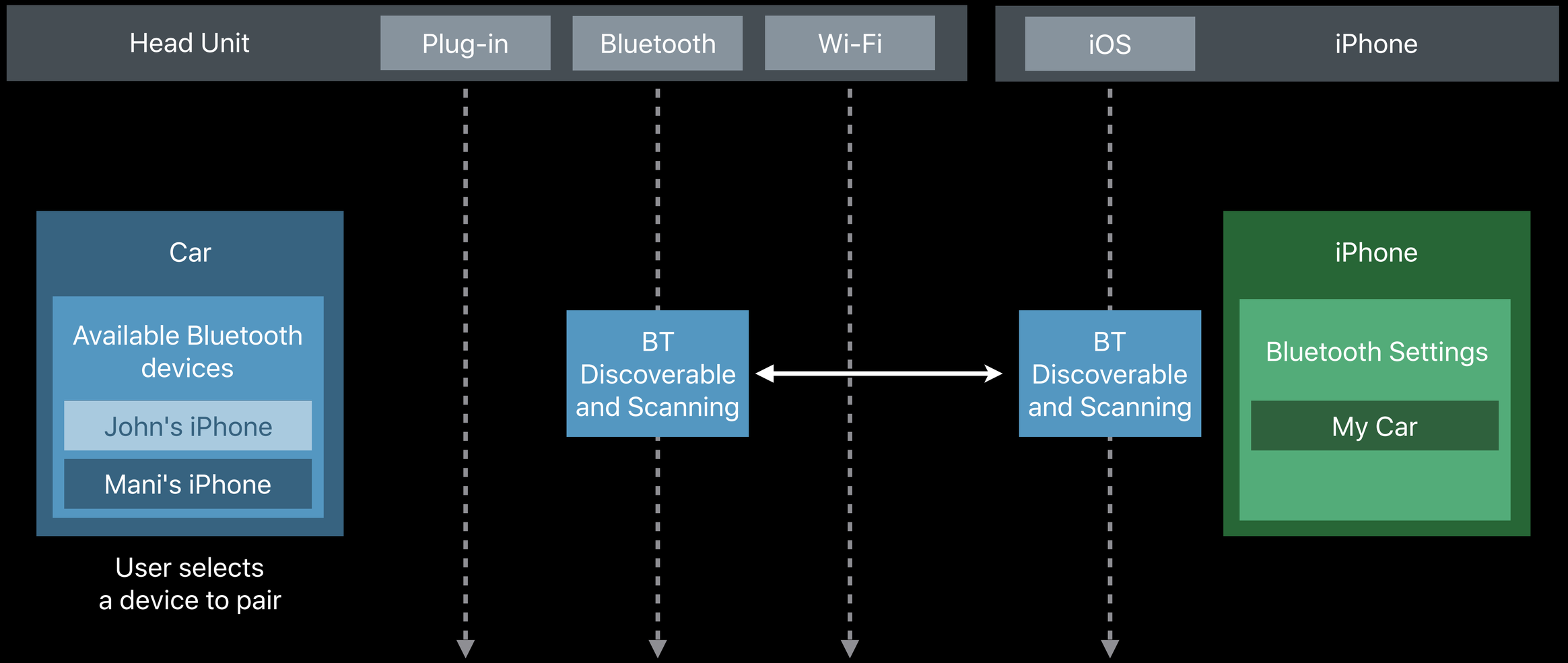

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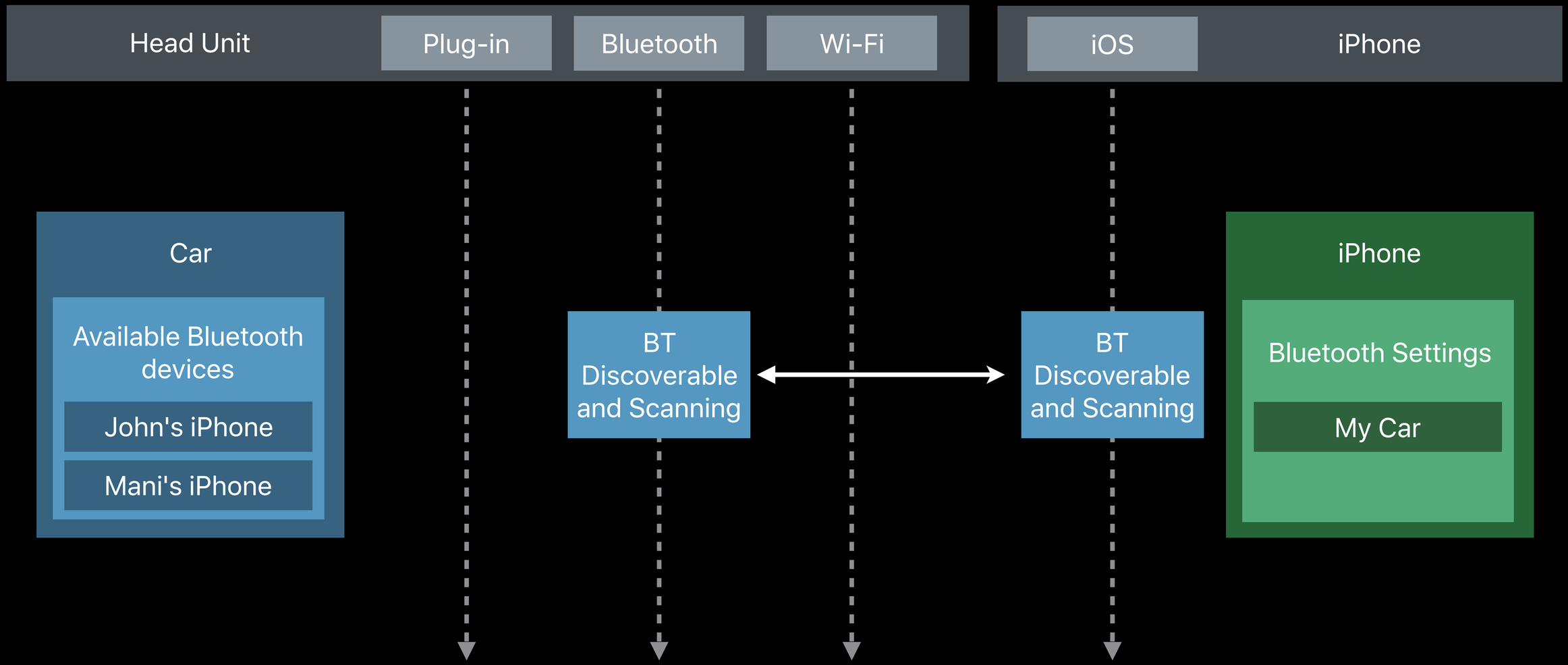

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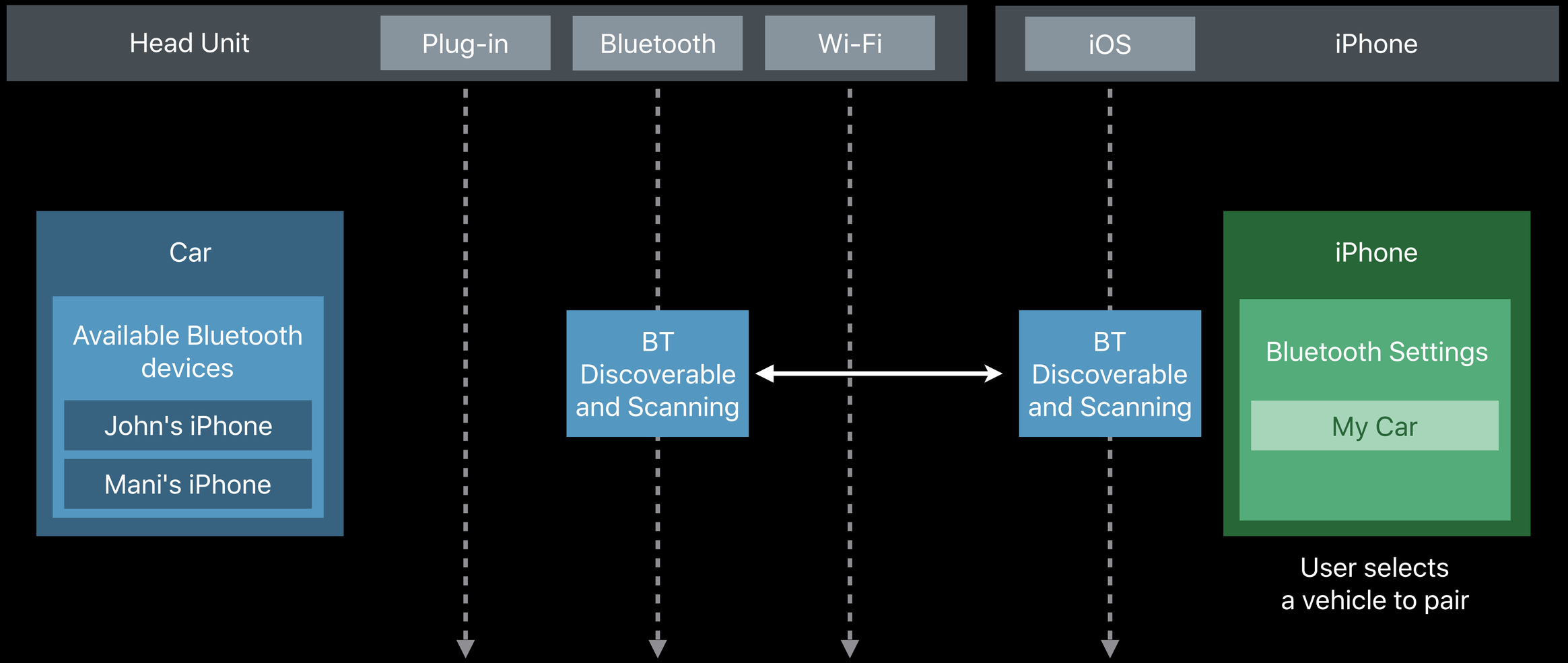
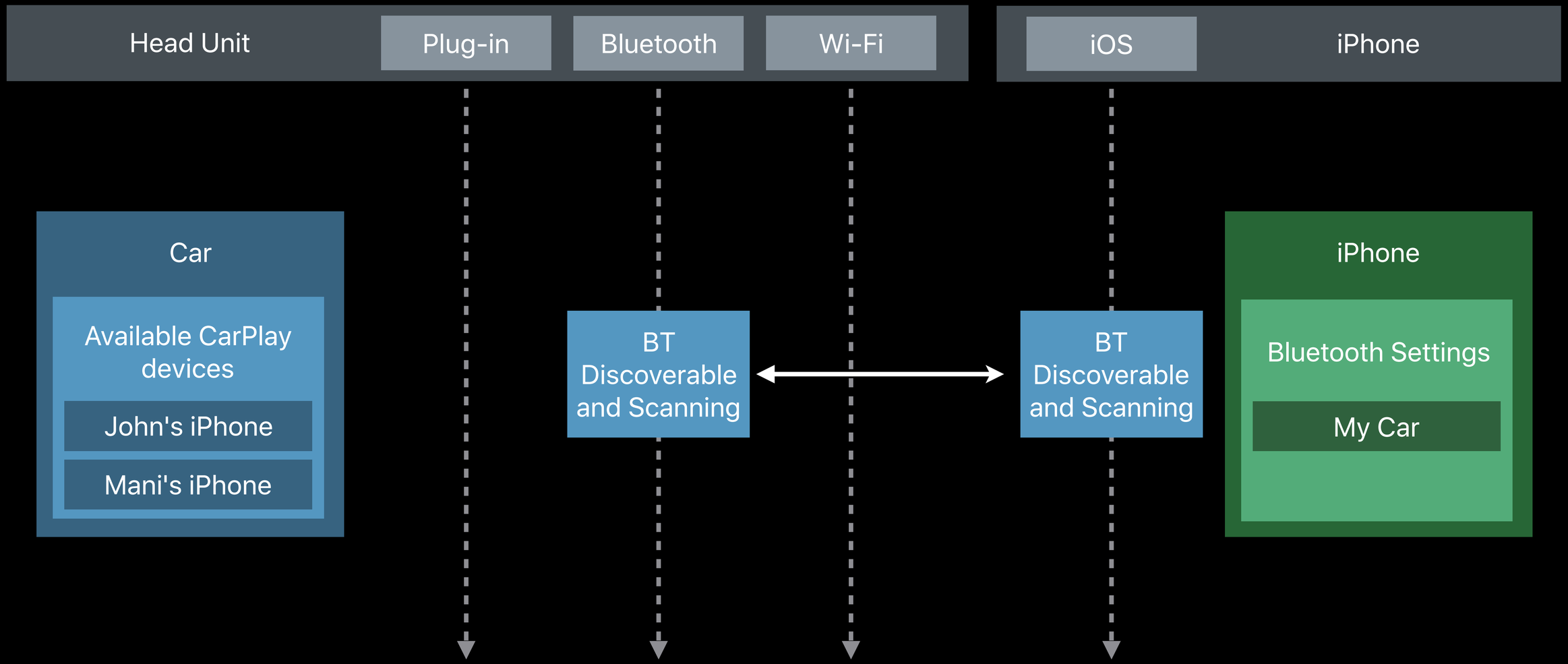
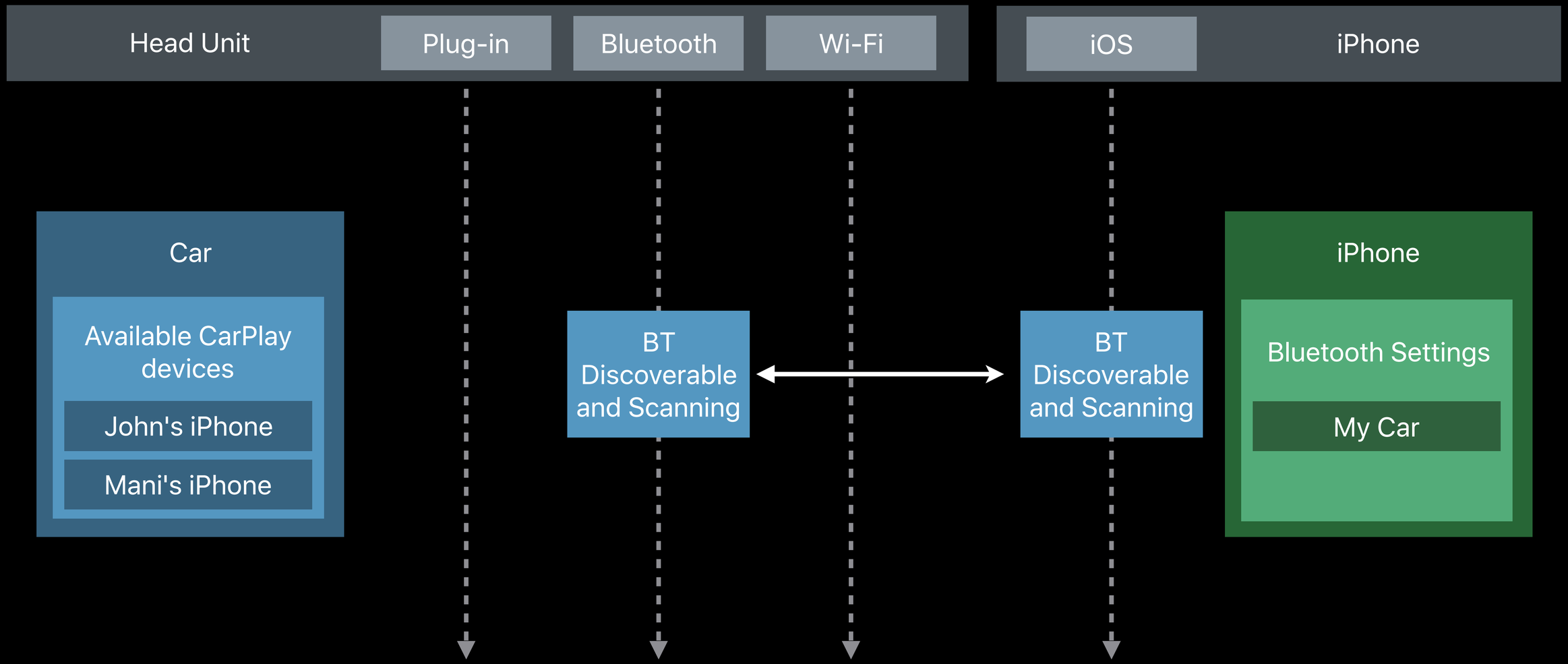


Option 3) CarPlay Specific Discovery

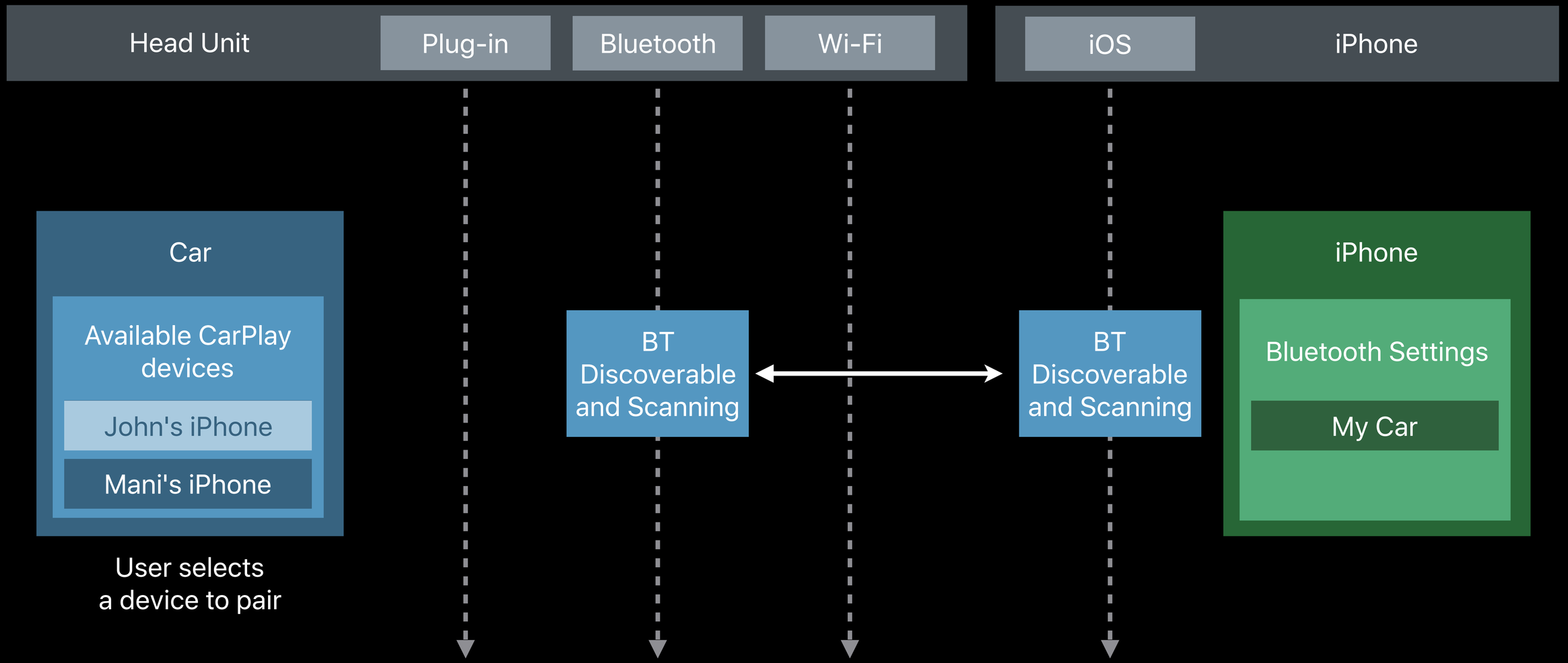


Option 3) CarPlay Specific Discovery



Query for Apple CarPlay Bluetooth EIR to display only CarPlay-capable devices

Option 3) CarPlay Specific Discovery



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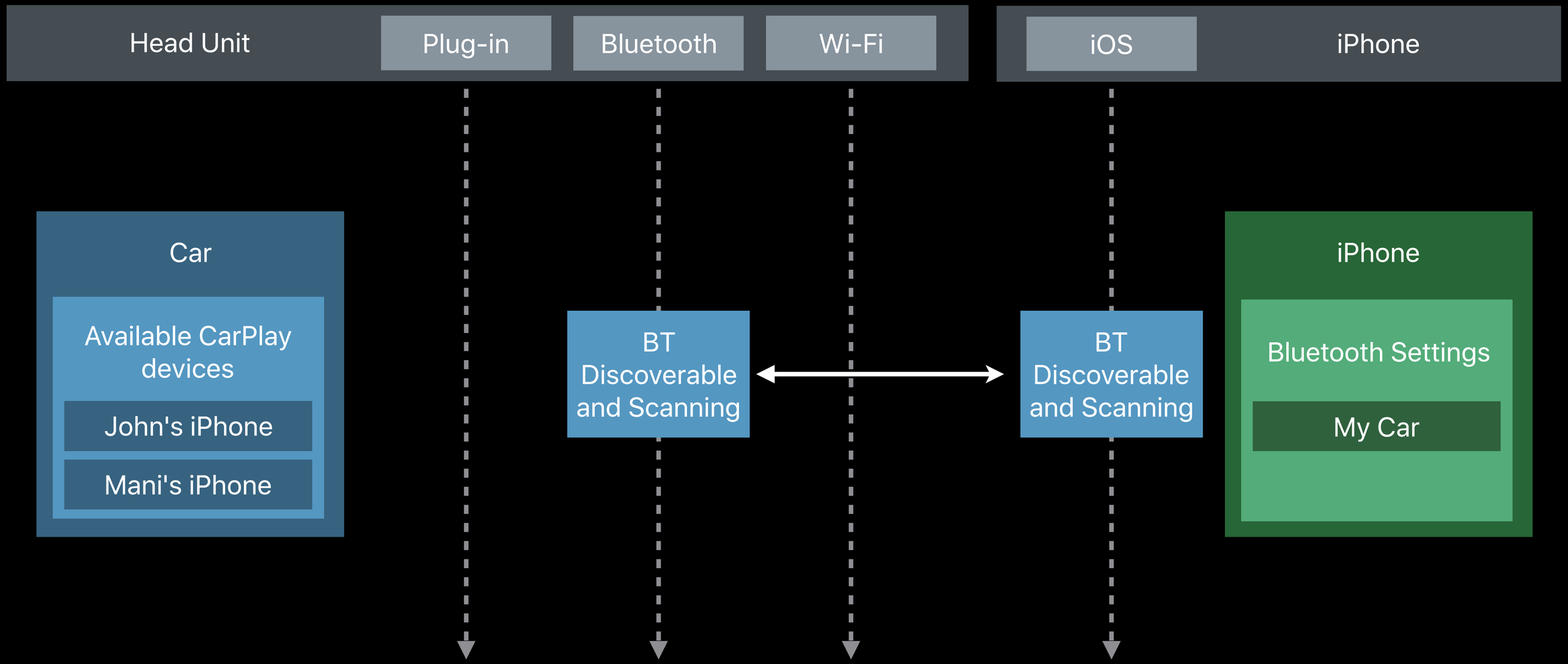

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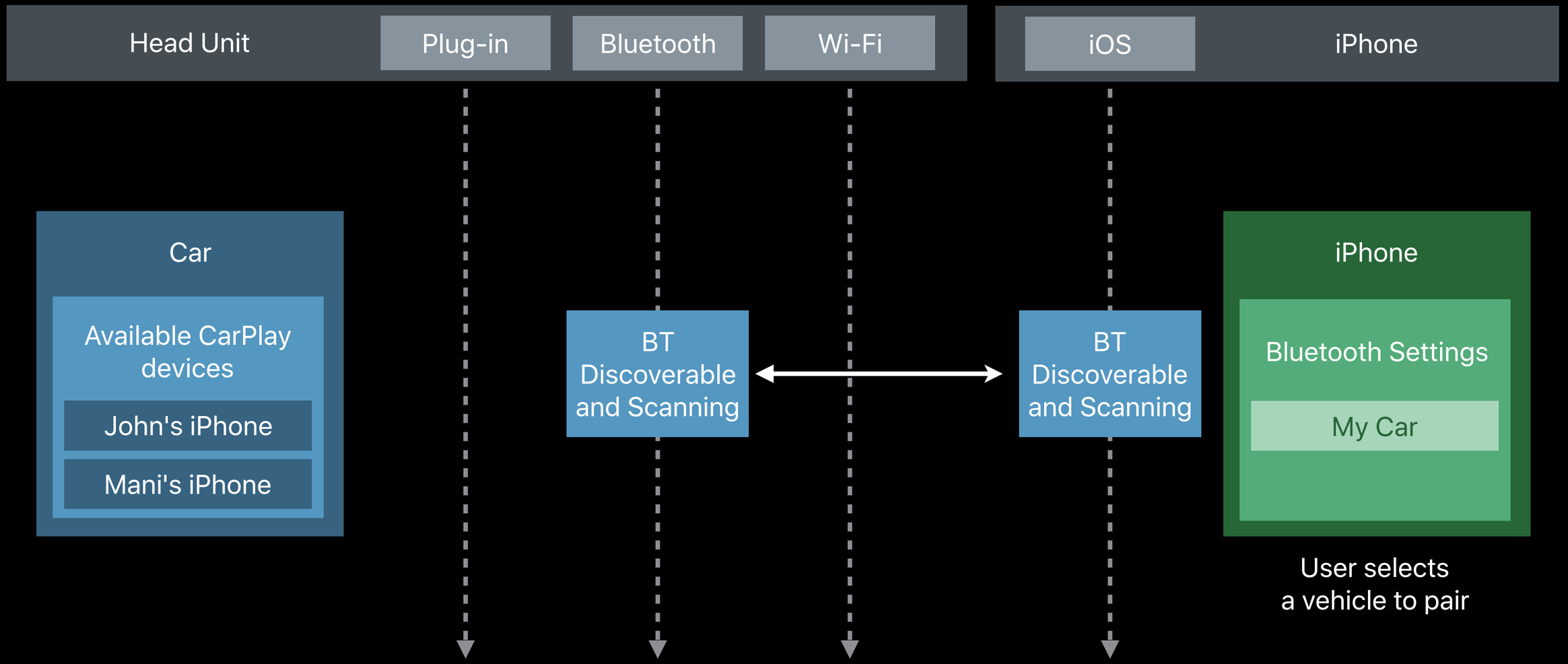
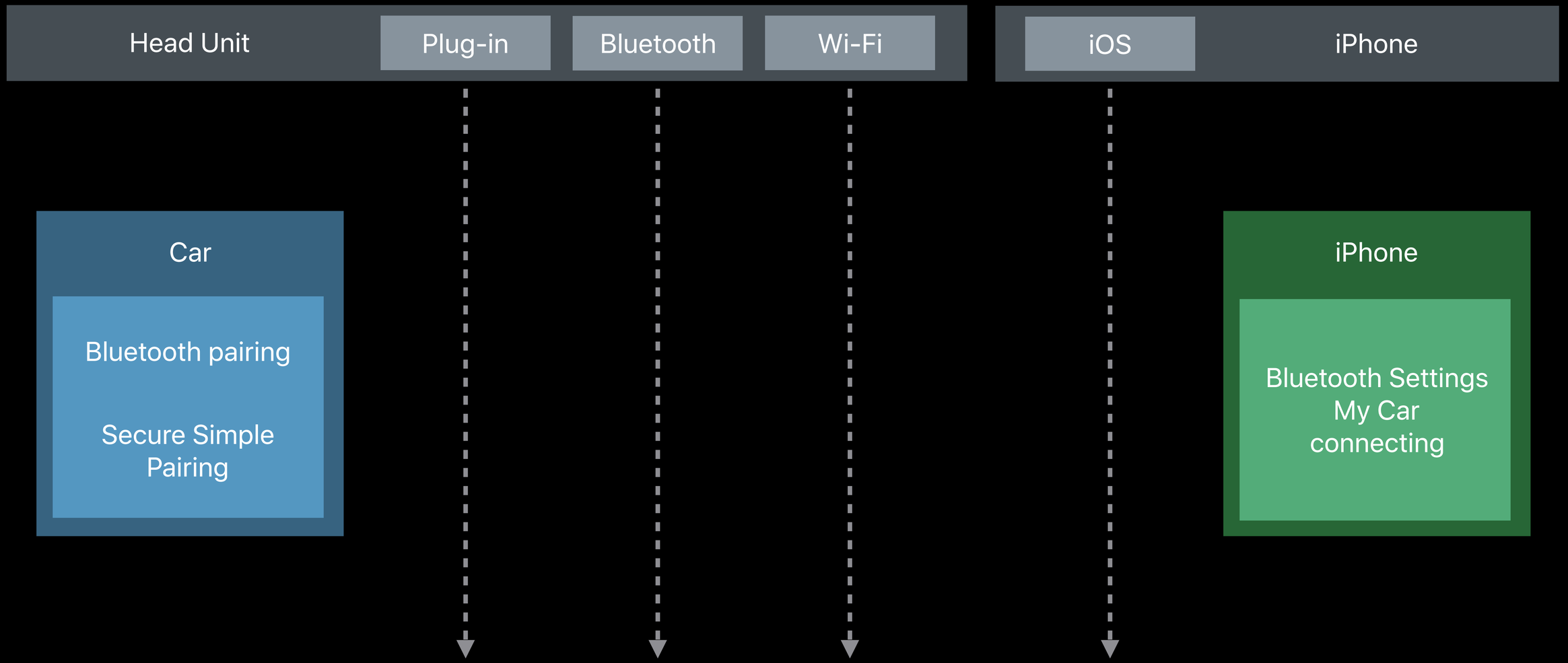
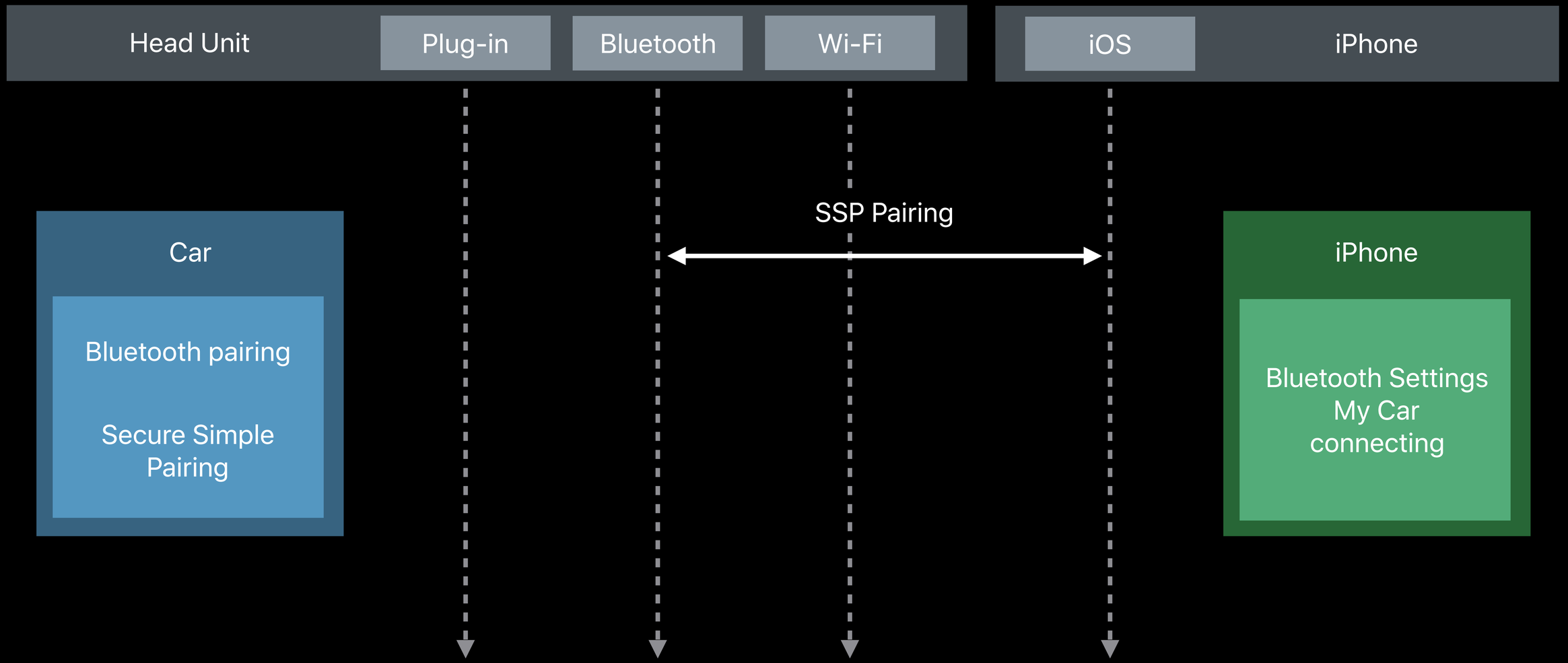


Query for Apple CarPlay Bluetooth EIR to display only CarPlay-capable devices

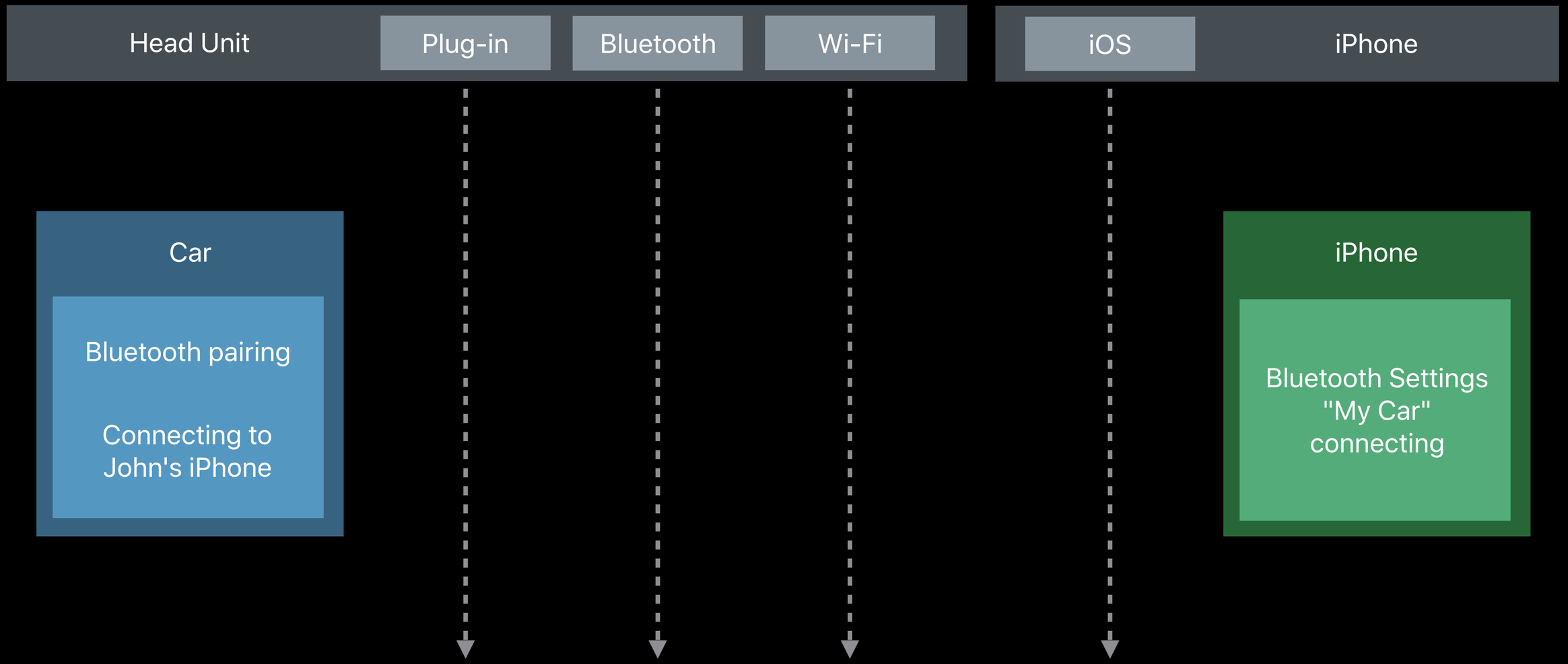
Bluetooth Pairing



Bluetooth Pairing



Connecting iAP2 over Bluetooth



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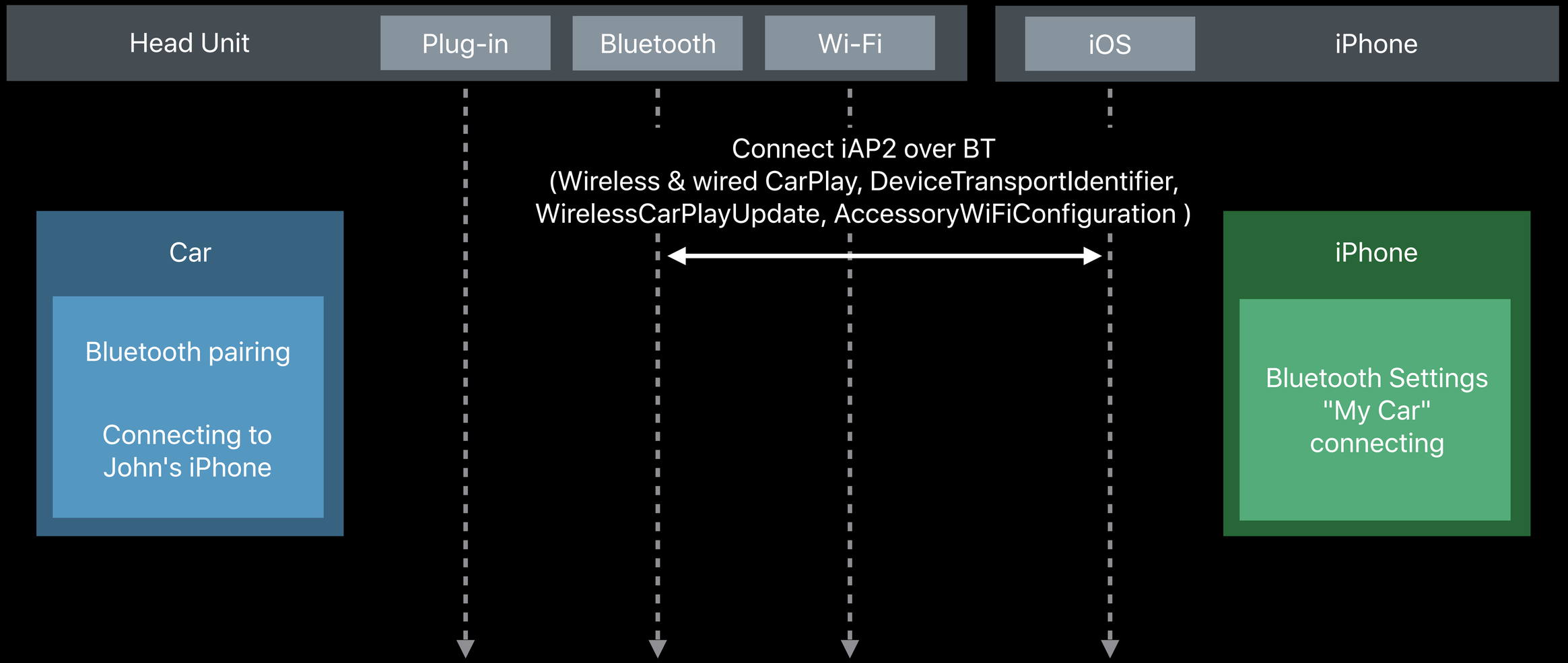

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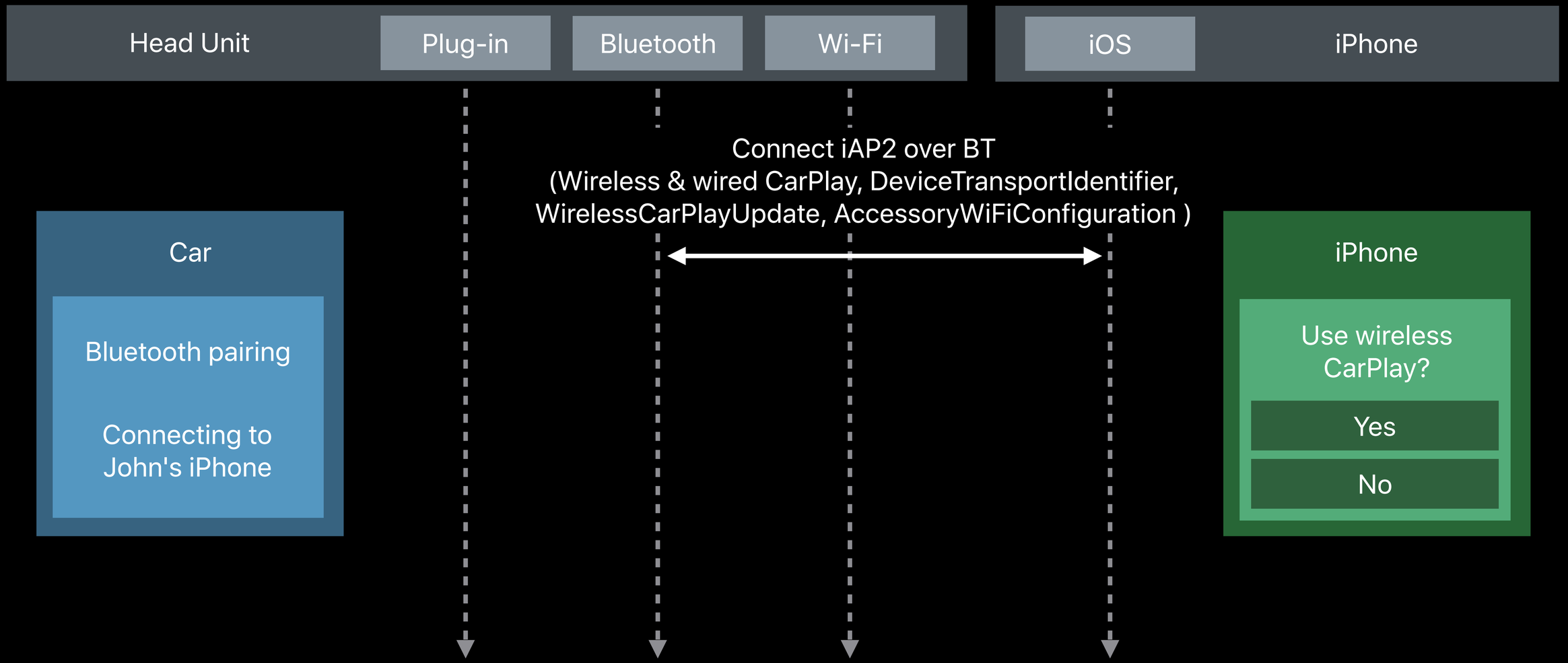

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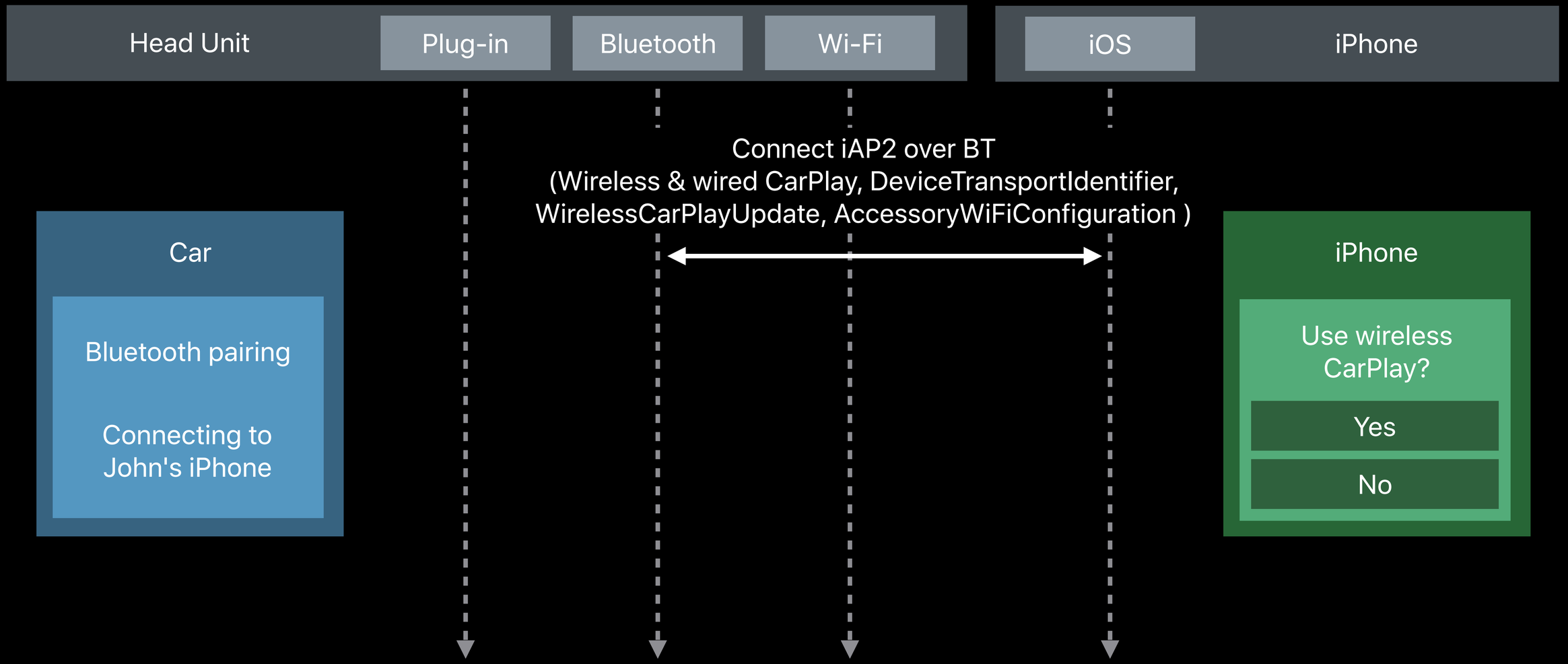
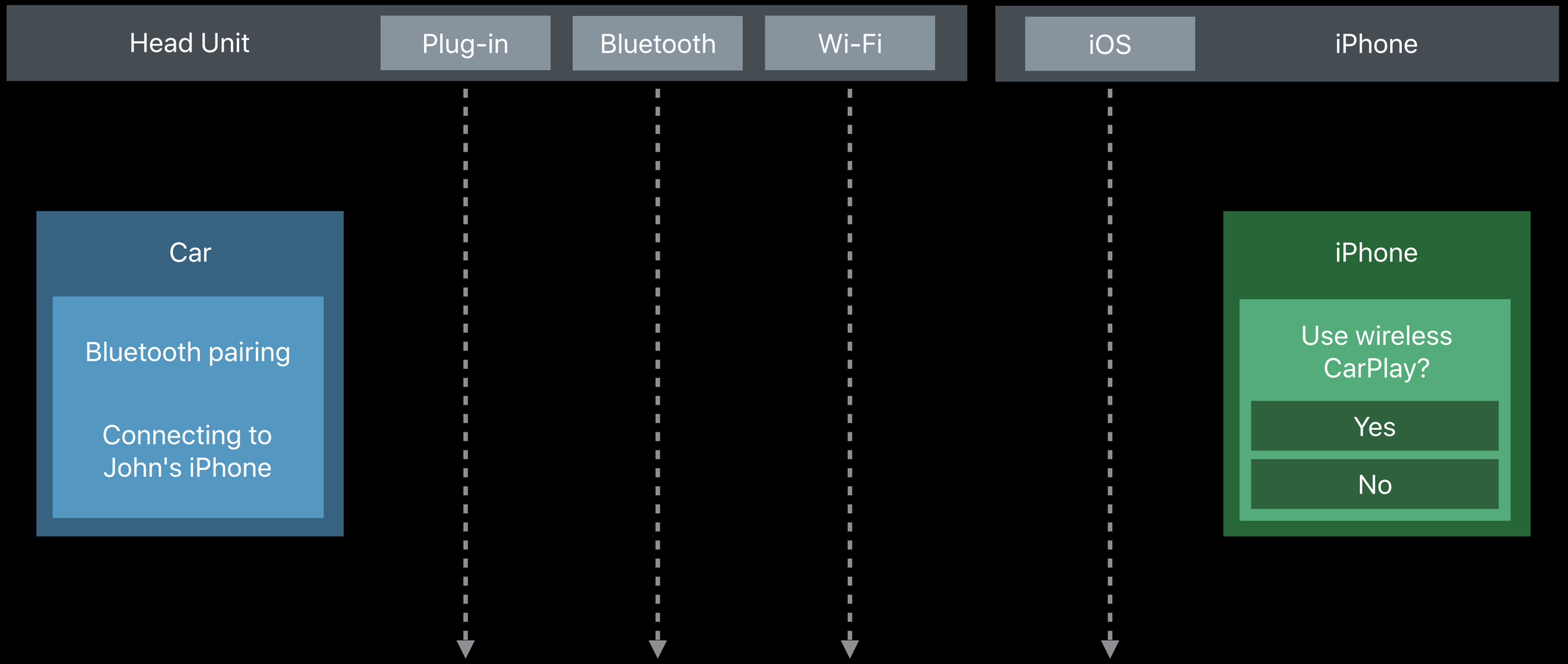
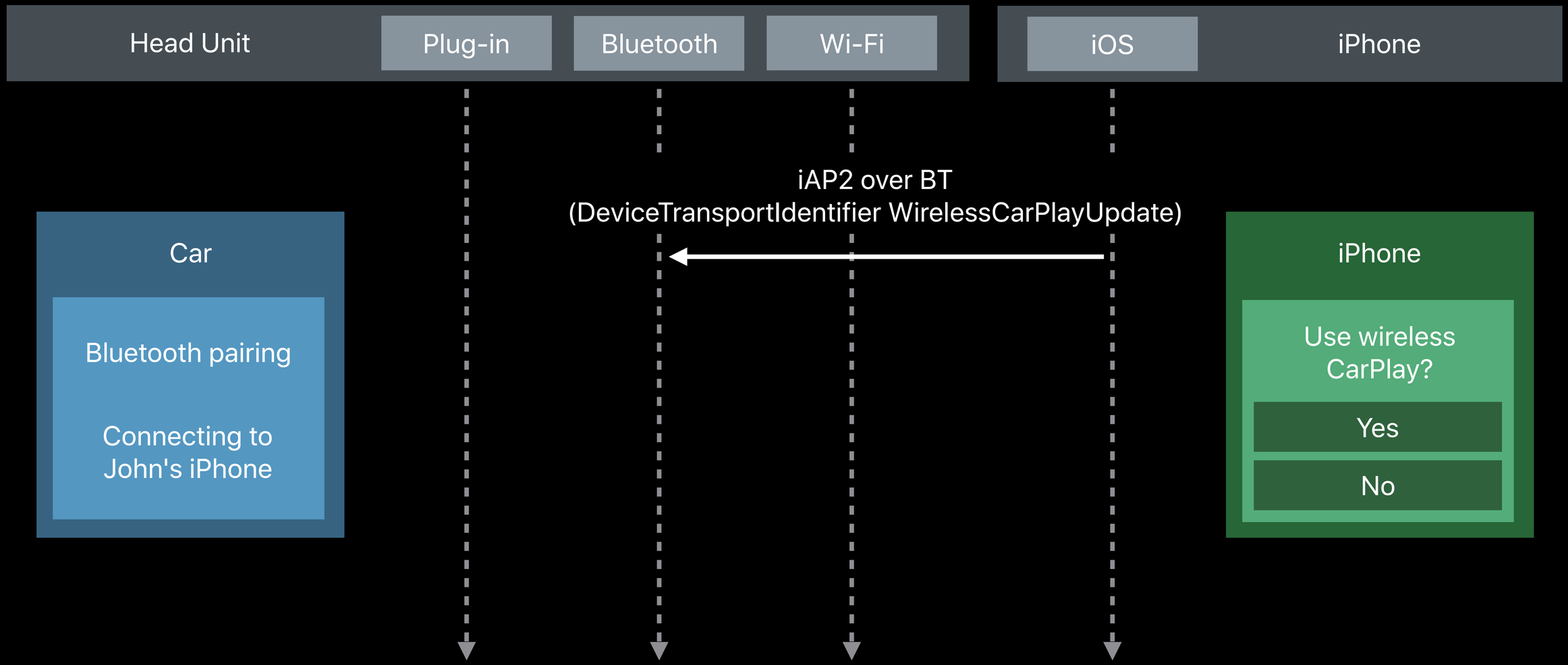


Connect additional Bluetooth profiles only if operating in the 5GHz band

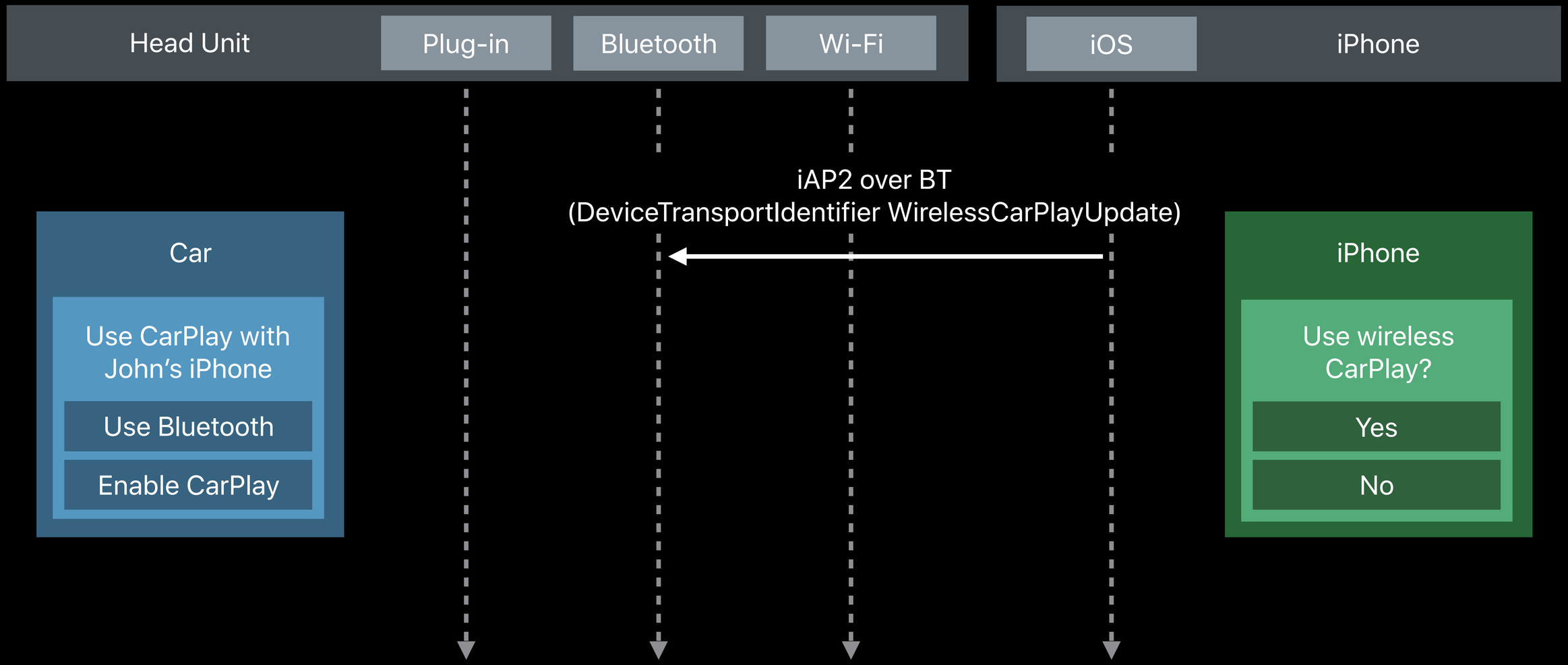
Identifying a CarPlay-Enabled Device



Identifying a CarPlay-Enabled Device

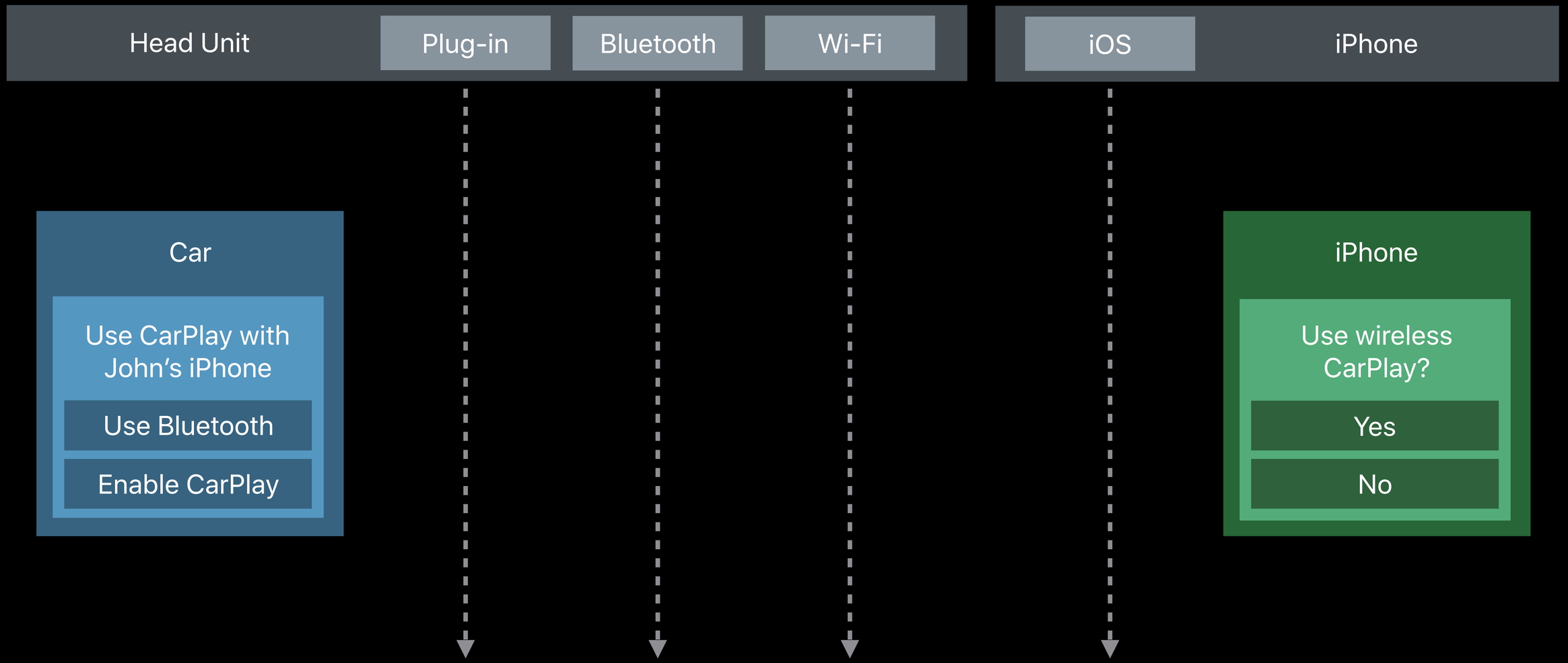


Identifying a CarPlay-Enabled Device

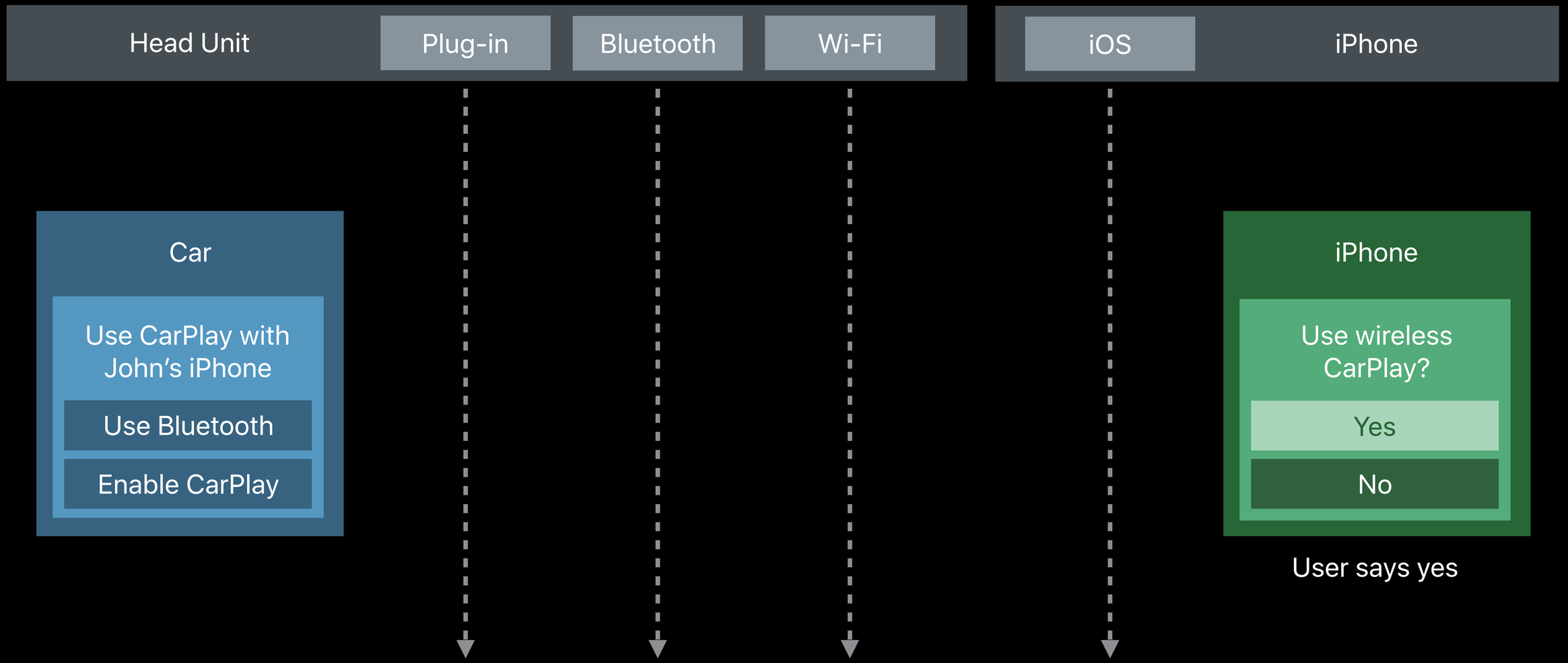


Show CarPlay related UI only if the device supports CarPlay

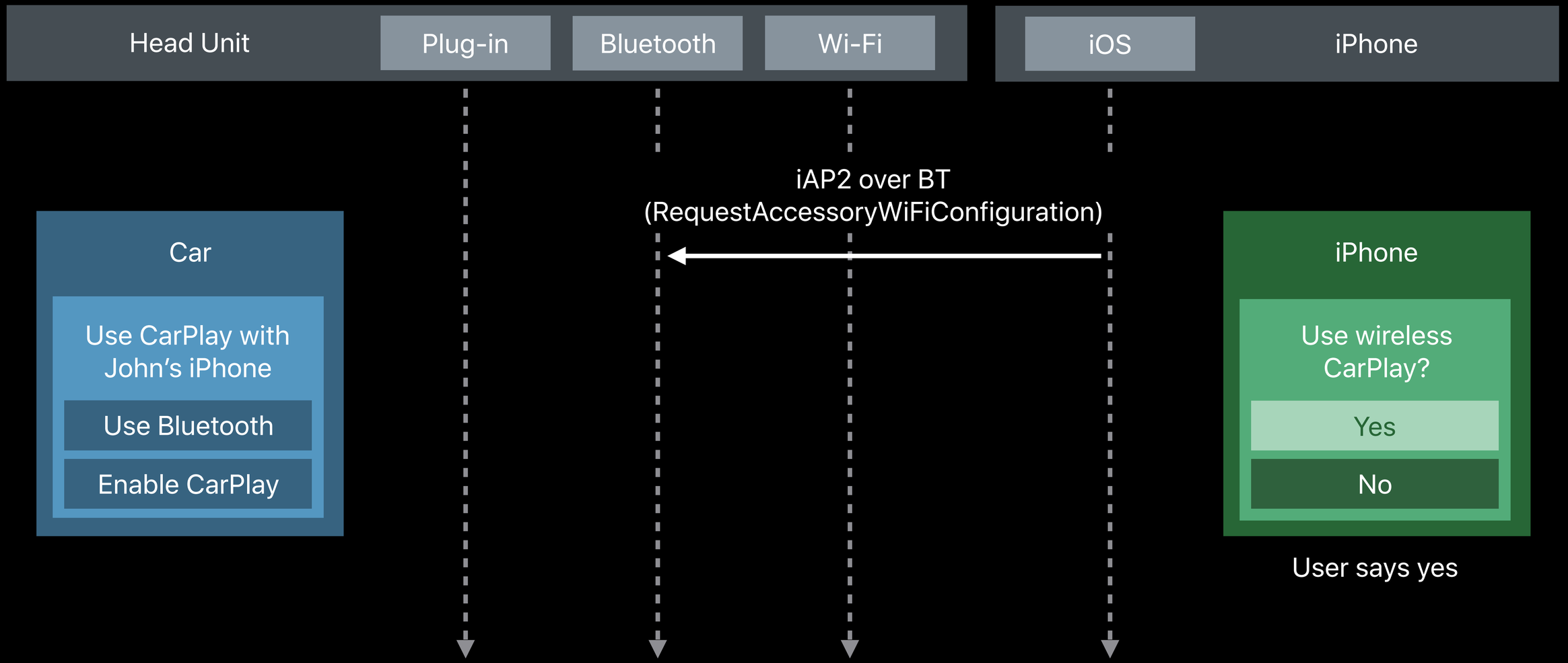
Handling for a User-Consent Screen



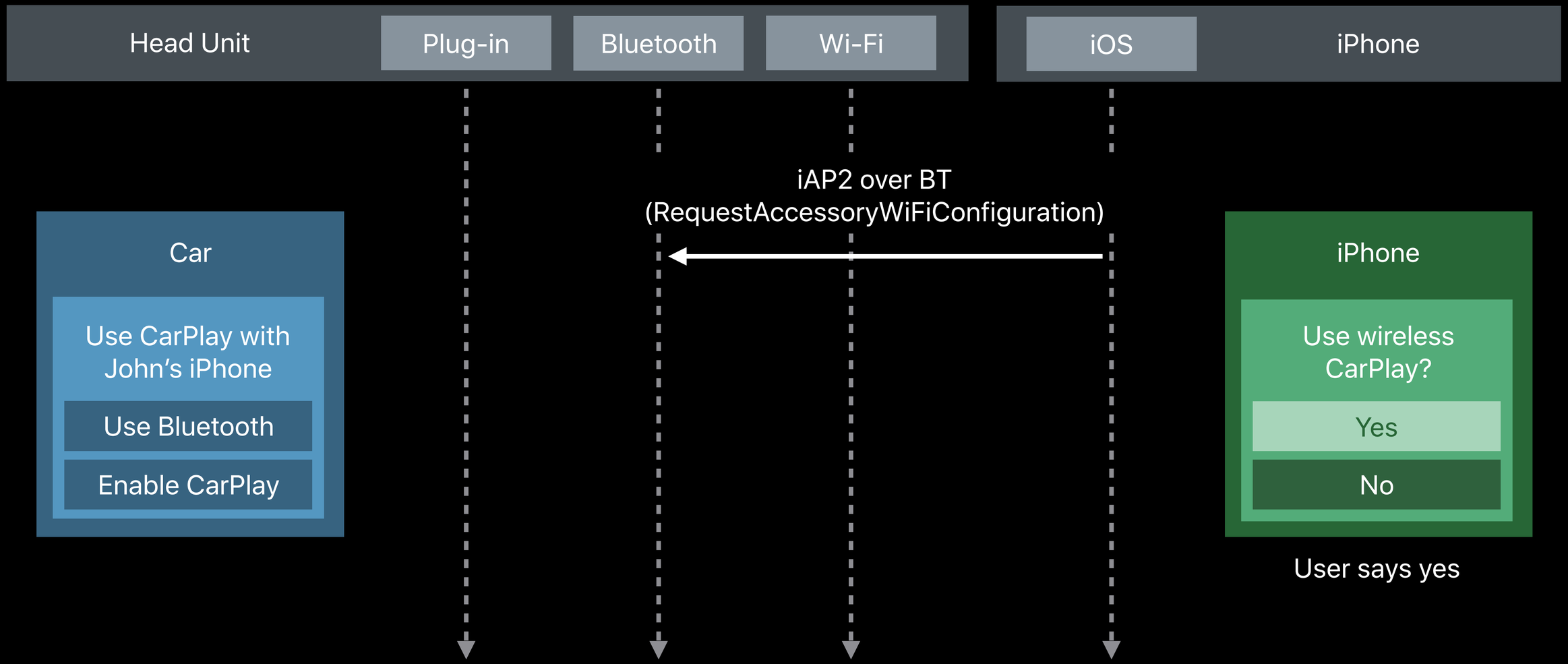
Handling for a User-Consent Screen



Handling for a User-Consent Screen

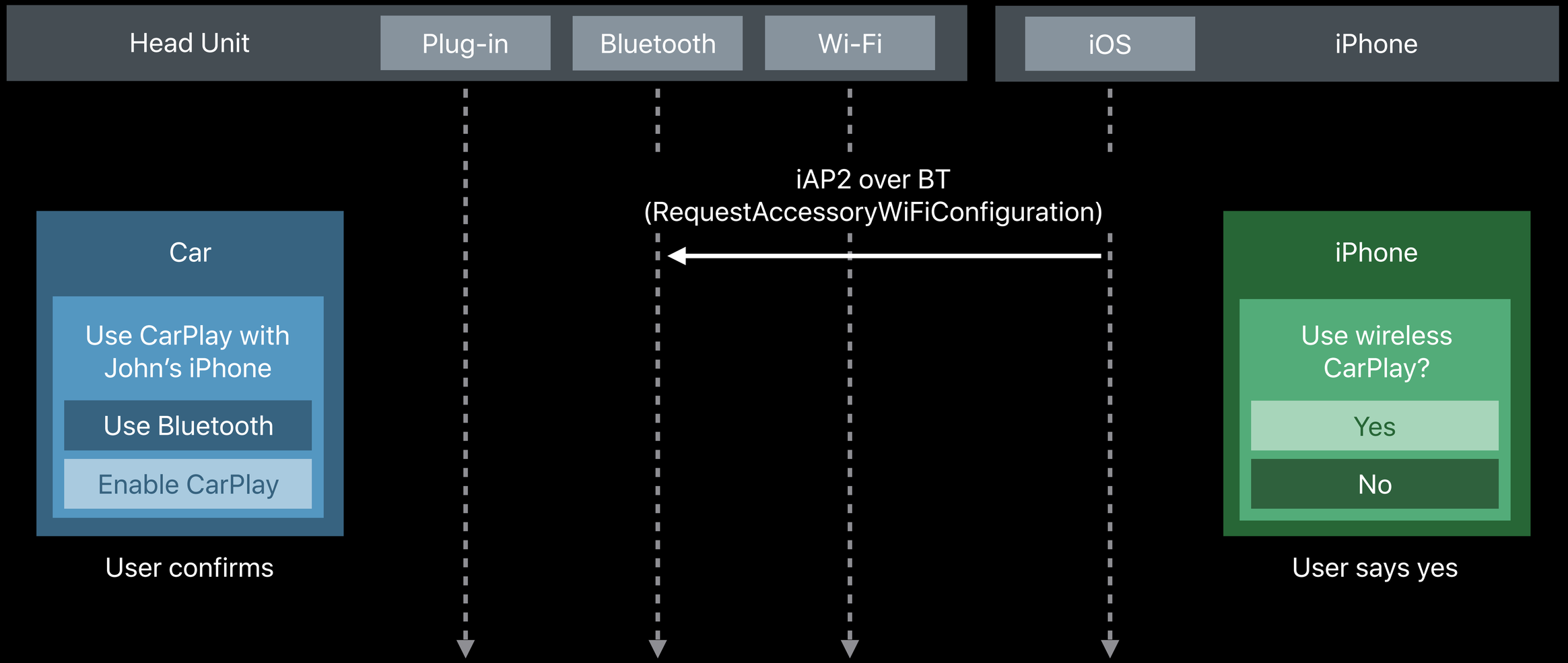


Handling for a User-Consent Screen



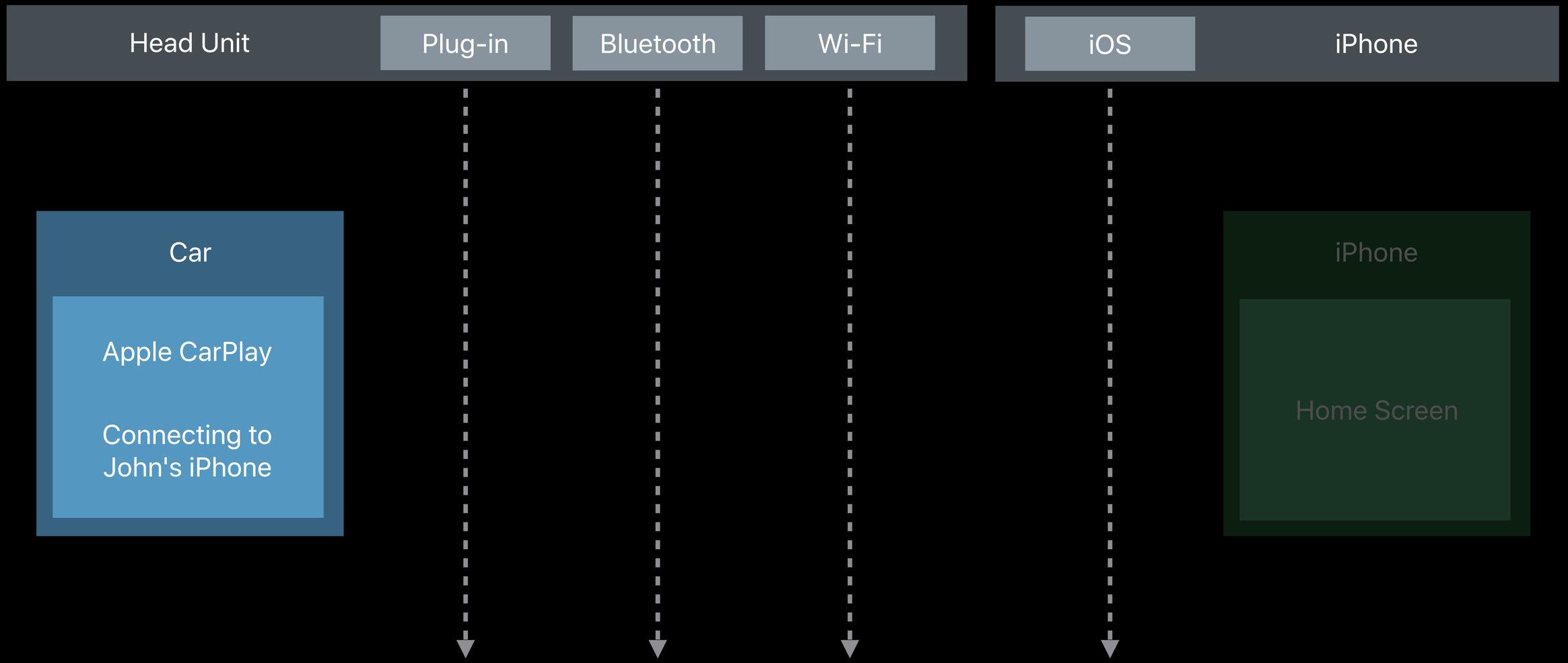
Do not provide the Wi-Fi credentials until the user has confirmed CarPlay

Handling for a User-Consent Screen



Do not provide the Wi-Fi credentials until the user has confirmed CarPlay

Connecting to Wi-Fi



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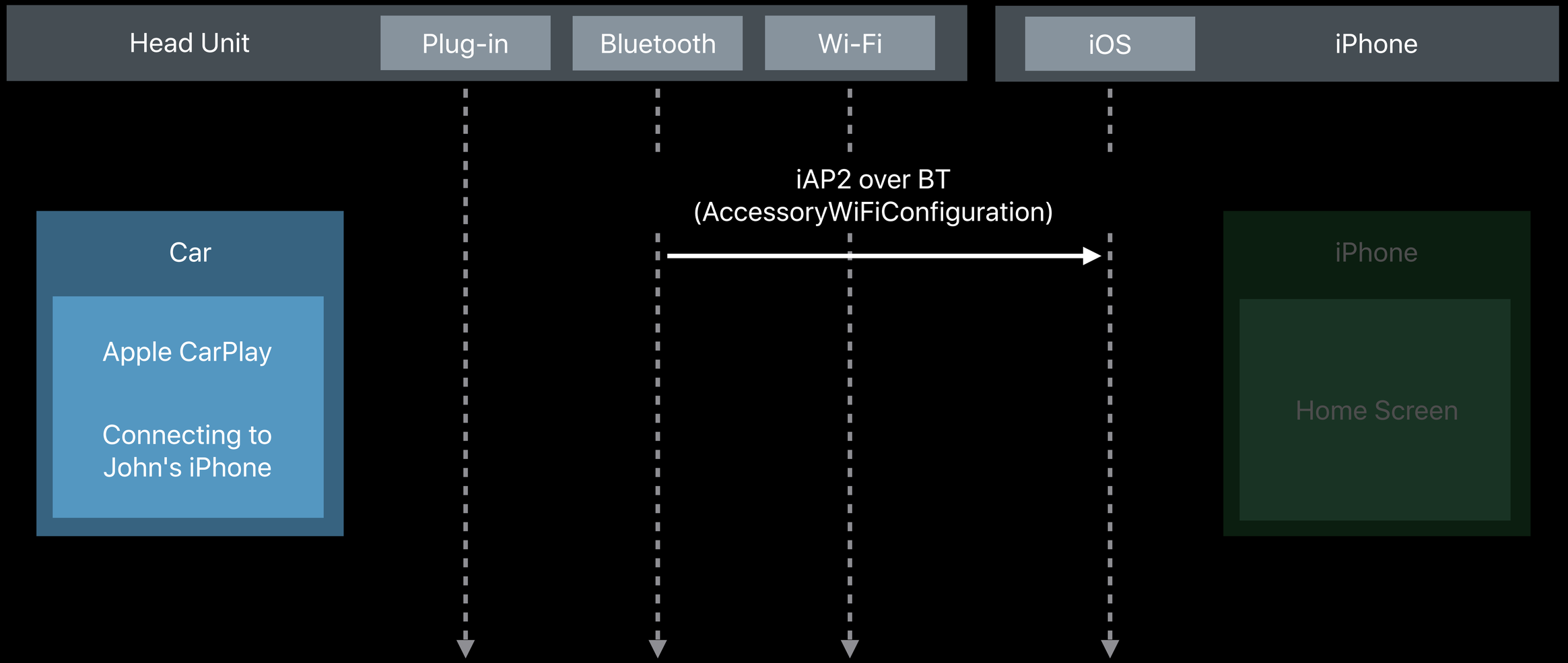

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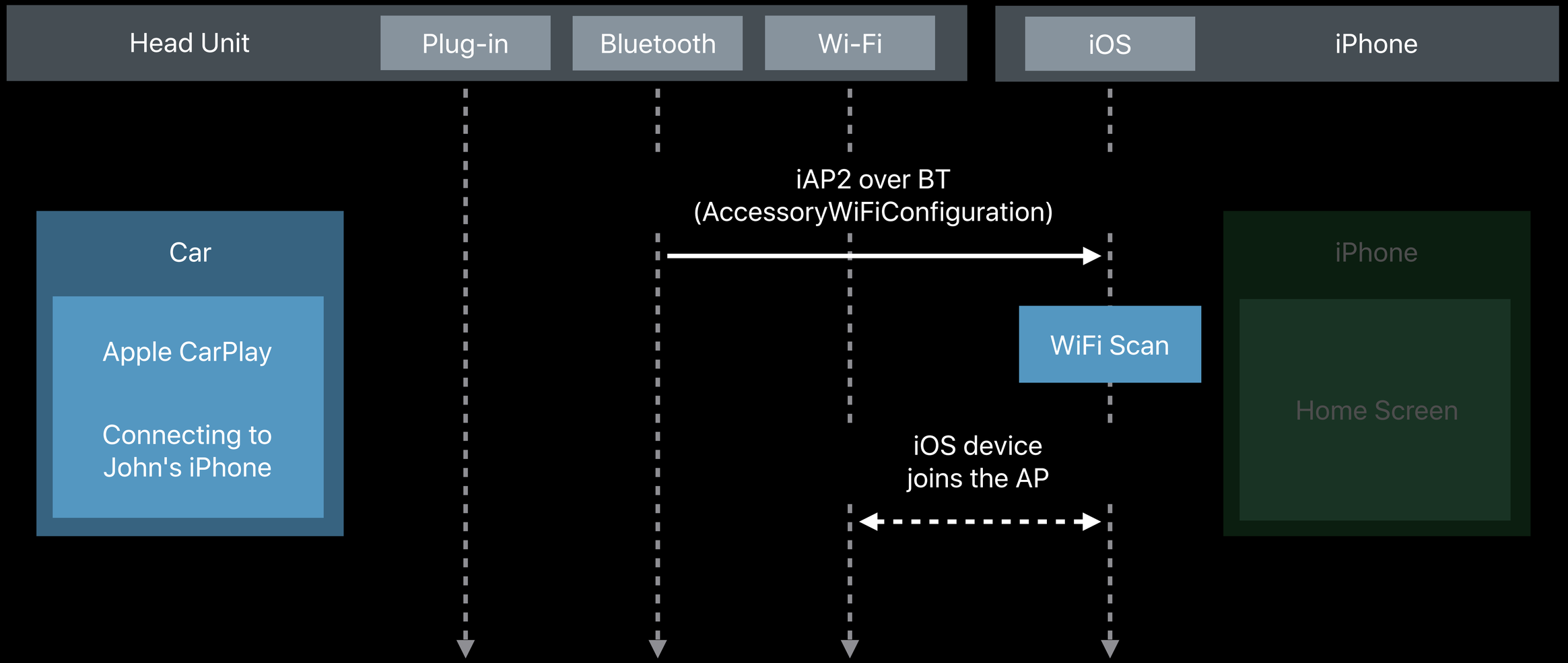
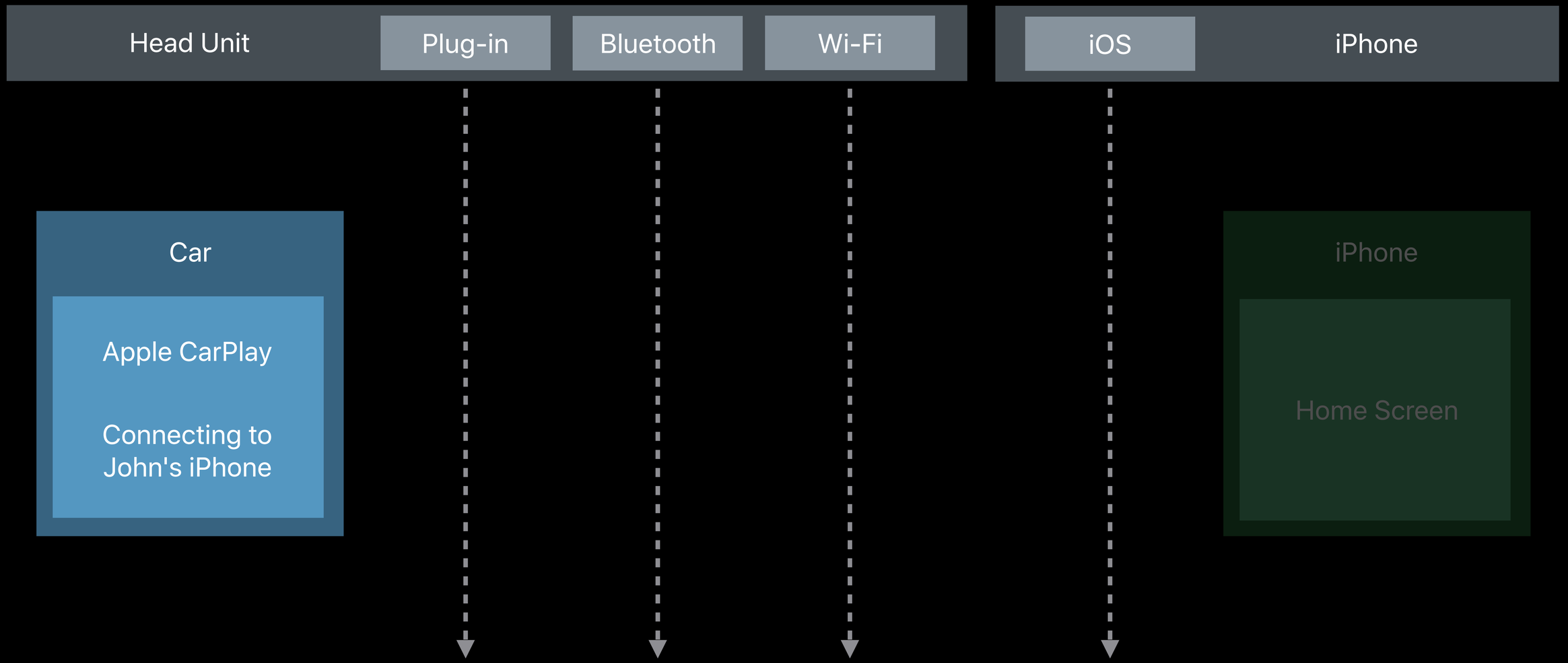


Selecting a CarPlay Device



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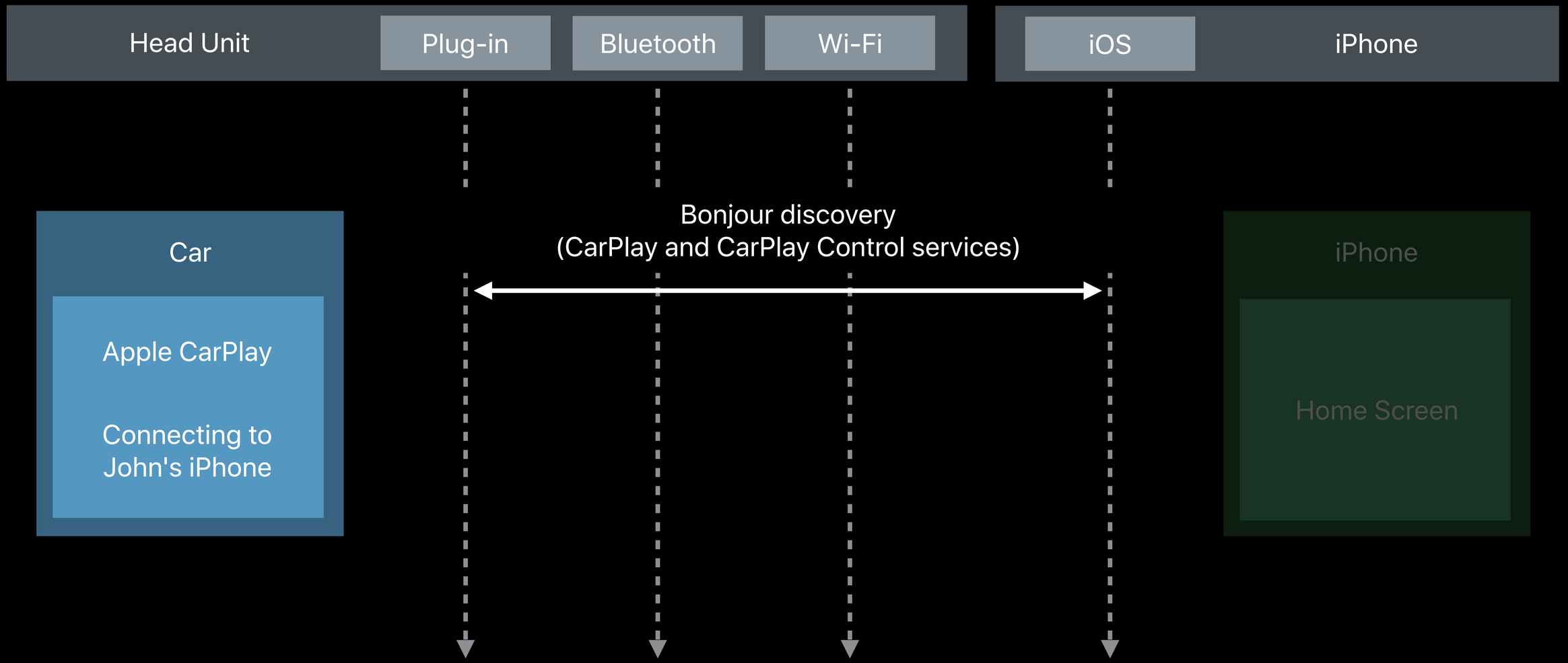

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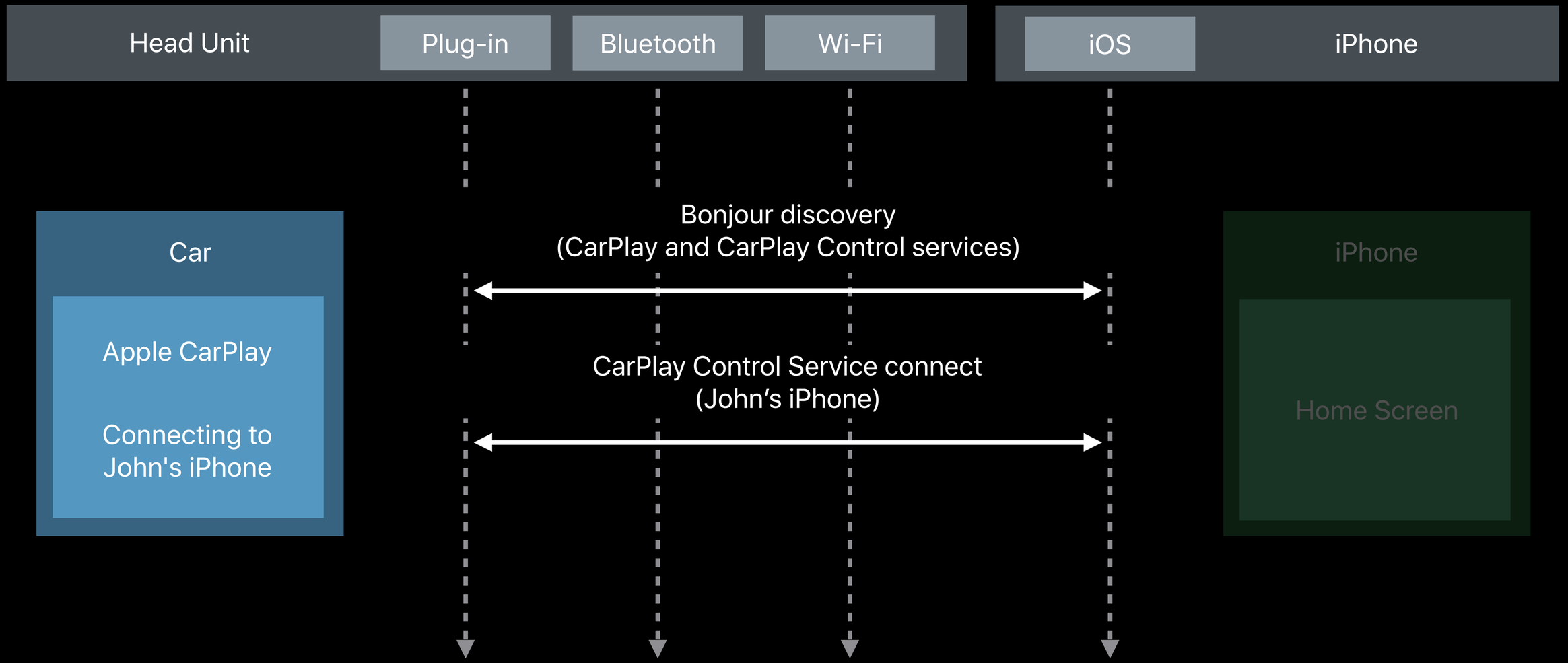
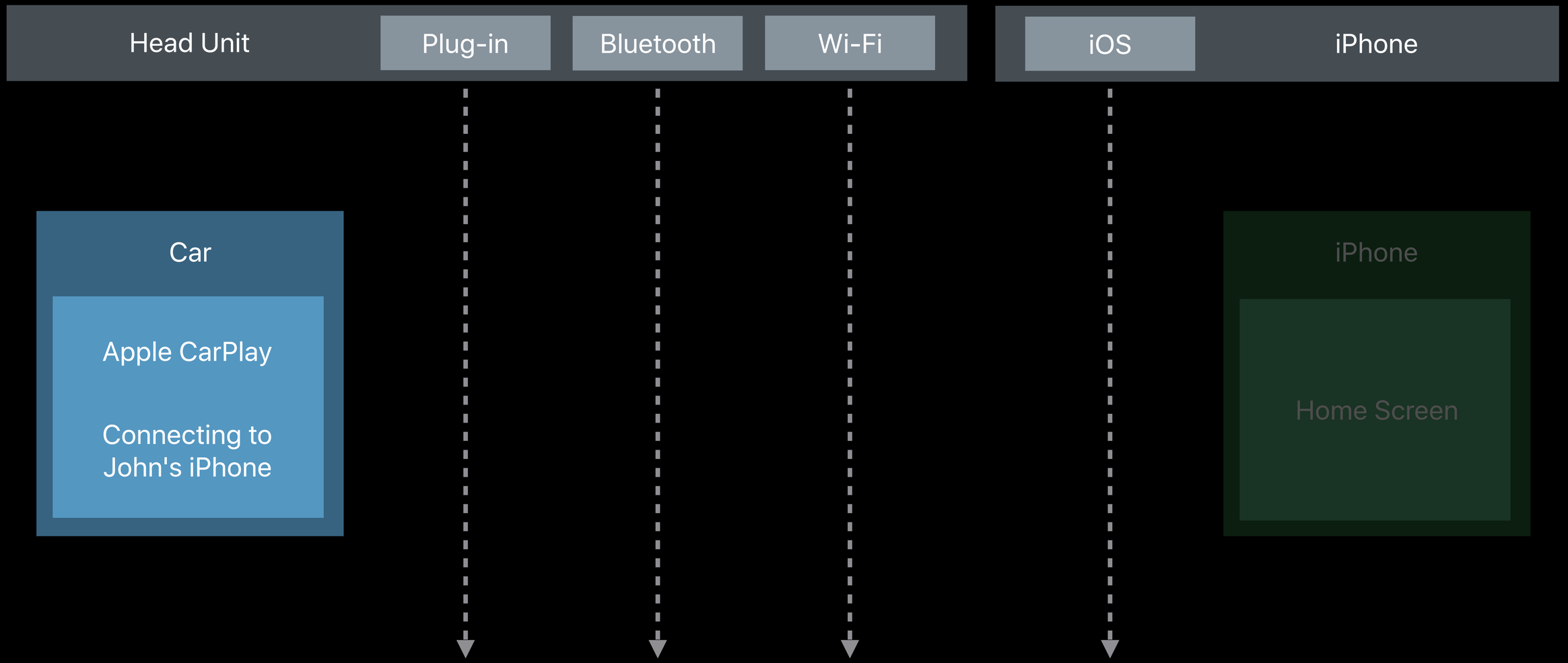


Starting a CarPlay Session



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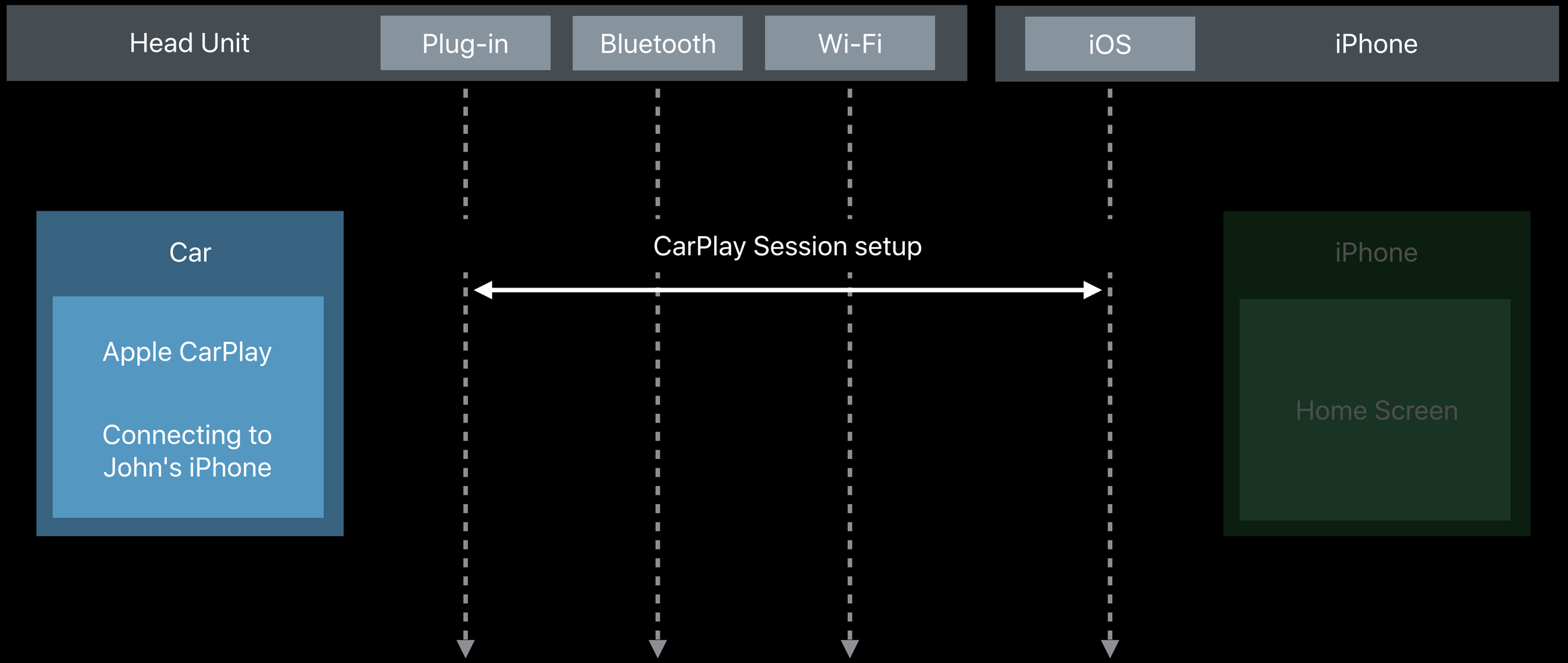

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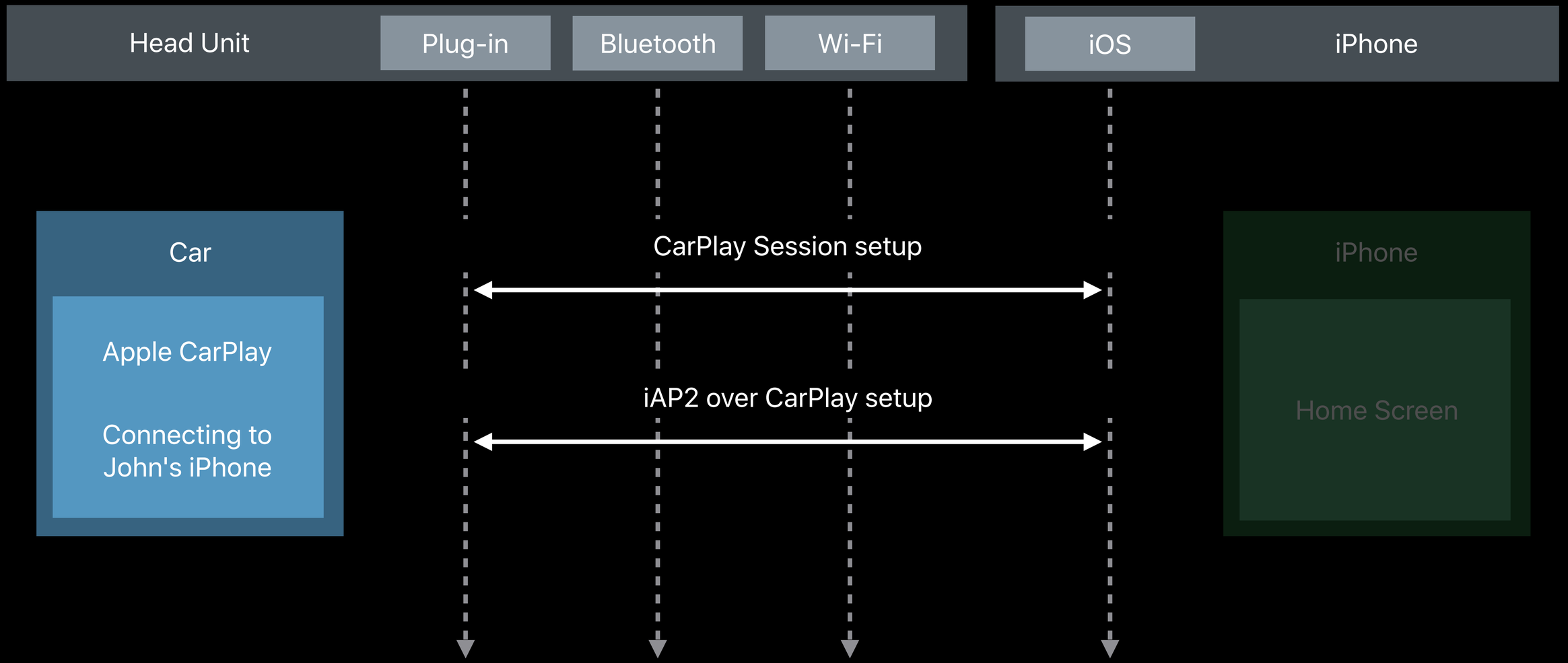
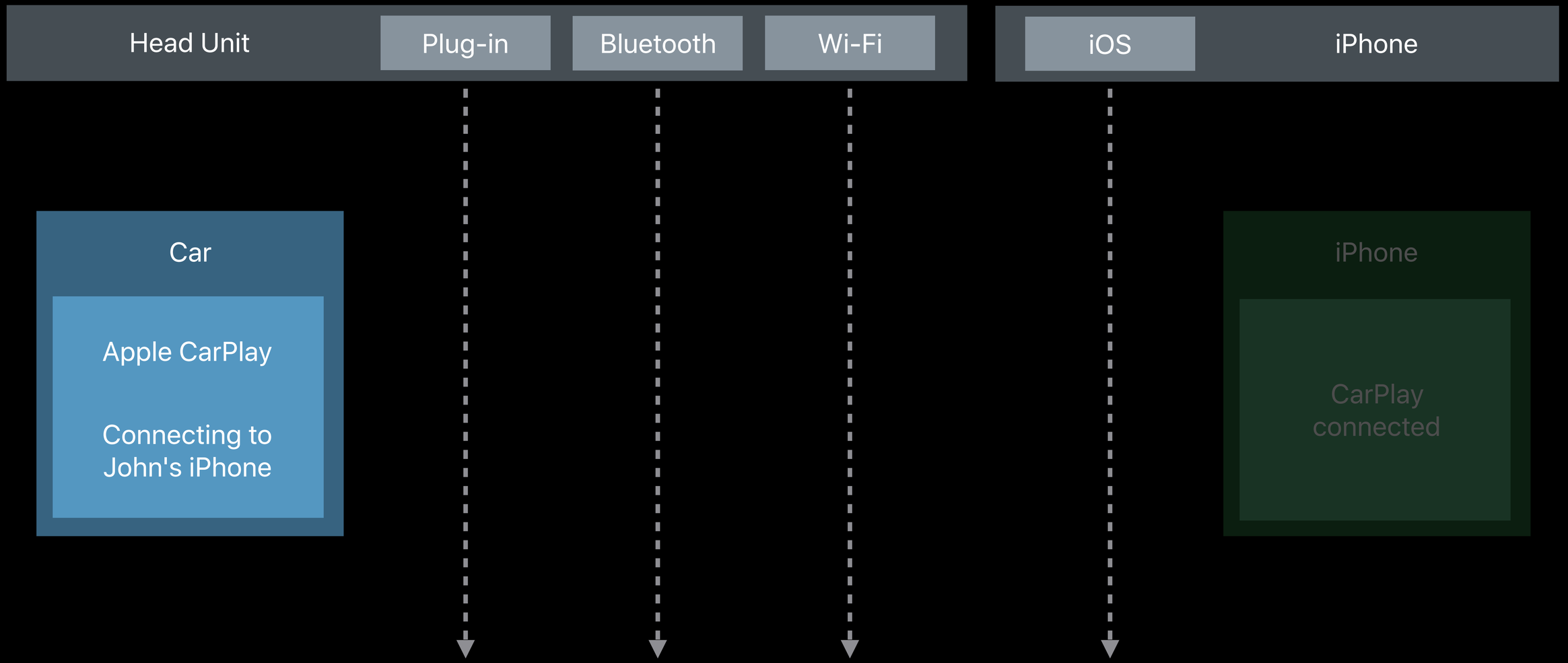
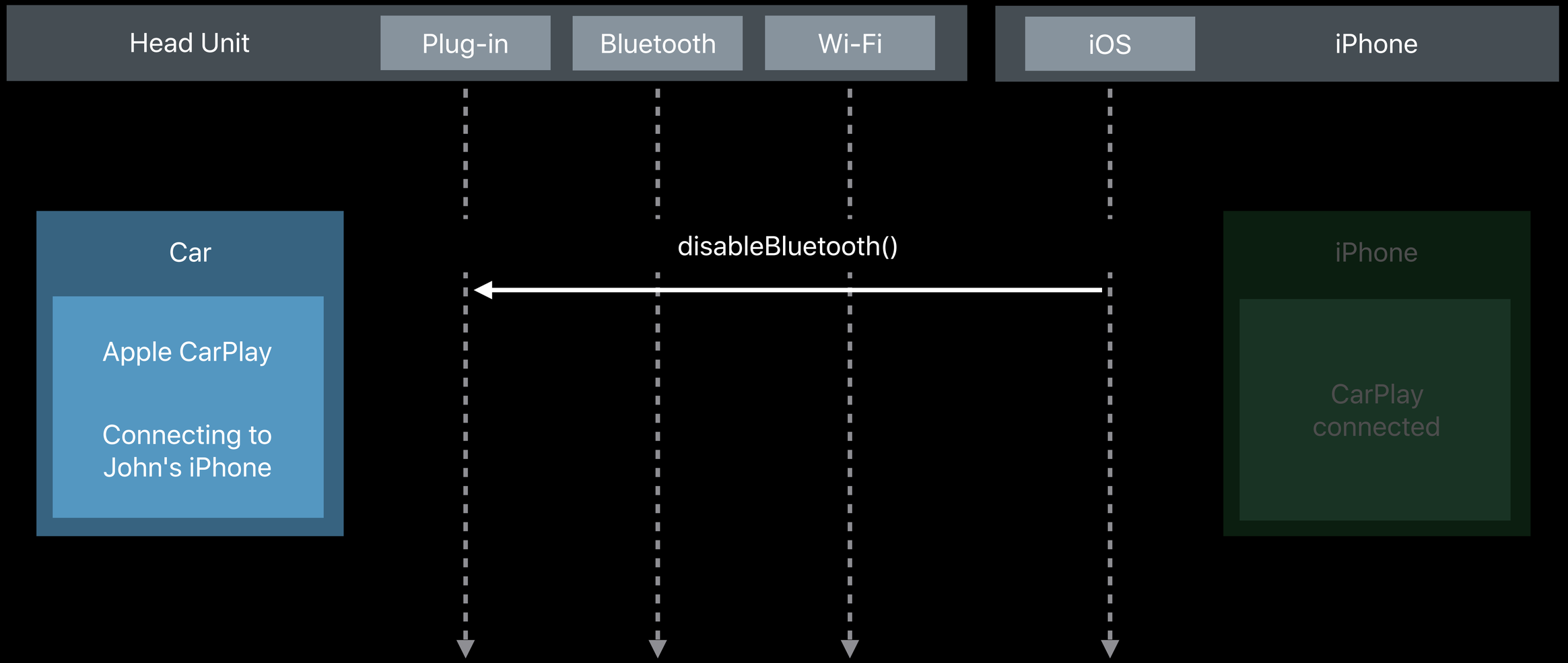


Starting a CarPlay Session



Starting a CarPlay Session



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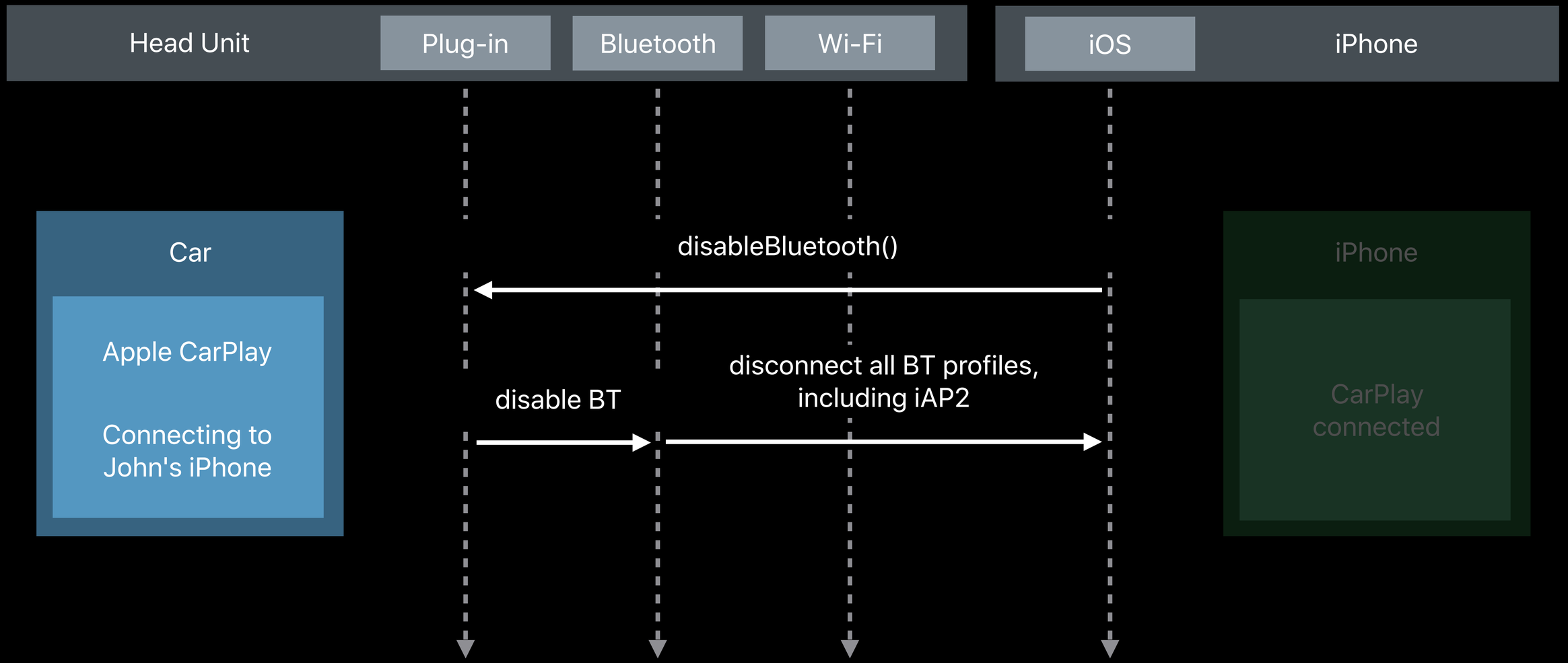

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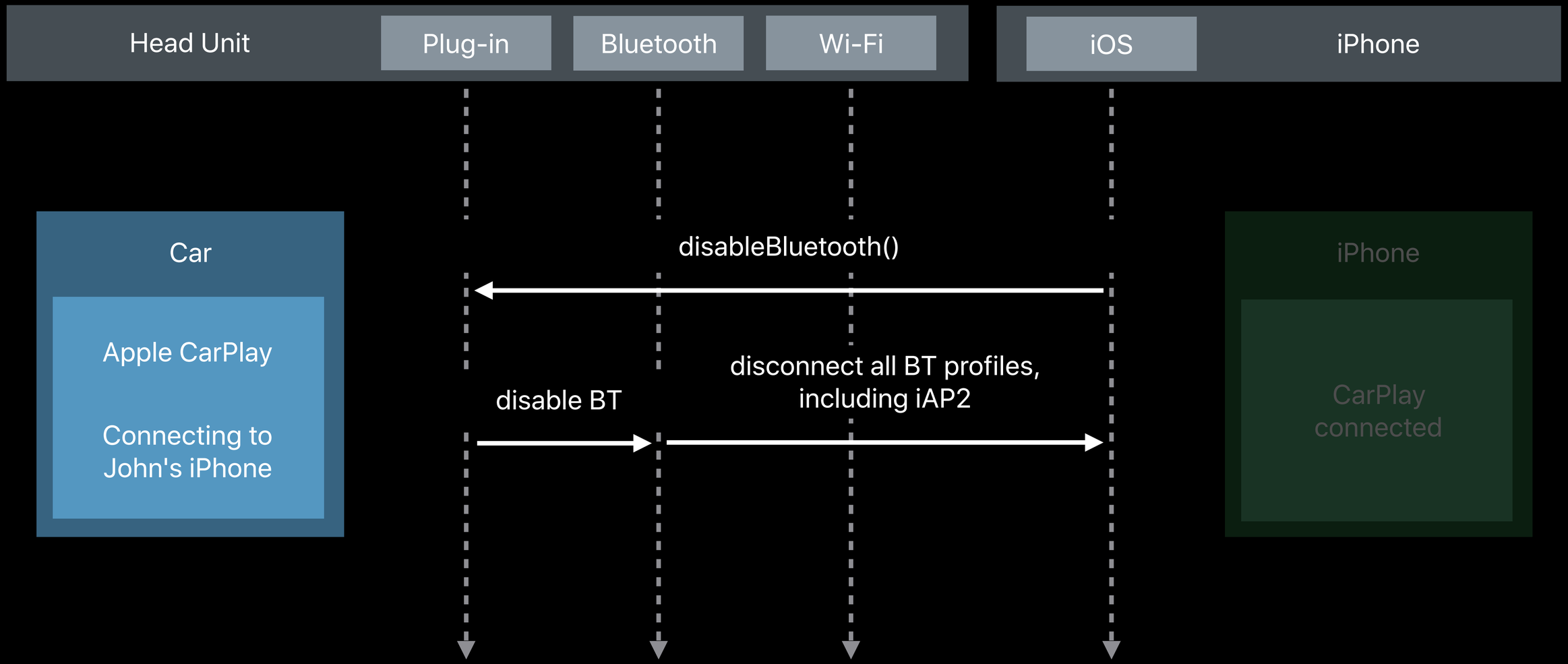
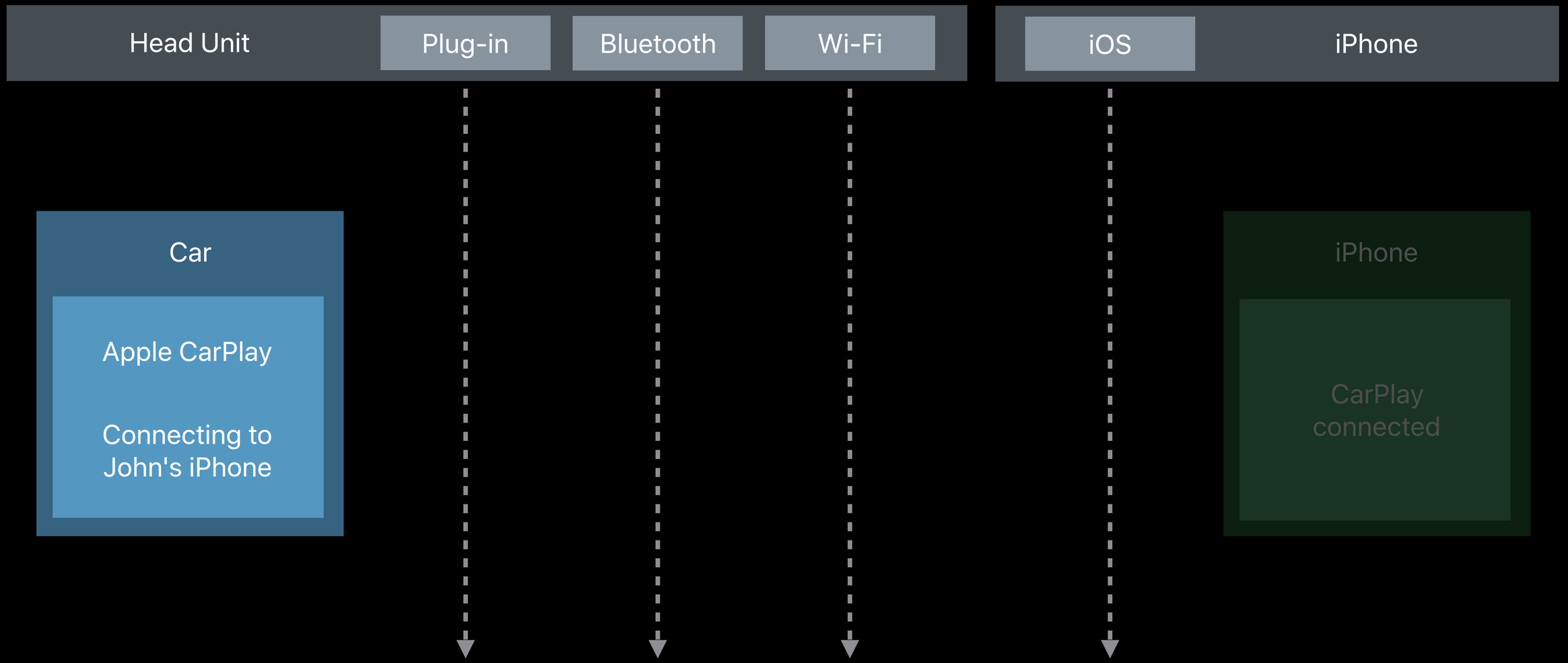


If operating in 2.4 GHz band, disallow all Bluetooth connections and scanning

Starting a CarPlay Session



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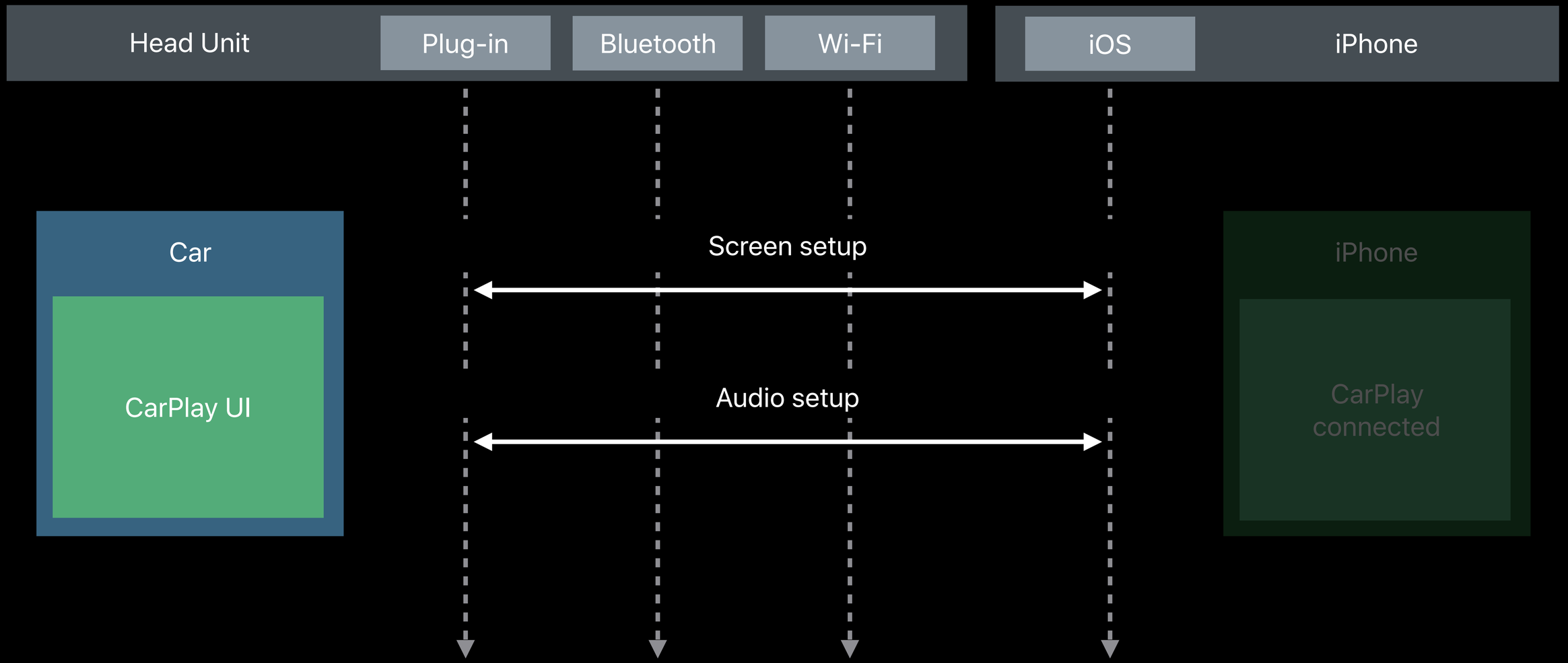

Setup and Pairing

General considerations

Setup and Pairing

General considerations

After setup is complete, the CarPlay UI must be displayed

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CarPlay may request to play music playback after setup is complete

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Store device as last connected device

Setup and Pairing

General considerations

After setup is complete, the CarPlay UI must be displayed

CarPlay may request to play music playback after setup is complete

Store device as last connected device

- Reconnect automatically when user returns to the car

Developing Wireless CarPlay Systems

Hardware requirements

Setup and pairing

Reconnecting

Wireless considerations

Developing Wireless CarPlay Systems

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Wireless considerations

Reconnecting

General considerations

Reconnecting

General considerations

On ignition, arbitrate between USB and wireless reconnection

Reconnecting

General considerations

On ignition, arbitrate between USB and wireless reconnection

Transport used for CarPlay depends on availability and connection sequence

Reconnecting

General considerations

On ignition, arbitrate between USB and wireless reconnection

Transport used for CarPlay depends on availability and connection sequence

Always check for CarPlay availability on device

Reconnecting

General considerations

On ignition, arbitrate between USB and wireless reconnection

Transport used for CarPlay depends on availability and connection sequence

Always check for CarPlay availability on device

After reconnection restore last user mode

Reconnecting

General considerations

On ignition, arbitrate between USB and wireless reconnection

Transport used for CarPlay depends on availability and connection sequence

Always check for CarPlay availability on device

After reconnection restore last user mode

Don’t interrupt active CarPlay session

Reconnecting

Common scenarios

Reconnecting

Common scenarios

Reconnecting

Common scenarios

When is iPhone plugged in?	Common scenario	Transport used for CarPlay

Reconnecting

Common scenarios

	When is iPhone plugged in?	Common scenario	Transport used for CarPlay
Single iPhone			

Reconnecting

Common scenarios

	When is iPhone plugged in?	Common scenario	Transport used for CarPlay
Single iPhone	Never	Morning commute	Wireless

Reconnecting

Common scenarios

	When is iPhone plugged in?	Common scenario	Transport used for CarPlay
Single iPhone	Never	Morning commute	Wireless
	During drive	Charging during evening commute	Wireless

Reconnecting

Common scenarios

	When is iPhone plugged in?	Common scenario	Transport used for CarPlay
Single iPhone	Never	Morning commute	Wireless
	During drive	Charging during evening commute	Wireless
	Before ignition	Re-entering car at gas station	USB

Reconnecting

Common scenarios

	When is iPhone plugged in?	Common scenario	Transport used for CarPlay
Single iPhone	Never	Morning commute	Wireless
	During drive	Charging during evening commute	Wireless
	Before ignition	Re-entering car at gas station	USB
	When the driver sits down	Long trip	First available

Reconnecting

Common scenarios

	When is iPhone plugged in?	Common scenario	Transport used for CarPlay
Single iPhone	Never	Morning commute	Wireless
	During drive	Charging during evening commute	Wireless
	Before ignition	Re-entering car at gas station	USB
	When the driver sits down	Long trip	First available
More than one iPhone			

Reconnecting

Common scenarios

	When is iPhone plugged in?	Common scenario	Transport used for CarPlay
Single iPhone	Never	Morning commute	Wireless
	During drive	Charging during evening commute	Wireless
	Before ignition	Re-entering car at gas station	USB
	When the driver sits down	Long trip	First available
More than one iPhone	When the driver sits down	Road trip with friends	First available

Reconnecting

Bluetooth device connection flow

Reconnecting

Bluetooth device connection flow

Wait for Bluetooth and Wi-Fi to boot up

Reconnecting

Bluetooth device connection flow

Wait for Bluetooth and Wi-Fi to boot up

Confirm last connected device is a CarPlay device

Reconnecting

Bluetooth device connection flow

Wait for Bluetooth and Wi-Fi to boot up

Confirm last connected device is a CarPlay device

Confirm CarPlay is not already active

Reconnecting

Bluetooth device connection flow

Wait for Bluetooth and Wi-Fi to boot up

Confirm last connected device is a CarPlay device

Confirm CarPlay is not already active

- Compare to saved `DeviceTransportIdentifier`

Reconnecting

Bluetooth device connection flow

Wait for Bluetooth and Wi-Fi to boot up

Confirm last connected device is a CarPlay device

Confirm CarPlay is not already active

- Compare to saved `DeviceTransportIdentifier`

Reconnect iAP2 over Bluetooth

Reconnecting

Bluetooth device connection flow

Wait for Bluetooth and Wi-Fi to boot up

Confirm last connected device is a CarPlay device

Confirm CarPlay is not already active

- Compare to saved `DeviceTransportIdentifier`

Reconnect iAP2 over Bluetooth

Confirm CarPlay is available using `WirelessCarPlayUpdate`

Reconnecting

Bluetooth device connection flow

Wait for Bluetooth and Wi-Fi to boot up

Confirm last connected device is a CarPlay device

Confirm CarPlay is not already active

- Compare to saved `DeviceTransportIdentifier`

Reconnect iAP2 over Bluetooth

Confirm CarPlay is available using `WirelessCarPlayUpdate`

Wait for CarPlay control discovery and connect

Reconnecting

USB device connection flow

Reconnecting

USB device connection flow

Wait for the user to connect a device over USB

Reconnecting

USB device connection flow

Wait for the user to connect a device over USB

Confirm CarPlay is not already active

Reconnecting

USB device connection flow

Wait for the user to connect a device over USB

Confirm CarPlay is not already active

- Compare to saved `DeviceTransportIdentifier`

Reconnecting

USB device connection flow

Wait for the user to connect a device over USB

Confirm CarPlay is not already active

- Compare to saved `DeviceTransportIdentifier`

Confirm CarPlay is available on the device

Reconnecting

USB device connection flow

Wait for the user to connect a device over USB

Confirm CarPlay is not already active

- Compare to saved `DeviceTransportIdentifier`

Confirm CarPlay is available on the device

- USB Vendor Request `GetSupportedCapabilities`

Reconnecting

USB device connection flow

Wait for the user to connect a device over USB

Confirm CarPlay is not already active

- Compare to saved `DeviceTransportIdentifier`

Confirm CarPlay is available on the device

- USB Vendor Request `GetSupportedCapabilities`

USB Role Switch and iAP2 over USB

Reconnecting

USB device connection flow

Wait for the user to connect a device over USB

Confirm CarPlay is not already active

- Compare to saved `DeviceTransportIdentifier`

Confirm CarPlay is available on the device

- USB Vendor Request `GetSupportedCapabilities`

USB Role Switch and iAP2 over USB

Wait for CarPlay control discovery and connect

Reconnecting

Reconnecting

Multiple devices may be available

Reconnecting

Multiple devices may be available

- USB only

Reconnecting

Multiple devices may be available

- USB only
- Wireless only

Reconnecting

Multiple devices may be available

- USB only
- Wireless only
- Both USB and wireless

Reconnecting

Multiple devices may be available

- USB only
- Wireless only
- Both USB and wireless

Users can choose any available device

Reconnecting

Multiple devices may be available

- USB only
- Wireless only
- Both USB and wireless

Users can choose any available device

- Reconnect using available transport

Reconnecting after Disconnect

Reconnecting after Disconnect

Scenario	Expected car behavior

Reconnecting after Disconnect

Scenario	Expected car behavior
Explicit disconnect	

Reconnecting after Disconnect

	Scenario	Expected car behavior
Explicit disconnect	User unplugs USB	
	User disconnects using native UI	

Reconnecting after Disconnect

	Scenario	Expected car behavior
Explicit disconnect	User unplugs USB	No reconnect attempt
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Reconnecting after Disconnect

	Scenario	Expected car behavior
Explicit disconnect	User unplugs USB	No reconnect attempt
	User disconnects using native UI	
iPhone no longer reachable		

Reconnecting after Disconnect

	Scenario	Expected car behavior
Explicit disconnect	User unplugs USB	No reconnect attempt
	User disconnects using native UI	
iPhone no longer reachable	User walks away from car	
	User turns off Wi-Fi on iPhone	

Reconnecting after Disconnect

	Scenario	Expected car behavior
Explicit disconnect	User unplugs USB	No reconnect attempt
	User disconnects using native UI	
iPhone no longer reachable	User walks away from car	Reconnect using CarPlay Control API, but if unsuccessful reconnect Bluetooth
	User turns off Wi-Fi on iPhone	

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Wireless performance depends on various characteristics

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Wireless performance depends on various characteristics

- Wi-Fi protocol (802.11n or 802.11ac)

Wireless Considerations

Wireless performance depends on various characteristics

- Wi-Fi protocol (802.11n or 802.11ac)
- Configuration (SISO or MIMO)

Wireless Considerations

Wireless performance depends on various characteristics

- Wi-Fi protocol (802.11n or 802.11ac)
- Configuration (SISO or MIMO)
- Frequency band (2.4 GHz or 5 GHz)

Wireless Considerations

Wireless performance depends on various characteristics

- Wi-Fi protocol (802.11n or 802.11ac)
- Configuration (SISO or MIMO)
- Frequency band (2.4 GHz or 5 GHz)
- Presence of other wireless technologies in same frequency band

Wireless Considerations

Wireless performance depends on various characteristics

- Wi-Fi protocol (802.11n or 802.11ac)
- Configuration (SISO or MIMO)
- Frequency band (2.4 GHz or 5 GHz)
- Presence of other wireless technologies in same frequency band
- Additional services (Internet data or others)

Wireless Considerations

Wireless performance depends on various characteristics

- Wi-Fi protocol (802.11n or 802.11ac)
- Configuration (SISO or MIMO)
- Frequency band (2.4 GHz or 5 GHz)
- Presence of other wireless technologies in same frequency band
- Additional services (Internet data or others)

Satisfy throughput and latency requirements in all possible coexistence scenarios

5 GHz Frequency Band

5 GHz Frequency Band

Highly recommended for wireless CarPlay

5 GHz Frequency Band

Highly recommended for wireless CarPlay

More channels for wireless usage

5 GHz Frequency Band

Highly recommended for wireless CarPlay

More channels for wireless usage

Less interference from other wireless systems

5 GHz Frequency Band

Highly recommended for wireless CarPlay

More channels for wireless usage

Less interference from other wireless systems

Less congested

2.4 GHz Frequency Band

2.4 GHz Frequency Band

Not recommended for wireless CarPlay

Highly congested

May be required for in-vehicle use in some regulatory domains

2.4 GHz Frequency Band

Not recommended for wireless CarPlay

Highly congested

May be required for in-vehicle use in some regulatory domains

If operating in this frequency band

2.4 GHz Frequency Band

Not recommended for wireless CarPlay

Highly congested

May be required for in-vehicle use in some regulatory domains

If operating in this frequency band

- Disable Bluetooth scanning and reconnections during active CarPlay sessions

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- If providing LTE connectivity on Band 40, use channels 6 or 11

Multiple Wi-Fi Access Points

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Use different channels if operating in same frequency band

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Provide same services on all access points with same SSID and password

- Use different SSID and password if offering different services

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Don’t use hidden SSIDs for CarPlay

Internet Data Connectivity

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Communicate status of Internet data connectivity

- Apple Device IE
- Interworking IE

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- Module installed or removed
- Connectivity no longer possible due to a failure
- Service contract expired or renewed

More Information

http://developer.apple.com/wwdc17/717

Related Sessions

Enabling Your App for CarPlay	WWDC 2017 Video
Developing CarPlay Systems, Part 1	WWDC 2016
Developing CarPlay Systems, Part 2	WWDC 2016

Labs

CarPlay Lab	Technology Lab D	Wed 4:00PM–6:00PM

WWDC17