Developing CarPlay Systems, Part 2

Session 723

Tanya Kancheva CarPlay Engineering
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Resource Management
Application State Management
System Overview
System Overview

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- Video
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System Overview

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- iAP2
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Location information
Hardware and system resources

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Speakers  Microphone  User Inputs  Center Display  Steering Wheel Inputs  Instrument Cluster  Location Information

Native sub-system

Audio  User Interface  User Input

CarPlay sub-system

Audio  User Interface (video)  User Input  iAP2
User interface and user input

Hardware and system resources

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Microphone
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Hardware and system resources

Native sub-system

User Input

CarPlay sub-system

User Input  iAP2

Instrument Cluster
Hardware and system resources

Audio

Instrument Cluster

Native sub-system

Audio
User Input

CarPlay sub-system

Audio
User Input
iAP2
Hardware and system resources

Audio

Phone and VR

Instrument Cluster

Native sub-system

Audio

User Input

CarPlay sub-system

Audio

User Input

iAP2
Hardware and system resources

Audio

Phone and VR
Media

Instrument Cluster

22°C

Phone
Radio
CD
Navi
Climate
Car
Settings
Apple-CarPlay

Native sub-system

User Input

CarPlay sub-system

User Input

iAP2
Hardware and system resources

Audio
- Phone and VR
- Media
- Alerts

Instrument Cluster

Native sub-system
- Audio
- Phone, VR audio
- User Input

CarPlay sub-system
- Audio
- User Input
- iAP2
Hardware and system resources

Audio

Phone and VR
Media
Alerts

Instrument Cluster

Native sub-system

User Input
Phone, VR audio
Media audio

CarPlay sub-system

User Input
iAP2

Audio

Media audio

Phone and VR

Video

Alerts

User Input

iAP2
Hardware and system resources

Audio
- Phone and VR
- Media
- Alerts

Instrument Cluster

Native sub-system
- Audio
  - Phone, VR audio
  - Media audio
  - User alert audio
- User Input

CarPlay sub-system
- Audio
- User Input
- iAP2
Audio

Hardware and system resources

- Phone and VR audio
- Media audio
- User alert audio

User Input

Native sub-system

CarPlay sub-system

- Main audio
- User Input
- iAP2

Instrument Cluster

Temperature 22°C
- Phone
- Radio
- CD
- Climate
- Car
- Settings
- Apple CarPlay
- Navi
Hardware and system resources

Native sub-system

Audio
- Phone and VR audio
- Media audio
- User alert audio
- User Input

CarPlay sub-system

Audio
- Main audio
- Alternate audio
- User Input
- iAP2

Instrument Cluster

Phone, VR audio

Media audio

User alert audio

User Input

Audio

Alerts
Audio

User Input

Native sub-system

Phone, VR audio
Media audio
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User Input

CarPlay sub-system

Main audio
Alternate audio
User Input
iAP2

Hardware and system resources
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User Input

Native sub-system

Phone and VR audio
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CarPlay sub-system
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Phone call audio

Hardware and system resources

22°C
Phone
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Apple CarPlay

Instrument Cluster
Audio

User Input

Native sub-system

Phone and VR

Media

Alerts

Hardware and system resources

Instrument Cluster

Phone call metadata

Phone call

Metadata

iAP2

CarPlay sub-system

Main audio

Alternate audio

User Input

User alert audio

Audio

Phone, VR audio

Media

User Input
Volume Management
What can I help you with?

Voice

Volume
Ringtone

Volume
Jackie and Wilson
Hozier - Hozier

Media

Volume
Resource Management
Resource Management

Managed Resources
Resource Manager
Resource Management Commands
Examples
Managed Resources
# Managed Resources

Two resources are coordinated

<table>
<thead>
<tr>
<th>mainScreen</th>
<th>Access to center display in car</th>
</tr>
</thead>
<tbody>
<tr>
<td>mainAudio</td>
<td>Access to speakers and microphone in car</td>
</tr>
</tbody>
</table>
# Managed Resources

Use for limited or undetermined periods of time

<table>
<thead>
<tr>
<th>Action</th>
<th>Description</th>
</tr>
</thead>
</table>
| take   | Use for undetermined period of time  
Resource owner changes permanently |
| borrow | Use for limited period of time  
Resource owner transferred temporarily until action completes  
When action completes, resource returns to previous owner |
Main Screen
Native user interface takes the display
Main Screen
Native user interface takes the display

Native UI takes the display when the user
• Presses a hard key linked to the native UI
• Presses the OEM icon in CarPlay
• Activates a feature using the native voice recognizer
Main Screen

Native user interface takes the display
Main Screen
Native user interface takes the display
Main Screen

CarPlay takes the display
Main Screen
CarPlay takes the display

CarPlay takes the display when the user

• Presses a hard key linked to CarPlay
• Selects the CarPlay button in the native UI
• Uses Siri to launch an application
  - For example “Open Maps”
Main Screen

Borrowing the display

Borrow the display for applications with limited duration
Main Screen
Borrowing the display

Borrow the display for applications with limited duration

• Phone calls
• Siri or native voice recognition
• Notifications
• Alerts
Main Screen
Native user interface owns the display
Main Screen

Native user interface owns the display
Main Screen
Native user interface owns the display
Main Screen
Display is returned to the native user interface
Main Audio

Distributes hardware resources based on audio type
Main Audio

Distributes hardware resources based on audio type

<table>
<thead>
<tr>
<th>Audio type</th>
<th>Hardware resource</th>
<th>Application</th>
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Main Audio

Distributes hardware resources based on audio type

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<tr>
<td>speechRecognition</td>
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## Main Audio

Distributes hardware resources based on audio type

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<tr>
<td>telephony</td>
<td>Speakers and microphone</td>
<td>Phone calls</td>
</tr>
<tr>
<td>default</td>
<td>Speakers and microphone</td>
<td>Undefined</td>
</tr>
</tbody>
</table>
Alternate Audio

Not a managed resource

Audio played over `alternateAudio`

- Maps turn-by-turn announcements
- New message alerts

Always mixed with content playing through the in-car speakers over `mainAudio`
Resource Manager

Tom Powell CarPlay Engineering
Resource Manager
Two systems need to manage access to screen and audio
Resource Manager
Arbitrates the access to the resources
Resource Manager

Responsibilities

Holds current state
Follows strict set of rules
Assigns resources
Resource Manager
Handling requests for resources
Resource Manager
Handling requests for resources
Resource Manager

Handling requests for resources

- Check state
- Assign resource
- Set new state
Resource Manager
Handling requests for resources
Resource Manager

Handling requests for resources

State changes should only be triggered by the resource manager

Resource Manager

Notify new screen owner
Resource Manager

Implement in native or CarPlay sub-system?
Resource Manager

Implement in native or CarPlay sub-system?
Resource Manager

iPhone is referred to as the “controller”
Head unit is referred to as the “accessory”
Same rules apply to both native and CarPlay applications
Resource Management Commands
## Commands for Managing Resources

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
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<tr>
<td><code>changeModes</code></td>
<td>Request or release resources</td>
</tr>
<tr>
<td><code>modesChanged</code></td>
<td>Notification that state changed</td>
</tr>
</tbody>
</table>
Request or Release Resources
Sent from head unit to controller
Request or Release Resources
Sent from head unit to controller

changeModes
Request or Release Resources
changeModes

States what the accessory intends to do with the resources
Declares why the head unit needs the resources
If the resource is transferred, it defines who can get access to it from the new owner
Notification that Resource Owner Changed
Sent from controller to head unit
Notification that Resource Owner Changed
Sent from controller to head unit

modesChanged
Notification that Resource Owner Changed

modesChanged

States the current owner of the managed resources
Sent when there is a state change
Examples
Examples

Play FM radio
Use native voice recognition
Show backup camera
Ask Siri to play music
Examples

- Play FM radio
- Use native voice recognition
- Show backup camera
- Ask Siri to play music
Play FM Radio
Play FM Radio

iPhone audio playing
Play FM Radio

iPhone audio playing
Play FM Radio

iPhone audio playing
Play FM Radio
Request to take the audio resource indefinitely

 iPhones audio playing
Play FM Radio
Request to take the audio resource indefinitely

 iPhones audio playing

{ resource: mainAudio, transferType: take }

 changeModes
Play FM Radio
Request to take the audio resource indefinitely

- iPhone audio playing

```javascript
{ resource: mainAudio,
  transferType: take
}
```
Play FM Radio

Audio resource is assigned to the head unit

 iPhones audio playing
Play FM Radio

Audio resource is assigned to the head unit

modesChanged

{ resource: mainAudio,
  owner: accessory }

iPhone audio playing
Play FM Radio
Audio resource is assigned to the head unit

iPhone audio playing

```javascript
{ resource: mainAudio,
  owner: accessory }
```
Play FM Radio
Play FM Radio

FM radio playing
Take Resources

Take resources for actions that last an undetermined period of time.
Resource owner changes permanently.
Don’t use resources when not the owner.
Examples

Play FM radio
Use native voice recognition
Show backup camera
Ask Siri to play music
Examples

- Play FM radio
- Use native voice recognition
- Show backup camera
- Ask Siri to play music
Use Native Voice Recognition
Use Native Voice Recognition

FM radio playing
Use Native Voice Recognition

FM radio playing
Use Native Voice Recognition

FM radio playing
Use Native Voice Recognition
Borrow audio and screen for duration of voice dialog

FM radio playing
Use Native Voice Recognition
Borrow audio and screen for duration of voice dialog

FM radio playing

changeModes

{ resource: mainAudio, transferType: borrow }
{ resource: mainScreen, transferType: borrow }
Use Native Voice Recognition

Borrow audio and screen for duration of voice dialog

FM radio playing

changeModes

{ resource: mainAudio,
  transferType: borrow }  
{ resource: mainScreen,
  transferType: borrow }
Use Native Voice Recognition

Audio and screen are assigned to head unit

FM radio playing
Use Native Voice Recognition

Audio and screen are assigned to head unit

FM radio playing

modesChanged

{ resource: mainAudio, owner: accessory }
{ resource: mainScreen, owner: accessory }
Use Native Voice Recognition

Audio and screen are assigned to head unit

FM radio playing

modesChanged

{ resource: mainAudio, owner: accessory }

{ resource: mainScreen, owner: accessory }
Use Native Voice Recognition
Use Native Voice Recognition
Use Native Voice Recognition

Return resources when finished

Native voice recognition
Use Native Voice Recognition
Return resources when finished

Native voice recognition

{ resource: mainAudio,
  transferType: unborrow }
{ resource: mainScreen,
  transferType: unborrow }

changeModes
Use Native Voice Recognition

Return resources when finished

Native voice recognition

```json
{ resource: mainAudio,  
  transferType: unborrow }
{ resource: mainScreen,  
  transferType: unborrow }
```
Use Native Voice Recognition

Resources are returned to the head unit
Use Native Voice Recognition

Resources are returned to the head unit

Native voice recognition

modesChanged

{ resource: mainAudio, owner: accessory }
{ resource: mainScreen, owner: accessory }
Use Native Voice Recognition

Resources are returned to the head unit

Native voice recognition

modesChanged

{ resource: mainAudio,
  owner: accessory }

{ resource: mainScreen,
  owner: accessory }
Use Native Voice Recognition
Use Native Voice Recognition

FM radio playing
Borrow Resources

Borrow resources for temporary actions

When action completes, resource returns to previous owner

Always borrow resources even if you are already the owner, since priorities may have changed
Examples

Play FM radio
Use native voice recognition
Show backup camera
Ask Siri to play music
Examples

Play FM radio
Use native voice recognition
Show backup camera
Ask Siri to play music
Show Backup Camera
Show Backup Camera

iPhone audio playing
Show Backup Camera
State that the screen can never be assigned to anyone else

iPhone audio playing
Show Backup Camera
State that the screen can never be assigned to anyone else

{ resource: mainScreen, transferType: borrow, borrowConstraint: never }
Show Backup Camera

State that the screen can never be assigned to anyone else

```javascript
{ resource: mainScreen,
  transferType: borrow,
  borrowConstraint: never }
```
Show Backup Camera

iPhone audio playing
Show Backup Camera

iPhone audio playing

{ resource: mainScreen,
  owner: accessory }

modesChanged
Show Backup Camera

iPhone audio playing

modesChanged

{ resource: mainScreen,
  owner: accessory }
Show Backup Camera

iPhone audio playing
Show Backup Camera

CarPlay does not appear if head unit constrains access
Show Backup Camera

CarPlay does not appear if head unit constrains access

Ringtone playing
Define the Constraints

Define the rules while you are the owner

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>anytime</td>
<td>Allow any application to get access</td>
</tr>
<tr>
<td>user-initiated</td>
<td>Allow only user-initiated applications to get access</td>
</tr>
<tr>
<td>never</td>
<td>Do not let any application get access</td>
</tr>
</tbody>
</table>
Define the Constraints
Define the rules while you are the owner

When taking resources, make sure to define both take constraints and borrow constraints.
When borrowing resources, only define borrow constraints.
In most cases use **anytime**, unless the native user interface needs immediate attention.
Examples

- Play FM radio
- Use native voice recognition
- Show backup camera
- Ask Siri to play music
Examples

Play FM radio
Use native voice recognition
Show backup camera
Ask Siri to play music
Ask Siri to Play Music
Ask Siri to Play Music

FM radio playing
Ask Siri to Play Music

FM radio playing
Ask Siri to Play Music

FM radio playing
Ask Siri to Play Music

Siri has been assigned resources and head unit is notified

FM radio playing
Ask Siri to Play Music

Siri has been assigned resources and head unit is notified

FM radio playing

```
{ resource: mainAudio, owner: controller }
{ resource: mainScreen, owner: controller }
```
Ask Siri to Play Music

Siri has been assigned resources and head unit is notified

FM radio playing

```json
{ resource: mainAudio,
  owner: controller }
{ resource: mainScreen,
  owner: controller }
```
Ask Siri to Play Music
Ask Siri to Play Music

Siri active

“What, play some music”
Ask Siri to Play Music

Siri ends, music playback starts and head unit is notified
Ask Siri to Play Music
Siri ends, music playback starts and head unit is notified

Siri active

```javascript
{ resource: mainAudio, owner: controller }
{ resource: mainScreen, owner: accessory }
```
Ask Siri to Play Music
Siri ends, music playback starts and head unit is notified

Siri active

modesChanged

{ resource: mainAudio,
  owner: controller };

{ resource: mainScreen,
  owner: accessory }
Ask Siri to Play Music
Ask Siri to Play Music

iPhone audio playing
Observe State Changes

State changes may occur at any time

• User actions
• Events on iPhone

After each state change, verify if the owner has changed and honor the new state
Application State Management
Application State Management

Manage applications which have similar features

Route guidance active
- Maps turn-by-turn versus native route guidance

Phone call in progress
- CarPlay phone call versus native phone call

Voice interaction in progress
- Siri versus native voice recognition
## Application State Management

<table>
<thead>
<tr>
<th>appState</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>TurnByTurn</td>
<td>Route guidance active</td>
</tr>
<tr>
<td>PhoneCall</td>
<td>Phone call in progress</td>
</tr>
<tr>
<td>Speech</td>
<td>Voice interaction in progress</td>
</tr>
</tbody>
</table>
Application State Management

Route guidance active
• Maps turn-by-turn versus native route guidance

Phone call in progress
• CarPlay phone call versus native phone call

Voice interaction in progress
• Siri versus native voice recognition
Route Guidance Active
Native navigation starts
Route Guidance Active
Native navigation starts

```
changeModes

{ appState: TurnByTurn
  state: true }
```
Route Guidance Active

Native navigation starts

changeModes

{ appState: TurnByTurn
  state: true }
Route Guidance Active

Turn-by-turn application state assigned to head unit
Route Guidance Active

Turn-by-turn application state assigned to head unit

modesChanged

{ appState: TurnByTurn,
  entity: Accessory }
Route Guidance Active

Turn-by-turn application state assigned to head unit

Native navigation announcements
Route Guidance Active
User sets destination with Apple Maps

Native navigation announcements
Route Guidance Active
User sets destination with Apple Maps

Native navigation announcements

“Siri, take me to the closest coffee shop”
Route Guidance Active

Turn-by-turn application state assigned to controller

modesChanged
Route Guidance Active

Turn-by-turn application state assigned to controller

modesChanged

{ appState: TurnByTurn,
  entity: Controller }
Route Guidance Active
Turn-by-turn application state assigned to controller

```javascript
modesChanged
{
  appState: TurnByTurn,
  entity: Controller
}
```
Route Guidance Active
Native navigation route guidance ends
Route Guidance Active
Apple Maps route guidance starts

Apple Maps turn-by-turn spoken directions
Application State Management

Route guidance active
• Maps turn-by-turn versus native route guidance

Phone call in progress
• CarPlay phone call versus native phone call

Voice interaction in progress
• Siri versus native voice recognition
Application State Management

Route guidance active
- Maps turn-by-turn versus native route guidance

Phone call in progress
- CarPlay phone call versus native phone call

Voice interaction in progress
- Siri versus native voice recognition
Phone Call in Progress
If head unit supports second phone connected using BT
Phone Call in Progress
If head unit supports second phone connected using BT

Phone call active

Mark Perlson
0:10
End  Hold
Phone Call in Progress

If head unit supports second phone connected using BT

Phone call active
Phone Call in Progress

If head unit supports second phone connected using BT

Phone call active

Ringtone
Application State Management

Route guidance active
  • Maps turn-by-turn versus native route guidance
Phone call in progress
  • CarPlay phone call versus native phone call
Voice interaction in progress
  • Siri versus native voice recognition
Application State Management

Route guidance active
• Maps turn-by-turn versus native route guidance

Phone call in progress
• CarPlay phone call versus native phone call

Voice interaction in progress
• Siri versus native voice recognition
Voice Recognition
If head unit supports native voice recognition
Voice Recognition

If head unit supports native voice recognition

Native voice recognition active
Voice Recognition

If head unit supports native voice recognition

Native voice recognition active
Voice Recognition

If head unit supports native voice recognition

Native voice recognition active
Voice Recognition

If head unit supports native voice recognition
Voice Recognition
If head unit supports native voice recognition
Summary

CarPlay relies on the same resources as your native system and is designed to coexist with your native user interface.

For a great CarPlay experience, consider resource handling for each use case and follow CarPlay design recommendations.

CarPlay specifications available through the MFi Program:

http://developer.apple.com/mfi
More Information

https://developer.apple.com/wwdc16/723
## Related Sessions

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<td>Video only</td>
</tr>
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<td>Labs</td>
<td>Lab Details</td>
</tr>
<tr>
<td>----------------------</td>
<td>----------------------------------</td>
</tr>
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<td>CarPlay Lab</td>
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</tr>
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<td>Frameworks Lab C</td>
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