

Flutter Recipes

Mobile Development Solutions for
iOS and Android

Fu Cheng



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**Mobile Development Solutions
for iOS and Android**

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Flutter Recipes: Mobile Development Solutions for iOS and Android

Fu Cheng

Sandringham, Auckland, New Zealand

ISBN-13 (pbk): 978-1-4842-4981-9

<https://doi.org/10.1007/978-1-4842-4982-6>

ISBN-13 (electronic): 978-1-4842-4982-6

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Cover image designed by Freepik (www.freepik.com)

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About the Author

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CHAPTER 1

Get Started

Recipes in this chapter help you set up your local development environment to get ready for building Flutter apps. Depending on the operating system of your machine, the steps to set up may be different. You only need to use the recipes for your own requirement. After using recipes in this chapter, you should be able to get the first Flutter app running on emulators or physical devices.

1-1. Installing Flutter SDK on Windows Problem

You have a Windows machine, and you want to start Flutter development on this machine.

Solution

Install Flutter SDK and set up Android platform on the Windows machine.

Discussion

Flutter SDK supports Windows platform. Installing Flutter on Windows is not a hard task as you may think. First of all, you need to make sure that your local development environment meets the minimum requirements. You'll need to have 64-bit Windows 7 SP1 or later and at least 400MB free disk

space for Flutter SDK to use. Flutter SDK also requires Windows PowerShell 5.0 or newer and Git for Windows to be available on the machine.

Windows PowerShell 5.0 is pre-installed with Windows 10. For Windows versions older than Windows 10, you need to install PowerShell 5.0 manually by following instructions from Microsoft (<https://docs.microsoft.com/en-us/powershell/scripting/setup/installing-windows-powershell>). You may already have Git for Windows installed since Git is a very popular tool for development. If you can run Git commands in PowerShell, then you are good to go. Otherwise, you need to download Git for Windows (<https://git-scm.com/download/win>) and install it. When installing Git for Windows, make sure the option “Git from the command line and also from 3rd-party software” is selected in the page “Adjusting your PATH environment”; see Figure 1-1.

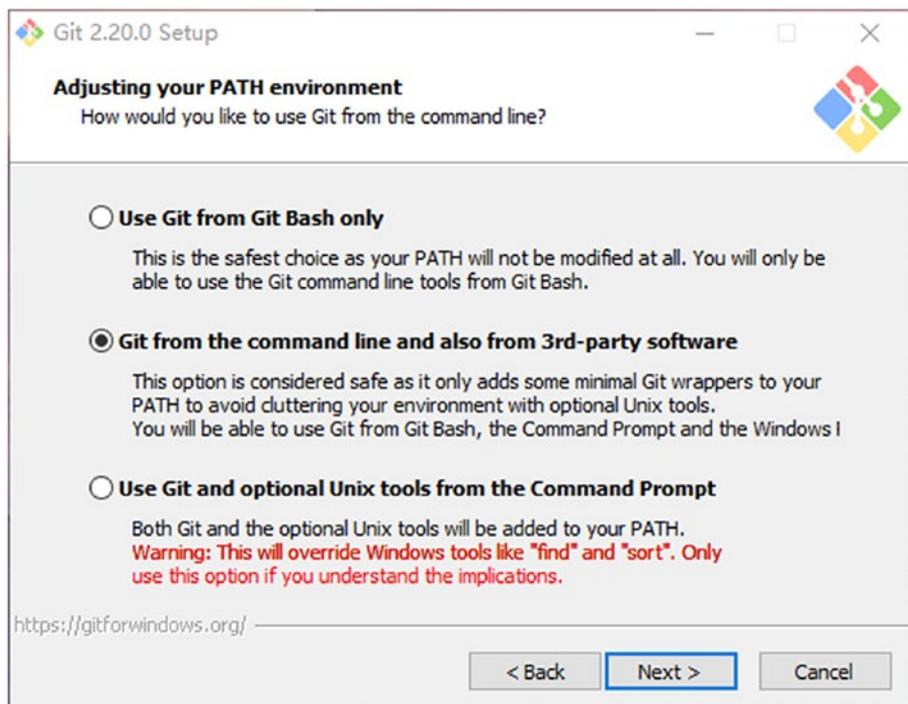


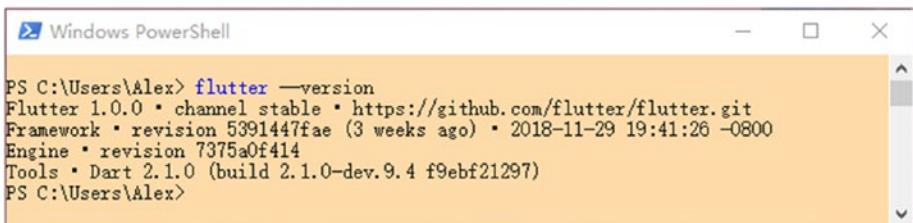
Figure 1-1. Git for Windows setup

After these minimum requirements have been satisfied, you can download the Flutter SDK zip bundles from the official web site (<https://flutter.dev/docs/get-started/install/windows>). Extract the downloaded zip file to the desired location on the local machine. It's recommended to avoid using the system driver where Windows is installed. In the extracted directory, double-click the file `flutter_console.bat` to start Flutter Console and run Flutter SDK commands.

To be able to run Flutter SDK commands in any Windows console, we need to add Flutter SDK to the PATH environment variable. The full path to `bin` of the installation directory should be added to the PATH. To modify the PATH on Windows 10

1. Open the Start Search and type “env” and select “Edit the system environment variables”.
2. Click the “Environment Variables...” button and find the row with “Path” in the first column under the “System Variables” section.
3. In the “Edit environment variable” dialog, click “New” and input the path of the bin directory of installed Flutter SDK.
4. Close all dialogs by clicking “OK”.

Now you can open a new PowerShell windows and type the command `flutter --version` to verify the installation; see Figure 1-2.



```
PS C:\Users\Alex> flutter --version
Flutter 1.0.0 • channel stable • https://github.com/flutter/flutter.git
Framework • revision 5391447fae (3 weeks ago) • 2018-11-29 19:41:26 -0800
Engine • revision 7375a0f414
Tools • Dart 2.1.0 (build 2.1.0-dev.9.4 f9ebf21297)
PS C:\Users\Alex>
```

Figure 1-2. Success installation of Flutter SDK on Windows

Only Android platform is supported on Windows. Continue the setup following Recipe 1-7.

1-2. Installing Flutter SDK on Linux

Problem

You have a Linux machine, and you want to start Flutter development on this machine.

Solution

Install Flutter SDK and set up Android platform on the Linux machine.

Discussion

Flutter SDK supports Linux platform. However, given that there are many different Linux distributions available, the actual steps to get Flutter SDK installed may be slightly different. This recipe is based on installing Flutter SDK on Ubuntu 18.04 LTS.

Flutter SDK requires several command-line tools to be available in the local environment, including `bash`, `mkdir`, `rm`, `git`, `curl`, `unzip`, and `which`. For most Linux distributions, the commands `bash`, `mkdir`, `rm`, `unzip`, and `which` should already be included by default. The easiest way to verify that is to open a terminal window and type these commands to see the output. You'll see "command not found" error if a command is not installed. `git` and `curl` are unlikely to be included by default. Most Linux distributions provide built-in package managers to install these tools. For Ubuntu, you can use `apt-get`; see the following command.

```
$ sudo apt-get update  
$ sudo apt-get install -y curl git
```

After the installation finishes successfully, you can type commands `curl` and `git` to verify.

Now you can download the Flutter SDK zip bundles from the official web site (<https://flutter.dev/docs/get-started/install/linux>). Extract the downloaded zip file to the desired location on the local machine. Open a terminal window, navigate to the directory of extracted Flutter SDK, and run the following command to verify the installation.

```
$ bin/flutter --version
```

It's recommended to add the `bin` directory of Flutter SDK to the `PATH` environment variable, so the `flutter` command can be run in any terminal session. For Ubuntu, you can edit the file `~/.profile`.

```
$ nano ~/.profile
```

Add the following line to this file and save.

```
export PATH=<flutter_dir>/bin:$PATH
```

In the current terminal window, you need to run `source ~/.profile` for the change to take effect. Or you can simply create a new terminal window. Type `flutter --version` in any terminal window to verify. You'll see the same output as Figure 1-2.

Only Android platform is supported on Linux. Continue the setup following Recipe 1-7.

1-3. Installing Flutter SDK on macOS Problem

You have a macOS machine, and you want to start Flutter development on this machine.

Solution

Install Flutter SDK and set up Android and iOS platforms on the macOS machine.

Discussion

For macOS, Flutter SDK requires several command-line tools to be available in the local environment. These tools are `bash`, `mkdir`, `rm`, `git`, `curl`, `unzip`, and `which`. macOS should already have these tools as part of the system. You can simply type these commands in the terminal to verify. The easiest way to install missing tools is to use Homebrew (<https://brew.sh/>). Homebrew is also important when setting up the iOS development environment. Use `brew install` to install tools, for example, `brew install git` to install Git.

After installing required tools, we can download the Flutter SDK zip bundle from the official web site (<https://flutter.dev/docs/get-started/install/macos>). Extract the downloaded zip file to the desired location on the local machine. The `flutter` command is located under the `bin` directory of the extracted location.

To run `flutter` command in any terminal session, the `PATH` environment variable should be updated to include the `bin` directory of the Flutter SDK. This is typically done by updating the profile of the shell. For the default bash, this file is `~/.bash_profile`. For zsh, this file is `~/.zshrc`. Modify this file to include the following line.

```
export PATH=<flutter_install_dir>/bin:$PATH
```

To make the current terminal window use the updated `PATH`, you need to run `source ~/.bash_profile`. You can also start a new terminal window which will automatically use the updated value of `PATH`.

Run `flutter --version` in any terminal window to verify the installation. You'll see the same output as Figure 1-2.

Both Android and iOS platforms are supported on macOS. Continue the setup following Recipes 1-4 and 1-7.

1-4. Setting Up iOS Platform

Problem

You want to develop Flutter apps for iOS platform.

Solution

Set up iOS platform for Flutter SDK on your Mac.

Discussion

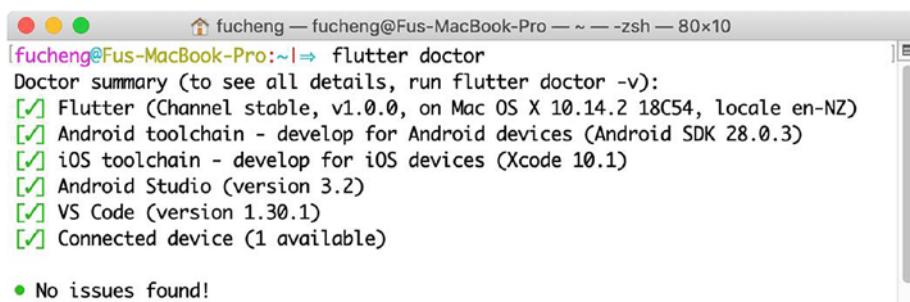
To develop Flutter apps for iOS, you need to have a Mac with at least Xcode 9.0. To set up the iOS platform, you need to go through the following steps:

1. Install Xcode (<https://developer.apple.com/xcode/>) from App Store.
2. Verify the path of the Xcode command-line tools.
Run the following command to show the current path to the command-line tools. Usually you should see output like /Applications/Xcode.app/Contents/Developer.

```
$ xcode-select -p
```

If the path shown in the output is not the one you want, for example, you have different versions of Xcode command-line tools installed, use `xcode-select -s` to switch to a different path. If you don't have the command-line tools installed, use `xcode-select --install` to open the installation dialog.

3. You need to open Xcode once to accept its license agreement. Or you can choose to run the command `sudo xcodebuild -license` to view and accept it.
4. Flutter SDK requires other tools for iOS platform, including `libimobiledevice`, `usbmuxd`, `ideviceinstaller`, `ios-deploy`, and `CocoaPods` (<https://cocoapods.org/>). All these tools can be installed using Homebrew. If you run the command `flutter doctor`, it shows the commands to install these tools using Homebrew. Simply run these commands and use `flutter doctor` to check again. When you see the green tick of “iOS toolchain,” the iOS platform is set up successfully for Flutter SDK to use; see Figure 1-3 for a sample output.



The screenshot shows a terminal window on a Mac OS X desktop. The title bar says "fucheng — fucheng@Fus-MacBook-Pro — ~ — zsh — 80x10". The command entered is "flutter doctor". The output shows the following:

```
fucheng@Fus-MacBook-Pro:~$ flutter doctor
Doctor summary (to see all details, run flutter doctor -v):
[✓] Flutter (Channel stable, v1.0.0, on Mac OS X 10.14.2 18C54, locale en-NZ)
[✓] Android toolchain - develop for Android devices (Android SDK 28.0.3)
[✓] iOS toolchain - develop for iOS devices (Xcode 10.1)
[✓] Android Studio (version 3.2)
[✓] VS Code (version 1.30.1)
[✓] Connected device (1 available)

• No issues found!
```

Figure 1-3. Output of `flutter doctor`

1-5. Setting Up iOS Simulators

Problem

You need a quick way to test Flutter apps on iOS platform.

Solution

Set up the iOS simulator.

Discussion

Xcode provides simulators for different iOS versions. You can download additional simulators using the tab Components in Xcode ➤ Preferences. To open the simulator, run the following command.

```
$ open -a Simulator
```

When the simulator is opened, you can switch the combination of different devices and iOS versions using the menu **Hardware ➤ Device**.

After the simulator is started, running `flutter devices` should show the simulator.

1-6. Setting Up iOS Devices

Problem

You have finished the testing of your Flutter apps on iOS simulator, and you want to test them on real iOS devices.

Solution

Deploy Flutter apps to iOS devices.

Discussion

Before deploying Flutter apps to iOS devices, you need to run `flutter doctor` to verify that iOS toolchain is set up correctly. To develop and test Flutter apps on devices, you need to have an Apple ID. If you want to distribute apps to App Store, you also need to enroll Apple Developer Program.

The first time you connect a physical device for iOS development, you need to trust the Mac to connect your device. Flutter apps need to be signed before deploying to devices. Open the `ios/Runner.xcworkspace` file of the Flutter app in Xcode. In the **General** tab, select the correct team in the **Signing** section. If you select the connected device as the running target, Xcode will finish the necessary configurations for code signing. The Bundle Identifier must be unique.

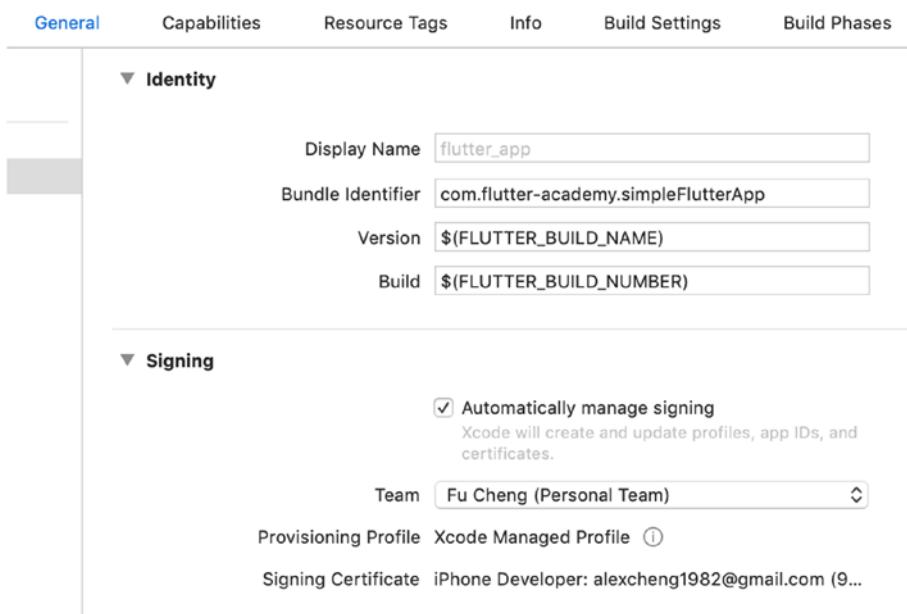


Figure 1-4. App signing in Xcode

The Flutter app can be deployed to the device using Xcode or the command `flutter run`. The first time you deploy the app, you may need to trust the development certificate in **General ▶ Device Management** of the Settings app on the iOS device.

1-7. Setting Up Android Platform

Problem

You want to develop Flutter apps for Android platform.

Solution

Install Android Studio to set up Android platform on your local machine.

Discussion

To develop Flutter apps for Android platform, we need to set up Android platform first. Flutter SDK requires a full installation of Android Studio for its Android platform dependencies, so we have to install Android Studio.

Go to Android Studio download page (<https://developer.android.com/studio/>) and click the “DOWNLOAD ANDROID STUDIO” button. You need to accept the terms and conditions to download it. The download page checks your platform and provides the most suitable version to download. If the provided option is not what you want, click the “DOWNLOAD OPTIONS” and select from the list of all download options; see Figure 1-5.

CHAPTER 1 GET STARTED

Android Studio downloads

| Platform | Android Studio package | Size | SHA-256 checksum |
|---------------------|---|---------|--|
| Windows (64-bit) | android-studio-ide-181.5056338-windows.exe Recommended | 927 MB | 6ee509f3391757fe87cc5c1e4970a0228fc1ad6ca34a8b31c0a28926179353a9 |
| | android-studio-ide-181.5056338-windows.zip No .exe installer | 1001 MB | 21aebb3a7fab4931b830ec40d836d6945eabb4f32acf1b52fae148d33599fd7c |
| Windows (32-bit) | android-studio-ide-181.5056338-windows32.zip No .exe installer | 1000 MB | 3a61a587c90e358ab15d076d0306550564ad4cc5a8aa1dd0c22c6af092e976a |
| Mac | android-studio-ide-181.5056338-mac.dmg | 989 MB | b8d2b7add6a7c776d16a8e48bd35c3e2bba18b4717131d7b9a00fa416ebe4480 |
| Linux | android-studio-ide-181.5056338-linux.zip | 1007 MB | b9ec0d44f2feaafe1e3fb1ed696bf325f9e05cfb6c1ace84dbf87ae249efa84 |

See the [Android Studio release notes](#).

Figure 1-5. Download options of Android Studio

Android Studio provides a GUI-based installer, so it's very easy to get it installed and running on the local machine. Installing Android Studio also installs Android SDK, Android SDK platform tools, and Android SDK build tools. Even you choose not to use Android Studio as the IDE, Android SDK and related tools are still required for Android development.

In the Android SDK page of preferences in Android Studio, you can also install additional Android SDK platforms and tools; see Figure 1-6. Android Studio also prompts available updates to installed Android SDK platforms and tools.

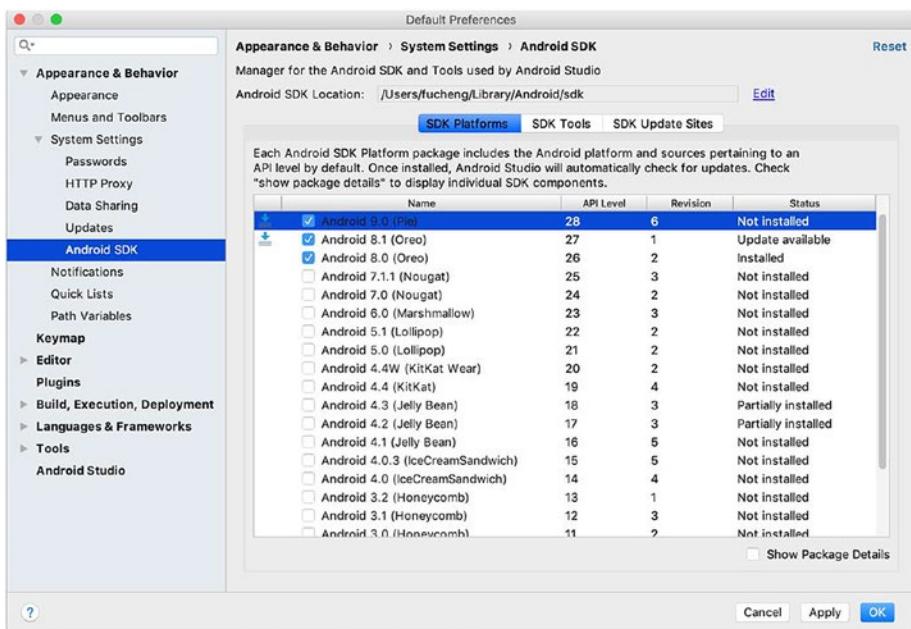


Figure 1-6. Manage Android SDK in Android Studio

1-8. Setting Up Android Emulators

Problem

You need a quick way to test Flutter apps for Android platform.

Solution

Set up the Android emulators.

Discussion

When developing Flutter apps, you can run them on Android emulators to see the results of running apps. To set up Android emulators, you can go through the following steps.

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Open an Android project in Android Studio and select **Tools > Android > AVD Manager** to open AVD Manager and click “Create Virtual Device...”; see Figure 1-7.



Figure 1-7. *Android Virtual Device Manager*

Choose a device definition, for example, Nexus 6P, and click Next; see Figure 1-8.

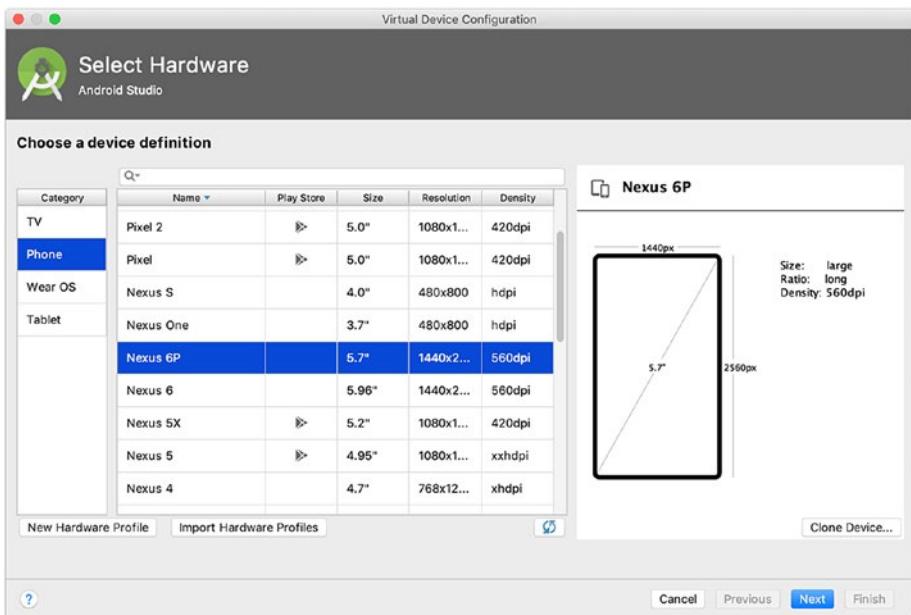


Figure 1-8. Select Hardware

Select a system image for the Android version you want to emulate and click Next; see Figure 1-9.

CHAPTER 1 GET STARTED

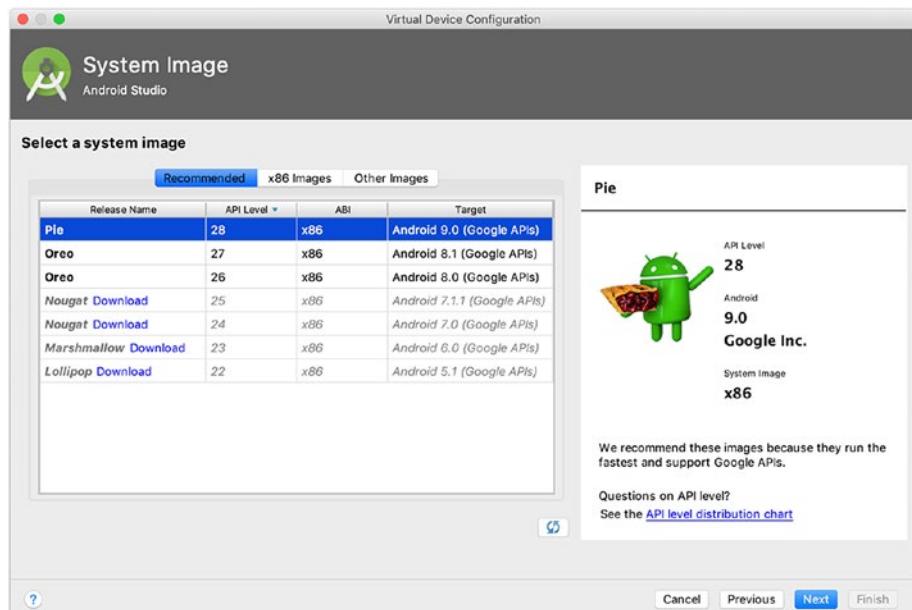


Figure 1-9. Select a system image

Select Hardware - GLE 2.0 for Emulated Performance to enable hardware acceleration and click Finish; see Figure 1-10.

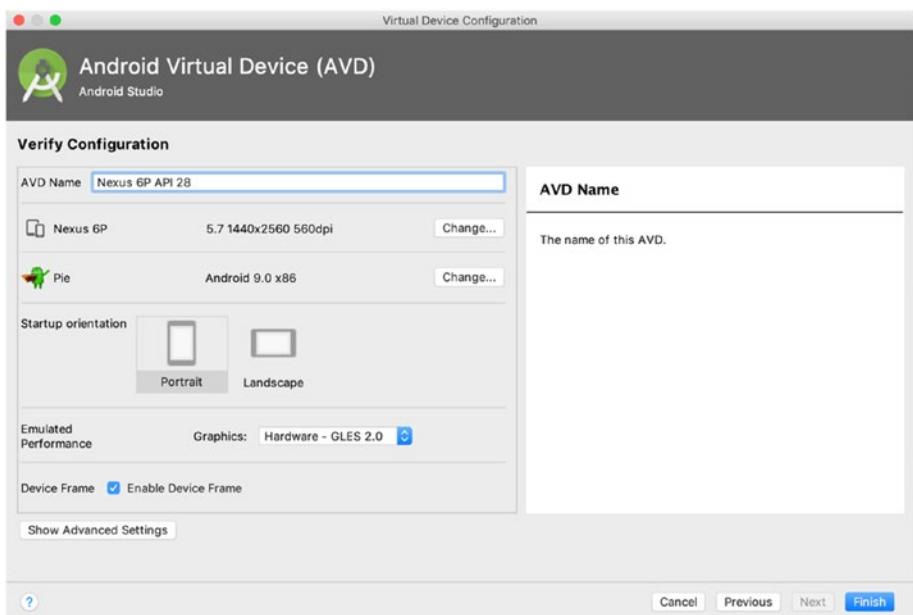


Figure 1-10. Select emulated performance

A new AVD is created and listed in AVD Manager. Android Studio official web site provides a comprehensive guide (<https://developer.android.com/studio/run/managing-avds>) on how to manage AVDs, if you want to know more details about AVD configurations.

In the AVD Manager, click the green triangle button to start the emulator. It may take some time for the emulator to start up and show the default Android home screen.

1-9. Setting Up Android Devices

Problem

You have finished the testing of your Flutter apps on emulators, and you want to test them on real Android devices.

Solution

Set up your Android device to run Flutter apps.

Discussion

To set up your Android device, you can go through the following steps:

1. You need to enable Developer options and USB debugging on your device. Check the instructions on the official Android web site (<https://developer.android.com/studio/debug/dev-options#enable>). You may also need to install Google USB driver (<https://developer.android.com/studio/run/win-usb>) on Windows machines.
2. Plug your device into your computer with a USB cable. The device prompts a dialog to ask for permissions, authorizing your computer to access your device.
3. Run the command `flutter devices` to verify Flutter SDK can recognize your device.

The Flutter app can be deployed to the device using Android Studio or the command `flutter run`.

1-10. Creating Flutter Apps Using Command Line

Problem

You have already set up your local environment to develop Flutter apps. Even though using Android Studio or VS Code is a good choice for development, you may still want to know how to do this from command line.

Solution

Use the commands from Flutter SDK to create and build Flutter apps.

Discussion

Using tools like Android Studio and VS Code can make Flutter development much easier. However, it's still valuable to know how to build Flutter apps using the command-line tools. This is important for continuous integration. It also allows you to use any other editors to develop Flutter apps.

The command `flutter create` can be used to create a new Flutter app. Actually, Android Studio and VS Code both use this command to create new Flutter apps. The following command creates a new Flutter app in the directory `flutter_app`.

```
$ flutter create flutter_app
```

This command creates various files in the specified directory as the skeleton code of the new app. Navigate to the directory `flutter_app` and use `flutter run` to run this app.

1-11. Creating Flutter Apps Using Android Studio

Problem

You want to have a powerful IDE that meets most of the requirements when developing Flutter apps.

Solution

Use Android Studio to create Flutter apps.

Discussion

Since we already have Android Studio installed to set up Android platform for Flutter SDK, it's a natural choice to use Android Studio as the IDE to develop Flutter apps. Android Studio itself is a powerful IDE based on IntelliJ platform. If you have used other products from JetBrains, like IntelliJ IDEA or WebStorm, you may find it's quite easy to get started with Android Studio.

To use Android Studio for Flutter development, Flutter and Dart plugins are required. To install these two plugins, open the **Plugins** page in **Preferences** dialog of Android Studio and click the “Browse repositories...” button. In the opened dialog, type in “Flutter” to search for the Flutter plugin to install; see Figure 1-11. Click the green Install button to install it. This will also prompt you to install the Dart plugin. Click Yes to install that as well. Restart Android Studio.

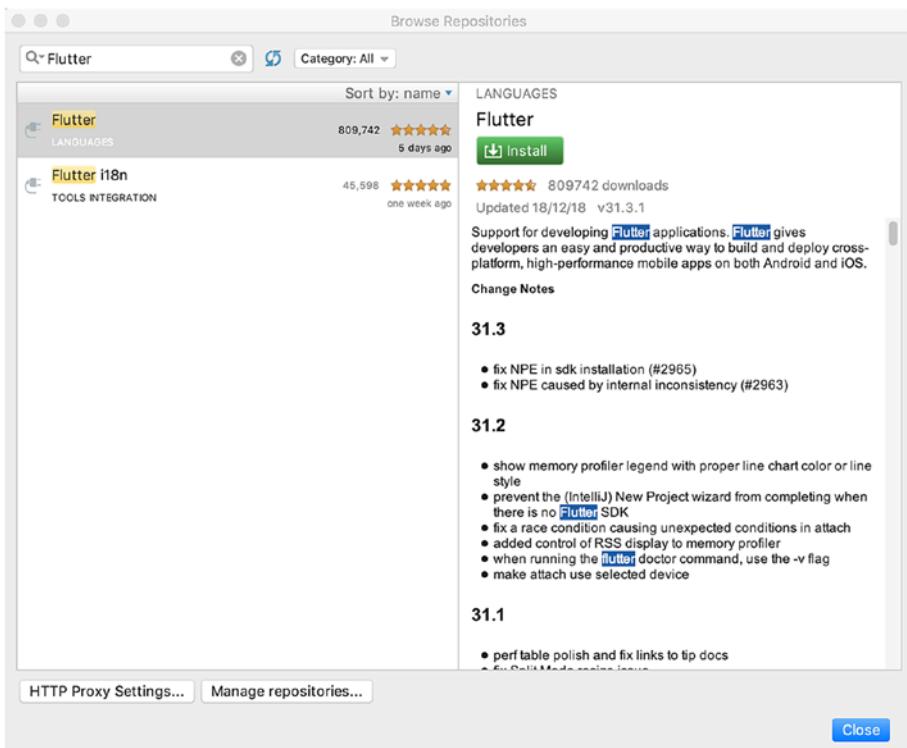


Figure 1-11. Install Flutter plugin in Android Studio

After restarting Android Studio, you should see a new option to start a new Flutter project. The wizard for Flutter projects has different pages to configure the new project.

The first page allows you to select type of the new Flutter project. The description in the page shows the difference of these four different project types. Most of the time, we are going to create a Flutter Application.

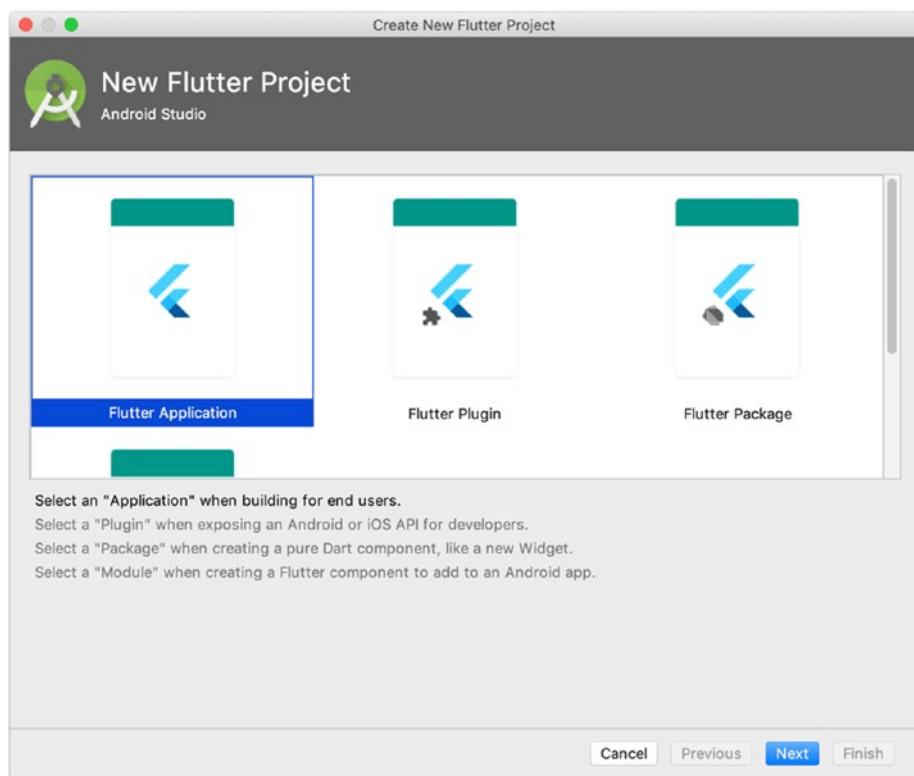


Figure 1-12. Select type of Flutter project

The second page allows you to customize basic configurations of the new Flutter project, including project name, location, and description.

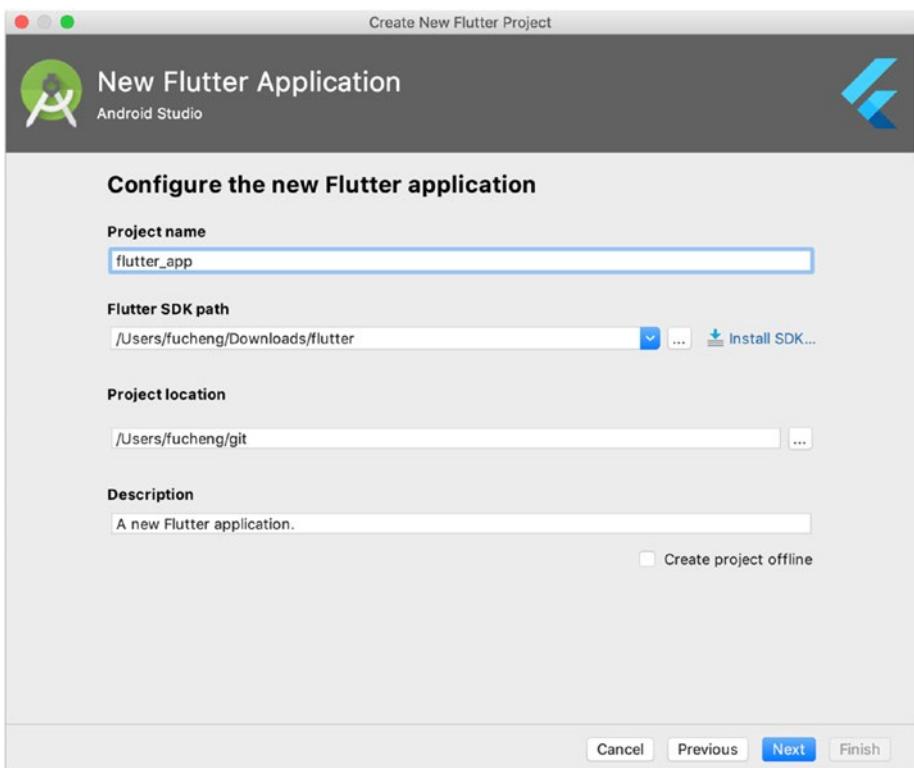


Figure 1-13. Basic project configurations

The last page allows you to customize some advanced project configurations. The company domain is used to create unique identifier for the project.

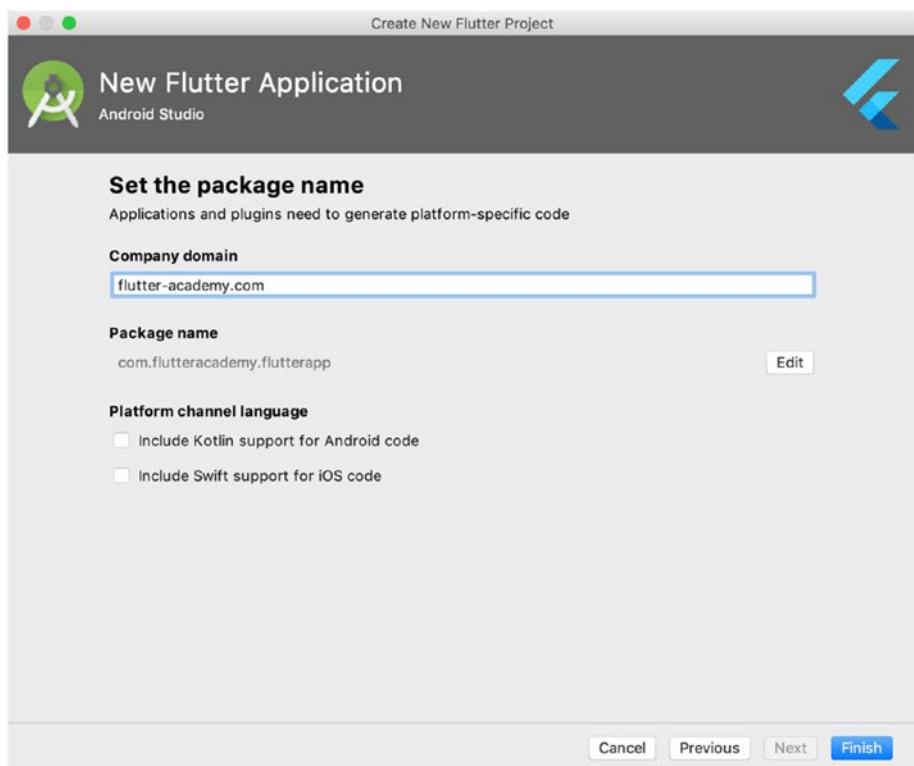


Figure 1-14. Advanced project configurations

After finishing the wizard, a new project is created and opened in Android Studio.

1-12. Creating Flutter Apps Using VS Code Problem

You want to use a light-weight editor to develop Flutter apps.

Solution

Use VS Code to create Flutter apps.

Discussion

VS Code (<https://code.visualstudio.com/>) is a popular light-weight editor in the community of front-end developers. With the extensions for Flutter and Dart, we can also use VS Code for Flutter development. Open the Extensions tab in VS Code and search for “flutter” to install the Flutter extension; see Figure 1-15. Flutter extension depends on the Dart extension, which will also be installed. After installing these two extensions, we can open the command palette and search “flutter” for available Flutter commands.

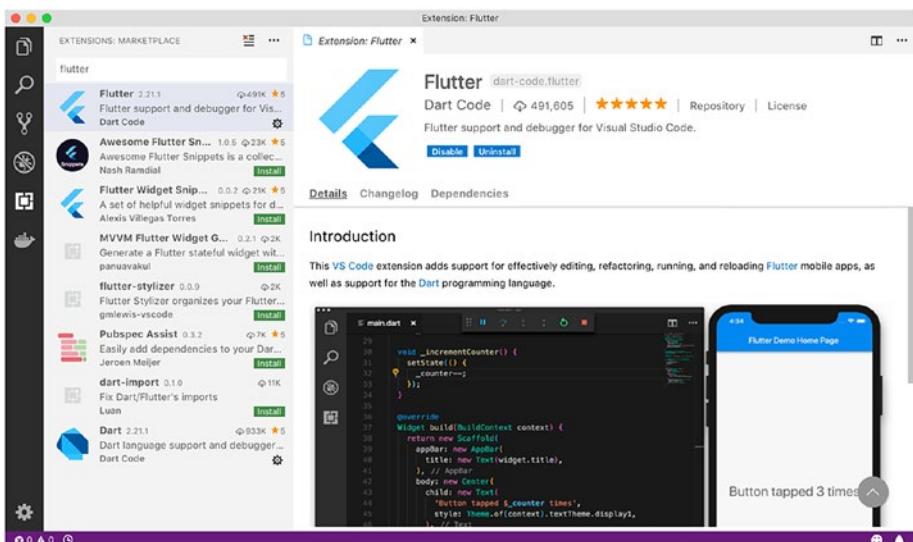


Figure 1-15. Install Flutter extension in VS Code

To create a new Flutter in VS Code, open the command palette and run the **Flutter: New Project** command. Input the name of the new project in the opened dialog. Select the directory of the project. VS Code opens a new window for the newly created project.

1-13. Running Flutter Apps

Problem

You want to run Flutter apps on emulators or devices.

Solution

Use `flutter run` command or IDEs to run Flutter apps.

Discussion

Depending on your preferred approach to develop Flutter apps, there are different ways to run Flutter apps. Before running Flutter apps, you must have at least one running emulator or connected device:

- The command `flutter run` starts the current Flutter app.
- In Android Studio, select the emulator or device from the dropdown menu shown in Figure 1-16, then click the **Run** button to start the app.
- In VS Code, select **Debug > Start Without Debugging** to start the app.

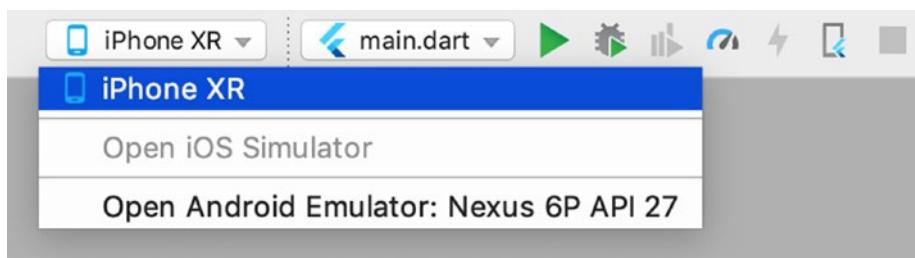


Figure 1-16. Select device in Android Studio

1-14. Understanding Code Structure of Flutter Apps

Problem

You want to know the typical structure of Flutter apps.

Solution

Go through the sample app generated by Flutter SDK and understand the files.

Discussion

Before going into details of developing Flutter apps, you should know about the code structure of Flutter apps, so you know where to add new files. Flutter apps have a predefined directory structure for various files in the app. When a new app is created, you can take a look of the generated files and have a basic understanding of them. Table 1-1 shows directories and files of the created app.

Table 1-1. Directories and files of a Flutter app

| Name | Description |
|---------------------------|---|
| lib | Main directory of app source code. The file <code>main.dart</code> is usually the entry point of the app. |
| test | Directory that contains test files. |
| android | Files for Android platform. |
| ios | Files for iOS platform. |
| <code>pubspec.yaml</code> | Package description for Dart pub tool. |
| <code>pubspec.lock</code> | Lock file for Dart pub tool. |
| <code>.metadata</code> | Flutter project description used by Flutter SDK. |

1-15. Fixing Configuration Issues of Flutter SDK

Problem

You want to make sure the configuration of your local development environment is correct for Flutter development.

Solution

Use the command `flutter doctor`.

Discussion

After Flutter SDK is installed, it needs to be configured with other supporting tools. The command `flutter doctor` is the primary tool to provide necessary help. This command checks the local environment and reports status of the Flutter SDK installation. For each problem it finds, it also gives instructions on how to fix them. All you need to do is to apply the suggested fixes and run `flutter doctor` again to verify the result. It's not necessary to fix all issues reported by `flutter doctor`. You can safely ignore some issues if they are not relevant. For example, if you are not going to use VS Code as the primary IDE, then it doesn't matter if VS Code is installed or not.

1-16. Summary

Recipes in this chapter provide instructions on how to get your local machine prepared for Flutter apps development. `flutter doctor` is a useful tool for setup. You should be able to fix most of the configuration issues by following instructions provided by this command. In the next chapter, we'll see recipes about using tools provided by Dart SDK, Flutter SDK, and IDEs.

CHAPTER 2

Know the Tools

Building Flutter apps cannot succeed without the help of various tools. During the development, we may need to use tools from Dart SDK, Flutter SDK, and IDEs. Making good use of these tools can increase your productivity. This chapter covers usage of tools from Dart SDK, Flutter SDK, Android Studio, and VS Code.

2-1. Using Dart Observatory

Problem

You want to know the internals of a running Flutter app.

Solution

Use Dart Observatory provided by Dart SDK.

Discussion

Dart Observatory is a tool provided by Dart SDK to profile and debug Dart applications. Since Flutter apps are also Dart applications, Observatory is also available for Flutter apps. Observatory is an important tool for debugging, tracing, and profiling Flutter apps. Observatory allows you to

- View an app's CPU profile.
- View an app's memory allocation profile.

CHAPTER 2 KNOW THE TOOLS

- Debug an app interactively.
- View snapshots of an app's heap.
- View logs generated by an app.

When a Flutter app is started using `flutter run`, Observatory is also started and waiting for connections. You can specify the port for Observatory to listen on, or let it listen on a random port by default. You can see the URL to access the Observatory in the command output. Navigate to the URL in the browser and you can see the UI of Observatory.

Note For best results, Google Chrome is recommended when using the Observatory. Other browsers may not function properly.

The top section of the Observatory UI shows the Dart VM information; see Figure 2-1. Click the **Refresh** button to update the information.



The screenshot shows the Dart Observatory interface. At the top, there is a blue header bar with the text "Observatory > vm@ws://127.0.0.1:51516/ws" on the left and a "Refresh" button on the right. Below the header, the word "VM" is centered above a table of system information. The table has two columns: "name" and "value". The "name" column includes "name", "version", "embedder", "started at", "uptime", "refreshed at", "pid", "peak memory", "current memory", "native zone memory", "native heap memory", and "native heap allocation count". The "value" column contains the corresponding details for each name. At the bottom of the table, there are three links: "see flags", "view timeline", and "view native memory profile".

| name | value |
|------------------------------|---|
| name | vm@ws://127.0.0.1:51516/ws |
| version | 2.1.0-dev.9.4.flutter-f9ebf21297 (Thu Nov 8 23:00:07 2018 +0100) on "ios_x64" |
| embedder | Flutter |
| started at | 2018-12-25 08:25:30.843 |
| uptime | 0:35:41.587000 |
| refreshed at | 2018-12-25 09:01:12.431 |
| pid | 95819 |
| peak memory | 280.4MB |
| current memory | 222.6MB |
| native zone memory | 0B |
| native heap memory | unavailable |
| native heap allocation count | unavailable |

see [flags](#) view [timeline](#)
view [native memory profile](#)

Figure 2-1. VM information in Dart Observatory

The bottom section shows a list of isolates; see Figure 2-2. Every Flutter app has an initial isolate for its entry point file. For each isolate, a pie chart shows the breakdown of activities of the VM. On the right side of the pie chart, a list of links points to different screens of other Observatory functionalities.

Isolates (1)

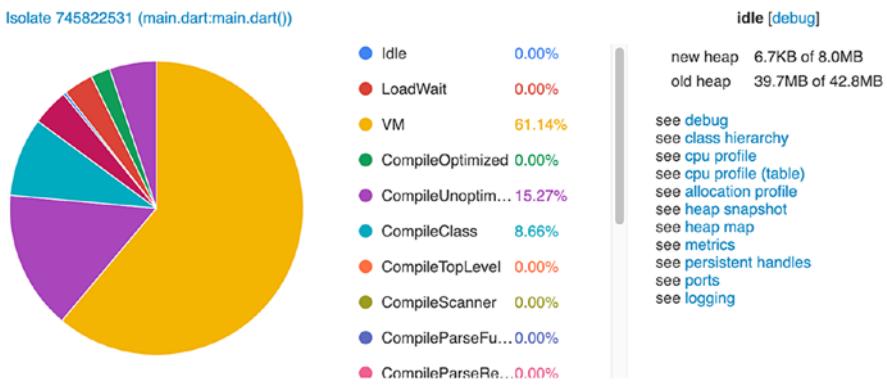


Figure 2-2. Isolate information in Dart Observatory

The details of these Observatory screens are out of the scope of this recipe; refer to the official documentation (<https://dart-lang.github.io/observatory/>) for instructions.

2-2. Using Hot Reload and Hot Restart

Problem

When developing Flutter apps, after you made some code changes, you want to see the result quickly.

Solution

Use hot reload and hot restart provided by Flutter SDK.

Discussion

When building mobile apps, it's crucial to be able to view effects of code changes efficiently, especially when building the UI. This enables us to quickly see the actual UI and update code iteratively. It's also very important to keep the app's current state when updating the app. Otherwise, it'll be very painful to manually reset the app to the previous state and continue testing. Suppose that the component you are developing is only accessible to registered users, to actually test the component, you may need to log in every time you made a code change, if the state is not preserved between app updates.

Hot reload provided by Flutter SDK is a killer feature that can significantly increase developers' productivity. With hot reload, the state is preserved between app updates, so you can see the UI updates instantly and continue the development and testing from the last execution point where you made the changes.

Depending on how a Flutter app is started, there are different ways to trigger hot reload. Only Flutter apps in debug mode can be hot reloaded:

- When the app is started by the command `flutter run`, enter `r` in the terminal window to trigger hot reload.
- When the app is started by Android Studio, saving the files automatically triggers hot reload. You can also click the **Flutter Hot Reload** button to manually trigger it.
- When the app is started by VS Code, saving the files automatically triggers hot reload. You can also run the command **Flutter: Hot Reload** with the keyboard shortcut `Control-F5` to manually trigger it.

If the app is hot reloaded successfully, you can see output in the console with details of the hot reload. Figure 2-3 shows the console output when a hot reload is triggered by saving files in Android Studio.

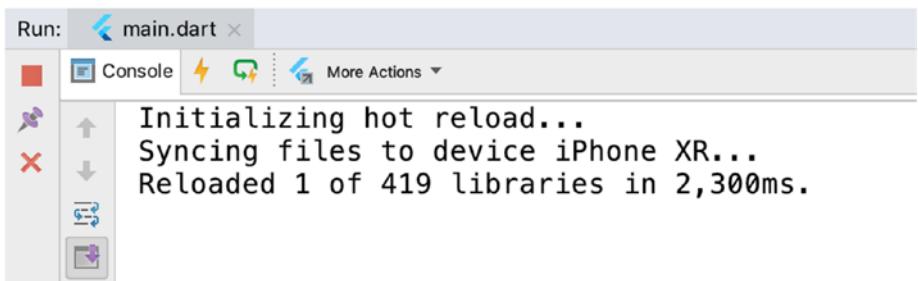


Figure 2-3. Hot reload output

Hot reload is so useful that you may want it to be available for all code changes you made. Unfortunately, there are still some cases that hot reload may not work:

- Your code change introduces compilation errors. You need to fix these compilation errors before hot reload can continue.
- Hot reload preserves the app state, and it tries to rebuild the widgets tree using the preserved state to reflect new changes. If your code change modifies the state, then the change to widgets may not be able to work with the old preserved state. Suppose that we have a widget that is designed to display a user's profile information. In the previous version, the state for a user only contains the username and name. In the new version, the state is updated to include a new property `email`, and the widget is updated to display the new property. After hot reload, the widget still uses the old state and doesn't see the new property. A hot restart is required in this case to pick up the state change.
- Changes to initializers of global variables and static fields can only be reflected after a hot restart.

- Changes to the app's `main()` method may only be reflected after a hot restart.
- Hot reload is not supported when an enumerated type is changed to a regular class or a regular class is changed to an enumerated type.
- Hot reload is not supported when changing the generic declarations of types.

If hot reload doesn't work, you can still use hot restart, which restarts the app from scratch. You can be sure that hot restart will reflect all changes you made. Depending on how a Flutter app is started, there are different ways to trigger hot restart:

- When the app is started by `flutter run`, enter R in the terminal window to trigger hot restart.
- When the app is started by Android Studio, click the **Flutter Hot Restart** button to trigger hot restart.
- When the app is started by VS Code, click the Restart button, or run the command **Flutter: Hot Restart** from command palette to trigger hot restart.

2-3. Upgrading Flutter SDK

Problem

You want to keep the Flutter SDK up to date to get latest features, bug fixes, and performance improvements.

Solution

Track different Flutter SDK channels and upgrade the SDK.

Discussion

From time to time, we may need to upgrade Flutter SDK to get new features, bug fixes, and performance improvements. Flutter SDK has different channels to get updates. Each channel is actually a Git branch in Flutter SDK's repository. Executing the command `flutter channel` shows all available channels; see Figure 2-4. The channel marked with a star symbol is the current channel. In Figure 2-4, the current channel is `stable`.

```
flutter-app — fucheng@Fus-MacBook-Pro — ..t/flutter-app...
[→ flutter channel
Flutter channels:
  beta
  dev
  master
* stable
```

Figure 2-4. Output of the command `flutter channel`

Table 2-1 shows four channels of Flutter SDK.

Table 2-1. Flutter SDK channels

| Channel | Description |
|---------|---|
| stable | Channel for stable builds. It's the recommended channel for product development. |
| beta | Channel for best build of the previous month. |
| dev | Channel for latest fully tested build. More tests are run in this channel than <code>master</code> . |
| master | Channel for active development with latest changes. If you want to try the latest features, this is the channel to track. Code in this channel usually works, but sometimes it may break accidentally. Use this channel at your own risk. |

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We can use the command `flutter channel <channel-name>` to switch to a different channel. For example, `flutter channel master` changes to the `master` channel. To get updates of the current channel, run the command `flutter upgrade`. The following command shows a typical way to switch channels.

```
$ flutter channel master  
$ flutter upgrade
```

2-4. Debugging Flutter Apps in Android Studio

Problem

You are using Android Studio to develop Flutter apps and want to find out why the code doesn't work the way you expected.

Solution

Use the built-in Flutter debugging support in Android Studio.

Discussion

Debugging is an important part of developers' daily routines. When debugging, we can see the actual code execution path in the runtime and inspect values of variables. If you have experiences with other programming languages, you should already have the basic debugging skills.

In Android Studio, you can click on the left gutter of a line in the editor to add breakpoints to that line. Click the **Debug** icon or use the menu **Run ➤ Debug** to start the app in debug mode; see Figure 2-5.



Figure 2-5. Click Debug icon to start debugging

Once the code execution hits a breakpoint, the execution is paused. You can inspect values of variables and interactively continue the execution using the buttons in the debug toolbar. There are different panels to see related information in debug mode.

Frames view in Figure 2-6 shows the current execution frames.

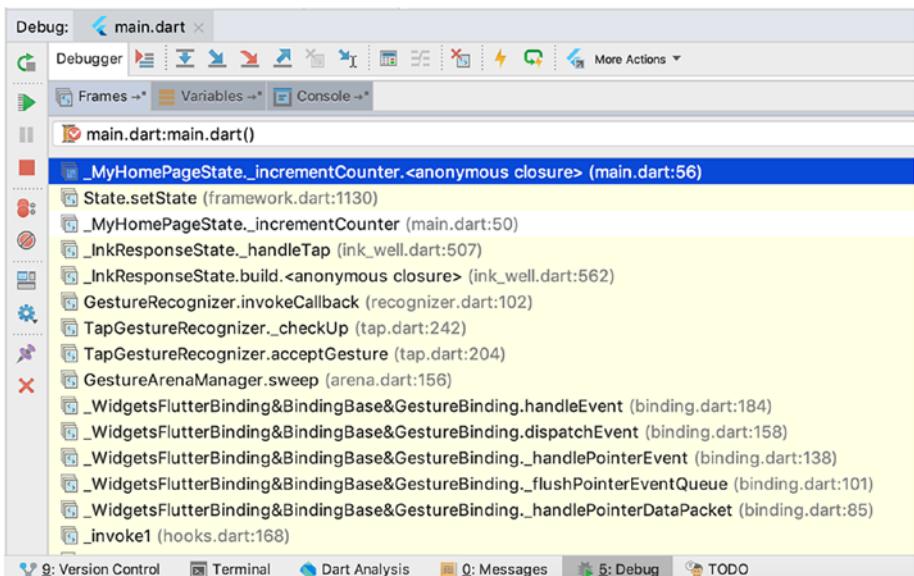


Figure 2-6. Frames view in Android Studio

Variables view in Figure 2-7 shows values of variables and objects. In this view, we can also add expressions to watch for values.

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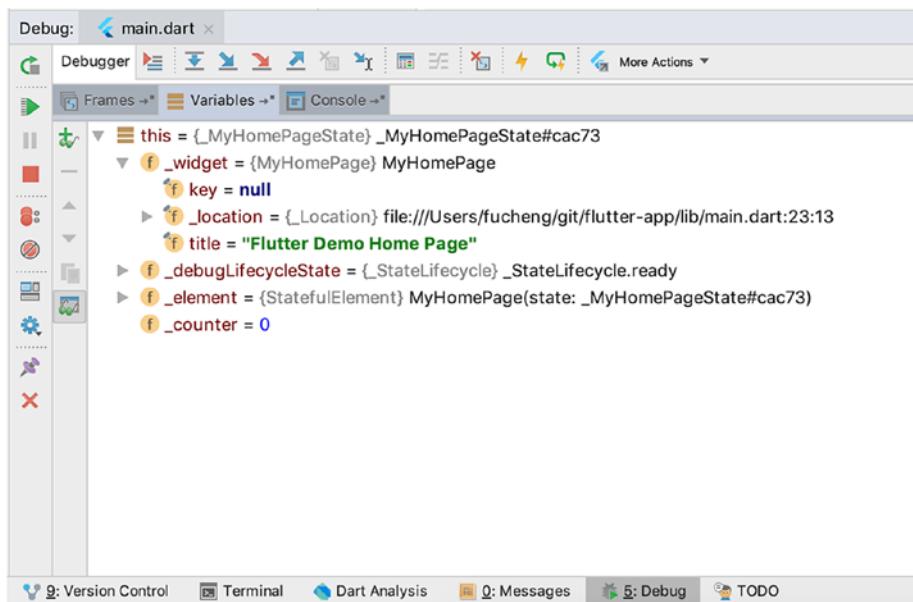


Figure 2-7. Variables view in Android Studio

Console view in Figure 2-8 shows messages displayed to the console.

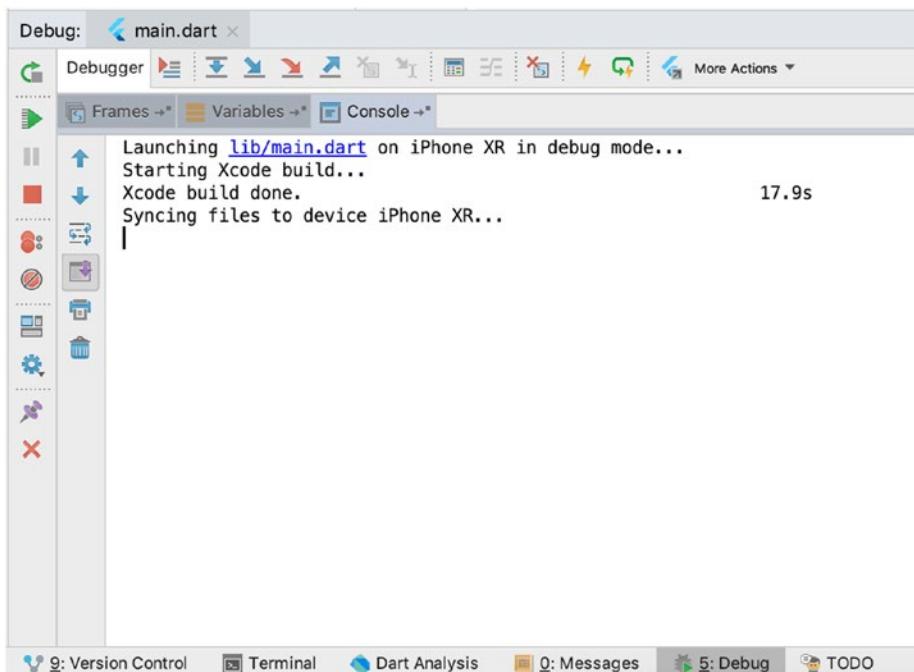


Figure 2-8. Console view in Android Studio

2-5. Viewing Outline of Flutter Apps in Android Studio

Problem

You want to see outline of Flutter apps to have a clear view of how widgets are organized.

Solution

Use Flutter Outline view in Android Studio.

Discussion

In Android Studio, Flutter Outline view can be opened from menu **View ➤ Tool Windows ➤ Flutter Outline**. This view displays a tree-like hierarchy of current open file; see Figure 2-9. Flutter Outline view is linked with the file editor. Selecting an element in the Flutter Outline view makes the editor to scroll and highlight the source code of this element. This link is bidirectional; selection in the editor also causes corresponding element to be selected in the Flutter Outline view.

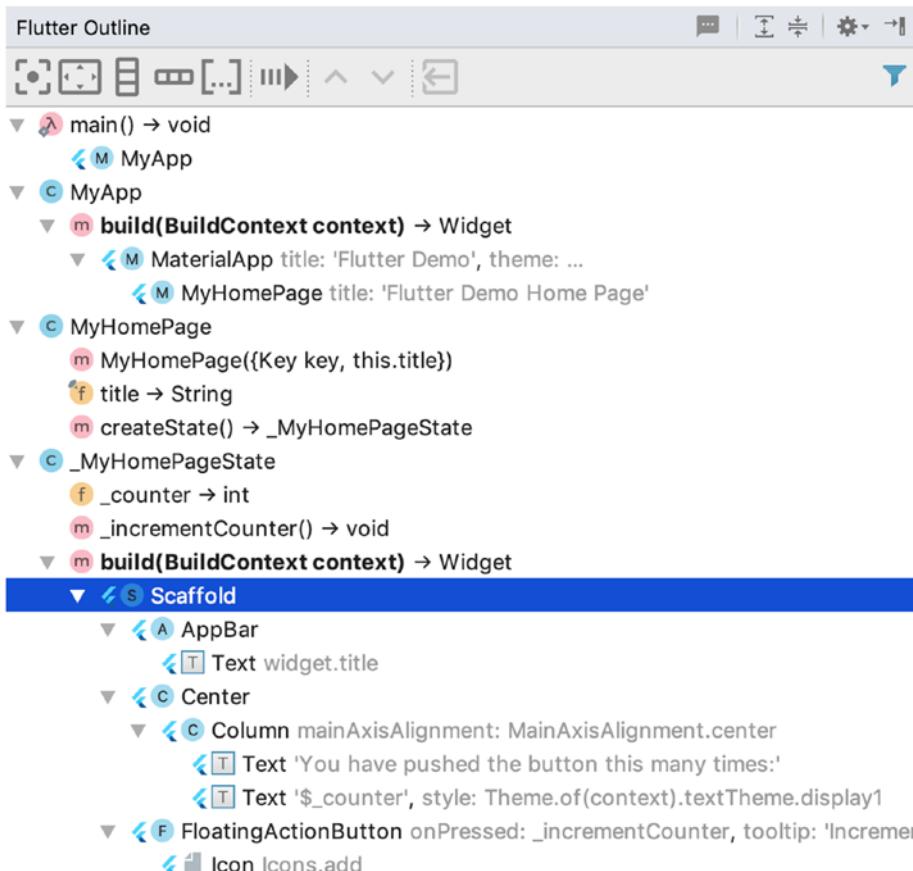


Figure 2-9. Flutter Outline view in Android Studio

The toolbar in Flutter Outline view has different actions to manage widgets. For example, Center widget button wraps the current widget with a Center widget.

2-6. Debugging Flutter Apps in VS Code Problem

You are using VS Code to develop Flutter apps and want to find out why the code doesn't work the way you expected.

Solution

Use the built-in Flutter debugging support in VS Code.

Discussion

In VS Code, you can click on the left gutter of a line in the editor to add breakpoints to that line. Use the menu **Debug ▶ Start Debugging** to start the app in debug mode.

Figure 2-10 shows the VS Code view in debug mode. There are different panels in this view:

- Variables – Shows values of variables.
- Watch – Manages watch expressions and views their values.
- Call stack – Views current call stack.
- Breakpoints – Views added breakpoints.
- Debug console – Views messages output to the console.

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The actions bar in the top contains actions including Continue, Step Over, Step Into, Step Out, Restart, and Stop.

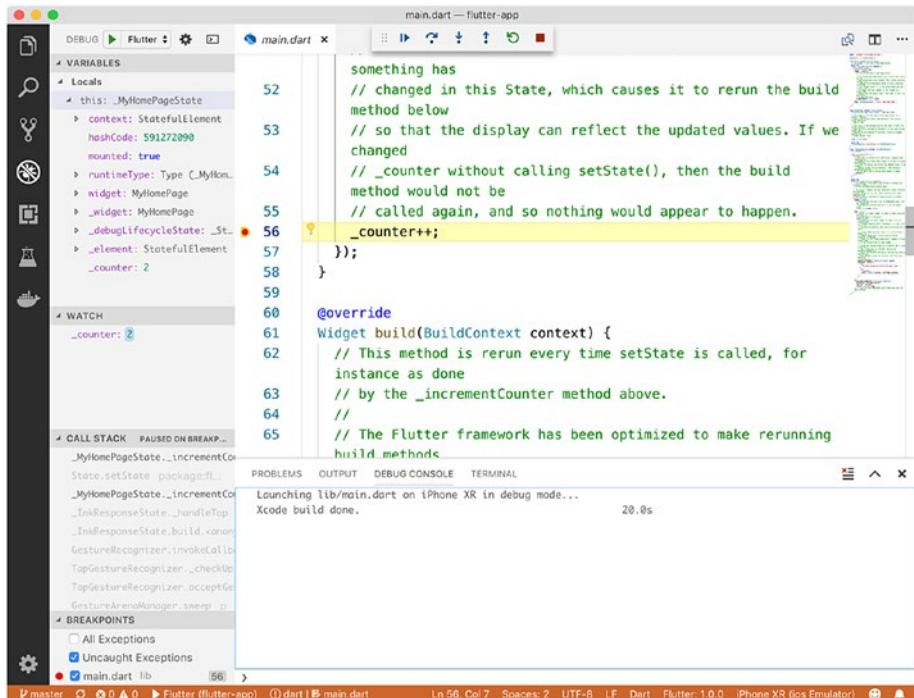


Figure 2-10. Debug in VS Code

2-7. Creating Flutter Projects

Problem

You want to create different types of Flutter projects.

Solution

Use the command `flutter create` with different arguments.

Discussion

`flutter create` is the command provided by Flutter SDK to create Flutter projects. In Recipe 1-10, we use this command to create a simple Flutter app. In Recipe 1-11, we also see the wizard provided by Android to create new Flutter projects, which allows customizations of the created projects. Under the hood, Android Studio also uses `flutter create` command. This command supports different arguments for various scenarios. The following code is the basic usage of `flutter create`. The output directory will contain files of the new project.

```
$ flutter create <output directory>
```

Type of Project

Use the argument `-t` or `--template` to specify the type of project to create. There are four types of projects; see Table 2-2.

Table 2-2. *Flutter project types*

| Project type | Description |
|--------------|--|
| app | A Flutter application. This is the default type. |
| package | A sharable Flutter project that contains modular Dart code. |
| plugin | A sharable Flutter project that contains platform-specific code for Android and iOS. |

The following command shows how to create a Flutter package and plugin.

```
$ flutter create -t package my_package
$ flutter create -t plugin my_plugin
```

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When creating plugins, we can also use the argument `-i` or `--ios-language` to specify the programming language of iOS code. Possible values are `objc` for Objective-C and `swift` for Swift. The default value is `objc`. For Android code, we can use the argument `-a` or `--android-language` to specify the programming language of Android code. Possible values are `java` for Java and `kotlin` for Kotlin. The default value is `java`. The following command shows how to create a Flutter plugin with Swift for iOS and Kotlin for Android.

```
$ flutter create -t plugin -i swift -a kotlin my_plugin
```

Code Sample

When creating a Flutter application, we can use the argument `-s` or `--sample` to specify the sample code to use as the file `lib/main.dart` of the new app. Given a sample id, the command tries to load the dart file with the URL https://docs.flutter.dev/snippets/<sample_id>.dart.

Project Configurations

There are some general configurations available when creating projects; see Table 2-3.

Table 2-3. Flutter project configurations

| Argument | Description | Default value |
|----------------|---|--|
| --project-name | Name of this new Flutter project. The name must be a valid dart package name. | Derived from the output directory name |
| --org | Organization name of this new Flutter project. The value should be in reverse domain notation, for example, com.example. The value is used as the Java package name for Android code and the prefix in the iOS bundle identifier. | com.example |
| --description | The description of this new Flutter project. | A new Flutter project |

The following command uses the project configurations in Table 2-3.

```
$ flutter create --org=com.mycompany --description="E-commerce app" my_ecommerce_app
```

Enable or Disable Features

There are additional flags to enable or disable some features; see Table 2-4. Only one argument of each pair can be specified at a time. The argument name with the prefix `--no` means disabling a feature, while the other one means enabling a feature. For example, `--overwrite` means enabling overwriting, while `--no-overwrite` means disabling overwriting. The default value On or Off means whether the feature is enabled or disabled by default, respectively. For example, the default value Off for the pair `--overwrite` and `--no-overwrite` means the `--no-overwrite` is used by default.

Table 2-4. Features of `flutter create`

| Arguments | Description | Default value |
|---|---|---------------|
| --overwrite / --no-overwrite | Whether to overwrite existing files. | Off |
| --pub / --no-pub | Whether to run flutter packages get after the project has been created. | On |
| --offline / --no-offline | Whether to run flutter packages get in offline mode or not. Only applicable when --pub is on. | Off |
| --with-driver-test / --no-with-driver-test | Whether to add a <code>flutter_driver</code> dependency and generate a sample Flutter Drive test. | Off |

2-8. Running Flutter Apps

Problem

You want to run Flutter apps.

Solution

Use the command `flutter run` with different arguments.

Discussion

`flutter run` is the command provided by Flutter SDK to start Flutter apps. `flutter run` has a lot of arguments for different usage scenarios.

Different Build Flavors

By default, `flutter run` builds a debug version of the app. Debug version is good for development and testing with hot reload support. There are other build flavors you can use for different scenarios; see Table 2-5.

Table 2-5. *Build flavors of flutter run*

| Argument | Description |
|------------------------|--|
| <code>--debug</code> | A debug version. This is the default build flavor. |
| <code>--profile</code> | A version specialized for performance profiling. This option does not currently support emulator targets. |
| <code>--release</code> | A release version ready for publishing to app store. |
| <code>--flavor</code> | A custom app flavor defined by platform-specific build setup. This requires using product flavors in Android Gradle scripts and custom Xcode schemes. |

Other Options

The argument `-t` or `--target` specifies the main entry point file of the app. It must be a Dart file that contains the `main()` method. The default value is `lib/main.dart`. The following command uses `lib/app.dart` as the entry point file.

```
$ flutter run -t lib/app.dart
```

If your app has different routes, use the argument `--route` to specify the route to load when running the app.

If you want to record the process id of the running Flutter app, use the argument `--pid-file` to specify the file to write the process id. With the process id, you can send the signal `SIGUSR1` to trigger a hot reload and

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SIGUSR2 to trigger a hot restart. In the following command, the process id is written to the file `~/app.pid`.

```
$ flutter run --pid-file ~/app.pid
```

Now we can send signals to the running Flutter app using `kill`.

```
$ kill -SIGUSR1 $(~/app.pid)
$ kill -SIGUSR2 $(~/app.pid)
```

Table 2-6 shows other arguments supported by `flutter run`.

Table 2-6. *Extra arguments of flutter run*

| Arguments | Description | Default value |
|-----------------------------------|--|------------------------|
| <code>--hot / --not-hot</code> | Whether hot reload should be enabled. | On |
| <code>--build / --no-build</code> | Whether the app should be built if necessary before running it. | On |
| <code>--pub / --no-pub</code> | Whether to run <code>flutter packages get</code> before running it. | On |
| <code>--target-platform</code> | Specify the target platform when building the app for Android devices. Possible values are <code>default</code> , <code>android-arm</code> , and <code>android-arm64</code> . | <code>default</code> |
| <code>--observatory-port</code> | Specify the port for Observatory debugger connections. | 0 (a random free port) |
| <code>--start-paused</code> | Make the app to start in a paused mode and wait for a debugger to connect. | |
| <code>--trace-startup</code> | Start tracing. | |

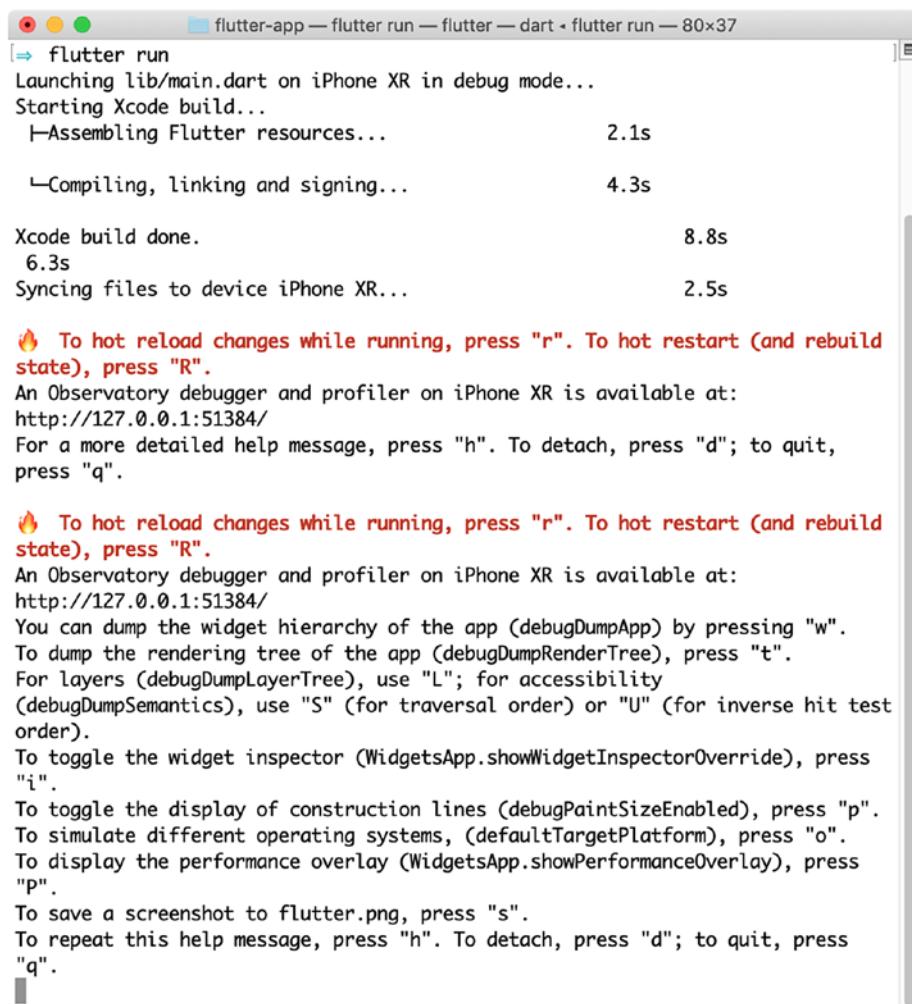
(continued)

Table 2-6. (continued)

| Arguments | Description | Default value |
|--------------------------------|---|---------------|
| --enable-software-rendering | Enable rendering using Skia. | |
| --skia-deterministic-rendering | Provide 100% deterministic Skia rendering when used with --enable-software-rendering. | |
| --trace-skia | Enable tracing of Skia code. | |

Figure 2-11 shows the output of running the command `flutter run`. From the output, we can see the Observatory port of the running app, which is very important for other Flutter SDK commands to work with the running app. We can interact with the console by pressing different keys. For example, pressing “r” triggers hot reload. After pressing “h”, `flutter run` shows a help message about all commands it can accept.

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The screenshot shows a terminal window titled "flutter-app — flutter run — flutter — dart" with the following log output:

```
[→ flutter run
Launching lib/main.dart on iPhone XR in debug mode...
Starting Xcode build...
└-Assembling Flutter resources...          2.1s
└-Compiling, linking and signing...        4.3s
Xcode build done.                      8.8s
  6.3s
Syncing files to device iPhone XR...    2.5s

🔥 To hot reload changes while running, press "r". To hot restart (and rebuild state), press "R".
An Observatory debugger and profiler on iPhone XR is available at:
http://127.0.0.1:51384/
For a more detailed help message, press "h". To detach, press "d"; to quit,
press "q".

🔥 To hot reload changes while running, press "r". To hot restart (and rebuild state), press "R".
An Observatory debugger and profiler on iPhone XR is available at:
http://127.0.0.1:51384/
You can dump the widget hierarchy of the app (debugDumpApp) by pressing "w".
To dump the rendering tree of the app (debugDumpRenderTree), press "t".
For layers (debugDumpLayerTree), use "L"; for accessibility
(debugDumpSemantics), use "S" (for traversal order) or "U" (for inverse hit test
order).
To toggle the widget inspector (WidgetsApp.showWidgetInspectorOverride), press
"i".
To toggle the display of construction lines (debugPaintSizeEnabled), press "p".
To simulate different operating systems, (defaultTargetPlatform), press "o".
To display the performance overlay (WidgetsApp.showPerformanceOverlay), press
"P".
To save a screenshot to flutter.png, press "s".
To repeat this help message, press "h". To detach, press "d"; to quit, press
"q".
```

Figure 2-11. Output of the command `flutter run`

2-9. Building Flutter App Binaries

Problem

You want to build app binaries for Android and iOS platforms.

Solution

Use the command `flutter build`.

Discussion

To deploy Flutter apps to devices and publish to app stores, we need to build the binaries for Android and iOS platforms. The command `flutter build` supports building these binaries.

Build APK Files for Android

The command `flutter build apk` builds the APK file for your app.

Table 2-7 shows the arguments supported by this command.

Table 2-7. Arguments of `flutter build apk`

| Argument | Description |
|------------------------|---|
| <code>--debug</code> | Build a debug version. |
| <code>--profile</code> | Build a version specialized for performance profiling. |
| <code>--release</code> | Build a release version ready for publishing to app store. |
| <code>--flavor</code> | Build a custom app flavor defined by platform-specific build setup. This requires using product flavors in Android Gradle scripts and custom Xcode schemes. |

(continued)

Table 2-7. (*continued*)

| Argument | Description |
|------------------------|--|
| --pub / --no-pub | Whether to run flutter packages get before building the app. |
| --build-number=<int> | An integer to specify an increasing internal version number. This value must be unique for each build. The value is used as “versionCode”. |
| --build-name=<x.y.z> | A string version number in the format of x.y.z. The value is used as “versionName”. |
| --build-shared-library | Compile to a *.so file. |
| --target-platform | The target platform. Possible values are android-arm and android-arm64. |

When building APK file, --release is the default mode. The following command builds a release version with build number 5 and version name 0.1.0.

```
$ flutter build apk --build-number=5 --build-name=0.1.0
```

Build for iOS

The command `flutter build ios` builds iOS application bundles. This command has the same arguments --debug, --profile, --release, --flavor, --pub, --no-pub, --build-number, and --build-version as `flutter build apk`. The value of --build-number is used as “CFBundleVersion”, while the value of --build-name is used as “CFBundleShortVersionString”.

It also has other arguments; see Table 2-8.

Table 2-8. Extra arguments of flutter build ios

| Argument | Description |
|----------------------------|--|
| --simulator | Build a version for the iOS simulator. |
| --no-simulator | Build a version for the iOS device. |
| --codesign / --no-codesign | Whether to sign the application bundle. Default value is --codesign. |

By default, `flutter build ios` builds the app for device, that is, `--no-simulator` is used. The following command builds a debug version for the simulator without signing the application bundle.

```
$ flutter build ios --debug --no-codesign --simulator
```

2-10. Installing Flutter Apps

Problem

You want to install Flutter apps to emulators or devices.

Solution

Use the command `flutter install`.

Discussion

The command `flutter install` installs the current Flutter app to emulators or devices. To install the app, you need to have at least one emulator started or one device connected. Before installing the app, a binary file should be available for the target emulator or device. Use `flutter build` to build the binary file first.

The following command installs the built binary.

```
$ flutter install
```

2-11. Managing Packages

Problem

You want to manage dependencies of Flutter apps.

Solution

Use the command `flutter packages`.

Discussion

Using packages is the Dart way to manage project dependencies. Flutter inherits the same way for dependency management. You may have seen similar concepts in other programming platforms. For the dependency management to work, we need to have a way to describe sharable components and their dependencies. We also need a tool to fetch dependencies. Table 2-9 shows package management tools for different platforms. Flutter SDK uses command `flutter packages` to manage dependencies, which uses Dart pub tool under the hood.

Table 2-9. Package management tools

| Platform | Description file | Tool |
|----------|------------------|------------------|
| Node.js | package.json | npm |
| | | Yarn |
| Dart | pubspec.yaml | pub |
| Flutter | | flutter packages |
| Java | pom.xml | Maven |
| | build.gradle | Gradle |
| Ruby | Gemfile | Bundler |

The command `flutter packages get` downloads dependent packages in a Flutter project. The command `flutter packages upgrade` upgrades packages in a Flutter project. These two commands simply wrap around the underlying `pub` tool from Dart. We can also use `flutter packages pub` to directly invoke Dart `pub` tool. The command `flutter packages` cannot do much as functionalities it provides are limited. You can always use `flutter packages pub` to delegate tasks to Dart `pub` tool.

Note You should use `flutter packages get` and `flutter packages upgrade` to manage dependencies of Flutter apps. Commands `pub get` and `pub upgrade` from Dart `pub` tool shouldn't be used. If you need more functionalities from Dart `pub` tool, use `flutter packages pub`.

The command `flutter packages test` is the same as `pub run test`, but different from `flutter test`. The tests run by `flutter packages test` are hosted in a pure Dart environment, so libraries like `dart:ui` are not available. This makes the tests run faster. If you are building libraries that don't depend on any packages from Flutter SDK, you should use this command to run tests.

2-12. Running Flutter Tests

Problem

You have written tests for Flutter apps, and you want to make sure these tests passed.

Solution

Use the command `flutter test`.

Discussion

Tests are essential part of maintainable software projects. You should have tests for Flutter apps. The command `flutter test` runs tests for a Flutter app. When running the command, you can provide a list of space-separated relative file paths to specify the test files to run. If no files provided, all files in the `test` directory that have file name ending with `_test.dart` are included. The following command runs the test file `test/mytest.dart`.

```
$ flutter test test/mytest.dart
```

Filter the Tests to Run

The argument `--name` specifies the regular expression to match the names of tests to run. A test file may contain multiple tests. If you only need to do simple substring matching, use `--plain-name` instead. The following commands show the usage of `--name` and `--plain-name`.

```
$ flutter test --name="smoke\d+"
$ flutter test --plain-name=smoke
```

You can specify multiple matching conditions using `--name` and `--plain-name`. The tests to run need to match all given conditions. The following command uses both `--name` and `--plain-name`.

```
$ flutter test --name="smoke.*" --plain-name=test
```

Test Coverage

If you want to know the coverage of your tests, use the argument `--coverage`. After the testing, `flutter test` generates test coverage information and saves to the file `coverage/lcov.info`. The output path of the coverage information can be specified using the argument `--coverage-path`. If you have base coverage data, you can put it into the path `coverage/lcov.base.info` and pass the argument `--merge-coverage` to `flutter test`, then Flutter SDK will use lcov to merge these two coverage files.

To view the coverage report, you need to have lcov installed. On macOS, lcov can be installed using Homebrew.

```
$ brew install lcov
```

The command `genhtml` generates HTML files from the `lcov` coverage information file. The following command generates the HTML coverage report. Open the generated file `index.html` to view the report.

```
$ genhtml coverage/lcov.info --output-directory coverage_report
```

Debug a Test

If you want to debug a test file, you can use the argument `--start-paused`. Only a single test file is allowed in this mode. The execution is paused until a debugger is connected. The following command debugs the file `test/simple.dart`.

```
$ flutter test --start-paused test/simple.dart
```

Other Options

There are other useful arguments; see Table 2-10.

Table 2-10. *Extra arguments of flutter test*

| Arguments | Description | Default value |
|--|---|---------------|
| <code>--j</code> , <code>--concurrency</code> | The number of concurrent tests to run. | 6 |
| <code>--pub</code> / <code>--no-pub</code> | Whether to run flutter packages get before running the tests. | On |

2-13. Analyzing the Code

Problem

Your Flutter code compiles successfully and looks good in tests. However, you want to know if there are any potential errors or bad code practices in your code.

Solution

Use the command `flutter analyze`.

Discussion

Even though your code compiles successfully and passes all tests, it's still possible for the code to have potential errors or bad smells. For example, a local variable is declared but never used. It's a good practice to keep the code as clean as possible. Dart provides the analyzer to analyze source code to find potential errors.

The command `flutter analyze` accepts a list of directories to scan Dart files. If no path is provided, `flutter analyze` simply analyzes current working directory. The following command analyzes the directory `~/my_app/lib`.

```
$ flutter analyze ~/my_app/lib
```

The analysis result can be written to a file with the argument `--write`. By default, the result is written to the console. You can also pass the argument `--watch` to let the analyzer watch for file system changes and run analysis continuously.

Table 2-11 shows extra arguments of `flutter analyze`.

Table 2-11. Extra arguments of flutter analyze

| Arguments | Description | Default value |
|--|--|---------------|
| --current-package / --no-current-package | Whether to analyze current project. If --no-current-package is enabled and no directory is specified, then nothing will be analyzed. | On |
| --pub / --no-pub | Whether to run flutter packages get before running the analysis. | On |
| --preamble / --no-preamble | Whether to show the current file being analyzed. | On |
| --congratulate / --no-congratulate | Whether to show output even there are no errors, warnings, hints, or lints. | On |
| --watch | Continuously monitors for file system changes, and runs analysis in response. | |

The command `flutter analyze` delegates the code analysis to Dart `dartanalyzer` tool. We can use the file `analysis_options.yaml` in the project's root directory to customize the analysis behavior.

Figure 2-12 shows the output of `flutter analyze` with one issue found in the code.

```
flutter-app — fucheng@Fus-MacBook-Pro — ..t/flutter-app — -zsh — 80x7
flutter analyze
Analyzing flutter-app...
info • The value of the local variable 'value' isn't used •
lib/main.dart:68:9 • unused_local_variable

1 issue found. (ran in 2.7s)
```

Figure 2-12. Output of the command `flutter analyze`

2-14. Managing Emulators

Problem

You want to manage different emulators used by Flutter SDK.

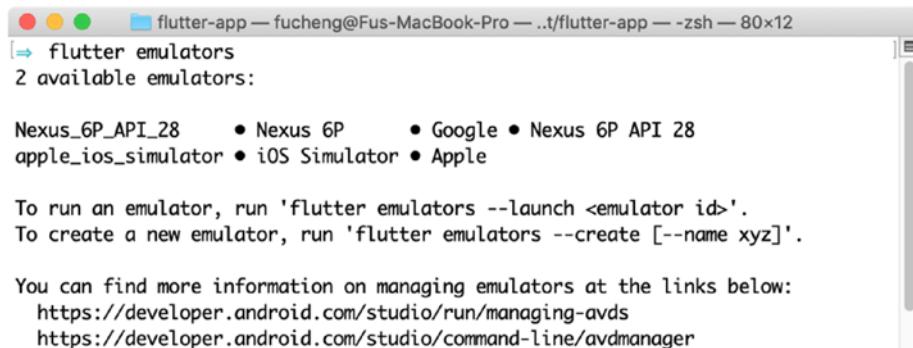
Solution

Use the command `flutter emulators`.

Discussion

When setting up the Android and iOS platforms for Flutter SDK, we also created emulators for Android and iOS. For Android, we can use AVD Manager to manage emulators. For iOS, we can use Xcode to manage simulators. It will be convenient if we can manage both Android emulators and iOS simulators in the same way. The command `flutter emulators` is the tool for managing emulators.

Running `flutter emulators` shows all available emulators for Flutter SDK to use; see Figure 2-13.



```
flutter-app — fucheng@Fus-MacBook-Pro — ..t/flutter-app — -zsh — 80x12
flutter emulators
2 available emulators:

Nexus_6P_API_28      • Nexus 6P      • Google • Nexus 6P API 28
apple_ios_simulator • iOS Simulator • Apple

To run an emulator, run 'flutter emulators --launch <emulator id>'.
To create a new emulator, run 'flutter emulators --create [--name xyz]'.

You can find more information on managing emulators at the links below:
  https://developer.android.com/studio/run/managing-avds
  https://developer.android.com/studio/command-line/avdmanager
```

Figure 2-13. Output of the command `flutter emulators`

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To start a simulator, use `flutter emulators --launch <emulator_id>`. The following command launches the `Nexus_6P_API_28` emulator. You only need to provide a partial ID to find the exact emulator to launch. The partial ID must only match one emulator.

```
$ flutter emulators --launch Nexus
```

We can also create a new Android emulator using `flutter emulators --create`. The following command creates a new emulator with the name `Pixel`. This command can only create emulators based on Pixel devices.

```
$ flutter emulators --create --name Pixel
```

2-15. Taking Screenshots

Problem

You want to take screenshots of your running apps.

Solution

Use the command `flutter screenshot`.

Discussion

Android emulators and iOS simulators both provide the native functionalities to take screenshots. For iOS simulators, this can be done using the menu **File ▶ New Screen Shot**. For Android emulators, this can be done by clicking the Screenshot icon in the floating control bar. But using the UI controls is not quite convenient. The screenshots taken by emulators are saved to the desktop by default. You have to configure the emulators to save to the desired location.

The command `flutter screenshot` is much easier to use than the built-in features in emulators. You can use the argument `-o` or `--output` to specify the location to save the screenshot; see the following command.

```
$ flutter screenshot -o ~/myapp/screenshots/home.png
```

`flutter screenshot` can take different types of screenshots. The argument `--type` accepts values in Table 2-12.

Table 2-12. *Types of screenshots*

| Type | Description |
|------------|---|
| Device | Use the device's native screenshot capabilities. The screenshot includes the entire screen currently being displayed. This is the default type. |
| Rasterizer | Screenshot of the Flutter app rendered using the rasterizer. |
| skia | Screenshot of the Flutter app rendered as a Skia picture. |

For the types of `rasterizer` and `skia`, the argument `--observatory-port` is required to provide the Dart Observatory port number of the running app. This port is displayed in the output of the command `flutter run`.

2-16. Attaching to Running Apps

Problem

Your Flutter app is not launched using `flutter run`, but you need want to interact with it.

Solution

Use the command `flutter attach`.

Discussion

When a Flutter app is launched using `flutter run`, we can interact with it using the console. However, the app can also be launched in other ways. For example, we can close the app on the device and open it again. In this case, we lose the control of the running app. `flutter attach` provides a way to attach to running apps.

If the app is already running and you know the port of its observatory, use `flutter attach --debug-port` to attach to it. The following command attaches to a running app.

```
$ flutter attach --debug-port 10010
```

If no observatory port is provided, `flutter attach` starts listening and scanning for new apps that become active. When a new observatory is detected, this command attaches to the app automatically.

```
$ flutter attach
```

In Figure 2-14, `flutter attach` is initially waiting for a new Flutter app to start. Once a Flutter app is started, `flutter attach` connects to it and shows the same console as `flutter run`.

```
flutter attach
Waiting for a connection from Flutter on iPhone XR...
Done.
Syncing files to device iPhone XR... 1.9s

🔥 To hot reload changes while running, press "r". To hot restart (and rebuild state), press "R".
An Observatory debugger and profiler on iPhone XR is available at:
http://127.0.0.1:53610/
For a more detailed help message, press "h". To detach, press "d"; to quit,
press "q".
```

Figure 2-14. Output of the command `flutter attach`

2-17. Tracing Running Flutter Apps

Problem

You want to trace the execution of a running app.

Solution

Use the command `flutter trace`.

Discussion

To start tracing, we need to know the observatory port of the running app and provide this port to `flutter trace` with the argument `--debug-port`. By default the tracing runs for 10 seconds and writes the result JSON file to the current directory with names like `trace_01.json`, `trace_02.json`, and so on. In the following command, the observatory port is 51240.

```
$ flutter trace --debug-port=51240
```

Use the argument `-d` or `--duration` to specify the duration in seconds for the tracing to run. The following command runs the tracing for 5 seconds.

```
$ flutter trace --debug-port=51240 -d 5
```

If you prefer to manually control the tracing progress, you can use `flutter trace --start` to start the tracing first, then use `flutter trace --stop` to stop the tracing at a later time. It's worth noting that when calling `flutter trace --stop`, the tracing needs to wait for the time specified in `--duration` before it's stopped. In the following command, after the

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second `flutter trace --stop`, the tracing waits for another 10 seconds before stopping, which is the default value of `--duration`.

```
$ flutter trace --start  
$ flutter trace --stop
```

To stop the tracing immediately, use the following command.

```
$ flutter trace --stop -d 0
```

2-18. Configuring Flutter SDK

Problem

You want to configure different settings of Flutter SDK.

Solution

Use the command `flutter config`.

Discussion

The command `flutter config` allows configuring some Flutter SDK settings. Table 2-13 shows arguments of `flutter config`.

Table 2-13. Arguments of *flutter config*

| Arguments | Description | Default value |
|---------------------------------|--|---------------|
| --analytics / --no-analytics | Whether to report anonymous tool usage statistics and crash reports. | On |
| --clear-ios-signing-cert | Clear the saved development certificate used to sign apps for iOS device deployment. | |
| --gradle-dir | Set the Gradle install directory. | |
| --android-sdk | Set the Android SDK directory. | |
| --android-studio-dir | Set the Android Studio install directory. | |

To remove a setting, simply configure it to an empty string. The following command disables analytics reporting.

```
$ flutter config --no-analytics
```

2-19. Showing App Logs

Problem

You want to see logs generated by Flutter apps running on emulators or devices.

Solution

Use the command `flutter logs`.

Discussion

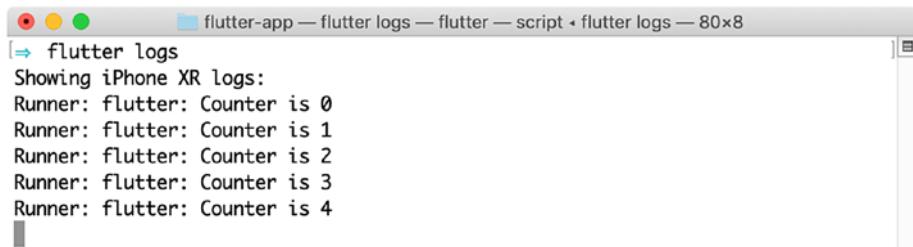
Even though we can debug a Flutter app's code to find out causes of certain problems, logs are still very valuable for error diagnosis. The easiest way to generate logs in Flutter apps is calling the `print()` method. The command `flutter logs` watches for logs generated on the device and prints out to the console.

```
$ flutter logs
```

Use the argument `-c` or `--clear` if you want to clear the log history before reading the logs.

```
$ flutter logs -c
```

Figure 2-15 shows the output of `flutter logs`.



```
flutter logs
Showing iPhone XR logs:
Runner: flutter: Counter is 0
Runner: flutter: Counter is 1
Runner: flutter: Counter is 2
Runner: flutter: Counter is 3
Runner: flutter: Counter is 4
```

Figure 2-15. Output of the command `flutter logs`

2-20. Formatting Source Code

Problem

You want to make sure that the source code of your app follows the same code style.

Solution

Use the command `flutter format`.

Discussion

It's a good practice to have the same code style for your app, especially for a development team. The consistent code style is also good for code reviews. The command `flutter format` can format the source code files to match the default code style of Dart.

To run `flutter format`, you need to provide a space-separated list of paths. The following command formats the current directory.

```
$ flutter format .
```

`flutter format` simply delegates the formatting task to Dart `dartfmt` tool. The code style is described in the official guide (<https://dart.dev/guides/language/effective-dart/style>) of Dart language. Table 2-14 shows extra arguments of `flutter format`.

Table 2-14. Extra arguments of `flutter format`

| Argument | Description |
|------------------------------------|--|
| <code>-n, --dry-run</code> | Just show which files would be modified without actually modifying them. |
| <code>--set-exit-if-changed</code> | Return exit code 1 if there are any formatting changes made by this command. |
| <code>-m, --machine</code> | Set the output format to JSON. |

2-21. Listing Connected Devices

Problem

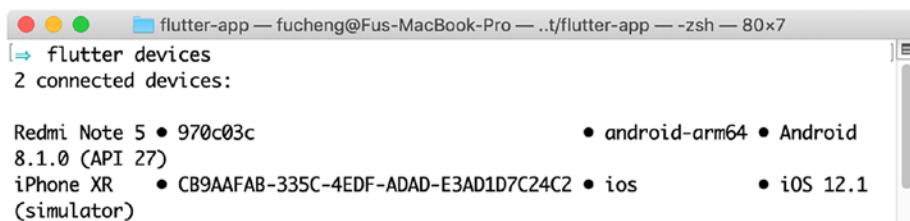
You want to see all connected devices that can be used by Flutter SDK.

Solution

Use the command `flutter devices`.

Discussion

Flutter SDK requires at least one emulator or device to be ready before running certain commands. Flutter SDK uses the term “device” to reference Android emulators, iOS simulators, and real devices. The command `flutter devices` lists all devices that can be used by Flutter SDK. Figure 2-16 shows the output of `flutter devices`.



```
flutter-app — fucheng@Fus-MacBook-Pro — ..t/flutter-app — -zsh — 80x7
flutter devices
2 connected devices:
  Redmi Note 5 • 970c03c • android-arm64 • Android
  8.1.0 (API 27)
  iPhone XR    • CB9AAFAB-335C-4EDF-ADAD-E3AD1D7C24C2 • ios
  (simulator)   • iOS 12.1
```

Figure 2-16. Output of `flutter devices`

2-22. Running Integration Tests

Problem

You have written integration tests using Flutter Driver, and you want to run these tests.

Solution

Use the command `flutter drive`.

Discussion

Flutter Driver is the tool provided by Flutter SDK to run integration tests. When running integration tests, the app itself is running in an emulator or a device, but the test scripts run on your local machine. During the tests, the test script connects to the running app and sends commands to the app to simulate different user actions. The test script can perform actions like tapping and scrolling. It can also read widget properties and verify their correctness.

`flutter drive` is the command to run integration tests. It can launch the app itself or connect to an existing running app. When `flutter drive` launches the app, it can take the same arguments as `flutter run`, including `--debug`, `--profile`, `--flavor`, `--route`, `--target`, `--observatory-port`, `--pub`, `--no-pub`, and `--trace-startup`. These arguments have the same meaning as in `flutter run`. When connecting to an existing app, the argument `--use-existing-app` needs to be specified with the observatory URL of the existing app; see the following command.

```
$ flutter drive --use-existing-app=http://localhost:50124
```

When launching the test script, `flutter drive` uses a convention to locate the test script file based on the entry point file of the app. The entry point file is specified using the argument `--target` with a default value of `lib/main.dart`. `flutter drive` tries to find the test script file in the `test_driver` directory with the same name but with a suffix `_test.dart`. For example, if the entry point file is `lib/main.dart`, it tries to find the test script file `test_driver/main_test.dart`. You can explicitly specify the test script file using the argument `--driver`; see the following command.

```
$ flutter drive --driver=test_driver/simple.dart
```

If the app is started by `flutter drive`, then the app will be stopped after test script finishes, unless the argument `--keep-app-running` is specified to keep it running. When connecting to an existing app, the app keeps running after test script finishes, unless the argument `--no-keep-app-running` is specified to stop it. The following command keeps the app running after the test.

```
$ flutter drive --keep-app-running
```

2-23. Enabling Bash Completion of Flutter SDK Commands

Problem

When typing Flutter SDK commands, you want to have the completion support for your shell.

Solution

Use the command `flutter bash-completion` to set up completion.

Discussion

With shell completion support, when you type some commands, the shell tries to complete it. `flutter bash-completion` prints the setup script to enable completion for bash and zsh. If no argument is provided, the setup script is printed out to the console. If a file path is provided, the setup script is then written to this file.

On macOS, we can use Homebrew to install `bash-completion` first.

```
$ brew install bash-completion
```

If you are using bash, you need to modify the file `~/.bash_profile` to add the following line.

```
[ -f /usr/local/etc/bash_completion ] && . /usr/local/etc/bash_completion
```

Then you can run `flutter bash-completion` to save the setup script to the directory `/usr/local/etc/bash_completion.d`; see the following command.

```
$ flutter bash-completion /usr/local/etc/bash_completion.d/flutter
```

Finally, you should run `source ~/.bash_profile` or restart the shell to enable the completion.

If you are using zsh, you can add the setup script to the file `~/.zshrc`. First you need to add the following line to the top of `~/.zshrc`.

```
autoload bashcompinit  
bashcompinit
```

Then you need to run the following command to add the setup script to `~/.zshrc`.

```
$ flutter bash-completion >> ~/.zshrc
```

Finally, you should run `source ~/.zshrc` or restart the shell to enable the completion.

2-24. Cleaning Build Files of Flutter Apps

Problem

You want to clean build files of Flutter apps.

Solution

Use the command `flutter clean`.

Discussion

The command `flutter clean` deletes files in the `build` directory. The disk size of the `build` directory can be large even for small apps. For example, after building the Flutter sample app, the size of the `build` directory is about 200M. When learning Flutter, you may create many small apps for testing. It's a good idea to run `flutter clean` for those apps when you think you have done with them. You'll find out that you can reclaim a large amount of disk space.

2-25. Managing Flutter SDK Cache

Problem

You want to explicitly manage the cache of Flutter SDK.

Solution

Use the command `flutter precache`.

Discussion

Flutter SDK keeps a cache of required artifacts in the `bin/cache` directory. This directory contains binary files of Dart SDK, Flutter Engine, Material fonts, and Gradle wrapper. This cache is populated automatically if it doesn't exist. The command `flutter precache` explicitly updates the cache. Most of Flutter commands update the cache automatically before execution, except for commands `config`, `precache`, `bash-completion`, and `upgrade`, so most of the time you don't need to explicitly run this command.

`flutter precache` has the argument `-a` or `--all-platforms` to specify whether artifacts for all platforms should be downloaded. By default, only artifacts of the current platform are downloaded.

```
$ flutter precache -a
```

2-26. Summary

This chapter is about the tools you may need to use when developing Flutter apps. You may not need to use all of these tools. With the help of IDEs, you can perform most of the actions inside of IDEs. Knowledge of these tools is still valuable because you can do more with these tools. In the next chapter, we'll see recipes about essential parts of Dart language.

CHAPTER 3

Essential Dart

Flutter projects can have cross-platform code and platform-specific code. Cross-platform code is written in Dart. Sufficient knowledge of Dart is a prerequisite for building Flutter apps. Details of Dart language is out of the scope of this book. You can find plenty of online resources related to Dart. However, it's still very helpful to cover essential part of Dart for building Flutter apps. Recipes in this chapter cover different aspects of Dart. You can skip this chapter if you are confident about your knowledge of Dart.

3-1. Understanding Built-In Types

Problem

You want to know the built-in types of Dart.

Solution

Dart has built-in types of numbers, strings, booleans, lists, maps, runes, and symbols.

Discussion

Dart has several built-in types, including numbers, strings, booleans, lists, maps, runes, and symbols.

Numbers

Numbers in Dart can be integer values no larger than 64 bits or 64-bit double-precision floating-point number specified by the IEEE 754 standard. Types `int` and `double` represent these two types of numbers, respectively. Type `num` is the supertype of `int` and `double`. Unlike primitive types in Java, numbers in Dart are also objects. They have methods to work with them.

In Listing 3-1, the type of `x` is `int`, while the type of `y` is `double`. The method `toRadixString()` returns a string value by converting the value to the specified radix. The method `toStringAsFixed()` makes sure that the given number of fraction digits is kept in the string representation. The static method `tryParse()` of `double` tries to parse a string as a `double` literal.

Listing 3-1. Numbers

```
var x = 10;
var y = 1.5;
assert(x.toRadixString(8) == '12');
assert(y.toStringAsFixed(2) == '1.50');
var z = double.tryParse('3.14');
assert(z == 3.14);
```

Strings

Dart strings are sequences of UTF-16 code units. Either single or double quotes can be used to create strings. It doesn't matter which quote is used. The key point is to be consistent across the whole code base. Dart has built-in support for string interpolation. Expressions can be embedded into strings using the form `${expression}` . Values of embedded expressions are evaluated when strings are used. If the expression is an identifier, then `{}` can be omitted. In Listing 3-2, `name` is an identifier, so we can use `$name` in the string.

Listing 3-2. String interpolation

```
var name = 'Alex';
assert('The length of $name is ${name.length}' == 'The length
of Alex is 4');
```

If you want to concatenate strings, you can simply place these string literals next to each other without the + operator; see Listing 3-3.

Listing 3-3. String concatenation

```
var longString = 'This is a long'
  'long'
  'long'
  'string';
```

Another way to create a multi-line string is to use a triple quote with either single or double quotes; see Listing 3-4.

Listing 3-4. Multi-line string

```
var longString2 = """
This is also a long
  long
  long
  string
""";
```

Booleans

Boolean values are represented using the type `bool`. `bool` type has only two objects: `true` and `false`. It's worth noting that only `bool` values can be used in `if`, `while`, and `assert` as conditions to check. JavaScript has a broader concept of truthy and falsy values, while Dart follows a stricter rule. For example, `if ('abc')` is valid in JavaScript, but not in Dart.

In Listing 3-5, name is an empty string. To use it in if, we need to invoke the getter isEmpty. We also need explicit check for null and 0.

Listing 3-5. Booleans

```
var name = "";
if (name.isEmpty) {
    print('name is empty');
}
var value;
assert(value == null);

var count = 5;
while(count-- != 0) {
    print(count);
}
```

Lists and Maps

Lists and maps are commonly used collection types. In Dart, arrays are List objects. Lists and maps can be created using literals or constructors. It's recommended to use collection literals when possible. Listing 3-6 shows how to create lists and maps using literals and constructors.

Listing 3-6. Lists and maps

```
var list1 = [1, 2, 3];
var list2 = List<int>(3);
var map1 = {'a': 'A', 'b': 'B'};
var map2 = Map<String, String>();
```

Runes

Runes are UTF-32 code points of a string. To express 32-bit Unicode values in a string, we can use the form \uXXXX, where XXXX is the four-digit hexadecimal value of the code point. If the code point cannot be expressed as four-digit hexadecimal value, then {} is required to wrap those digits, for example, \u{XXXX}. In Listing 3-7, the string value contains two emojis.

Listing 3-7. Runes

```
var value = '\u{1F686} \u{1F6B4}';
print(value);
```

Symbols

A Symbol object represents an operator or identifier. Symbols can be created using constructor `Symbol(<name>)` or symbol literal `#<name>`. Symbols created with the same name are equal; see Listing 3-8. Symbols should be used when you want to reference identifiers by name.

Listing 3-8. Symbols

```
assert(Symbol('a') == #a);
```

3-2. Using Enumerated Types

Problem

You want to have a type-safe way to declare a set of constant values.

Solution

Use enumerated type.

Discussion

Like other programming languages, Dart has enumerated types. To declare an enumerated type, use the `enum` keyword. Each value in an enum has an `index` getter to get the zero-based position of the value. Use `values` to get a list of all values in an enum. Enums are usually used in `switch` statements. In Listing 3-9, the enum type `TrafficColor` has three values. The index of first value `red` is 0.

Listing 3-9. Enumerated type

```
enum TrafficColor { red, green, yellow }

void main() {
  assert(TrafficColor.red.index == 0);
  assert(TrafficColor.values.length == 3);

  var color = TrafficColor.red;
  switch (color) {
    case TrafficColor.red:
      print('stop');
      break;
    case TrafficColor.green:
      print('go');
      break;
    case TrafficColor.yellow:
      print('be careful');
  }
}
```

3-3. Using Dynamic Type

Problem

You don't know the type of an object or you don't care about the type.

Solution

Use the `dynamic` type.

Discussion

Dart is a strong-typed language. Most of the time, we want an object to have a defined type. However, sometimes we may not know or don't care about the actual type; we can use `dynamic` as the type. The `dynamic` type is often confused with the `Object` type. Both `Object` and `dynamic` permit all values. `Object` should be used if you want to state that all objects are accepted. If the type is `dynamic`, we can use `is` operator to check whether it's the desired type. The actual type can be retrieved using `runtimeType`. In Listing 3-10, the actual type of `value` is `int`, then the type is changed to `String`.

Listing 3-10. Use dynamic type

```
dynamic value = 1;
print(value.runtimeType);
value = 'test';
if (value is String) {
    print('string');
}
```

3-4. Understanding Functions

Problem

You want to understand functions in Dart.

Solution

Functions in Dart are very powerful and flexible.

Discussion

Functions in Dart are objects and have the type `Function`. Functions can be assigned to values, passed in function arguments, and used as function return values. It's very easy to create high-order functions in Dart. A function may have zero or many parameters. Some parameters are required, while some are optional. Required arguments come first in the parameters list, followed by optional parameters. Optional positional parameters are wrapped in `[]`.

When a function has a long list of parameters, it's hard to remember the position and meaning of these parameters. It's better to use named parameters. Named parameters can be marked as required using the `@required` annotation. Parameters can have default values specified using `=`. If no default value is provided, the default value is `null`.

In Listing 3-11, the function `sum()` has an optional positional argument `initial` with the default value `0`. The function `joinToString()` has a required named argument `separator` and two optional named arguments `prefix` and `suffix`. The arrow syntax used in `joinToString()` is a shorthand for function body with only one expression. The syntax `=> expr` is the same as `{ return expr; }`. Using arrow syntax makes code shorter and easier to read.

Listing 3-11. Function parameters

```
import 'package:meta/meta.dart';

int sum(List<int> list, [int initial = 0]) {
    var total = initial;
    list.forEach((v) => total += v);
    return total;
}

String joinToString(List<String> list,
    {@required String separator, String prefix = ", " String
     suffix = ""}) =>
    '$prefix${list.join(separator)}$suffix';

void main() {
    assert(sum([1, 2, 3]) == 6);
    assert(sum([1, 2, 3], 10) == 16);

    assert(joinToString(['a', 'b', 'c'], separator: ',') ==
        'a,b,c');
    assert(
        joinToString(['a', 'b', 'c'], separator: '-', prefix:
        '*', suffix: '?') ==
        '*a-b-c?');
}
```

Sometimes you may not need a name for a function. These anonymous functions are useful when providing callbacks. In Listing 3-12, an anonymous function is passed to the method `forEach()`.

Listing 3-12. Anonymous functions

```
var list = [1, 2, 3];
list.forEach((v) => print(v * 10));
```

3-5. Using Typedefs

Problem

You want to have an alias of a function type.

Solution

Use typedefs.

Discussion

In Dart, functions are objects. Functions are instances of the type Function. But the actual type of a function is defined by the types of its parameters and the type of its return value. What matters is the actual function type when a function is used as a parameter or return value. typedef in Dart allows us to create an alias of a function type. The type alias can be used just like other types. In Listing 3-13, Processor<T> is an alias of the function type which has a parameter of type T and a return type of void. This type is used as the parameter type in the function process().

Listing 3-13. typedef

```
typedef Processor<T> = void Function(T value);

void process<T>(List<T> list, Processor<T> processor) {
  list.forEach((item) {
    print('processing $item');
    processor(item);
    print('processed $item');
  });
}
```

```
void main() {  
  process([1, 2, 3], print);  
}
```

3-6. Using Cascade Operator

Problem

You want to make a sequence of operations on the same object.

Solution

Use the cascade operator (..) in Dart.

Discussion

Dart has a special cascade operator (..) which allows us to make a sequence of operations on the same object. To chain operations on the same object in other programming languages, we usually need to create a fluent API in which each method returns the current object. The cascade operator in Dart makes this requirement unnecessary. Methods can still be chained even though they don't return the current object. The cascade operator also supports field access. In Listing 3-14, cascade operator is used to access the fields and method in classes User and Address.

Listing 3-14. Using cascade operator

```
class User {  
  String name, email;  
  Address address;  
  
  void sayHi() => print('hi, $name');  
}
```

```
class Address {  
  String street, suburb, zipCode;  
  void log() => print('Address: $street');  
}  
  
void main() {  
  User()  
    ..name = 'Alex'  
    ..email = 'alex@example.org'  
    ..address = (Address()  
      ..street = 'my street'  
      ..suburb = 'my suburb'  
      ..zipCode = '1000'  
      ..log())  
    ..sayHi();  
}
```

3-7. Overriding Operators

Problem

You want to override operators in Dart.

Solution

Define overriding methods in class for operators.

Discussion

Dart has many operators. Only a subset of these operators can be overridden. These overridable operators are <, +, |, [], >, /, ^, []=, <=, ~/, &, ~, >=, *, <<, ==, -, %, and >>. For some classes, using operators is

more concise than using methods. For example, the `List` class overrides the `+` operator for list concatenation. The code `[1] + [2]` is very easy to understand. In Listing 3-15, the class `Rectangle` overrides operators `<` and `>` to compare instances by area.

Listing 3-15. Overriding operators

```
class Rectangle {  
    int width, height;  
    Rectangle(this.width, this.height);  
  
    get area => width * height;  
  
    bool operator <(Rectangle rect) => area < rect.area;  
    bool operator >(Rectangle rect) => area > rect.area;  
}  
  
void main() {  
    var rect1 = Rectangle(100, 100);  
    var rect2 = Rectangle(200, 150);  
    assert(rect1 < rect2);  
    assert(rect2 > rect1);  
}
```

3-8. Using Constructors

Problem

You want to create new instances of Dart classes.

Solution

Use constructors.

Discussion

Like other programming languages, objects in Dart are created by constructors. Usually, constructors are created by declaring functions with the same name as their classes. Constructors can have arguments to provide necessary values to initialize new objects. If no constructor is declared for a class, a default constructor with no arguments is provided. This default constructor simply invokes the no-argument constructor in the superclass. However, if a constructor is declared, this default constructor doesn't exist.

A class may have multiple constructors. You can name these constructors in the form `ClassName.identifier` to better clarify the meanings.

In Listing 3-16, the class `Rectangle` has a regular constructor that takes four arguments. It also has a named constructor `Rectangle.fromPosition`.

Listing 3-16. Constructors

```
class Rectangle {  
    final num top, left, width, height;  
  
    Rectangle(this.top, this.left, this.width, this.height);  
  
    Rectangle.fromPosition(this.top, this.left, num bottom, num  
    right)  
        : assert(right > left),  
          assert(bottom > top),  
          width = right - left,  
          height = bottom - top;  
  
    @override  
    String toString() {
```

```
        return 'Rectangle{top: $top, left: $left, width: $width,
height: $height}';
    }
}

void main(List<String> args) {
    var rect1 = Rectangle(100, 100, 300, 200);
    var rect2 = Rectangle.fromPosition(100, 100, 300, 200);
    print(rect1);
    print(rect2);
}
```

It's common to use factories to create objects. Dart has a special kind of factory constructors that implements this pattern. A factory constructor doesn't always return a new instance of a class. It may return a cached instance, or an instance of a subtype. In Listing 3-17, the class `ExpensiveObject` has a named constructor `ExpensiveObject._create()` to actually create a new instance. The factory constructor only invokes `ExpensiveObject._create()` when `_instance` is null. When running the code, you can see that the message "created" is only printed once.

Listing 3-17. Factory constructor

```
class ExpensiveObject {
    static ExpensiveObject _instance;
    ExpensiveObject._create() {
        print('created');
    }

    factory ExpensiveObject() {
        if (_instance == null) {
            _instance = ExpensiveObject._create();
        }
    }
}
```

```
    return _instance;  
}  
}  
  
void main() {  
    ExpensiveObject();  
    ExpensiveObject();  
}
```

3-9. Extending a Class

Problem

You want to inherit behavior from an existing class.

Solution

Extend from the existing class to create a subclass.

Discussion

Dart is an object-oriented programming language. It provides support for inheritance. A class can extend from a superclass using the keyword `extends`. The superclass can be referred as `super` in the subclass. Subclasses can override instance methods, getters, and setters of superclasses. Overriding members should be annotated with the `@override` annotation.

Abstract classes are defined using the `abstract` modifier. Abstract classes cannot be instantiated. Abstract methods in abstract classes don't have implementations and must be implemented by non-abstract subclasses.

In Listing 3-18, the class `Shape` is abstract with an abstract method `area()`. Classes `Rectangle` and `Circle` both extend from `Shape` and implement the abstract method `area()`.

Listing 3-18. Inheritance

```
import 'dart:math' show pi;

abstract class Shape {
    double area();
}

class Rectangle extends Shape {
    double width, height;
    Rectangle(this.width, this.height);

    @override
    double area() {
        return width * height;
    }
}

class Square extends Rectangle {
    Square(double width) : super(width, width);
}

class Circle extends Shape {
    double radius;
    Circle(this.radius);

    @override
    double area() {
        return pi * radius * radius;
}
}
```

```
void main() {  
    var rect = Rectangle(100, 50);  
    var square = Square(50);  
    var circle = Circle(50);  
    print(rect.area());  
    print(square.area());  
    print(circle.area());  
}
```

3-10. Adding Features to a Class

Problem

You want to reuse a class's code but are limited by single inheritance of Dart.

Solution

Use mixins.

Discussion

Inheritance is a common way to reuse code. Dart only supports single inheritance, that is, a class can have at most one superclass. If you want to reuse code from multiple classes, mixins should be used. A class can declare multiple mixins using the keyword `with`. A mixin is a class that extends from `Object` and declares no constructors. A mixin can be declared as a regular class using `class` or as a dedicated mixin using `Mixin`. In Listing 3-19, `CardHolder` and `SystemUser` are mixins. The class `Assistant` extends from `Student` and has the mixin `SystemUser`, so we can use the `useSystem()` method of `Assistant` instances.

Listing 3-19. Mixins

```
class Person {  
    String name;  
  
    Person(this.name);  
}  
  
class Student extends Person with CardHolder {  
    Student(String name) : super('Student: $name') {  
        holder = this;  
    }  
}  
  
class Teacher extends Person with CardHolder {  
    Teacher(String name) : super('Teacher: $name') {  
        holder = this;  
    }  
}  
  
mixin CardHolder {  
    Person holder;  
  
    void swipeCard() {  
        print('${holder.name} swiped the card');  
    }  
}  
  
mixin SystemUser {  
    Person user;  
  
    void useSystem() {  
        print('${user.name} used the system.');  
    }  
}
```

```
class Assistant extends Student with SystemUser {  
    Assistant(String name) : super(name) {  
        user = this;  
    }  
}  
  
void main() {  
    var assistant = Assistant('Alex');  
    assistant.swipeCard();  
    assistant.useSystem();  
}
```

3-11. Using Interfaces

Problem

You want to have a contract for classes to follow.

Solution

Use implicit interface of a class.

Discussion

You should be familiar with interfaces as the contract of classes. Unlike other object-oriented programming languages, Dart has no concept of interfaces. Every class has an implicit interface that contains all the instance members of this class and the interfaces it implements. You can use `implements` to declare that a class implements the API of another class. In Listing 3-20, class `CachedDataLoader` implements the implicit interface of class `DataLoader`.

Listing 3-20. Interfaces

```
class DataLoader {  
    void load() {  
        print('load data');  
    }  
}  
  
class CachedDataLoader implements DataLoader {  
    @override  
    void load() {  
        print('load from cache');  
    }  
}  
  
void main() {  
    var loader = CachedDataLoader();  
    loader.load();  
}
```

3-12. Using Generics

Problem

You want to have type safety when your code is designed to work with different types.

Solution

Use generic classes and generic methods.

Discussion

Generics are not a strange concept to developers, especially for Java and C# developers. With generics, we can add type parameters to classes and methods. Generics are usually used in collections to create type-safe collections. Listing 3-21 shows the usage of generic collections in Dart. Dart generic types are reified, which means type information are available at runtime. That's why the type of names is `List<String>`.

Listing 3-21. Generic collections

```
var names = <String>['a', 'b', 'c'];
print(names is List<String>);
var values = <String, int>{'a': 1, 'b': 2, 'c': 3};
print(values.values.toList());
```

We can use generics to create classes that deal with different types. In Listing 3-22, `Pair<F, S>` is a generic class with two type parameters F and S. Use `extends` to specify the upper bound of a generic type parameter. The type parameter P in `CardHolder` has an upper bound of type `Person`, so that `CardHolder<Student>` is valid.

Listing 3-22. Generic types

```
class Pair<F, S> {
  F first;
  S second;

  Pair(this.first, this.second);
}

class Person {}

class Teacher extends Person {}
```

```
class Student extends Person {}

class CardHolder<P extends Person> {
  P holder;
  CardHolder(this.holder);
}

void main() {
  var pair = Pair('a', 1);
  print(pair.first);
  var student = Student();
  var cardHolder = CardHolder(student);
  print(cardHolder is CardHolder<Student>);
  print(cardHolder);
}
```

Generic methods can be added to regular classes. In Listing 3-23, the regular class Calculator has two generic methods add and subtract.

Listing 3-23. Generic methods

```
class Calculator {
  T add<T extends num>(T v1, T v2) => v1 + v2;
  T subtract<T extends num>(T v1, T v2) => v1 - v2;
}

void main() {
  var calculator = Calculator();
  int r1 = calculator.add(1, 2);
  double r2 = calculator.subtract(0.1, 0.2);
  print(r1);
  print(r2);
}
```

3-13. Using Libraries

Problem

You want to reuse libraries from Dart SDK or the community.

Solution

Use `import` to import libraries to use them in your app.

Discussion

When developing non-trivial Dart apps, it's inevitable to use libraries. These can be built-in libraries in Dart SDK or libraries contributed by the community. To use these libraries, we need to import them with `import` first. `import` has only one argument to specify the URI of the library. Built-in libraries have the URI scheme `dart:`, for example, `dart:html` and `dart:convert`. Community packages have the URI scheme `package:` and are managed by the Dart `pub` tool. Listing 3-24 shows examples of importing libraries.

Listing 3-24. Import libraries

```
import 'dart:html';
import 'package:meta/meta.dart';
```

It's possible that two libraries export the same identifiers. To avoid conflicts, we can use `as` to provide prefixes for one of the libraries or both. In Listing 3-25, both `lib1.dart` and `lib2.dart` export the class `Counter`. After assigning different prefixes to these two libraries, we can use the prefix to access the class `Counter`.

Listing 3-25. Rename libraries

```
import 'lib1.dart' as lib1;  
import 'lib2.dart' as lib2;  
  
lib1.Counter counter;
```

You don't need to import all members of a library. Use `show` to explicitly include members. Use `hide` to explicitly exclude members. In Listing 3-26, when importing the library `dart:math`, only `Random` is imported; when importing the library `dart:html`, only `Element` is excluded.

Listing 3-26. Show and hide members

```
import 'dart:math' show Random;  
import 'dart:html' hide Element;
```

3-14. Using Exceptions

Problem

You want to deal with failures in Dart apps.

Solution

Report failures using `throw`. Handle exceptions using `try-catch-finally`.

Discussion

Code fails. It's natural for code to report failures and handle them. Dart has a similar exception mechanism as Java, except that all exceptions in Dart are unchecked exceptions. Methods in Dart don't declare exceptions they may

throw, so it's not required to catch exceptions. However, uncaught exceptions cause the isolate to suspend and may result in program termination. Proper failure handing is also a key characteristic of robust apps.

Report Failures

We can use `throw` to throw exceptions. In fact, all non-null objects can be thrown, not only types that implement types `Error` or `Exception`. It's recommended to only throw objects of types `Error` and `Exception`.

An `Error` object represents a bug in the code that should not happen. For example, if a list only contains three elements, trying to access the fourth element causes a `RangeError` to be thrown. Unlike `Exceptions`, `Errors` are not intended to be caught. When an error occurred, the safest way is to terminate the program. `Errors` carry clear information about why they happen.

Comparing to `Errors`, `Exceptions` are designed to be caught and handled programmatically. For example, sending HTTP requests may not succeed, so we need to handle exceptions in the code to deal with failures. `Exceptions` usually carry useful data about the failures. We should create custom types that extend from `Exception` to encapsulate necessary data.

Catch Exceptions

When an exception is thrown, you can catch it to stop it from propagating, unless you rethrow it. The goal to catch an exception is to handle it. You shouldn't catch an exception if you don't want to handle it. `Exceptions` are caught using `try`, `catch`, and on. If you don't need to access the exception object, using `on` is enough. With `catch`, you can access the exception object and the stack trace. Use `on` to specify the type of exception to be caught.

When you catch an exception, you should handle it. However, sometimes you may only want to partially handle it. In this case, you should use `rethrow` to rethrow the exception. It's a bad practice to catch an exception but not handle it completely.

If you want some code to run whether or not an exception is thrown, you can put the code in a `finally` clause. If no exception is thrown, `finally` clause runs after the `try` block. If an exception is thrown, `finally` clause runs after the matching `catch` clause.

In Listing 3-27, the function `getNumber()` throws a custom exception type `ValueTooLargeException`. In the function `main()`, the exception is caught and rethrown.

Listing 3-27. Use exceptions

```
import 'dart:math' show Random;

var random = Random();

class ValueTooLargeException implements Exception {
    int value;
    ValueTooLargeException(this.value);

    @override
    String toString() {
        return 'ValueTooLargeException{value: $value}';
    }
}

int getNumber() {
    var value = random.nextInt(10);
    if (value > 5) {
        throw ValueTooLargeException(value);
    }
    return value;
}
```

```
void main() {  
    try {  
        print(getNumber());  
    } on ValueTooLargeException catch (e) {  
        print(e);  
        rethrow;  
    } finally {  
        print('in finally');  
    }  
}
```

3-15. Summary

Learning a new programming language is not an easy task. Even though Dart looks similar with other programming languages, there are still some unique features in Dart. This chapter only provides a brief introduction of important features in Dart.

CHAPTER 4

Widget Basics

When building Flutter apps, most of the time you are dealing with widgets. This chapter provides basic background information about widgets in Flutter. It also covers several basic widgets that display texts, images, icons, buttons, and placeholders.

4-1. Understanding Widgets

Problem

You want to know how to use components in Flutter.

Solution

Widgets are everywhere in Flutter.

Discussion

If you have been involved in development of user interface, you should be familiar with concepts like widgets or components. These concepts represent reusable building blocks to create user interface. A good user interface library should have a large number of high-quality and easy-to-use components. Buttons, icons, images, menus, dialogs, and form inputs are all examples of components. Components can be big or small. Complicated components are usually composed of small components. You can create your own components by following the component model. You can also

choose to share your components to the community. A good eco-system of components is a key factor for a user interface library to be successful.

Flutter uses widgets to describe reusable building blocks in the user interface. Comparing to other libraries, widget in Flutter is a much broader concept. Not only common components like buttons and form inputs are widgets, layout constraints are also expressed as widgets in Flutter. For example, if you want to place a widget in the center of a box, you simply wrap the widget into a `Center` widget. Widgets are also used to retrieve context data. For example, `DefaultTextStyle` widget gets the `TextStyle` applies to un-styled `Text` widgets.

Widget in Flutter is an immutable description of a part of the user interface. All fields of a widget class are final and set in the constructor. Widget constructors only have named parameters. A widget can have one or many widgets as the children. Widgets of a Flutter app creates a tree-like hierarchy. The `main()` method of a Flutter app's entry point file uses the `runApp()` method to start the app. The only parameter of `runApp()` is a `Widget` object. This `Widget` object is the root of the app's widgets tree. Widgets are only static configurations that describe how to configure a subtree in the hierarchy. To actually run the app, we need a way to manage instantiation of widgets.

Flutter uses `Element` to represent an instantiation of a `Widget` at a particular location in the tree. A `Widget` can be instantiated zero or many times. The process to turn `Widgets` to `Elements` is called inflation. `Widget` class has a `createElement()` method to inflate the widget to a concrete instance of `Element`. Flutter framework is responsible for managing the lifecycle of elements. The widget associated with an element may change over time. The framework updates the element to use the new configuration.

When running the app, Flutter framework is responsible for rendering elements to create a render tree, so the end user can actually see the user interface. A render tree is composed of `RenderObjects` with the root of a `RenderView`. If you are using Android Studio, you can actually see the widgets tree and the render tree in **Flutter Inspector** view. Select View ➤ Tool Windows ➤ Flutter Inspector to open the Flutter Inspector view.

Figure 4-1 shows the widgets tree in Flutter Inspector. The top panel shows the widgets tree, while the bottom panel shows the details of a widget.

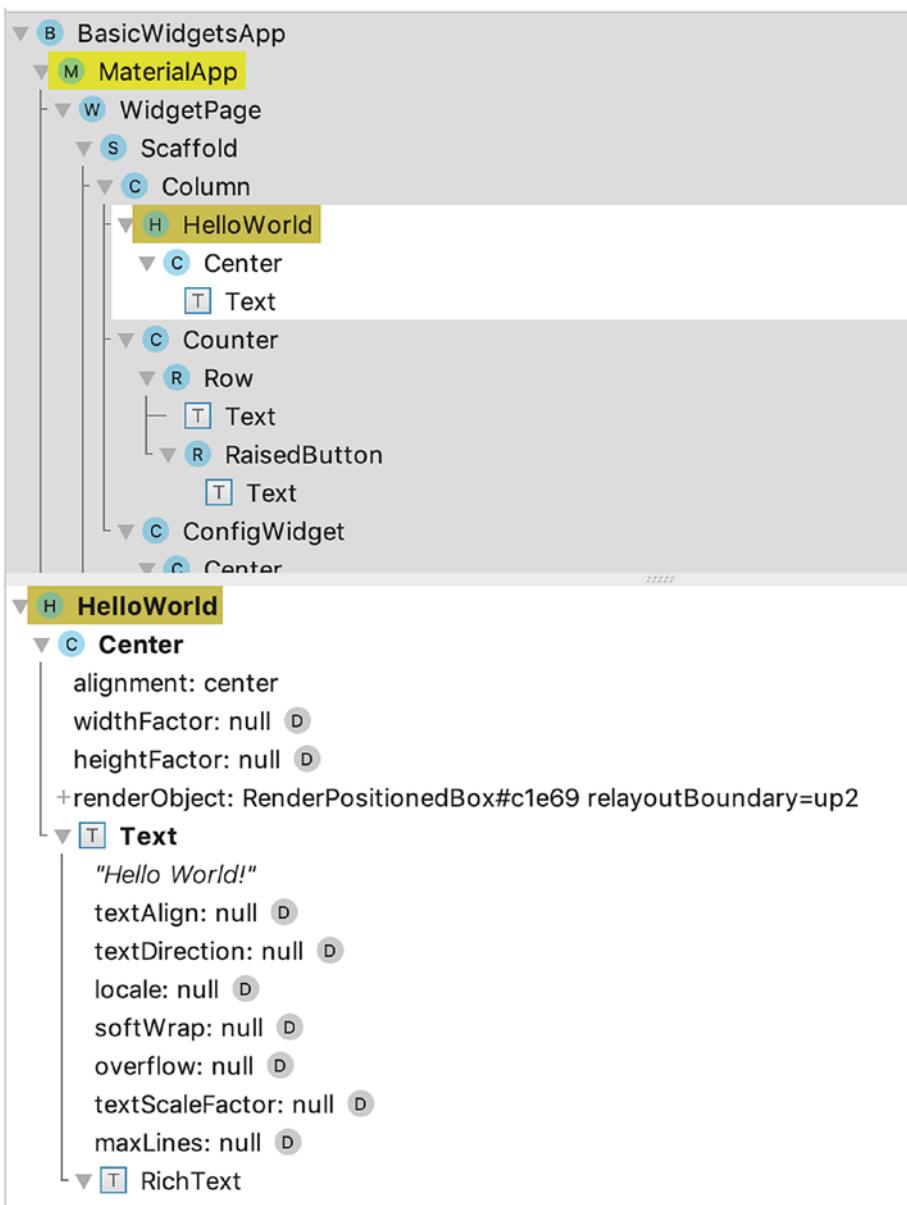


Figure 4-1. Widgets tree in Flutter Inspector

CHAPTER 4 WIDGET BASICS

Figure 4-2 shows the render tree in Flutter Inspector. The root is a `RenderView`.

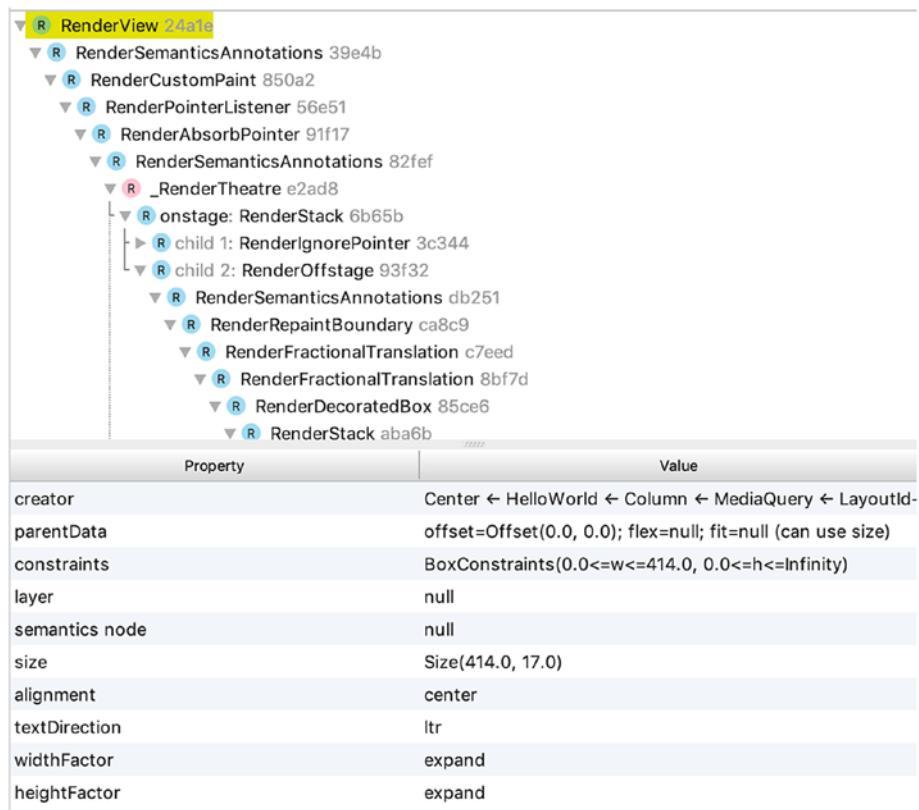


Figure 4-2. Render tree in Flutter Inspector

4-2. Understanding BuildContext

Problem

You want to access information related to a widget in the widgets tree.

Solution

WidgetBuilder functions have a BuildContext parameter to access information related to a widget in the widgets tree. You can see BuildContext in StatelessWidget.build() and State.build() methods.

Discussion

When building a widget, the location of the widget in the widgets tree may determine its behavior, especially when it has an InheritedWidget as its ancestor. BuildContext class provides methods to access information related to the location; see Table 4-1.

Table 4-1. Methods of BuildContext

| Name | Description |
|--|---|
| ancestorInheritedElementForWidgetOfType<T> | Get the InheritedElement corresponding to the nearest ancestor widget of the given type of InheritedWidget. |
| ancestorRenderObjectOfType<T> | Get the RenderObject of the nearest ancestor RenderObjectWidget widget. |
| ancestorStateOfType<T> | Get the State object of the nearest ancestor StatefulWidget widget. |
| rootAncestorStateOfType<T> | Get the State object of the furthest ancestor StatefulWidget widget. |
| ancestorWidgetOfType<T> | Get the nearest ancestor Widget. |
| findRenderObject | Get the current RenderObject for the widget. |

(continued)

Table 4-1. (continued)

| Name | Description |
|---------------------------|--|
| inheritFromElement | Register this BuildContext with the given ancestor InheritedElement such that this BuildContext is rebuilt when the ancestor's widget changes. |
| ancestorWidgetOfExactType | Get the nearest InheritedWidget of the given type and register this BuildContext such that this BuildContext is rebuilt when the widget changes. |
| visitAncestorElements | Visit ancestor elements. |
| visitChildElements | Visit children elements. |

BuildContext is actually the interface of Element class. In StatelessWidget.build() and State.build() methods, the BuildContext object represents the location where the current widget is inflated. In Listing 4-1, ancestorWidgetOfExactType() method is used to get the ancestor widget of type Column.

Listing 4-1. Use BuildContext

```
class WithBuildContext extends StatelessWidget {
  @override
  Widget build(BuildContext context) {
    Column column = context.ancestorWidgetOfExactType(Column);
    return Text(column.children.length.toString());
  }
}
```

4-3. Understanding Stateless Widget Problem

You want to create a widget that has no mutable state.

Solution

Extend from StatelessWidget class.

Discussion

When using a widget to describe a part of user interface, if the part can be fully described using the configuration information of the widget itself and the BuildContext in which it's inflated, then this widget should extend from StatelessWidget. When creating a StatelessWidget class, you need to implement the build() method which accepts a BuildContext and returns a Widget. In Listing 4-2, HelloWorld class extends from StatelessWidget class and returns a Center widget in the build() method.

Listing 4-2. Example of StatelessWidget

```
class HelloWorld extends StatelessWidget {  
  const HelloWorld({Key key}) : super(key: key);  
  
  @override  
  Widget build(BuildContext context) {  
    return Center(  
      child: Text('Hello World!'),  
    );  
  }  
}
```

4-4. Understanding StatefulWidget Problem

You want to create a widget that has mutable state.

Solution

Extend from StatefulWidget class.

Discussion

If a part of user interface may change dynamically, you need to extend from StatefulWidget class. StatefulWidget widgets themselves are immutable with states managed in State objects created by them. A StatefulWidget subclass needs to implement the createState() method that returns a State< StatefulWidget > object. When the state changes, the State object should call setState() method to notify the framework to trigger the update. In Listing 4-3, _CounterState class is the State object of the Counter widget. When the button is pressed, the value is updated in the setState() method, which updates the _CounterState widget to show the new value.

Listing 4-3. Example of StatefulWidget

```
class Counter extends StatefulWidget {  
    @override  
    _CounterState createState() => _CounterState();  
}  
  
class _CounterState extends State<Counter> {  
    int value = 0;  
  
    @override  
    Widget build(BuildContext context) {
```

```
return Row(  
    children: <Widget>[  
        Text('$value'),  
        RaisedButton(  
            child: Text('+'),  
            onPressed: () {  
                setState(() {  
                    value++;  
                });  
            },  
        ),  
    ],  
);  
}  
}
```

4-5. Understanding Inherited Widget Problem

You want to propagate data down the widgets tree.

Solution

Extend from `InheritedWidget` class.

Discussion

When building a subtree of widgets, you may need to propagate data down the widgets tree. For example, your root widget of a subtree may define some context data, for example, configuration data retrieved from the server. Other widgets in the subtree may also need to access the context

data. One possible way is to add the context data to a widget's constructor, then propagate the data as constructor parameter of children widgets. The major drawback of this solution is that you need to add the constructor parameter to all widgets in the subtree. Even though some widgets may not actually need the data, they still need to have the data to pass to their children widgets.

A better approach is to use `InheritedWidget` class. `BuildContext` class has an `inheritFromWidgetOfExactType()` method to get the nearest instance of a particular type of `InheritedWidget`. With `InheritedWidget`, you can store the context data in an `InheritedWidget` instance. If a widget needs to access the context data, you can use `inheritFromWidgetOfExactType()` method to get the instance and access the data. If an inherited widget changes state, it will cause its consumers to rebuild.

In Listing 4-4, `ConfigWidget` class has the data `config`. The static `of()` method gets the nearest ancestor `ConfigWidget` instance for the `config` value. The method `updateShouldNotify()` determines when the consumer widgets should be notified.

Listing 4-4. Example of `InheritedWidget`

```
class ConfigWidget extends InheritedWidget {  
  const ConfigWidget({  
    Key key,  
    @required this.config,  
    @required Widget child,  
  }) : assert(config != null),  
        assert(child != null),  
        super(key: key, child: child);  
  
  final String config;  
  
  static String of(BuildContext context) {  
    final ConfigWidget configWidget =
```

```
    context.inheritFromWidgetOfExactType(ConfigWidget);
    return configWidget?.config ?? "";
}

@Override
bool updateShouldNotify(ConfigWidget oldWidget) {
    return config != oldWidget.config;
}
}
```

In Listing 4-5, ConfigUserWidget class uses the ConfigWidget.of() method to get the config value.

Listing 4-5. Use of ConfigWidget

```
class ConfigUserWidget extends StatelessWidget {
    @override
    Widget build(BuildContext context) {
        return Text('Data is ${ConfigWidget.of(context)}');
    }
}
```

In Listing 4-6, ConfigWidget instance has a config value of “Hello!” and a descendant ConfigUserWidget instance.

Listing 4-6. Complete example

```
ConfigWidget(
    config: 'Hello!',
    child: Center(
        child: ConfigUserWidget(),
    ),
);
```

4-6. Displaying Text

Problem

You want to display some text.

Solution

Use the `Text` and `RichText` widgets.

Discussion

Almost all apps need to display some text to the end users. Flutter provides several classes related to text. `Text` and `RichText` are the two widgets to display text. In fact, `Text` uses `RichText` internally. The `build()` method of `Text` widget returns a `RichText` instance. The difference between `Text` and `RichText` is that `Text` uses the style from the closest enclosing `DefaultTextStyle` object, while `RichText` requires explicit style.

Text

`Text` has two constructors. The first constructor `Text()` accepts a `String` as the text to display. Another constructor `Text.rich()` accepts a `TextSpan` object to represent both text and style. The simplest form to create a `Text` widget is `Text('Hello world')`, which displays text using the style from the closest enclosing `DefaultTextStyle` object. Both `Text()` and `Text.rich()` constructors have several named parameters to customize them; see Table 4-2.

Table 4-2. Named parameters of `Text()` and `Text.rich()`

| Name | Type | Description |
|-----------------|---------------|---|
| style | TextStyle | Style of the text. |
| textAlign | TextAlign | How text should be aligned horizontally. |
| textDirection | TextDirection | Direction of text. |
| locale | Locale | Locale to select font based on Unicode. |
| softWrap | bool | Whether to break text at soft line breaks. |
| overflow | TextOverflow | How to handle text overflow. |
| textScaleFactor | double | The factor to scale the text. |
| maxLines | int | The maximum number of lines. If the text exceeds the limit, it will be truncated according to the strategy specified in <code>overflow</code> . |
| semanticsLabel | String | Semantics label for the text. |

`TextAlign` is an enum type with values shown in Table 4-3.

Table 4-3. *TextAlign values*

| Name | Description |
|---------|---|
| left | Align text on the left edge of its container. |
| right | Align text on the right edge of its container. |
| center | Align text in the center of its container. |
| justify | For lines of text end with soft line breaks, stretch these lines to fill the width of the container; for lines of text end with hard line breaks, align them toward the start edge. |
| start | Align text on the leading edge of its container. The leading edge is the left edge for left-to-right text, while it's the right edge for right-to-left text. |
| end | Align text on the trailing edge of its container. The trailing edge is the opposite of the leading edge. |

It's recommended to always use `TextAlign` values `start` and `end` instead of `left` and `right` to better handle bidirectional text. `TextDirection` is an enum type with values `ltr` and `rtl`. `TextOverflow` is an enum type with values shown in Table 4-4.

Table 4-4. *TextOverflow values*

| Name | Description |
|----------|--|
| clip | Clip the overflowing text. |
| fade | Fade the overflowing text to be transparent. |
| ellipsis | Add an ellipsis after the overflowing text. |

`DefaultTextStyle` is an `InheritedWidget` that has properties `style`, `textAlign`, `softWrap`, `overflow`, and `maxLines` which have the same meaning as named parameters shown in Table 4-2. If a named parameter is provided in the constructors `Text()` and `Text.rich()`, then the provided value overrides the value in the nearest ancestor `DefaultTextStyle` object. Listing 4-7 shows several examples of using `Text` widget.

Listing 4-7. Examples of Text

```
Text('Hello World')

Text(
    'Bigger Bold Text',
    style: TextStyle(fontWeight: FontWeight.bold),
    textScaleFactor: 2.0,
);

Text(
    'Lorem ipsum dolor sit amet, consectetur adipiscing elit, sed
    do eiusmod tempor incididunt',
    maxLines: 1,
    overflow: TextOverflow.ellipsis,
);
```

TextSpan

The constructor `Text.rich()` takes a `TextSpan` object as the required parameter. `TextSpan` represents an immutable span of text. `TextSpan()` constructor has four named parameters; see Table 4-5. `TextSpans` are organized in a hierarchy. A `TextSpan` object may have many `TextSpan` objects as the children. Children `TextSpans` can override styles from their parent.

Table 4-5. Named parameters of *TextSpan()*

| Name | Type | Description |
|------------|-------------------|---|
| style | TextStyle | Style of the text and children. |
| text | String | Text in the span. |
| children | List<TextSpan> | TextSpans as children of this span. |
| recognizer | GestureRecognizer | A gesture recognizer to receive events. |

Listing 4-8 shows the example of using `Text.rich()`. This example displays the sentence “The quick brown fox jumps over the lazy dog” using different styles.

Listing 4-8. Example of `Text.rich()`

```
Text.rich(TextSpan(
  style: TextStyle(
    fontSize: 16,
  ),
  children: [
    TextSpan(text: 'The quick brown '),
    TextSpan(
      text: 'fox',
      style: TextStyle(
        fontWeight: FontWeight.bold,
        color: Colors.red,
      )),
    TextSpan(text: ' jumps over the lazy '),
    TextSpan(
      text: 'dog',
      style: TextStyle(
```

```
        color: Colors.blue,  
    )),  
],  
));
```

RichText

RichText always uses TextSpan objects to represent text and styles. RichText() constructor has a required named parameter text of the type TextSpan. It also has optional named parameters textAlign, textDirection, softWrap, overflow, textScaleFactor, maxLines, and locale. These optional named parameters have the same meaning as Text() constructor shown in Table 4-2.

Text displayed in RichText requires explicit styling. You can use DefaultTextStyle.of() to get the default style from the BuildContext object. This is exactly what Text does internally. Text widget gets the default style and merges with the style provided in the style parameter, then creates a RichText with a TextSpan wrapping the text and merged style. If you find out that you do need to use the default style as the base, you should use Text directly instead of RichText. Listing 4-9 shows an example of using RichText.

Listing 4-9. Example of RichText

```
RichText(  
    text: TextSpan(  
        text: 'Level 1',  
        style: TextStyle(color: Colors.black),  
        children: [  
            TextSpan(  
                text: 'Level 2',  
                style: TextStyle(fontWeight: FontWeight.bold),
```

```
children: [
    TextSpan(
        text: 'Level 3',
        style: TextStyle(color: Colors.red),
    ),
],
),
],
],
),
);
);
```

4-7. Applying Styles to Text

Problem

You want the displayed text to have different styles.

Solution

Use `TextStyle` to describe styles.

Discussion

`TextStyle` describes styles applied to text. `TextStyle()` constructor has many named parameters to describe the style; see Table 4-6.

Table 4-6. Named parameters of `TextStyle()`

| Name | Type | Description |
|-----------------|---------------------|---|
| color | Color | Color of the text. |
| fontSize | Double | Size of font. |
| fontWeight | FontWeight | Typeface thickness. |
| fontStyle | FontStyle | Typeface variant. |
| letterSpacing | Double | Space between each letter. |
| wordSpacing | Double | Space between each word. |
| textBaseline | TextBaseline | Common baseline to align this text span and its parent span. |
| height | Double | Height of the text. |
| locale | Locale | Locale to select region-specific glyphs. |
| foreground | Paint | Foreground for the text. |
| background | Paint | Background for the text. |
| shadows | List<Shadow> | Shadows painted underneath the text. |
| decoration | TextDecoration | Decoration of the text. |
| decorationColor | Color | Color of text decorations. |
| decorationStyle | TextDecorationStyle | Style of text decorations. |
| debugLabel | String | Description of the style for debugging. |
| fontFamily | String | Name of the font. |
| package | String | Use with <code>fontFamily</code> if the font is defined in a package. |

FontWeight class defines values w100, w200, w300, w400, w500, w600, w700, w800, and w900. FontWeight.w100 is the thinnest, while w900 is the thickest. FontWeight.bold is an alias of FontWeight.w700, while FontWeight.normal is an alias of FontWeight.w400. FontStyle is an enum type with two values italic and normal. TextBaseline is an enum type with values alphabetic and ideographic.

TextDecoration class defines different types of text decorations. You can also use constructor TextDecoration.combine() to create a new TextDecoration instance by combining a list of TextDecoration instances. For example, TextDecoration.combine([TextDecoration.underline, TextDecoration.overline]) instance draws lines underneath and above text. Table 4-7 shows constants in TextDecoration.

Table 4-7. *TextDecoration constants*

| Name | Description |
|-------------|------------------------------|
| none | No decoration. |
| underline | Draw a line underneath text. |
| overline | Draw a line above text. |
| lineThrough | Draw a line through text. |

TextDecorationStyle is an enum type with values shown in Table 4-8. TextDecorationStyle defines the style of lines created by TextDecoration.

Table 4-8. *TextDecorationStyle values*

| Name | Description |
|--------|-------------------------|
| solid | Draw a solid line. |
| double | Draw two lines. |
| dotted | Draw a dotted line. |
| dashed | Draw a dashed line. |
| wavy | Draw a sinusoidal line. |

Listing 4-10 shows an example of using TextDecoration and TextDecorationStyle.

Listing 4-10. Example of using TextDecoration and TextDecorationStyle

```
Text(
  'Decoration',
  style: TextStyle(
    fontWeight: FontWeight.w900,
    decoration: TextDecoration.lineThrough,
    decorationStyle: TextDecorationStyle.dashed,
  ),
);
```

If you want to create a copy of a TextStyle instance with some properties updated, use the `copyWith()` method. The `apply()` method also creates a new TextStyle instance, but it allows updating some properties using factor and delta. For example, the named parameters `fontSizeFactor` and `fontSizeDelta` can update the font size. The updated value of `fontSize` is calculated with "`fontSize * fontSizeFactor + fontSizeDelta`". You can also update values of `height`, `letterSpacing`, and `wordSpacing` using the same pattern. For `fontWeight`, only

`fontWeightDelta` is supported. In Listing 4-11, the `TextStyle` applied to the text has updated values of `fontSize` and `decoration`.

Listing 4-11. Update TextStyle

```
Text(  
    'Scale',  
    style: DefaultTextStyle.of(context).style.apply(  
        fontSizeFactor: 2.0,  
        fontSizeDelta: 1,  
        decoration: TextDecoration.none,  
    ),  
);
```

4-8. Displaying Images

Problem

You want to display images loaded from network.

Solution

Use `Image.network()` with the image URL to load and display an image.

Discussion

If you have images hosted in your own servers or other places, you can display them using the `Image.network()` constructor. `Image.network()` constructor only requires the URL of the image to load. An image widget should be given specific dimension using the named parameters `width` and `height` or placed in a context that sets tight layout constraints. This is because the dimension of the image may change when the image is

loaded. Without a strict size constraint, the image widget may affect layout of other widgets. In Listing 4-12, the size of the image widget is specified with named parameters `width` and `height`.

Listing 4-12. Example of `Image.network()`

```
Image.network(
    'https://picsum.photos/400/300',
    width: 400,
    height: 300,
);
```

All downloaded images are cached regardless of HTTP headers. This means that all HTTP cache control headers will be ignored. You can use `cachebuster` to force cached images to refresh. For example, you can add a random string to the image URL.

If extra HTTP headers are required to load the image, you can specify the `headers` parameter of type `Map<String, String>` to provide these headers. A typical use case is to load protected images that require HTTP headers for authentication.

If an image cannot cover the whole area of a box, you can use the `repeat` parameter of type `ImageRepeat` to specify how images are repeated. `ImageRepeat` is an enum type with values shown in Table 4-9. The default value is `noRepeat`.

Table 4-9. `ImageRepeat` values

| Name | Description |
|-----------------------|--|
| <code>Repeat</code> | Repeat in both x and y directions. |
| <code>repeatX</code> | Repeat only in the x direction. |
| <code>repeatY</code> | Repeat only in the y direction. |
| <code>noRepeat</code> | No repeat. The uncovered area will be transparent. |

In Listing 4-13, the image is placed into a `SizedBox` which is larger than the image. By using `ImageRepeat.repeat`, the box is filled with this image.

Listing 4-13. Repeated images

```
SizedBox(  
    width: 400,  
    height: 300,  
    child: Image.network(  
        'https://picsum.photos/300/200',  
        alignment: Alignment.topLeft,  
        repeat: ImageRepeat.repeat,  
    ),  
);
```

4-9. Displaying Icons

Problem

You want to use icons.

Solution

Use `Icon` to show icons from Material Design or icon packs from community.

Discussion

Icons are used extensively in mobile apps. Comparing to text, icons take less screen estate to express the same semantics. Icons can be created from font glyphs or images. The `Icon` widget is drawn with a font glyph. A font glyph is described with `IconData` class. To create an `IconData` instance, the Unicode code point of this icon in the font is required.

Icons class has a number of predefined IconData constants for icons in Material Design (<https://material.io/tools/icons/>). For example, Icons.call is the IconData constant for the icon named “call”. If the app uses Material Design, then these icons can be used out of box. CupertinoIcons class has a number of predefined IconData constants for iOS-style icons.

Icon() constructor has named parameters size and color to specify the size and color of the icon, respectively. Icons are always square with width and height both equal to size. The default value of size is 24. Listing 4-14 creates a red Icons.call icon of size 100.

Listing 4-14. Example of Icon()

```
Icon(  
  Icons.call,  
  size: 100,  
  color: Colors.red,  
)
```

To use the popular Font Awesome icons, you can use the package font_awesome_flutter (https://pub.dartlang.org/packages/font_awesome_flutter). After adding the package dependency to pubspec.yaml file, you can import the file to use FontAwesomeIcons class. Similar with Icons class, FontAwesomeIcons class has a number of IconData constants for different icons in Font Awesome. Listing 4-15 creates a blue FontAwesomeIcons.angry icon of size 80.

Listing 4-15. Use Font Awesome icon

```
Icon(  
  FontAwesomeIcons.angry,  
  size: 80,  
  color: Colors.blue,  
)
```

4-10. Using Buttons with Text

Problem

You want to use buttons with text.

Solution

Use button widgets FlatButton, RaisedButton, OutlineButton, and CupertinoButton.

Discussion

Flutter has different types of buttons for Material Design and iOS. These button widgets all have a required parameter onPressed to specify the handler function when pressed. If the onPressed handler is null, the button is disabled. The content of a button is specified with the parameter child of type Widget. FlatButton, RaisedButton, and OutlineButton have different styles and behaviors reacting to touches:

- A FlatButton has zero elevation and no visible borders. It reacts to touches by filling with color specified by highlightColor.
- A RaisedButton has elevation and is filled with color. It reacts to touches by increasing elevation to highlightElevation.
- An OutlineButton has borders, an initial elevation of 0.0, and transparent background. It reacts to touches by making its background opaque with the color and increasing its elevation to highlightElevation.

FlatButtons should be used on toolbars, in dialogs, in cards, or inline with other content where there is enough space to make buttons' presence

obvious. `RaisedButtons` should be used where using space is not enough to make the buttons stand out. `OutlineButton` is the cross between `RaisedButton` and `FlatButton`. `OutlineButtons` can be used when neither `FlatButtons` nor `RaisedButtons` are appropriate.

If you prefer the iOS-style button, you can use the `CupertinoButton` widget. `CupertinoButton` reacts to touches by fading out and in. Listing 4-16 shows examples of creating different types of buttons.

Listing 4-16. Different types of buttons

```
FlatButton(  
    child: Text('Flat'),  
    color: Colors.white,  
    textColor: Colors.grey,  
    highlightColor: Colors.red,  
    onPressed: () => {},  
)  
  
RaisedButton(  
    child: Text('Raised'),  
    color: Colors.blue,  
    onPressed: () => {},  
)  
  
OutlineButton(  
    child: Text('Outline'),  
    onPressed: () => {},  
)  
  
CupertinoButton(  
    child: Text('Cupertino'),  
    color: Colors.green,  
    onPressed: () => {},  
)
```

4-11. Using Buttons with Icons

Problem

You want to use buttons with icons.

Solution

Use IconButton widget, FlatButton.icon(), RaisedButton.icon(), and OutlineButton.icon().

Discussion

There are two ways to create a button with an icon. If only the icon is enough, use IconButton widget. If both the icon and text are required, use constructors FlatButton.icon(), RaisedButton.icon(), or OutlineButton.icon().

IconButton constructor requires the icon parameter to specify the icon. FlatButton.icon(), RaisedButton.icon(), and OutlineButton.icon() use the parameters icon and label to specify the icon and text, respectively. Listing 4-17 shows examples of using IconButton() and RaisedButton.icon().

Listing 4-17. Examples of IconButton() and RaisedButton.icon()

```
IconButton(  
    icon: Icon(Icons.map),  
    iconSize: 50,  
    tooltip: 'Map',  
    onPressed: () => {},  
);
```

```
RaisedButton.icon(  
    icon: Icon(Icons.save),  
    label: Text('Save'),  
    onPressed: () => [],  
) ;
```

4-12. Adding Placeholders

Problem

You want to add placeholders to represent widgets that will be added later.

Solution

Use Placeholder.

Discussion

Before implementing the interface of an app, you usually have a basic idea about how the app looks like. You can start by breaking down the interface into many widgets. You can use placeholders to represent unfinished widgets during development, so you can test the layout of other widgets. For example, if you need to create two widgets, one displays at the top, while the other one displays at the bottom. If you choose to create the bottom widget first and use a placeholder for the top widget, you can see the bottom widget in its desired position.

The Placeholder() constructor takes named parameters `color`, `strokeWidth`, `fallbackWidth`, and `fallbackHeight`. The placeholder is drawn as a rectangle and two diagonals. The parameters `color` and `strokeWidth` specify color and width of the lines, respectively. By default, the placeholder fits its container. However, if the placeholder's container is unbounded, it uses the given `fallbackWidth` and `fallbackHeight` to

determine the size. Both `fallbackWidth` and `fallbackHeight` have the default value `400.0`. Listing 4-18 shows an example of `Placeholder` widget.

Listing 4-18. Example of Placeholder

```
Placeholder(  
  color: Colors.red,  
  strokeWidth: 1,  
  fallbackHeight: 200,  
  fallbackWidth: 200,  
);
```

4-13. Summary

Widgets are everywhere in Flutter apps. This chapter provides basic introduction of widgets in Flutter, including `StatelessWidget`, `StatefulWidget`, and `InheritedWidget`. This chapter also covers usage of common basic widgets to display text, images, icons, buttons, and placeholders. The next chapter will discuss layout in Flutter.

CHAPTER 5

Layout Widgets

Layout is always a challenging task when building user interface. When it comes to mobile apps, layout is much more complicated considering the large number of different screen resolutions for devices. This chapter covers recipes related to layout in Flutter.

5-1. Understanding Layout in Flutter Problem

You want to know how layout works in Flutter.

Solution

Layout in Flutter is implemented by a set of widgets. These layout widgets wrap other widgets to apply different layout constraints.

Discussion

For mobile apps, the layout must be responsive to work with different screen resolutions without writing a lot of hard-to-maintain code. Luckily, with the evolution of layout techniques, it's now easier to build responsive layout. If you have experiences with web development with CSS, you may have heard CSS Flexible Box Layout Module specification by W3C (<https://www.w3.org/TR/css-flexbox-1/>). The flex layout model is

powerful because it allows developers to express what the layout should be, instead of how to implement the actual layout. This declarative approach shifts the heavy lifting work to the underlying framework. The result layout code is easier to understand and maintain.

For example, if you want to place a box in the center of a container, the old approach may require calculating the size of the box and container to determine the position of the box. When using flex layout, the layout can be simplified as CSS code in Listing 5-1.

Listing 5-1. CSS code to center an item

```
.container {  
    display: flex;  
    width: 400px;  
    height: 400px;  
    justify-content: center;  
    align-items: center;  
    border: 1px solid green;  
}  
  
.item {  
    width: 200px;  
    height: 200px;  
    border: 1px solid red;  
}
```

The idea of flex layout has now been used not only in web design but also in mobile apps. React Native uses flex layout (<https://facebook.github.io/react-native/docs/flexbox>). Flutter also uses the idea of flex layout. As discussed in Recipe 4-1, layout is implemented as widgets. You can see widget classes like Flex, Row, Column, and Flexible in Flutter, which have names derived from flex layout concepts. The flex layout model in CSS is out of the scope of this book. However, it's still valuable to understand this W3C specification, which can help you better understand flex layout in Flutter.

RenderObject

The layout algorithm in Flutter is responsible for determining the dimension and position for each `RenderObject` instance in the render tree. `RenderObject` class is very flexible to work with any coordinate system or layout protocol. `RenderObject` class defines the basic layout protocol with the `layout()` method. The `layout()` method has one required positional parameter of type `Constraints`. `Constraints` class specifies the layout constraints that children must obey. For a particular `Constraints` instance, there may be multiple results that can satisfy it. The child is free to use any of these results as long as it's permissible. Sometimes, a `Constraints` instance may only leave one valid result to the child. This kind of `Constraints` instances are said to be tight. Tight constraints are generally less flexible, but they offer better performance as widgets with tight constraints don't need to relayout.

The `layout()` method has a named parameter `parentUsesSize` to specify whether the parent needs to use the layout information computed by the child. If `parentUsesSize` is true, it means the layout of the parent depends on the layout of the child. In this case, whenever the child needs to lay out, the parent may also need to lay out. After the layout is done, each `RenderObject` instance will have some fields set to include the layout information. The actual stored information depends on the layout implementation. This piece of layout information is stored in the `parentData` property.

By default, Flutter uses a 2D Cartesian coordinate system implemented with the `RenderBox` class. `RenderBox` class implements the box layout model with `BoxConstraints` class. In the box layout model, each `RenderBox` instance is treated as a rectangle with the size specified as a `Size` instance. Each box has its own coordinate system. The coordinate of the upper left corner is `(0,0)`, while the lower right corner has the coordinate `(width, height)`. `RenderBox` class uses `BoxParentData` as the type of layout data. The `BoxParentData.offset` property specifies the offset to paint the child in the parent's coordinate system.

BoxConstraints

A `BoxConstraints` instance is specified by four named double parameters: `minWidth`, `maxWidth`, `minHeight`, and `maxHeight`. The values of these must satisfy the following rules. `double.infinity` is a valid value for constraints:

- `0.0 <= minWidth <= maxWidth <= double.infinity`
- `0.0 <= minHeight <= maxHeight <= double.infinity`

After the box layout, the size of a `RenderBox` instance must satisfy constraints of the `BoxConstraints` instance applied to it:

- `minWidth <= Size.width <= maxWidth`
- `minHeight <= Size.height <= maxHeight.`

If the minimum constraint and the maximum constraint are the same in an axis, then this axis is tightly constrained. For example, if the values of `minWidth` and `maxWidth` are the same, then width is tight. A `BoxConstraints` instance is said to be tight when both width and height are tight. If the minimum constraint is `0.0` in an axis, then this axis is loose. If the maximum constraint is not infinite in an axis, then this axis is bounded; otherwise, this axis is unbounded.

Layout Algorithm

In the box layout model, layout is done in one pass with the render tree. It first walks down the render tree by passing constraints. In this phase, render objects are laid out using constraints passed by their parents. In the second phase, it walks up the render tree by passing concrete results that determine the size and offset of each render object.

Layout Widgets

Flutter provides a set of layout widgets for different layout requirements. There are two categories of these widgets. The first category is for widgets that contain a single child, which are descendant classes of `SingleChildScrollView` class. The second category is for widgets that can contain multiple children, which are descendant classes of `MultiChildScrollView` class. Constructors of these widgets have a similar pattern. The first named parameter is `key` of type `Key`. The last named parameter of single child layout widget constructors is `child` of type `Widget`, while the last named parameter of multiple children layout widget constructor is `children` of type `List<Widget>`.

These layout widgets are subclasses of `RenderObjectWidget` class. `RenderObjectWidget` class is used to configure `RenderObjectElements`. `RenderObjectElements` wrap `RenderObjects`.

5-2. Placing Widgets in the Center

Problem

You want to place a widget in the center of another widget.

Solution

Wrap the widget with a `Center` widget.

Discussion

To place a widget in the center of another widget, you can simply wrap the widget in a `Center` widget. This widget will be placed in the center of the `Center` widget both horizontally and vertically. This `Center` widget will be the child of the original parent widget. `Center` constructor has two named

parameters `widthFactor` and `heightFactor` to specify the size factor for width and height, respectively. Listing 5-2 shows an example of using `Center` widget.

Listing 5-2. Example of `Center` widget

```
Center(  
    widthFactor: 2.0,  
    heightFactor: 2.0,  
    child: Text("Center"),  
)
```

`Center` widget is actually a subclass of `Align` widget with `alignment` set of `Alignment.center`. The behavior of `Center` widget is the same as `Align` widget discussed in Recipe 5-3.

5-3. Aligning Widgets

Problem

You want to align a widget in different position of its parent widget.

Solution

Wrap the widget with an `Align` widget.

Discussion

With `Align` widget, you can align a child widget in different position. `Align` widget constructor has the named parameter `alignment` of type `AlignmentGeometry` to specify the alignment. `Center` widget is actually a special kind of `Align` widget with `alignment` always set to `Alignment.`

`center`. `Align` widget constructor also has the named parameters `widthFactor` and `heightFactor`.

`AlignmentGeometry` class has two subclasses to be used in different situations. `Alignment` class represents alignment in visual coordinates. `Alignment` has two properties `x` and `y` to represent the position in the rectangle of the 2D coordinate system. The properties `x` and `y` specify the position in the horizontal and vertical direction, respectively. `Alignment(0.0, 0.0)` means the center of the rectangle. A unit of 1.0 means the distance from the center to one side of the rectangle. A unit of 2.0 means the length of the rectangle in a particular direction. For example, the value 2.0 of `x` means the width of the rectangle. Positive values of `x` mean positions to the right of the center, while negative values of `x` mean positions to the left. The same rule also applies to values of `y`. `Align` has several constants for commonly used positions; see Table 5-1.

Table 5-1. *Alignment constants*

| Name | Value | Description |
|---------------------------|------------------------------------|--|
| <code>bottomCenter</code> | <code>Alignment(0.0, 1.0)</code> | Center point of the bottom edge. |
| <code>bottomLeft</code> | <code>Alignment(-1.0, 1.0)</code> | Leftmost point of the bottom edge. |
| <code>bottomRight</code> | <code>Alignment(1.0, 1.0)</code> | Rightmost point of the bottom edge. |
| <code>center</code> | <code>Alignment(0.0, 0.0)</code> | Center point both horizontally and vertically. |
| <code>centerLeft</code> | <code>Alignment(-1.0, 0.0)</code> | Center point of the left edge. |
| <code>centerRight</code> | <code>Alignment(1.0, 0.0)</code> | Center point of the right edge. |
| <code>topCenter</code> | <code>Alignment(0.0, -1.0)</code> | Center point of the top edge. |
| <code>topLeft</code> | <code>Alignment(-1.0, -1.0)</code> | Leftmost point of the top edge. |
| <code>topRight</code> | <code>Alignment(1.0, -1.0)</code> | Rightmost point of the top edge. |

If you want to consider text direction in alignment, you need to use `AlignmentDirectional` class instead of `Alignment` class. `AlignmentDirectional` class has the property `start` instead of `x`. The `start` value grows in the same direction as the text direction. The value of `start` has the same meaning of `x` in `Alignment` when the text direction is left-to-right. If the text direction is right-to-left, the value of `start` is the opposite of `x` in `Alignment`. `AlignmentDirectional` class also has several constants for commonly used positions; see Table 5-2. These constants use `start` and `end` instead of `left` and `right` to represent different directions.

Table 5-2. *AlignmentDirectional constants*

| Name | Value | Description |
|--------------|---|--|
| bottomCenter | <code>AlignmentDirectional(0.0, 1.0)</code> | Center point of the bottom edge. |
| bottomStart | <code>AlignmentDirectional(-1.0, 1.0)</code> | Bottom corner on the start side. |
| bottomEnd | <code>AlignmentDirectional(1.0, 1.0)</code> | Bottom corner on the end side. |
| center | <code>AlignmentDirectional(0.0, 0.0)</code> | Center point both horizontally and vertically. |
| centerStart | <code>AlignmentDirectional(-1.0, 0.0)</code> | Center point of the start edge. |
| centerEnd | <code>AlignmentDirectional(1.0, 0.0)</code> | Center point of the end edge. |
| topCenter | <code>AlignmentDirectional(0.0, -1.0)</code> | Center point of the top edge. |
| topStart | <code>AlignmentDirectional(-1.0, -1.0)</code> | Top corner on the start side. |
| topEnd | <code>AlignmentDirectional(1.0, -1.0)</code> | Top corner on the end side. |

The `resolve()` method of `AlignmentGeometry` takes a parameter of type `TextDirection` and returns an `Alignment` instance. You can use this method to convert an `AlignmentDirectional` instance to an `Alignment` instance.

The constrained passed to its child is the result of calling the `loosen()` method on this widget's constraints object. This means the child can choose a size not exceeding this widget. The size of the widget itself depends on values of parameters `widthFactor` and `heightFactor` and its constraints object. For the width, if `widthFactor` is not null or `constraints.maxWidth` is `double.infinity`, then the width is the closest value to `childWidth * (widthFactory ?? 1.0)` constrained by the constraints. Otherwise, the width is determined by the constraints. The same rule applies to the height.

Listing 5-3 shows an example of using `Align` widget.

Listing 5-3. Example of Align widget

```
Align(  
  alignment: Alignment.topLeft,  
  child: SizedBox(  
    width: 200,  
    height: 200,  
    child: Center(  
      child: Text("TopLeft"),  
    ),  
  ),  
)
```

5-4. Imposing Constraints on Widgets

Problem

You want to impose layout constraints on widgets.

Solution

Use `ConstrainedBox` or `SizedBox`.

Discussion

As discussed in Recipe 5-1, `Constraints` and `BoxConstraints` instances are usually used in the `layout()` method of `RenderObject` and `RenderBox`, respectively. When building the widgets tree, you may also want to impose layout constraints on widgets. In this case, you can use `ConstrainedBox` widget. `ConstrainedBox` constructor has a required named parameter `constraints` of type `BoxConstraints` to specify the constraints to impose on the child.

`SizedBox` widget can be treated as a special kind of `ConstrainedBox`. `SizedBox` has named parameters `width` and `height` which are used to create a tight constraint using `BoxConstraints.tightFor()` method. `SizedBox(width: width, height: height, child: child)` is the same as `ConstrainedBox(constraints: BoxConstraints.tightFor(width: width, height: height), child: child)`. If you want to impose tight constraints, then `SizedBox` is more convenient than `ConstrainedBox`. `SizedBox` has other named constructors for other common use cases; see Table 5-3.

Table 5-3. *SizedBox constructors*

| Name | Meaning | Description |
|----------------------------------|--|--------------------------------|
| <code>SizedBox.expand()</code> | <code>SizedBox(width: double.infinity, height: double.infinity)</code> | As large as its parent allows. |
| <code>SizedBox.shrink()</code> | <code>SizedBox(width: 0.0, height: 0.0)</code> | As small as its parent allows. |
| <code>SizedBox.fromSize()</code> | <code>SizedBox(width: size.width; height: size.height)</code> | A box with the specified size. |

The actual constraints applied to the child widget is the combination of provided constraints parameter and the constraints provided by the parent of `ConstrainedBox` or `SizedBox`. The combination is done by calling `providedConstraints.enforce(parentConstraints)`. The result constraints respect the parent constraints and are as close as possible to the provided constraints. The size of `ConstrainedBox` or `SizedBox` is the size of the child widget after layout.

Listing 5-4 shows four examples of using `ConstrainedBox` and `SizedBox`. The first example is a typical usage pattern of `SizedBox`. The second example with `SizedBox.shrink()` causes the image not to be displayed. The third example is a typical usage pattern of `ConstrainedBox`. The last example shows how a `ConstrainedBox` instance respects constraints from parent.

Listing 5-4. Examples of `ConstrainedBox` and `SizedBox`

```
SizedBox(
    width: 100,
    height: 100,
    child: Text('SizedBox'),
)
```

```
SizedBox.shrink(  
    child: Image.network('https://picsum.photos/50'),  
)  
  
ConstrainedBox(  
    constraints: BoxConstraints(  
        maxWidth: 50,  
        minHeight: 50,  
    ),  
    child: Text('ConstrainedBox'),  
)  
  
ConstrainedBox(  
    constraints: BoxConstraints(  
        maxWidth: 200,  
    ),  
    child: ConstrainedBox(  
        constraints: BoxConstraints(  
            maxHeight: 200,  
        ),  
        child: Image.network('https://picsum.photos/300'),  
    ),  
)
```

5-5. Imposing No Constraints on Widgets Problem

You want to impose constraints on widgets to allow them to render at natural size.

Solution

Use `UnconstrainedBox`.

Discussion

`UnconstrainedBox` is the opposite of `ConstrainedBox` in Recipe 5-4.

`UnconstrainedBox` imposes no constraints on its child. The child can render freely on the unlimited space provided by the `UnconstrainedBox` instance. `UnconstrainedBox` will try to use the child widget's size to determine its own size by following the limitations of its own constraints.

If the child widget's size is bigger than the maximum size of `UnconstrainedBox` can provide, the child widget will be clipped. Otherwise, the child widget is aligned based on the value of the parameter `alignment` of type `AlignmentGeometry`. If the child overflows the parent, a warning is displayed in debug mode. When using `UnconstrainedBox`, it's still possible to add constraints to one axis using the parameter `constrainedAxis` of type `Axis`. Then the child is only allowed to render unconstrained on the other axis.

In Listing 5-5, the `UnconstrainedBox` widget is placed in a `SizedBox` widget with fixed width and height. The `UnconstrainedBox` widget is constrained on the horizontal axis, which means the minimum and maximum width are both 100px. The image's width is 200px, so it's scaled down to 100px to meet the width constraint. This causes the image height to scale down to 150px, which exceeds the maximum height 100px of the parent `SizedBox` widget. When running in debug mode, you can see warning messages that the top and bottom are overflowed by 25px.

Listing 5-5. Example of `UnconstrainedBox`

```
SizedBox(  
  width: 100,  
  height: 100,
```

```
    child: UnconstrainedBox(  
        constrainedAxis: Axis.horizontal,  
        child: Image.network('https://picsum.photos/200/300'),  
    ),  
)
```

5-6. Imposing Constraints on Widgets when Ignoring Parents

Problem

You want to impose constraints no matter where a widget is placed.

Solution

Use `OverflowBox`.

Discussion

When imposing constraints on widgets, constraints from the parent widget are generally respected. Respecting parent constraints makes a widget's layout flexible to adapt different use cases. Sometimes you may want a widget to only respect explicitly provided constraints and ignore parent's constraints. In this case, you can use `OverflowBox`.

`OverflowBox` constructor has named parameters `alignment`, `minWidth`, `maxWidth`, `minHeight`, and `maxHeight`. If any of the constraints related parameter is null, the corresponding value from parent's constraints is used. If you provide non-null values to all four constraints related parameters, the layout of `OverflowBox`'s child is completely irrelevant to the current widget.

In Listing 5-6, the `OverflowBox` widget is created with non-null values of all four constraints related parameters, so even though it's placed inside of a `SizedBox` widget, its size is always `Size(200, 200)`.

Listing 5-6. Example of `OverflowBox`

```
SizedBox(  
    width: 100,  
    height: 100,  
    child: OverflowBox(  
        minWidth: 200,  
        minHeight: 200,  
        maxWidth: 200,  
        maxHeight: 200,  
        child: Image.network('https://picsum.photos/300'),  
    ),  
)
```

5-7. Limiting Size to Allow Child Widget to Overflow

Problem

You want a widget to have a size and allow child widget to overflow.

Solution

Use `SizedOverflowBox`.

Discussion

SizedOverflowBox is created with a size. The widget's actual size respects its constraints and is as close as possible to the requested size. The child's layout only uses SizedOverflowBox widget's constraints.

In Listing 5-7, the SizedOverflowBox widget is placed in a ConstrainedBox widget with constraints BoxConstraints.loose(Size(100, 100)). The requested size of SizedOverflowBox widget is Size(50, 50). The actual size of SizedOverflowBox is also Size(50, 50). The child Image widget only uses the constraints of SizedOverflowBox. The result is the image widget has a size of Size(100, 100), which overflows its parent.

Listing 5-7. Example of SizedOverflowBox

```
ConstrainedBox(  
    constraints: BoxConstraints.loose(Size(100, 100)),  
    child: SizedOverflowBox(  
        size: Size(50, 50),  
        child: Image.network('https://picsum.photos/400'),  
    ),  
)
```

5-8. Limiting Widgets Size when Unbounded Problem

You have a widget that normally matches its parent's size, but you want it to be used in other places where size constraints are required.

Solution

Use LimitedBox.

Discussion

Some widgets are normally designed to be as big as possible to match their parents' size. But these widgets need to be constrained in other places. For example, when these widgets are added to a vertical list, the height need to be limited. `LimitedBox` constructor has named parameters `maxWidth` and `maxHeight` to specify the limitations. If a `LimitedBox` widget's maximum width is unbounded, then its child's width is limited to `maxWidth`. If this `LimitedBox`'s maximum height is unbounded, then its child's height is limited to `maxHeight`.

In Listing 5-8, the `maxHeight` of a `LimitedBox` widget is set to 100, so the child's maximum height is 100px.

Listing 5-8. Example of LimitedBox

```
LimitedBox(  
    maxHeight: 100,  
    child: Image.network('https://picsum.photos/400'),  
)
```

5-9. Scaling and Positioning Widgets Problem

You want to scale and position a widget.

Solution

Use `FittedBox` with different fit mode and alignment.

Discussion

Align widget in Recipe 5-3 can position its child using different alignments. FittedBox widget supports scaling and positioning of its child. The fit mode is specified using the parameter `fit` of type `BoxFit`. `BoxFit` is an enum type with values shown in Table 5-4.

Table 5-4. *BoxFit values*

| Name | Description |
|------------------------|---|
| <code>fill</code> | Fill the target box. Source's aspect ratio is ignored. |
| <code>contain</code> | As large as possible to contain the source entirely in the target box. |
| <code>cover</code> | As small as possible to cover the entire target box. |
| <code>fitWidth</code> | Only make sure the full width of the source is shown. |
| <code>fitHeight</code> | Only make sure the full height of the source is shown. |
| <code>none</code> | Align the source within the target box and discard anything outside the box. |
| <code>scaleDown</code> | Align the source with the target box and scale down when necessary to ensure the source fits in the box. If the source is shrunk, this is the same as <code>contain</code> ; otherwise, it is the same as <code>none</code> . |

FittedBox is usually used when displaying images. Listing 5-9 shows an example to demonstrate different values of `BoxFit`. `ImageBox` widget uses a `SizedBox` widget to limit its size and places the image inside of a `FittedBox` widget. The `DecoratedBox` widget creates a red border to show the boundary of `ImageBox` widget.

Listing 5-9. Different values of BoxFit

```
class FitPage extends StatelessWidget {  
  @override  
  Widget build(BuildContext context) {  
    return Scaffold(  
      appBar: AppBar(  
        title: Text('Fit'),  
      ),  
      body: Center(  
        child: Wrap(  
          spacing: 20,  
          runSpacing: 20,  
          alignment: WrapAlignment.spaceAround,  
          children: <Widget>[  
            ImageBox(fit: BoxFit.fill),  
            ImageBox(fit: BoxFit.contain),  
            ImageBox(fit: BoxFit.cover),  
            ImageBox(fit: BoxFit.fitWidth),  
            ImageBox(fit: BoxFit.fitHeight),  
            ImageBox(fit: BoxFit.none),  
            ImageBox(fit: BoxFit.scaleDown),  
          ],  
        ),  
      ),  
    );  
  }  
  
  class ImageBox extends StatelessWidget {  
    const ImageBox({  
      Key key,
```

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```
    this.boxWidth = 150,  
    this.boxHeight = 170,  
    this.imageWidth = 200,  
    this.fit,  
});  
  
final double boxWidth;  
final double boxHeight;  
final double imageWidth;  
final BoxFit fit;  
  
@override  
Widget build(BuildContext context) {  
  return DecoratedBox(  
    decoration: BoxDecoration(border: Border.all(color:  
      Colors.red)),  
    child: SizedBox(  
      width: boxWidth,  
      height: boxHeight,  
      child: FittedBox(  
        fit: fit,  
        child: SizedBox(  
          width: imageWidth,  
          height: imageWidth,  
          child: Image.network('https://dummyimage.  
            com/${imageWidth.toInt()}'  
            '&text=${fit.toString().substring(7)}'),  
        ),  
      ),  
    ),  
  );  
}  
}
```

Figure 5-1 shows the screenshot of code in Listing 5-9. Text in an image shows the BoxFit value used in this `ImageBox` widget.

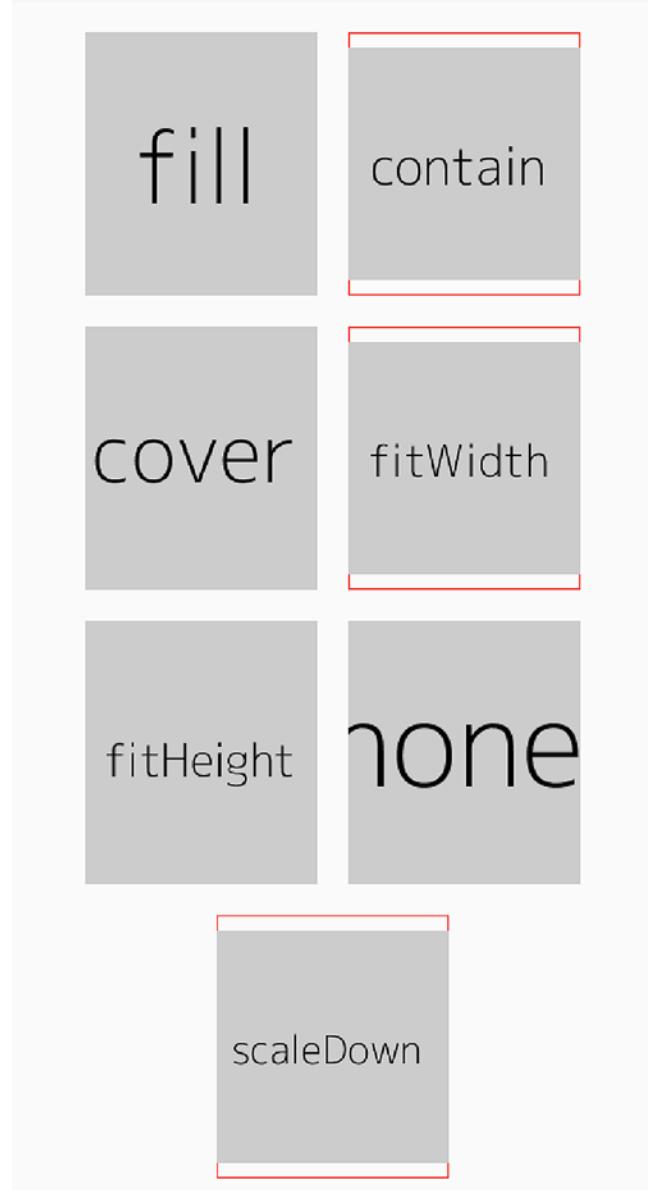


Figure 5-1. Different values of BoxFit

5-10. Rotating Widgets

Problem

You want to rotate a widget.

Solution

Use `RotatedBox`.

Discussion

`RotatedBox` widget rotates its child before layout. Rotation is specified by an `int` type of clockwise quarter turns with `quarterTurns` parameter. The value 1 of `quarterTurns` parameter means rotating 90 degrees clockwise.

In Listing 5-10, the `Text` widget is rotated one quarter turn.

Listing 5-10. Example of `RotatedWidget`

```
RotatedBox(  
    quarterTurns: 1,  
    child: Text(  
        'Hello World',  
        textScaleFactor: 2,  
    ),  
)
```

5-11. Adding Padding when Displaying Widgets

Problem

You want to add padding around a widget.

Solution

Use Padding.

Discussion

Padding widget creates empty space around its child. The layout constraints passed to its child are the widget's constraints after shrinking by the padding, which causes the child to lay out at a smaller size.

The padding is specified in the required padding parameter of type `EdgeInsetsGeometry`.

Similar with `AlignmentGeometry`, `EdgeInsetsGeometry` has two subclasses `EdgeInsets` and `EdgeInsetsDirectional`. `EdgeInsets` class expresses offsets in visual coordinates. Offsets values are specified for left, right, top, and bottom edges. Table 5-5 shows constructors of `EdgeInsets` class.

Table 5-5. *EdgeInsets constructors*

| Name | Description |
|-------------------------------------|---|
| <code>EdgeInsets.all()</code> | All the offsets have the given value. |
| <code>EdgeInsets.fromLTRB()</code> | Specify values of offsets for left, top, right, and bottom edges. |
| <code>EdgeInsets.only()</code> | It has named parameters left, top, right, and bottom with default value of 0.0. |
| <code>EdgeInsets.symmetric()</code> | It has named parameters vertical and horizontal to create symmetrical offsets. |

To consider text direction, `EdgeInsetsDirectional` class should be used instead of `EdgeInsets`. `EdgeInsetsDirectional` class uses `start` and `end` instead of `left` and `right`. It has `EdgeInsetsDirectional.fromSTEB()` constructor to create insets from offsets of `start`, `top`, `end`, and `bottom`. The `EdgeInsetsDirectional.only()` constructor is similar with `EdgeInsets`. `only()`.

Listing 5-11 shows an example of `Padding` widget.

Listing 5-11. Example of Padding

```
Padding(  
    padding: EdgeInsets.all(20),  
    child: Image.network('https://picsum.photos/200'),  
)
```

5-12. Sizing Widgets to Aspect Ratio

Problem

You want to size widgets to maintain a specific aspect ratio.

Solution

Use `AspectRatio`.

Discussion

`AspectRatio` constructor has the required parameter `aspectRatio` to specify the aspect ratio value of width/height. For example, a 4:3 aspect ratio uses the value of `4.0/3.0`. `AspectRatio` widget tries to find the best size to maintain the aspect ratio while respecting its layout constraints.

The process starts from setting the width to the maximum width of the constraints. If the maximum width is finite, then the height is calculated by `width / aspectRatio`. Otherwise, the height is set to the maximum height of the constraints and width is set to `height * aspectRatio`. There may be extra steps to make sure the result width and height meet the layout constraints. For example, if the height is less than the minimum height of the constraints, then height is set to this minimum value and width is calculated based on the height and aspect ratio. The general rule is to check width before height and maximum value before minimum value. The final size may not meet the ratio requirement, but it must meet the layout constraints.

In Listing 5-12, `AspectRatio` widget is placed in a `ConstrainedBox` with a loose constraints of `Size(200, 200)`. The aspect ratio is $4.0 / 3.0$, so the height is calculated based on $200 / (4.0 / 3.0) = 150.0$. The result size of `ApsectRatio` is `Size(200.0, 150.0)`.

Listing 5-12. Example of `AspectRatio`

```
ConstrainedBox(  
    constraints: BoxConstraints.loose(Size(200, 200)),  
    child: AspectRatio(  
        aspectRatio: 4.0 / 3.0,  
        child: Image.network('https://picsum.photos/400/300'),  
    ),  
)
```

5-13. Transforming Widgets

Problem

You want to apply a transformation on a widget.

Solution

Use `Transform`.

Discussion

`Transform` widget can apply a transformation on its child before painting it. Transformations are expressed using `Matrix4` instances. `Transform` constructor has named parameters shown in Table 5-6.

Table 5-6. *Named parameters of Transform*

| Name | Type | Description |
|--------------------------------|--------------------------------|--|
| <code>transform</code> | <code>Matrix4</code> | Matrix to transform the child. |
| <code>origin</code> | <code>Offset</code> | Origin of the coordinate system to apply the transform. |
| <code>alignment</code> | <code>AlignmentGeometry</code> | Alignment of the origin. |
| <code>transformHitTests</code> | <code>bool</code> | Should the transform be applied when performing hit tests. |

`Transform` class has other constructors to create common transformations:

- `Transform.rotate()` – Transform the child by rotating specified angle.

- `Transform.scale()` – Transform the child by scaling uniformly with specified scale factor.
- `Transform.translate()` – Transform the child by translating specified offset.

Listing 5-13 shows examples of using `Transform`'s named constructors.

Listing 5-13. Examples of Transform

```
Transform.rotate(  
    angle: pi / 4.0,  
    origin: Offset(10, 10),  
    child: Text('Hello World'),  
)  
  
Transform.translate(  
    offset: Offset(50, 50),  
    child: Text('Hello World'),  
)
```

5-14. Controlling Different Layout Aspects on a Widget

Problem

You want to define different layout aspects for a widget.

Solution

Use Container.

Discussion

Flutter has many widgets to control different aspects of layout. For example, `SizedBox` widget controls the size, while `Align` widget controls the alignment. If you want to control different layout aspects on the same widget, you can wrap these widgets in a nested way. Actually, Flutter provides a `Container` widget to make it easier to define different layout aspects.

Table 5-7 shows the named parameters of `Container` constructor. You cannot provide non-null values to both `color` and `decoration`, because `color` is just a shorthand to create `decoration` with value `BoxDecoration(color: color)`. If `width` or `height` is not null, their values are used to tighten the constraints.

Table 5-7. *Named parameters of Container*

| Name | Type | Description |
|--------------------------|---------------------------------|--|
| <code>alignment</code> | <code>AlignmentGeometry</code> | Alignment of the child. |
| <code>padding</code> | <code>EdgeInsetsGeometry</code> | Empty space inside the decoration. |
| <code>color</code> | <code>Color</code> | Background color. |
| <code>decoration</code> | <code>Decoration</code> | Decoration to paint behind the child. |
| <code>foreground</code> | <code>Decoration</code> | Decoration to paint in front of the child. |
| <code>Decoration</code> | | |
| <code>width</code> | <code>double</code> | Width of the child. |
| <code>height</code> | <code>double</code> | Height of the child. |
| <code>constraints</code> | <code>BoxConstraints</code> | Additional constraints. |
| <code>margin</code> | <code>EdgeInsetsGeometry</code> | Empty space to surround the decoration. |
| <code>transform</code> | <code>Matrix4</code> | Transformation applied to the container. |

`Container` is a composition of different widgets based on the values of parameters. Listing 5-14 shows the nesting structure of different widgets

used by Container and the parameters these widgets may use. If the value of a parameter is null, then the corresponding widget may not exist.

Listing 5-14. Structure of Container

```
Transform (transform)
- Padding (margin)
- ConstrainedBox (constraints, width, height)
  - DecoratedBox (foregroundDecoration)
    - DecoratedBox (decoration, color)
      - Padding (padding, decoration)
        - Align (alignment)
        - child
```

Listing 5-15 shows an example of Container widget that uses all named parameters.

Listing 5-15. Example of Container

```
Container(
  alignment: Alignment.bottomRight,
  padding: EdgeInsets.all(16),
  color: Colors.red.shade100,
  foregroundDecoration: BoxDecoration(
    image: DecorationImage(
      image: NetworkImage('https://picsum.photos/100'),
    ),
  ),
  width: 300,
  height: 300,
  constraints: BoxConstraints.loose(Size(400, 400)),
  margin: EdgeInsets.all(32),
  transform: Matrix4.rotationZ(0.1),
  child: Text(
```

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```
'Hello World',  
    textScaleFactor: 3,  
)  
)
```

Figure 5-2 shows the structure of the Container widget in Listing 5-15. You can see clearly how these widgets are nested.

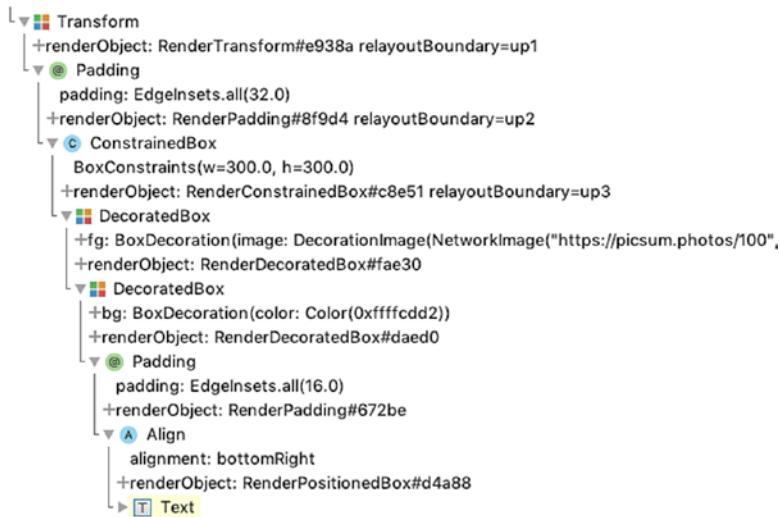


Figure 5-2. Structure of Container

5-15. Implementing Flex Box Layout

Problem

You have multiple widgets to lay out, and you want them to be able to take extra space.

Solution

Use Flex, Column, Row, Flexible, and Expanded.

Discussion

To lay out multiple widgets using the flex box model, you can use a set of widgets provided by Flutter, including Flex, Column, Row, Flexible, Expanded, and Spacer. In fact, only Flex and Flexible widgets are important to understand. Flex widget is used as the layout container, while Flexible widget is used to wrap children widgets inside the container. Flex widget displays its children in one-dimension array. It supports layout of children in two directions, horizontal and vertical. Row and Column are subclasses of Flex that only places children in the horizontal and vertical direction, respectively. Flexible widget of a Flex container can control how a child flexes to take extra space. Children of Flex widget can be flexible or not. If you want a child to be flexible, you can simply wrap it in a Flexible widget.

Same as CSS flex box layout, Flex widget uses two axes for layout. The axis where children are placed along is the *main axis*. The other axis is the *cross axis*. The main axis is configured using the direction parameter of type Axis. If the value is Axis.horizontal, then the main axis is horizontal axis, while the cross axis is vertical axis. If the value is Axis.vertical, then the main axis is vertical axis, while the cross axis is horizontal axis. Row widget always uses horizontal axis as the main axis, and Column widget always uses vertical axis as the main axis. If the main axis is known, then Row or Column widget should be used instead of Flex widget.

Flex Box Layout Algorithm

Layout of Flex children is complicated and done in multiple steps. The first step is to lay out each child with a null or zero flex factor. These are non-flexible children. The constraints used to lay out these children depend on the value of crossAxisAlignment. If the value of crossAxisAlignment is CrossAxisAlignment.stretch, then the constraints will be tight cross-axis constraints of the maximum size on the cross axis. Otherwise,

the constraints only set the maximum value for the cross axis. For example, if the direction is Axis.horizontal and crossAxisAlignment is CrossAxisAlignmentAlignment.stretch, then the constraints for these non-flexible children set both minHeight and maxHeight to maxHeights of the Flex's constraints. This makes these children take all space on the cross axis. During the first step, the total allocated size for these children and the maximum value of cross-axis size are recorded.

The second step is to lay out each child with a flex factor. These are flexible children. From the first step, the allocated size of main axis is known. The free space can be calculated based on the max size and allocated size of main axis. The free space is distributed among all flexible children based on the flex factor. A child with a flex factor of 2.0 will receive twice the amount of free space as a child with a flex factor of 1.0. Suppose there are three children with flex factors 1.0, 2.0, and 3.0, if the free space is 120px, then these children will receive space of 20px, 40px, and 60px, respectively. The calculated value based on flex factor for each child will be the maximum constraints on the main axis. The minimum constraints on the main axis depends on the value of FlexFit for the child. If fit value is FlexFit.tight, then the minimum value is the same as the maximum, which creates tight constraints on the main axis. If fit value is FlexFit.loose, then the minimum value is 0.0, which creates loose constraints on the main axis. The constraints on the cross axis are the same as Flex widget's constraints. The final constraints are used to lay out these flex children.

The third step is to determine the extent of main and cross axis. If the value of mainAxisSize is MainAxisSize.max, then the main-axis extent is the maximum constraints of current Flex widget. Otherwise, the main-axis extent is the allocated size for all children. The extent of cross axis is the maximum value of cross-axis constraints of all children.

The last step is to determine the position of each child based on the value of mainAxisAlignment and crossAxisAlignment.

Table 5-8 shows values of the enum MainAxisAlignment.

Table 5-8. *MainAxisAlignment values*

| Name | Description |
|--------------|--|
| start | Place the children close to the start of the main axis. The start position is determined by TextDirection for horizontal direction and VerticalDirection for vertical direction. |
| end | Place the children close to the end of the main axis. The end position is determined using the same way as start. |
| center | Place the children close to the middle. |
| spaceBetween | Distribute the free space evenly between the children. |
| spaceAround | Distribute the free space evenly between the children with half of the space before and after the first and last child. |
| spaceEvenly | Distribute the free space evenly between the children including before and after the first and last child. |

Table 5-9 shows values of the enum CrossAxisAlignment.

Table 5-9. *CrossAxisAlignment values*

| Name | Description |
|----------|--|
| start | Place the children with start edge aligned with the start side of the cross axis. The start position is determined by TextDirection for horizontal direction and VerticalDirection for vertical direction. |
| end | Place the children with end edge aligned with the end side of the cross axis. The end position is determined using the same way as start. |
| center | Place the children with center aligned with the middle of the cross axis. |
| stretch | Require the children to fill the cross axis. |
| baseline | Match baselines of children on the cross axis. |

Flexible

Flexible has the flex parameter to specify the flex factor and fit parameter to specify the BoxFit value. The default value of flex parameter is 1, while the default value of fit is BoxFit.loose. Expanded is a subclass of Flexible with fit parameter set to BoxFit.tight.

In Listing 5-16, Column widget is placed in a LimitedBox widget to limit its height. All children of Column widget are non-flexible.

Listing 5-16. Flex widget with non-flexible children

```
LimitedBox(
  maxHeight: 320,
  child: Column(
    crossAxisAlignment: CrossAxisAlignment.end,
    mainAxisAlignment: MainAxisAlignment.spaceAround,
    children: <Widget>[
      Image.network('https://picsum.photos/50'),
      Image.network('https://picsum.photos/70'),
      Image.network('https://picsum.photos/90'),
    ],
  ),
)
```

In Listing 5-17, Column widget has both flexible and non-flexible children. Flexible widgets can be created by wrapping with Flexible or Expanded widgets.

Listing 5-17. Flex widget with flexible and non-flexible children

```
LimitedBox(
  maxHeight: 300,
  child: Column(
    mainAxisAlignment: MainAxisAlignment.spaceBetween,
```

```
children: <Widget>[  
    Flexible(  
        child: Image.network('https://picsum.photos/50'),  
    ),  
    Image.network('https://picsum.photos/40'),  
    Expanded(  
        child: Image.network('https://picsum.photos/50'),  
    ),  
    Expanded(  
        flex: 2,  
        child: Image.network('https://picsum.photos/50'),  
    ),  
],  
)  
)
```

5-16. Displaying Overlapping Widgets Problem

You want to lay out widgets that may overlap with each other.

Solution

Use Stack or IndexedStack.

Discussion

Children of Stack widget can be positioned or non-positioned. Positioned children are wrapped in a Positioned widget with at least one non-null property. Size of a Stack widget is determined by all the non-positioned children. The layout process has two phases.

The first phase is to lay out all non-positioned children. The constraints used for non-positioned children depend on the value of fit property of type StackFit:

- StackFit.loose – Loose constraints created by constraints.loosen()
- StackFit.expand – Tight constraints created by BoxConstraints.tight(constraints.biggest)
- StackFit.passThrough – The same constraints as Stack widget

Size of the Stack widget is determined by the maximum size of all non-positioned children.

In the second phase, all non-positioned children are positioned according to the alignment property. The constraints used for positioned children are determined by the size of Stack widget and their properties. Positioned widget has six properties: left, top, right, bottom, width, and height. Properties left, right, and width are used to determine the tight width constraint. Properties top, bottom, and height are used to determine the tight height constraint. For example, if both left and right values are not null, the tight width constraint is widthOfStack - right - left. The positioned child is then positioned based on the left, right, top, and bottom values in two axes. If all these values are null, it's positioned based on the alignment.

Children of Stack are painted in the order with the first child being at the bottom. The order in the children array determines how children overlap with each other.

IndexedStack class is a subclass of Stack. An IndexedStack instance only shows a single child from a list of children. IndexedStack constructor not only has the same parameters as Stack constructor but also includes a parameter index of type int to specify the index of child to display. If the value of parameter index is null, then nothing will be displayed. The layout of IndexedStack is the same as Stack. IndexedStack class simply has

a different way to paint itself. This means even though only one child is displayed, all the children still need to lay out the same way as Stack.

Listing 5-18 shows an example of Stack widget with positioned child.

Listing 5-18. Example of Stack

```
Stack(  
    children: <Widget>[  
        Image.network('https://picsum.photos/200'),  
        Image.network('https://picsum.photos/100'),  
        Positioned(  
            right: 0,  
            bottom: 0,  
            child: Image.network('https://picsum.photos/150'),  
        ),  
    ],  
)
```

5-17. Displaying Widgets in Multiple Runs

Problem

You want to display widgets in multiple horizontal or vertical runs.

Solution

Use Wrap.

Problem

Flex widget doesn't allow size of children to exceed the size of the main axis. Wrap widget creates new runs; there is no enough space to fit the children. Table 5-10 shows named parameters of Wrap constructor.

Table 5-10. Named parameters of *Wrap*

| Name | Value | Default value | Description |
|--------------------|--------------------|--------------------------|---|
| direction | Axis | Axis.horizontal | Direction of the main axis. |
| alignment | WrapAlignment | WrapAlignment.start | Alignment of children within a run in the main axis. |
| spacing | Double | 0.0 | Space between children in a run in the main axis. |
| runAlignment | WrapAlignment | WrapAlignment.start | Alignment of runs in the cross axis. |
| runSpacing | Double | 0.0 | Space between runs in the cross axis. |
| crossAxisAlignment | WrapCrossAlignment | WrapCrossAlignment.start | Alignment of children within a run in the cross axis. |
| textDirection | TextDirection | | Order to lay out children horizontally. |
| verticalDirection | VerticalDirection | VerticalDirection.down | Order to lay out children vertically. |
| children | List<Widget> | [] | Children. |

WrapAlignment enum has the same values as MainAxisAlignment.
WrapCrossAlignment enum only has values start, end, and center.

Listing 5-19 shows an example of Wrap widget by wrapping ten Image widgets.

Listing 5-19. Example of Wrap

```
Wrap(  
    spacing: 10,  
    runSpacing: 5,  
    crossAxisAlignment: WrapCrossAlignment.center,  
    children: List.generate(  
        10,  
        (index) => Image.network('https://picsum.photos/${50 +  
            index * 10}'),  
    ),  
)
```

5-18. Creating Custom Single Child Layout Problem

You want to create a custom layout for a single child.

Solution

Use CustomSingleChildLayout.

Discussion

If those built-in layout widgets for a single child cannot meet your requirement, you can create a custom layout using CustomSingleChildLayout. CustomSingleChildLayout widget simply

delegates the layout to a `SingleChildScrollViewDelegate` instance. You need to create your own subclass of `SingleChildScrollViewDelegate` to implement methods shown in Table 5-11.

Table 5-11. Methods of `SingleChildScrollViewDelegate`

| Name | Description |
|--|---|
| <code>getConstraintsForChild (BoxConstraints constraints)</code> | Get the constraints for the child. |
| <code>getPositionForChild(Size size, Size childSize)</code> | Get the position of the child based on the size of this widget and child. |
| <code>getSize(BoxConstraints constraints)</code> | Get the size of this widget. |
| <code>shouldRelayout()</code> | Should relayout. |

The size of this widget is the result of the size returned by delegate's `getSize()` method after applying the constraints. Layout of child is done using the constraints returned by delegate's `getConstraintsForChild()` method. Finally the position of child is updated with the value returned by delegate's `getPositionForChild()` method.

In Listing 5-20, `FixedPositionLayoutDelegate` class overrides `getSize()` method to provide the size of the parent widget. It also overrides `getPositionForChild()` methods to provide the position of the child. The `getConstraintsForChild()` method is also overridden to return tighten constraints.

Listing 5-20. Custom single child layout delegate

```
class FixedPositionLayoutDelegate extends SingleChildScrollViewDelegate {
  @override
```

```
bool shouldRelayout(SingleChildScrollViewDelegate oldDelegate) {
    return false;
}

@Override
Size getSize(BoxConstraints constraints) {
    return constraints.constrain(Size(300, 300));
}

@Override
BoxConstraints getConstraintsForChild(BoxConstraints constraints) {
    return constraints.tighten(width: 300, height: 300);
}

@Override
Offset getPositionForChild(Size size, Size childSize) {
    return Offset(50, 50);
}
}
```

Listing 5-21 shows how to use FixedPositionLayoutDelegate.

Listing 5-21. Example of FixedPositionLayoutDelegate

```
CustomSingleChildScrollView(
    delegate: FixedPositionLayoutDelegate(),
    child: Image.network('https://picsum.photos/100'),
)
```

5-19. Creating Custom Multiple Children Layout

Problem

You want to create a custom layout for multiple children.

Solution

Use `CustomMultiChildLayout` and `MultiChildLayoutDelegate`.

Discussion

If those built-in widgets for multiple children cannot meet your requirement, you can create a custom layout using `CustomMultiChildLayout`. Similar to `CustomSingleChildScrollView`, `CustomMultiChildLayout` delegates the layout logic to a `MultiChildLayoutDelegate` instance. All children of `CustomMultiChildLayout` must be wrapped in a `LayoutId` widget to provide unique ids for them. Of all the methods shown in Table 5-12, `performLayout()` and `shouldRelayout()` methods must be implemented. All other methods have default implementation. In the implementation of `performLayout()` method, the `layoutChild()` method must be called exactly once for each child.

Table 5-12. Methods of MultiChildLayoutDelegate

| Name | Description |
|---|---|
| hasChild(Object childId) | Check if a child with the given id exists. |
| layoutChild(Object childId, BoxConstraints constraints) | Layout the child with the provided constraints. |
| positionChild(Object childId, Offset offset) | Position the child with the given offset. |
| getSize(BoxConstraints constraints) | Get the size of this widget. |
| performLayout(Size size) | The actual layout logic. |
| shouldRelayout() | Should relayout. |

Listing 5-22 shows a custom multiple children layout delegate. This delegate uses increasing int values as the layout id. Layout ids of children must start from 0. In the performLayout() method, layoutChild() method is called on each child, starting with the first child with loose constraints, which allows the first child to take the natural size. The actual size of the first child is recorded. Then positionChild() method is called with Offset.zero to place the first child at the top left corner. After the first child, layoutChild() and positionChild() methods are called on all the other children with increasing size and position offsets, respectively.

Listing 5-22. Custom multiple children layout delegate

```
class GrowingSizeLayoutDelegate extends MultiChildLayoutDelegate {
    @override
    void performLayout(Size size) {
        int index = 0;
```

```
Size childSize = layoutChild(index, BoxConstraints.  
    loose(size));  
Offset offset = Offset.zero;  
positionChild(index, offset);  
index++;  
  
while (hasChild(index)) {  
    double sizeFactor = 1.0 + index * 0.1;  
    double offsetFactor = index * 10.0;  
    childSize = layoutChild(  
        index,  
        BoxConstraints.tight(Size(  
            childSize.width * sizeFactor, childSize.height *  
            sizeFactor)));  
    offset = offset.translate(offsetFactor, offsetFactor);  
    positionChild(index, offset);  
    index++;  
}  
}  
  
@override  
bool shouldRelayout(MultiChildLayoutDelegate oldDelegate) {  
    return false;  
}  
  
@override  
Size getSize(BoxConstraints constraints) =>  
    constraints.constrain(Size(400, 400));  
}
```

Listing 5-23 shows the usage of `GrowingSizeLayoutDelegate`. The children of `CustomMultiChildLayout` are six images nested in `SizedBox`. The wrapping `LayoutId` widget is required to pass the layout id to the delegate.

Listing 5-23. Example of GrowingSizeLayoutDelegate

```
CustomMultiChildLayout(  
    delegate: GrowingSizeLayoutDelegate(),  
    children: List.generate(  
        6,  
        (index) => LayoutId(  
            id: index,  
            child: DecoratedBox(  
                decoration:  
                    BoxDecoration(border: Border.all(color: Colors.  
                        red)),  
                child: SizedBox(  
                    width: 70,  
                    height: 70,  
                    child: Image.network(  
                        'https://dummyimage.com/${50 + index * 10}'),  
                    ),  
                ),  
            ),  
        ),  
    ),  
)
```

Figure 5-3 shows the result of using GrowingSizeLayoutDelegate.

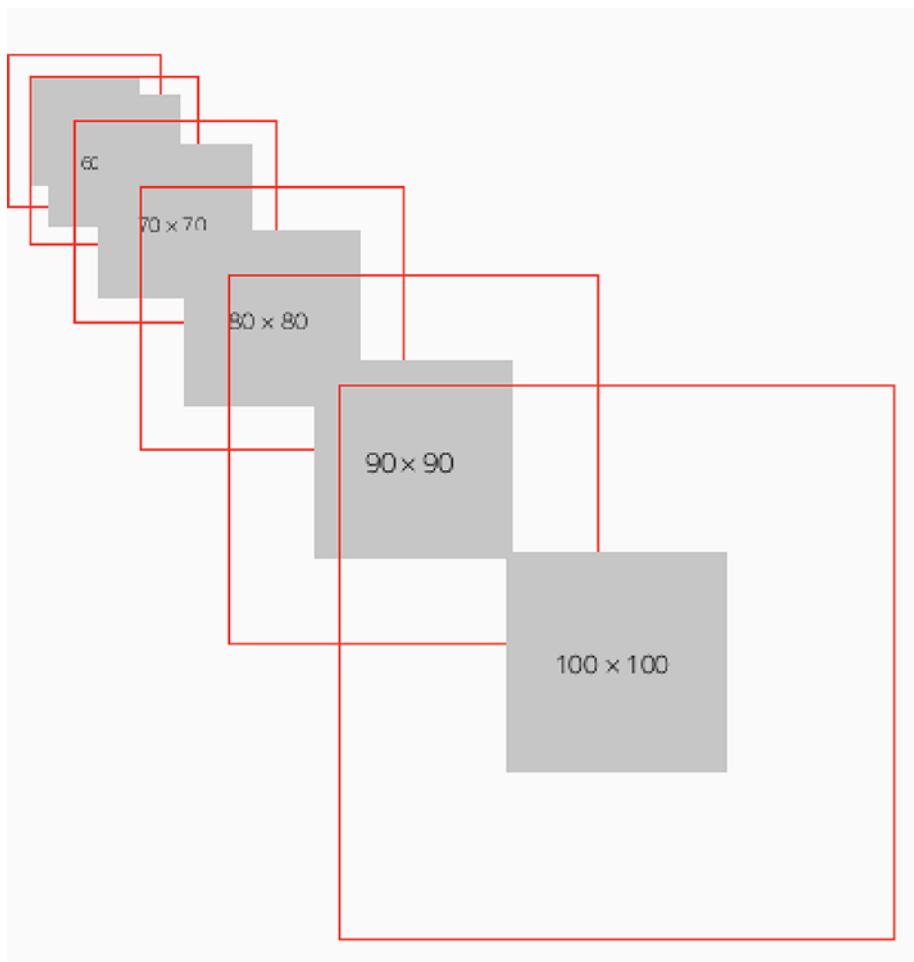


Figure 5-3. Result of using `GrowingSizeLayoutDelegate`

5-20. Summary

With the layout widgets in Flutter, it's easy to satisfy common layout requirements in build Flutter apps. This chapter covers many layout widgets for single child and multiple children. In the next chapter, we'll discuss form widgets.

CHAPTER 6

Form Widgets

Form controls are important in mobile apps to interact with the user. Flutter provides a set of form widgets for Material Design and iOS style. These form widgets generally have no internal state. Their appearance and behavior are purely defined by constructor parameters. With state maintained in ancestor widgets, form widgets are re-rendered to reflect to state changes. This chapter covers recipes related to basic usage of form widgets.

6-1. Collecting Text Inputs

Problem

You want to collect text inputs.

Solution

Use `TextField` for Material Design and `CupertinoTextField` for iOS style.

Discussion

To collect user inputs in Flutter apps, you can use `TextField` widget for Material Design or `CupertinoTextField` widget for iOS style. Both widgets have similar usage pattern and behavior. In fact, both widgets wrap the same `EditableText` which provides the basic text input capability with support for scrolling, selection, and cursor movement. `EditableText` is a

highly customizable widget with many named parameters. This recipe focuses on how to set the initial value of a `TextField` or `CupertinoTextField` widget and get the text from it.

The text of an `EditableText` widget is controlled by a `TextEditingController` instance. You can use the `controller` parameter to set a `TextEditingController` instance when creating a new `EditableText` widget. The controller maintains a bidirectional data binding with the corresponding `EditableText` widget. The controller has a `text` property to track the current editing text and a `selection` property of type `TextSelection` to track the currently selected text. Whenever the text in a `EditableText` widget is modified or selected by user, the text and selection properties of the associated `TextEditingController` instance will be updated. If you modify the text or selection properties of the `TextEditingController` instance, the `EditableText` widget will update itself. `TextEditingController` class is a subclass of `ValueNotifier<TextEditingValue>`, so you can add listeners to the controller to get notifications when the text or selection changes. When creating a new `TextEditingController` instance, you can pass some text with the `text` parameter, which becomes the initial text of the corresponding `EditableText` widget.

Let's see three different ways to get the text from `EditableText` widgets.

Using `TextEditingController`

The first way is using `TextEditingController`. The `ReverseText` widget in Listing 6-1 is used to reverse an input string. The `TextEditingController` instance is created with initial text "`<input>`". When the button is pressed, the `_value` is updated to the text retrieved from the controller. The reversed string is displayed.

Listing 6-1. Use TextEditingController to get text

```
class ReverseText extends StatefulWidget {  
    @override  
    _ReverseTextState createState() => _ReverseTextState();  
}  
  
class _ReverseTextState extends State<ReverseText> {  
    final TextEditingController _controller =  
    TextEditingController(  
        text: "<input>",  
    );  
    String _value;  
  
    @override  
    Widget build(BuildContext context) {  
        return Column(  
            mainAxisAlignment: MainAxisAlignment.start,  
            children: <Widget>[  
                Row(  
                    children: <Widget>[  
                        Expanded(  
                            child: TextField(  
                                controller: _controller,  
                            ),  
                        ),  
                        RaisedButton(  
                            child: Text('Go'),  
                            onPressed: () {  
                                this.setState(() {  
                                    _value = _controller.text;  
                                });  
                            },  
                        ),  
                    ],  
                ),  
            ],  
        );  
    }  
}
```

```
        ),  
        ],  
        ),  
        Text( (_value ?? "").split("").reversed.join()),  
        ],  
    );  
}  
}  
}
```

Figure 6-1 shows the screenshot of code in Listing 6-1.



Figure 6-1. Use `TextEditingController`

Using Listeners of `TextEditingController`

A `TextEditingController` instance is also an instance of `ValueNotifier<TextEditingValue>`, so you can add listeners to it and react to notifications. In Listing 6-2, the listener function `_handleTextChanged` calls `setState()` function to update the state when receiving change notifications. The listener is added in the `initState()` function and removed in the `dispose()` function, which makes sure resource is properly cleaned up.

Listing 6-2. Use `TextEditingController` listener

```
class ReverseTextWithListener extends StatefulWidget {  
    @override  
    _ReverseTextWithListenerState createState() =>  
        _ReverseTextWithListenerState();  
}
```

```
class _ReverseTextWithListenerState extends  
State<ReverseTextWithListener> {  
    TextEditingController _controller;  
    String _value;  
  
    @override  
    void initState() {  
        super.initState();  
        _controller = TextEditingController(  
            text: "<input>",  
        );  
        _controller.addListener(_handleTextChanged);  
    }  
  
    @override  
    Widget build(BuildContext context) {  
        return Column(  
            mainAxisAlignment: MainAxisAlignment.start,  
            children: <Widget>[  
                TextField(  
                    controller: _controller,  
                ),  
                Text( (_value ?? "").split("").reversed.join()),  
            ],  
        );  
    }  
  
    @override  
    void dispose() {  
        _controller.removeListener(_handleTextChanged);  
        super.dispose();  
    }  
}
```

```

void _handleTextChanged() {
    this.setState(() {
        this._value = _controller.text;
    });
}
}

```

Figure 6-2 shows the screenshot of code in Listing 6-2.

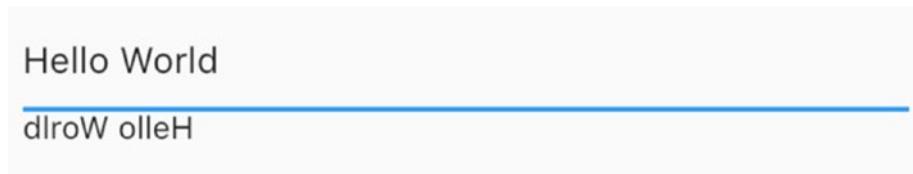


Figure 6-2. Use *TextEditingController* listener

Using Callbacks

The last way to get text from `EditText` widgets is using the callbacks. There are three types of callbacks related to text editing; see Table 6-1.

Table 6-1. *EditText* callbacks

| Name | Type | Description |
|--------------------------------|---|---|
| <code>onChanged</code> | <code>ValueChanged<String></code> | Called when text changed. |
| <code>onEditingComplete</code> | <code>VoidCallback</code> | Called when user submits the text. |
| <code>onSubmitted</code> | <code>ValueChanged<String></code> | Called when user finishes editing the text. |

If you want to actively watch for text changes, you should use `onChanged` callback. When user finishes editing the text, both `onEditingComplete` and `onSubmitted` callbacks will be invoked.

The difference is that `onEditingComplete` callback doesn't provide access to the submitted text.

In Listing 6-3, different messages are logged in different callbacks. All the log messages are displayed in a `RichText` widget.

Listing 6-3. `EditableText` callbacks

```
class TextFieldCallbacks extends StatefulWidget {  
  @override  
  _TextFieldCallbacksState createState() =>  
  _TextFieldCallbacksState();  
}  
  
class _TextFieldCallbacksState extends  
State<TextFieldCallbacks> {  
  List<String> _logs = List();  
  
  void _log(String value) {  
    this.setState(() {  
      this._logs.add(value);  
    });  
  }  
  
  @override  
  Widget build(BuildContext context) {  
    return Column(  
      mainAxisAlignment: MainAxisAlignment.start,  
      children: <Widget>[  
        TextField(  
          onChanged: (text) => _log('changed: $text'),  
          onEditingComplete: () => _log('completed'),  
          onSubmit: (text) => _log('submitted: $text'),  
        ),  
      ],  
    );  
  }  
}
```

```
    Text.rich(TextSpan(  
        children: this._logs.map((log) => TextSpan(text:  
            '$log\n')).toList(),  
    )),  
    ],  
);  
}  
}
```

Figure 6-3 shows the screenshot of code in Listing 6-3.

Hello

```
changed: H  
changed: He  
changed: Hel  
changed: Hell  
changed: Hello  
completed  
submitted: Hello
```

Figure 6-3. *EditText callbacks*

Although examples in Listings 6-1, 6-2, and 6-3 use `TextField`, the same pattern can also be applied to `CupertinoTextField`.

6-2. Customizing Keyboard for Text Input Problem

You want to customize the keyboard used to edit the text.

Solution

Use keyboardType, textInputAction, and keyboardAppearance parameters.

Discussion

EditableText widget allows customization of the keyboard used for editing the text. You can use keyboardType parameter of type TextInputType class to set a keyboard type suitable for the text. For example, if the EditableText widget is used to edit phone numbers, then TextInputType.phone is a better choice for the keyboardType parameter. Table 6-2 shows constants in TextInputType. TextInputType.number constant is used for unsigned numbers without a decimal point. For other types of numbers, you can use TextInputType.numberWithOptions({bool signed: false, bool decimal: false }) constructor to set whether the numbers should be signed or a decimal point should be included.

Table 6-2. *TextInputType constants*

| Name | Description |
|--------------|--|
| text | Plain text. |
| multiline | Multi-line text. |
| number | Unsigned number without a decimal point. |
| phone | Phone numbers. |
| datetime | Date and time. |
| emailAddress | Email addresses. |
| url | URLs. |

The `textInputAction` parameter of type `TextInputAction` enum sets the logic action to perform when user is submitting the text. For example, if the text field is for use to input search queries, then the `TextInputAction.search` value makes the keyboard to display the text “Search”. The user can expect a search action to perform after tapping the action button. `TextInputAction` enum defined a set of actions. The buttons for these actions may have different appearances on different platforms or different versions of the same platform. Most of these actions are supported by both Android and iOS. They are mapped to IME input types on Android and keyboard return types on iOS. Table 6-3 shows values of `TextInputAction` and their mappings on Android and iOS. Some actions may only be supported on Android or iOS. Using an unsupported action will cause an error to be thrown in the debug mode. However, in the release mode, an unsupported action will be mapped to `IME_ACTION_UNSPECIFIED` on Android and `UIReturnKeyDefault` on iOS, respectively.

Table 6-3. *TextInputAction values*

| Name | Android IME input type | iOS keyboard return type |
|----------------|-------------------------------------|---------------------------------------|
| none | <code>IME_ACTION_NONE</code> | N/A |
| unspecified | <code>IME_ACTION_UNSPECIFIED</code> | <code>UIReturnKeyDefault</code> |
| done | <code>IME_ACTION_DONE</code> | <code>UIReturnKeyDone</code> |
| search | <code>IME_ACTION_SEARCH</code> | <code>UIReturnKeySearch</code> |
| send | <code>IME_ACTION_SEND</code> | <code>UIReturnKeySend</code> |
| next | <code>IME_ACTION_NEXT</code> | <code>UIReturnKeyNext</code> |
| previous | <code>IME_ACTION_PREVIOUS</code> | N/A |
| continueAction | N/A | <code>UIReturnKeyContinue</code> |
| join | N/A | <code>UIReturnKeyJoin</code> |
| route | N/A | <code>UIReturnKeyRoute</code> |
| emergencyCall | N/A | <code>UIReturnKeyEmergencyCall</code> |
| newline | <code>IME_ACTION_NONE</code> | <code>UIReturnKeyDefault</code> |

The last keyboardAppearance parameter of type Brightness sets the appearance of the keyboard. Brightness enum has two values, dark and light. The parameter is only used for iOS.

Listing 6-4 shows the usage of keyboardType and last keyboardAppearance parameters.

Listing 6-4. keyboardType and keyboardAppearance parameters

```
TextField(  
    keyboardType: TextInputType.phone,  
)  
  
TextField(  
    keyboardType: TextInputType.numberWithOptions(  
        signed: true,  
        decimal: true,  
)  
)  
  
TextField(  
    textInputAction: TextInputAction.search,  
    keyboardAppearance: Brightness.dark,  
)
```

6-3. Add Decorations to Text Input in Material Design

Problem

You want to add decorations like prefix and suffix to text fields in Material Design.

Solution

Use the decoration parameter of type InputDecoration.

Discussion

TextField widget supports adding different decorations to present various information to user. For example, if the value of text input is invalid, you can add a red border and some text below the text input to indicate that. You can also add text or icons as the prefix or suffix. If the TextField widget is for editing currency value, you can add a currency symbol as the prefix. The decoration parameter of type InputDecoration of TextField is used to add this information. InputDecoration class has many named parameters, which we will review next.

Borders

Let's start from adding borders to text input widgets. InputDecoration constructor has several parameters of type InputBorder that are related to borders, including errorBorder, disabledBorder, focusedBorder, focusedErrorBorder, and enabledBorder. The names of these parameters indicate when these borders will be displayed based on the state. There is also a border parameter, but this parameter is only used to provide the shape of the border.

InputBorder class is abstract, so one of its subclasses UnderlineInputBorder or OutlineInputBorder should be used. UnderlineInputBorder class only has a border at the bottom side. UnderlineInputBorder constructor has parameters borderSide of type BorderSide and borderRadius of type BorderRadius. BorderSide class defines color, width, and style of one side of a border. A border's style is defined by BorderStyle enum which has values none and solid. A BorderSide with style BorderStyle.none won't be rendered. BorderRadius class defines a set of radii for each corner of a rectangle.

The radius for a corner is created using Radius class. The shape of a radius can be circular or elliptical. Circular or elliptical radii can be created using constructors Radius.circular(double radius) and Radius.elliptical(double x, double y), respectively. BorderRadius has topLeft, topRight, bottomLeft, and bottomRight properties of type Radius to represent radii of these four corners. You can use BorderRadius.only() to specify different Radius instances for each corner or use BorderRadius.all() to use a single Radius instance for all corners.

OutlineInputBorder class draws a rectangle around the widget.

OutlineInputBorder constructor also has parameters borderSide and borderRadius. It also has the gapPadding parameter to specify the horizontal padding for the label text displayed in a gap of the border.

In Listing 6-5, both TextField widgets declare borders that are rendered when they gain focus using focusedBorder parameter.

Listing 6-5. Examples of InputDecoration

```
TextField(  
    decoration: InputDecoration(  
        enabledBorder: UnderlineInputBorder(  
            borderSide: BorderSide(color: Colors.red),  
            borderRadius: BorderRadius.all(Radius.elliptical(5, 10)),  
        ),  
    ),  
)  
  
TextField(  
    decoration: InputDecoration(  
        labelText: 'Username',  
        focusedBorder: OutlineInputBorder(  
            borderSide: BorderSide(color: Colors.blue),  
            borderRadius: BorderRadius.circular(10),  
        ),  
    ),  
)
```

```
        gapPadding: 2,  
    ),  
    ),  
)
```

Figure 6-4 shows the screenshot of code in Listing 6-5. The second TextField is focused, so the focused border is displayed.

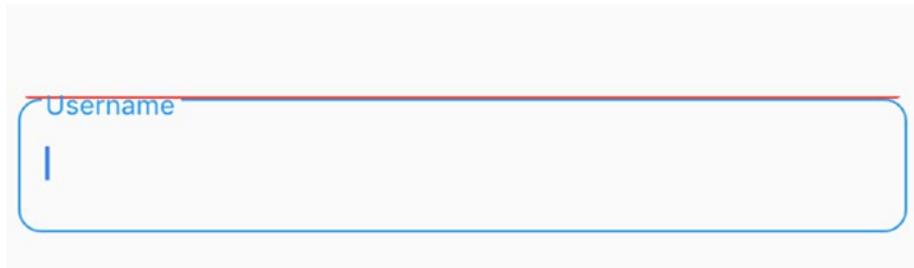


Figure 6-4. Borders

Prefix and Suffix

Prefix and suffix in a text input can provide information and actions that are useful when editing text. Prefix and suffix can both be plain text or widgets. When using text, you can customize the style of the text. InputDecoration constructor has parameters prefix, prefixIcon, prefixText, and prefixStyle to customize the prefix. It also has parameters suffix, suffixIcon, suffixText, and suffixStyle to customize the suffix. You cannot specify non-null values to both prefix and prefixText. This restriction also applies to suffix and suffixText. You can only provide a widget or text, but not both at the same time.

Listing 6-6. Example of prefix and suffix

```
TextField(  
    decoration: InputDecoration(  
        prefixIcon: Icon(Icons.monetization_on),
```

```

prefixText: 'Pay ',
prefixStyle: TextStyle(fontStyle: FontStyle.italic),
suffixText: '.00',
),
)

```

Figure 6-5 shows the screenshot of Listing 6-6.

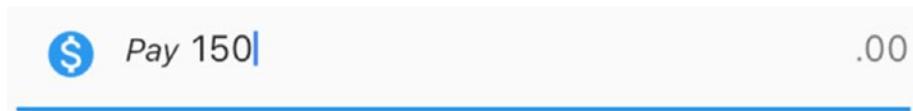


Figure 6-5. Prefix and suffix

Text

You can add different types of text as the decorations and customize their styles. There are five types of text shown in Table 6-4.

Table 6-4. Different types of text

| Type | Text | Style | Description |
|---------|-------------|--------------|--|
| Label | labelText | labelStyle | Labels are displayed above the input field. |
| Helper | helperText | helperStyle | Helper text are displayed below the input field. |
| Hint | hintText | hintStyle | Hints are displayed in the input field when it's empty. |
| Error | errorText | errorStyle | Errors are displayed below the input field. |
| Counter | counterText | counterStyle | Counters are displayed below the input field but aligned to the right. |

If errorText value is not null, the input field is set to the error state.

Listing 6-7. Example of text

```
TextField(  
    keyboardType: TextInputType.emailAddress,  
    decoration: InputDecoration(  
        labelText: 'Email',  
        labelStyle: TextStyle(fontWeight: FontWeight.bold),  
        hintText: 'Email address for validation',  
        helperText: 'For receiving validation emails',  
        counterText: '10',  
    ),  
)
```

Figure 6-6 shows the screenshot of code in Listing 6-7.

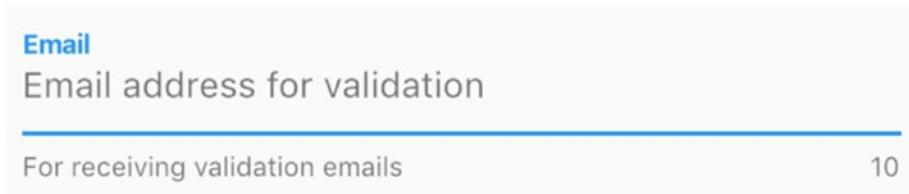


Figure 6-6. Text of `TextField`

6-4. Setting Text Limits

Problem

You want to control the length of text.

Solution

Use `maxLength` parameter.

Discussion

To set the maximum length of text in `TextField` and `CupertinoTextField`, you can use the `maxLength` parameter. The default value of `maxLength` parameter is `null`, which means there is no restriction on the number of characters. If `maxLength` parameter is set, a character counter is displayed below the text input, which shows the number of characters entered and the number of allowed characters. If `maxLength` parameter is set to `TextField.noMaxLength`, then only the number of characters entered is displayed. When `maxLength` is set, if the characters reach the limit, the behavior depends on the value of `maxLengthEnforced` parameter. If `maxLengthEnforced` is `true`, which is the default value, no more characters can be entered. If `maxLengthEnforced` is `false`, additional characters can be entered, but the widget switches to the error style.

Listing 6-8. Examples of `maxLength`

```
TextField(  
    maxLength: TextField.noMaxLength,  
)  
  
TextField(  
    maxLength: 10,  
    maxLengthEnforced: false,  
)  
  
CupertinoTextField(  
    maxLength: 10,  
)
```

Figure 6-7 shows the screenshot of two `TextField` widgets in Listing 6-8.

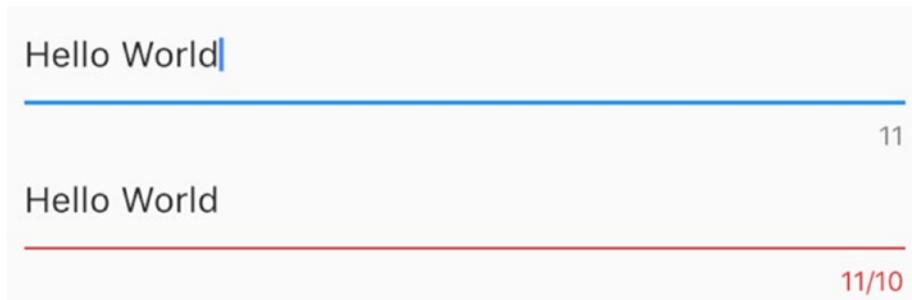


Figure 6-7. Text limits

6-5. Selecting Text

Problem

You want to select some text in the text input.

Solution

Use selection property of TextEditingController.

Discussion

In Recipe 6-1, you have seen the example of using TextEditingController to get and set the text of widgets using EditableText. TextEditingController can also be used to get the text selection by user and select text. This is done by getting or setting the value of selection property of type TextSelection.

TextSelection is a subclass of TextRange. You can use TextRange.textInside() to get the selected text. TextSelection class uses baseOffset and extentOffset properties to represent the position which the selection originates and terminates, respectively. The value of baseOffset may be larger than, smaller than, or equal to extentOffset. If baseOffset equals to

extentOffset, the selection is collapsed. Collapsed text selection contains zero characters, but they are used to represent text insertion points. TextSelection.collapsed() constructor can create a collapsed selection at specified offset.

In Listing 6-9, when text selection changes, the selected text is displayed. The first button selected the text in the range [0, 5], while the second button moves the cursor to offset 1.

Listing 6-9. Text selection

```
class TextSelectionExample extends StatefulWidget {  
    @override  
    _TextSelectionExampleState createState() =>  
        _TextSelectionExampleState();  
}  
  
class _TextSelectionExampleState extends  
State<TextSelectionExample> {  
    TextEditingController _controller;  
    String _selection;  
  
    @override  
    void initState() {  
        super.initState();  
        _controller = new TextEditingController();  
        _controller.addListener(_handleTextSelection);  
    }  
  
    @override  
    void dispose() {  
        _controller.removeListener(_handleTextSelection);  
        super.dispose();  
    }  
}
```

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```
override
Widget build(BuildContext context) {
  return Column(
    mainAxisAlignment: MainAxisAlignment.start,
    children: <Widget>[
      TextField(
        controller: _controller,
      ),
      Row(
        children: <Widget>[
          RaisedButton(
            child: Text('Select text [0, 5]'),
            onPressed: () {
              setState(() {
                _controller.selection =
                  TextSelection(baseOffset: 0,
                  extentOffset: 5);
              });
            },
          ),
          RaisedButton(
            child: Text('Move cursor to offset 1'),
            onPressed: () {
              setState(() {
                _controller.selection = TextSelection.
                  collapsed(offset: 1);
              });
            },
          ),
        ],
      ),
    ],
  ),
}
```

```
Text.rich(TextSpan(  
    children: [  
        TextSpan(  
            text: 'Selected:',  
            style: TextStyle(fontWeight: FontWeight.bold),  
        ),  
        TextSpan(text: _selection ?? ""),  
    ],  
)),  
],  
);  
}  
  
_handleTextSelection() {  
    TextSelection selection = _controller.selection;  
    if (selection != null) {  
        setState(() {  
            _selection = selection.textInside(_controller.text);  
        });  
    }  
}  
}
```

Figure 6-8 shows the screenshot of code in Listing 6-9.

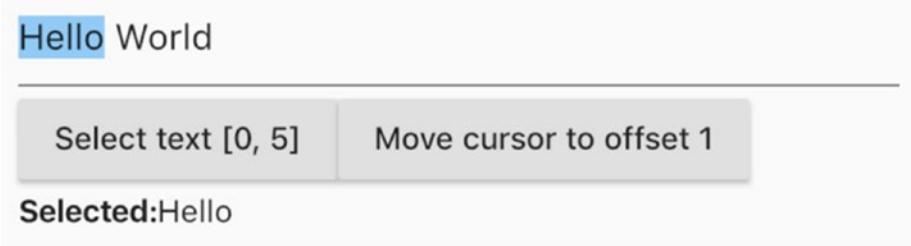


Figure 6-8. Text selection

6-6. Formatting Text

Problem

You want to format the text.

Solution

Use `TextInputFormatter` with `EditableText`.

Discussion

When the user is typing in a text input, you may want to validate and format the entered text. A common requirement is to remove characters in a blacklist. This is done by providing a list of `TextInputFormatter` instances as the `inputFormatters` parameter of `TextField` and `CupertinoTextField`.

`TextInputFormatter` is an abstract class with only `formatEditUpdate` (`TextEditingValue oldValue, TextEditingValue newValue`) to implement. The `oldValue` and `newValue` parameters represent the previous text and new text, respectively. The return value is another `TextEditingValue` instance representing the formatted text. `TextInputFormatter` instances can be chained. When chained, the value of `oldValue` to invoke `formatEditUpdate` method is always the previous text, but the value of `newValue` is the return value of invoking the `formatEditUpdate` method of previous `TextInputFormatter` instance in the chain.

There are already three built-in implementation classes of `TextInputFormatter` shown in Table 6-5. These classes are used in implementation of `TextField` and `CupertinoTextField`. For example, when the value of `maxLines` parameter is 1, `BlacklistingTextInputFormatter` `singleLineFormatter` is added to the list of `TextInputFormatter` instances to filter out the “\n” character.

Table 6-5. Implementations of `TextInputFormatter`

| Name | Description |
|--------------------------------------|---|
| LengthLimitingText InputFormatter | Limit the number of characters can be entered. |
| BlacklistingText InputFormatter | Replace characters matching regular expression pattern with given string. |
| WhitelistingText InputFormatter | Allow only characters matching given regular expression pattern. |

Instead of declaring new subclasses of `TextInputFormatter`, an easier way is to use `TextInputFormatter.withFunction()` method with a function matching the type of `formatEditUpdate()` method.

In Listing 6-10, the input text is formatted to use uppercase.

Listing 6-10. Format text

```
TextField(
    inputFormatters: [
        TextInputFormatter.withFunction((oldValue, newValue) {
            return newValue.copyWith(text: newValue.text?.
                toUpperCase());
        }),
    ],
)
```

6-7. Selecting a Single Value Problem

You want to select a single value from a list of values.

Solution

Use a group of Radio widgets.

Discussion

Radio buttons are commonly used for scenarios requiring single selections. Only one radio button in a group can be selected. Radio class has a type parameter T representing the type of values. When creating Radio instances, you need to provide required parameters including value, groupValue, and onChanged. A Radio widget doesn't maintain any state. Its appearance is purely determined by value and groupValue parameters. When the selection of a radio group is changed, onChanged listener is invoked with the selected value. Table 6-6 shows the named parameters of Radio constructor.

Table 6-6. Named parameters of Radio

| Name | Type | Description |
|-------------|-----------------|---|
| value | T | Value of this radio button. |
| groupValue | T | Selected value of this group of radio buttons. The radio button with groupValue is in selected state. |
| onChanged | ValueChanged<T> | Listener function when selection changed. |
| activeColor | Color | Color when this radio button is selected. |

In Listing 6-11, Fruit.allFruits variable is a list of all Fruit instances. `_selectedFruit` is the currently selected Fruit instance. For each Fruit instance, a `Radio<Fruit>` widget is created with the `groupValue` set to `_selectedFruit`.

Listing 6-11. Example of using Radio

```
class FruitChooser extends StatefulWidget {  
    @override  
    _FruitChooserState createState() => _FruitChooserState();  
}  
  
class _FruitChooserState extends State<FruitChooser> {  
    Fruit _selectedFruit;  
  
    @override  
    Widget build(BuildContext context) {  
        return Column(  
            mainAxisAlignment: MainAxisAlignment.start,  
            children: <Widget>[  
                Column(  
                    children: Fruit.allFruits.map((fruit) {  
                        return Row(  
                            children: <Widget>[  
                                Radio<Fruit>(  
                                    value: fruit,  
                                    groupValue: _selectedFruit,  
                                    onChanged: (value) {  
                                        setState(() {  
                                            _selectedFruit = value;  
                                        });  
                                    },  
                                ),  
                                Expanded(  
                                    child: Text(fruit.name),  
                                ),  
                            ],  
                        );  
                    }).toList(),  
                ),  
            ],  
        );  
    }  
}
```

```
    ),  
    Text(_selectedFruit != null ? _selectedFruit.name : "")  
  ],  
);  
}  
}
```

Figure 6-9 shows the screenshot of the example in Listing 6-11.

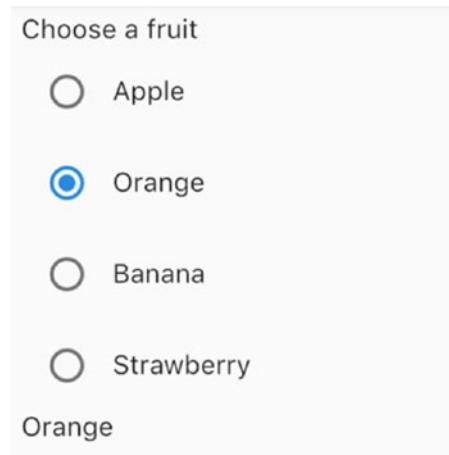


Figure 6-9. Radio widgets

6-8. Selecting a Single Value from Dropdown

Problem

You want to select a single value from a dropdown list.

Solution

Use DropdownButton.

Discussion

A DropdownButton widget shows a list of items when tapped.

DropdownButton class is generic with the type parameter representing the type of values. The list of items is specified using the items parameter of type List< DropdownMenuItem<T>>. DropdownMenuItem widget is a simple wrapper with the value and a child widget. When the selection is changed, the onChanged callback will be invoked with the value of selected item. Value of the selected item is passed as value parameter. If value is null, the hint widget is displayed instead.

In Listing 6-12, each Fruit instance is mapped to a DropdownMenuItem widget.

Listing 6-12. Example of DropdownButton

```
class FruitChooser extends StatefulWidget {
  @override
  _FruitChooserState createState() => _FruitChooserState();
}

class _FruitChooserState extends State<FruitChooser> {
  Fruit _selectedFruit;

  @override
  Widget build(BuildContext context) {
    return Column(
      mainAxisAlignment: MainAxisAlignment.start,
      children: <Widget>[
        DropdownButton(
          value: _selectedFruit,
          items: Fruit.allFruits.map((fruit) {
            return DropdownMenuItem(
              value: fruit,
              child: Text(fruit.name),
            );
          })
        )
      ],
    );
  }
}
```

```
    );
}).toList(),
onChanged: (fruit) {
    setState(() {
        _selectedFruit = fruit;
    });
},
hint: Text('Select a fruit'),
),
],
);
}
}
```

Figure 6-10 shows the screenshot of an expanded DropdownButton.

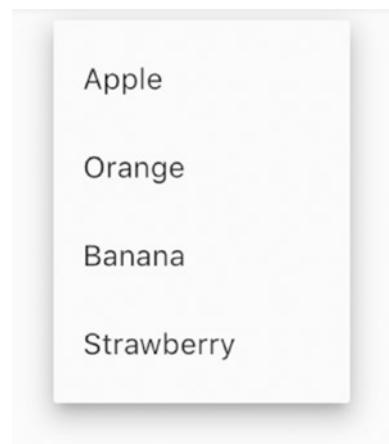


Figure 6-10. Expanded DropdownButton

6-9. Selecting Multiple Values

Problem

You want to select multiple values.

Solution

Use Checkbox widget.

Discussion

Checkboxes are commonly used to allow multiple selections. A checkbox can display three values, true, false, and null, if this checkbox is created with parameter tristate set to true. Otherwise, only values true and false are allowed. If the value is null, a dash is displayed. A checkbox itself doesn't maintain any state. Its appearance is purely determined by the value parameter. When the value of a checkbox is changed, the onChanged callback is invoked with the value of the new state.

In Listing 6-13, selected fruits are maintained in a List<Fruit> instance. Each Fruit instance is mapped to a Checkbox widget. The value of a Checkbox depends on whether corresponding Fruit instance is in the _selectedFruits list.

Listing 6-13. Example of Checkbox

```
class FruitSelector extends StatefulWidget {  
  @override  
  _FruitSelectorState createState() => _FruitSelectorState();  
}  
  
class _FruitSelectorState extends State<FruitSelector> {  
  List<Fruit> _selectedFruits = List();  
  
  @override  
  Widget build(BuildContext context) {
```

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```
return Column(
  mainAxisAlignment: MainAxisAlignment.start,
  children: <Widget>[
    Column(
      children: Fruit.allFruits.map((fruit) {
        return Row(
          children: <Widget>[
            Checkbox(
              value: _selectedFruits.contains(fruit),
              onChanged: (selected) {
                setState(() {
                  if (selected) {
                    _selectedFruits.add(fruit);
                  } else {
                    _selectedFruits.remove(fruit);
                  }
                });
              },
            ),
            Expanded(
              child: Text(fruit.name),
            )
          ],
        );
      }).toList(),
    ),
    Text(_selectedFruits.join(', ')),
  ],
);
```

Figure 6-10 shows the screenshot of the example in Listing 6-13.

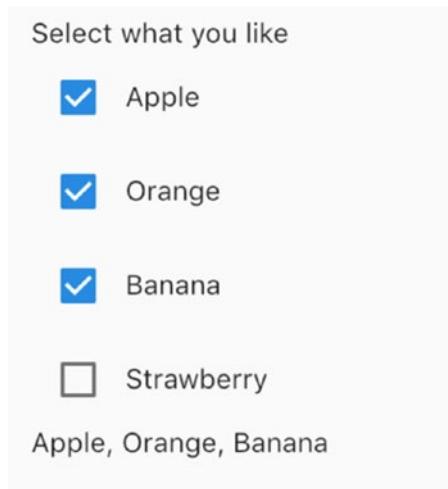


Figure 6-11. Checkbox

6-10. Toggling On/Off State

Problem

You want to toggle the on/off state.

Solution

Use Switch for Material Design and CupertinoSwitch for iOS style.

Discussion

Switch is a commonly used UI control to toggle the on/off state of a setting. Switch widget is used for Material Design. A Switch widget can be in two states, active and inactive. A Switch widget itself doesn't maintain any state. Its behavior and appearance are purely determined by values of constructor parameters. If the value parameter is true, then Switch widget is in active state; otherwise, it's in inactive state. When the on/off state of

a Switch widget is changed, the onChanged callback is invoked with the new state to be. You can customize the appearance of a Switch widget in different states using parameters activeColor, activeThumbImage, activeTrackColor, inactiveThumbColor, inactiveThumbImage, and inactiveTrackColor.

In Listing 6-14, the Switch widget is used to control the state of another TextField widget.

Listing 6-14. Example of Switch

```
class NameInput extends StatefulWidget {  
    @override  
    _NameInputState createState() => _NameInputState();  
}  
  
class _NameInputState extends State<NameInput> {  
    bool _useCustomName = false;  
  
    _buildNameInput() {  
        return TextField(  
            decoration: InputDecoration(labelText: 'Name'),  
        );  
    }  
  
    _buildToggle() {  
        return Row(  
            children: <Widget>[  
                Switch(  
                    value: _useCustomName,  
                    onChanged: (value) {  
                        setState(() {  
                            _useCustomName = value;  
                        });  
                    },  
                ),  
            ],  
        );  
    }  
}
```

```
    activeColor: Colors.green,  
    inactiveThumbColor: Colors.grey.shade200,  
,  
    Expanded(  
        child: Text('Use custom name'),  
,  
    ],  
);  
}  
  
@override  
Widget build(BuildContext context) {  
    return Column(  
        mainAxisAlignment: MainAxisAlignment.start,  
        children: _useCustomName  
            ? [_buildToggle(), _buildNameInput()]  
            : [_buildToggle()],  
    );  
}  
}
```

Figure 6-12 shows the screenshot of example in Listing 6-14.

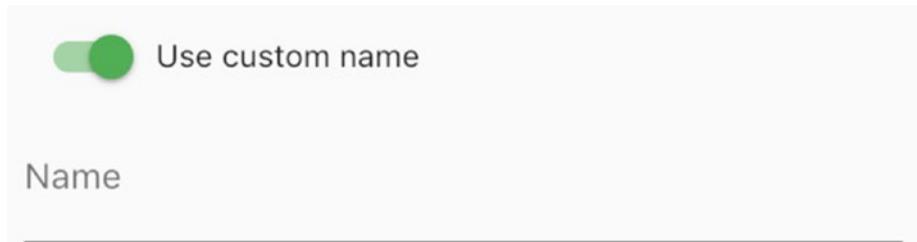


Figure 6-12. Switch

CupertinoSwitch widget creates an iOS-style switch and it works the same way as Switch, but it only supports customization of the active color. Switch widget has the constructor Switch.adaptive() to create either a Switch widget or CupertinoSwitch widget depends on the target platform. When a CupertinoSwitch widget is created using Switch.adaptive(), only constructor parameters accepted by CupertinoSwitch() are used; other parameters are ignored.

Listing 6-15 shows examples of using CupertinoSwitch and Switch.adaptive().

Listing 6-15. Example of CupertinoSwitch

```
CupertinoSwitch(  
    value: true,  
    onChanged: (value) => {},  
    activeColor: Colors.red.shade300,  
)  
  
Switch.adaptive(  
    value: true,  
    onChanged: (value) => {},  
)
```

6-11. Selecting from a Range of Values

Problem

You want to select from a range of continuous or a discrete set of values.

Solution

Use Slider for Material Design or CupertinoSlider for iOS style.

Discussion

A slider is commonly used to select from a range of continuous or a discrete set of values. You can use Slider widget for Material Design or CupertinoSlider for iOS style. These two widgets have the same behavior but different visual appearance. When creating sliders, you need to provide a valid range of the values using min and max parameters. If non-null value is used for divisions parameter, a set of discrete values will be the selections. Otherwise, a continuous range of values will be the selections. For example, if value in min is 0.0 and max is 10.0, with the divisions set to 5, then values of selections are 0.0, 2.0, 4.0, 6.0, 8.0, and 10.0. A slider widget doesn't maintain any state. Its behavior and appearance are purely determined by constructor parameters. When the value of a slider is changed, the onChanged callback is invoked with the selected value. You can also use onChangeStart and onChangeEnd callbacks to get notifications when the value starts to change and it's done changing, respectively. You can further customize a slider's appearance using label, activeColor, and inactiveColor. Only activeColor parameter is supported by CupertinoSlider. The slider widget will be disabled if onChanged is null or if the range is empty.

In Listing 6-16, a Slider widget is created with the given value of divisions parameter and shows the current value.

Listing 6-16. Example of Slider

```
class SliderValue extends StatefulWidget {
  SliderValue({Key key, this.divisions}) : super(key: key);

  final int divisions;

  @override
  _SliderValueState createState() =>
    _SliderValueState(divisions);
}
```

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```
class _SliderValueState extends State<SliderValue> {
    _SliderValueState(this.divisions);

    final int divisions;
    double _value = 0.0;

    @override
    Widget build(BuildContext context) {
        return Row(
            children: <Widget>[
                Expanded(
                    child: Slider(
                        value: _value,
                        min: 0.0,
                        max: 10.0,
                        divisions: divisions,
                        onChanged: (value) {
                            setState(() {
                                _value = value;
                            });
                        },
                    ),
                ),
                Text(_value.toStringAsFixed(2)),
            ],
        );
    }
}
```

The usage of CupertinoSlider is similar with Slider. You can simply replace Slider with CupertinoSlider in Listing 6-16. Figure 6-13 shows screenshot of Slider and CupertinoSlider.



Figure 6-13. Slider and CupertinoSlider

6-12. Using Chips

Problem

You want to have compact alternatives to represent different types of entities.

Solution

Use different types of Chips.

Discussion

When space is limited, traditional widget like buttons, radio buttons, and checkboxes may not be suitable. Chips in Material Design can be used in this case to represent the same semantic but use less space.

Chip widget is the generic chip implementation that has a required label and an optional avatar. It can also include a delete button when setting a non-null onDeleted callback.

InputChip widget is more powerful than Chip widget. An InputChip widget can be selectable by setting the onSelected callback and pressable by setting the onPressed callback. However, you cannot set non-null values

to both onSelected and onPressed callbacks. When using onSelected, an InputChip widget behaves like a checkbox. You can use the selected parameter to set the state. When using onPressed, an InputChip widget behaves like a button.

A ChoiceChip widget behaves like a radio button with selected parameter to set its state and onSelected callback to notify state changes. However, ChoiceChip widget doesn't have a parameter similar with groupValue in Radio widget, so you have to set the selected state manually.

A FilterChip widget behaves like a checkbox. FilterChip constructor has the same parameters as ChoiceChip constructor.

An ActionChip widget behaves like a button with the onPressed parameter. The difference between action chips and buttons is that action chips cannot be disabled by setting onPressed parameter to null. Action chips should be removed if their actions are not applicable. This behavior is consistent with the goal to using chips for reducing space.

In fact, all these chip widgets wrap RawChip widgets by using only a subset of parameters supported by RawChip constructor.

In Listing 6-17, ChoiceChip widget is used to implement single selection.

Listing 6-17. Example of ChoiceChip

```
class FruitChooser extends StatefulWidget {  
    @override  
    _FruitChooserState createState() => _FruitChooserState();  
}  
  
class _FruitChooserState extends State<FruitChooser> {  
    Fruit _selectedFruit;  
  
    @override  
    Widget build(BuildContext context) {
```

```

return Column(
  mainAxisAlignment: MainAxisAlignment.start,
  children: <Widget>[
    Wrap(
      spacing: 5,
      children: Fruit.allFruits.map((fruit) {
        return ChoiceChip(
          label: Text(fruit.name),
          selected: _selectedFruit == fruit,
          onSelected: (selected) {
            setState(() {
              _selectedFruit = selected ? fruit : null;
            });
          },
          selectedColor: Colors.red.shade200,
        );
      }).toList(),
    ),
    Text(_selectedFruit != null ? _selectedFruit.name : ""),
  ],
);
}
}

```

In Listing 6-18, FilterChip widget is used to implement multiple selections.

Listing 6-18. Example of FilterChip

```

class FruitSelector extends StatefulWidget {
  @override
  _FruitSelectorState createState() => _FruitSelectorState();
}

```

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```
class _FruitSelectorState extends State<FruitSelector> {
  List<Fruit> _selectedFruits = List();

  @override
  Widget build(BuildContext context) {
    return Column(
      mainAxisAlignment: MainAxisAlignment.start,
      children: <Widget>[
        Wrap(
          spacing: 5,
          children: Fruit.allFruits.map((fruit) {
            return FilterChip(
              label: Text(fruit.name),
              selected: _selectedFruits.contains(fruit),
              onSelected: (selected) {
                setState(() {
                  if (selected) {
                    _selectedFruits.add(fruit);
                  } else {
                    _selectedFruits.remove(fruit);
                  }
                });
              },
              selectedColor: Colors.blue.shade200,
            );
          }).toList(),
        ),
        Text(_selectedFruits.join(', ')),
      ],
    );
  }
}
```

Figure 6-14 shows the screenshot of examples in Listings 6-17 and 6-18.



Figure 6-14. *ChoiceChip and FilterChip*

6-13. Selecting Date and Time

Problem

You want to select date and time.

Solution

Use `showDatePicker()` and `showTimePicker()` functions for Material Design or `CupertinoDatePicker` and `CupertinoTimerPicker` for iOS style.

Discussion

For Material Design, you can use widgets like `YearPicker`, `MonthPicker`, and `DayPicker` or `showDatePicker()` function to allow user to pick dates. The `showTimePicker()` function is used to pick times. Widgets are rarely used to pick dates. Most of the time, `showDatePicker()` and `showTimePicker()` functions are used to show dialogs.

`YearPicker` widget shows a list of years to pick. When creating `YearPicker` widgets, you need to provide `DateTime` instances for selected date, earliest date, and latest date using `selectedDate`, `firstDate`, and

`lastDate` parameters, respectively. When the selection is changed, the `onChanged` callback is invoked with the selected `DateTime` instance.

`MonthPicker` widget shows a list of months to pick. `MonthPicker` constructor has the same parameters `selectedDate`, `firstDate`, `lastDate`, and `onChanged` as `YearPicker`. It also has a predicate function `selectableDayPredicate` to customize which days are selectable.

`DayPicker` widget shows the days of a given month to pick. `DayPicker` constructor has all the parameters of `MonthPicker` and the `displayedMonth` parameter to set the month to pick for days.

If you want to show a dialog for user to select dates, `showDatePicker()` function is easier to use than creating your own dialogs. You need to pass `DateTime` instances for parameters `initialDate`, `firstDate`, and `lastDate`. The `context` parameter of type `BuildContext` is also required. This function can work in two modes defined in the `DatePickerMode` enum. `DatePickerMode.day` means choosing a month a day, while `DatePickerMode.year` means choosing a year. The return value of `showDatePicker()` function is a `Future<DateTime>` representing the selected date.

In Listing 6-19, the `TextField` widget has an `IconButton` as the suffix. When the button is pressed, `showDatePicker()` function is invoked to show the date picker dialog. The selected date is displayed in the `TextField` widget.

Listing 6-19. Pick date

```
class PickDate extends StatefulWidget {
  @override
  _PickDateState createState() => _PickDateState();
}

class _PickDateState extends State<PickDate> {
  DateTime _selectedDate = DateTime.now();
  TextEditingController _controller = TextEditingController();
```

```
@override
Widget build(BuildContext context) {
    return TextField(
        controller: _controller,
        decoration: InputDecoration(
            labelText: 'Date',
            suffix: IconButton(
                icon: Icon(Icons.date_range),
                onPressed: () {
                    showDatePicker(
                        context: context,
                        initialDate: _selectedDate,
                        firstDate: DateTime.now().subtract(Duration(days: 30)),
                        lastDate: DateTime.now().add(Duration(days: 30)),)
                    .then((selectedDate) {
                        if (selectedDate != null) {
                            _selectedDate = selectedDate;
                            _controller.text = DateFormat.yMd().format(_selectedDate);
                        }
                    });
                },
            ),
        );
    }
}
```

The showTimePicker() function shows a dialog to pick times. You need to pass the initialTime parameter of type TimeOfDay as the initial time to show. The return value is a Future<TimeOfDay> instance representing the

selected time. The code in Listing 6-20 uses the similar pattern as Listing 6-19 to show the time picker dialog.

Listing 6-20. Pick time

```
class PickTime extends StatefulWidget {  
    @override  
    _PickTimeState createState() => _PickTimeState();  
}  
  
class _PickTimeState extends State<PickTime> {  
    TimeOfDay _selectedTime = TimeOfDay.now();  
    TextEditingController _controller = TextEditingController();  
  
    @override  
    Widget build(BuildContext context) {  
        return TextField(  
            controller: _controller,  
            decoration: InputDecoration(  
                labelText: 'Time',  
                suffix: IconButton(  
                    icon: Icon(Icons.access_time),  
                    onPressed: () {  
                        showTimePicker(  
                            context: context,  
                            initialTime: _selectedTime,  
                        ).then((selectedTime) {  
                            if (selectedTime != null) {  
                                _selectedTime = selectedTime;  
                                _controller.text = _selectedTime.  
                                    format(context);  
                            }  
                        });  
        );  
    }  
}
```

```
        },
        )),
    );
}
}
```

For iOS style, you can use CupertinoDatePicker and CupertinoTimerPicker widgets to pick date and time, respectively. A CupertinoDatePicker can have different modes based on the mode parameter of enum CupertinoDatePickerMode, including date, time, and dateAndTime. Similar to widgets in Material Design, CupertinoDatePicker constructor has parameters initialDateTime, minimumDate, maximumDate, and onDateTimeChanged. A CupertinoTimerPicker can also have different modes based on the mode parameter of enum CupertinoTimerPickerMode, including hm, ms, and hms. The difference is that CupertinoTimerPicker uses Duration instances to set the initial value and as the value in onTimerDurationChanged callback.

6-14. Wrapping Form Fields

Problem

You want to wrap form widgets as form fields.

Solution

Use FormField or TextFormField.

Discussion

Form widgets can be used as normal widgets. However, these form widgets don't maintain any state; you always need to wrap them in stateful widgets to keep the state. A typical usage pattern is to use the onChanged callback

to update the state and trigger the rebuild of the form widget. Since this is a typical pattern of using form widgets, Flutter has a built-in `FormField` widget to maintain the current state of a form widget. It handles the updates and validation errors.

`FormField` class is generic with type parameter `T` representing the type of value. A `FormField` can be used as a standalone widget or be part of a `Form` widget. This recipe only discusses the standalone usage. Table 6-7 shows the named parameters of `FormField` constructor.

Table 6-7. *Named parameters of FormField*

| Name | Type | Description |
|---------------------------|--|---|
| <code>builder</code> | <code>FormFieldBuilder<T></code> | Build the widget representing this form field. |
| <code>onSaved</code> | <code>FormFieldSetter<T></code> | Callback when the form is saved. |
| <code>validator</code> | <code>FormFieldValidator<T></code> | Validator of the form field. |
| <code>initialValue</code> | <code>T</code> | Initial value. |
| <code>autovalidate</code> | <code>boolean</code> | Whether to validate automatically after every change. |
| <code>enabled</code> | <code>boolean</code> | Whether this form field is enabled. |

`FormFieldBuilder<T>` type is a typedef in the form of `Widget` (`FormFieldState<T>` field). `FormFieldState<T>` class extends from `State` class and represents the current state of the form field. `FormFieldBuilder` is responsible for building the widget based on the state. From `FormFieldState`, you can get the current value and error text of the form field. You can also use methods of `FormFieldState` in Table 6-8. `FormFieldValidator<T>` is also a typedef in the form of `String(T value)`. It takes the current value as the input and returns a non-null string as the error message if the validation fails. `FormFieldSetter<T>` type is a typedef in the form of `void(T newValue)`.

Table 6-8. Methods in FormFieldState

| Name | Description |
|-----------------------|---|
| save() | Call the onSaved() method with the current value. |
| validate() | Call the validator and set the errorText if validation fails. |
| didChange(T value) | Update the field's state to the new value. |
| reset() | Reset the field to its initial value. |

When wrapping TextFields inside of FormFields, it's better to use the built-in TextFormField. TextFormField widget already handles setting text using TextEditingController and using the error text returned by FormFieldValidator to update the input decoration. TextFormField constructor supports parameters from TextField and FormField constructors. TextFormField in Listing 6-21 has a validator to validate text length.

Listing 6-21. TextFormField

```
class NameInput extends StatelessWidget {
  @override
  Widget build(BuildContext context) {
    return TextFormField(
      decoration: InputDecoration(
        labelText: 'Name',
      ),
      validator: (value) {
        if (value == null || value.isEmpty) {
          return 'Name is required.';
        } else if (value.length < 6) {
          return 'Minimum length is 6.';
        }
      },
    );
}
```

```
        } else {
            return null;
        }
    },
    autovalidate: true,
);
}
}
```

Figure 6-15 shows the screenshot of code in Listing 6-21.

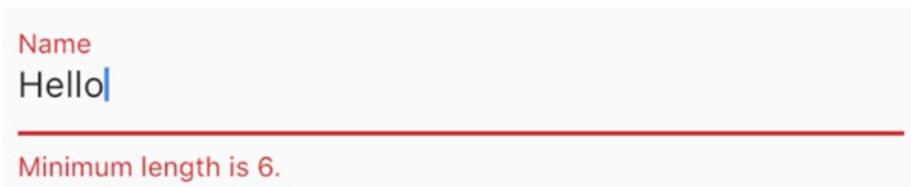


Figure 6-15. *TextField*

FormFieldState instances are only accessible in the builder function of TextFormField. If you need to access the state from other places, you can pass a GlobalKey as the key parameter of TextFormField, then use the currentState property to access the current state.

In Listing 6-22, the state of TextFormField is a List<PizzaTopping> instance. With the GlobalKey, the current value can be retrieved when the button is pressed.

Listing 6-22. TextFormField

```
class PizzaToppingsSelector extends StatelessWidget {
    final GlobalKey<FormFieldState<List<PizzaTopping>>>
        _formFieldKey =
    GlobalKey();
```

```
@override
Widget build(BuildContext context) {
    return Column(
        children: <Widget>[
            FormField<List<PizzaTopping>>(
                key: _formFieldKey,
                initialValue: List(),
                builder: (state) {
                    return Wrap(
                        spacing: 5,
                        children: PizzaTopping.allPizzaToppings.
                            map((topping) {
                                return ChoiceChip(
                                    label: Text(topping.name),
                                    selected: state.value.contains(topping),
                                    onSelected: state.value.length < 2 ||
                                        state.value.contains(topping)
                                        ? (selected) {
                                            List<PizzaTopping> newValue = List.
                                                of(state.value);
                                            if (selected) {
                                                newValue.add(topping);
                                            } else {
                                                newValue.remove(topping);
                                            }
                                            state.didChange(newValue);
                                        }
                                        : null,
                                );
                            }).toList(),
            );
        ],
    );
}
```

```
        },
        ),
        RaisedButton(
            child: Text('Get toppings'),
            onPressed: () => print(_formFieldKey.currentState?.value),
        ),
    ],
);
}
}
```

6-15. Creating Forms

Problem

You want to create a form with multiple form fields.

Solution

Use Form.

Discussion

When using form fields, generally you're trying to build a form with multiple form fields. Managing form fields separately is a tedious task when dealing with multiple form fields. Form is a convenient wrapper for multiple form fields. You need to wrap all form fields in FormField widgets and use a Form widget as the common ancestor of all these FormField widgets. Form widget is a stateful widget with state managed by associated FormState instance. FormState class has methods save(), validate(), and

reset(). These methods call corresponding functions on all FormFieldState instances of descendant FormField widgets.

There are two ways to get the FormState instance depends on the location of the widget wants to use FormState. If the widget is a descendant of the Form widget, using Form.of(BuildContext context) is an easy way to get the closest FormState instance. The second way is to use GlobalKey instance when creating the Form widget, then use GlobalKey.currentState to get the FormState.

Listing 6-23 shows the code of a login form. Two TextFormField widgets are created with GlobalKey instances.

Listing 6-23. Login form

```
class LoginForm extends StatefulWidget {  
    @override  
    _LoginFormState createState() => _LoginFormState();  
}  
  
class _LoginFormState extends State<LoginForm> {  
    final GlobalKey<FormFieldState<String>> _usernameFormFieldKey  
    = GlobalKey();  
    final GlobalKey<FormFieldState<String>> _passwordFormFieldKey  
    = GlobalKey();  
  
    _notEmpty(String value) => value != null && value.isNotEmpty;  
  
    get _value => {  
        'username': _usernameFormFieldKey.currentState?.value,  
        'password': _passwordFormFieldKey.currentState?.value  
    });  
  
    @override  
    Widget build(BuildContext context) {  
        return Form(
```

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```
child: Column(
  children: <Widget>[
    TextFormField(
      key: _usernameFormFieldKey,
      decoration: InputDecoration(
        labelText: 'Username',
      ),
      validator: (value) =>
        !_notEmpty(value) ? 'Username is required' :
        null,
    ),
    TextFormField(
      key: _passwordFormFieldKey,
      obscureText: true,
      decoration: InputDecoration(
        labelText: 'Password',
      ),
      validator: (value) =>
        !_notEmpty(value) ? 'Password is required' :
        null,
    ),
  ],
  Builder(builder: (context) {
    return Row(
      mainAxisAlignment: MainAxisAlignment.end,
      children: <Widget>[
        RaisedButton(
          child: Text('Log In'),
          onPressed: () {
            if (Form.of(context).validate()) {
              print(_value);
            }
          }
        )
      ],
    );
  })
);
```

```
        },
    ),
    FlatButton(
        child: Text('Reset'),
        onPressed: () => Form.of(context).reset(),
    )
],
));
}),
],
),
);
}
}
```

Figure 6-16 shows the screenshot of the login form.

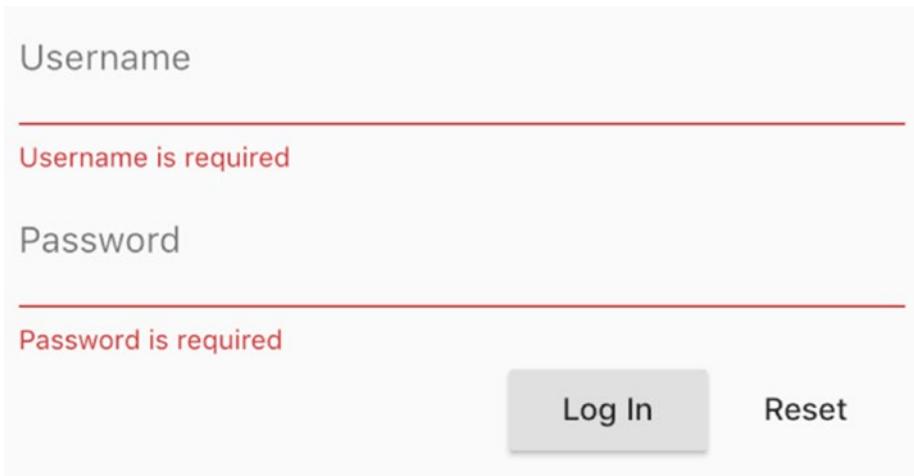


Figure 6-16. Login form

6-16. Summary

Form widgets are important to interact with user. This chapter covers form widgets for Material Design and iOS style, including text input, radio button, checkbox, dropdown, switch, chip, and slider. In the next chapter, we'll discuss widgets for application scaffolding.

CHAPTER 7

Common Widgets

In Flutter apps, some widgets are widely used for different purposes. This chapter discusses some common widgets.

7-1. Displaying a List of Items

Problem

You want to display a scrollable list of items.

Solution

Use ListView widget as the container of items.

Discussion

Flutter layout widgets like Flex, Row, and Column don't support scrolling, and these widgets are not designed to be used to display items when scrolling is required. If you want to display a large number of items, you should use ListView widget. You can think ListView as the scrollable counterpart of Flex widget.

There are three different ways to create ListView widgets using different constructors:

- Create from a static list of children widgets.
- Create by building children on demand based on the scrolling position.
- Create a custom implementation.
- This recipe focuses on the first two ways.

ListView with Static Children

If you have a static list of children that may exceed the size of their parent widget, you can wrap them in a ListView widget to enable scrolling. This is done by invoking the ListView() constructor with the children parameter of type Widget[]. The scrolling direction is determined by the scrollDirection parameter of type Axis. The default scroll direction is Axis.vertical. If you want to display the children in a reverse order, you can set the reverse parameter to true. Listing 7-1 shows a ListView widget with three children.

Listing 7-1. ListView with static children

```
ListView(  
    children: <Widget>[  
        ExampleWidget(name: 'Box 1'),  
        ExampleWidget(name: 'Box 2'),  
        ExampleWidget(name: 'Box 3'),  
    ],  
)
```

The default ListView() constructor should only be used when you have a small number of children. All children will be created, even though some of them are not visible in the viewport. This is likely to have performance impact.

ListView with Item Builders

If you have a large number of items or items need to be dynamically created, you can use `ListView.builder()` and `ListView.separated()` constructors. Instead of a static list of widgets, you need to provide builder functions of type `IndexedWidgetBuilder` to build items on demand. `IndexedWidgetBuilder` is `typedef` of `Widget(BuildContext context, int index)`. The `index` parameter is the index of the item to build. `ListView` widget determines the indices of items in the viewport and invokes the builder function to build the items to render. If the total number of items is known, you should pass this number as the `itemCount` parameter. If `itemCount` is non-null, the builder function will only be invoked with indices greater than or equal to zero and less than `itemCount`. If `itemCount` is null, the builder function needs to return null to indicate that no more items are available.

When using `ListView.builder()` constructor, you only need to provide the `itemBuilder` parameter of type `IndexedWidgetBuilder`. For `ListView.separated()` constructor, apart from the `itemBuilder` parameter, you also need to provide the `separatorBuilder` parameter of type `IndexedWidgetBuilder` to build the separators between items. When using `ListView.separated()`, the `itemCount` parameter is required. Listing 7-2 shows examples of using `ListView.builder()` and `ListView.separated()`.

Listing 7-2. ListView with item builders

```
ListView.builder(  
    itemCount: 20,  
    itemBuilder: (context, index) {  
        return ExampleWidget(name: 'Dynamic Box ${index + 1}');  
    },  
);
```

```
ListView.separated(  
    itemBuilder: (context, index) {  
        return ExampleWidget(name: 'Separated Box ${index + 1}');  
    },  
    separatorBuilder: (context, index) {  
        return Divider(  
            height: 8,  
        );  
    },  
    itemCount: 20,  
);
```

If the extent of an item in the scroll direction is known, you should pass this value as the itemExtent parameter. Non-null values of itemExtent parameter make the scrolling more efficient.

ListTile

You can use any widget as child of ListView. If you the item to include text, icon, and other control, you can use ListTile and its subclasses. A list tile contains one to three lines of text and leading and trailing widgets surrounding the text. Table 7-1 shows

Table 7-1. Parameters of ListTile

| Name | Type | Description |
|----------------|--------------------------|--|
| title | Widget | Title of the list tile. |
| subtitle | Widget | Optional content displayed below the title. |
| isThreeLine | bool | Whether the list tile may have three lines of text. |
| leading | Widget | Widget displayed before the title. |
| trailing | Widget | Widget displayed after the title. |
| enabled | bool | Whether the list tile is enabled. |
| selected | bool | Whether the list tile is selected. When selected, icons and text are rendered with the same color. |
| onTap | GestureTapCallback | Callback when the title is tapped. |
| onLongPress | GestureLongPressCallback | Callback when the title is long pressed. |
| dense | bool | When true, the size of the tile is reduced. |
| contentPadding | EdgeInsetsGeometry | Padding inside of the tile. |

Listing 7-3 shows an example of using ListTile.

Listing 7-3. Example of ListTile

```
ListTile(
    title: Text('Title'),
    subtitle: Text('Description'),
    leading: Icon(Icons.shop),
    trailing: Icon(Icons.arrow_right),
)
```

If you want to have a checkbox in a list tile, you can use `CheckboxListTile` widget which combines `ListTile` and `Checkbox`. `CheckboxListTile` constructor has the same parameters `title`, `subtitle`, `isThreeLine`, `selected`, and `dense` as `ListTile` constructor. It also has parameters `value`, `onChanged`, and `activeColor` used for `Checkbox` constructor.

Table 7-2. Parameters of `CheckboxListTile`

| Name | Type | Description |
|------------------------------|--------------------------------------|--|
| <code>secondary</code> | <code>Widget</code> | Widget displayed on the opposite side of the tile. |
| <code>controlAffinity</code> | <code>ListTileControlAffinity</code> | Where to place the control in the tile. |

`ListTileControlAffinity` enum defines the position of control in the list tile. It has three values, `leading`, `trailing`, and `platform`. When the position of control is specified, the secondary widget is always placed on the opposite side.

Listing 7-4. Example of `CheckboxListTile`

```
class CheckboxInListTile extends StatefulWidget {
  @override
  _CheckboxInListTileState createState() => _CheckboxInListTileState();
}

class _CheckboxInListTileState extends State<CheckboxInListTile> {
  bool _value = false;

  @override
  Widget build(BuildContext context) {
    return CheckboxListTile(

```

```

        title: Text('Checkbox'),
        subtitle: Text('Description'),
        value: _value,
        onChanged: (value) {
            setState(() {
                _value = value;
            });
        },
        secondary: Icon(_value ? Icons.monetization_on : Icons.
            money_off),
    );
}
}
}

```

If you want to add a radio button in a list tile, you can use RadioListTile<T> widget. For the parameters of RadioListTile constructor, value, groupValue, onChanged, and activeColor have the same meaning as in Radio constructor; title, subtitle, isThreeLine, dense, secondary, selected, and controlAffinity have the same meaning as in CheckboxListTile constructor. Listing 7-5 shows an example of using RadioListTile.

Listing 7-5. Example of RadioListTile

```

enum CustomColor { red, green, blue }

class RadioInListTile extends StatefulWidget {
    @override
    _RadioInListTileState createState() => _RadioInListTileState();
}

```

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```
class _RadioInListTileState extends State<RadioInListTile> {
    CustomColor _selectedColor;

    @override
    Widget build(BuildContext context) {
        return Column(
            children: CustomColor.values.map((color) {
                return RadioListTile<CustomColor>(
                    title: Text(color.toString()),
                    value: color,
                    groupValue: _selectedColor,
                    onChanged: (value) {
                        setState(() {
                            _selectedColor = value;
                        });
                    },
                );
            }).toList(),
        );
    }
}
```

If you want to add switch to a list tile, you can use SwitchListTile. Some parameters of SwitchListTile constructor come from Switch constructor, while other parameters come from ListTile constructor. Listing 7-6 shows an example of using SwitchListTile.

Listing 7-6. Example of SwitchListTile

```
class SwitchInListTile extends StatefulWidget {
    @override
    _SwitchInListTileState createState() => _SwitchInListTileState();
}
```

```
class _SwitchInListTileState extends State<SwitchInListTile> {  
  bool _value = false;  
  
  @override  
  Widget build(BuildContext context) {  
    return SwitchListTile(  
      title: Text('Switch'),  
      subtitle: Text('Description'),  
      value: _value,  
      onChanged: (value) {  
        setState(() {  
          _value = value;  
        });  
      },  
    );  
  }  
}
```

Figure 7-1 shows the screenshot of different ListTiles.

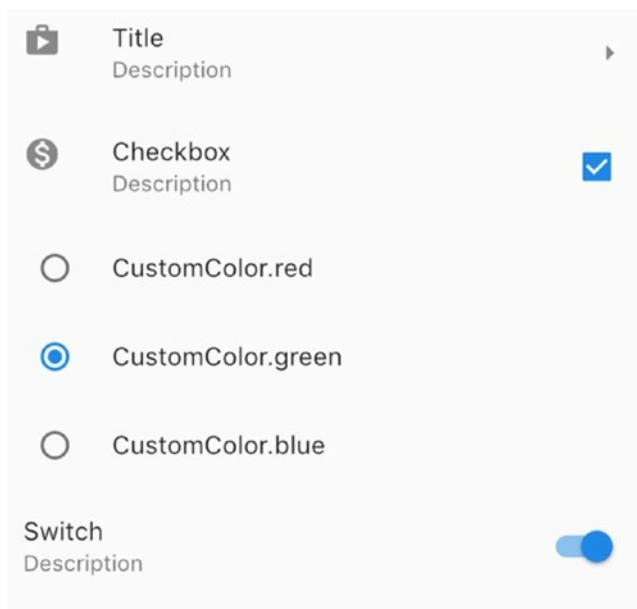


Figure 7-1. *ListTiles*

7-2. Displaying Items in a Grid

Problem

You want to display items in a grid.

Solution

Use GridView.

Discussion

ListView widget displays items in a linear array. To display widgets in a two-dimensional array, you can use GridView. The actual layout of children of GridView is delegated to an implementation of SliverGridDelegate. Flutter provides two built-in implementations of

`SliverGridDelegate`, `SliverGridDelegateWithFixedCrossAxisCount` and `SliverGridDelegateWithMaxCrossAxisExtent`. You can also create your own implementations of `SliverGridDelegate`.

There are three ways to provide the children of the `GridView`. You can provide a static list of widgets, or use builder function of type `IndexedWidgetBuilder`, or provide an implementation of `SliverChildDelegate`.

Depending on the choice of `SliverGridDelegate` and providing children, you can use different `GridView` constructors. Table 7-3 shows the usage of different constructors.

Table 7-3. *GridView constructors*

| Name | Delegate | Children |
|---------------------------------|--|-----------------------------------|
| <code>GridView()</code> | <code>SliverGridDelegate</code> | <code>Widget[]</code> |
| <code>GridView.builder()</code> | <code>SliverGridDelegate</code> | <code>IndexedWidgetBuilder</code> |
| <code>GridView.count()</code> | <code>SliverGridDelegateWithFixedCrossAxisCount</code> | <code>Widget[]</code> |
| <code>GridView.extent()</code> | <code>SliverGridDelegateWithMaxCrossAxisExtent</code> | <code>Widget[]</code> |
| <code>GridView.custom()</code> | <code>SliverGridDelegate</code> | <code>SliverChildDelegate</code> |

`SliverGridDelegateWithFixedCrossAxisCount` class uses the `crossAxisCount` parameter to specify the fixed number of tiles in the cross axis. For example, if the scroll direction of `GridView` is vertical, the `crossAxisCount` parameter specifies the number of columns. Listing 7-7 shows an example of using `GridView.count()` to create a grid with three columns.

Listing 7-7. Example of using GridView.count()

```
GridView.count(  
    crossAxisCount: 3,  
    children: List.generate(10, (index) {  
        return ExampleWidget(  
            name: 'Fixed Count ${index + 1}',  
        );  
    }),  
,
```

SliverGridDelegateWithMaxCrossAxisExtent class uses the maxCrossAxisExtent parameter to specify the maximum extent in the cross axis. The actual cross-axis extent for tiles will be as large as possible to evenly divide the cross-axis extent of the GridView and won't exceed the specified maximum value. For example, if the cross-axis extent of the GridView is 400 and the value of maxCrossAxisExtent is 120, then the cross-axis extent for tiles is 100. If the GridView's scroll direction is vertical, it will have four columns. Listing 7-8 shows an example of using GridView.extent().

Listing 7-8. Example of using GridView.extent()

```
GridView.extent(  
    maxCrossAxisExtent: 250,  
    children: List.generate(10, (index) {  
        return ExampleWidget(  
            name: 'Max Extent ${index + 1}',  
        );  
    }),  
,
```

To use a builder function to create children, you need to use GridView.builder() constructor with a SliverGridDelegate implementation.

Listing 7-9 shows an example of using `GridView.builder()` with `SliverGridDelegateWithFixedCrossAxisCount`.

Listing 7-9. Example of using `GridView.builder()`

```
GridView.builder(
    itemCount: 32,
    gridDelegate:
        SliverGridDelegateWithFixedCrossAxisCount
            (crossAxisCount: 3),
    itemBuilder: (context, index) {
        return ExampleWidget(
            name: 'Builder ${index + 1}',
        );
    },
);
```

Both `SliverGridDelegateWithFixedCrossAxisCount` and `SliverGridDelegateWithMaxCrossAxisExtent` classes have other named parameters to configure the layout; see Table 7-4.

Table 7-4. Parameters of built-in `SliverGridDelegate` implementations

| Name | Type | Description |
|-------------------------------|---------------------|--|
| <code>mainAxisSpacing</code> | <code>double</code> | Spacing of tiles along the main axis. |
| <code>crossAxisSpacing</code> | <code>double</code> | Spacing of tiles along the cross axis. |
| <code>childAspectRatio</code> | <code>double</code> | Ratio of cross-axis to main-axis extent for the tiles. |

When using these two `SliverGridDelegate` implementations, the cross-axis extent of each tile is determined first, then the main-axis extent is determined by the `childAspectRatio` parameter. If `GridView` is used

to display images with desired aspect ratio, you can use the same ratio as the value of childAspectRatio parameter. Both GridView.count() and GridView.extent() constructors have the same named parameters in Table 7-4 to pass these parameters to the underlying SliverGridDelegate implementations. Listing 7-10 shows an example of using childAspectRatio parameter when displaying images.

Listing 7-10. Using childAspectRatio parameter

```
GridView.count(  
    crossAxisCount: 3,  
    childAspectRatio: 4 / 3,  
    children: List.generate(10, (index) {  
        return Image.network('https://picsum.photos/400/300');  
    }),  
) ;
```

Just like using ListTile in ListView, you can also use GridTile in GridView. A grid tile has a required child widget and optional header and footer widgets. For header and footer of grid tiles, it's typical to use the GridTileBar widget. GridTileBar is similar with ListTile. GridTileBar constructor has parameters title, subtitle, leading, trailing, and backgroundColor.

Listing 7-11. Example of GridTile and GridTileBar

```
GridView.count(  
    crossAxisCount: 2,  
    children: <Widget>[  
        GridTile(  
            child: ExampleWidget(name: 'Simple'),  
        ),  
        GridTile(  
            child: ExampleWidget(name: 'Complex'),  
        ),  
    ],  
);
```

```
child: ExampleWidget(name: 'Header & Footer'),
header: GridTileBar(
    title: Text('Header'),
    backgroundColor: Colors.red,
),
footer: GridTileBar(
    title: Text('Footer'),
    subtitle: Text('Description'),
    backgroundColor: Colors.blue,
),
),
],
);
```

Figure 7-2 shows the screenshot of code in Listing 7-11.

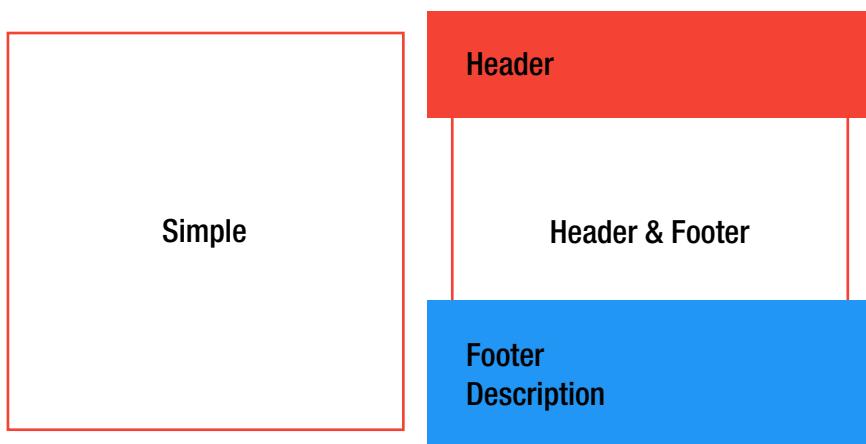


Figure 7-2. *GridTile and GridTileBar*

7-3. Displaying Tabular Data

Problem

You want to display tabular data or use table layout for children.

Solution

Use Table widget.

Discussion

If you want to display tabular data, using data tables is a natural choice. Tables can also be used for layout purpose to organize children. For these two usage scenarios, you can use the Table widget.

A Table widget may have multiple rows. A table row is represented with TableRow widget. Table widget constructor has the children parameter of type List<TableRow> to provide the list of rows. TableRow constructor also has the children parameter of type List<Widget> to provide the list of cells in this row. Every row in a table must have the same number of children.

The border of a table is defined using TableBorder class. TableBorder is similar with Border, but TableBorder has two extra sides:

- horizontalInside – The inner horizontal borders between rows
- verticalInside – The inner vertical borders between columns

[Listing 7-12](#) shows an example of a simple table with three rows and four columns.

Listing 7-12. Simple table

```
Table(  
    border: TableBorder.all(color: Colors.red.shade200),  
    children: [  
        TableRow(children: [Text('A'), Text('B'), Text('C'),  
            Text('D')]),  
        TableRow(children: [Text('E'), Text('F'), Text('G'),  
            Text('H')]),  
        TableRow(children: [Text('I'), Text('J'), Text('K'),  
            Text('L')]),  
    ],  
)
```

Width of columns in a table is configured by TableColumnWidth implementations. The columnWidths parameter of type Map<int, TableColumnWidth> defines the mapping between column index and its TableColumnWidth implementation. Table 7-5 shows built-in TableColumnWidth implementations. MinColumnWidth and MaxColumnWidth classes combine other TableColumnWidth implementations. If no TableColumnWidth implementation is found for a column, the defaultColumnWidth parameter is used to get the default TableColumnWidth implementation. The default value of defaultColumnWidth is FlexColumnWidth(1.0), which means all columns share the same width.

Table 7-5. *TableColumnWidth implementations*

| Name | Performance | Description |
|----------------------|-------------|--|
| FixedColumnWidth | High | Use fixed number of pixels as the column width. |
| FlexColumnWidth | Medium | Use flex factor to divide remaining space once all the other non-flexible columns have been sized. |
| FractionColumnWidth | Medium | Use a fraction of the table's max width as the column width. |
| IntrinsicColumnWidth | Low | Use the intrinsic dimensions of all cells in a column to determine the column width. |
| MinColumnWidth | | Minimum of two TableColumnWidth objects. |
| MaxColumnWidth | | Maximum of two TableColumnWidth objects. |

Listing 7-13 shows an example of a table with different column width.

Listing 7-13. Table with different column width

```
Table(
  border: TableBorder.all(color: Colors.blue.shade200),
  columnWidths: {
    0: FixedColumnWidth(100),
    1: FlexColumnWidth(1),
    2: FlexColumnWidth(2),
    3: FractionColumnWidth(0.2),
  },
  children: [
    TableRow(children: [Text('A'), Text('B'), Text('C'),
    Text('D')]),
  ],
)
```

```
TableRow(children: [Text('E'), Text('F'), Text('G'),  
Text('H')]),  
TableRow(children: [Text('I'), Text('J'), Text('K'),  
Text('L')]),  
],  
);
```

The vertical alignment of cells is configured with values of `TableCellVerticalAlignment` enum. `TableCellVerticalAlignment` enum has values top, middle, bottom, baseline, and fill. The `defaultVerticalAlignment` parameter of `Table` constructor specifies the default `TableCellVerticalAlignment` value. If you want to customize vertical alignment of a single cell, you can wrap the cell widget inside of `TableCell` widget and specify the `verticalAlignment` parameter. Listing 7-14 shows an example of specifying vertical alignment for cells.

Listing 7-14. Vertical alignment of table cells

```
class VerticalAlignmentTable extends StatelessWidget {  
  @override  
  Widget build(BuildContext context) {  
    return Table(  
      border: TableBorder.all(color: Colors.green.shade200),  
      defaultVerticalAlignment: TableCellVerticalAlignment.  
        bottom,  
      children: [  
        TableRow(children: [  
          TextCell('A'),  
          TableCell(  
            verticalAlignment: TableCellVerticalAlignment.  
              middle,  
            child: Text('B'),  
          ),  
        ],  
      ],  
    );  
  }  
}
```

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```
        Text('C'),
        Text('D'),
    ]),
    TableRow(children: [Text('E'), Text('F'), Text('G'),
    Text('H')]),
    TableRow(children: [Text('I'), Text('J'), Text('K'),
    Text('L')]),
],
);
}
}

class TextCell extends StatelessWidget {
TextCell(this.text, {this.height = 50});

final String text;
final double height;

@Override
Widget build(BuildContext context) {
    return ConstrainedBox(
        constraints: BoxConstraints(
            minHeight: height,
        ),
        child: Text(text),
    );
}
}
```

Figure 7-3 shows the screenshot of different tables.

| | | | |
|---|---|---|---|
| A | B | C | D |
| E | F | G | H |
| I | J | K | L |

| | | | |
|---|---|---|---|
| A | B | C | D |
| E | F | G | H |
| I | J | K | L |

| | | | |
|---|---|---|---|
| A | B | C | D |
| E | F | G | H |
| I | J | K | L |

Figure 7-3. Tables

7-4. Scaffolding Material Design Pages

Problem

You want to scaffold Material Design pages.

Solution

Use Scaffold and other related widgets.

Discussion

Material Design apps have common layout structures. Scaffold widget puts together other common widgets to create the basic page structures. Table 7-6 shows the elements that can be included in a Scaffold widget. Widgets specified as drawer and endDrawer are initially hidden and can be revealed by swiping. The swiping direction depends on the text direction. The drawer widget uses the same direction as the text direction, while the

endDrawer widget uses the opposite direction. For example, if the text direction is left-to-right, drawer widget is opened by swiping from left to right, and endDrawer widget is opened by swiping from right to left.

The second column in Table 7-6 only lists preferred widget types for these elements. Scaffold constructor actually accepts any type of widgets. For example, you can use ListView widget as the drawer. However, these preferred widgets are more suitable.

Table 7-6. *Scaffold elements*

| Parameter | Widget | Description |
|-------------------------|-------------------------------------|--|
| appBar | AppBar | An app bar to display at the top. |
| floatingActionButton | FloatingActionButton | A button to float above the body in the bottom right corner. |
| drawer | Drawer | A hidden panel to display to the side of the body. |
| endDrawer | Drawer | A hidden panel to display to the side of the body. |
| bottomNavigationBar | BottomAppBar BottomNavigationBar | Navigation bar to display at the bottom. |
| bottomSheet | BottomSheet | Persistent bottom sheet. |
| persistentFooterButtons | List<Widget> | A set of buttons to display at the bottom. |
| body | Widget | Primary content. |

App Bar

AppBar widget displays basic information of the current screen. It consists of a toolbar and other widgets. Table 7-7 shows the elements of an AppBar widget. These elements are also named parameters of AppBar constructor.

Table 7-7. Parameters of *AppBar*

| Name | Description |
|---------------|--|
| title | Primary widget in the toolbar. |
| leading | Widget to display before the title. |
| actions | List of widgets to display after the title. |
| bottom | Widget to display at the bottom. |
| flexibleSpace | Widget to stack behind the toolbar and the bottom. |

If the leading widget is null and automaticallyImplyLeading parameter is true, the actual leading widget is deduced from the state. If the Scaffold has a drawer, the leading widget is a button to open the drawer. If the nearest Navigator has previous routes, the leading widget is a BackButton to go back to previous route.

Widgets in the list of actions are usually IconButton. If there is no enough space for these IconButton, you can use a PopupMenuButton as the last action and put other actions in the popup menu. TabBar widget is usually used as the bottom widget. Listing 7-15 shows an example of using AppBar.

Listing 7-15. Example of *AppBar*

```
AppBar(
  title: Text('Scaffold'),
  actions: <Widget>[
    IconButton(
      icon: Icon(Icons.search),
      onPressed: () {},
    ),
  ],
);
```

Floating Action Button

FloatingActionButton widget is a special kind of buttons to provide quick access to primary action. A floating action button is a circular icon that usually displays at the bottom right corner of the screen. In the Gmail app, the email list screen has a floating action button to compose new emails.

There are two types of FloatingActionButton. When using FloatingActionButton() constructor, you only need to provide the child widget and onPressed callback. When using FloatingActionButton.extend() constructor, you need to provide icon and label widgets and onPressed callback. For both constructors, foregroundColor and backgroundColor parameters can customize the colors. Listing 7-16 shows an example of using FloatingActionButton.

Listing 7-16. Example of FloatingActionButton

```
FloatingActionButton(  
    child: Icon(Icons.create),  
    onPressed: () {},  
);
```

Drawer

Drawer widget is a convenient wrapper for the panel that displays at the edge of a Scaffold widget when sliding. Although you can use Drawer to wrap any widget, it's common to show app logo, information of current user, and links to app pages in the drawer. ListView widget is usually used as the child of Drawer widget to enable scrolling in the drawer.

To show app logo and information of current user, you can use the provided DrawerHeader widget and its subclass UserAccountsDrawerHeader. DrawerHeader widget wraps a child widget and has a predefined style. UserAccountsDrawerHeader is a specific

widget to show user details. Table 7-8 shows sections that can be added in a UserAccountsDrawerHeader widget. You can also use onDetailsPressed parameter to add a callback when the area with account name and email is tapped.

Table 7-8. Sections in UserAccountsDrawerHeader

| Name | Description |
|-----------------------|--|
| currentAccountPicture | Picture of the current user's account. |
| otherAccountsPictures | List of pictures of the current user's other accounts. You can only have up to three of these pictures. |
| accountName | Name of the current user's account. |
| accountEmail | Email of the current user's account. |

Listing 7-17 shows an example of using Drawer with UserAccountsDrawerHeader.

Listing 7-17. Example of Drawer

```
Drawer(
  child: ListView(
    children: <Widget>[
      UserAccountsDrawerHeader(
        currentAccountPicture: CircleAvatar(
          child: Text('JD'),
        ),
        accountName: Text('John Doe'),
        accountEmail: Text('john.doe@example.com'),
      ),
      ListTile(
        leading: Icon(Icons.search),
        title: Text('Search'),
      ),
    ],
  ),
)
```

```
        ),  
        ListTile(  
            leading: Icon(Icons.history),  
            title: Text('History'),  
        ),  
    ],  
),  
);
```

Bottom App Bar

BottomAppBar widget is a simplified version of AppBar that displays at the bottom of a Scaffold. It's common to only add icon buttons in the bottom app bar. If the scaffold also has a floating action button, the bottom app bar also creates the notch for the button to dock. Listing 7-18 shows an example of using BottomAppBar.

Listing 7-18. Example of BottomAppBar

```
BottomAppBar(  
    child: Text('Bottom'),  
    color: Colors.red,  
);
```

Bottom Navigation Bar

BottomNavigationBar widget provides extra links to navigate between different views. Table 7-9 shows the parameters of BottomNavigationBar constructor.

Table 7-9. Parameters of BottomNavigationBar

| Name | Type | Description |
|--------------|-------------------------------|--|
| items | List<BottomNavigationBarItem> | List of items. |
| currentIndex | int | Index of the selected item. |
| onTap | ValueChanged<int> | Callback when selected item changed. |
| type | BottomNavigationBarType | Type of the navigation bar. |
| fixedColor | Color | Color of selected item when type is BottomNavigationBarType.fixed. |
| iconSize | double | Size of icons. |

When an item is tapped, the onTap callback is invoked with index of the tapped item. Depending on the number of items, there can be different ways to show these items. The layout of items is defined by values of BottomNavigationBarType enum. If the value is fixed, these items have fixed width and always display text labels. If the value is shifting, location of items may change according to the selected item and only text label of selected item is displayed. BottomNavigationBar has a default strategy to select the type. When there are less than four items, BottomNavigationBarType.fixed is used; otherwise, BottomNavigationBarType.shifting is used. You can use the type parameter to override the default behavior.

Table 7-10 shows parameters of BottomNavigationBarItem constructor. Both icon and title parameters are required. If the type of BottomNavigationBar is BottomNavigationBarType.shifting, then the background of navigation bar is determined by the backgroundColor of selected item. You should specify the backgroundColor parameter to differentiate items.

Table 7-10. Parameters of BottomNavigationBarItem

| Name | Type | Description |
|-----------------|--------|--|
| icon | Widget | Item's icon. |
| title | Widget | Item's title. |
| activeIcon | Widget | Icon to display when the item is selected. |
| backgroundColor | Color | Item's background color. |

Listing 7-19 shows an example of using BottomNavigationBar and BottomNavigationBarItem.

Listing 7-19. Example of BottomNavigationBar

```
BottomNavigationBar(
  currentIndex: 1,
  type: BottomNavigationBarType.shifting,
  items: [
    BottomNavigationBarItem(
      icon: Icon(Icons.cake),
      title: Text('Cake'),
      backgroundColor: Colors.red.shade100,
    ),
    BottomNavigationBarItem(
      icon: Icon(Icons.map),
      title: Text('Map'),
      backgroundColor: Colors.green.shade100,
    ),
    BottomNavigationBarItem(
      icon: Icon(Icons.alarm),
      title: Text('Alarm'),
    ),
  ],
)
```

```
    backgroundColor: Colors.blue.shade100,  
),  
],  
);
```

Bottom Sheet

BottomSheet widget displays at the bottom of the app to provide additional information. The system sharing sheet is a typical example of bottom sheet. There are two types of bottom sheets:

- Persistent bottom sheets are always visible. Persistent bottom sheets can be created using ScaffoldState.showBottomSheet function and bottomSheet parameter of Scaffold constructor.
- Modal bottom sheets behave like modal dialogs. Modal bottom sheets can be created using showModalBottomSheet function.

BottomSheet constructor uses a WidgetBuilder function to create the actual content. You also need to provide an onClosing callback that's invoked when the bottom sheet begins to close. Listing 7-20 shows an example of using BottomSheet.

Listing 7-20. Example of BottomSheet

```
BottomSheet(  
  onClosing: () {},  
  builder: (context) {  
    return Text('Bottom');  
  },  
);
```

Scaffold State

Scaffold is a stateful widget. You can use Scaffold.of() method to get the ScaffoldState object of nearest Scaffold widget from the build context. ScaffoldState has different methods to interact with other components; see Table 7-11.

Table 7-11. Methods of ScaffoldState

| Name | Description |
|---------------------------------|----------------------------------|
| openDrawer() | Open the drawer. |
| openEndDrawer() | Open the drawer on the end side. |
| showSnackBar(SnackBar snackbar) | Show the SnackBar. |
| hideCurrentSnackBar() | Hide the current SnackBar. |
| removeCurrentSnackBar() | Remove the current SnackBar. |
| showBottomSheet() | Show a persistent bottom sheet. |

SnackBar

SnackBar widget shows a message with an optional action at the bottom of the screen. To create a SnackBar widget, the constructor requires the content parameter to specify the content. The duration parameter controls how long the snack bar is displayed. To add an action to the snack bar, you can use action parameter of type SnackBarAction. When an action is provided, the snack bar is dismissed when the action is pressed.

To create a SnackBarAction instance, you need to provide the label and onPressed callback. You can customize the button label color using textColor parameter. The button of a snack bar action can only be pressed once.

The showSnackBar() method of ScaffoldState shows a SnackBar widget. There can be at most one snack bar displayed at a time. If ScaffoldState() method is invoked when another snack bar is still visible,

the given snack bar is added to a queue and will be displayed after other snack bars are dismissed. The return type of showSnackBar() method is ScaffoldFeatureController<SnackBar, SnackbarClosedReason>. SnackbarClosedReason is an enum that defines the reasons a snack bar may be closed.

Listing 7-21 shows an example of opening snack bar.

Listing 7-21. Example of Snackbar

```
Scaffold.of(context).showSnackBar(SnackBar(  
    content: Text('This is a message.'),  
    action: SnackBarAction(label: 'OK', onPressed: () {}),  
));
```

7-5. Scaffolding iOS Pages

Problem

You want to scaffold iOS pages.

Solution

Use CupertinoPageScaffold.

Discussion

For iOS apps, you can use CupertinoPageScaffold widget to create the basic layout of pages. Comparing to Scaffold in Material Design, customizations provided by CupertinoPageScaffold are limited. You can only specify navigation bar, child, and background color.

CupertinoNavigationBar widget is similar with AppBar in Material Design, but CupertinoNavigationBar can only have leading, middle, and trailing widgets. The middle widget is centered between leading and

trailing widgets. The leading widget can be automatically implied based on the navigation state when automaticallyImplyLeading parameter is true. The middle widget can also be automatically implied when automaticallyImplyMiddle parameter is true.

Listing 7-22 shows an example of using CupertinoPageScaffold and CupertinoNavigationBar.

Listing 7-22. Example of CupertinoPageScaffold

```
CupertinoPageScaffold(  
    navigationBar: CupertinoNavigationBar(  
        middle: Text('App'),  
        trailing: CupertinoButton(  
            child: Icon(CupertinoIcons.search),  
            onPressed: () {},  
        ),  
    ),  
    child: Container(),  
);
```

7-6. Creating Tab Layout in Material Design Problem

You want to create tab bars and tabs.

Solution

Use TabBar, Tab, and TabController.

Discussion

Tab layout is widely used in mobile apps to organize multiple sections in one page. To implement tab layout in Material Design, you need to work with several widgets. TabBar widget is the container of Tab widgets. TabController widget is responsible for coordinating TabBar and TabView.

A Tab widget must have at least some text, an icon, or a child widget, but it cannot have both text and child widget. To create a TabBar, you need to provide a list of tabs. You can choose to use an explicitly created TabController instance or use the shared DefaultTabController instance. DefaultTabController is an inherited widget. TabBar will try to look up an ancestor DefaultTabController instance if no TabController is provided.

You can choose to provide a TabController instance or use the inherited DefaultTabController. To create a TabController, you need to provide the number of tabs and a TickerProvider instance.

In Listing 7-23, the mixin SingleTickerProviderStateMixin of _TabPageState is an implementation of TickerProvider, so the current instance of _TabPageState is passed as the vsync parameter of TabController constructor. The TabController instance is shared by TabBar and TabBarView.

Listing 7-23. TabBar with provided TabController

```
class TabPage extends StatefulWidget {
  @override
  _TabPageState createState() => _TabPageState();
}

class _TabPageState extends State<TabPage> with
SingleTickerProviderStateMixin {
  final List<Tab> _tabs = [
    Tab(text: 'List', icon: Icon(Icons.list)),
    Tab(text: 'Map', icon: Icon(Icons.map)),
  ];
}
```

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```
];
TabController _tabController;

@Override
void initState() {
    super.initState();
    _tabController = TabController(length: _tabs.length, vsync:
        this);
}

@Override
void dispose() {
    _tabController.dispose();
    super.dispose();
}

@Override
Widget build(BuildContext context) {
    return Scaffold(
        appBar: AppBar(
            title: Text('Tab'),
            bottom: TabBar(
                tabs: _tabs,
                controller: _tabController,
            ),
        ),
        body: TabBarView(
            children: _tabs.map((tab) {
                return Center(
                    child: Text(tab.text),
                );
            }).toList(),
            controller: _tabController,
        ),
    );
}
```

```
        ),  
    );  
}  
}
```

If you don't need to interact with TabController, using DefaultTabController is a better choice. Code in Listing 7-24 uses DefaultTabController to implement the same functionality as code in Listing 7-23.

Listing 7-24. DefaultTabController

```
class DefaultTabControllerPage extends StatelessWidget {  
    final List<Tab> _tabs = [  
        Tab(text: 'List', icon: Icon(Icons.list)),  
        Tab(text: 'Map', icon: Icon(Icons.map))  
    ];  
  
    @override  
    Widget build(BuildContext context) {  
        return DefaultTabController(  
            length: _tabs.length,  
            child: Scaffold(  
                appBar: AppBar(  
                    bottom: TabBar(tabs: _tabs),  
                ),  
                body: TabBarView(  
                    children: _tabs.map((tab) {  
                        return Center(  
                            child: Text(tab.text),  
                        );  
                    }).toList(),  
                ),  
            ),  
        );  
    }  
}
```

```
        ),  
    );  
}  
}
```

7-7. Implementing Tab Layout in iOS

Problem

You want to implement tab layout in iOS apps.

Solution

Use CupertinoTabScaffold, CupertinoTabBar, and CupertinoTabView.

Discussion

Tab layout can also be implemented for iOS apps with widgets CupertinoTabScaffold, CupertinoTabBar, and CupertinoTabView. When creating CupertinoTabScaffold, you should use CupertinoTabBar as the value of tabBar parameter. Tabs in CupertinoTabBar are represented as BottomNavigationBarItem widgets. The tabBuilder parameter specifies the builder function to build the view for each tab. Listing 7-25 shows an example of implementing tab layout.

Listing 7-25. Tab layout for iOS style

```
class CupertinoTabPage extends StatelessWidget {  
    @override  
    Widget build(BuildContext context) {  
        return CupertinoTabScaffold(  
            tabBar: CupertinoTabBar(items: [
```

```
BottomNavigationBarItem(icon: Icon(CupertinoIcons.  
settings)),  
BottomNavigationBarItem(icon: Icon(CupertinoIcons.  
info)),  
]),  
tabBuilder: (context, index) {  
    return CupertinoTabView(  
        builder: (context) {  
            return Center(  
                child: Text('Tab $index'),  
            );  
        },  
    );  
},  
);  
}  
}
```

7-8. Summary

This chapter discusses common widgets in Flutter, including list view, grid view, table layout, page scaffolding, and tab layout. These widgets create the basic structure of pages in Flutter. In the next chapter, we'll discuss page navigation in Flutter apps.

CHAPTER 8

Page Navigation

Flutter apps may have multiple screens or pages. Pages are groups of functionalities. The user navigates between different pages to use different functionalities. Concepts like pages are called routes in Flutter. Routes not only include full-screen pages but also modal dialogs and popups. Routes are managed by Navigator widget. This chapter discusses recipes related to page navigation in Flutter.

8-1. Implementing Basic Page Navigation Problem

You want to have basic page navigation support.

Solution

Use `Navigator.push()` to navigate to a new route and `Navigator.pop()` to navigate to the previous route.

Discussion

Routes are managed by Navigator widget. The navigator manages a stack of routes. Routes can be pushed on the stack using `push()` method and popped off the stack using `pop()` method. The top element in the stack is the currently active route. Navigator is a stateful widget with

`NavigatorState` as its state. To interact with the navigator, you can use the static methods of `Navigator` or get an instance of `NavigatorState`. By using `Navigator.of()` method, you can get the nearest enclosing `NavigatorState` instance of the given build context. You can explicitly create `Navigator` widgets, but most of the time you'll use the `Navigator` widget created by `WidgetsApp`, `MaterialApp`, or `CupertinoApp` widget.

Routes are represented using implementations of abstract `Route` class. For example, `PageRoute` represents full-screen modal route, and `PopupRoute` represents modal routes that overlay a widget over the current route. Both `PageRoute` and `PopupRoute` classes are subclasses of `ModalRoute` class. For Material Design apps, the easiest way to create a full-screen page is using `MaterialPageRoute` class. `MaterialPageRoute` uses a `WidgetBuilder` function to build the content of the route.

In Listing 8-1, `Navigator.of(context)` gets the `NavigatorState` instance to work with. The new route pushed to the navigator is a `MaterialPageRoute` instance. The new route has a button that uses `NavigatorState.pop()` method to pop the current route off the navigator. In fact, when using `Scaffold` widget, a back button is added automatically in the app bar, so there is no need to use an explicit back button.

Listing 8-1. Page navigation using Navigator

```
class SimpleNavigationPage extends StatelessWidget {  
  @override  
  Widget build(BuildContext context) {  
    return Scaffold(  
      appBar: AppBar(  
        title: Text('Simple Navigation'),  
      ),  
      body: Center(  
        child: RaisedButton(  
          child: Text('Show page'),  
        ),  
      ),  
    );  
  }  
}
```

```
onPressed: () {
    Navigator.of(context).
    push(MaterialPageRoute(builder: (context) {
        return Scaffold(
            appBar: AppBar(
                title: Text('New Page'),
            ),
            body: Center(
                child: Column(
                    mainAxisAlignment: MainAxisAlignment.
                    center,
                    children: <Widget>[
                        Text('A new page'),
                        RaisedButton(
                            child: Text('Go back'),
                            onPressed: () {
                                Navigator.of(context).pop();
                            },
                        ),
                    ],
                    ),
                ),
            );
        }));
    },
),
);
},
);
}
}
```

Navigator class has static methods like `push()` and `pop()` which do the same thing as the same method in `NavigatorState` class, but these static methods require an extra `BuildContext` parameter. `Navigator.push(context)` is actually the same as `Navigator.of(context).push()`. You can choose to use either method.

8-2. Using Named Routes

Problem

You want to navigate to the same route from different places.

Solution

Use named routes with `Navigator.pushNamed()` method.

Discussion

When using `Navigator.push()` method to push new routes to the navigator, new routes are built on demand using builder functions. This approach doesn't work well when routes can be navigated from different places, because we don't want to duplicate the code of building the routes. In this case, using named routes is a better choice. A named route has a unique name. `Navigator.pushNamed()` method uses the name to specify the route to push to the navigator.

Named routes need to be registered before they can be navigated to. The easiest way to register named routes is using the `routes` parameter of `WidgetsApp`, `MaterialApp`, or `CupertinoApp` constructor. The `routes` parameter is a `Map<String, WidgetBuilder>` object with keys as the route names. Route names are usually in path-like format starting with "/". This is similar to how web apps organize the pages. For example, you can have route names like `/log_in`, `/orders`, and `/orders/1234`.

In Listing 8-2, pressing the “Sign Up” button pushes the named route /sign_up to the navigator.

Listing 8-2. Use named route

```
class LogInPage extends StatelessWidget {  
    @override  
    Widget build(BuildContext context) {  
        return Scaffold(  
            appBar: AppBar(  
                title: Text('Log In'),  
            ),  
            body: Center(  
                child: RaisedButton(  
                    child: Text('Sign Up'),  
                    onPressed: () {  
                        Navigator.pushNamed(context, '/sign_up');  
                    },  
                ),  
            ),  
        );  
    }  
}
```

In Listing 8-3, two named routes are registered in routes parameter.

Listing 8-3. Register named routes

```
class PageNavigationApp extends StatelessWidget {  
    @override  
    Widget build(BuildContext context) {  
        return MaterialApp(  
            title: 'Page Navigation',
```

```
home: IndexPage(),  
routes: {  
  '/sign_up': (context) => SignUpPage(),  
  '/log_in': (context) => LogInPage(),  
},  
);  
}  
}
```

8-3. Passing Data Between Routes

Problem

You want to pass data between different routes.

Solution

Pass data to routes using constructor parameters or `RouteSettings` objects and pass data from routes using `result` parameter of `Navigator.pop()` method.

Discussion

A route may require additional data when building its content. A route may also return some data when popped off. For example, a route to edit user details may need the current details as the input and return updated details as the output. Depending on how routes are navigated to, there are different ways to pass data between routes.

When using `Navigator.push()` method to push new routes, the easiest way is to pass the data as constructor parameters of the widget returned by `WidgetBuilder` function. When using `Navigator.pop()` method, you

can use the optional `result` parameter to pass return value to the previous route. The return value of `Navigator.push()` method is a `Future<T>` object. This `Future` object will be resolved when the newly pushed route is popped off. The resolved value is the return value passed when invoking `Navigator.pop()` method. If the route is popped off using the back button, then the resolved value is `null`.

In Listing 8-4, `UserDetails` class contains first name and last name of a user. `UserDetailsPage` displays the user's details. When the edit button is pressed, a new route is pushed to the navigator. Content of the new route is an `EditUserDetailsPage` widget with the `UserDetails` object as the constructor parameter. The return value of the new route is also a `UserDetails` object, which is used to update the state of `UserDetailsPage`.

Listing 8-4. User details page

```
class UserDetails {  
    UserDetails(this.firstName, this.lastName);  
  
    final String firstName;  
    final String lastName;  
}  
  
class UserDetailsPage extends StatefulWidget {  
    @override  
    _UserDetailsPageState createState() =>  
        _UserDetailsPageState();  
}  
  
class _UserDetailsPageState extends State<UserDetailsPage> {  
    UserDetails _userDetails = UserDetails('John', 'Doe');  
  
    @override  
    Widget build(BuildContext context) {  
        return Scaffold(  
            body: Center(  
                child: Column(  
                    mainAxisAlignment: MainAxisAlignment.spaceEvenly,  
                    children:   
                        [Text(_userDetails.firstName),  
                            Text(_userDetails.lastName),  
                            ElevatedButton(  
                                onPressed: () {  
                                    Navigator.push(context, MaterialPageRoute(  
                                        builder: (context) =>  
                                            EditUserDetailsPage(userDetails: _userDetails));  
                                    ));  
                                },  
                                child: Text('Edit'),  
                            ),  
                        ],  
                ),  
            ),  
        );  
    }  
}
```

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```
appBar: AppBar(  
    title: Text('User Details'),  
,  
body: Column(  
    children: <Widget>[  
        Text('First name: ${_userDetails.firstName}'),  
        Text('Last name: ${_userDetails.lastName}'),  
        RaisedButton.icon(  
            label: Text('Edit (route builder)'),  
            icon: Icon(Icons.edit),  
            onPressed: () async {  
                UserDetails result = await Navigator.push(  
                    context,  
                    MaterialPageRoute<UserDetails>(  
                        builder: (BuildContext context) {  
                            return EditUserDetailsPage(_userDetails);  
                        },  
                    ),  
                );  
                if (result != null) {  
                    setState(() {  
                        _userDetails = result;  
                    });  
                }  
            },  
        ),  
    ],  
,  
);  
}  
}
```

In Listing 8-5, `EditUserDetailsPage` uses two `TextField` widgets to edit user details. When the save button is pressed, the updated `UserDetails` object is returned using `Navigator.pop()` method.

Listing 8-5. Edit user details page

```
class EditUserDetailsPage extends StatefulWidget {
    EditUserDetailsPage(this.userDetails);
    final UserDetails userDetails;

    @override
    _EditUserDetailsPageState createState() =>
        _EditUserDetailsPageState(userDetails);
}

class _EditUserDetailsPageState extends
State<EditUserDetailsPage> {
    _EditUserDetailsPageState(this._userDetails);

    UserDetails _userDetails;
    final GlobalKey<FormFieldState<String>> _firstNameKey =
        GlobalKey();
    final GlobalKey<FormFieldState<String>> _lastNameKey =
        GlobalKey();

    @override
    Widget build(BuildContext context) {
        return Scaffold(
            appBar: AppBar(
                title: Text('Edit User Details'),
            ),
            body: Column(
                children: <Widget>[
                    TextFormField(

```

```
key: _firstNameKey,
decoration: InputDecoration(
    labelText: 'First name',
),
initialValue: _userDetails.firstName,
),
TextFormField(
    key: _lastNameKey,
decoration: InputDecoration(
    labelText: 'Last name',
),
initialValue: _userDetails.lastName,
),
RaisedButton(
    child: Text('Save'),
onPressed: () {
    Navigator.pop(
        context,
        UserDetails(_firstNameKey.currentState?.
value,
            _lastNameKey.currentState?.value));
},
)
],
),
);
}
}
```

If named routes are used, data can be passed to the route using the arguments parameter of `Navigator.pushNamed()` method. In Listing 8-6, `pushNamed()` method is used to navigate to the `/edit_user` route with current `UserDetails` object.

Listing 8-6. Pass data to named route

```
UserDetails result = await Navigator.pushNamed(
  context,
  '/edit_user',
  arguments: _userDetails,
);
```

The named route `/edit_user` is registered in `MaterialApp`. The route parameters cannot be used, because you cannot access the data passed to the route in the builder function. The `onGenerateRoute` parameter of `WidgetsApp`, `MaterialApp`, or `CupertinoApp` should be used instead. The type of `onGenerateRoute` parameter is `RouteFactory`, which is a typedef of function type `Route (RouteSettings settings)`. `RouteSettings` class contains data that may be required when creating the `Route` object. Table 8-1 shows properties of `RouteSettings` class.

Table 8-1. Properties of `RouteSettings`

| Name | Type | Description |
|-----------------------------|---------------------|--|
| <code>name</code> | <code>String</code> | Name of the route. |
| <code>arguments</code> | <code>Object</code> | Data passed to the route. |
| <code>isInitialRoute</code> | <code>bool</code> | Whether this route is the first route pushed to the navigator. |

When implementing the `onGenerateRoute` function, you need to return routes based on the provided `RouteSettings` object. In Listing 8-7, the `name` property is checked first, then a `MaterialPageRoute` is returned with `EditUserDetailsPage` as the content. The `arguments` property of `RouteSettings` is used in `EditUserDetailsPage` constructor. The value of `arguments` property is the `UserDetails` object passed in Listing 8-6.

Listing 8-7. Use onGenerateRoute

```
MaterialApp(  
    onGenerateRoute: (RouteSettings settings) {  
        if (settings.name == '/edit_user') {  
            return MaterialPageRoute<UserDetails>(  
                settings: settings,  
                builder: (context) {  
                    return EditUserDetailsPage(settings.arguments);  
                },  
            );  
        }  
    },  
);
```

8-4. Implementing Dynamic Route Matching

Problem

You want to use complicated logic to match route names.

Solution

Use onGenerateRoute parameter.

Discussion

When named routes are registered using the routes parameter of WidgetsApp, only the whole route name can be used to match the Route objects. If you want to use complicated logic to match Route objects with route names, you can

use `onGenerateRoute` parameter and `RouteSettings` object. For example, you can match all route names start with `/order` to a single `Route` object.

In Listing 8-8, all route names starting with `/order` will navigate to a route using `OrderPage`.

Listing 8-8. Route matching

```
MaterialApp(  
    onGenerateRoute: (RouteSettings settings) {  
        if (settings.name.startsWith('/order')) {  
            return MaterialPageRoute(  
                settings: settings,  
                builder: (context) {  
                    return OrderPage();  
                },  
            );  
        }  
    },  
)
```

8-5. Handling Unknown Routes

Problem

You want to handle the case of navigating to an unknown route.

Solution

Use `onUnknownRoute` parameter of `Navigator`, `WidgetsApp`, `MaterialApp`, and `CupertinoApp`.

Discussion

It's possible that the navigator may be asked to navigate to an unknown route. This can be caused by programming errors in the app or external requests for route navigation. If `onGenerateRoute` function returns null for the given `RouteSettings` object, the `onUnknownRoute` function is invoked to provide a fallback route. This `onUnknownRoute` function is usually used for error handling, just like 404 pages in web apps. The type of `onUnknownRoute` is also `RouteFactory`.

In Listing 8-9, `onUnknownRoute` function returns the route that shows the `NotFoundPage` widget.

Listing 8-9. Use `onUnknownRoute`

```
MaterialApp(  
    onUnknownRoute: (RouteSettings settings) {  
        return MaterialPageRoute(  
            settings: settings,  
            builder: (BuildContext context) {  
                return NotFoundPage(settings.name);  
            },  
        );  
    },  
)
```

8-6. Displaying Material Design Dialogs

Problem

You want to show Material Design dialogs.

Solution

Use `showDialog()` function and `Dialog`, `SimpleDialog`, and `AlertDialog` widgets.

Discussion

To use Material Design dialogs, you need to create dialog widgets and show them. `Dialog` class and its subclasses `SimpleDialog` and `AlertDialog` can be used to create dialogs.

`SimpleDialog` widget presents several options to the user. Options are represented using `SimpleDialogOption` class. A `SimpleDialogOption` widget can have a child widget and an `onPressed` callback. When creating `SimpleDialog`, you can provide a list of children and an optional title. `AlertDialog` widget presents content and a list of actions to the user. `AlertDialog` is used to acknowledge user or ask for confirmation.

To show dialogs, you should use `showDialog()` function. Invoking this function pushes dialog route to the navigator. Dialogs are closed using `Navigator.pop()` method. The `showDialog()` function uses a `WidgetBuilder` function to build the dialog content. The return value of `showDialog()` function is a `Future<T>` object which is actually the return value of `Navigator.push()` method.

In Listing 8-10, pressing the button shows a simple dialog with two options.

Listing 8-10. Show simple dialogs

```
RaisedButton(
    child: Text('Show SimpleDialog'),
    onPressed: () async {
        String result = await showDialog<String>(
            context: context,
```

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```
builder: (BuildContext context) {
    return SimpleDialog(
        title: Text('Choose Color'),
        children: <Widget>[
            SimpleDialogOption(
                child: Text('Red'),
                onPressed: () {
                    Navigator.pop(context, 'Red');
                },
            ),
            SimpleDialogOption(
                child: Text('Green'),
                onPressed: () {
                    Navigator.pop(context, 'Green');
                },
            ),
        ],
    );
});
```

```
print(result);
},
```

```
);
```

Figure 8-1 shows the screenshot of code in Listing 8-10.

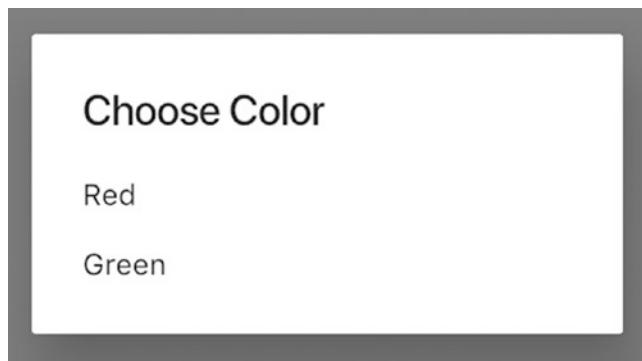


Figure 8-1. Material Design simple dialog

In Listing 8-11, pressing the button shows an alert dialog with two actions.

Listing 8-11. Show alert dialog

```
RaisedButton(  
    child: Text('Show AlertDialog'),  
    onPressed: () async {  
        bool result = await showDialog<bool>(  
            context: context,  
            builder: (BuildContext context) {  
                return AlertDialog(  
                    title: Text('Delete'),  
                    content: Text('Delete this item?'),  
                    actions: <Widget>[  
                        FlatButton(  
                            child: Text('Yes'),  
                            onPressed: () {  
                                Navigator.pop(context, true);  
                            },  
                        ),  
                    ],  
                );  
            },  
        );  
        if (result == true) {  
            print('User chose Yes');  
        } else {  
            print('User chose No');  
        }  
    },  
,
```

```
FlatButton(  
    child: Text('No'),  
    onPressed: () {  
        Navigator.pop(context, false);  
    },  
),  
],  
);  
},  
);  
print(result);  
,  
);
```

Figure 8-2 shows the screenshot of code in Listing 8-11.

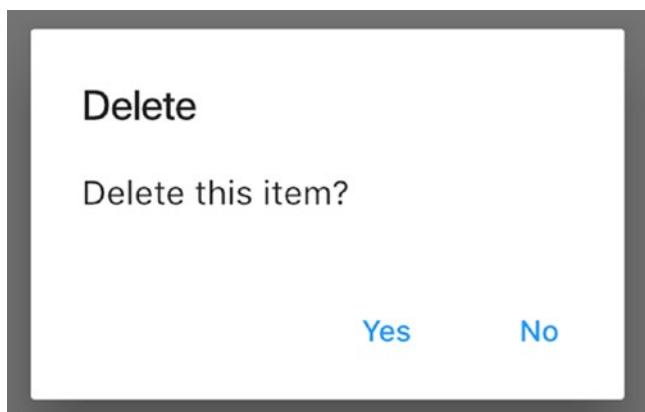


Figure 8-2. Material Design alert dialog

8-7. Displaying iOS Dialogs

Problem

You want to display iOS dialogs.

Solution

Use `showCupertinoDialog()` function and `CupertinoAlertDialog` and `CupertinoPopupSurface` widgets.

Discussion

For iOS apps, you can use `showCupertinoDialog()` function and widgets like `CupertinoAlertDialog` and `CupertinoPopupSurface` to show dialogs. The `showCupertinoDialog()` function is similar with `showDialog()` function for Material Design. This function also uses `Navigator.push()` method to push dialog route to the navigator. `CupertinoAlertDialog` is a built-in dialog implementation to acknowledge user or require for confirmation. A `CupertinoAlertDialog` may have title, content, and a list of actions. Actions are represented using `CupertinoDialogAction` widget. Table 8-2 shows parameters of `CupertinoDialogAction` constructor.

Table 8-2. Parameters of `CupertinoDialogAction`

| Name | Type | Description |
|----------------------------------|---------------------------|--|
| <code>child</code> | <code>Widget</code> | Content of the action. |
| <code>onPressed</code> | <code>VoidCallback</code> | Action pressed callback. |
| <code>isDefaultAction</code> | <code>bool</code> | Whether this action is the default action. |
| <code>isDestructiveAction</code> | <code>bool</code> | Whether this action is destructive. Destructive actions have a different style. |
| <code>textStyle</code> | <code>TextStyle</code> | Text style applied to the action. |

In Listing 8-12, pressing the button shows an iOS-style alert dialog.

Listing 8-12. Show iOS alert dialog

```
CupertinoButton(  
    child: Text('Show Alert Dialog'),  
    onPressed: () async {  
        bool result = await showCupertinoDialog<bool>(  
            context: context,  
            builder: (BuildContext context) {  
                return CupertinoAlertDialog(  
                    title: Text('Delete'),  
                    content: Text('Delete this item?'),  
                    actions: <Widget>[  
                        CupertinoDialogAction(  
                            child: Text('Delete'),  
                            onPressed: () {  
                                Navigator.pop(context, true);  
                            },  
                            isDestructiveAction: true,  
                        ),  
                        CupertinoDialogAction(  
                            child: Text('Cancel'),  
                            onPressed: () {  
                                Navigator.pop(context, false);  
                            },  
                        ),  
                    ],  
                );  
            },  
        );  
        print(result);  
    },  
);
```

Figure 8-3 shows the screenshot of code in Listing 8-12.

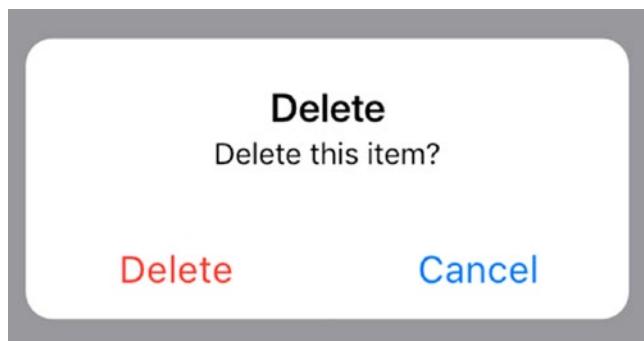


Figure 8-3. iOS alert dialog

If you want to create a custom dialog, you can use `CupertinoPopupSurface` widget which creates rounded rectangle surface.

8-8. Displaying iOS Action Sheets

Problem

You want to present a set of actions for the user to choose in iOS apps.

Solution

Use `showCupertinoModalPopup()` function and `CupertinoActionSheet` widget.

Discussion

If you want to present a set of actions for the user to choose in iOS apps, you can use `showCupertinoModalPopup()` function to display `CupertinoActionSheet` widgets. A `CupertinoActionSheet` can have a title, a message, a cancel button, and a list of actions. Actions are represented

as CupertinoActionSheetAction widgets. CupertinoActionSheetAction constructor has parameters `child`, `onPressed`, `isDefaultAction`, and `isDestructiveAction`, which have the same meaning as in CupertinoDialogAction constructor shown in Table 8-2.

In Listing 8-13, pressing the button shows an action sheet with three actions and a cancel button.

Listing 8-13. Show iOS action sheet

```
CupertinoButton(  
    child: Text('Show Action Sheet'),  
    onPressed: () async {  
        String result = await showCupertinoModalPopup<String>(  
            context: context,  
            builder: (BuildContext context) {  
                return CupertinoActionSheet(  
                    title: Text('What to do'),  
                    message: Text('Please select an action'),  
                    actions: <Widget>[  
                        CupertinoActionSheetAction(  
                            child: Text('Duplicate'),  
                            isDefaultAction: true,  
                            onPressed: () {  
                                Navigator.pop(context, 'duplicate');  
                            },  
                        ),  
                        CupertinoActionSheetAction(  
                            child: Text('Move'),  
                            onPressed: () {  
                                Navigator.pop(context, 'move');  
                            },  
                        ),  
                    ],  
                );  
            }  
        );  
    }  
);
```

```
CupertinoActionSheetAction(  
    isDestructiveAction: true,  
    child: Text('Delete'),  
    onPressed: () {  
        Navigator.pop(context, 'delete');  
    },  
,  
],  
cancelButton: CupertinoActionSheetAction(  
    child: Text('Cancel'),  
    onPressed: () {  
        Navigator.pop(context);  
    },  
,  
);  
},  
);  
print(result);  
,  
);
```

Figure 8-4 shows the screenshot of code in Listing 8-13.

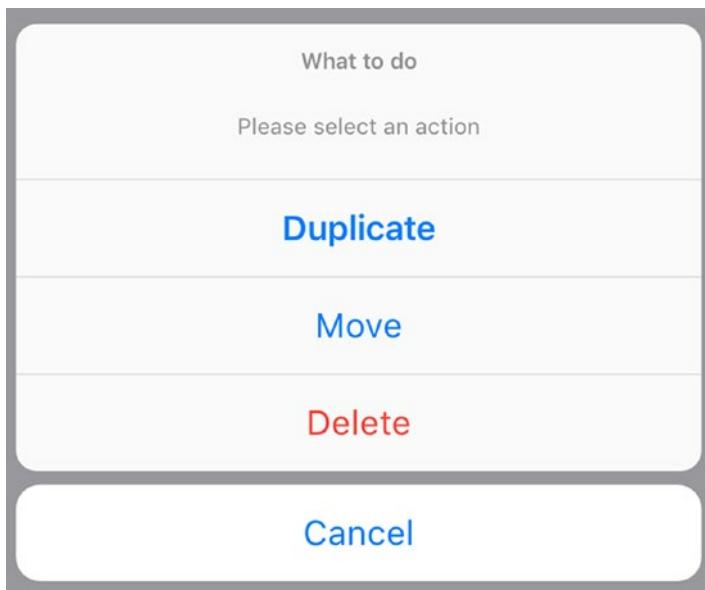


Figure 8-4. iOS action sheet

8-9. Showing Material Design Menus

Problem

You want to show menus in Material Design apps.

Solution

Use `showMenu()` function and implementations of `PopupMenuEntry` class.

Discussion

To use `showMenu()` function, you need to have a list of `PopupMenuEntry` objects. There are different types of `PopupMenuEntry` implementations:

- `PopupMenuItem` – Menu item for a single value
- `CheckedPopupMenuItem` – Menu item with a checkmark

- PopupMenuItemDivider – Horizontal divider between menu items

PopupMenu is a generic with the type of its value. Table 8-3 shows parameters of PopupMenuItem constructor. CheckedMenuItem is a subclass of MenuItem. CheckedMenuItem has the checked property to specify whether to display a checkmark.

Table 8-3. Parameters of PopupMenuItem constructor

| Name | Type | Description |
|---------|--------|---|
| child | Widget | Content of the menu item. |
| value | T | Value for the menu item. |
| enabled | bool | Whether this menu item can be selected. |
| height | double | Height of the menu item. Default to 48. |

The showMenu() function returns a Future<T> object which resolves to the value of selected menu item. This function also uses Navigator.push() method to show the menu. Table 8-4 shows major parameters of showMenu() function. When initialValue is specified, the first item with a matching value is highlighted.

Table 8-4. Parameters of showMenu()

| Name | Type | Description |
|--------------|-------------------------|---------------------------------------|
| items | List<PopupMenuEntry<T>> | A list of menu items. |
| initialValue | T | Initial value to highlight menu item. |
| position | RelativeRect | Position to show the menu. |

The menu in Listing 8-14 contains a PopupMenuItem, a PopupMenuDivider, and a CheckedPopupMenuItem.

Listing 8-14. Show menu

```
RaisedButton(  
    child: Text('Show Menu'),  
    onPressed: () async {  
        String result = await showMenu<String>(  
            context: context,  
            position: RelativeRect.fromLTRB(0, 0, 0, 0),  
            items: [  
                PopupMenuItem(  
                    value: 'red',  
                    child: Text('Red'),  
                ),  
                PopupMenuDivider(),  
                CheckedPopupMenuItem(  
                    value: 'green',  
                    checked: true,  
                    child: Text('Green'),  
                )  
            ],  
            initialValue: 'green',  
        );  
        print(result);  
    },  
);
```

The main difficulty of using `showMenu()` function is to provide proper value for the `position` parameter. If the menu is triggered by pressing a button, using `PopupMenuButton` is a better choice, because the menu position is calculated automatically based on the button's position.

Table 8-5 shows major parameters of PopupMenuItem constructor. PopupMenuItemBuilder function takes a BuildContext object as the argument and returns a List<PopupMenuEntry<T>> object.

Table 8-5. Parameters of PopupMenuItem

| Name | Type | Description |
|--------------|------------------------------|--|
| itemBuilder | PopupMenu ItemBuilder<T> | Builder function to create menu items. |
| initialValue | T | Initial value. |
| onSelected | PopupMenu ItemSelected<T> | Callback when a menu item is selected. |
| onCanceled | PopupMenuCanceled | Callback when the menu is dismissed without selection. |
| tooltip | String | Tooltip of the button. |
| child | Widget | Content of the button. |
| icon | Icon | Icon of the button. |

Listing 8-15 shows how to use PopupMenuItem to implement the same menu as in Listing 8-14.

Listing 8-15. Use PopupMenuItem

```
PopupMenuButton(  
  itemBuilder: (BuildContext context) {  
    return <PopupMenuEntry<String>>[  
      PopupMenuItem(  
        value: 'red',  
        child: Text('Red'),  
      ),
```

```
PopupMenuDivider(),
CheckedPopupMenuItem(
    value: 'green',
    checked: true,
    child: Text('Green'),
)
];
},
initialValue: 'green',
child: Text('Select color'),
onSelected: (String value) {
    print(value);
},
onCanceled: () {
    print('no selections');
},
);
)
```

Figure 8-5 shows the screenshot of the menu created in Listings 8-14 and 8-15.

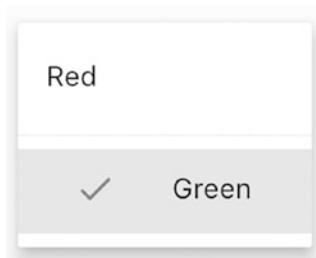


Figure 8-5. Material Design menu

8-10. Managing Complicated Page Flows Using Nested Navigators

Problem

You want to have complicated page flows.

Solution

Use nested Navigator instances.

Discussion

A Navigator instance manages its own stack of routes. For simple apps, one Navigator instance is generally enough, and you can simply use the Navigator instance created by `WidgetsApp`, `MaterialApp`, or `CupertinoApp`. If your app has complicated page flows, you may need to use nested navigators. Since Navigator itself is also a widget, Navigator instances can be created like normal widgets. The Navigator instance created by `WidgetsApp`, `MaterialApp`, or `CupertinoApp` becomes the root navigator. All navigators are organized in a hierarchy. To get the root navigator, you can set `rootNavigator` parameter to `true` when invoking `Navigator.of()` method. Table 8-6 shows parameters of Navigator constructor.

Table 8-6. Parameters of Navigator

| Name | Type | Description |
|------------------------------|--|---|
| <code>onGenerateRoute</code> | <code>RouteFactory</code> | Generate a route for a given <code>RouteSettings</code> object. |
| <code>onUnknownRoute</code> | <code>RouteFactory</code> | Handle unknown routes. |
| <code>initialRoute</code> | <code>String</code> | Name of the first route. |
| <code>observers</code> | <code>List<NavigatorObserver></code> | Observers of state changes in the navigator. |

Let's use a concrete example to explain how nested navigators can be used. Suppose that you are building a social news reading app, after a new user is signed up, you want to show the user an optional on-boarding page. This on-boarding page has several steps for the user to complete. The user can go back and forth to only complete interested steps. The user can also skip this page and return to app's home page. The on-boarding page has its own navigator to handle navigation of steps.

In Listing 8-16, the navigator has two named routes. The initial route is set to `on_boarding/topic`, so `UserOnBoardingTopicPage` is displayed first.

Listing 8-16. User on-boarding page

```
class UserOnBoardingPage extends StatelessWidget {  
    @override  
    Widget build(BuildContext context) {  
        return Scaffold(  
            appBar: AppBar(  
                title: Text('Get Started'),  
            ),  
            body: Navigator(  
                initialRoute: 'on_boarding/topic',  
                onGenerateRoute: (RouteSettings settings) {  
                    WidgetBuilder builder;  
                    switch (settings.name) {  
                        case 'on_boarding/topic':  
                            builder = (BuildContext context) {  
                                return UserOnBoardingTopicPage();  
                            };  
                            break;  
                        case 'on_boarding/follower':  
                            builder = (BuildContext context) {  
                                return UserOnBoardingFollowPage();  
                            };  
                    }  
                },  
            ),  
        );  
    }  
}
```

```
        break;
    }
    return MaterialPageRoute(
        builder: builder,
        settings: settings,
    );
},
),
);
}
}
```

In Listing 8-17, pressing the “Next” button navigates to the next step with route name `on_boarding/follower`. Pressing the “Done” button uses the root navigator to pop off the on-boarding page.

Listing 8-17. Step to select topics

```
class UserOnBoardingTopicPage extends StatelessWidget {
    @override
    Widget build(BuildContext context) {
        return Column(
            children: <Widget>[
                Text('Select interested topics'),
                RaisedButton.icon(
                    icon: Icon(Icons.arrow_forward),
                    label: Text('Next'),
                    onPressed: () {
                        Navigator.pushNamed(context, 'on_boarding/
                            follower');
                    },
                ),
            ],
        );
    }
}
```

```
RaisedButton.icon(  
    icon: Icon(Icons.check),  
    label: Text('Done'),  
    onPressed: () {  
        Navigator.of(context, rootNavigator: true).pop();  
    },  
),  
],  
);  
}  
}
```

Figure 8-6 shows the screenshot of code in Listing 8-17.

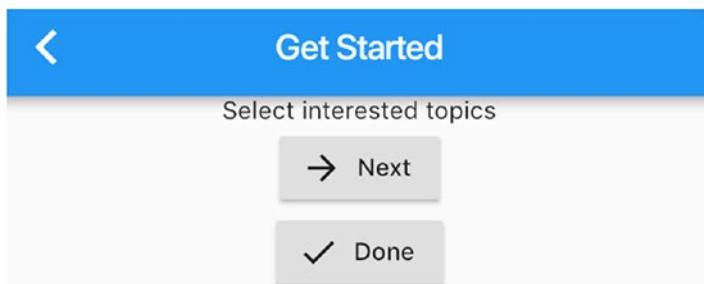


Figure 8-6. Step to select topics

CupertinoTabView has its own navigator instance. When creating CupertinoTabView, you can provide routes, onGenerateRoute, onUnknownRoute, and navigatorObservers parameters. These parameters are used to configure the Navigator instance. When using CupertinoTabScaffold to create tab layout, each tab view has its own navigation state and history.

When using nested navigators, it's important to make sure that the correct navigator instance is used. If you want to show and close full-screen pages or modal dialogs, you should use the root navigator obtained

by `Navigator.of(context, rootNavigator: true)`. Invoking `Navigator.of(context)` can only get the nearest enclosing `Navigator` instance. There is no way to get intermediate `Navigator` instances in the hierarchy. You need to use the `BuildContext` object at the correct location of the widgets tree. Functions like `showDialog()` and `showMenu()` always use `Navigator.of(context)` internally. You can only use the passed-in `BuildContext` object to control which `Navigator` instance is used by these functions.

8-11. Observing Navigator State Changes

Problem

You want to get notified when state of navigator is changed.

Solution

Use `NavigatorObserver`.

Discussion

Sometimes, you may want to get notified when the state of navigator is changed. For example, you want to analyze the page flows of users using the app to improve user experiences. When creating `Navigator` instances, you can provide a list of `NavigatorObserver` objects as the observers of navigator state changes. Table 8-7 shows methods of `NavigatorObserver` interface.

Table 8-7. Methods of *NavigatorObserver*

| Name | Description |
|---|--|
| didPop(Route route, Route previousRoute) | The route is popped and previousRoute is the newly active route. |
| didPush(Route route, Route previousRoute) | The route is pushed and previousRoute is the previously active route. |
| didRemove(Route route, Route previousRoute) | The route is removed and previousRoute is the route immediately below the removed route. |
| didReplace(Route newRoute, Route oldRoute) | The oldRoute is replaced with newRoute. |
| didStartUserGesture(Route route, Route previousRoute) | User starts moving the route using gesture. The route immediately below route is previousRoute. |
| didStopUserGesture() | User stops moving route using gesture. |

In Listing 8-18, LoggingNavigatorObserver class logs messages when routes are pushed and popped.

Listing 8-18. Logging navigator observer

```
class LoggingNavigatorObserver extends NavigatorObserver {
  @override
  void didPush(Route<dynamic> route, Route<dynamic>
  previousRoute) {
    print('push: ${_routeName(previousRoute)} ->
    ${_routeName(route)}');
  }
}
```

```

@Override
void didPop(Route<dynamic> route, Route<dynamic>
previousRoute) {
    print(' pop: ${_routeName(route)} -> ${_
    routeName(previousRoute)}');
}

String _routeName(Route<dynamic> route) {
    return route != null
        ? (route.settings?.name ?? route.runtimeType.
        toString())
        : 'null';
}
}

```

NavigatorObserver interface is useful when you want to have a global handler for all state changes in a navigator. If you are only interested in state changes related to a particular route, then using RouteObserver class is a better choice. RouteObserver class is also an implementation of NavigatorObserver interface.

To get notified of state changes related to a Route object, your class needs to implement RouteAware interface. Table 8-8 shows methods of RouteAware interface.

Table 8-8. Methods of RouteAware

| Name | Description |
|---------------|---|
| didPop() | Callback when the current route is popped off. |
| didPopNext() | Called when the current route becomes active after the top route is popped off. |
| didPush() | Called when the current route is pushed. |
| didPushNext() | Called when the current route is no longer active after a new route is pushed. |

To actually get notified for a Route object, you need to use `subscribe()` method of `RouteObserver` to subscribe a `RouteAware` object to a `Route` object. When the subscription is no longer required, you should use `unsubscribe()` to unsubscribe the `RouteAware` object.

In Listing 8-19, `_ObservedPageState` class implements `RouteAware` interface and overrides `didPush()` and `didPop()` methods to print out some messages. `ModalRoute.of(context)` gets the nearest enclosing `ModalRoute` object from build context, which is the route that `ObservedPage` is in. By using `ModalRoute.of(context)`, there is no need for explicitly passing `Route` objects. The current `_ObservedPageState` object subscribes to state changes in current route using the `subscribe()` method of the passed-in `RouteObserver` object. The subscription is removed when the `_ObservedPageState` object is disposed.

Listing 8-19. Use `RouteObserver`

```
class ObservedPage extends StatefulWidget {
  ObservedPage(this.routeObserver);
  final RouteObserver<PageRoute<dynamic>> routeObserver;

  @override
  _ObservedPageState createState() => _ObservedPageState(routeObserver);
}

class _ObservedPageState extends State<ObservedPage> with
RouteAware {
  _ObservedPageState(this._routeObserver);
  final RouteObserver<PageRoute<dynamic>> _routeObserver;

  @override
  void didChangeDependencies() {
    super.didChangeDependencies();
  }
}
```

```
_routeObserver.subscribe(this, ModalRoute.of(context));  
}  
  
@override  
void dispose() {  
    _routeObserver.unsubscribe(this);  
    super.dispose();  
}  
  
@override  
void didPush() {  
    print('pushed');  
}  
  
@override  
void didPop() {  
    print('popped');  
}  
  
@override  
Widget build(BuildContext context) {  
    return Scaffold(  
        appBar: AppBar(  
            title: Text('Observed (Stateful)'),  
        ),  
    );  
}  
}
```

8-12. Stopping Routes from Popping Problem

You want to stop routes from popping off the navigator.

Solution

Use `WillPopCallback` with `ModalRoute` objects.

Discussion

When a route is pushed to a navigator, the route can be popped off using the back button in the Scaffold or system's back button in Android.

Sometimes you may want to stop the route from being popped off. For example, if there are unsaved changes in the page, you may want to show an alert dialog first to ask for confirmation. When `Navigator.maybePop()` method is used instead of `Navigator.pop()` method, you have a chance to decide whether the request to pop off a route should proceed.

`ModalRoute` class has `addScopedWillPopCallback()` method to add `WillPopCallback` that decides whether the route should be popped off. `WillPopCallback` is a typedef of function type `Future<bool> ()`. If the returned `Future<bool>` object resolves to `true`, then the route can be popped off. Otherwise, the route cannot be popped off. You can add multiple `WillPopCallback` functions to a `ModalRoute` object. If any of the `WillPopCallback` function vetoes the request, the route won't be popped off.

In Listing 8-20, a `WillPopCallback` function is added to the current route. The return value of `WillPopCallback` function is the `Future<bool>` object returned by `showDialog()`.

Listing 8-20. Veto route popping request

```
class VetoPopPage extends StatelessWidget {  
    @override  
    Widget build(BuildContext context) {  
        ModalRoute.of(context).addScopedWillPopCallback(() {  
            return showDialog<bool>(  
                context: context,  
                builder: (BuildContext context) {  
                    return AlertDialog(  
                        title: Text('Exit?'),  
                        actions: <Widget>[  
                            FlatButton(  
                                child: Text('Yes'),  
                                onPressed: () {  
                                    Navigator.pop(context, true);  
                                },  
                            ),  
                            FlatButton(  
                                child: Text('No'),  
                                onPressed: () {  
                                    Navigator.pop(context, false);  
                                },  
                            ),  
                        ],  
                    );  
                },  
            );  
        });  
        return Scaffold(  
            appBar: AppBar(
```

```
        title: Text('Veto Pop'),  
        ),  
        body: Container(),  
    );  
}  
}
```

8-13. Summary

It's common to have multiple pages in Flutter apps. This chapter discusses basic concepts of implementing page navigation in Flutter. This chapter also covers dialogs, menus, and action sheets. In the next chapter, we'll discuss backend service interaction in Flutter.

CHAPTER 9

Service Interaction

Many non-trivial mobile apps require interaction with backend services. This chapter covers essential concepts related to service interactions in Flutter.

9-1. Working with Futures

Problem

You want to work with Future objects.

Solution

Use `then()` and `catchError()` methods to handle results of Future objects.

Discussion

When using code from Flutter and Dart libraries, you may encounter functions that return Future objects. `Future<T>` class from `dart:async` library is a representation of delayed computations. A Future object represents a potential value or error that will be available in the future. When given a Future object, you can register callbacks to handle the value or error once it is available. Future class is one of the basic building blocks of asynchronous programming in Dart.

Given a Future object, there are three different cases regarding its result:

- The computation never completes. No callbacks will be invoked.
- The computation completes with a value. Value callbacks are invoked with the value.
- The computation completes with an error. Error callbacks are invoked with the error.

To register callbacks to a Future object, you can use `then()` method to register a value callback and an optional error callback or use `catchError()` method to register an error callback only. It's recommended to use `then()` method to only register a value callback. This is because if an error callback is registered using `onError` parameter of `then()` method, this error callback cannot handle the error thrown in the value callback. Most of the time, you want the error callback to handle all possible errors. If an error of a Future object is not handled by its error callbacks, this error will be handled by the global handler.

In Listing 9-1, the Future object may complete with value 1 or an Error object. Both value and error callbacks are registered to handle the result.

Listing 9-1. Use `then()` and `catchError()` methods to handle result

```
Future.delayed(  
    Duration(seconds: 1),  
    () {  
        if (Random().nextBool()) {  
            return 1;  
        } else {  
            throw Error();  
        }  
    },  
,
```

```

).then((value) {
    print(value);
}).catchError((error) {
    print('error: $error');
});

```

Return values of then() and catchError() methods are also Future objects. Given a Future object A, the result of invoking A.then(func) is another Future object B. If the func callback runs successfully, the Future B will complete with the return value of invoking func function. Otherwise, Future B will complete with the error thrown when invoking func function. Invoking B.catchError(errorHandler) returns a new Future object C. The error handler can handle errors thrown in Future B, which may be thrown in Future A itself or in its value handler. By using then() and catchError() methods, Future objects form a chain of handling asynchronous computations.

In Listing 9-2, multiple then() methods are chained together to process the result in sequence.

Listing 9-2. Chained then() methods

```

Future.value(1)
    .then((value) => value + 1)
    .then((value) => value * 10)
    .then((value) => value + 2)
    .then((value) => print(value));

```

If you want to call functions when a future completes, you can use whenComplete() method. Functions added using whenComplete() are called when this future completes, no matter it completes with a value or an error. The whenComplete() method is equivalent of a finally block in other programming languages. The chain of then().catchError().whenComplete() is equivalent of “try-catch-finally”.

Listing 9-3 shows an example of using `whenComplete()` method.

Listing 9-3. Using `whenComplete()`

```
Future.value(1).then((value) {  
    print(value);  
}).whenComplete(() {  
    print('complete');  
});
```

It's possible for the computation of Future object to take a long time to complete. You can use `timeout()` method to set the time limit on the computation. When invoking `timeout()` method, you need to provide a `Duration` object as the time limit and an optional `onTimeout` function to provide the value when a timeout happens. The return value of `timeout()` method is a new Future object. If the current Future object doesn't complete before the time limit, the result of calling `onTimeout` function is the result of the new Future object. If no `onTimeout` function is provided, the new Future object will complete with a `TimeoutException` when current future is timed out.

In Listing 9-4, the Future object will complete in 5 seconds with value 1, but the time limit is set to 2 seconds. The value 10 returned by `onTimeout` function will be used instead.

Listing 9-4. Use `timeout()` method

```
Future.delayed(Duration(seconds: 5), () => 1)  
.timeout(  
    Duration(seconds: 2),  
    onTimeout: () => 10,  
)  
.then((value) => print(value));
```

9-2. Using `async` and `await` to Work with Futures

Problem

You want to work with Future objects like they are synchronous.

Solution

Use `async` and `await`.

Discussion

Future objects represent asynchronous computations. The usual way to work with Future objects is registering callbacks to handle results. This callback-based style may create a barrier for developers that are used to synchronous operations. Using `async` and `await` is a syntax sugar in Dart to make working with Future objects like normal synchronous operations.

Given a Future object, `await` can wait for its completion and return its value. The code after the `await` can use the returned value directly, just like it is the result of a synchronous call. When `await` is used, its enclosing function must be marked as `async`. This means the function returns a Future object.

In Listing 9-5, the return value of `getValue()` function is a Future object. In `calculate()` function, `await` is used to get the return value of `getValue()` function and assign to `value` variable. Since `await` is used, `calculate()` function is marked as `async`.

Listing 9-5. Use `async/await`

```
Future<int> getValue() {  
  return Future.value(1);  
}
```

```
Future<int> calculate() async {
    int value = await getValue();
    return value * 10;
}
```

When `await` is used to handle `Future` objects, you can use `try-catch-finally` to handle errors thrown in `Future` objects. This allows `Future` objects to be used just like normal synchronous operations. Listing 9-6 shows an example of using `try-catch-finally` and `await/async` together.

Listing 9-6. Use `try-catch-finally` and `await/async`

```
Future<int> getErrorValue() {
    return Future.error('invalid value');
}

Future<int> calculateWithError() async {
    try {
        return await getErrorValue();
    } catch (e) {
        print(e);
        return 1;
    } finally {
        print('done');
    }
}
```

9-3. Creating Futures

Problem

You want to create `Future` objects.

Solution

Use Future constructors `Future()`, `Future.delayed()`, `Future.sync()`, `Future.value()`, and `Future.error()` to create Future objects.

Discussion

If you need to create Future objects, you can use its constructors, `Future()`, `Future.delayed()`, `Future.sync()`, `Future.value()`, and `Future.error()`:

- `Future()` constructor creates a Future object that runs the computation asynchronously.
- `Future.delayed()` constructor creates a Future object that runs the computation after a delay specified using a `Duration` object.
- `Future.sync()` constructor creates a Future object that runs the computation immediately.
- `Future.value()` constructor creates a Future object that completes with the given value.
- `Future.error()` constructor creates a Future object that completes with the given error and optional stack trace.

Listing 9-7 shows examples of using different Future constructors.

Listing 9-7. Create Future objects

```
Future(() => 1).then(print);
Future.delayed(Duration(seconds: 3), () => 1).then(print);
Future.sync(() => 1).then(print);
Future.value(1).then(print);
Future.error(Error()).catchError(print);
```

9-4. Working with Streams

Problem

You want to work with a stream of events.

Solution

Use Stream<T> class and its subclasses.

Discussion

With Future class, we can represent a single value which may be available in the future. However, we may also need to work with a sequence of events. Stream<T> class in dart:async library represents a source of asynchronous events. To help with this, the Future class has asStream() method to create a Stream containing the result of the current Future object.

If you have experiences with Reactive Streams (www.reactive-streams.org/), you may find Stream in Dart is a similar concept. There can be three types of events in a stream:

- Data event represents actual data in the stream. These events are also called elements in the stream.
- Error event represents errors occurred.
- Done event represents that the end of stream has reached. No more events will be emitted.

To receive events from a stream, you can use the listen() method to set up listeners. The return value of listen() method is a StreamSubscription object representing the active subscription. Depending on the number of subscriptions allowed on the stream, there are two types of streams:

- A single-subscription stream allows only a single listener during the whole lifecycle of the stream. It only starts emitting events when a listener is set up, and it stops emitting events when the listener unsubscribes.
- A broadcast stream allows any number of listeners. Events are emitted when they are ready, even though there are no subscribed listener.

Given a `Stream` object, the property `isBroadcast` can be used to check whether it is a broadcast stream. You can use the `asBroadcastStream()` method to create a broadcast stream from a single-subscription stream.

Stream Subscription

Table 9-1 shows parameters of `listen()` method. You can provide any number of handlers for different events and ignore those uninterested events.

Table 9-1. Parameters of `listen()` method

| Name | Type | Description |
|----------------------------|-----------------------------|---|
| <code>onData</code> | <code>void (T event)</code> | Handler of data events. |
| <code>onError</code> | <code>Function</code> | Handler of error events. |
| <code>onDone</code> | <code>void ()</code> | Handler of done event. |
| <code>cancelOnError</code> | <code>bool</code> | Whether to cancel the subscription when the first error event is emitted. |

In Listing 9-8, handlers for three types of events are provided.

Listing 9-8. Use listen() method

```
Stream.fromIterable([1, 2, 3]).listen(
  (value) => print(value),
  onError: (error) => print('error: $error'),
  onDone: () => print('done'),
  cancelOnError: true,
);
```

With the StreamSubscription object returned by listen() method, you can manage the subscription. Table 9-2 show methods of StreamSubscription class.

Table 9-2. Methods of StreamSubscription

| Name | Description |
|------------------------------|--|
| cancel() | Cancels this subscription. |
| pause([Future resumeSignal]) | Requests the stream to pause events emitting. If resumeSignal is provided, the stream will resume when the future completes. |
| resume() | Resumes the stream after a pause. |
| onData() | Replaces the data event handler. |
| onError() | Replaces the error event handler. |
| onDone() | Replaces the done event handler. |
| asFuture([E futureValue]) | Returns a future that handles the completion of stream. |

The asFuture() method is useful when you want to handle the completion of a stream. Since a stream can complete normally or with an error, using this method overwrites existing onDone and onError callbacks. In the case of an error event, the subscription is cancelled, and the

returned Future object is completed with the error. In the case of a done event, the Future object completes with the given futureValue.

Stream Transformation

The power of stream is to apply various transformations on the stream to get another stream or a value. Table 9-3 shows methods in Stream class that return another Stream object.

Table 9-3. Stream transformations

| Name | Description |
|---|---|
| asyncExpand<E>(Stream<E> convert(T event)) | Transforms each element into a stream and concatenates elements in these streams as the new stream. |
| asyncMap<E>(FutureOr<E> convert(T event)) | Transforms each element into a new event. |
| distinct([bool equals (T previous, T next)]) | Skips duplicate elements. |
| expand<S>(Iterable<S> convert(T element)) | Transforms each element into a sequence of elements. |
| handleError(Function onError, { bool test(dynamic error) }) | Handles errors in the stream. |
| map<S>(S convert(T event)) | Transforms each element into a new event. |
| skip(int count) | Skips elements in the stream. |
| skipWhile(bool test (T element)) | Skips elements while they match the predicate. |

(continued)

Table 9-3. (continued)

| Name | Description |
|--|--|
| take(int count) | Takes only the first count elements from the stream. |
| takeWhile(bool test (T element)) | Takes elements while they match the predicate. |
| timeout(Duration timeLimit, { void onTimeout(EventSink<T> sink) }) | Handles error when the time between two events exceeds the time limit. |
| transform<S>(StreamTransformer <T, S> streamTransformer) | Transforms the stream. |
| where(bool test(T event)) | Filters elements in the stream. |

Listing 9-9 shows examples of using stream transformations. Code below each statement shows the result of the execution.

Listing 9-9. Stream transformations

```
Stream.fromIterable([1, 2, 3]).asyncExpand((int value) {  
    return Stream.fromIterable([value * 5, value * 10]);  
}).listen(print);  
// -> 5, 10, 10, 20, 15, 30  
  
Stream.fromIterable([1, 2, 3]).expand((int value) {  
    return [value * 5, value * 10];  
}).listen(print);  
// -> 5, 10, 10, 20, 15, 30  
  
Stream.fromIterable([1, 2, 3]).asyncMap((int value) {  
    return Future.delayed(Duration(seconds: 1), () => value * 10);  
})
```

```
}).listen(print);
// -> 10, 20, 30

Stream.fromIterable([1, 2, 3]).map((value) => value * 10).
listen(print);
// -> 10, 20, 30

Stream.fromIterable([1, 1, 2]).distinct().listen(print);
// -> 1, 2

Stream.fromIterable([1, 2, 3]).skip(1).listen(print);
// -> 2, 3

Stream.fromIterable([1, 2, 3])
  .skipWhile((value) => value % 2 == 1)
  .listen(print);
// -> 2, 3

Stream.fromIterable([1, 2, 3]).take(1).listen(print);
// -> 1

Stream.fromIterable([1, 2, 3])
  .takeWhile((value) => value % 2 == 1)
  .listen(print);
// -> 1

Stream.fromIterable([1, 2, 3]).where((value) => value % 2 ==
1).listen(print);
// -> 1, 3
```

There are other methods in `Stream` class that return a `Future` object; see Table 9-4. These operations return a single value instead of a stream.

Table 9-4. Methods for single values

| Name | Description |
|---|---|
| any(bool test(T element)) | Checks whether any element in the stream matches the predicate. |
| every(bool test(T element)) | Checks whether all elements in the stream match the predicate. |
| contains(Object needle) | Checks whether the stream contains the given element. |
| drain<E>([E futureValue]) | Discards all elements in the stream. |
| elementAt(int index) | Gets the element at the given index. |
| firstWhere(bool test(T element), { T orElse() }) | Finds the first element matching the predicate. |
| lastWhere(bool test(T element), { T orElse() }) | Finds the last element matching the predicate. |
| singleWhere(bool test(T element), { T orElse() }) | Finds the single element matching the predicate. |
| fold<S>(S initialValue, S combine(S previous, T element)) | Combines elements in the stream into a single value. |
| forEach(void action(T element)) | Runs an action on each element of the stream. |
| join([String separator = ""]) | Combines the elements into a single string. |
| pipe(StreamConsumer<T> streamConsumer) | Pipes the events into a StreamConsumer. |

(continued)

Table 9-4. (continued)

| Name | Description |
|--|--|
| reduce(T combine(T previous, T element)) | Combines elements in the stream into a single value. |
| toList() | Collects the elements into a list. |
| toSet() | Collects the elements into a set. |

Listing 9-10 shows examples of using methods in Table 9-4. Code below each statement shows the result of the execution.

Listing 9-10. Methods return Future objects

```
Stream.fromIterable([1, 2, 3]).forEach(print);
// -> 1, 2, 3

Stream.fromIterable([1, 2, 3]).contains(1).then(print);
// -> true

Stream.fromIterable([1, 2, 3]).any((value) => value % 2 == 0).then(print);
// -> true

Stream.fromIterable([1, 2, 3]).every((value) => value % 2 == 0).then(print);
// -> false

Stream.fromIterable([1, 2, 3]).fold(0, (v1, v2) => v1 + v2).then(print);
// -> 6

Stream.fromIterable([1, 2, 3]).reduce((v1, v2) => v1 * v2).then(print);
// -> 6
```

```
Stream.fromIterable([1, 2, 3])
    .firstWhere((value) => value % 2 == 1)
    .then(print);
// -> 1

Stream.fromIterable([1, 2, 3])
    .lastWhere((value) => value % 2 == 1)
    .then(print);
// -> 3

Stream.fromIterable([1, 2, 3])
    .singleWhere((value) => value % 2 == 1)
    .then(print);
// -> Unhandled exception: Bad state: Too many elements
```

9-5. Creating Streams

Problem

You want to create Stream objects.

Solution

Use different Stream constructors.

Discussion

There are different Stream constructors to create Stream objects:

- Stream.empty() constructor creates an empty broadcast stream.
- Stream.fromFuture() constructor creates a single-subscription stream from a Future object.

- `Stream.fromFutures()` constructor creates a stream from a list of Future objects.
- `Stream.fromIterable()` constructor creates a single-subscription stream from elements of an Iterable object.
- `Stream.periodic()` constructor creates a stream that periodically emits data events at the given intervals.

Listing 9-11 shows examples of different Stream constructors.

Listing 9-11. Use Stream constructors

```
Stream.fromIterable([1, 2, 3]).listen(print);
Stream.fromFuture(Future.value(1)).listen(print);
Stream.fromFutures([Future.value(1), Future.error('error'),
Future.value(2)])
    .listen(print);
Stream.periodic(Duration(seconds: 1), (int count) => count * 2)
    .take(5)
    .listen(print);
```

Another way to create streams is using `StreamController` class. A `StreamController` object can send different events to the stream it controls. The default `StreamController()` constructor creates a single-subscription stream, while `StreamController.broadcast()` constructor creates a broadcast stream. With `StreamController`, you can generate elements in stream programmatically.

In Listing 9-12, different events are sent to the stream controlled by the `StreamController` object.

Listing 9-12. Use StreamController

```
StreamController<int> controller = StreamController();  
controller.add(1);  
controller.add(2);  
controller.stream.listen(print, onError: print, onDone: () =>  
print('done'));  
controller.addError('error');  
controller.add(3);  
controller.close();
```

9-6. Building Widgets Based on Streams and Futures

Problem

You want to build a widget that updates its content based on the data in a stream or a future.

Solution

Use `StreamBuilder<T>` or `FutureBuilder<T>` widget.

Discussion

Given a `Steam` or `Future` object, you may want to build a widget that updates its content based on the data in it. You can use `StreamBuilder<T>` widget to work with `Stream` objects and `FutureBuilder<T>` widget to work with `Future` objects. Table 9-5 shows parameters of `StreamBuilder<T>` constructor.

Table 9-5. Parameters of StreamBuilder<T>

| Name | Type | Description |
|-------------|-----------------------|-----------------------------------|
| stream | Stream<T> | The stream for the builder. |
| builder | AsyncWidgetBuilder<T> | Builder function for the widget. |
| initialData | T | Initial data to build the widget. |

AsyncWidgetBuilder is a typedef of function type Widget (BuildContext context, AsyncSnapshot<T> snapshot). AsyncSnapshot class represents the snapshot of interaction with an asynchronous computation. Table 9-6 shows properties of AsyncSnapshot<T> class.

Table 9-6. Properties of AsyncSnapshot<T>

| Name | Type | Description |
|-----------------|-----------------|---|
| connectionState | ConnectionState | State of connection to the asynchronous computation. |
| data | T | The latest data received by the asynchronous computation. |
| error | Object | The latest error object received by the asynchronous computation. |
| hasData | bool | Whether data property is not null. |
| hasError | bool | Whether error property is not null. |

You can determine the connection state using the value of connectionState. Table 9-7 shows values of ConnectionState enum.

Table 9-7. Values of ConnectionState

| Name | Description |
|---------|--|
| none | Not connected to the asynchronous computation. |
| waiting | Connected to the asynchronous computation and waiting for interaction. |
| active | Connected to an active asynchronous computation. |
| done | Connected to a terminated asynchronous computation. |

When using `StreamBuilder` widget to build the UI, the typical way is to return different widgets according to the connection state. For example, if the connection state is `waiting`, then a process indicator may be returned.

In Listing 9-13, the stream has five elements that are generated every second. If the connection state is `none` or `waiting`, a `CircularProgressIndicator` widget is returned. If the state is `active` or `done`, a `Text` widget is returned according to the value of `data` and `error` properties.

Listing 9-13. Use StreamBuilder

```
class StreamBuilderPage extends StatelessWidget {
    final Stream<int> _stream =
        Stream.periodic(Duration(seconds: 1), (int value) =>
    value * 10).take(5);

    @override
    Widget build(BuildContext context) {
        return Scaffold(
            appBar: AppBar(
                title: Text('Stream Builder'),
            ),
    ),
```

```
body: Center(
    child: StreamBuilder(
        stream: _stream,
        initialData: 0,
        builder: (BuildContext context, AsyncSnapshot<int>
            snapshot) {
            switch (snapshot.connectionState) {
                case ConnectionState.none:
                case ConnectionState.waiting:
                    return CircularProgressIndicator();
                case ConnectionState.active:
                case ConnectionState.done:
                    if (snapshot.hasData) {
                        return Text('${snapshot.data ?? ""}');
                    } else if (snapshot.hasError) {
                        return Text(
                            '${snapshot.error}',
                            style: TextStyle(color: Colors.red),
                        );
                    }
                }
            return null;
        },
    ),
),
);
}
}
```

The usage of FutureBuilder widget is similar with StreamBuilder widget. When using a FutureBuilder with a Future object, you can convert the Future object to a Stream object using `asStream()` method first, then use StreamBuilder with the converted Stream object.

In Listing 9-14, we use a different way to build the UI. Instead of checking the connection state, `hasData` and `hasError` properties are used to check the status.

Listing 9-14. Use FutureBuilder

```
class FutureBuilderPage extends StatelessWidget {
    final Future<int> _future = Future.delayed(Duration(seconds: 1),
() {
    if (Random().nextBool()) {
        return 1;
    } else {
        throw 'invalid value';
    }
});

@Override
Widget build(BuildContext context) {
    return Scaffold(
        appBar: AppBar(
            title: Text('Future Builder'),
        ),
        body: Center(
            child: FutureBuilder(
                future: _future,
                builder: (BuildContext context, AsyncSnapshot<int>
snapshot) {
                    if (snapshot.hasData) {
                        return Text('${snapshot.data}');
                    } else if (snapshot.hasError) {
                        return Text(
                            '${snapshot.error}',
                            style: TextStyle(color: Colors.red),
                        );
                    }
                },
            ),
        ),
    );
}
```

```
    );
} else {
    return CircularProgressIndicator();
}
},
),
),
);
}
}
```

9-7. Handle Simple JSON Data

Problem

You want to have a simple way to handle JSON data.

Solution

Use `jsonEncode()` and `jsonDecode()` functions from `dart:convert` library.

Discussion

JSON is a popular data format for web services. To interact with backend services, you may need to handle JSON data in two scenarios:

- JSON data serialization converts objects in Dart to JSON strings.
- JSON data deserialization converts JSON strings to objects in Dart.

For both scenarios, if you only need to handle simple JSON data occasionally, then using `jsonEncode()` and `jsonDecode()` functions from `dart:convert` library is a good choice. The `jsonEncode()` function converts Dart objects to strings, while `jsonDecode()` function converts strings to Dart objects. In Listing 9-15, data object is serialized to JSON string first, then the JSON string is deserialized to Dart object again.

Listing 9-15. Handle JSON data

```
var data = {  
  'name': 'Test',  
  'count': 100,  
  'valid': true,  
  'list': [  
    1,  
    2,  
    {  
      'nested': 'a',  
      'value': 123,  
    },  
  ],  
};  
String str = jsonEncode(data);  
print(str);  
Object obj = jsonDecode(str);  
print(obj);
```

The JSON encoder in `dart:convert` library only supports a limited number of data types, including numbers, strings, booleans, `null`, lists, and maps with string keys. To encode other types of objects, you need to use the `toEncodable` parameter to provide a function which converts the object to an encodable value first. The default `toEncodable` function calls

`toJson()` method on the object. It's a common practice to add `toJson()` method to custom classes that need to be serialized as JSON strings.

In Listing 9-16, `toJson()` method of `ToEncode` class returns a list which will be used as the input of JSON serialization.

Listing 9-16. Use `toJson()` function

```
class ToEncode {
    ToEncode(this.v1, this.v2);

    final String v1;
    final String v2;

    Object toJson() {
        return [v1, v2];
    }
}

print(jsonEncode(ToEncode('v1', 'v2')));
```

If you want to have indent in the serialized JSON strings, you need to use `JsonEncoder` class directly. In Listing 9-17, two spaces are used as the indent.

Listing 9-17. Add indent

```
String indentString = JsonEncoder.withIndent('  ');
convert(data);
print(indentString);
```

9-8. Handle Complex JSON Data Problem

You want to have a type-safe way to handle JSON data.

Solution

Use `json_annotation` and `json_serializable` libraries.

Discussion

Using `jsonEncode()` and `jsonDecode()` functions from `dart:convert` library can easily work with simple JSON data. When the JSON data has a complicated structure, using these two functions is not quite convenient. When deserializing JSON strings, the results are usually lists or maps. If the JSON data has a nested structure, it's not easy to extract the values from lists or maps. When serializing objects, you need to add `toJson()` methods to these classes to build the lists or maps. These tasks can be simplified using code generation with `json_annotation` and `json_serializable` libraries.

The `json_annotation` library provides annotations to customize JSON serialization and deserialization behavior. The `json_serializable` library provides the build process to generate code that handles JSON data. To use these two libraries, you need to add them into `pubspec.yaml` file. In Listing 9-18, `json_serializable` library is added to dependencies, while `json_annotation` library is added to dev_dependencies.

Listing 9-18. Add `json_annotation` and `json_serializable`

dependencies:

```
  json_annotation: ^2.0.0
```

dev_dependencies:

```
  build_runner: ^1.0.0
```

```
  json_serializable: ^2.0.0
```

In Listing 9-19, Person class is in the `json_serialize.dart` file. The annotation `@JsonSerializable()` means generating code for Person

class. The generated code is in the `json_serialize.g.dart` file. Functions `$_PersonFromJson()` and `$_PersonToJson()` used in Listing 9-19 come from the generated file. The `$_PersonFromJson()` function is used in the `Person.fromJson()` constructor, while `$_PersonToJson()` function is used in the `toJson()` method.

Listing 9-19. Use `json_serializable`

```
import 'package:json_annotation/json_annotation.dart';

part 'json_serialize.g.dart';

@JsonSerializable()
class Person {
  Person({this.firstName, this.lastName, this.email});

  final String firstName;
  final String lastName;
  final String email;

  factory Person.fromJson(Map<String, dynamic> json) =>
  $_PersonFromJson(json);

  Map<String, dynamic> toJson() => $_PersonToJson(this);
}
```

To generate the code, you need to run `flutter packages pub run build_runner build` command. Listing 9-20 shows the generated file.

Listing 9-20. Generated code to handle JSON data

```
part of 'json_serialize.dart';

Person $_PersonFromJson(Map<String, dynamic> json) {
  return Person(
    firstName: json['firstName'] as String,
```

```

        lastName: json['lastName'] as String,
        email: json['email'] as String);
}

Map<String, dynamic> _$PersonToJson(Person instance) =>
<String, dynamic>{
    'firstName': instance.firstName,
    'lastName': instance.lastName,
    'email': instance.email
};

```

`JsonSerializable` annotation has different properties to customize the behavior; see Table 9-8.

Table 9-8. Properties of `JsonSerializable`

| Name | Default value | Description |
|--------------------------|---------------|--|
| anyMap | false | When true, use <code>Map</code> as the map type; otherwise, <code>Map<String, dynamic></code> is used. |
| checked | false | Whether to add extra checks to validate data types. |
| createFactory | true | Whether to generate the function that converts maps to objects. |
| createToJson | true | Whether to generate the function that can be used as <code>toJson()</code> function. |
| disallowUnrecognizedKeys | false | When true, unrecognized keys are treated as an error; otherwise, they are ignored. |
| explicitToJson | false | When true, generated <code>toJson()</code> function uses <code>toJson</code> on nested objects. |

(continued)

Table 9-8. (continued)

| Name | Default value | Description |
|----------------------------|----------------------|--|
| fieldRename | FieldRename. none | Strategy to convert names of class fields to JSON map keys. |
| generateTo JsonFunction | true | When true, generate top-level function; otherwise, generate a mixin class with toJson() function. |
| includeIfNull | true | Whether to include fields with null values. |
| nullable | true | Whether to handle null values gracefully. |
| useWrappers | false | Whether to use wrapper classes to minimize the usage of Map and List instances during serialization. |

The generateToJsonFunction property determines how toJson() functions are generated. When the value is true, top-level functions like _\$PersonToJson() in Listing 9-20 will be generated. In Listing 9-21, generateToJsonFunction property is set to false for User class.

Listing 9-21. User class

```
@JsonSerializable(  
    generateToJsonFunction: false,  
)  
class User extends Object with _$UserSerializerMixin {  
    User(this.name);  
  
    final String name;  
}
```

In Listing 9-22, instead of a function, the `_UserSerializerMixin` class is generated with `toJson()` method. `User` class in Listing 9-21 only needs to use this mixin class.

Listing 9-22. Generated code for `User` class

```
User _$UserFromJson(Map<String, dynamic> json) {
    return User(json['name'] as String);
}

abstract class _$UserSerializerMixin {
    String get name;
    Map<String, dynamic> toJson() => <String, dynamic>{'name':
        name};
}
```

`JsonProperty` annotation specifies how a field is serialized. Table 9-9 shows properties of `JsonProperty`.

Table 9-9. Properties of `JsonProperty`

| Name | Description |
|--------------------------------|---|
| <code>name</code> | JSON map key. If null, the field name is used. |
| <code>nullable</code> | Whether to handle null values gracefully. |
| <code>includeIfNull</code> | Whether to include this field if the value is null. |
| <code>ignore</code> | Whether to ignore this field. |
| <code>fromJson</code> | A function to deserialize this field. |
| <code>toJson</code> | A function to serialize this field. |
| <code>defaultValue</code> | The value to use as the default value. |
| <code>required</code> | Whether this field is required in the JSON map. |
| <code>disallowNullValue</code> | Whether to disallow null values. |

Listing 9-23 shows an example of using `JsonProperty`.

Listing 9-23. Use `JsonProperty`

```
@JsonProperty(
    name: 'first_name',
    required: true,
    includeIfNull: true,
)
final String firstName;
```

`JsonValue` annotation specifies the enum value used for serialization. In Listing 9-24, `JsonValue` annotation is added to all enum values of `Color`.

Listing 9-24. Use `JsonValue`

```
enum Color {
    @JsonValue('R')
    Red,
    @JsonValue('G')
    Green,
    @JsonValue('B')
    Blue
}
```

`JsonLiteral` annotation reads JSON data from a file and converts the content into an object. It allows easy access to content of static JSON data files. In Listing 9-25, `JsonLiteral` annotation is added to the `data` getter. `_dataJsonLiteral` is the generated variable of the data in the JSON file.

Listing 9-25. Use `JsonLiteral`

```
@JsonLiteral('data.json', asConst: true)
Map get data => _$dataJsonLiteral;
```

9-9. Handling XML Data

Problem

You want to handle XML data in Flutter apps.

Solution

Use `xml` library.

Discussion

XML is a popular data exchange format. You can use `xml` library to handle XML data in Flutter apps. You need to add `xml: ^3.3.1` to dependencies of `pubspec.yaml` file first. Similar with JSON data, there are two usage scenarios of XML data:

- Parse XML documents and query data.
- Build XML documents.

Parse XML Documents

To parse XML documents, you need to use `parse()` function which takes a XML string as the input and returns parsed `XmlElement` object. With the `XmlElement` object, you can query and traverse the XML document tree to extract data from it.

To query the document tree, you can use `findElements()` and `findAllElements()` methods. These two methods accept a tag name and an optional namespace as the parameters and return an `Iterable<XmlElement>` object. The difference is that `findElements()` method only searches direct children, while `findAllElements()` method searches all descendant children. To traverse the document tree, you can use properties shown in Table 9-10.

Table 9-10. Properties of *XmlParent*

| Name | Type | Description |
|-----------------|----------------------|---|
| children | XmlNodeList<XmlNode> | Direct children of this node. |
| ancestors | Iterable<XmlNode> | Ancestors of this node in reverse document order. |
| descendants | Iterable<XmlNode> | Descendants of this node in document order. |
| attributes | List<XmlAttribute> | Attribute nodes of this node in document order. |
| preceding | Iterable<XmlNode> | Nodes preceding the opening tag of this node in document order. |
| following | Iterable<XmlNode> | Nodes following the closing tag of this node in document order. |
| parent | XmlNode | Parent of this node, can be null. |
| firstChild | XmlNode | First child of this node, can be null. |
| lastChild | XmlNode | Last child of this node, can be null. |
| nextSibling | XmlNode | Next sibling of this node, can be null. |
| previousSibling | XmlNode | Previous sibling of this node, can be null. |
| root | XmlNode | Root of the tree. |

In Listing 9-26, the input XML string (excerpt from <https://msdn.microsoft.com/en-us/windows/desktop/ms762271>) is parsed and queried for the first book element. Then text of the title element and value of the id attribute are extracted.

Listing 9-26. XML document parsing and querying

```
String xmlStr = '''
<?xml version="1.0"?>
<catalog>
  <book id="bk101">
    <Author>Gambardella, Matthew</author>
    <title>XML Developer's Guide</title>
    <genre>Computer</genre>
    <price>44.95</price>
    <publish_date>2000-10-01</publish_date>
    <description>An in-depth look at creating applications
      with XML.</description>
  </book>
  <book id="bk102">
    <Author>Ralls, Kim</author>
    <title>Midnight Rain</title>
    <genre>Fantasy</genre>
    <price>5.95</price>
    <publish_date>2000-12-16</publish_date>
    <description>A former architect battles corporate
      zombies, an evil sorceress, and her own childhood to
      become queen of the world.</description>
  </book>
</catalog>
''';
```

```

XmlDocument document = parse(xmlStr);
XmlElement firstBook = document.rootElement.
findElements('book').first;
String title = firstBook.findElements('title').single.text;
String id = firstBook.attributes
    .firstWhere((XmlAttribute attr) => attr.name.local == 'id')
    .value;
print('$id => $title');

```

Build XML Documents

To build XML documents, you can use `XmlBuilder` class. `XmlBuilder` class provides methods to build different components of XML documents; see Table 9-11. With these methods, we can build XML documents in a top-down fashion, which starts from the root element and build nested content layer by layer.

Table 9-11. Methods of `XmlBuilder`

| Name | Description |
|---------------------------|---|
| <code>element()</code> | Creates a <code>XmlElement</code> node with specified tag name, namespaces, attributes, and nested content. |
| <code>attribute()</code> | Creates a <code>XmlAttribute</code> node with specified name, value, namespace, and type. |
| <code>text()</code> | Creates a <code>XmlText</code> node with specified text. |
| <code>namespace()</code> | Binds namespace prefix to the uri. |
| <code>cdata()</code> | Creates a <code>XmlCDATA</code> node with specified text. |
| <code>comment()</code> | Creates a <code>XmlComment</code> node with specified text. |
| <code>processing()</code> | Creates a <code>XmlProcessing</code> node with specified target and text. |

After finishing the building, the `build()` method of `XmlBuilder` can be used to build the `XmlNode` as the result. In Listing 9-27, the root element is a `note` element with `id` attribute. Value of `nest` parameter is a function which uses builder methods to build the content of the node element.

Listing 9-27. Use `XmlBuilder`

```
XmlBuilder builder = XmlBuilder();
builder.processing('xml', 'version="1.0"');
builder.element(
    'note',
    attributes: {
        'id': '001',
    },
    nest: () {
        builder.element('from', nest: () {
            builder.text('John');
        });
        builder.element('to', nest: () {
            builder.text('Jane');
        });
        builder.element('message', nest: () {
            builder
                ..text('Hello!')
                ..comment('message to send');
        });
    },
);
XmlNode xmlNode = builder.build();
print(xmlNode.toXmlString(pretty: true));
```

Listing 9-28 shows the built XML document by code in Listing 9-27.

Listing 9-28. Built XML document

```
<?xml version="1.0"?>
<note id="001">
  <from>John</from>
  <to>Jane</to>
  <message>Hello!
    <!--message to send-->
  </message>
</note>
```

9-10. Handling HTML Data Problem

You want to parse HTML document in Flutter apps.

Solution

Use `html` library.

Discussion

Even though JSON and XML data format are popular in Flutter apps, you may still need to parse HTML document to extract data. This process is called screen scraping. You can use `html` library to parse HTML document. To use this library, you need to add `html: ^0.13.4+1` to the dependencies of `pubspec.yaml` file.

The `parse()` function parses HTML strings into `Document` objects. These `Document` objects can be queried and manipulated using W3C DOM API. In Listing 9-29, HTML string is parsed first, then `getElementsByName()`

method is used to get the li elements, and finally id attribute and text are extracted from li elements.

Listing 9-29. Parse HTML document

```
import 'package:html/dom.dart';
import 'package:html/parser.dart' show parse;

void main() {
  String htmlStr = '''
<ul>
  <li id="001">John</li>
  <li id="002">Jane</li>
  <li id="003">Mary</li>
</ul>
''';
  Document document = parse(htmlStr);
  var users = document.getElementsByName('li').map((Element
element) {
    return {
      'id': element.attributes['id'],
      'name': element.text,
    };
  });
  print(users);
}
```

9-11. Sending HTTP Requests

Problem

You want to send HTTP requests to backend services.

Solution

Use `HttpClient` from `dart:io` library.

Discussion

HTTP protocol is a popular choice to expose web services. The representation can be JSON or XML. By using `HttpClient` class from `dart:io` library, you can easily interact with backend services over HTTP.

To use `HttpClient` class, you need to choose a HTTP method first, then prepare the `HttpClientRequest` object for the request, and process the `HttpClientResponse` object for the response. `HttpClient` class has different pairs of methods corresponding to different HTTP methods. For example, `get()` and `getUrl()` methods are both used to send HTTP GET requests. The difference is that `get()` method accepts host, port, and path parameters, while `getUrl()` method accepts `url` parameter of type `Uri`. You can see other pairs like `post()` and `postUrl()`, `put()` and `putUrl()`, `patch()` and `patchUrl()`, `delete()` and `deleteUrl()`, and `head()` and `headUrl()`.

These methods return `Future<HttpClientRequest>` objects. You need to chain the returned `Future` objects with `then()` method to prepare `HttpClientRequest` object. For example, you can modify HTTP request headers or write request body. The `then()` method needs to return the value of `HttpClientRequest.close()` method, which is a `Future<HttpClientResponse>` object. In the `then()` method of the `Future<HttpClientResponse>` object, you can use this object to get response body, headers, cookies, and other information.

In Listing 9-30, `request.close()` method is called directly in the first `then()` method, because we don't need to do anything to the `HttpClientRequest` object. The `_handleResponse()` function decodes

HTTP response as UTF-8 strings and prints them out. `HttpClientResponse` class implements `Stream<List<int>>`, so the response body can be read as streams.

Listing 9-30. Send HTTP GET request

```
void _handleResponse(HttpClientResponse response) {  
    response.transform(utf8.decoder).listen(print);  
}  
  
HttpClient httpClient = HttpClient();  
httpClient  
    .getUrl(Uri.parse('https://httpbin.org/get'))  
    .then((HttpClientRequest request) => request.close())  
    .then(_handleResponse);
```

If you need to send HTTP POST, PUT, and PATCH requests with body, you can use `HttpClientRequest.write()` method to write the body; see Listing 9-31.

Listing 9-31. Write HTTP request body

```
httpClient  
    .postUrl(Uri.parse('https://httpbin.org/post'))  
    .then((HttpClientRequest request) {  
        request.write('hello');  
        return request.close();  
    }).then(_handleResponse);
```

If you need to modify HTTP request headers, you can use the `HttpClientRequest.headers` property to modify the `HttpHeaders` object; see Listing 9-32.

Listing 9-32. Modify HTTP request headers

```
httpClient
  .getUrl(Uri.parse('https://httpbin.org/headers'))
  .then((HttpClientRequest request) {
    request.headers.set(HttpHeaders.userAgentHeader, 'my-agent');
    return request.close();
}).then(_handleResponse);
```

If you need to support HTTP basic authentication, you can use `HttpClient.addCredentials()` method to add `HttpClientBasicCredentials` objects; see Listing 9-33.

Listing 9-33. Basic authentication

```
String username = 'username', password = 'password';
Uri uri = Uri.parse('https://httpbin.org/basic-
auth/$username/$password');
httpClient.addCredentials(
  uri, null, HttpClientBasicCredentials(username, password));
httpClient
  .getUrl(uri)
  .then((HttpClientRequest request) => request.close())
  .then(_handleResponse);
```

9-12. Connecting to WebSocket Problem

You want to connect to WebSocket servers in Flutter apps.

Solution

Use WebSocket class in `dart:io` library.

Discussion

WebSockets are widely used in web apps to provide bidirectional communications between browser and server. They can also provide real-time updates of data in the backend. If you already have a WebSocket server that interacts with the web app running in the browser, you may also want the same feature to be available in Flutter apps. `WebSocket` class in `dart:io` library can be used to implement the WebSocket connections.

The static `WebSocket.connect()` method connects to a WebSocket server. You need to provide the server URL with scheme `ws` or `wss`. You can optionally provide a list of subprotocols and a map of headers. The return value of `connect()` method is a `Future<WebSocket>` object. `WebSocket` class implements `Stream` class, so you can read data sent from server as streams. To send data to the server, you can use `add()` and `addStream()` methods.

In Listing 9-34, the `WebSocket` connects to the demo echo server. By using `listen()` method to subscribe to the `WebSocket` object, we can process data sent from the server. The two `add()` method calls send two messages to the server.

Listing 9-34. Connect to `WebSocket`

```
WebSocket.connect('ws://demos.kaazing.com/echo').  
then((WebSocket webSocket) {  
  webSocket.listen(print, onError: print);  
  webSocket.add('hello');  
  webSocket.add('world');  
  webSocket.close();  
}).catchError(print);
```

9-13. Connecting to Socket Problem

You want to connect to socket servers.

Solution

Use `Socket` class in `dart:io` library.

Discussion

If you want to connect to socket servers in Flutter apps, you can use `Socket` class from `dart:io` library. The static `Socket.connect()` method connects to a socket server at specified host and port and returns a `Future<Socket>` object. `Socket` class implements `Stream<List<int>>`, so you can read data from server by subscribing to the stream. To send data to the server, you can use `add()` and `addStream()` methods.

In Listing 9-35, a socket server is started on port 10080. This server converts the received strings into uppercase and sends back the results.

Listing 9-35. Simple socket server

```
import 'dart:io';
import 'dart:convert';

void main() {
  ServerSocket.bind('127.0.0.1', 10080).then((serverSocket) {
    serverSocket.listen((socket) {
      socket.addStream(socket
        .transform(utf8.decoder)
        .map((str) => str.toUpperCase())
        .transform(utf8.encoder));
    });
  });
}
```

```
    });
});
}
```

In Listing 9-36, `Socket.connect()` method is used to connect to the socket server shown in Listing 9-35. Data received from the server is printed out. Two strings are sent to the server.

Listing 9-36. Connect to socket server

```
void main() {
    Socket.connect('127.0.0.1', 10080).then((socket) {
        socket.transform(utf8.decoder).listen(print);
        socket.write('hello');
        socket.write('world');
        socket.close();
    });
}
```

9-14. Interacting JSON-Based REST Services

Problem

You want to use JSON-based REST services.

Solution

Use `HttpClient`, `json_serialize` library, and `FutureBuilder` widget.

Discussion

It's a popular choice for mobile apps backend to expose services over HTTP protocol with JSON as the representation. By using `HttpClient`, `json_serialize` library, and `FutureBuilder` widget, you can build the UI to work with these REST services. This recipe provides a concrete example which combines content in Listings 9-6, 9-8, and 9-11.

This example uses GitHub Jobs API (<https://jobs.github.com/api>) to get job listings on GitHub web site. In Listing 9-37, `Job` class represents a job listing. In the `JsonSerializable` annotation, `createToJson` property is set to `false`, because we only need to parse JSON response from the API. The `_parseDate` function parses the string in `created_at` field of the JSON object. You need to add `intl` library to use `DateFormat` class.

Listing 9-37. Job class

```
part 'github_jobs.g.dart';

DateFormat _dateFormat = DateFormat('EEE MMM dd HH:mm:ss
yyyy');
DateTime _parseDate(String str) =>
    _dateFormat.parse(str.replaceFirst(' UTC', ")), true);

@JsonSerializable(
    createToJson: false,
)
class Job {
    Job();

    String id;
    String type;
    String url;
    @JsonKey(name: 'created_at', fromJson: _parseDate)
    DateTime createdAt;
```

```

String company;
@JsonKey(name: 'company_url')
String companyUrl;
@JsonKey(name: 'company_logo')
String companyLogo;
String location;
String title;
String description;
@JsonKey(name: 'how-to-apply')
String howToApply;

factory Job.fromJson(Map<String, dynamic> json) =>
$JobFromJson(json);
}

```

In Listing 9-38, a `HttpClient` object is used to send a HTTP GET request to GitHub Jobs API and parse the JSON response using `jsonDecode()` function. The `Future` object of type `Future<List<Job>>` is used by `FutureBuilder` widget to build the UI. `JobsList` widget takes a `List<Job>` object and displays the list using `ListView` widget.

Listing 9-38. Widget to show jobs

```

class GitHubJobsPage extends StatelessWidget {
final Future<List<Job>> _jobs = HttpClient()
  .getUrl(Uri.parse('https://jobs.github.com/positions.
  json'
    '?description=java&location=new+york'))
  .then((HttpClientRequest request) => request.close())
  .then((HttpClientResponse response) {
return response.transform(utf8.decoder).join(").
then((String content) {
  return (jsonDecode(content) as List<dynamic>)

```

```
.map((json) => Job.fromJson(json))
.toList();
});

});

@Override
Widget build(BuildContext context) {
    return Scaffold(
        appBar: AppBar(
            title: Text('GitHub Jobs'),
        ),
        body: FutureBuilder<List<Job>>(
            future: _jobs,
            builder: (BuildContext context,
                AsyncSnapshot<List<Job>> snapshot) {
                if (snapshot.hasData) {
                    return JobsList(snapshot.data);
                } else if (snapshot.hasError) {
                    return Center(
                        child: Text(
                            '${snapshot.error}',
                            style: TextStyle(color: Colors.red),
                        ),
                    );
                } else {
                    return Center(
                        child: CircularProgressIndicator(),
                    );
                }
            },
        ),
    );
}
```

```
    }
}

class JobsList extends StatelessWidget {
    JobsList(this.jobs);
    final List<Job> jobs;

    @override
    Widget build(BuildContext context) {
        return ListView.separated(
            itemBuilder: (BuildContext context, int index) {
                Job job = jobs[index];
                return ListTile(
                    title: Text(job.title),
                    subtitle: Text(job.company),
                );
            },
            separatorBuilder: (BuildContext context, int index) {
                return Divider();
            },
            itemCount: jobs.length,
        );
    }
}
```

9-15. Interacting with gRPC Services

Problem

You want to interact with gRPC services.

Solution

Use grpc library.

Discussion

gRPC (<https://grpc.io/>) is a high-performance, open-source universal RPC framework. This recipe shows how to interact with gRPC services. The gRPC service to interact is the greeter service from gRPC official examples (<https://github.com/grpc/grpc/tree/master/examples/node>). You need to start the gRPC server first.

To use this gRPC service in Flutter apps, you need to install Protocol Buffers compiler (<https://github.com/protocolbuffers/protobuf>) first. After downloading the release file for your platform and extracting its content, you need to add the extracted bin directory to the PATH environment variable. You can run `protoc --version` command to verify the installation. The version used in this recipe is 3.7.1.

You also need to install Dart protoc plugin (https://github.com/dart-lang/protobuf/tree/master/protoc_plugin). The easiest way to install is to run the following command.

```
$ flutter packages pub global activate protoc_plugin
```

Because we use `flutter packages` to run the installation, the binary file is put under the `.pub-cache/bin` directory of the Flutter SDK. You need to add this path to PATH environment variable. The plugin requires `dart` command to be available, so you also need to add `bin/cache/dart-sdk/bin` directory of Flutter SDK to PATH environment variable. Now we can use `protoc` to generate Dart files for interactions with the greeter service. In the following command, `lib/grpc/generated` is the output path of generated files. `proto_file_path` is the path of proto files. `helloworld.proto` file contains the definition for greeter service. Libraries `protobuf` and `grpc` also need to be added to the dependencies of `pubspec.yaml` file.

```
$ protoc --dart_out=grpc:lib/grpc/generated --proto_path=<proto_file_path> <proto_file_path>/helloworld.proto
```

The generated `helloworld.pbgrpc.dart` file provides `GreeterClient` class to interact with the service. In Listing 9-39, a `ClientChannel` is created to connect to the gRPC server. The channel is required when creating a `GreeterClient` object. The `sayHello()` method sends requests to the server and receives responses.

Listing 9-39. Interact with gRPC service

```
import 'package:grpc/grpc.dart';

import 'generated/helloworld.pbgrpc.dart';

void main() async {
    final channel = new ClientChannel('localhost',
        port: 50051,
        options: const ChannelOptions(
            credentials: const ChannelCredentials.insecure()));
    final stub = new GreeterClient(channel);

    try {
        var response = await stub.sayHello(new HelloRequest()..name =
            'John');
        print('Received: ${response.message}');
    } catch (e) {
        print('Caught error: $e');
    }
    await channel.shutdown();
}
```

9-16. Summary

This chapter focuses on different ways to interact with backend services, including HTTP, WebSocket, Socket, and gRPC. Futures and Streams play an important role in asynchronous computations. This chapter also discusses how to handle JSON, XML, and HTML data. In the next chapter, we'll discuss state management in Flutter apps.

CHAPTER 10

State Management

When building Flutter apps, you need to manage the state when the apps are running. The state may change due to user interactions or background tasks. This chapter covers recipes that use different solutions for state management in Flutter.

10-1. Managing State Using StatefulWidget

Problem

You want to have a simple way to manage state in the UI.

Solution

Create your own subclasses of StatelessWidget.

Discussion

StatefulWidget class is the fundamental way in Flutter to manage state. A stateful widget rebuilds itself when its state changes. If the state to manage is simple, using stateful widgets is generally good enough. You don't need to use third-party libraries discussed in other recipes.

Stateful widgets use State objects to store the state. When creating your own subclasses of StatefulWidget, you need to override createState() method to return a State object. For each subclass StatefulWidget, there will be a corresponding subclass of State class to manage the state. The createState() method returns an object of the corresponding subclass of State. The actual state is usually kept as private variables of the subclass of State.

In the subclass of State, you need to implement build() method to return a Widget object. When the state changes, the build() method will be called to get the new widget to update the UI. To trigger the rebuild of the UI, you need to call setState() method explicitly to notify the framework. The parameter of setState() method is a VoidCallback function that contains the logic to update the internal state. When rebuilding, the build() method uses the latest state to create widget configurations. Widgets are not updated but replaced when necessary.

SelectColor widget in Listing 10-1 is a typical example of stateful widget. _SelectColorState class is the State implementation for SelectColor widget. _selectedColor is the internal variable that maintains the current selected color. The value of _selectedColor is used by the DropdownButton widget to determine the selected option to render and the Text widget to determine the text to display. In the onChanged handler of DropdownButton, setState() method is called to update the value of _selectedColor variable, which notifies the framework to run _SelectColorState.build() method again to get the new widget configuration to update the UI.

Listing 10-1. Example of stateful widget

```
class SelectColor extends StatefulWidget {  
    @override  
    _SelectColorState createState() => _SelectColorState();  
}
```

```
class _SelectColorState extends State<SelectColor> {
    final List<String> _colors = ['Red', 'Green', 'Blue'];
    String _selectedColor;

    @override
    Widget build(BuildContext context) {
        return Column(
            children: <Widget>[
                DropdownButton(
                    value: _selectedColor,
                    items: _colors.map((String color) {
                        return DropdownMenuItem(
                            value: color,
                            child: Text(color),
                        );
                    }).toList(),
                    onChanged: (value) {
                        setState(() {
                            _selectedColor = value;
                        });
                    },
                ),
                Text('Selected: ${_selectedColor ?? ""}'),
            ],
        );
    }
}
```

State objects have their own lifecycle. You can override different lifecycle methods in subclasses of State to perform actions on different stages. Table 10-1 shows these lifecycle methods.

Table 10-1. *Lifecycle methods of State*

| Name | Description |
|----------------------------------|---|
| initState() | Called when this object is inserted into the widgets tree. Should be used to perform initialization of state. |
| didChangeDependencies() | Called when a dependency of this object changes. |
| didUpdateWidget (T oldWidget) | Called when the widget of this object changes. Old widget is passed as a parameter. |
| reassemble() | Called when the app is reassembled during debugging. This method is only called during development. |
| build(BuildContext context) | Called when the state changes. |
| deactivate() | Called when this object is removed from the widgets tree. |
| dispose() | Called when this object is removed from the widgets tree permanently. This method is called after deactivate(). |

Of the methods listed in Table 10-1, initState() and dispose() methods are easy to understand. These two methods will only be called once during the lifecycle. However, other methods may be invoked multiple times.

The didChangeDependencies() method is typically used when the state object uses inherited widgets. This method is called when an inherited widget changes. Most of the time, you don't need to override this method, because the framework calls build() method automatically after a dependency changes. Sometimes you may need to perform some expensive tasks after a dependency changes. In this case, you should put

the logic into `didChangeDependencies()` method instead of performing the task in `build()` method.

The `reassemble()` method is only used during development, for example, during hot reload. This method is not called in release builds. Most of the time, you don't need to override this method.

The `didUpdateWidget()` method is called when the state's widget changes. You should override this method if you need to perform cleanup tasks on the old widget or reuse some state from the old widget. For example, `_TextFieldState` class for `TextField` widget overrides `didUpdateWidget()` method to initialize `TextEditingController` object based on the value of the old widget.

The `deactivate()` method is called when the state object is removed from the widgets tree. This state object may be inserted back to the widgets tree at a different location. You should override this method if the build logic depends on the widget's location. For example, `FormFieldState` class for `FormField` widget overrides `deactivate()` method to unregister the current form field from the enclosing form.

In Listing 10-1, the whole content of the widget is built in the `build()` method, so you can simply call `setState()` method in the `onPressed` callback of `DropdownButton`. If the widget has a complex structure, you can pass down a function that updates the state to the children widgets. In Listing 10-2, the `onPressed` callback of `RaisedButton` is set by the constructor parameter of `CounterButton`. When the `CounterButton` is used in `Counter` widget, the provided handler function uses `setState()` to update the state.

Listing 10-2. Pass state change function to descendant widget

```
class Counter extends StatefulWidget {  
  @override  
  _CounterState createState() => _CounterState();  
}  
class _CounterState extends State<Counter> {  
  int count = 0;  
  void increment() {  
    setState(() {  
      count++;  
    });  
  }  
}
```

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```
class _CounterState extends State<Counter> {
    int count = 0;
    @override
    Widget build(BuildContext context) {
        return Column(
            children: <Widget>[
                CounterButton(() {
                    setState(() {
                        count++;
                    });
                }),
                CounterText(count),
            ],
        );
    }
}

class CounterText extends StatelessWidget {
    CounterText(this.count);
    final int count;

    @override
    Widget build(BuildContext context) {
        return Text('Value: ${count ?? "}"');
    }
}

class CounterButton extends StatelessWidget {
    CounterButton(this.onPressed);
    final VoidCallback onPressed;

    @override
    Widget build(BuildContext context) {
```

```
        return RaisedButton(  
            child: Text('+'),  
            onPressed: onPressed,  
        );  
    }  
}
```

10-2. Managing State Using Inherited Widgets

Problem

You want to propagate state down the widgets tree.

Solution

Create your own subclasses of `InheritedWidget`.

Discussion

When using stateful widgets to manage state, the state is stored in `State` objects. If a descendant widget needs to access the state, the state needs to be passed down to it from the root of subtree, just like how `count` state is passed in Listing 10-2. When the widget has a relatively deep subtree structure, it's inconvenient to add constructor parameters for passing the state down. In this case, using `InheritedWidget` is a better choice.

When `InheritedWidget` is used, the method `BuildContext.inheritFromWidgetOfExactType()` can get the nearest instance of a particular type of inherited widget from the build context. Descendant widgets can easily access state data stored in an inherited widget. When `inheritFromWidgetOfExactType()` method is called, the build context

registers itself to the inherited widget. When the inherited widget changes, the build context is rebuilt automatically to get the new values from the inherited widget. This means no manual updates are required for descendant widgets that use state from the inherited widget.

The Config class in Listing 10-3 represents the state. It has color and fontSize properties. Config class overrides == operator and hashCode property to implement correct equality check. The copyWith() method can be used to create new instances of Config class by updating a partial set of properties. The Config.fallback() constructor creates a Config object with default values.

Listing 10-3. Config class for inherited widget

```
class Config {  
  const Config({this.color, this.fontSize});  
  
  const Config.fallback()  
    : color = Colors.red,  
      fontSize = 12.0;  
  
  final Color color;  
  final double fontSize;  
  
  Config copyWith({Color color, double fontSize}) {  
    return Config(  
      color: color ?? this.color,  
      fontSize: fontSize ?? this.fontSize,  
    );  
  }  
  
  @override  
  bool operator ==(other) {  
    if (other.runtimeType != runtimeType) return false;  
    final Config typedOther = other;  
  }  
}
```

```
        return color == typedOther.color && fontSize == typedOther.  
        fontSize;  
    }  
  
    @override  
    int get hashCode => hashValues(color, fontSize);  
}
```

The `ConfigWidget` in Listing 10-4 is an inherited widget. It keeps a `Config` object as its internal state. The `updateShouldNotify()` method is called to check whether registered build contexts should be notified after the inherited widget changes. This is a performance optimization to avoid unnecessary updates. The static `of()` method is a common practice to get the inherited widget or the state associated with the inherited widget. The `of()` method of `ConfigWidget` uses `inheritFromWidgetOfExactType()` to get the nearest enclosing `ConfigWidget` instance from build context and gets `config` property from the widget. If no `ConfigWidget` object is found, the default `Config` instance is returned.

Listing 10-4. `ConfigWidget` as inherited widget

```
class ConfigWidget extends InheritedWidget {  
    const ConfigWidget({  
        Key key,  
        @required this.config,  
        @required Widget child,  
    }) : super(key: key, child: child);  
  
    final Config config;  
  
    static Config of(BuildContext context) {  
        final ConfigWidget configWidget =  
            context.inheritFromWidgetOfExactType(ConfigWidget);  
        return configWidget?.config ?? const Config.fallback();  
    }  
}
```

```
    @override
    bool updateShouldNotify(ConfigWidget oldWidget) {
        return config != oldWidget.config;
    }
}
```

In Listing 10-5, both `ConfiguredText` and `ConfiguredBox` widgets use `ConfigWidget.of(context)` to get the `Config` object and use its properties when building the UI.

Listing 10-5. Use `ConfigWidget` to get the `Config` object

```
class ConfiguredText extends StatelessWidget {
    @override
    Widget build(BuildContext context) {
        Config config = ConfigWidget.of(context);
        return Text(
            'Font size: ${config.fontSize}',
            style: TextStyle(
                color: config.color,
                fontSize: config.fontSize,
            ),
        );
    }
}

class ConfiguredBox extends StatelessWidget {
    @override
    Widget build(BuildContext context) {
        Config config = ConfigWidget.of(context);
        return Container(
            decoration: BoxDecoration(color: config.color),
            child: Text('Background color: ${config.color}'),
        );
    }
}
```

```
    );  
}  
}
```

ConfigUpdater widget in Listing 10-6 is used to update the Config object. It also uses ConfigWidget.of(context) to get the Config object to update. The onColorChanged and onFontSizeIncreased callbacks are used to trigger update of Config object.

Listing 10-6. ConfigUpdater to update Config object

```
typedef SetColorCallback = void Function(Color color);  
  
class ConfigUpdater extends StatelessWidget {  
  const ConfigUpdater({this.onColorChanged, this.  
onFontSizeIncreased});  
  
  static const List<Color> _colors = [Colors.red, Colors.green,  
Colors.blue];  
  final SetColorCallback onColorChanged;  
  final VoidCallback onFontSizeIncreased;  
  
  @override  
  Widget build(BuildContext context) {  
    Config config = ConfigWidget.of(context);  
    return Column(  
      children: <Widget>[  
        DropdownButton(  
          value: config.color,  
          items: _colors.map((Color color) {  
            return DropdownMenuItem(  
              value: color,  
              child: Text(color.toString()),  
            );  
          }).  
        );  
    );  
  }  
}  
  
void main() {  
  runApp(MyApp());  
}  
  
class MyApp extends StatelessWidget {  
  @override  
  Widget build(BuildContext context) {  
    return MaterialApp(  
      title: 'Material App',  
      theme: ThemeData(  
        primarySwatch: Colors.blue,  
      ),  
      home: MyHomePage(),  
    );  
  }  
}  
  
class MyHomePage extends StatefulWidget {  
  @override  
  _MyHomePageState createState() => _MyHomePageState();  
}  
  
class _MyHomePageState extends State<MyHomePage> {  
  Config config = Config();  
  
  void onColorChanged(Color color) {  
    config.color = color;  
    setState(() {});  
  }  
  
  void onFontSizeIncreased() {  
    config.fontSize += 1;  
    setState(() {});  
  }  
  
  @override  
  void initState() {  
    config.fontSize = 16;  
    config.color = Colors.red;  
    super.initState();  
  }  
  
  @override  
  Widget build(BuildContext context) {  
    return Scaffold(  
      appBar: AppBar(  
        title: Text('Material App'),  
      ),  
      body: Center(  
        child: Column(  
          mainAxisAlignment: MainAxisAlignment.spaceEvenly,  
          children: <Widget>[  
            Text('Color: ${config.color.name}'),  
            Text('FontSize: ${config.fontSize}'),  
            Row(  
              mainAxisAlignment: MainAxisAlignment.spaceEvenly,  
              children: <Widget>[  
                ElevatedButton(onPressed: () {  
                  onColorChanged(Colors.green);  
                },  
                child: Text('Green')),  
                ElevatedButton(onPressed: () {  
                  onColorChanged(Colors.blue);  
                },  
                child: Text('Blue')),  
                ElevatedButton(onPressed: () {  
                  onFontSizeIncreased();  
                },  
                child: Text('Increase'))  
              ],  
            ),  
          ],  
        ),  
      ),  
    );  
  }  
}
```

```
        }).toList(),
        onChanged: onColorChanged,
    ),
    RaisedButton(
        child: Text('Increase font size'),
        onPressed: onFontSizeIncreased,
    )
],
);
}
}
```

Now we can put these widgets together to build the whole UI. In Listing 10-7, ConfiguredPage is a stateful widget with a Config object as its state. ConfigUpdater widget is a child of ConfiguredPage to update the Config object. ConfiguredPage constructor also has child parameter to provide child widget that uses ConfigWidget.of(context) to get the correct Config object. For the onColorChanged and onFontSizeIncreased callbacks of ConfigWidget, setState() method is used to update the state of ConfiguredPage widget and triggers update of ConfigWidget. The framework notifies ConfigUpdater and other widgets to update with latest value of Config object.

Listing 10-7. ConfiguredPage to use ConfigWidget

```
class ConfiguredPage extends StatefulWidget {
    ConfiguredPage({Key key, this.child}) : super(key: key);
    final Widget child;

    @override
    _ConfiguredPageState createState() => _ConfiguredPageState();
}
```

```
class _ConfiguredPageState extends State<ConfiguredPage> {
  Config _config = Config(color: Colors.green, fontSize: 16);

  @override
  Widget build(BuildContext context) {
    return ConfigWidget(
      config: _config,
      child: Column(
        children: <Widget>[
          ConfigUpdater(
            onColorChanged: (Color color) {
              setState(() {
                _config = _config.copyWith(color: color);
              });
            },
            onFontSizeIncreased: () {
              setState(() {
                _config = _config.copyWith(fontSize: _config.fontSize + 1.0);
              });
            },
          ),
          Container(
            decoration: BoxDecoration(border: Border.all()),
            padding: EdgeInsets.all(8),
            child: widget.child,
          ),
        ],
      ),
    );
  }
}
```

In Listing 10-8, ConfigWidgetPage widget uses ConfiguredPage widget to wrap ConfiguredText and ConfiguredBox widgets.

Listing 10-8. ConfigWidgetPage to build the UI

```
class ConfigWidgetPage extends StatelessWidget {  
  @override  
  Widget build(BuildContext context) {  
    return Scaffold(  
      appBar: AppBar(  
        title: Text('Inherited Widget'),  
      ),  
      body: ConfiguredPage(  
        child: Column(  
          children: <Widget>[  
            ConfiguredText(),  
            ConfiguredBox(),  
          ],  
        ),  
      ),  
    );  
  }  
}
```

10-3. Managing State Using Inherited Model Problem

You want to get notified and rebuild UI based on aspects of changes.

Solution

Create your own subclasses of InheritedModel.

Discussion

If we take a closer look at the `ConfiguredText` and `ConfiguredBox` widgets in Listing 10-5 of Recipe 10-2, we can see that `ConfiguredBox` widget only depends on the `color` property of the `Config` object. If the `fontSize` property changes, there is no need for `ConfiguredBox` widget to rebuild. These unnecessary rebuilds may cause performance issues, especially if the widget is complex.

`InheritedModel` widget allows you to divide a state into multiple aspects. A build context can register to get notified only for a particular aspect. When state changes in `InheritedModel` widget, only dependent build contexts registered to matching aspects will be notified.

`InheritedModel` class extends from `InheritedWidget` class. It has a type parameter to specify the type of aspect. `ConfigModel` class in Listing 10-9 is the `InheritedModel` subclass for `Config` object. The type of aspect is `String`. When implementing `InheritedModel` class, you still need to override `updateShouldNotify()` method to determine whether dependents should be notified. The `updateShouldNotifyDependent()` method determines whether a dependent should be notified based on the set of aspects it depends on. The `updateShouldNotifyDependent()` method is only called when `updateShouldNotify()` method returns true. For the `ConfigModel`, only “color” and “fontSize” aspects are defined. If the dependent depends on the “color” aspect, then it’s notified only when the `color` property of `Config` object changes. This is also applied to “fontSize” aspect for `fontSize` property.

The static `of()` method has an extra `aspect` parameter to specify the aspect the build context depends on. The static `InheritedModel.inheritFrom()` method is used to make the build context depend on specified aspect. When aspect is `null`, this method is the same as using `BuildContext.inheritFromWidgetOfExactType()` method.

Listing 10-9. ConfigModel as InheritedModel

```
class ConfigModel extends InheritedModel<String> {
  const ConfigModel({
    Key key,
    @required this.config,
    @required Widget child,
  }) : super(key: key, child: child);

  final Config config;

  static Config of(BuildContext context, String aspect) {
    ConfigModel configModel =
        InheritedModel.inheritFrom(context, aspect: aspect);
    return configModel?.config ?? Config.fallback();
  }

  @override
  bool updateShouldNotify(ConfigModel oldWidget) {
    return config != oldWidget.config;
  }

  @override
  bool updateShouldNotifyDependent(
    ConfigModel oldWidget, Set<String> dependencies) {
    return (config.color != oldWidget.config.color &&
        dependencies.contains('color')) ||
        (config.fontSize != oldWidget.config.fontSize &&
            dependencies.contains('fontSize'));
  }
}
```

In Listing 10-10, ConfiguredModelText widget uses null as the aspect, because it depends on both “color” and “fontSize” aspects.

ConfiguredModelBox widget uses color as the aspect. If font size is updated, only ConfiguredModelText widget is rebuilt.

Listing 10-10. Use ConfigModel to get Config object

```
class ConfiguredModelText extends StatelessWidget {  
  @override  
  Widget build(BuildContext context) {  
    Config config = ConfigModel.of(context, null);  
    return Text(  
      'Font size: ${config.fontSize}',  
      style: TextStyle(  
        color: config.color,  
        fontSize: config.fontSize,  
      ),  
    );  
  }  
}  
  
class ConfiguredModelBox extends StatelessWidget {  
  @override  
  Widget build(BuildContext context) {  
    Config config = ConfigModel.of(context, 'color');  
    return Container(  
      decoration: BoxDecoration(color: config.color),  
      child: Text('Background color: ${config.color}'),  
    );  
  }  
}
```

10-4. Managing State Using Inherited Notifier

Problem

You want dependent widgets to rebuild based on notifications from Listenable objects.

Solution

Create your own subclasses of InheritedNotifier widget.

Discussion

Listenable class is typically used to manage listeners and notify clients for updates. You can use the same pattern to notify dependents to rebuild with InheritedNotifier. InheritedNotifier widget also extends from InheritedWidget class. When creating InheritedNotifier widgets, you need to provide Listenable objects. When the Listenable object sends notifications, dependents of this InheritedNotifier widget are notified for rebuilding.

In Listing 10-11, ConfigNotifier uses ValueNotifier<Config> as the type of Listenable. The static of() method gets the Config object from ConfigNotifier object.

Listing 10-11. ConfigNotifier as InheritedNotifier

```
class ConfigNotifier extends InheritedNotifier<ValueNotifier<Config>> {
    ConfigNotifier({
        Key key,
        @required notifier,
```

```

    @required Widget child,
}) : super(key: key, notifier: notifier, child: child);

static Config of(BuildContext context) {
    final ConfigNotifier configNotifier =
        context.inheritFromWidgetOfExactType(ConfigNotifier);
    return configNotifier?.notifier?.value ?? Config.
fallback();
}
}

```

To use `ConfigNotifier` widget, you need to create a new instance of `ValueNotifier<Config>`. To update the `Config` object, you can simply set the `value` property to a new value. `ValueNotifier` object will send notifications, which notify dependent widgets to rebuild.

Listing 10-12. `ConfiguredNotifierPage` to use `ConfigNotifier`

```

class ConfiguredNotifierPage extends StatelessWidget {
    ConfiguredNotifierPage({Key key, this.child}) : super(key:
key);
    final Widget child;
    final ValueNotifier<Config> _notifier =
        ValueNotifier(Config(color: Colors.green, fontSize: 16));

    @override
    Widget build(BuildContext context) {
        return ConfigNotifier(
            notifier: _notifier,
            child: Column(
                children: <Widget>[
                    ConfigUpdater(
                        onColorChanged: (Color color) {

```

```
        _notifier.value = _notifier.value.copyWith(color:  
            color);  
    },  
    onFontSizeIncreased: () {  
        Config oldConfig = _notifier.value;  
        _notifier.value =  
            oldConfig.copyWith(fontSize: oldConfig.  
                fontSize + 1.0);  
    },  
),  
Container(  
    decoration: BoxDecoration(border: Border.all()),  
    padding: EdgeInsets.all(8),  
    child: child,  
),  
],  
,  
);  
}  
}
```

10-5. Managing State Using Scoped Model Problem

You want to have a simple solution to handle model changes.

Solution

Use `scoped_model` package.

Discussion

In Recipes 10-1, 10-2, 10-3, and 10-4, you have seen the usage of `StatefulWidget`, `InheritedWidget`, `InheritedModel`, and `InheritedNotifier` widgets to manage state. These widgets are provided by Flutter framework. These widgets are low-level APIs, so they are inconvenient to use in complex apps. The `scoped_model` package (https://pub.dev/packages/scoped_model) is a library to allow easily passing a data model from a parent widget down to its descendants. It's built on top of `InheritedWidget`, but with an easy-to-use API. To use this package, you need to add `scoped_model: ^1.0.1` to the dependencies of `pubspec.yaml` file. We'll use the same example as in Recipe 10-2 to demonstrate the usage of `scoped_model` package.

Listing 10-13 shows the `Config` model using `scoped_model` package. The `Config` class extends from `Model` class. It has private fields to store the state. The `setColor()` and `increaseFontSize()` methods update `_color` and `_fontSize` fields, respectively. These two methods use `notifyListeners()` internally to notify descendant widgets to rebuild.

Listing 10-13. Config model as scoped model

```
import 'package:scoped_model/scoped_model.dart';

class Config extends Model {
  Color _color = Colors.red;
  double _fontSize = 16.0;

  Color get color => _color;
  double get fontSize => _fontSize;

  void setColor(Color color) {
    _color = color;
    notifyListeners();
  }
}
```

```
void increaseFontSize() {  
    _fontSize += 1;  
    notifyListeners();  
}  
}
```

In Listing 10-14, `ScopedModelText` widget shows how to use the model in descendant widgets. `ScopedModelDescendant` widget is used to get the nearest enclosing model object. The type parameter determines the model object to get. The `builder` parameter specified the build function to build the widget. The build function has three parameters. The first parameter of type `BuildContext` is common for build functions. The last parameter is the model object. If a portion of the widget UI doesn't rely on the model and should not be rebuilt when model changes, you can specify it as the `child` parameter of `ScopedModelDescendant` widget and access it in the second parameter of the build function.

Listing 10-14. `ScopedModelText` uses `ScopedModelDescendant`

```
class ScopedModelText extends StatelessWidget {  
    @override  
    Widget build(BuildContext context) {  
        return ScopedModelDescendant<Config>(  
            builder: (BuildContext context, Widget child, Config  
            config) {  
                return Text(  
                    'Font size: ${config.fontSize}',  
                    style: TextStyle(  
                        color: config.color,  
                        fontSize: config.fontSize,  
                    ),  
                );  
            },  
        );  
    },
```

```
    );
}
```

In Listing 10-15, `ScopedModelUpdater` widget simply uses `setColor()` and `increaseFontSize()` methods to update the state.

Listing 10-15. `ScopedModelUpdater` to update `Config` object

```
class ScopedModelUpdater extends StatelessWidget {
    static const List<Color> _colors = [Colors.red, Colors.green,
    Colors.blue];

    @override
    Widget build(BuildContext context) {
        return ScopedModelDescendant<Config>(
            builder: (BuildContext context, Widget child, Config
            config) {
                return Column(
                    children: <Widget>[
                        DropdownButton(
                            value: config.color,
                            items: _colors.map((Color color) {
                                return DropdownMenuItem(
                                    value: color,
                                    child: Text(color.toString()),
                                );
                            }).toList(),
                            onChanged: (Color color) {
                                config.setColor(color);
                            },
                        ),
                        RaisedButton(

```

```
        child: Text('Increase font size'),
        onPressed: () {
            config.increaseFontSize();
        },
    ),
],
);
},
);
}
}
```

ScopedModel widget in Listing 10-16 is the last piece to put Model and ScopedModelDescendant together. The model parameter specifies the model object managed by the ScopedModel object. All the ScopedModelDescendant widgets under the ScopedModel object get the same model object.

Listing 10-16. ScopedModelPage uses ScopedModel

```
class ScopedModelPage extends StatelessWidget {
    @override
    Widget build(BuildContext context) {
        return Scaffold(
            appBar: AppBar(
                title: Text('Scoped Model'),
            ),
            body: ScopedModel(
                model: Config(),
                child: Column(
                    children: <Widget>[
                        ScopedModelUpdater(),
                        ScopedModelText()
                    ]
                )
            )
        );
    }
}
```

```
    ],
),
),
),
);
}
}
```

You can also use static `ScopedModel.of()` method to get the `ScopedModel` object, then use its `model` property to get the model object.

10-6. Managing State Using Bloc

Problem

You want to use Bloc pattern to manage state.

Solution

Use `bloc` and `flutter_bloc` packages.

Discussion

Bloc (Business Logic Component) is an architecture pattern to separate presentation from business logic. Bloc was designed to be simple, powerful, and testable. Let's start from core concepts in Bloc.

States represent a part of the application's state. When state changes, UI widgets are notified to rebuild based on the latest state. Each application has its own way to define states. Typically, you'll use Dart classes to describe states.

Events are sources of changes to states. Events can be generated by user interactions or background tasks. For example, pressing a button may generate an event that describes the intended action. When the response

of a HTTP request is ready, an event can also be generated to include the response body. Events are typically described as Dart classes. Events may also have payload carried with them.

When events are dispatched, handling these events may cause the current state transits to a new state. UI widgets are then notified to rebuild using the new state. An event transition consists of the current state, the event, and the next state. If all state transitions are recorded, we can easily track all user interactions and state changes. We can also implement time-travelling debugging.

Now we can have a definition of Bloc. A Bloc component transforms a stream of events into a stream of states. A Bloc has an initial state as the state before any events are received. For each event, a Bloc has a `mapEventToState()` function that takes a received event and returns a stream of states to be consumed by the presentation layer. A Bloc also has the `dispatch()` method to dispatch events to it.

In this recipe, we'll use the GitHub Jobs API (<https://jobs.github.com/api>) to get job listings on GitHub. The user can input a keyword for search and see the results. To consume this, we will be using the `http` package (<https://pub.dev/packages/http>). Add this package to your `pubspec.yaml` file.

Let's start from the states. Listing 10-17 shows classes for different states. `JobsState` is the abstract base class for all state classes. `JobsState` class extends from `Equatable` class in the `equatable` package. `Equatable` class is used to provide implementations for `==` operator and `hashCode` property. `JobsEmpty` is the initial state. `JobsLoading` means the job listing data is still loading. `JobsLoaded` means job listing data is loaded. The payload type of `JobsLoaded` event is `List<Job>`. `JobsError` means an error occurred when fetching the data.

Listing 10-17. Bloc states

```
import 'package:http/http.dart' as http;

abstract class JobsState extends Equatable {
    JobsState([List props = const []]) : super(props);
}

class JobsEmpty extends JobsState {}

class GetJobsEvent extends JobsEvent {
    GetJobsEvent({@required this.keyword})
        : assert(keyword != null),
        super([keyword]);

    final String keyword;
}

class GitHubJobsClient {
    Future<List<Job>> getJobs(keyword) async {
        final response = await http.get('https://jobs.github.com/
            positions.json?description=${keyword}');
        if (response.statusCode != 200) {
            throw new Exception("Unable to fetch data");
        }else{
            var result = new List<Job>();
            final rawResult = json.decode(response.body);
            for(final jsonJob in rawResult){
                result.add(Job.fromJson(jsonJob));
            }
        }
    }
}
```

```

class JobsLoading extends JobsState {}

class JobsLoaded extends JobsState {
  JobsLoaded({@required this.jobs})
    : assert(jobs != null),
    super([jobs]);

  final List<Job> jobs;
}

class JobsError extends JobsState {}

```

Listing 10-18 shows the events. `JobsEvent` is the abstract base class for event classes. `GetJobsEvent` class represents the event to get jobs data.

Listing 10-18. Bloc events

```

abstract class JobsEvent extends Equatable {
  JobsEvent([List props = const []]) : super(props);
}

class GetJobsEvent extends JobsEvent {
  GetJobsEvent({@required this.keyword})
    : assert(keyword != null),
    super([keyword]);

  final String keyword;
}

```

Listing 10-19 shows the Bloc. `JobsBloc` class extends from `Bloc<JobsEvent, JobsState>` class. Type parameters of `Bloc` are event and state classes. `JobsEmpty` is the initial state. In the `mapEventToState()` method, if the event is `GetJobsEvent`, a `JobsLoading` state is emitted first to the stream. Then `GitHubJobsClient` object is used to fetch the data. If the data is fetched successfully, a `JobsLoaded` state is emitted with the loaded data. Otherwise, a `JobsError` state is emitted instead.

Listing 10-19. Bloc

```
class JobsBloc extends Bloc<JobsEvent, JobsState> {
  JobsBloc({@required this.jobsClient}) : assert(jobsClient != null);

  final GitHubJobsClient jobsClient;

  @override
  JobsState get initialState => JobsEmpty();

  @override
  Stream<JobsState> mapEventToState(JobsEvent event) async* {
    if (event is GetJobsEvent) {
      yield JobsLoading();
      try {
        List<Job> jobs = await jobsClient.getJobs(event.keyword);
        yield JobsLoaded(jobs: jobs);
      } catch (e) {
        yield JobsError();
      }
    }
  }
}
```

GitHubJobs class in Listing 10-20 is the widget to use the JobsBloc class in Listing 10-19. The JobsBloc object is created in initState() method and disposed in dispose() method. In the KeywordInput widget, when user inputs the keyword in the text field and presses the search button, a GetJobsEvent is dispatched to the JobsBloc object. In the JobsView widget, BlocBuilder widget is used to build UI based on the state in the Bloc. Here we check the actual type of JobsState and return different widgets.

Listing 10-20. GitHub jobs widget using Bloc

```
class GitHubJobs extends StatefulWidget {
    GitHubJobs({Key key, @required this.jobsClient})
        : assert(jobsClient != null),
        super(key: key);

    final GitHubJobsClient jobsClient;

    @override
    _GitHubJobsState createState() => _GitHubJobsState();
}

class _GitHubJobsState extends State<GitHubJobs> {
    JobsBloc _jobsBloc;

    @override
    void initState() {
        super.initState();
        _jobsBloc = JobsBloc(jobsClient: widget.jobsClient);
    }

    @override
    Widget build(BuildContext context) {
        return Column(
            children: <Widget>[
                Padding(
                    padding: const EdgeInsets.all(8.0),
                    child: KeywordInput(
                        jobsBloc: _jobsBloc,
                    ),
                ),
                Expanded(
                    child: JobsView(

```

```
        jobsBloc: _jobsBloc,
    ),
),
],
);
}

@Override
void dispose() {
    _jobsBloc.dispose();
    super.dispose();
}
}

class KeywordInput extends StatefulWidget {
KeywordInput({this.jobsBloc});

final JobsBloc jobsBloc;

@Override
_KnowledgeInputState createState() => _KnowledgeInputState();
}

class _KnowledgeInputState extends State<KeywordInput> {
final GlobalKey<FormFieldState<String>> _knowledgeFormKey =
GlobalKey();

@Override
Widget build(BuildContext context) {
    return Row(
        children: <Widget>[
            Expanded(
                child: TextFormField(
                    key: _knowledgeFormKey,
            ),
        ],
    );
}
}
```

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```
        ),  
        IconButton(  
            icon: Icon(Icons.search),  
            onPressed: () {  
                String keyword = _keywordFormKey.currentState?.  
                    value ?? "";  
                if (keyword.isNotEmpty) {  
                    widget.jobsBloc.dispatch(GetJobsEvent(keyword:  
                        keyword));  
                }  
            },  
        ),  
    ],  
);  
}  
}  
  
class JobsView extends StatelessWidget {  
    JobsView({this.jobsBloc});  
  
    final JobsBloc jobsBloc;  
  
    @override  
    Widget build(BuildContext context) {  
        return BlocBuilder(  
            bloc: jobsBloc,  
            builder: (BuildContext context, JobsState state) {  
                if (state is JobsEmpty) {  
                    return Center(  
                        child: Text('Input keyword and search'),  
                    );  
                } else if (state is JobsLoading) {  
                    return Center(  
                        child: CircularProgressIndicator(),  
                    );  
                } else if (state is JobsSuccess) {  
                    return ListView.builder(  
                        itemCount: state.jobs.length,  
                        itemBuilder: (context, index) {  
                            return ListTile(  
                                title: Text(state.jobs[index].title),  
                                subtitle: Text(state.jobs[index].location),  
                            );  
                        },  
                    );  
                }  
            },  
        );  
    }  
}
```

```
        child: CircularProgressIndicator(),
    );
} else if (state is JobsError) {
    return Center(
        child: Text(
            'Failed to get jobs',
            style: TextStyle(color: Colors.red),
        ),
    );
} else if (state is JobsLoaded) {
    return JobsList(state.jobs);
}
},
);
}
}
```

10-7. Managing State Using Redux Problem

You want to use Redux as the state management solution.

Solution

Use `redux` and `flux_redux` packages.

Discussion

Redux (<https://redux.js.org/>) is a popular library to manage state in apps. Originated for React, Redux has been ported to different languages. The `redux` package is a Dart implementation of Redux. The `flux_redux`

package allows using Redux store when building Flutter widgets. If you have used Redux before, the same concepts are used in Flutter.

Redux uses a single global object as the state. This object is the single source of truth for the app, and it's called the store. Actions are dispatched to the store to update the state. Reducer functions accept the current state and an action as the parameters and return the next state. The next state becomes the input of the next run of the reducer function. UI widgets can select partial data from the store to build the content.

To use `flutter_redux` package, you need to add `flutter_redux: ^0.5.3` to the dependencies of `pubspec.yaml` file. We'll use the same example of listing jobs on GitHub to demonstrate the usage of Redux in Flutter.

Let's start from the state. `JobsState` class in Listing 10-21 represents the global state. The state has three properties, `loading` represents whether the data is still loading, `error` represents whether an error occurred when loading the data, and `data` presents the list of data. By using the `copyWith()` method, we can new `JobsState` objects by updating some properties.

Listing 10-21. `JobsState` for Redux

```
class JobsState extends Equatable {  
  JobsState({bool loading, bool error, List<Job> data})  
      : _loading = loading,  
        _error = error,  
        _data = data,  
        super([loading, error, data]);  
  
  final bool _loading;  
  final bool _error;  
  final List<Job> _data;  
  
  bool get loading => _loading ?? false;  
  bool get error => _error ?? false;
```

```
List<Job> get data => _data ?? [];
bool get empty => _loading == null && _error == null && _data
== null;

JobsState copyWith({bool loading, bool error, List<Job>
data}) {
    return JobsState(
        loading: loading ?? this._loading,
        error: error ?? this._error,
        data: data ?? this._data,
    );
}
}
```

Listing 10-22 shows the actions. These actions trigger state changes.

Listing 10-22. Actions for Redux

```
abstract class JobsAction extends Equatable {
    JobsAction([List props = const []]) : super(props);
}

class LoadJobAction extends JobsAction {
    LoadJobAction({@required this.keyword})
        : assert(keyword != null),
        super([keyword]);

    final String keyword;
}

class JobLoadedAction extends JobsAction {
    JobLoadedAction({@required this.jobs})
        : assert(jobs != null),
        super([jobs]);
```

```

    final List<Job> jobs;
}

class JobLoadErrorAction extends JobsAction {}

```

Listing 10-23 shows the reducer function to update state according to the action.

Listing 10-23. Reducer function for Redux

```

JobsState jobsReducers(JobsState state, dynamic action) {
    if (action is LoadJobAction) {
        return state.copyWith/loading: true);
    } else if (action is JobLoadErrorAction) {
        return state.copyWith/loading: false, error: true);
    } else if (action is JobLoadedAction) {
        return state.copyWith/loading: false, data: action.jobs);
    }
    return state;
}

```

Actions defined in Listing 10-22 can only be used for synchronous operations. For example, if you want to dispatch the JobLoadedAction, you need to have the List<Job> object ready first. However, the operation to load jobs data is asynchronous. You'll need to use thunk functions as the middleware of Redux store. A thunk function takes the store as the only parameter. It uses the store to dispatch actions. A thunk action can be dispatched to the store, just like other normal actions.

The getJobs() function in Listing 10-24 takes a GitHubJobsClient object and a search keyword as the parameters. This function returns a thunk function of type ThunkAction<JobsState>. ThunkAction comes from redux_thunk package. In the thunk function, a LoadJobAction is dispatched first. Then GitHubJobsClient object is used to get the jobs

data. Depending on the result of data loading, a `JobLoadedAction` or `JobLoadErrorAction` is dispatched.

Listing 10-24. Thunk function for Redux

```
ThunkAction<JobsState> getJobs(GitHubJobsClient jobsClient,  
String keyword) {  
    return (Store<JobsState> store) async {  
        store.dispatch(LoadJobAction(keyword));  
        try {  
            List<Job> jobs = await jobsClient.getJobs(keyword);  
            store.dispatch(JobLoadedAction(jobs: jobs));  
        } catch (e) {  
            store.dispatch(JobLoadErrorAction());  
        }  
    };  
}
```

Now we can use the Redux store to build the widgets. You can use two helper widgets to access data in the store. In Listing 10-25, `StoreBuilder` widget is used to provide direct access to the store. The store is available as the second parameter of the build function. `StoreBuilder` widget is usually used when you need to dispatch actions. `StoreConnector` widget allows using a converter function to transform the state first. When the search icon is pressed, the `getJobs()` function in Listing 10-24 is called first to create the thunk function, then dispatches the thunk function to the store. When using `StoreConnector` widget, the converter function simply gets the current state from the store. The state object is then used in build function.

Listing 10-25. GitHub jobs widget using Redux store

```
class GitHubJobs extends StatefulWidget {
  GitHubJobs({
    Key key,
    @required this.store,
    @required this.jobsClient,
  }) : assert(store != null),
        assert(jobsClient != null),
        super(key: key);

  final Store<JobsState> store;
  final GitHubJobsClient jobsClient;

  @override
  _GitHubJobsState createState() => _GitHubJobsState();
}

class _GitHubJobsState extends State<GitHubJobs> {
  @override
  Widget build(BuildContext context) {
    return StoreProvider<JobsState>(
      store: widget.store,
      child: Column(
        children: <Widget>[
          Padding(
            padding: const EdgeInsets.all(8.0),
            child: KeywordInput(
              jobsClient: widget.jobsClient,
            ),
          ),
          Expanded(
            child: JobsView(),
          )
        ],
      ),
    );
  }
}
```

```
        ),
      ],
    ),
  );
}

class KeywordInput extends StatefulWidget {
  KeywordInput({this.jobsClient});

  final GitHubJobsClient jobsClient;

  @override
  _KeywordInputState createState() => _KeywordInputState();
}

class _KeywordInputState extends State<KeywordInput> {
  final GlobalKey<FormFieldState<String>> _keywordFormKey =
  GlobalKey();

  @override
  Widget build(BuildContext context) {
    return Row(
      children: <Widget>[
        Expanded(
          child: TextFormField(
            key: _keywordFormKey,
          ),
        ),
        StoreBuilder<JobsState>(
          builder: (BuildContext context, Store<JobsState>
          store) {
            return IconButton(
              icon: Icon(Icons.search),

```

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```
        onPressed: () {
            String keyword = _keywordFormKey.currentState?.
                value ?? "";
            if (keyword.isNotEmpty) {
                store.dispatch(getJobs(widget.jobsClient,
                    keyword));
            }
        },
    );
},
),
],
);
}
}

class JobsView extends StatelessWidget {
@override
Widget build(BuildContext context) {
    return StoreConnector<JobsState, JobsState>(
        converter: (Store<JobsState> store) => store.state,
        builder: (BuildContext context, JobsState state) {
            if (state.empty) {
                return Center(
                    child: Text('Input keyword and search'),
                );
            } else if (state.loading) {
                return Center(
                    child: CircularProgressIndicator(),
                );
            } else if (state.error) {
                return Center(

```

```
        child: Text(
            'Failed to get jobs',
            style: TextStyle(color: Colors.red),
        ),
    );
} else {
    return JobsList(state.data);
}
},
);
}
}
```

The last step is to create the store. The store in Listing 10-26 is created with the reducer function, the initial state, and the thunk middleware from redux_thunk package.

Listing 10-26. Create the store

```
final store = new Store<JobsState>(
    jobsReducers,
    initialState: JobsState(),
    middleware: [thunkMiddleware],
);
```

10-8. Managing State Using Mobx Problem

You want to use Mobx to manage state.

Solution

Use `mobx` and `flutter_mobx` packages.

Discussion

Mobx (<https://mobx.js.org>) is a state management library which connects reactive data with the UI. MobX originates from developing web apps using JavaScript. It's also ported to Dart (<https://mobx.pub>). In Flutter apps, we can use `mobx` and `flutter_mobx` packages to build apps with Mobx. Mobx for Flutter uses `build_runner` package to generate code for the store. The `build_runner` and `mobx_codegen` packages need to be added as `dev_dependencies` to `pubspec.yaml` file.

Mobx uses observables to manage the state. The whole state of an app consists of core state and derived state. Derived state is computed from core state. Actions mutate observables to update the state. Reactions are observers of the state and get notified whenever an observable they track is changed. In Flutter app, the reactions are used to update the widgets.

Comparing to Redux for Flutter, Mobx uses code generation to simplify the usage of store. You don't need to write boilerplate code to create actions. Mobx provides several annotations. You just annotate the code with these annotations. This is similar with how `json_annotation` and `json_serialize` packages work. We'll use the same example of showing job listings on GitHub to demonstrate the usage of Mobx. Add this package to your `pubspec.yaml` file if it is not already present.

Listing 10-27 shows the basic code of `jobs_store.dart` file for the Mobx store. This file uses the generated part file `jobs_store.g.dart`. `_JobsStore` is the abstract class of the store for jobs. It implements `Store` class from Mobx. Here we defined two observables using `@observable` annotation. The first observable keyword is a simple string that manages the current search keyword. The `getJobsFuture` observable is an `ObservableFuture<List<Job>>` object that manages the asynchronous

operation to get the jobs using API. Those properties marked using @computed annotation are derived observables to check the status of data loading. We also define two actions using @action annotation. The setKeyword() action sets the getJobsFuture observable to an empty state and keyword observable to the provided value. The getJobs() action uses GitHubJobsClient.getJobs() method to load the data. The getJobsFuture observable is updated to an ObservableFuture object wrapping the returned future.

Listing 10-27. Mobx store

```
import 'package:meta/meta.dart';
import 'package:mobx/mobx.dart';

part 'jobs_store.g.dart';

class JobsStore = _JobsStore with _$JobsStore;

abstract class _JobsStore implements Store {
  _JobsStore({@required this.jobsClient}) : assert(jobsClient != null);

  final GitHubJobsClient jobsClient;

  @observable
  String keyword = "";

  @observable
  ObservableFuture<List<Job>> getJobsFuture = emptyResponse;

  @computed
  bool get empty => getJobsFuture == emptyResponse;

  @computed
  bool get hasResults =>
    getJobsFuture != emptyResponse &&
    getJobsFuture.status == FutureStatus.fulfilled;
```

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```
@computed
bool get loading =>
    getJobsFuture != emptyResponse &&
    getJobsFuture.status == FutureStatus.pending;

@computed
bool get hasError =>
    getJobsFuture != emptyResponse &&
    getJobsFuture.status == FutureStatus.rejected;

static ObservableFuture<List<Job>> emptyResponse =
ObservableFuture.value([]);

List<Job> jobs = [];

[action]
Future<List<Job>> getJobs() async {
    jobs = [];
    final future = jobsClient.getJobs(keyword);
    getJobsFuture = ObservableFuture(future);

    return jobs = await future;
}

[action]
void setKeyword(String keyword) {
    getJobsFuture = emptyResponse;
    this.keyword = keyword;
}
}
```

The flutter packages pub run build_runner build command is required to generate code. JobsStore class is the store to use. Listing 10-28 shows the widget that uses the store. In the onPressed callback of the search button, setKeyword() method is called first to update the keyword, then

`getJobs()` method is called to trigger the data loading. The `Observer` widget uses a build function to build the UI using computed observables and fields in `JobsStore` object. Whenever these observables change, `Observer` widget rebuilds to update the UI.

Listing 10-28. GitHub jobs widget using Mobx store

```
class GitHubJobs extends StatefulWidget {
  GitHubJobs({Key key, @required this.jobsStore})
    : assert(jobsStore != null),
      super(key: key);

  final JobsStore jobsStore;

  @override
  _GitHubJobsState createState() => _GitHubJobsState();
}

class _GitHubJobsState extends State<GitHubJobs> {
  @override
  Widget build(BuildContext context) {
    JobsStore jobsStore = widget.jobsStore;
    return Column(
      children: <Widget>[
        Padding(
          padding: const EdgeInsets.all(8.0),
          child: KeywordInput(
            jobsStore: jobsStore,
          ),
        ),
        Expanded(
          child: JobsView(
            jobsStore: jobsStore,
          ),
        ),
      ],
    );
  }
}
```

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```
        ),
        ],
    );
}
}

class KeywordInput extends StatefulWidget {
    KeywordInput({this.jobsStore});

    final JobsStore jobsStore;

    @override
    _KeywordInputState createState() => _KeywordInputState();
}

class _KeywordInputState extends State<KeywordInput> {
    final GlobalKey<FormFieldState<String>> _keywordFormKey =
    GlobalKey();

    @override
    Widget build(BuildContext context) {
        return Row(
            children: <Widget>[
                Expanded(
                    child: TextFormField(
                        key: _keywordFormKey,
                    ),
                ),
                IconButton(
                    icon: Icon(Icons.search),
                    onPressed: () {
                        String keyword = _keywordFormKey.currentState?.
                        value ?? "";
                    }
                );
            ],
        );
    }
}
```

```
        if (keyword.isNotEmpty) {
            widget.jobsStore.setKeyword(keyword);
            widget.jobsStore.getJobs();
        }
    },
),
],
);
}
}

class JobsView extends StatelessWidget {
JobsView({this.jobsStore});

final JobsStore jobsStore;

@Override
Widget build(BuildContext context) {
    return Observer(
        builder: (BuildContext context) {
            if (jobsStore.empty) {
                return Center(
                    child: Text('Input keyword and search'),
                );
            } else if (jobsStore.loading) {
                return Center(
                    child: CircularProgressIndicator(),
                );
            } else if (jobsStore.hasError) {
                return Center(
                    child: Text(
                        'Failed to get jobs',
                        style: TextStyle(color: Colors.red),
                    )
                );
            }
        }
    );
}
```

```
        ),  
    );  
} else {  
    return JobsList(jobsStore.jobs);  
}  
},  
);  
}  
}
```

10-9. Summary

This chapter discusses different state management solutions for Flutter apps. In these solutions, `StatefulWidget`, `InheritedWidget`, `InheritedModel`, and `InheritedNotifier` widgets are provided by Flutter framework. `Scoped model`, `Bloc`, `Redux`, and `Mobx` libraries are third-party solutions. You are free to choose whatever solution that suits best for your requirement. In the next chapter, we'll discuss animations in Flutter.

CHAPTER 11

Animations

Animations play an important role in mobile apps to provide visual feedback for end users. This chapter covers recipes related to animations in Flutter.

11-1. Creating Simple Animations

Problem

You want to create simple animations.

Solution

Use `AnimationController` class to create simple animations.

Discussion

Animations in Flutter have a value and a status. The value of an animation may change over time. Animations are represented using abstract `Animation<T>` class. `Animation` class extends from `Listenable` class. You can add listeners to `Animation` objects to get notified for changes of value or status.

`AnimationController` class is a subclass of `Animation<double>` class. `AnimationController` class provides control over the animation it creates. To create an `AnimationController` object, you can provide a lower bound,

an upper bound, and a duration. The value of `AnimationController` object changes from the lower bound to the upper bound over the duration. A `TickerProvider` object is also required. For stateful widget, you can use `TickerProviderStateMixin` or `SingleTickerProviderStateMixin` class as the mixin of the state class. If only one `AnimationController` object is used for the state, using `SingleTickerProviderStateMixin` is more efficient.

[Listing 11-1](#) shows an example of using `AnimationController` in stateful widgets to animate the size of an image. The `AnimationController` object is created in the body of `initState()` method and disposed in `dispose()` method. This is a typical pattern of using `AnimationController`. `_GrowingImageState` class has the `SingleTickerProviderStateMixin` mixin, so the `AnimationController` constructor uses this object as the `vsync` parameter. In the listener of `AnimationController` object, `setState()` method is called to trigger the rebuild of the widget. The `forward()` method starts the running of the animation in forward direction. In the `build()` method, the current value of `AnimationController` object is used to control the size of the `SizedBox` widget. In the runtime, the size of `SizedBox` widget grows from 0 to 400 in 10 seconds.

Listing 11-1. Using `AnimationController`

```
class GrowingImage extends StatefulWidget {  
    @override  
    _GrowingImageState createState() => _GrowingImageState();  
}  
  
class _GrowingImageState extends State<GrowingImage>  
    with SingleTickerProviderStateMixin {  
    AnimationController controller;  
  
    @override  
    void initState() {
```

```
super.initState();
controller = AnimationController(
    lowerBound: 0,
    upperBound: 400,
    duration: const Duration(seconds: 10),
    vsync: this,
)
..addListener(() {
    setState(() {});
})
..forward();
}

@Override
Widget build(BuildContext context) {
    return SizedBox(
        width: controller.value,
        height: controller.value,
        child: Image.network('https://picsum.photos/400'),
    );
}

@Override
void dispose() {
    controller.dispose();
    super.dispose();
}
}
```

Table 11-1 shows methods of `AnimationController` to control the progress of animation.

Table 11-1. Methods to control animation

| Name | Description |
|-----------|---|
| forward() | Starts the running of animation in forward direction. |
| reverse() | Starts the running of animation in backward direction. |
| stop() | Stops the running of animation. |
| repeat() | Starts the running of animation and restarts when it completes. |
| reset() | Sets the value to the lower bound and stops the animation. |

An animation may be in different status. `AnimationStatus` enum represents different statuses for an animation. Table 11-2 shows all values of this enum. You can use `addStatusListener()` method to add a listener to get notified when the status changes.

Table 11-2. Values of `AnimationStatus`

| Name | Description |
|-----------|---|
| forward | The animation is running in forward direction. |
| reverse | The animation is running in backward direction. |
| dismissed | The animation is stopped at the beginning. |
| completed | The animation is stopped at the end. |

In Listing 11-2, a status listener is added to the `AnimationController` object. When the animation is in the `completed` status, it starts running in backward direction.

Listing 11-2. Status listener

```
var controller = AnimationController(
    lowerBound: 0,
    upperBound: 300,
```

```
duration: const Duration(seconds: 10),  
vsync: this,  
)  
..addListener(() {  
  setState(() {});  
})  
.addStatusListener((AnimationStatus status) {  
  if (status == AnimationStatus.completed) {  
    controller.reverse();  
  }  
})  
.forward();
```

Listing 11-1 shows a typical pattern to use animations with stateful widgets. `AnimatedWidget` widget makes the use of animations much easier. `AnimatedWidget` constructor requires a `Listenable` object. Whenever the `Listenable` object emits a value, the widget rebuilds itself. Listing 11-3 shows an example of using `AnimatedWidget`. Although `AnimatedWidget` class is typically used with `Animation` objects, you can still use it with any `Listenable` object.

Listing 11-3. Example of `AnimatedWidget`

```
class AnimatedImage extends AnimatedWidget {  
  AnimatedImage({Key key, this.animation})  
    : super(key: key, listenable: animation);  
  
  final Animation<double> animation;  
  
  @override  
  Widget build(BuildContext context) {  
    return SizedBox(  
      width: animation.value,  
      height: animation.value,
```

```
        child: Image.network('https://picsum.photos/300'),  
    );  
}  
}
```

11-2. Creating Animations Using Linear Interpolation

Problem

You want to create animations for other data types using linear interpolation.

Solution

Use Tween class and its subclasses.

Discussion

AnimationController class uses double as its value type. Double values are useful for animations with size or position. You may still need to animate other types of data. For example, you can animate the background color from red to green. For these scenarios, you can use Tween class and its subclasses.

Tween class represents linear interpolation between a beginning and ending value. To create a Tween object, you need to provide these two values. Tween objects can provide values for animations to use. By using the animate() method with another Animation object, you can create a new Animation object that is driven by the provided Animation object but uses values from the Tween object. Subclasses of Tween need to implement

the `lerp()` method that takes an animation value and returns the interpolated value.

In Listing 11-4, `AnimatedColor` widget uses `Animation<Color>` object to update the background color. `ColorTween` object is created with beginning value `Colors.red` and ending value `Colors.green`.

Listing 11-4. Example of `ColorTween`

```
class AnimatedColorTween extends StatefulWidget {  
    @override  
    _AnimatedColorTweenState createState() => _  
        AnimatedColorTweenState();  
}  
  
class _AnimatedColorTweenState extends  
State<AnimatedColorTween>  
    with SingleTickerProviderStateMixin {  
    AnimationController controller;  
    Animation<Color> animation;  
  
    @override  
    void initState() {  
        super.initState();  
        controller = AnimationController(  
            duration: const Duration(seconds: 10),  
            vsync: this,  
        );  
        animation =  
            ColorTween(begin: Colors.red, end: Colors.green).  
            animate(controller);  
        controller.forward();  
    }  
}
```

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```
    @override
    Widget build(BuildContext context) {
        return AnimatedColor(
            animation: animation,
        );
    }

    @override
    void dispose() {
        controller.dispose();
        super.dispose();
    }
}

class AnimatedColor extends AnimatedWidget {
    AnimatedColor({Key key, this.animation})
        : super(key: key, listenable: animation);

    final Animation<Color> animation;

    @override
    Widget build(BuildContext context) {
        return Container(
            width: 300,
            height: 300,
            decoration: BoxDecoration(color: animation.value),
        );
    }
}
```

There are many other subclasses of Tween for different objects, including AlignmentTween, BorderTween, BoxConstraintsTween, DecorationTween, EdgeInsetsTween, SizeTween, TextStyleTween, and more.

11-3. Creating Curved Animations

Problem

You want to create curved animations.

Solution

Use CurvedAnimation or CurveTween class.

Discussion

Except from linear animations, you can also create curved animations that use curves to adjust the rate of changes. A curve is a mapping of unit interval to another unit interval. Curve class and its subclasses are built-in types of curves. The `transform()` method of Curve class returns the mapped value of the curve for a given point. A curve must map the input 0.0 to 0.0 and 1.0 to 1.0. Table 11-3 shows different types of curves.

Table 11-3. Different types of curves

| Name | Description |
|-----------------|--|
| Cubic | Cubic curve defined by two control points. Created with four double values as x and y coordinates of these two points. |
| ElasticInCurve | Oscillation curve that grows in magnitude while overshooting its bounds. Created with duration of the oscillation. |
| ElasticOutCurve | Oscillation curve that shrinks in magnitude while overshooting its bounds. Created with duration of the oscillation. |

(continued)

Table 11-3. (continued)

| Name | Description |
|-------------------|--|
| ElasticInOutCurve | Oscillation curve that grows then shrinks in magnitude while overshooting its bounds. Created with duration of the oscillation. |
| Interval | Created with begin, end, and a curve. Its value is 0.0 until begin and 1.0 after end. Values between begin and end are defined by the curve. |
| SawTooth | A sawtooth curve that repeats the given number of times. |
| Threshold | A curve that is 0.0 until the threshold, then jumps to 1.0. |

You can use either constructors of Curve subclasses in Table 11-3 to create new curves or use constants in Curves class. Constants in Curves class are generally good enough for most cases. For a Curve object, you can use the flipped property to get a new curve that is the inversion of this one.

With Curve objects, you can create curved animations using CurvedAnimation class. Table 11-4 shows parameters of CurvedAnimation constructor. If reverseCurve parameter is null, the specified curve is used in both directions.

Table 11-4. Parameters of CurvedAnimation

| Name | Type | Description |
|--------------|-------------------|---|
| parent | Animation<double> | The animation to apply the curve. |
| curve | Curve | The curve to use in forward direction. |
| reverseCurve | Curve | The curve to use in backward direction. |

In Listing 11-5, AnimatedBox widget uses the animation value to determine the left position of the box. The CurvedAnimation object is created with Curves.easeInOut curve.

Listing 11-5. CurvedAnimation

```
class CurvedPosition extends StatefulWidget {  
  @override  
  _CurvedPositionState createState() => _CurvedPositionState();  
}  
  
class _CurvedPositionState extends State<CurvedPosition>  
  with SingleTickerProviderStateMixin {  
  AnimationController controller;  
  Animation<double> animation;  
  
  @override  
  void initState() {  
    super.initState();  
    controller = AnimationController(  
      duration: const Duration(seconds: 5),  
      vsync: this,  
    )..forward();  
    animation = CurvedAnimation(parent: controller, curve:  
      Curves.easeInOut);  
  }  
  
  @override  
  Widget build(BuildContext context) {  
    return AnimatedBox(  
      animation: animation,  
    );  
  }  
  
  @override  
  void dispose() {  
    controller.dispose();  
    super.dispose();  
  }  
}
```

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```
    }
}

class AnimatedBox extends AnimatedWidget {
    AnimatedBox({Key key, this.animation})
        : super(key: key, listenable: animation);

    final Animation<double> animation;
    final double _width = 400;

    @override
    Widget build(BuildContext context) {
        return Container(
            width: _width,
            height: 20,
            child: Stack(
                children: <Widget>[
                    Positioned(
                        left: animation.value * _width,
                        bottom: 0,
                        child: Container(
                            width: 10,
                            height: 10,
                            decoration: BoxDecoration(color: Colors.red),
                        ),
                    ),
                ],
            ),
        );
    }
}
```

CurveTween class uses a Curve object to transform the value of the animation. You can use CurveTween objects when you need to chain a curve animation with another Tween object.

11-4. Chaining Tweens

Problem

You want to chain tweens.

Solution

Use `chain()` method of `Animatable` class or `drive()` method of `Animation` class.

Discussion

`Animatable` is the superclass of `Tween`, `CurveTween`, and `TweenSequence` classes. Given an `Animatable` object, you can use the `chain()` method with another `Animatable` object as the parent. For a given input value, the parent `Animatable` object is evaluated first, then the result is used as the input of the current `Animatable` object. You can use multiple `chain()` methods to create complex animations.

In Listing 11-6, the `Tween` object is chained with another `CurveTween` object.

Listing 11-6. Chain tweens

```
var animation = Tween(begin: 0.0, end: 300.0)
    .chain(CurveTween(curve: Curves.easeOut))
    .animate(controller);
```

You can also use the `drive()` method of `Animation` class to chain an `Animatable` object.

11-5. Creating Sequences of Tweens

Problem

You want to create a sequence of tweens for different stages.

Solution

Use TweenSequence class.

Discussion

By using TweenSequence class, you can use different Animatable objects for different stages of an animation. A TweenSequence object is defined by a list of TweenSequenceItem objects. Each TweenSequenceItem object has an Animatable object and a weight. The weight defines the relative percentage of this TweenSequenceItem object in the whole duration of its parent TweenSequence object.

In Listing 11-7, the animation is created with 40% of linear tween and 60% of curved tween.

Listing 11-7. Example of TweenSequence

```
var animation = TweenSequence([
    TweenSequenceItem(
        tween: Tween(begin: 0.0, end: 100.0),
        weight: 40,
    ),
    TweenSequenceItem(
        tween: Tween(begin: 100.0, end: 300.0)
            .chain(CurveTween(curve: Curves.easeInOut)),
        weight: 60,
    )
]).animate(controller);
```

11-6. Running Simultaneous Animations

Problem

You want to run simultaneous animations in `AnimatedWidget`.

Solution

Use `evaluate()` method of `Animatable` class.

Discussion

`AnimatedWidget` constructor only supports a single `Animation` object. If you want to use multiple animations in an `AnimatedWidget` object, you need to create multiple `Tween` objects in the `AnimatedWidget` object and use `evaluate()` method to get the values for the `Animation` object.

In Listing 11-8, `_leftTween` and `_bottomTween` objects determine the left and bottom properties, respectively.

Listing 11-8. Simultaneous animations

```
class AnimatedBox extends AnimatedWidget {  
    AnimatedBox({Key key, this.animation})  
        : super(key: key, listenable: animation);  
  
    final Animation<double> animation;  
    final double _width = 400;  
    final double _height = 300;  
    static final _leftTween = Tween(begin: 0, end: 1.0);  
    static final _bottomTween = CurveTween(curve: Curves.ease);  
  
    @override  
    Widget build(BuildContext context) {  
        return Container(  
            width: _width,  
            height: _height,  
            decoration: BoxDecoration(  
                color: Colors.white,  
                border: Border.all(  
                    color: Colors.black,  
                    width: 2.0),  
                boxShadow: [BoxShadow(  
                    color: Colors.black,  
                    offset: Offset(0, 10),  
                    blurRadius: 10.0)],  
            ),  
            child: Stack(  
                children: [Container(  
                    width: _width - 2 * 2.0,  
                    height: _height - 2 * 2.0,  
                    decoration: BoxDecoration(  
                        color: Colors.white,  
                        border: Border.all(  
                            color: Colors.black,  
                            width: 2.0),  
                        boxShadow: [BoxShadow(  
                            color: Colors.black,  
                            offset: Offset(0, 10),  
                            blurRadius: 10.0)],  
                    ),  
                    Positioned(  
                        left: 2.0,  
                        top: 2.0,  
                        child: Container(  
                            width: _width - 4.0,  
                            height: _height - 4.0,  
                            decoration: BoxDecoration(  
                                color: Colors.white,  
                                border: Border.all(  
                                    color: Colors.black,  
                                    width: 2.0),  
                                boxShadow: [BoxShadow(  
                                    color: Colors.black,  
                                    offset: Offset(0, 10),  
                                    blurRadius: 10.0)],  
                            ),  
                        ),  
                    ),  
                ],  
            ),  
        );  
    }  
}
```

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```
width: _width,  
height: _height,  
margin: EdgeInsets.all(10),  
decoration: BoxDecoration(border: Border.all()),  
child: Stack(  
    children: <Widget>[  
        Positioned(  
            left: _leftTween.evaluate(animation) * _width,  
            bottom: _bottomTween.evaluate(animation) * _height,  
            child: Container(  
                width: 10,  
                height: 10,  
                decoration: BoxDecoration(color: Colors.red),  
            ),  
        ),  
    ],  
,  
);  
}  
}
```

11-7. Creating Staggered Animations

Problem

You want to create sequential or overlapping animations.

Solution

Use Interval class.

Discussion

With TweenSequence class, you can create a sequence of tweens. However, tweens specified in TweenSequence objects cannot be overlapping. To create overlapping animations, you can use Interval curve to specify the begin and end time of an animation.

In Listing 11-9, three Tween objects animate in different intervals specified in Interval objects. These Tween objects are controlled by the same Animation object.

Listing 11-9. Staggered animations

```
class AnimatedContainer extends StatelessWidget {  
    AnimatedContainer({Key key, this.animation})  
        : width = Tween(begin: 0.0, end: 300.0).  
        animate(CurvedAnimation(  
            parent: animation,  
            curve: Interval(0.0, 0.5, curve: Curves.  
            easeInOut))),  
        height = Tween(begin: 0.0, end: 200.0).  
        animate(CurvedAnimation(  
            parent: animation,  
            curve: Interval(0.2, 0.7, curve: Curves.  
            bounceInOut))),  
        backgroundColor = ColorTween(begin: Colors.red, end:  
        Colors.green)  
            .animate(CurvedAnimation(  
                parent: animation,  
                curve: Interval(0.3, 1.0, curve: Curves.  
                elasticInOut))),  
        super(key: key);  
}
```

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```
final Animation<double> animation;
final Animation<double> width;
final Animation<double> height;
final Animation<Color> backgroundColor;

Widget _build(BuildContext context, Widget child) {
  return Container(
    width: width.value,
    height: height.value,
    decoration: BoxDecoration(color: backgroundColor.value),
    child: child,
  );
}

@Override
Widget build(BuildContext context) {
  return AnimatedBuilder(
    animation: animation,
    builder: _build,
  );
}
```

11-8. Creating Hero Animations

Problem

You want to animate an element across two routes.

Solution

Use Hero widget.

Discussion

When switching from the current route to a new route, it's better to have some elements in the new route to indicate the navigation context. For example, the current route displays a list of items. When the user taps one item to navigate to the details route, the new route should have a widget to show brief information about the selected item.

Hero widget is shared between two routes. A Hero widget is created with a tag and a child widget. The tag is the unique identifier of a Hero widget. If the source route and target route both have a Hero widget with the same tag, then during route transition, the Hero widget in source route is animated to the location in the target route. Tags of Hero widget must be unique in the same widgets tree.

In Listing 11-10, ImageHero class wraps a Hero widget that displays an image in a SizedBox widget. The tag is set to the image's URL.

Listing 11-10. Hero widget

```
class ImageHero extends StatelessWidget {  
    ImageHero({Key key, this.imageUrl, this.width, this.height})  
        : super(key: key);  
  
    final String imageUrl;  
    final double width;  
    final double height;  
  
    @override  
    Widget build(BuildContext context) {  
        return SizedBox(  
            width: width,  
            height: height,  
            child: Hero(  
                tag: imageUrl,
```

```
        child: Image.network(imageUrl),
    ),
);
}
}
```

Listing 11-11 shows the current route that displays a list of images. ImageHero widget is wrapped in a GridTile widget. Tapping an image navigates to the new route with ImageView widget.

Listing 11-11. Current route with ImageHero

```
class ImagesPage extends StatelessWidget {
  @override
  Widget build(BuildContext context) {
    return Scaffold(
      appBar: AppBar(
        title: Text('Images'),
      ),
      body: GridView.count(
        crossAxisCount: 2,
        children: List.generate(8, (int index) {
          String imageUrl = 'https://picsum.
          photos/300?random&$index';
          return GridTile(
            child: InkWell(
              onTap: () {
                Navigator.push(
                  context,
                  MaterialPageRoute(builder: (BuildContext
                  context) {
                    return ImageView(imageUrl: imageUrl);
                  }),
                );
              }
            );
          );
        })
      );
    }
}
```

```
        );
    },
    child: ImageHero(
        imageUrl: imageUrl,
        width: 300,
        height: 300,
    ),
),
);
}),
),
),
);
}
}
```

Listing 11-12 shows the ImageView widget. It also has an ImageHero widget with the same tag as the selected image. This is required to make the animation work.

Listing 11-12. New route with ImageHero

```
class ImageView extends StatelessWidget {
    ImageView({Key key, this.imageUrl}) : super(key: key);
    final String imageUrl;

    @override
    Widget build(BuildContext context) {
        return Scaffold(
            appBar: AppBar(
                title: Text('Image'),
            ),
            body: Row(
                children: <Widget>[
```

```
    ImageHero(
        width: 50,
        height: 50,
        imageUrl: imageUrl,
    ),
    Expanded(
        child: Text('Image Detail'),
    ),
],
),
);
}
}
```

11-9. Using Common Transitions

Problem

You want to have a simple way to use different types of Tween objects for animations.

Solution

Use different types of transitions.

Discussion

It's common to use different types of Tween objects to animate different aspects of widgets. You can use `AnimatedWidget` or `AnimatedBuilder` class to work with Tween objects. Flutter SDK provides several transition widgets to make certain animations easy to use.

ScaleTransition widget animates the scale of a widget. To create a ScaleTransition object, you need to provide an Animation<double> object as the scale. The alignment parameter specifies the alignment of the origin of scaling coordinates relative to the box. Listing 11-13 shows an example of ScaleTransition.

Listing 11-13. Example of ScaleTransition

```
class ScaleBox extends StatelessWidget {  
  ScaleBox({Key key, Animation<double> animation})  
    : _animation = CurveTween(curve: Curves.ease).  
      animate(animation),  
    super(key: key);  
  
  final Animation<double> _animation;  
  
  @override  
  Widget build(BuildContext context) {  
    return ScaleTransition(  
      scale: _animation,  
      alignment: Alignment.centerLeft,  
      child: Container(  
        height: 100,  
        decoration: BoxDecoration(color: Colors.red),  
      ),  
    );  
  }  
}
```

Another example of transition widget is FadeTransition widget that animates the opacity. Listing 11-14 shows an example of FadeTransition.

Listing 11-14. Example of FadeTransition

```
class FadeBox extends StatelessWidget {  
  FadeBox({Key key, Animation<double> animation})  
    : _animation = CurveTween(curve: Curves.ease).  
      animate(animation),  
      super(key: key);  
  
  final Animation<double> _animation;  
  
  @override  
  Widget build(BuildContext context) {  
    return FadeTransition(  
      opacity: _animation,  
      child: Container(  
        height: 100,  
        decoration: BoxDecoration(color: Colors.red),  
      ),  
    );  
  }  
}
```

11-10. Creating Physics Simulations

Problem

You want to use physics simulations.

Solution

Use simulations in physics library.

Discussion

Animations in the animation library are either linear or curved. The physics library provides physics simulations, including springs, friction, and gravity. `Simulation` class is the base class for all simulations. A simulation is also changing over time. For a point of time, the method `x()` returns the position, the method `dx()` returns the velocity, and `isDone()` method returns whether the simulation is done. Given a `Simulation` object, you can use `animateWith()` method of `AnimationController` class to drive the animation using this simulation.

`SpringSimulation` class represents the simulation for a particle attached to a spring. To create a `SpringSimulation` object, you can provide the parameters listed in Table 11-5.

Table 11-5. Parameters of SpringSimulation

| Name | Type | Description |
|------------------------|--------------------------------|--|
| <code>spring</code> | <code>SpringDescription</code> | The description of a spring. |
| <code>start</code> | <code>double</code> | The start distance. |
| <code>end</code> | <code>double</code> | The end distance. |
| <code>velocity</code> | <code>double</code> | The initial velocity. |
| <code>tolerance</code> | <code>Tolerance</code> | Magnitudes of differences for distances, durations, and velocity to be considered equal. |

To create `SpringDescription` objects, you can use the `SpringDescription()` constructor with parameters to specify mass, stiffness, and damping coefficient. The `SpringDescription.withDampingRatio()` constructor uses a damping ratio instead of damping coefficient. Listing 11-15 shows an example of creating `SpringSimulation` object.

Listing 11-15. Spring simulation

```
SpringSimulation _springSimulation = SpringSimulation(
    SpringDescription.withDampingRatio(
        mass: 1.0,
        stiffness: 50,
        ratio: 1.0,
    ),
    0.0,
    1.0,
    1.0)
..tolerance = Tolerance(distance: 0.01, velocity: double.
infinity);
```

An easier way to use spring simulation is using the `fling()` method of `AnimationController` class. This method drives the animation with a critically damped spring.

`GravitySimulation` class represents a simulation for a particle that follows Newton's second law of motion. Table 11-6 shows parameters of `GravitySimulation` constructor.

Table 11-6. Parameters of `GravitySimulation`

| Name | Type | Description |
|--------------|--------|---|
| acceleration | double | Acceleration of the particle. |
| distance | double | Initial distance. |
| endDistance | double | End distance for the simulation to be done. |
| velocity | double | Initial velocity. |

In Listing 11-16, `SimulationController` widget uses a `Simulation` object to drive the animation.

Listing 11-16. Use simulation with animation

```
typedef BuilderFunc = Widget Function(BuildContext,  
Animation<double>);  
  
class SimulationController extends StatefulWidget {  
  SimulationController({Key key, this.simulation, this.  
    builder})  
    : super(key: key);  
  final Simulation simulation;  
  final BuilderFunc builder;  
  
  @override  
  _SimulationControllerState createState() =>  
  _SimulationControllerState();  
}  
  
class _SimulationControllerState extends  
State<SimulationController>  
  with SingleTickerProviderStateMixin {  
  AnimationController controller;  
  
  @override  
  void initState() {  
    super.initState();  
    controller = AnimationController(  
      vsync: this,  
      ..animateWith(widget.simulation));  
  }  
  
  @override  
  Widget build(BuildContext context) {  
    return widget.builder(context, controller.view);  
  }  
}
```

```
    @override
    void dispose() {
        controller.dispose();
        super.dispose();
    }
}
```

11-11. Summary

This chapter covers recipes related to animations in Flutter. AnimationController class is used to control animations. Subclasses of Tween class create linear animations for different types of data. AnimatedWidget and AnimatedBuilder are useful widgets that use animations. In the next chapter, we'll discuss integration with native platform in Flutter.

CHAPTER 12

Platform Integration

In mobile apps, it's common to integrate with the native platform. You can write platform-specific code to use native platform API. There are a large number of plugins to perform different tasks.

12-1. Reading and Writing Files

Problem

You want to read and write files.

Solution

Use File API.

Discussion

In mobile apps, you may need to save files on the device. The `dart:io` library provides files API to read and write files. `File` class has methods to read content, write content, and query metadata of files. Operations with file system can be synchronous or asynchronous. Most of these operations have a pair of methods in `File` class. The asynchronous method returns a `Future` object, while the synchronous method uses `Sync` as the name suffix and returns the actual value. For example, `readAsString()` and `readAsStringSync()` methods are the pair for read operation that returns a string. Table 12-1 shows asynchronous methods of `File` class.

Table 12-1. Asynchronous methods of File

| Name | Description |
|---|--|
| copy(String newPath) | Copy this file to a new path. |
| create({bool recursive: false}) | Create this file. If recursive is true, all directories will be created. |
| open() | Open the file for random access with a RandomAccessFile object. |
| readAsBytes() | Read the entire file content as a list of bytes. |
| readAsString({Encoding encoding: utf8}) | Read the entire file content as a string using specified encoding. |
| readAsLines(({Encoding encoding: utf8}) | Read the entire file content as lines of text using specified encoding. |
| writeAsBytes(List<int> bytes) | Write a list of bytes to the file. |
| writeAsString(String contents) | Write a string to the file. |
| rename(String newPath) | Rename this file to a new path. |
| delete({bool recursive: false}) | Delete this file. |
| exists() | Check whether this file exists. |
| stat() | Return a FileStat object that describes the file. |
| lastAccessed() | Get the last accessed time of this file. |
| lastModified() | Get the last modified time of this file. |
| length() | Get the length of this file. |

Directory class represents directories in the file system. Given a Directory object, list() or listSync() methods can be used to list files and sub-directories.

To create File objects, you can use the default constructor with a path. For Flutter apps, the path may be platform-specific. There are two common places to store files for mobile apps:

- Temporary directory to store temporary files that may be cleared at any time
- Documents directory to store files that are private to the app and will only be cleared when the app is deleted

To get the platform-specific paths for these two locations, you can use the path_provider package (https://pub.dev/packages/path_provider). This package provides getTemporaryDirectory() function to get the path of the temporary directory and getApplicationDocumentsDirectory() function to get the application documents directory.

In Listing 12-1, readConfig() method reads the config.txt file from the application documents directory, while writeConfig() method writes a string to the same file.

Listing 12-1. Read and write files

```
class ConfigFile {
  Future<File> get _configFile async {
    Directory directory = await
      getApplicationDocumentsDirectory();
    return File('${directory.path}/config.txt');
  }

  Future<String> readConfig() async {
    return _configFile
      .then((file) => file.readAsString())
```

```
        .catchError((error) => 'default config');  
    }  
  
    Future<File> writeConfig(String config) async {  
        File file = await _configFile;  
        return file.writeAsString(config);  
    }  
}
```

12-2. Storing Key-Value Pairs

Problem

You want to store type-safe key-value pairs.

Solution

Use shared_preferences plugin.

Discussion

You can use files API to store any data on the device. Using generic files API means that you need to deal with data serialization and deserialization yourself. If the data you need to store is simple key-value pairs, using shared_preferences plugin (https://pub.dev/packages/shared_preferences) is a better choice. This plugin provides a map-based API to manage type-safe key-value pairs. The type of keys is always String. Only several types can be used as values, including String, bool, double, int, and List<String>.

To manage key-value pairs, you need to use the static SharedPreferences.getInstance() method to get the SharedPreferences object. Table 12-2 shows methods of SharedPreferences class. For each

supported data type, there is a pair of methods to get and set the value. For example, `getBool()` and `setBool()` methods are used to get and set `bool` values.

Table 12-2. Methods of SharedPreference

| Name | Description |
|--|---|
| <code>get(String key)</code> | Read the value for the specified key. |
| <code>containsKey(String key)</code> | Check whether specified key exists. |
| <code>getKeys()</code> | Get a set of keys. |
| <code>remove(String key)</code> | Remove the pair with the specified key. |
| <code>clear()</code> | Remove all pairs. |
| <code>setString(String key, String value)</code> | Write a String value. |
| <code>getString()</code> | Read a String value. |

In Listing 12-2, `SharedPreferences` class is used to read and write a key-value pair.

Listing 12-2. Use SharedPreferences

```
class AppConfig {
    Future<SharedPreferences> _getPrefs() async {
        return await SharedPreferences.getInstance();
    }

    Future<String> getName() async {
        SharedPreferences prefs = await _getPrefs();
        return prefs.getString('name') ?? '';
    }

    Future<bool> setName(String name) async {
        SharedPreferences prefs = await _getPrefs();
```

```
        return prefs.setString('name', name);  
    }  
}
```

12-3. Writing Platform-Specific Code

Problem

You want to write platform-specific code.

Solution

Use platform channels to pass messages between Flutter app and the underlying host platform.

Discussion

In Flutter apps, most of code is written in platform agnostic Dart code. Features provided by Flutter SDK are limited. Sometimes you may still need to write platform-specific code to use native platform APIs. A generated Flutter app already has platform-specific code in `android` and `ios` directories. Code in these two directories is required to build native bundles.

Flutter uses message passing to call platform-specific APIs and get the result back. Messages are passed through platform channels. Flutter code sends messages to the host over a platform channel. Host code listens on the platform channel and receives the message. It then uses platform-specific API to generate the response and sends it back over the same channel to the Flutter code. Messages passed are actually asynchronous method calls.

In Flutter code, platform channels are created using `MethodChannel` class. All channel names in an app must be unique. It's recommended to

use a domain name as the prefix of channel names. To send method calls over a channel, these method calls must be encoded into binary format before being sent, and results received are decoded into Dart values.

Encoding and decoding are done using subclasses of `MethodCodec` class:

- `StandardMethodCodec` class uses standard binary encoding.
- `JSONMethodCodec` class uses UTF-8 JSON encoding.

`MethodChannel` constructor has `name` parameter to specify the channel name and `codec` parameter to specify the `MethodCodec` object. The default `MethodCodec` object used is a `StandardMethodCodec` object.

Given a `MethodChannel` object, the `invokeMethod()` method invokes a method on the channel with specified arguments. The return value is a `Future<T>` object. This `Future` object may complete with different values:

- It completes with the result if the method call succeeds.
- It completes with a `PlatformException` if the method call fails.
- It completes with a `MissingPluginException` if the method has not been implemented.

The `invokeListMethod()` method also invokes a method but returns a `Future<List<T>>` object. The `invokeMapMethod()` method invokes a method and returns a `Future<Map<K, V>>` object. Both `invokeListMethod()` and `invokeMapMethod()` methods use `invokeMethod()` internally, but add extra type cast.

In Listing 12-3, the `getNetworkOperator` method is invoked over the channel and returns the network operator.

Listing 12-3. Get network operator

```
class NetworkOperator extends StatefulWidget {  
  @override  
  _NetworkOperatorState createState() =>  
  _NetworkOperatorState();  
}  
  
class _NetworkOperatorState extends State<NetworkOperator> {  
  static const channel = const MethodChannel('flutter-recipes/  
network');  
  
  String _networkOperator = "  
";  
  
  @override  
  void initState() {  
    super.initState();  
    _getNetworkOperator();  
  }  
  
  Future<void> _getNetworkOperator() async {  
    String operator;  
    try {  
      operator = await channel.invokeMethod('getNetworkOperator'  
        ') ?? 'unknown';  
    } catch (e) {  
      operator = 'Failed to get network operator: ${e.  
        message}';  
    }  
  
    setState(() {  
      _networkOperator = operator;  
    });  
  }  
}
```

```
@override
Widget build(BuildContext context) {
  return Container(
    child: Center(
      child: Text(_networkOperator),
    ),
  );
}
```

The handler of `getNetworkOperator` method call needs to be implemented in both Android and iOS platforms. Listing 12-4 shows the Java implementation. The `getNetworkOperator()` method uses Android API to get network operator. In the method call handler of the channel, if the method name is `getNetworkOperator`, the result of `getNetworkOperator()` method is sent back as success response using `Result.success()` method. If you want to send back error response, you can use `Result.error()` method. If the method is unknown, you should use `Result.notImplemented()` to mark the method as unimplemented.

Listing 12-4. Android implementation of `getNetworkOperator`

```
public class MainActivity extends FlutterActivity {
  private static final String CHANNEL = "flutter-recipes/
  network";

  @Override
  protected void onCreate(Bundle savedInstanceState) {
    super.onCreate(savedInstanceState);
    GeneratedPluginRegistrant.registerWith(this);

    new MethodChannel(getFlutterView(), CHANNEL)
      .setMethodCallHandler((methodCall, result) -> {
        if ("getNetworkOperator".equals(methodCall.method)) {
```

```
        result.success(getNetworkOperator());
    } else {
        result.notImplemented();
    }
});

private String getNetworkOperator() {
    TelephonyManager telephonyManager =
        ((TelephonyManager) getSystemService(Context.TELEPHONY_
        SERVICE));
    return telephonyManager.getNetworkOperatorName();
}
}
```

Listing 12-5 shows the `AppDelegate.swift` file for iOS platform. The `receiveNetworkOperator()` function uses iOS API to get the carrier name and send back as response using `FlutterResult`.

Listing 12-5. Swift implementation of `getNetworkOperator`

```
import UIKit
import Flutter
import CoreTelephony

@UIApplicationMain
@objc class AppDelegate: FlutterAppDelegate {
    override func application(
        _ application: UIApplication,
        didFinishLaunchingWithOptions launchOptions:
        [UIApplicationLaunchOptionsKey: Any]?
    ) -> Bool {
        GeneratedPluginRegistrant.register(with: self)
    }
}
```

```
guard let controller = window?.rootViewController as?
FlutterViewController else {
    fatalError("rootViewController is not type
FlutterViewController")
}
let networkChannel = FlutterMethodChannel(name: "flutter-
recipes/network", binaryMessenger: controller)
networkChannel.setMethodCallHandler({
    [weak self] (call: FlutterMethodCall, result:
FlutterResult) -> Void in
    guard call.method == "getNetworkOperator" else {
        result(FlutterMethodNotImplemented)
        return
    }
    self?.receiveNetworkOperator(result: result)
})

return super.application(application,
didFinishLaunchingWithOptions: launchOptions)
}

private func receiveNetworkOperator(result: FlutterResult) {
    let networkInfo = CTTelephonyNetworkInfo()
    let carrier = networkInfo.subscriberCellularProvider
    result(carrier?.carrierName)
}
}
```

12-4. Creating Plugins

Problem

You want to create sharable plugins that contain platform-specific code.

Solution

Create Flutter projects using the plugin template.

Discussion

Recipe 12-4 shows how to add platform-specific code to Flutter apps. Code added to a Flutter app cannot be shared between different apps. If you want to make the platform-specific code reusable, you can create Flutter plugins. Plugins are another type of projects supported in Flutter SDK. Plugins can be shared like other Dart packages using Dart pub tool (<https://pub.dev/>).

To create a new Flutter plugin, you can use `flutter create --template=plugin` command. The `template=plugin` parameter means using the `plugin` template to create a Flutter project. You can choose to use either Java or Kotlin for Android and Objective-C or Swift for iOS, respectively. By default, Java is used for Android and Objective-C is used for iOS. You can use `-a` parameter with values `java` and `kotlin` to specify the language for Android and `-i` parameter with values `objc` and `swift` to specify the language for iOS. The following command shows how to create a plugin using Swift for iOS.

```
$ flutter create --template=plugin -i swift network
```

You can also use Android Studio or VS Code to create new plugins.

The newly created plugin already has skeleton code that gets the platform version. We can use the code in Recipe 12-3 to implement the

plugin with new method to get the network operator. In the directory of generated plugin, there are several sub-directories:

- The `lib` directory contains plugin's public Dart API.
- The `android` directory contains Android implementation of the public API.
- The `ios` directory contains iOS implementation of the public API.
- The `example` directory contains an example Flutter app that uses this plugin.
- The `test` directory contains test code.

We first define the public Dart API in `lib/network_plugin.dart` file. In Listing 12-6, the value of the `networkOperator` property is retrieved by calling `getNetworkOperator` method using the method channel.

Listing 12-6. Plugin Dart API

```
class NetworkPlugin {  
    static const MethodChannel _channel =  
        const MethodChannel('network_plugin');  
  
    static Future<String> get networkOperator async {  
        return await _channel.invokeMethod('getNetworkOperator');  
    }  
}
```

The `NetworkPlugin.java` file in Listing 12-7 is the Android implementation of the plugin. `NetworkPlugin` class implements `MethodCallHandler` interface to handle method calls received from the platform channel.

Listing 12-7. Android implementation

```
public class NetworkPlugin implements MethodCallHandler {  
    public static void registerWith(Registrar registrar) {  
        final MethodChannel channel = new MethodChannel(registrar.  
messenger(), "network_plugin");  
        channel.setMethodCallHandler(new NetworkPlugin(registrar));  
    }  
  
    NetworkPlugin(Registrar registrar) {  
        this.registrar = registrar;  
    }  
  
    private final PluginRegistry.Registrar registrar;  
  
    @Override  
    public void onMethodCall(MethodCall call, Result result) {  
        if (call.method.equals("getNetworkOperator")) {  
            result.success(getNetworkOperator());  
        } else {  
            result.notImplemented();  
        }  
    }  
  
    private String getNetworkOperator() {  
        Context context = registrar.context();  
        TelephonyManager telephonyManager =  
            ((TelephonyManager) context.getSystemService(Context.  
TELEPHONY_SERVICE));  
        return telephonyManager.getNetworkOperatorName();  
    }  
}
```

The `SwiftNetworkPlugin.swift` file in Listing 12-8 is the Swift implementation of the plugin.

Listing 12-8. Swift implementation

```
public class SwiftNetworkPlugin: NSObject, FlutterPlugin {
    public static func register(with registrar:
        FlutterPluginRegistrar) {
        let channel = FlutterMethodChannel(name: "network_plugin",
            binaryMessenger: registrar.messenger())
        let instance = SwiftNetworkPlugin()
        registrar.addMethodCallDelegate(instance, channel: channel)
    }

    public func handle(_ call: FlutterMethodCall,
        result: @escaping FlutterResult) {
        if (call.method == "getNetworkOperator") {
            self.receiveNetworkOperator(result: result)
        } else {
            result(FlutterMethodNotImplemented)
        }
    }

    private func receiveNetworkOperator(result: FlutterResult) {
        let networkInfo = CTTelephonyNetworkInfo()
        let carrier = networkInfo.subscriberCellularProvider
        result(carrier?.carrierName)
    }
}
```

The example project and test code also need to be updated with new API.

12-5. Displaying Web Pages

Problem

You want to display web pages.

Solution

Use `webview_flutter` plugin.

Discussion

If you want to display web pages inside of Flutter apps, you can use `webview_flutter` plugin (https://pub.dartlang.org/packages/webview_flutter). After adding `webview_flutter: ^0.3.6` to the dependencies of `pubspec.yaml` file, you can use `WebView` widget to show web pages and interact with them. For iOS, you need to add the `io.flutter.embedded_views_preview` key with value YES to the `ios/Runner/Info.plist` file.

Table 12-3 shows parameters of `WebView` constructor. To control the web view, you need to use `onWebViewCreated` callback to get the `WebViewController` object. The value of `javascriptMode` can be `JavascriptMode.disabled` or `JavascriptMode.unrestricted`. To enable JavaScript execution in the web pages, `JavascriptMode.unrestricted` should be set as the value. The `navigationDelegate` of type `NavigationDelegate` is a function that takes a `NavigationRequest` object and returns value of `NavigationDecision` enum. If the return value is `NavigationDecision.prevent`, the navigation request is blocked. If the return value is `NavigationDecision.navigate`, then navigation

request can continue. You can use navigation delegate to block users from accessing restricted pages. The `onPageFinished` callback receives the URL of the loaded page.

Table 12-3. Parameters of `WebView` constructor

| Name | Description |
|---------------------------------|---|
| <code>initialUrl</code> | The initial URL to load. |
| <code>onWebViewCreated</code> | Callback when the <code>WebView</code> is created. |
| <code>javascriptMode</code> | Whether JavaScript is enabled. |
| <code>javascriptChannels</code> | Channels to receive messages sent by JavaScript code running in the web view. |
| <code>navigationDelegate</code> | Determines whether a navigation request should be handled. |
| <code>onPageFinished</code> | Callback when a page loading is finished. |
| <code>gestureRecognizers</code> | Gestures recognized by the web view. |

After getting the `WebViewController` object, you can use methods shown in Table 12-4 to interact with the web view. All these methods are asynchronous and return `Future` objects. For example, the `canGoBack()` method returns a `Future<bool>` object.

Table 12-4. Methods of *WebViewController*

| Name | Description |
|--|--|
| evaluateJavascript(String javascriptString) | Evaluate JavaScript code in the context of current page. |
| loadUrl(String url, { Map<String, String> headers }) | Load the specified URL. |
| reload() | Reload the current URL. |
| goBack() | Go back in the navigation history. |
| canGoBack() | Whether it's valid to go back in the history. |
| goForward() | Go forward in the navigation history. |
| canGoForward() | Whether it's valid to go forward in history. |
| clearCache() | Clear the cache. |
| currentUrl() | Get the current URL. |

Listing 12-9 shows an example of using `WebView` widget to interact with Google Search page. Because the creation of `WebView` widget is asynchronous, the `Completer<WebViewController>` object is used to capture the `WebViewController` object. In the `onWebViewCreated` callback, the `Completer<WebViewController>` object is completed with the created `WebViewController` object. In the `onPageFinished` callback, the `evaluateJavascript()` method of `WebViewController` object is used to execute JavaScript code that sets value to the input and clicks the search button. This causes the `WebView` widget to load the search result page.

The `JavascriptChannel` object is created with a channel name and a `JavascriptMessageHandler` function to handle the messages sent from JavaScript code running in the web page. The message handler in Listing 12-9 uses a `SnackBar` widget to show the received message. The channel

name “Messenger” becomes the global object that has a postMessage function to be used in JavaScript code to send messages back.

Listing 12-9. Use WebView

```
class GoogleSearch extends StatefulWidget {  
    @override  
    _GoogleSearchState createState() => _GoogleSearchState();  
}  
  
class _GoogleSearchState extends State<GoogleSearch> {  
    final Completer<WebViewController> _controller =  
        Completer<WebViewController>();  
  
    @override  
    Widget build(BuildContext context) {  
        return WebView(  
            initialUrl: 'https://google.com',  
            javascriptMode: JavascriptMode.unrestricted,  
            javascriptChannels:  
                <JavascriptChannel>[_javascriptChannel(context)].  
                toSet(),  
            onWebViewCreated: (WebViewController webViewController) {  
                _controller.complete(webViewController);  
            },  
            onPageFinished: (String url) {  
                _controller.future.then((WebViewController  
                    webViewController) {  
                    webViewController.evaluateJavascript(  
                        'Messenger.postMessage("Loaded in " + navigator.  
                        userAgent);');  
                    webViewController.evaluateJavascript(  
                        'document.getElementsByName("q")[0].  
                        value="flutter";'  
                );  
            },  
        );  
    }  
}
```

```
        'document.querySelector("button[aria-  
label*=Search]").click();');  
    });  
},  
);  
}  
  
JavascriptChannel _javascriptChannel(BuildContext context) {  
    return JavascriptChannel(  
        name: 'Messenger',  
        onMessageReceived: (JavascriptMessage message) {  
            Scaffold.of(context).showSnackBar(  
                SnackBar(content: Text(message.message)),  
            );  
        }  
    );  
}
```

12-6. Playing Videos

Problem

You want to play videos.

Solution

Use video_player plugin.

Discussion

If you want play videos from assets, file system, or network, you can use `video_player` plugin (https://pub.dev/packages?q=video_player). To use this plugin, you need to add `video_player: ^0.10.0+5` to the dependencies of `pubspec.yaml` file. For iOS, you need to use a real device instead of a simulator for development and testing. If you want to load videos from arbitrary locations, you need to add the code in Listing 12-10 to `ios/Runner/Info.plist` file. Using `NSAllowsArbitraryLoads` reduces the security of the app. It's better to check Apple's guide (https://developer.apple.com/documentation/security/preventing_insecure_network_connections) for network security.

Listing 12-10. iOS HTTP security config

```
<key>NSAppTransportSecurity</key>
<dict>
    <key>NSAllowsArbitraryLoads</key>
    <true/>
</dict>
```

If you need to load videos from network on Android, you need to add code in Listing 12-11 to the `android/app/src/main/AndroidManifest.xml` file.

Listing 12-11. Android

```
<uses-permission android:name="android.permission.INTERNET"/>
```

To play videos, you need to use constructors shown in Table 12-5 to create `VideoPlayerController` objects.

Table 12-5. Constructors of *VideoPlayerController*

| Name | Description |
|--|--------------------------------------|
| VideoPlayerController.asset(String dataSource, { String package }) | Play a video from assets. |
| VideoPlayerController.file(File file) | Play a video from local file system. |
| VideoPlayerController.network(String dataSource) | Play a video loaded from network. |

After creating a `VideoPlayerController` object, you can use methods shown in Table 12-6 to control the video playing. All these methods return `Future` objects. The `initialize()` method must be called first to initialize the controller. You can only call other methods after the `Future` object returned by `initialize()` method completes successfully.

Table 12-6. Methods of *VideoPlayerController*

| Name | Description |
|--------------------------|--|
| play() | Play the video. |
| pause() | Pause the video. |
| seekTo(Duration moment) | Seek to the specified position. |
| setLooping(bool looping) | Whether to loop the video. |
| setVolume(double volume) | Set the volume of audio. |
| initialize() | Initialize the controller. |
| dispose() | Dispose the controller and clean up resources. |

VideoPlayerController class extends from ValueNotifier<VideoPlayerValue> class. You can get notified when the state changes by adding listeners to it. VideoPlayerValue class contains different properties to access the state of the video. VideoPlayer class is the actual widget that displays the video. It requires a VideoPlayerController object.

VideoPlayerView class in Listing 12-12 is a widget to play video loaded from specified URL. In the initState() method, VideoPlayerController.network() constructor is used to create the VideoPlayerController object. FutureBuilder widget uses the Future object returned by initialize() method to build the UI. Since VideoPlayerController object is also a Listenable object, we can use AnimatedBuilder with the VideoPlayerController object. AspectRatio widget uses the aspectRatio property to make sure the proper aspect ratio is used when playing the video. VideoProgressIndicator widget shows a progress bar to indicate video playback progress.

Listing 12-12. Playing video

```
class VideoPlayerView extends StatefulWidget {  
    VideoPlayerView({Key key, this.videoUrl}) : super(key: key);  
  
    final String videoUrl;  
  
    @override  
    _VideoPlayerViewState createState() => _  
    VideoPlayerViewState();  
}  
  
class _VideoPlayerViewState extends State<VideoPlayerView> {  
    VideoPlayerController _controller;  
    Future<void> _initializedFuture;  
  
    @override  
    void initState() {
```

```
super.initState();
_controller = VideoPlayerController.network(widget.
videoUrl);
_initializedFuture = _controller.initialize();
}

@Override
Widget build(BuildContext context) {
return FutureBuilder(
future: _initializedFuture,
builder: (context, snapshot) {
if (snapshot.connectionState == ConnectionState.done) {
return AnimatedBuilder(
animation: _controller,
child: VideoProgressIndicator(_controller,
allowScrubbing: true),
builder: (context, child) {
return Column(
children: <Widget>[
AspectRatio(
aspectRatio: _controller.value.aspectRatio,
child: VideoPlayer(_controller),
),
Row(
children: <Widget>[
IconButton(
icon: Icon(_controller.value.isPlaying
? Icons.pause
: Icons.play_arrow),
onPressed: () {
if (_controller.value.isPlaying) {
_controller.pause();
```

```
        } else {
            _controller.play();
        }
    },
),
Expanded(child: child),
],
),
],
);
},
);
}
else {
    return Center(child: CircularProgressIndicator());
}
},
);
}
}

@Override
void dispose() {
    _controller.dispose();
    super.dispose();
}
}
```

12-7. Using Cameras

Problem

You want to use cameras to take pictures or record videos.

Solution

Use camera plugin.

Discussion

If you want to access the cameras on the device, you can use camera plugin (<https://pub.dev/packages/camera>). To install this plugin, you need to add camera: ^0.5.0 to the dependencies of pubspec.yaml file. For iOS, you need to add code in Listing 12-13 to the ios/Runner/Info.plist file. These two key-value pairs describe the purpose of accessing camera and microphone. This is required to protect user privacy.

Listing 12-13. Privacy requirements for iOS

```
<key>NSCameraUsageDescription</key>
<string>APPNAME requires access to your phone's camera.
</string>
<key>NSMicrophoneUsageDescription</key>
<string>APPNAME requires access to your phone's microphone.
</string>
```

For Android, the minimum Android SDK version needs to set to 21 in the android/app/build.gradle file.

To access cameras, you need to create CameraController objects. CameraController constructor requires parameters of types CameraDescription and ResolutionPreset. CameraDescription class describes a camera. ResolutionPreset enum describes the quality of screen resolution. ResolutionPreset is an enum with values low, medium, and high. To get CameraDescription objects, you can use availableCameras() function to get a list of available cameras with type List<CameraDescription>.

Table 12-7 shows methods of CameraController class. All these methods return Future objects. A CameraController object needs to be initialized first. Other methods should only be called after the Future object returned by initialize() completes successfully. CameraController class extends from ValueNotifier<CameraValue> class, so you can add listeners to it to get notified of state changes.

Table 12-7. Methods of CameraController

| Name | Description |
|--------------------------------------|--|
| takePicture(String path) | Take a picture and save to a file. |
| prepareForVideoRecording() | Prepare for video recording. |
| startVideoRecording(String filePath) | Start a video recording and save to a file. |
| stopVideoRecording() | Stop the current video recording. |
| startImageStream() | Start streaming of images. |
| stopImageStream() | Stop the current streaming of images. |
| initialize() | Initialize the controller. |
| dispose() | Dispose the controller and clean up resources. |

In Listing 12-14, the CameraController object is created with passed-in CameraDescription object. FutureBuilder widget builds the actual UI after the CameraController object is initialized. CameraPreview widget shows live preview of the camera. When the icon is pressed, a picture is taken and saved to the temporary directory.

Listing 12-14. Use camera

```
class CameraView extends StatefulWidget {
  CameraView({Key key, this.camera}) : super(key: key);
  final CameraDescription camera;
```

```
    @override
    _CameraViewState createState() => _CameraViewState();
}

class _CameraViewState extends State<CameraView> {
    CameraController _controller;
    Future<void> _initializedFuture;

    @override
    void initState() {
        super.initState();
        _controller = CameraController(widget.camera,
            ResolutionPreset.high);
        _initializedFuture = _controller.initialize();
    }

    @override
    Widget build(BuildContext context) {
        return FutureBuilder<void>(
            future: _initializedFuture,
            builder: (context, snapshot) {
                if (snapshot.connectionState == ConnectionState.done) {
                    return Column(
                        children: <Widget>[
                            Expanded(child: CameraPreview(_controller)),
                            IconButton(
                                icon: Icon(Icons.photo_camera),
                                onPressed: () async {
                                    String path = join((await
                                        getTemporaryDirectory()).path,
                                        '${DateTime.now().png}');
                                    await _controller.takePicture(path);
                                    Scaffold.of(context).showSnackBar(

```

```
        SnackBar(content: Text('Picture saved to  
$path')));  
    },  
    ),  
    ],  
);  
} else {  
    return Center(child: CircularProgressIndicator());  
}  
},  
);  
}  
  
@override  
void dispose() {  
    _controller.dispose();  
    super.dispose();  
}  
}
```

In Listing 12-15, `availableCameras()` function gets a list of `CameraDescription` objects and only the first one is used to create the `CameraView` widget.

Listing 12-15. Select camera

```
class CameraSelector extends StatelessWidget {  
    final Future<CameraDescription> _cameraFuture =  
        availableCameras().then((list) => list.first);  
  
    @override  
    Widget build(BuildContext context) {  
        return FutureBuilder<CameraDescription>(  
            future: _cameraFuture,  
            builder: (context, snapshot) {  
                if (snapshot.connectionState == ConnectionState.done) {  
                    return CameraView(camera: snapshot.data!);  
                } else {  
                    return Center(child: CircularProgressIndicator());  
                }  
            },  
        );  
    }  
}
```

```
builder: (context, snapshot) {
    if (snapshot.connectionState == ConnectionState.done) {
        if (snapshot.hasData) {
            return CameraView(camera: snapshot.data);
        } else {
            return Center(child: Text('No camera available!'));
        }
    } else {
        return Center(child: CircularProgressIndicator());
    }
},
);
}
}
```

12-8. Using System Share Sheet

Problem

You want to allow user sharing items using system share sheet.

Solution

Use share plugin.

Discussion

If you want to allow user sharing items in the app, you can use the share plugin (<https://pub.dev/packages/share>) to show the system share sheet. To use this plugin, you need to add share: ^0.6.1 to the dependencies of pubspec.yaml file.

The API provided by share plugin is very simple. It only has a static `share()` method to share some text. You can share plain text or a URL. Listing 12-16 shows how to use `share()` method to share a URL.

Listing 12-16. Share a URL

```
Share.share('https://flutter.dev');
```

12-9. Summary

Flutter apps can use platform-specific code to call native platform APIs. There are a large number of community plugins to use different futures on the native platform, including cameras, microphones, sensors, and more. In the next chapter, we'll discuss miscellaneous topics in Flutter.

CHAPTER 13

Miscellaneous

This chapter covers recipes of miscellaneous topics in Flutter.

13-1. Using Assets

Problem

You want to bundle static assets in the app.

Solution

Use assets.

Discussion

Flutter apps can include both code and static assets. There are two types of assets:

- Data files including JSON, XML, and plain text files
- Binary files including images and videos

Assets are declared in the `flutter/assets` section of the `pubspec.yaml` file. During the build process, these assets files are bundled into the app's binary files. These assets can be accessed in the runtime. It's common to put assets under the `assets` directory. In Listing 13-1, two files are declared as assets in `pubspec.yaml` file.

Listing 13-1. Assets in pubspec.yaml file

```
flutter:  
  assets:  
    - assets/dog.jpg  
    - assets/data.json
```

In the runtime, subclasses of AssetBundle class are used to load content from the assets. The `load()` method retrieves the binary content, while `loadString()` method retrieves the string content. You need to provide the assets key when using these two methods. The key is the same as asset path declared in `pubspec.yaml` file. The static application-level `rootBundle` property refers to the `AssetBundle` object that contains assets packaged with the app. You can use this property directly to load assets. It's recommended to use static `DefaultAssetBundle.of()` method to get the `AssetBundle` object from build context.

In Listing 13-2, the JSON file `assets/data.json` is loaded as string using `loadString()` method.

Listing 13-2. Load string assets

```
class TextAssets extends StatelessWidget {  
  @override  
  Widget build(BuildContext context) {  
    return FutureBuilder<String>(  
      future: DefaultAssetBundle.of(context)  
          .loadString('assets/data.json')  
          .then((json) {  
            return jsonDecode(json)['name'];  
          }),  
      builder: (context, snapshot) {  
        if (snapshot.connectionState == ConnectionState.done) {  
          return Center(child: Text(snapshot.data));  
        }  
      },  
    );  
  }  
}
```

```
        } else {
            return Center(child: CircularProgressIndicator());
        }
    },
);
}
}
```

If the assets file is an image, you can use `AssetImage` class with `Image` widget to display it. In Listing 13-3, `AssetImage` class is used to display the `assets/dog.jpg` image.

Listing 13-3. Use `AssetImage`

```
Image(
    image: AssetImage('assets/dog.jpg'),
)
```

For an image asset, it's common to have multiple variants with different resolutions for the same file. When using `AssetImage` class to load an asset image, the variant that most closely matches the current device pixel ratio will be used.

In Listing 13-4, the `assets/2.0x/dog.jpg` file is the variant of `assets/dog.jpg` with resolution ratio 2.0. If the device pixel ratio is 1.6, the `assets/2.0x/dog.jpg` file is used.

Listing 13-4. Image assets variants

```
flutter:
  assets:
    - assets/dog.jpg
    - assets/2.0x/dog.jpg
    - assets/3.0x/dog.jpg
```

13-2. Using Gestures

Problem

You want to allow user using gestures to perform actions.

Solution

Use GestureDetector widget to detect gestures.

Discussion

Users of mobiles app are used to gestures when performing actions. For example, when viewing pictures gallery, using swiping gesture can easily navigate between different pictures. In Flutter, we can use GestureDetector widget to detect gestures and invoke specified callbacks for gestures. GestureDetector constructor has a large number of parameters to provide callbacks for different events. A gesture may dispatch multiple events during its lifecycle. For example, the gesture of horizontal drag can dispatch three events. The following are the handler parameters for these three events:

- onHorizontalDragStart callback means the pointer may begin to move horizontally.
- onHorizontalDragUpdate callback means the pointer is moving in the horizontal direction.
- onHorizontalDragEnd callback means the pointer is longer in contact with the screen.

Callbacks of different events can receive details about the events. In Listing 13-5, the GestureDetector widget wraps a Container widget. In the onHorizontalDragEnd callback handler, the velocity property of DragEndDetails object is the moving velocity of the pointer. We use this property to determine the drag direction.

Listing 13-5. Use GestureDetector

```
class SwipingCounter extends StatefulWidget {  
    @override  
    _SwipingCounterState createState() => _SwipingCounterState();  
}  
  
class _SwipingCounterState extends State<SwipingCounter> {  
    int _count = 0;  
  
    @override  
    Widget build(BuildContext context) {  
        return Column(  
            children: <Widget>[  
                Text('${_count}'),  
                Expanded(  
                    child: GestureDetector(  
                        child: Container(  
                            decoration: BoxDecoration(color: Colors.grey.  
                                shade200),  
                        ),  
                        onHorizontalDragEnd: (DragEndDetails details) {  
                            setState(() {  
                                double dx = details.velocity.  
                                    pixelsPerSecond.dx;  
                                _count += (dx > 0 ? 1 : (dx < 0 ? -1 : 0));  
                            });  
                        },  
                    ),  
                ),  
            ],  
        );  
    }  
}
```

13-3. Supporting Multiple Locales

Problem

You want the app to support multiple locales.

Solution

Use `Localizations` widget and `LocalizationsDelegate` class.

Discussion

Flutter has built-in support for internalization. If you want to support multiple locales, you need to use `Localizations` widget. `Localizations` class uses a list of `LocalizationsDelegate` objects to load localized resources. `LocalizationsDelegate<T>` class is a factory of a set of localized resources of type T. The set of localized resources is usually a class with properties and methods to provide localized values.

To create a `Localizations` object, you need to provide the `Locale` object and a list of `LocalizationsDelegate` objects. Most of the time, you don't need to explicitly create a `Localizations` object. `WidgetsApp` widget already creates a `Localizations` object. `WidgetsApp` constructor has parameters that are used by the `Localizations` object. When you need to use localized values, you can use static `Localizations.of<T>(BuildContext context, Type type)` method to get the nearest enclosing localized resources object of the given type.

By default, Flutter only provides US English localizations. To support other locales, you need to add Flutter's own localizations for those locales first. This is done by adding `flutter_localizations` package to the dependencies of `pubspec.yaml` file; see Listing 13-6. With this package, you can use localized values defined in `MaterialLocalizations` class.

Listing 13-6. flutter_localizations

```
dependencies:  
  flutter:  
    sdk: flutter  
  flutter_localizations:  
    sdk: flutter
```

After adding the flutter_localizations package, we need to enable those localized values. In Listing 13-7, this is done by adding GlobalMaterialLocalizations.delegate and GlobalWidgetsLocalizations.delegate to the localizationsDelegates list of MaterialApp constructor. The value of localizationsDelegates parameter is passed to the Localizations constructor. The supportedLocales parameter specifies the supported locales.

Listing 13-7. Enable Flutter localized values

```
MaterialApp(  
  localizationsDelegates: [  
    GlobalMaterialLocalizations.delegate,  
    GlobalWidgetsLocalizations.delegate,  
  ],  
  supportedLocales: [  
    const Locale('en'),  
    const Locale('zh', 'CN'),  
  ],  
);
```

In Listing 13-8, MaterialLocalizations.of() method gets the MaterialLocalizations object from the build context. The copyButtonLabel property is a localized value defined in MaterialLocalizations class. In the runtime, the label of the button depends on the device's locale. MaterialLocalizations.of()

method uses `Localizations.of()` internally to look up the `MaterialLocalizations` object.

Listing 13-8. Use localized values

```
RaisedButton(  
    child: Text(MaterialLocalizations.of(context).  
copyButtonLabel),  
    onPressed: () {},  
);
```

`MaterialLocalizations` class only provides a limit set of localized values. For your own apps, you need to create custom localized resources classes. `AppLocalizations` class in Listing 13-9 is a custom localized resources class. `AppLocalizations` class has the `appName` property as an example of simple localizable strings. The `greeting()` method is an example of localizable strings that require parameters. `AppLocalizationsEn` and `AppLocalizationsZhCn` classes are implementations of `AppLocalizations` class for `en` and `zh_CN` locales, respectively.

Listing 13-9. AppLocalizations and localized subclasses

```
abstract class AppLocalizations {  
    String get appName;  
    String greeting(String name);  
  
    static AppLocalizations of(BuildContext context) {  
        return Localizations.of<AppLocalizations>(context,  
            AppLocalizations);  
    }  
}
```

```
class AppLocalizationsEn extends AppLocalizations {  
    @override  
    String get appName => 'Demo App';  
  
    @override  
    String greeting(String name) {  
        return 'Hello, $name';  
    }  
}  
  
class AppLocalizationsZhCn extends AppLocalizations {  
    @override  
    String get appName => '示例应用';  
  
    @override  
    String greeting(String name) {  
        return '你好, $name';  
    }  
}
```

We also need to create a custom `LocalizationsDelegate` class to load `AppLocalizations` objects. There are three methods need to be implemented:

- `isSupported()` method checks whether a locale is supported.
- `load()` method loads the localized resources object for a given locale.
- `shouldReload()` method checks whether the `load()` method should be called to load the resource again.

In the `load()` method of Listing 13-10, `AppLocalizationsEn` or `AppLocalizationsZhCn` object is returned based on the given locale.

Listing 13-10. Custom LocalizationsDelegate

```
class _AppLocalizationsDelegate
    extends LocalizationsDelegate<AppLocalizations> {
  const _AppLocalizationsDelegate();

  static const List<Locale> _supportedLocales = [
    const Locale('en'),
    const Locale('zh', 'CN')
  ];

  @override
  bool isSupported(Locale locale) {
    return _supportedLocales.contains(locale);
  }

  @override
  Future<AppLocalizations> load(Locale locale) {
    return Future.value(locale == Locale('zh', 'CN')
        ? AppLocalizationsZhCn()
        : AppLocalizationsEn());
  }

  @override
  bool shouldReload(LocalizationsDelegate<AppLocalizations>
  old) {
    return false;
  }
}
```

_AppLocalizationsDelegate object needs to be added to the list of localizationsDelegates in Listing 13-7. Listing 13-11 shows an example of using AppLocalizations class.

Listing 13-11. Use AppLocalizations

```
Text(AppLocalizations.of(context).greeting('John'))
```

13-4. Generating Translation Files

Problem

You want to extract localizable strings from code and integrate translated strings.

Solution

Use tools in `intl_translation` package.

Discussion

Recipe 13-3 describes how to support multiple locales using `Localizations` widget and `LocalizationsDelegate` class. The major drawback of solution in Recipe 13-3 is that you need to manually create localized resources classes for all supported locales. Because localized strings are directly embedded in source code, it's hard to get translators involved. A better choice is to use tools provided by `intl_translation` package to automate the process. You need to add `intl_translation: ^0.17.3` to the `dev_dependencies` of the `pubspec.yaml` file.

Listing 13-12 shows the new `AppLocalizations` class which has the same `appName` property and `greeting()` method as Listing 13-9. `Intl.message()` method describes a localized string. Only the message string is required. Parameters like `name`, `desc`, `args`, and `examples` are used to help translators to understand the message string.

Listing 13-12. AppLocalizations using Intl.message()

```
class AppLocalizations {  
    static AppLocalizations of(BuildContext context) {  
        return Localizations.of<AppLocalizations>(context,  
            AppLocalizations);  
    }  
  
    String get appName {  
        return Intl.message(  
            'Demo App',  
            name: 'appName',  
            desc: 'Name of the app',  
        );  
    }  
  
    String greeting(String name) {  
        return Intl.message(  
            'Hello, $name',  
            name: 'greeting',  
            args: [name],  
            desc: 'Greeting message',  
            examples: const {'name': 'John'},  
        );  
    }  
}
```

Now we can use the tool provided by `intl_translation` package to extract localized messages from source code. The following command extracts messages declared with `Intl.message()` from `lib/app_intl.dart` file and saves to `lib/l10n` directory. After running this command, you should see the generated `intl_messages.arb` file in `lib/l10n` directory. Generated files are in ARB (Application Resource Bundle) format

(<https://github.com/googlei18n/app-resource-bundle>) which can be used as input of translation tools like Google Translator Toolkit. ARB files are actually JSON files; you can simply use text editors to modify them.

```
$ flutter packages pub run intl_translation:extract_to_arb
--locale=en --output-dir=lib/l10n lib/app_intl.dart
```

Now you can duplicate the `intl_messages.arb` file for each supported locale and get them translated. For example, the `intl_messages_zh.arb` file is the translated version for zh locale. After translated files are ready, you can use the following command to generate Dart files. After running this command, you should see a `messages_all.dart` file and `messages_*`.`dart` files for each locale.

```
$ flutter packages pub run intl_translation:generate_from_arb
--output-dir=lib/l10n --no-use-deferred-loading lib/app_intl.
dart lib/l10n/intl_*.arb
```

The `initializeMessages()` function in `messages_all.dart` file can be used to initialize messages for a given locale. The static `load()` method in Listing 13-13 uses `initializeMessages()` function to initialize messages first, then sets the default locale.

Listing 13-13. Load messages

```
class AppLocalizations {
    static Future<AppLocalizations> load(Locale locale) {
        final String name =
            locale.countryCode.isEmpty ? locale.languageCode :
            locale.toString();
        final String localeName = Intl.canonicalizedLocale(name);
        return initializeMessages(localeName).then((_) {
            Intl.defaultLocale = localeName;
            return AppLocalizations();
        });
    }
}
```

```
});  
}  
}
```

This static `AppLocalizations.load()` method can be used by the `load()` method of `LocalizationsDelegate` class to load `AppLocalizations` object.

13-5. Painting Custom Elements

Problem

You want to paint custom elements.

Solution

Use `CustomPaint` widget with `CustomPainter` and `Canvas` classes.

Discussion

If you want to completely customize the painting of a widget, you can use `CustomPaint` widget. `CustomPaint` widget provides a canvas on which to draw custom elements. Table 13-1 shows the parameters of `CustomPaint` constructor. During the painting process, the painter paints on the canvas first, then the child widget is painted, and finally the `foregroundPainter` paints on the canvas.

Table 13-1. Parameters of CustomPaint

| Name | Type | Description |
|-------------------|---------------|---|
| painter | CustomPainter | The painter that paints before the child. |
| foregroundPainter | CustomPainter | The painter that paints after the child. |
| size | Size | The size to paint. |
| child | Widget | The child widget. |

To create `CustomPainter` objects, you need to create subclasses of `CustomPainter` and override `paint()` and `shouldRepaint()` methods. In `paint()` method, the `canvas` parameter can be used to draw custom elements. `Canvas` class has a set of methods to draw different elements; see Table 13-2.

Table 13-2. Methods of Canvas

| Name | Description |
|------------------------------|---|
| <code>drawArc()</code> | Draw an arc. |
| <code>drawCircle()</code> | Draw a circle with specified center and radius. |
| <code>drawImage()</code> | Draw an <code>Image</code> object. |
| <code>drawLine()</code> | Draw a line between two points. |
| <code>drawOval()</code> | Draw an oval. |
| <code>drawParagraph()</code> | Draw text. |
| <code>drawRect()</code> | Draw a rectangle with specified <code>Rect</code> object. |
| <code>drawRRect()</code> | Draw a rounded rectangle. |

Most of the methods in Canvas class have a parameter of type Paint to describe the style to use when drawing on the canvas. In Listing 13-14, Shapes class draws a rectangle and a circle on the canvas. In the CustomShapes widget, the Text widget is painted above the Shapes painter.

Listing 13-14. Use CustomPaint

```
class CustomShapes extends StatelessWidget {  
  @override  
  Widget build(BuildContext context) {  
    return Container(  
      width: 300,  
      height: 300,  
      child: CustomPaint(  
        painter: Shapes(),  
        child: Center(child: Text('Hello World')),  
      ),  
    );  
  }  
  
  class Shapes extends CustomPainter {  
    @override  
    void paint(Canvas canvas, Size size) {  
      Rect rect = Offset(5, 5) & (size - Offset(5, 5));  
      canvas.drawRect(  
        rect,  
        Paint()  
          ..color = Colors.red  
          ..strokeWidth = 2  
          ..style = PaintingStyle.stroke,  
      );  
    }  
  }  
}
```

```
canvas.drawCircle(  
    rect.center,  
    (rect.shortestSide / 2) - 10,  
    Paint()..color = Colors.blue,  
);  
}  
  
@override  
bool shouldRepaint(CustomPainter oldDelegate) {  
    return false;  
}  
}
```

13-6. Customizing Themes

Problem

You want to customize themes in Flutter apps.

Solution

Use ThemeData class for Material Design and CupertinoThemeData class for iOS.

Discussion

It's a common requirement to customize look and feel of an app. For Flutter apps, if Material Design is used, you can use ThemeData class to customize the theme. ThemeData class has a large number of parameters to configure different aspects of the theme. MaterialApp class has the theme parameter to provide the ThemeData object. For iOS style, CupertinoThemeData class has the same purpose to specify

the theme. `CupertinoApp` class also has the `theme` parameter of type `CupertinoThemeData` to customize the theme.

If you need to access the current theme object, you can use static `Theme.of()` method to get nearest enclosing `ThemeData` object for a build context in Material Design. The similar `CupertinoTheme.of()` method can be used for iOS style.

In Listing 13-15, the first `Text` widget uses the `textTheme.headline` property of current `Theme` object as the style. The second `Text` widget uses the `colorScheme.error` property as the color to display error text.

Listing 13-15. Use Theme

```
class TextTheme extends StatelessWidget {  
  @override  
  Widget build(BuildContext context) {  
    return Column(  
      children: <Widget>[  
        Text('Headline', style: Theme.of(context).textTheme.  
          headline),  
        Text('Error',  
          style: TextStyle(color: Theme.of(context).  
            colorScheme.error)),  
      ],  
    );  
  }  
}
```

13-7. Summary

This chapter discusses miscellaneous topics in Flutter that are useful in different scenarios. In the next chapter, we'll discuss testing and debugging in Flutter.

CHAPTER 14

Testing and Debugging

This chapter covers recipes related to testing and debugging Flutter apps.

14-1. Writing Unit Tests

Problem

You want to write unit tests.

Solution

Use API in test package.

Discussion

Unit tests are very important in app development. To write tests in Flutter apps, you need to add test: ^1.5.3 to the dev_dependencies section of pubspec.yaml file. Test files are usually put in the test directory. The MovingBox class in Listing 14-1 is the class to test. The move() method updates the internal _offset variable.

Listing 14-1. Dart class to test

```
class MovingBox {
  MovingBox({Offset initPos = Offset.zero}) : _offset =
    initPos;
  Offset _offset;

  get offset => _offset;

  void move(double dx, double dy) {
    _offset += Offset(dx, dy);
  }
}
```

[Listing 14-2](#) shows the tests of `MovingBox` class. The `group()` function creates a group to describe a set of tests. The `test()` function creates a test case with the given description and body. The body is a function that uses `expect()` function to declare expectations to verify. To call the `expect()` function, you need to provide the actual value and a matcher to check the value. The matcher can be simple values or functions from the `matcher` package. Common matcher functions include `contains()`, `startsWith()`, `endsWith()`, `lessThan()`, `greaterThan()`, and `inInclusiveRange()`.

Listing 14-2. Test of `MovingBox`

```
void main() {
  group('MovingBox', () {
    test('position should be (0.0) by default', () {
      expect(MovingBox().offset, Offset.zero);
    });

    test('postion should be initial value', () {
      expect(MovingBox(initPos: Offset(10, 10)).offset,
        Offset(10, 10));
    });
}
```

```
test('position should be moved', () {
    final box = MovingBox();
    box.move(5, 5);
    expect(box.offset, Offset(5, 5));
    box.move(-1, -1);
    expect(box.offset, Offset(4, 4));
});
});
}
```

You can use `async` functions as body of `expect()` function to write asynchronous tests. In Listing 14-3, the first test case uses an `async` function with `await` to get the value of a `Future` object. In the second test case, `completion()` function waits for completion of a `Future` object and verify the value. The `throwsA()` function verifies that a `Future` object throws the given error. In the third test case, `expectAsync1()` function wraps another function to verify the result and checks its invocation times.

Listing 14-3. Asynchronous tests

```
void main() {
    test('future with async', () async {
        var value = await Future.value(1);
        expect(value, equals(1));
    });

    test('future', () {
        expect(Future.value(1), completion(equals(1)));
        expect(Future.error('error'), throwsA(equals('error'))));
    });

    test('future callback', () {
        Future.error('error').catchError(expectAsync1((error) {
            expect(error, equals('error'));
        }));
    });
}
```

```
    }, count: 1));
});
}
```

You can use `setUp()` function to add a function to run before tests. Similarly, the `tearDown()` function is used to add a function to run after tests. The `setUp()` function should be used to prepare the context for test cases to run. The `tearDown()` function should be used to run cleanup tasks. The `setUp()` and `tearDown()` functions usually come in pairs. In Listing 14-4, `setUp()` and `tearDown()` functions will be called twice.

Listing 14-4. `setUp()` and `tearDown()` functions

```
void main() {
  setUp(() {
    print('setUp');
  });

  test('action1', () {
    print('action1');
  });

  test('action2', () {
    print('action2');
  });

  tearDown(() {
    print('tearDown');
  });
}
```

After running the test case in Listing 14-4, the output should look like what's shown in Listing 14-5.

Listing 14-5. Output with `setUp()` and `tearDown()` functions

```
setUp  
action1  
tearDown  
setUp  
action2  
tearDown
```

14-2. Using Mock Objects in Tests

Problem

You want to mock dependencies in test cases.

Solution

Use `mockito` package.

Discussion

When writing test cases, the classes to test may have dependencies that require external resources. For example, a service class needs to access backend API to get data. When testing these classes, you don't want to use the real dependencies. Depending on external resources, introduce uncertainty to execution of test cases and make them unstable. Using live services also makes it difficult to test all possible scenarios.

A better approach is to create mock objects to replace these dependencies. With mock objects, you can easily emulate different scenarios. Mock objects are alternative implementations of classes. You can create mock objects manually or use `mockito` package. To use `mockito` package, you need to add `mockito: ^4.0.0` to the `dev_dependencies` section of `pubspec.yaml` file.

GitHubJobsClient class in Listing 14-6 uses Client class from http package to access GitHub Jobs API.

Listing 14-6. GitHubJobsClient class to test

```
class GitHubJobsClient {  
    GitHubJobsClient({@required this.httpClient}) :  
        assert(httpClient != null);  
  
    final http.Client httpClient;  
  
    Future<List<Job>> getJobs(String keyword) async {  
        Uri url = Uri.https(  
            'jobs.github.com', '/positions.json', {'description':  
                keyword});  
        http.Response response = await httpClient.get(url);  
        if (response.statusCode != 200) {  
            throw Exception('Failed to get job listings');  
        }  
        return (jsonDecode(response.body) as List<dynamic>)  
            .map((json) => Job.fromJson(json))  
            .toList();  
    }  
}
```

To test GitHubJobsClient class, we can create a mock object for http.Client object. In Listing 14-7, MockHttpClient class is the mock class for http.Client class. In the first test case, when the get() method of MockHttpClient is called with the specified Uri object, a Future<Response> object with JSON string is used as the result. We can verify that getJobs() method of GitHubJobsClient can parse the response and return a List object with one element. In the second test case, the return result of get() method of MockHttpClient is set to a

Future<Response> with HTTP 500 error. We then verify an exception is thrown by calling getJobs() method.

Listing 14-7. GitHubJobsClient test with mock

```
import 'package:mockito/mockito.dart';
class MockHttpClient extends Mock implements http.Client {}

void main() {
  group('getJobs', () {
    Uri url = Uri.https(
      'jobs.github.com', '/positions.json', {'description':
      'flutter'});
    test('should return list of jobs', () {
      final httpClient = MockHttpClient();
      when(httpClient.get(url))
        .thenAnswer((_) async => http.Response('[{"id": "123"}]', 200));
      final jobsClient = GitHubJobsClient(httpClient:
      httpClient);
      expect(jobsClient.getJobs('flutter'),
      completion(hasLength(1)));
    });
    test('should throws an exception', () {
      final httpClient = MockHttpClient();
      when(httpClient.get(url))
        .thenAnswer((_) async => http.Response('error', 500));
      final jobsClient = GitHubJobsClient(httpClient:
      httpClient);
      expect(jobsClient.getJobs('flutter'), throwsException);
    });
  });
}
```

14-3. Writing Widget Tests

Problem

You want to write test cases to test widgets.

Solution

Use `flutter_test` package.

Discussion

Using `test` and `mockito` packages is enough to write tests for Dart classes. However, you need to use `flutter_test` package to write tests for widgets. The `flutter_test` package is already included in the `pubspec.yaml` file for new projects created by `flutter create` command. Test cases for widgets are declared using `testWidgets()` function. When calling `testWidgets()`, you need to provide a description and a callback to run inside the Flutter test environment. The callback receives a `WidgetTester` object to interact with widgets and the test environment. After the widget under test is created, you can use `Finder` objects and matchers to verify state of the widget.

Table 14-1 shows methods of `WidgetTester` class. The `pumpWidget()` method is usually the entry point of a test by creating the widget to test. When testing stateful widgets, after changing the state, you need to call `pump()` method to trigger the rebuild. If the widget uses animations, you should use `pumpAndSettle()` method to wait for animations to finish. Methods like `enterText()` and `ensureVisible()` use `Finder` objects to find the widgets to interact with.

Table 14-1. Methods of WidgetTester

| Name | Description |
|-----------------|--|
| pumpWidget() | Render the specified widget. |
| pump() | Trigger a frame that causes the widget to rebuild. |
| pumpAndSettle() | Repeatedly call pump() method until there are no frames scheduled. |
| enterText() | Enter text to a text input widget. |
| pageBack() | Dismiss the current page. |
| runAsync() | Run a callback asynchronously. |
| dispatchEvent() | Dispatch an event. |
| ensureVisible() | Make a widget visible by scrolling its ancestor Scrollable widget. |
| drag() | Drag the widget by given offset. |
| press() | Press the widget. |
| longPress() | Long press the widget. |
| tap() | Tap the widget. |

ToUppercase widget in Listing 14-8 is a stateful widget to test. It has a TextField widget to input text. When the button is pressed, the uppercase of input text is displayed using a Text widget.

Listing 14-8. Widget to test

```
class ToUppercase extends StatefulWidget {
  @override
  _ToUppercaseState createState() => _ToUppercaseState();
}
```

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```
class _ToUppercaseState extends State<ToUppercase> {
  final _controller = TextEditingController();

  @override
  Widget build(BuildContext context) {
    return Column(
      children: <Widget>[
        Row(
          children: <Widget>[
            Expanded(child: TextField(controller:
              _controller)),
            RaisedButton(
              child: Text('Uppercase'),
              onPressed: () {
                setState(() {});
              },
            ),
          ],
        ),
        Text(_controller.text ?? "").toUpperCase(),
      ],
    );
  }
}
```

Listing 14-9 shows the test case of ToUppercase widget. The `_wrapInMaterial()` function wraps the ToUppercase widget in a `MaterialApp` before testing. This is because `TextField` widget requires an ancestor `Material` widget. In the test case, the widget is rendered using `pumpWidget()` first. The `find` object is a top-level constant of

CommonFinders class. It has convenient methods to create different kinds of Finder objects. Here we find the widget of type TextField and uses enterText() to input the text “abc”. Then the RaisedButton widget is tapped and the state is changed. The pump() method is required to trigger the rebuild. Finally, we verify that a Text widget exists with the text “ABC”.

Listing 14-9. Test ToUppercase widget

```
Widget _wrapInMaterial(Widget widget) {  
    return MaterialApp(  
        home: Scaffold(  
            body: widget,  
        ),  
    );  
}  
  
void main() {  
    testWidgets('ToUppercase', (WidgetTester tester) async {  
        await tester.pumpWidget(_wrapInMaterial(ToUppercase()));  
        await tester.enterText(find.byType(TextField), 'abc');  
        await tester.tap(find.byType(RaisedButton));  
        await tester.pump();  
        expect(find.text('ABC'), findsOneWidget);  
    });  
}
```

Table 14-2. *Methods of CommonFinders*

| Name | Description |
|------------------|--|
| byType() | Find widgets by type. |
| byIcon() | Find Icon widgets by icon data. |
| byKey() | Find widgets by a particular Key object. |
| byTooltip() | Find Tooltip widgets with the given message. |
| byWidget() | Find widgets by the given widget instance. |
| text() | Find Text and EditableText widgets with the given text. |
| widgetWithIcon() | Find widgets that contain a descendant widget with the icon. |
| widgetWithText() | Find widgets that contain a Text descendant with the given text. |

Finder objects are used with matchers to verify the state. There are four matchers to work with Finder objects:

- findsOneWidget expects exactly one widget is found.
- findsNothing expects no widgets are found.
- findsNWidgets expects specified number of widgets are found.
- findsWidgets expects at least one widget is found.

14-4. Writing Integration Tests

Problem

You want to write integration tests running on emulators or real devices.

Solution

Use `flutter_driver` package.

Discussion

Unit tests and widget tests can only test individual classes, functions, or widgets. These tests are running on development or testing machines. These tests cannot test integration between different components of an app. Integration tests should be used for this scenario.

Integration testing comes in two parts. The first part is the instrumented app deployed to an emulator or real device. The second part is the test code to drive the app and verify state of the app. The app under test is isolated from the test code to avoid interference.

The `flutter_driver` package is required to write integration tests. You need to add `flutter_driver` package to the `dev_dependencies` section of the `pubspec.yaml` file; see Listing 14-10.

Listing 14-10. Add `flutter_driver` package

```
dev_dependencies:  
  flutter_driver:  
    sdk: flutter
```

Integration test files are usually put in the `test_driver` directory. The target to test is the page to search job listings on GitHub. It's important to provide `ValueKey` objects as the key parameter of the widgets that need to be used by integration tests. This makes it easier to find those widgets in the test case. In Listing 14-11, `Key('keyword')` creates a `ValueKey` object with name "keyword".

Listing 14-11. Add key to widget

```
TextField(  
    key: Key('keyword'),  
    controller: _controller,  
)
```

The `github_jobs.dart` file in `test_driver` directory contains an instrumented version of the page to test. Listing 14-12 shows the content of `github_jobs.dart` file. The `enableFlutterDriverExtension()` function from the `flutter_driver` package enables Flutter Driver to connect to the app.

Listing 14-12. App to test using Flutter Driver

```
void main() {  
  enableFlutterDriverExtension();  
  runApp(SampleApp());  
}
```

Listing 14-13 shows the content of `github_jobs_test.dart` file. The file name is selected by appending `_test` suffix to the name of the app file. This is the convention used by Flutter Driver to find the Dart file to run the app under test. In the `setUpAll()` function, `FlutterDriver.connect()` is used to connect to the app. In the test case, `find` is the top-level constant of `CommonFinders` object that has convenient methods to create `SerializableFinder` objects. The `byValueKey()` method finds the `TextField` widget in Listing 14-11 by the specified key. The `tap()` method of `FlutterDriver` taps at the `TextField` widget to make it gain focus. Then `enterText()` method is used to input search keyword to the focused `TextField` widget. The search button is then tapped to trigger the loading of data. If the data is loaded successfully, the `ListView` widget with `jobsList` key is available. The `waitFor()` method waits for the `ListView` widget to appear.

Listing 14-13. Test using Flutter Driver

```
void main() {
  group('GitHub Jobs', () {
    FlutterDriver driver;

    setUpAll(() async {
      driver = await FlutterDriver.connect();
    });

    test('searches by keyword', () async {
      await driver.tap(find.byValueKey('keyword'));
      await driver.enterText('android');
      await driver.tap(find.byValueKey('search'));
      await driver.waitFor(find.byValueKey('jobsList'),
        timeout: Duration(seconds: 5));
    });
  });

  tearDownAll(() {
    if (driver != null) {
      driver.close();
    }
  });
});
```

Now we can use the following command to run the integration test. Flutter Driver deploys the app to the emulator or real device and runs the test code to verify the result.

```
$ flutter driver --target=test_driver/github_jobs.dart
```

Table 14-3 shows methods of `FlutterDriver` class that can be used to interact with the app during tests. If you want to perform custom actions, you can provide a `DataHandler` function when calling

`enableFlutterDriverExtension()` function. Messages sent using `requestData()` method will be handled by the `DataHandler`.

Table 14-3. *Methods of FlutterDriver*

| Name | Description |
|---|--|
| <code>enterText()</code> | Enter text into the currently focused text input. |
| <code>getText()</code> | Get text in the Text widget. |
| <code>tap()</code> | Taps at the widget. |
| <code>waitFor()</code> | Wait until the finder locates a widget. |
| <code>waitForAbsent()</code> | Wait until the finder can no longer locate a widget. |
| <code>scroll()</code> | Scroll in a widget by the given offset. |
| <code>scrollIntoView()</code> | Scroll the Scrollable ancestor of the widget until it's visible. |
| <code>scrollUntilVisible(SerializableFinder scrollable, SerializableFinder item)</code> | Repeatedly call <code>scroll()</code> in the scrollable widget until the item is visible, then call <code>scrollIntoView()</code> on the item. |
| <code>traceAction()</code> | Run the action and return its performance trace. |
| <code>startTracing()</code> | Start recording performance traces. |
| <code>stopTracingAndDownloadTimeline()</code> | Stop recording performance traces and download the result. |
| <code>forceGC()</code> | For a garbage collection to run. |
| <code>getRenderTree()</code> | Returns a dump of the current render tree. |
| <code>requestData()</code> | Sends a message to the app and receives a response. |
| <code>screenshot()</code> | Take a screenshot. |

Methods in `FlutterDriver` class use `SerializableFinder` objects to locate widgets. Table 14-4 shows methods of `CommonFinders` class to create `SerializableFinder` objects. These methods only support using `String` or `int` values as parameters. This is because values need to be serialized when sending to the app.

Table 14-4. Methods of `CommonFinders` in `flutter_driver`

| Name | Description |
|---------------------------|---|
| <code>byType()</code> | Find widgets by class name. |
| <code>byValueKey()</code> | Find widgets by key. |
| <code>byTooltip()</code> | Find widgets with a tooltip with the given message. |
| <code>text()</code> | Find <code>Text</code> and <code>EditableText</code> widgets with the given text. |
| <code>pageBack()</code> | Find the back button. |

14-5. Debugging Apps

Problem

You want to debug issues found in the apps.

Solution

Use IDE and utilities provided by Flutter SDK.

Discussion

When the code doesn't work as you expected in the runtime, you need to debug the code to find out the cause. With the help of IDEs, it's quite straightforward to debug Flutter apps. You can add breakpoints in the code and start the app in debug mode.

Another common approach to debug code is to write outputs to the system console using `print()` function. These logs can be viewed using `flutter logs` command. Android Studio also displays these logs in the Console view. You can also use `debugPrint()` function to throttle the output to avoid the logs being dropped by Android.

When creating your own widgets, you should override `debugFillProperties()` method to add custom diagnostic properties. These properties can be viewed in Flutter Inspector. In Listing 14-14, the `DebugWidget` has `name` and `price` properties. In the `debugFillProperties()` method, two `DiagnosticsProperty` objects are added using `DiagnosticPropertiesBuilder` object.

Listing 14-14. `debugFillProperties()`

```
class DebugWidget extends StatelessWidget {  
    DebugWidget({Key key, this.name, this.price}) : super(key:  
        key);  
  
    final String name;  
    final double price;  
  
    @override  
    Widget build(BuildContext context) {  
        return Text('$name - $price');  
    }  
  
    @override  
    void debugFillProperties(DiagnosticPropertiesBuilder  
        properties) {  
        super.debugFillProperties(properties);  
  
        properties.add(StringProperty('name', name));  
        properties.add(DoubleProperty('price', price));  
    }  
}
```

There are different types of `DiagnosticsProperty` subclasses to use based on the property type. Table 14-5 shows common `DiagnosticsProperty` subclasses.

Table 14-5. *Methods of CommonFinders*

| Name | Description |
|-------------------------------|--|
| <code>StringProperty</code> | For <code>String</code> property. |
| <code>DoubleProperty</code> | For <code>double</code> property. |
| <code>PercentProperty</code> | Format <code>double</code> property as percentage. |
| <code>IntProperty</code> | For <code>int</code> property. |
| <code>FlagProperty</code> | Format <code>bool</code> property as flags. |
| <code>EnumProperty</code> | For <code>enum</code> property. |
| <code>IterableProperty</code> | For <code>Iterable</code> property. |

14-6. Summary

This chapter covers topics related to testing and debugging Flutter apps.

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