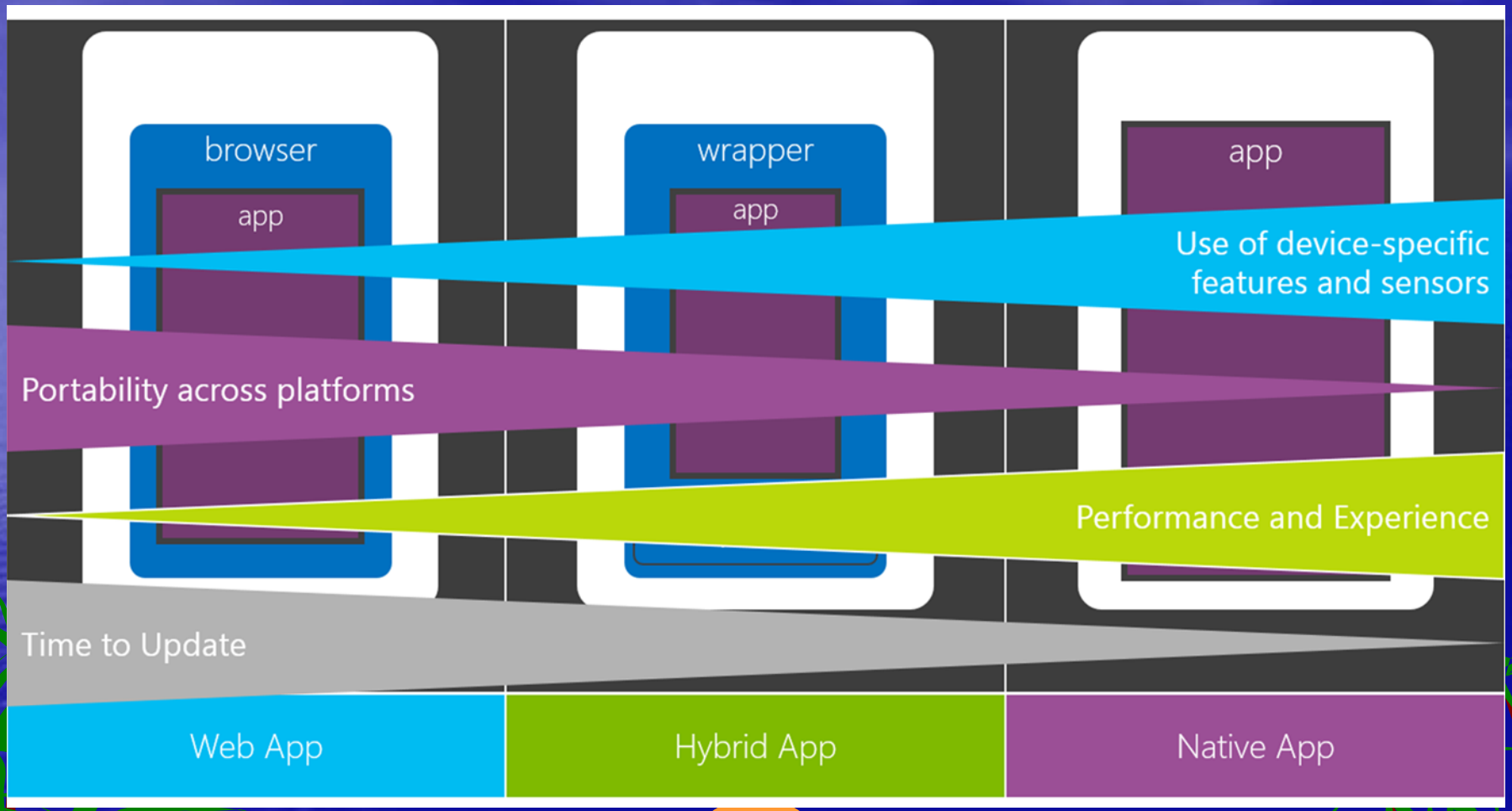
Mobile Computing

The Flutter Framework

What is Flutter

- Flutter is an open-source application development kit created by Google
  - Ultimately it aims applications for
    - Mobile (Android and iOS)
    - Web (deployed in servers, embedded in browsers, PWA) (beta)
    - Desktop (still in alpha)
      - Windows (needs VS 2019)
      - MacOS (needs XCode)
      - Linux (needs CLang, CMake, GTK)
    - The experimental Google OS Fuchsia
  - It uses the Dart programming language and runtime
  - Tools, Resources and Installation from
    - https://flutter.dev

Mobile Application Approaches



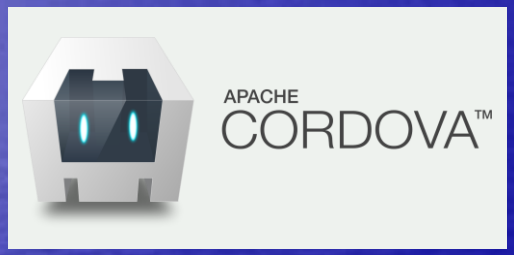
Web Applications for Mobile

- Same technologies as other web applications
  - Run on the device browser and a remote server

  - Limited in some features
    - Use of device hardware and controls
    - UX different from native
    - Performance

Popular Hybrid Frameworks

- Hybrid Apps run on the device and off-line
  - More integrated but still with some drawbacks
    - Non-native experience
    - Performance problems concerning certain components



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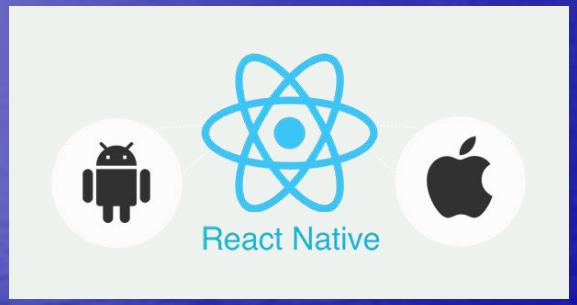
RhoMobile
(Tau technologies)

Near Native (Hybrid-native) technologies

- Produce and execute on native (or VM) code
  - UI near the native, facilities to access the original API
    - With good performance



JSX, JS
. web like separated UI specification

C#
. architecture pattern oriented (MVVM)
. separated UI specification
. Xamarin.Forms rendered with Android / iOS native views

Dart
. widgets

Flutter Development Tools

- You can install your development tools
  - Windows, MacOS, or Linux
    - Flutter SDK, Dart SDK, Android and/or iOS SDK
    - CLI tools
  - With plugins, high level IDEs


Android Studio

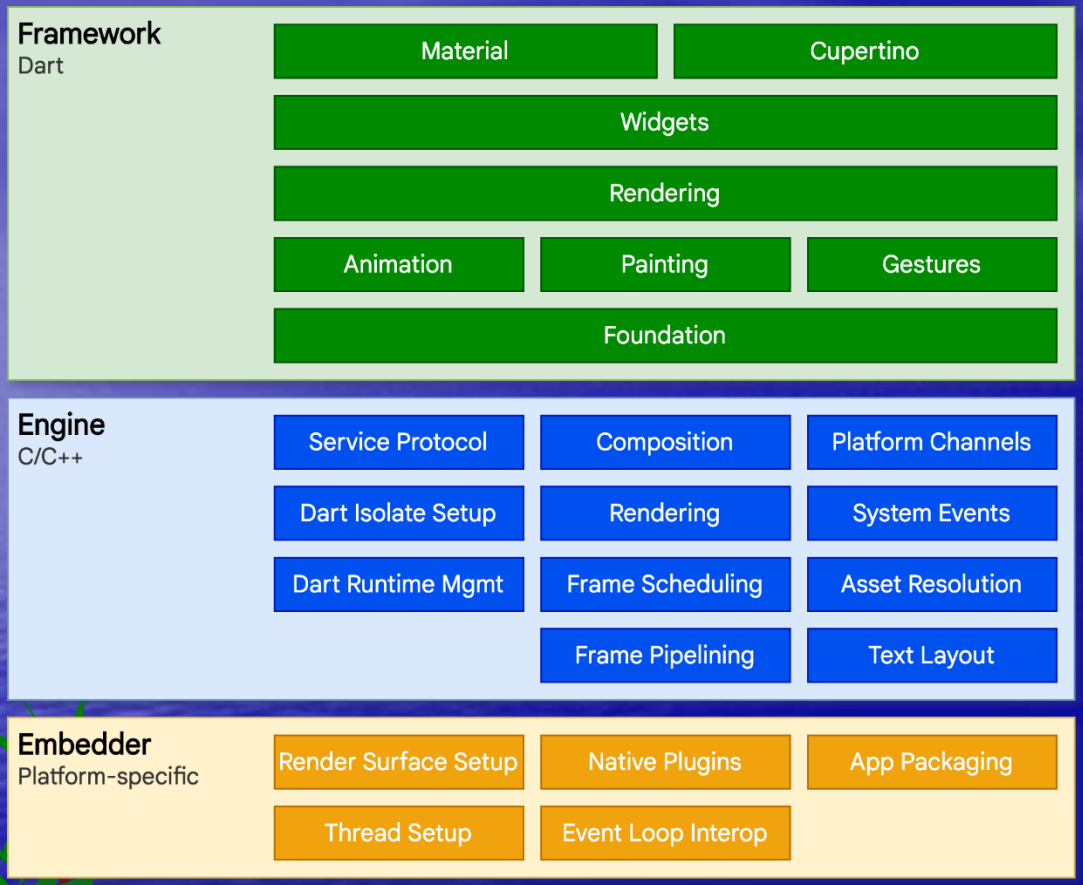

IntelliJ Idea


Visual Studio Code


Emacs

  - Android app can be tested and executed in any OS with the Android SDK
  - iOS app can only be completed and executed through a Mac with XCode and the iOS SDK
    - A paid development license from Apple is needed (for devices)

Flutter Layered Architecture



Flutter Framework – Developer interface
Main app code uses the 2 top layers (everything is a widget)
Customizations can involve classes from the previous-to-last layer (animations, input gestures, drawing, …)

Flutter Engine – Set of primitives used by the Framework. It comprises graphics (Skia), text rendering, file and network I/O, plugin architecture, and the Dart run-time.
This layer is exposed in the Framework as the low-level dart:ui package

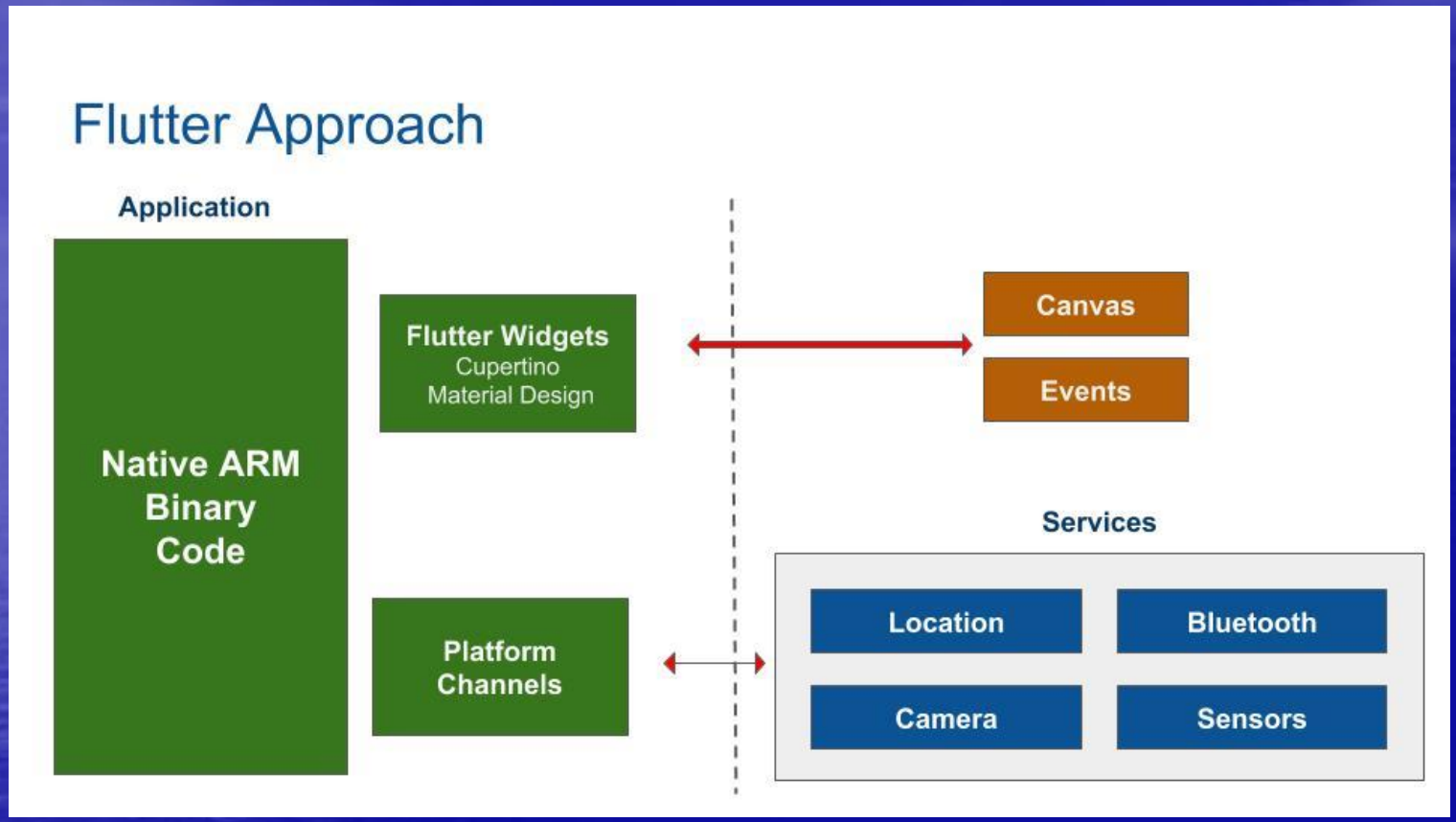
Flutter Embedder – code layer that interfaces the native OS and their services. It provides a connection with the native message loop, allowing the flutter app to run on the top of a native app.
It is written in Java (Android) or Objective-C (iOS), and C++ (all OS's)

Flutter follows a reactive model of UI. The UI is a tree of widgets, with a separated associated state. A change in state automatically triggers a UI update.

$$UI = f(state)$$

(https://flutter.dev/docs/resources/architectural-overview)

Flutter and Native OS



Flutter UI through Widgets – draw direct in the screen represented by a canvas receive the events generated by the user interaction

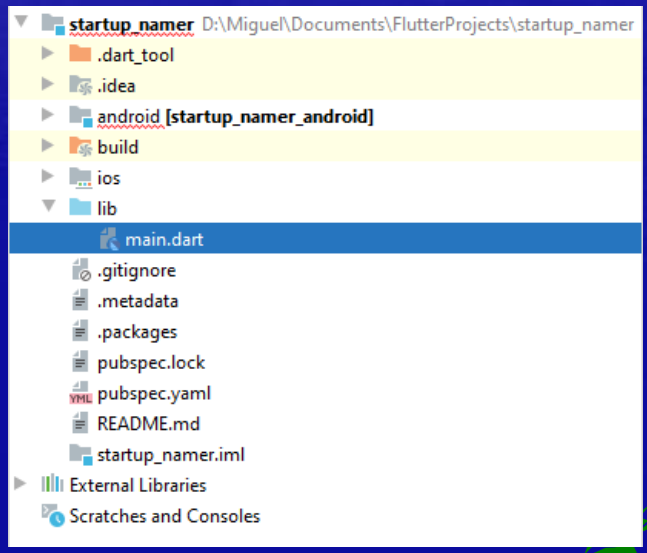
Other functionalities need calling and data exchange with native services that is done using Flutter platform channels

Flutter Side App and Widgets

- Flutter apps start from the Dart main() function
  - A call to the Framework runApp(…) should be made
    - The parameter should be a widget derived object, with the UI of the app's home page

```
import 'package:flutter/… ';    // needed Dart and Flutter imports

void main() => runApp(MyApp());

class MyApp extends StatelessWidget {
  @override
  Widget build(BuildContext context) {
    return MaterialApp (
      …
    );
  }
}
```

one of the Framework top level widgets:
WidgetApp
CupertinoApp
MaterialApp

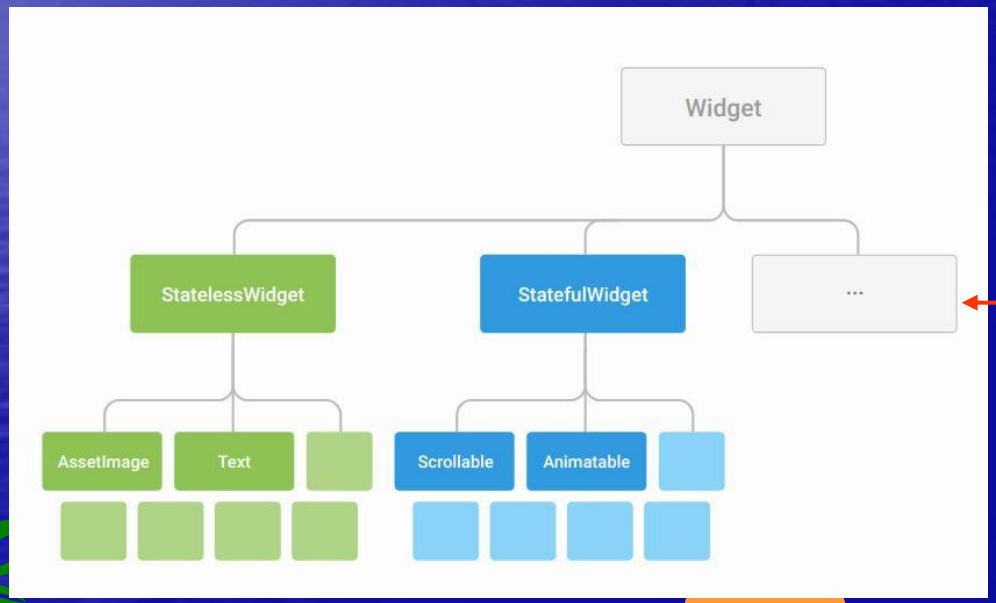


Flutter project structure

- The top widget is usually one of the App widgets of the Framework

Widgets

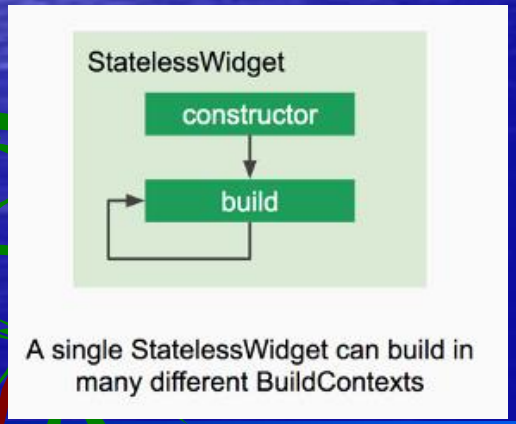
- All the UI is made by a tree of Widgets
  - Not only displayed objects, but also almost anything related to a UI is a Widget (e.g. the GestureDetector or the Align widget)
    - Almost all widgets are a StatelessWidget or a StatefulWidget



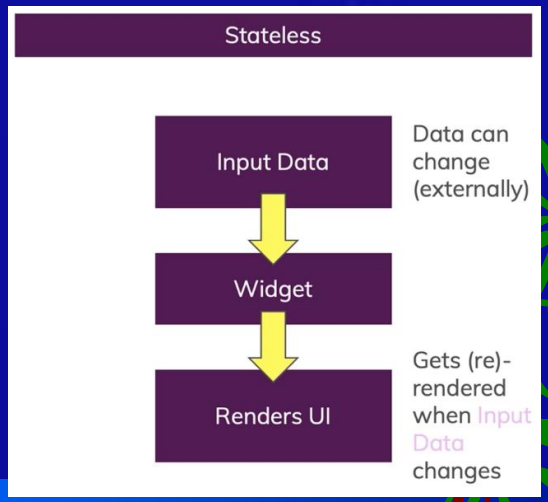
we have also in the Framework:
. PreferredSizeWidget
. RenderObjectWidget
. ProxyWidget

Stateless Widgets

- **Stateless widgets are immutable**
  - They receive configuration data through the constructor
    - The constructor calls the build(…) method that returns the widget object
    - The build(…) cannot be called again
  - To redraw a StatelessWidget a new instance must be created

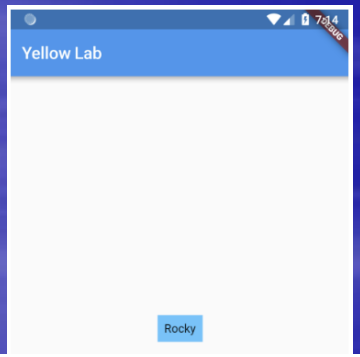


Widgets receive a BuildContext in the build( ) method
It is a reference to the location of a Widget in the UI tree
It can contain properties concerning the widgets rendering



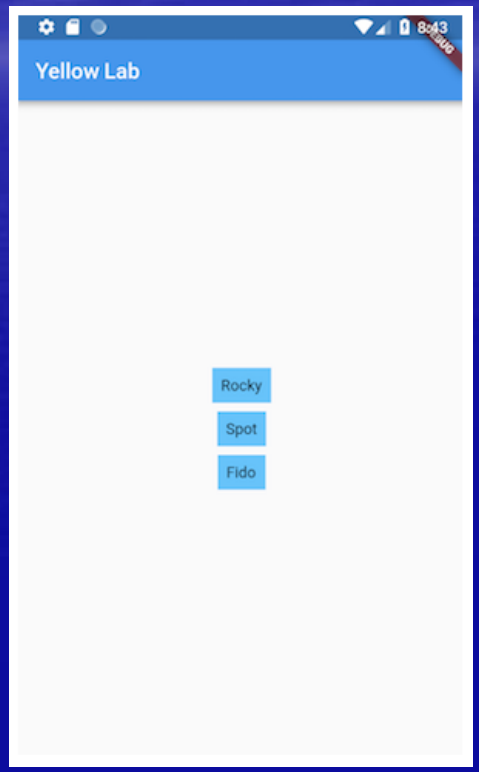
Stateless Example

One dog




```dart
import 'package:flutter/material.dart';

void main() {
 runApp(new DogApp());
}

class DogApp extends StatelessWidget {
 @override
 Widget build(BuildContext context) {
   return MaterialApp(
     title: 'My Dog App',
     home: Scaffold(
       appBar: AppBar(
         title: Text('Yellow Lab'),
       ),
       body: Center(
         child: DecoratedBox(
           decoration: BoxDecoration(color: Colors.lightBlueAccent),
           child: Padding(
             padding: const EdgeInsets.all(8.0)
             child: Text('Rocky'),
           ),
         ),
       ),
     ),
   );
 }
```

Three Dogs in a column




```dart
      body: Center(
        child: Column(
          mainAxisAlignment: MainAxisAlignment.center,
          children: [
            DogName('Rocky'),
            SizedBox(height: 8.0),
            DogName('Spot'),
            SizedBox(height: 8.0),
            DogName('Fido'),
          ],
        ),
      ),
    );
  }
}
```

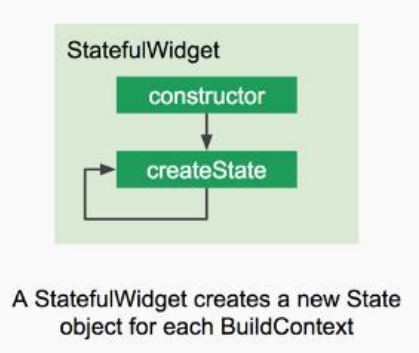
composition pattern

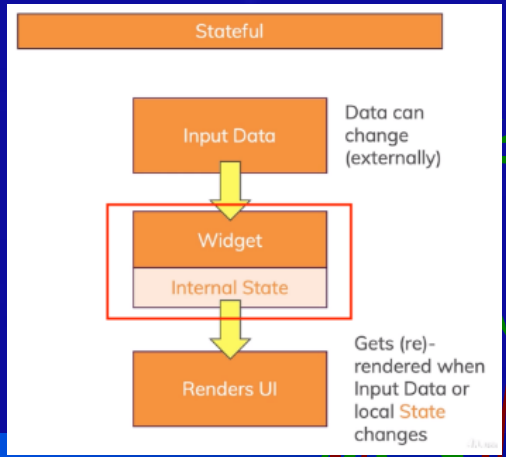
```dart
class DogName extends StatelessWidget {
 final String name;

const DogName(this.name);

 @override
 Widget build(BuildContext context) {
   return DecoratedBox(
     decoration: BoxDecoration(color: Colors.lightBlueAccent),
     child: Padding(
       padding: const EdgeInsets.all(8.0),
       child: Text(name),
     ),
   );
 }
}
```

Stateful Widgets

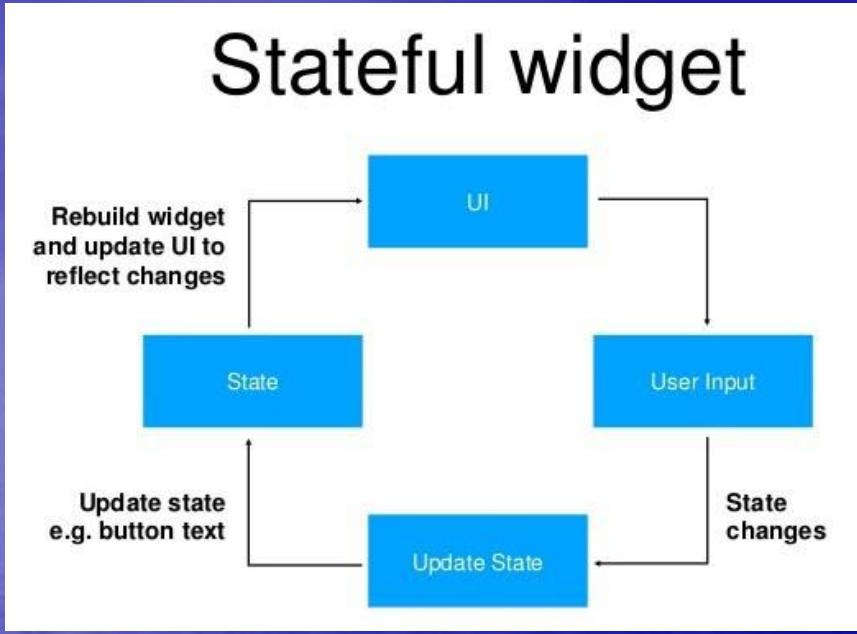
- **Have an associated state object**
  - **The state object is mutable and redraws the immutable widget through its build() method**
    - **The StatefulWidget derived class should override at least the createState() method, that returns the associated state object**
    - **The associated State class should derive the build() method that returns the Widget (created the first time or redrawn)**

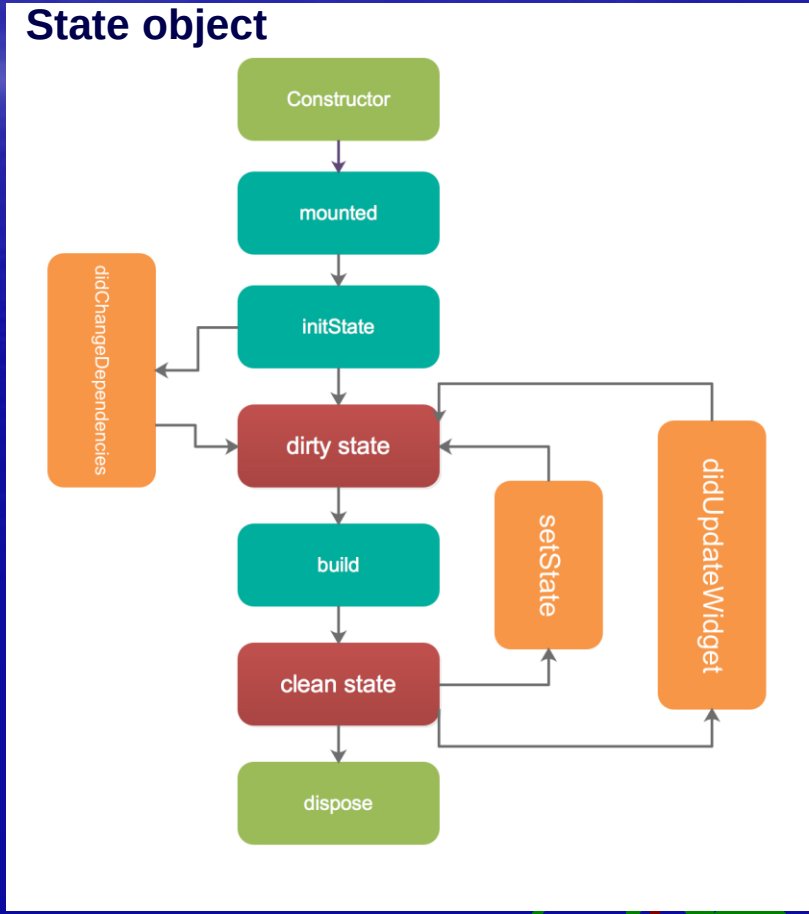
```
class MyWidget extends StatefulWidget {
  @override
  _MyWidgetState createState() => _MyWidgetState();
}

class _MyWidgetState extends State<MyWidget> {
  sometype value = initvalue;

  @override
  Widget build(BuildContext context) {
    return Container(
      ...                    // the UI of this widget
    );
  }
}
```





Stateful Lyfecycle





createState() call Immediately after construction

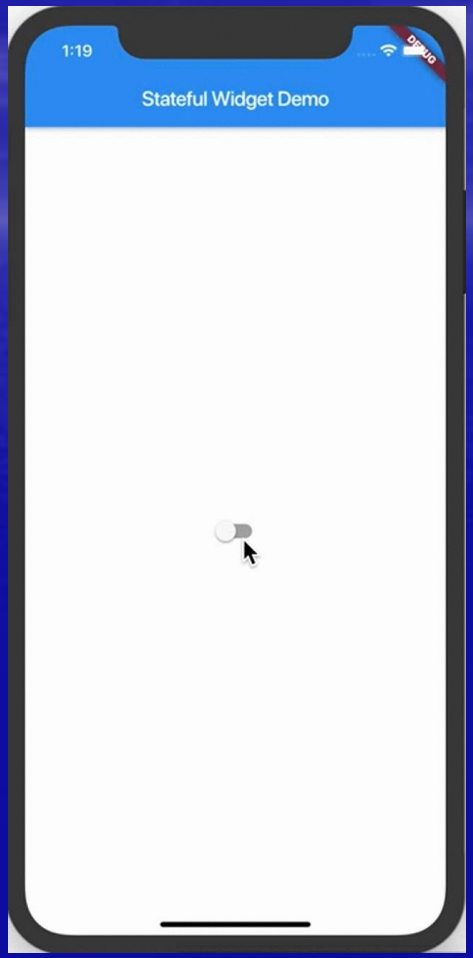
initState() call Called after creation if overridden

build() call To create or redraw a widget tree
dependent on the state
Automatically called if state changes
(using setState() or didUpdateWidget()

setState() call Should be called with a function parameter that changes the state and makes a rebuild

Stateful Widget Example

```dart
import 'package:flutter/material.dart';

void main() => runApp(MyHomePage());

class MyHomePage extends StatefulWidget {
  MyHomePage({Key key, this.title}) : super(key: key);
  final String title;
  @override
  _MyHomePageState createState() => _MyHomePageState();
}

class _MyHomePageState extends State<MyHomePage> {
  bool value = false;

  @override
  Widget build(BuildContext context) {
    return MaterialApp(
      home: new Scaffold(
        backgroundColor: value ? Colors.black : Colors.white,
        appBar: new AppBar(
          title: new Text('Stateful Widget Demo'),
        ),
        body: Center(
          child: Switch(
              value: value,
              onChanged: (v) {
                setState(() {
                  value = v;
                });
              }),
        ),
      ),
    );
  }
}
```



When the user clicks the Switch the onChanged method runs.

It calls setState() on _MyHomePageState changing the property value.

The widgets that depend on it (Scaffold, Switch) are rebuilt.

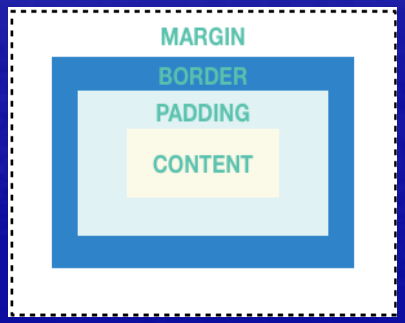
Some Generic Layout Widgets

The Widgets Flutter Framework library contains 935 classes and 3 exception types

Some represent the top-level app like MaterialApp or CupertinoApp and some others the common structure of a page, like Scaffold

To organize the page (screen) widget tree there are many other widgets that can be used, with one or multiple children.

Many visual widgets can have the depicted decorations around them, usually defined in other widgets, like Padding, BoxDecoration, or the Container.



Column

Row

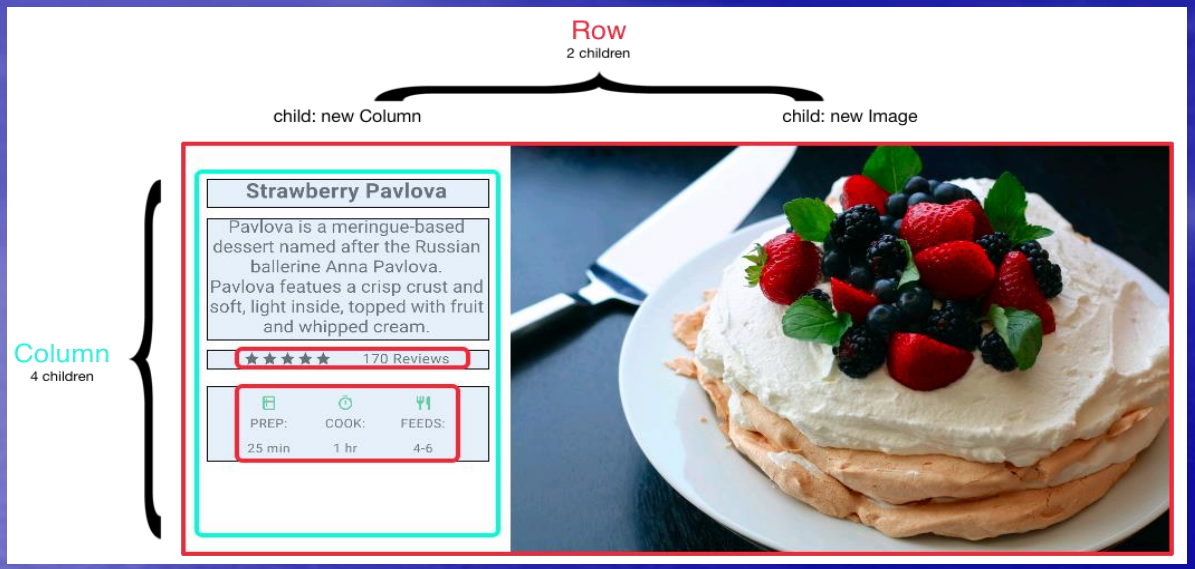
Layout a list of children in vertical or horizontal direction

Stack

Layout the children overlapped

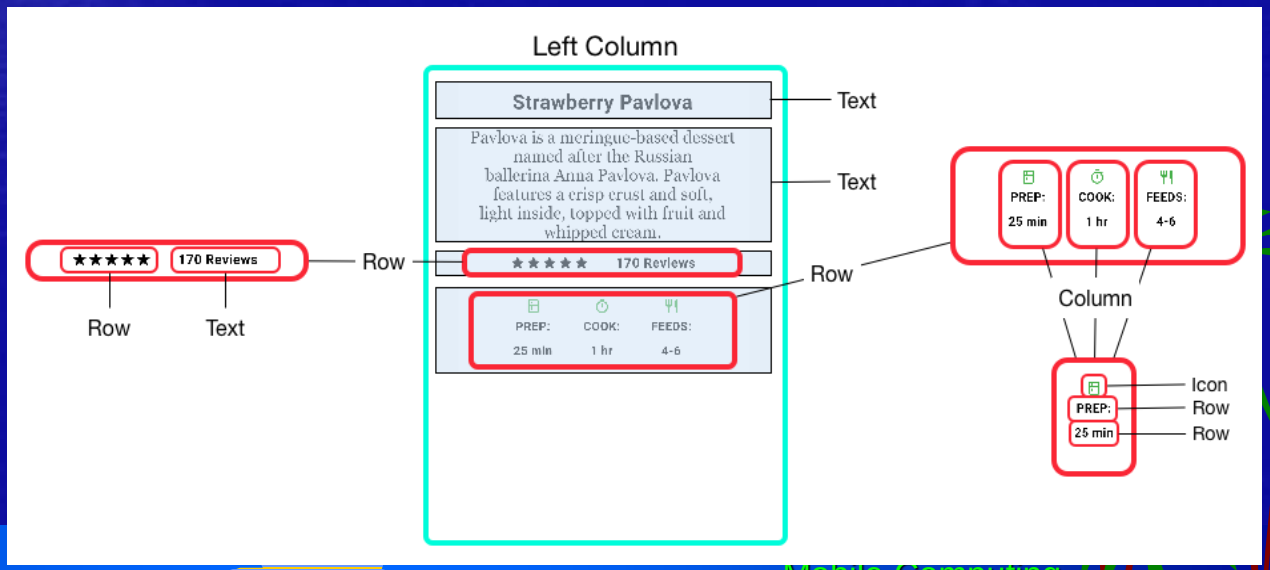
Scrollable displays of other widgets in a linear or tabular layout

An Example

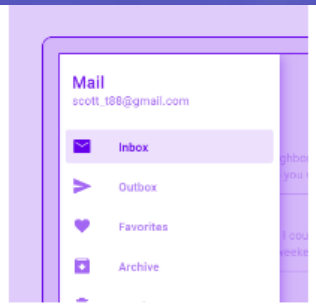


Top structure

The left Column

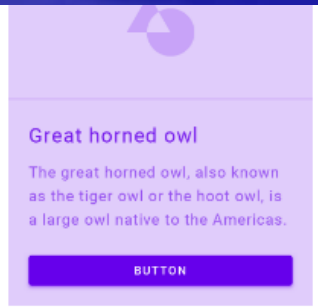


Some Other Widgets



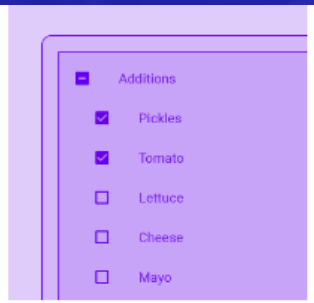
Drawer

A Material Design panel that slides in horizontally from the edge of a Scaffold to show navigation links in an application.



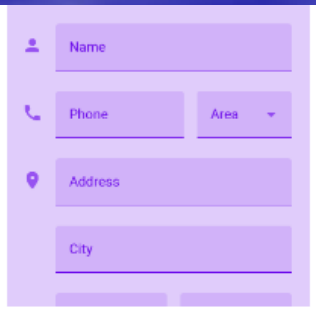
RaisedButton

A Material Design raised button. A raised button consists of a rectangular piece of material that hovers over the interface.



Checkbox

Checkboxes allow the user to select multiple options from a set. The Checkbox widget implements this component.



TextField

Touching a text field places the cursor and displays the keyboard. The TextField widget implements this component.

Image

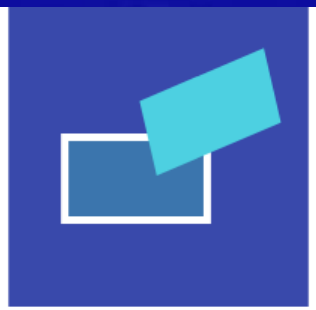
A widget that displays an image.

Date & Time Pickers

Date pickers use a dialog window to select a single date on mobile. Time pickers use a dialog to select a single time (in the hours:minutes format) on mobile.

Text

A run of text with a single style.



Transform

A widget that applies a transformation before painting its child.

Page Navigation

The Navigator widget allows the replacement of a page by another using a stack discipline. It is possible to create a set of navigation routes previously in the app, or build it when we want to navigate to it.

```
void main() {
 runApp(MaterialApp(
   home: MyAppHome(),                  // becomes the route named '/'
   routes: <String, WidgetBuilder> {
     '/a': (BuildContext context) => MyPage(title: 'page A'),
     '/b': (BuildContext context) => MyPage(title: 'page B'),
     '/c': (BuildContext context) => MyPage(title: 'page C'),
   },
 ));
}
```

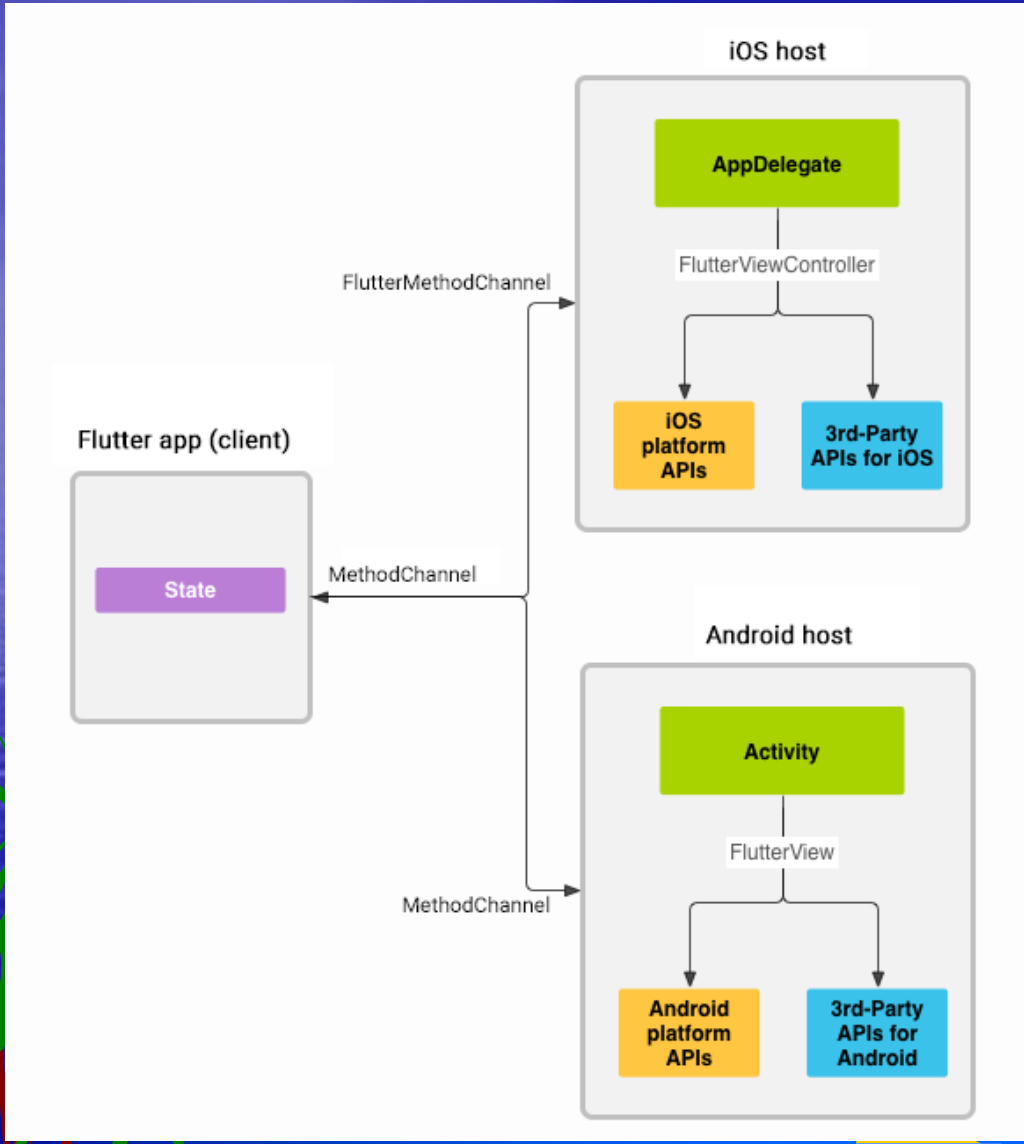
```
// within the MyAppHome widget
...
Navigator.of(context).pushNamed('/b');
```

Or

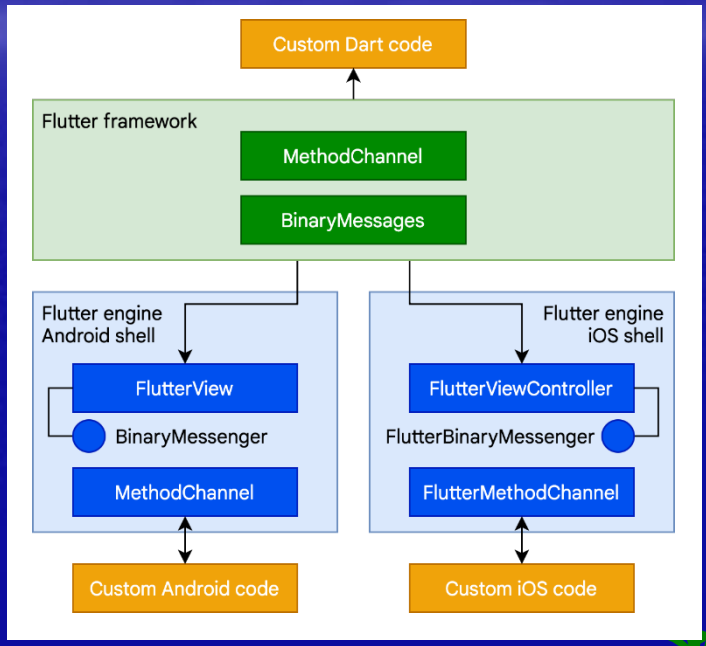
```
// within the MyAppHome widget
...
Navigator.of(context).push(MaterialPageRoute(
     builder: (context) => MyPage(title: 'page B') )
);
```

```
// within the MyPage widget
...
Navigator.of(context).pop();
```

Platform Specific Code



It is possible to call any native functionality using MethodChanels



The concrete MethodChannel must be implemented both in the Flutter side, and the native side in the interfacing FlutterView

Example

```dart
// Dart side
const channel = MethodChannel('foo');
final String greeting = await channel.invokeMethod('bar', 'world');
print(greeting);
```

```kotlin
// Android (Kotlin)
val channel = MethodChannel(flutterView, "foo")
channel.setMethodCallHandler { call, result ->
  when (call.method) {
    "bar" -> result.success("Hello, ${call.arguments}")
    else -> result.notImplemented()
  }
}
```

```swift
// iOS (Swift)
let channel = FlutterMethodChannel(name: "foo", binaryMessenger: flutterView)
channel.setMethodCallHandler {
  (call: FlutterMethodCall, result: FlutterResult) -> Void in
  switch (call.method) {
    case "bar": result("Hello, \(call.arguments as! String)")
    default: result(FlutterMethodNotImplemented)
  }
}
```

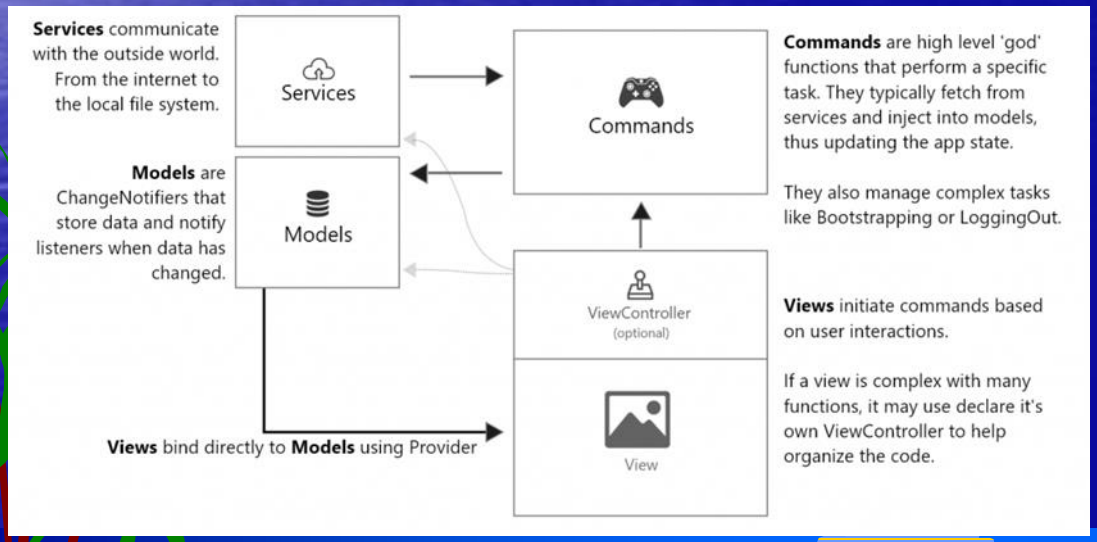
App Architecture

. There are some difficulties in managing State and Business Logic (Domain Logic, linked to data, and Application Logic, linked to functionalities/user operations) in Flutter applications.

. It is not easy to adapt well known architectures, like MVC, to the Flutter app structure.

. Many architectural patterns have been proposed with corresponding plugins … (https://flutter.dev/docs/development/data-and-backend/state-mgmt/options)

. One of them leverages the Flutter class ChangeNotifier (notifies if data changes) and the package Provider (binds Models to the BuildContext) to implement a clean MVC+S architecture.
(https://blog.gskinner.com/archives/2020/09/flutter-state-management-with-mvcs.html)



Provider package:
(https://pub.dev/packages/provider)