CMPS 312

State Management with

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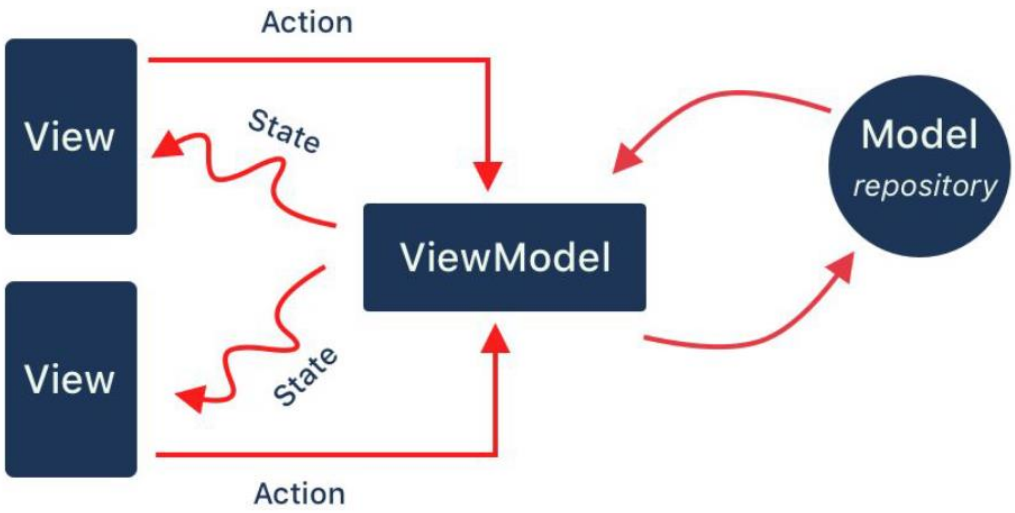
CSE@QU

Outline

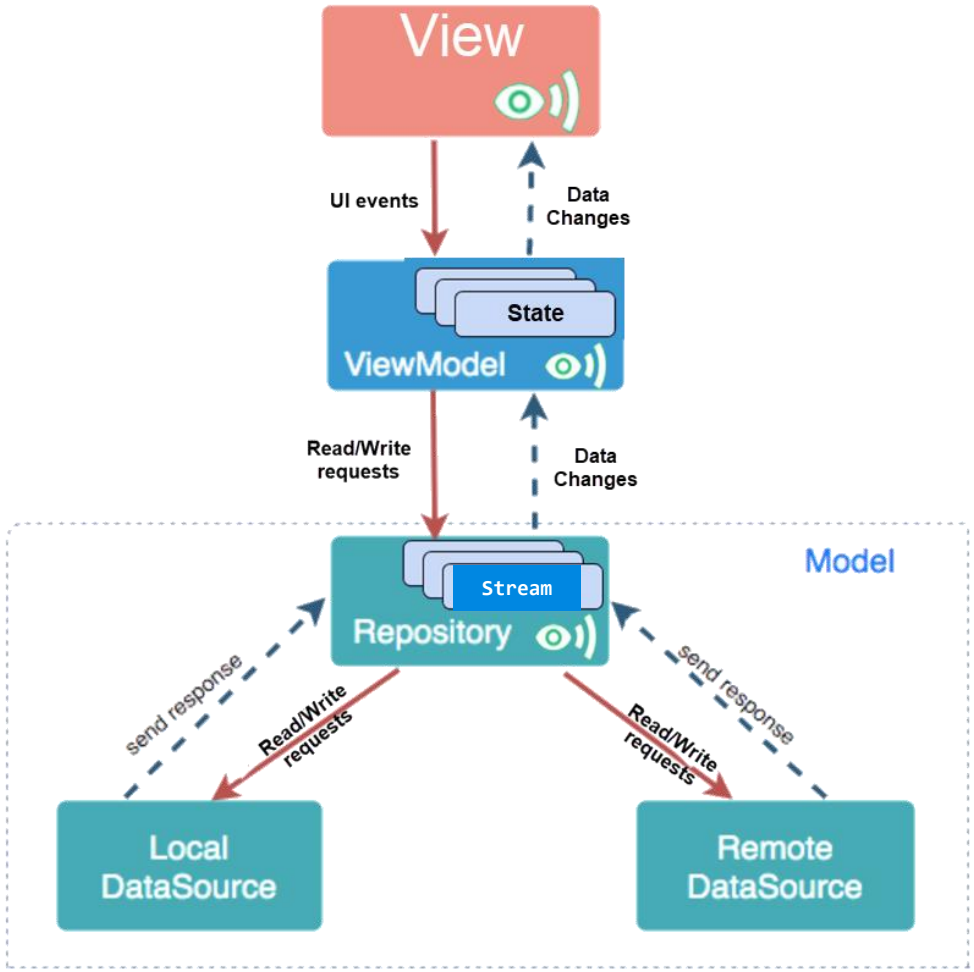
1. Model-View-ViewModel (MVVM)
2. Riverpod Providers (ViewModel)

MVVM Architecture



Back

Model-View-ViewModel (MVVM) Architecture



View = UI to display state & collect user input

- It **observes** state changes from the ViewModel to update the UI accordingly

- Calls the ViewModel to handle events such as button clicks, form input, etc.

ViewModel

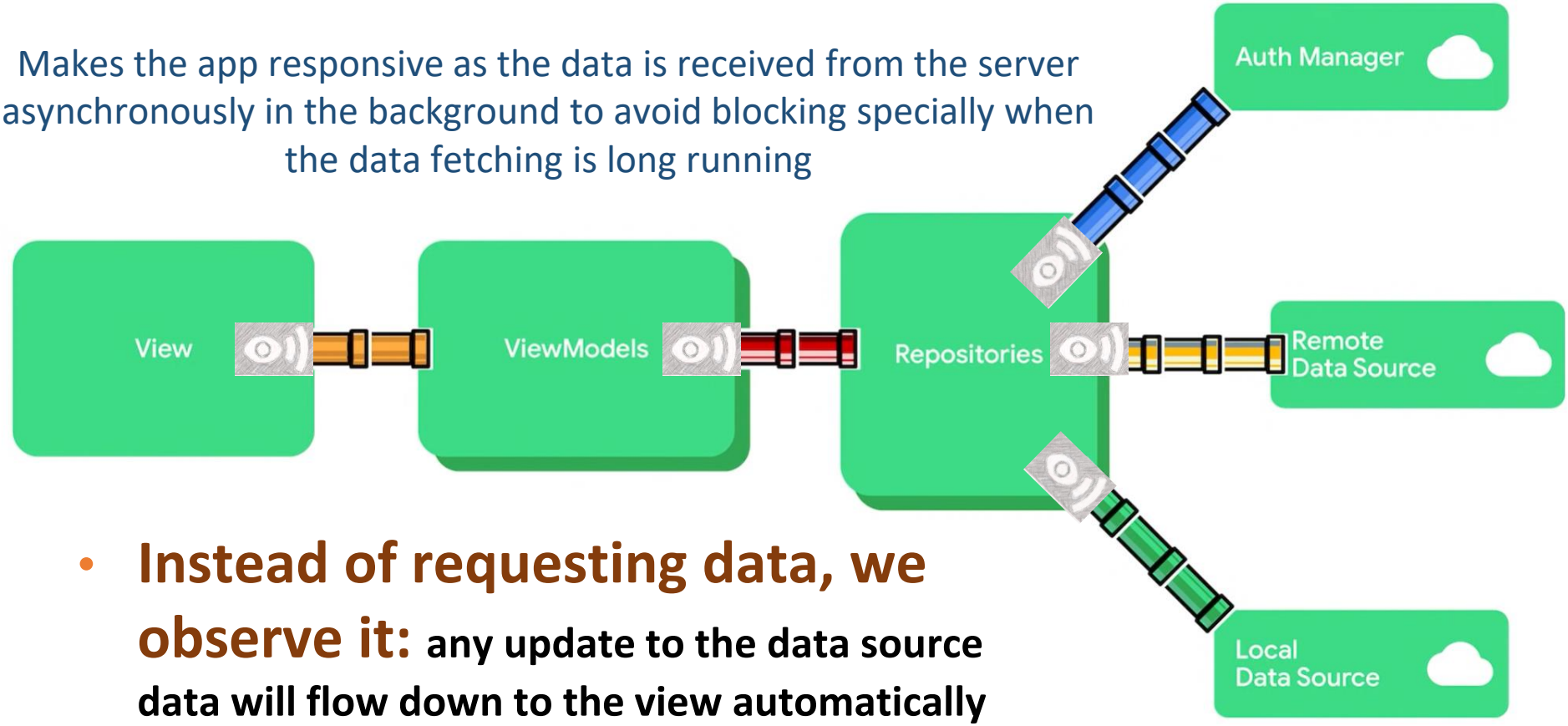
- Manages **state** (i.e., data needed by the UI)
  - Interacts with the Model to read/write data based on user input
  - Expose the state as **Observables** that the UI can subscribe-to to get data changes
- Implements UI logic / computation (e.g., Filtering or Sorting Data, Validate user input, check correct email format or check both the password and confirm password fields match)

Model - handles data operations

- Model has **entities** that represent app data
- **Repositories** read/write data from either a Local Database or a Remote Web API
- Implements data-related logic / computation

Notifiers are used to keep the View in synch with the data sources

Makes the app responsive as the data is received from the server asynchronously in the background to avoid blocking specially when the data fetching is long running



- **Instead of requesting data, we observe it: any update to the data source data will flow down to the view automatically**
- Repo observes data changes from data sources
- ViewModel observes data changes from the Repo
- View observes data changes from the ViewModel

MVVM Key Principles

- Separation of concerns:
  - View, ViewModel, and Model are **separate components** with distinct roles
- Loose coupling:
  - ViewModel **has no direct reference to the View**
  - View never accesses the model directly
  - Model unaware of the view
- Observer pattern:
  - View observes the ViewModel (to get data changes)
  - ViewModel observes the Model (to get data changes)

Advantages of MVVM

- ***Separation of concerns* = separate UI from app logic**
  - App logic is not intermixed with the UI. Consequently, code is cleaner, flexible and easier to understand and change
  - Allow changing a component without significantly disturbing the others (e.g., View can be completely changed without touching the model)
  - Easier **testing** of the App components

MVVM => Easily maintainable and testable app

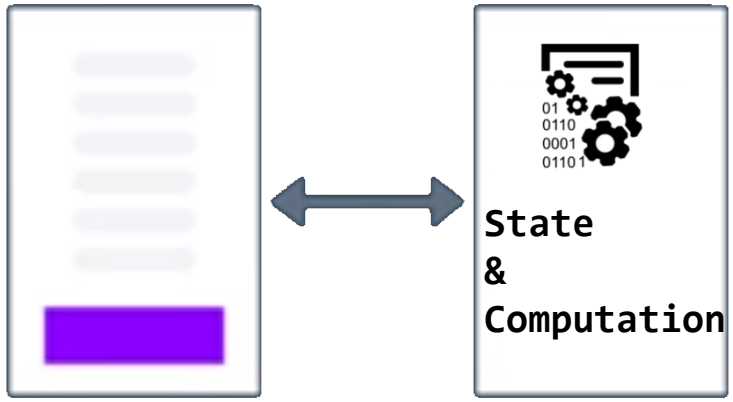
Riverpod Providers (ViewModel)

Riverpod

- Allows you to efficiently create, manage, and share states across the app
- Promotes clean code by **separating** business logic from UI, which simplifies testing and maintenance
- It provides different types of providers to manage various kinds of state
- Allows data caching

Provider

- Provider acts as the ViewModel is used to **store and manage state** (i.e., data needed by the UI)
- A **State** variable is an **observable data holder** whose reads and writes are observed by Flutter to trigger UI rebuild
- Provider exposes **State** variables that the View observes and update the UI accordingly
  - This decouples the Provider from the View: the Provider does NOT have any direct reference to the View
  - The View can observe the Provider State variables for changes then update the UI

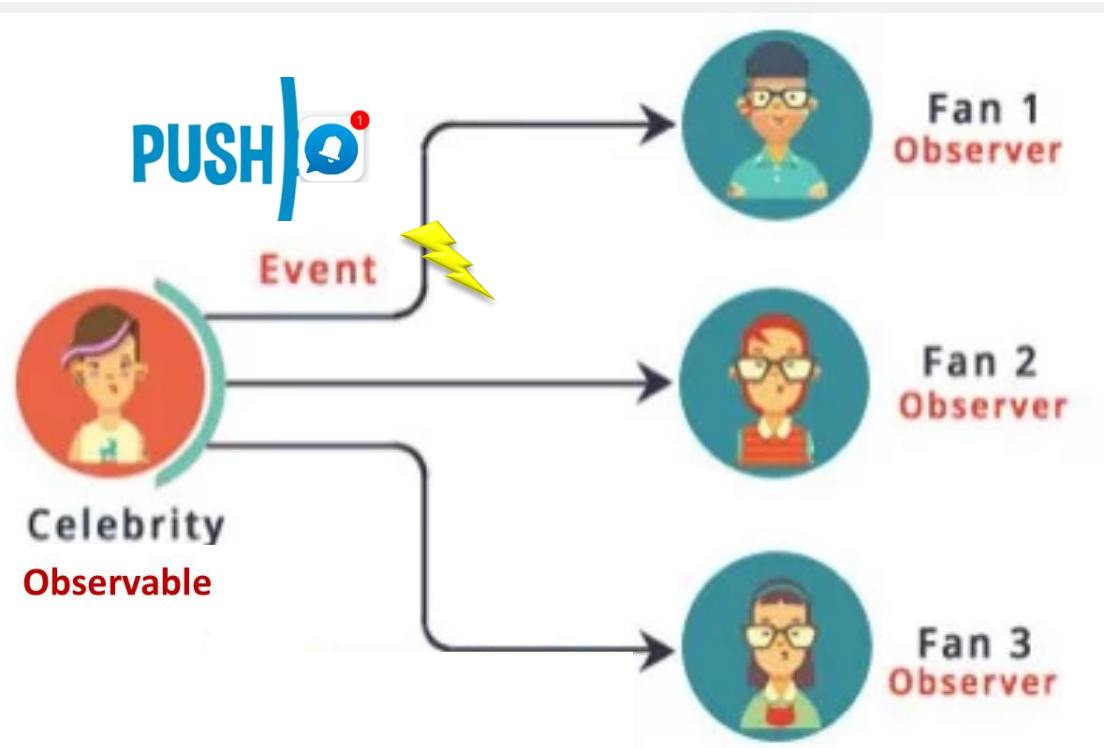


Use **Provider**:

- Manages state
- Read/write data from a Repository

Observable - Real-Life Example

- A celebrity who has many fans on Instagram. Fans want to get all the latest updates (photos, videos, posts etc.). Here fans are **Observers** and celebrity is an **Observable**



“no contexts in ViewModels” rule

- ViewModel should **not be aware of the View** who is interacting with
  => It should be decoupled from the View

  - ViewModel should not hold a reference to Widgets
  - Should not have any Flutter framework related code
  - As this defeats the purpose of separating the UI from the data
  - Can lead to memory leaks and crashes (due to null pointer exceptions) as the ViewModel outlives the View
    - if you rotate a screen 3 times, 3 three different screen instances will be created, but you only have one ViewModel instance

Main Providers in Riverpod

Provider Type	Description	Key Features	Typical Usage
Provider	Provides immutable data that doesn't change over time.	- Used for static, read-only values. - Ideal for objects created once and shared across the app. - No reactivity or updates.	- Providing configuration data, constants, or dependencies that don't change. - Example: API base URLs, theme settings.
NotifierProvider	Provides a stateful object that extends `Notifier<T>`.	- Allows state management logic with an object. - Use `Notifier` to create a class with business logic.	- Managing complex state logic such as authentication state, form validation, or application settings.
FutureProvider	Handles asynchronous data	- Automatically rebuilds when the `Future` completes. - Returns a loading/error state while waiting. - Useful for fetching async data.	- Fetching data from an API. - Asynchronous initialization like loading user data, preferences, or remote configuration at startup.
StreamProvider	Handles continuous asynchronous data from a `Stream`.	- Provides real-time data updates. - Useful for data that continuously changes. - Returns a loading/error state while waiting for updates.	- Real-time data streams like a chat application. - Listening to database changes or sensor data. - WebSocket connections.

Providers - Example Usage Scenarios

- **Provider**: Static configurations like app themes or localization settings
- **NotifierProvider**: Managing shopping cart in eCommerce app
- **FutureProvider**: Fetching weather data
- **StreamProvider**: Listening to Firebase Firestore document updates or real-time messaging

Provider

- Provider provides a shared read-only value to to the parts of your app that need it
  - Used to provide a value that doesn't change, such as configuration data, a service, or a theme
  - It does not rebuild UI when the value changes
- Using simple static variable is simpler but:
  - Static variable is **globally** accessible and can't be scoped to different parts of the widget tree (vs. provider could make data available to only a subpart of the widget tree)
  - Riverpod takes care of automatic resource disposal and ensures that providers are disposed of when not needed (e.g., removing listeners when widgets are destroyed)
  - Static variables persist throughout the app's lifetime

Provider Example

```
final apiUrlProvider = Provider<String>(
      (ref) => "https://api.example.com"
);

class ApiUrlScreen extends ConsumerWidget {
  @override
  Widget build(BuildContext context, WidgetRef ref) {
    // Reading the API URL using the provider
    final apiUrl = ref.read(apiUrlProvider);

    return Center(
        child: Text('API URL: $apiUrl’),
    );
  }
}
```

Consuming Providers from the UI

- For widgets to be able to read/watch providers, we need to wrap the root widget in a **ProviderScope** widget
  - This is where the state of the app providers will be stored

```
void main() {
  runApp(
    ProviderScope(child: MyApp())
  )}
```

- Widgets should extend **`ConsumerWidget`** instead of StatelessWidget (or **`ConsumerStatefulWidget`** instead of StatefulWidget) to get a **WidgetRef** object to access the declared providers
  - **`ref.read`** / **`ref.watch`** enables reading/watching providers

```
class CounterScreen extends ConsumerWidget {
  @override
  Widget build(BuildContext context, WidgetRef ref) {
    final counter = ref.watch(counterProvider);
    ...
```

How to read provider state

- `ref.watch()`: Any widget that is listening to this provider will rebuild whenever the provider's state changes
- `ref.read()`: Typically used for accessing a provider's current state without listening to it
  - Use **`ref.read`** when logic is performed in event handlers such as `onPressed`
  - Whenever possible, prefer using **`ref.watch`** over **`ref.read`** to yield a reactive UI

NotifierProvider

- **NotifierProvider** is responsible for creating and providing an instance of a **Notifier class** to the parts of your app that need it
  - Acts as the mechanism that makes the state available to the app
- Key Features:
  - Encapsulation: Keeps state management logic encapsulated within the Notifier class
  - The Provider allows Widgets to **listen to changes** in the state managed by the Notifier and rebuild themselves when the state changes

NotifierProvider - Notifier class

- A Notifier is a class that **holds** the mutable state and the **logic** to manipulate that state (i.e., methods to update or compute it) => the "**how**" of state changes
  - Must extend the `Notifier<T>`
  - Must override the `build` method to initialize the state
  - It encapsulates state management methods that mutate the state
    - Listeners get notified of the changes, making the UI reactive to these changes
  - E.g. CounterNotifier class holds the counter state and provides methods to increment and decrement the counter
    - Listeners get notified whenever the state changes
- Public methods on this class are accessible to consumers using:

```
ref.read(yourProvider.notifier).yourMethod()
```

NotifierProvider - Example

```
class CounterNotifier extends Notifier<int> {
  @override
  int build() => 0;
  void increment() => state++;
}

final counterProvider =
    NotifierProvider<CounterNotifier, int>(() => CounterNotifier());


class CounterScreen extends ConsumerWidget {
  @override
  Widget build(BuildContext context, WidgetRef ref) {
    final counter = ref.watch(counterProvider);
        ...
        ElevatedButton(
          onPressed: () =>
             ref.read(counterProvider.notifier).increment(),
          child: const Text('Increment'),
      ); ...
```

NotifierProvider - Example

- **`NotifierProvider`** creates an instance of **`CounterNotifier`** to allow widgets to listen for state changes
- **`NotifierProvider<CounterNotifier, int>`** has two generic data types:
  - **`CounterNotifier`**: specifies the type of the Notifier class that will manage the state
    - The Notifier is responsible for managing how the state is updated
  - **`int`** : specifies the type of the state being managed by the Notifier
    - The state is what the UI listens to and rebuilds when it changes

FutureProvider

- FutureProvider is used to handle asynchronous operations, like fetching data from an API or database queries
  - **UI rebuilds when the future is completed**: it listens to a Future and triggers a UI rebuild once the operation completes and data is received
  - Handles the **loading**, **error**, and **data** states in a structured manner, e.g.:
    - **loading**: show a spinner until data is available
    - **error**: display error message if something fails
    - **data**: show the received data

FutureProvider Example

```dart
final weatherProvider = FutureProvider<String>((ref) async {
  await Future.delayed(const Duration(seconds: 2)); // Simulate network call
  return "Sunny";  // Data returned from API
});

class WeatherScreen extends ConsumerWidget {
  @override
  Widget build(BuildContext context, WidgetRef ref) {
    final weatherAsync = ref.watch(weatherProvider);

    return Scaffold(
      appBar: AppBar(title: const Text('Weather Forecast')),
      body: weatherAsync.when(
        loading: () => const CircularProgressIndicator(),  // Loading state
        error: (err, stack) => Text('Error: $err'),  // Error state
        data: (weather) => Text('Weather: $weather'), // Success state
      ),
    );
  }
}
```

StreamProvider

- StreamProvider is used to listen to asynchronous data streams
  - 🌊 Returns a stream of values produced asynchronously one by one over time instead of all at once (e.g., receive live updates from a database or Web API then use it to update the UI)
  - Provides the latest emitted value from the stream to the widgets to update the UI when new data arrives from the stream
  - Used for real-time data such as stock prices, chat messages, or sensor readings
  - Handles the **loading**, **error**, and **data** states in a structured manner

StreamProvider Example

```dart
final stockPriceProvider = StreamProvider<double>((ref) async* {
  // Simulate fetching stock prices from an API.
  await Future.delayed(const Duration(seconds: 1));
  yield 150.0; // Initial price
  await Future.delayed(const Duration(seconds: 2));
  yield 152.5; // New price update
  await Future.delayed(const Duration(seconds: 2));
  yield 151.0; // Another update
});

class StockPriceScreen extends ConsumerWidget {
  @override
  Widget build(BuildContext context, WidgetRef ref) {
    final stockPriceAsync = ref.watch(stockPriceProvider);

    return Center(
        child: stockPriceAsync.when(
          data: (price) => Text("Stock Price: \$${price}"),
          loading: () => const CircularProgressIndicator(),
          error: (err, stack) => Text("Error: $err"),
    );
}}
```

Provider.autoDispose

- .autoDispose is used to automatically dispose the provider when no longer needed (i.e., when the UI is no longer listening)
  - improving performance and reducing memory usage

```
final weatherProvider =
FutureProvider.autoDispose<String>((ref) async {
  // Simulate network call
  await Future.delayed(const Duration(seconds: 2));
  return "Sunny"; // Data returned from API
});
```