CMPS 312

State Management with

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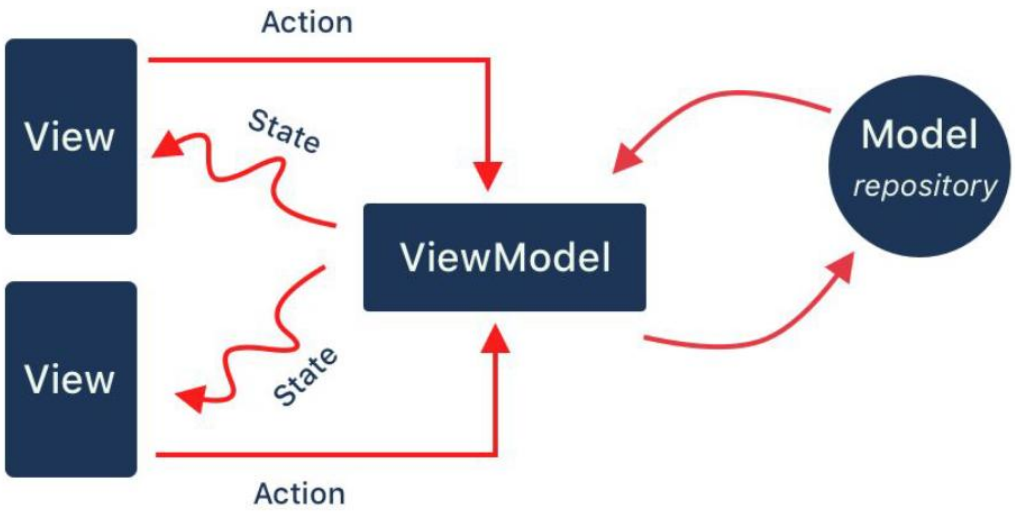
CSE@QU

Outline

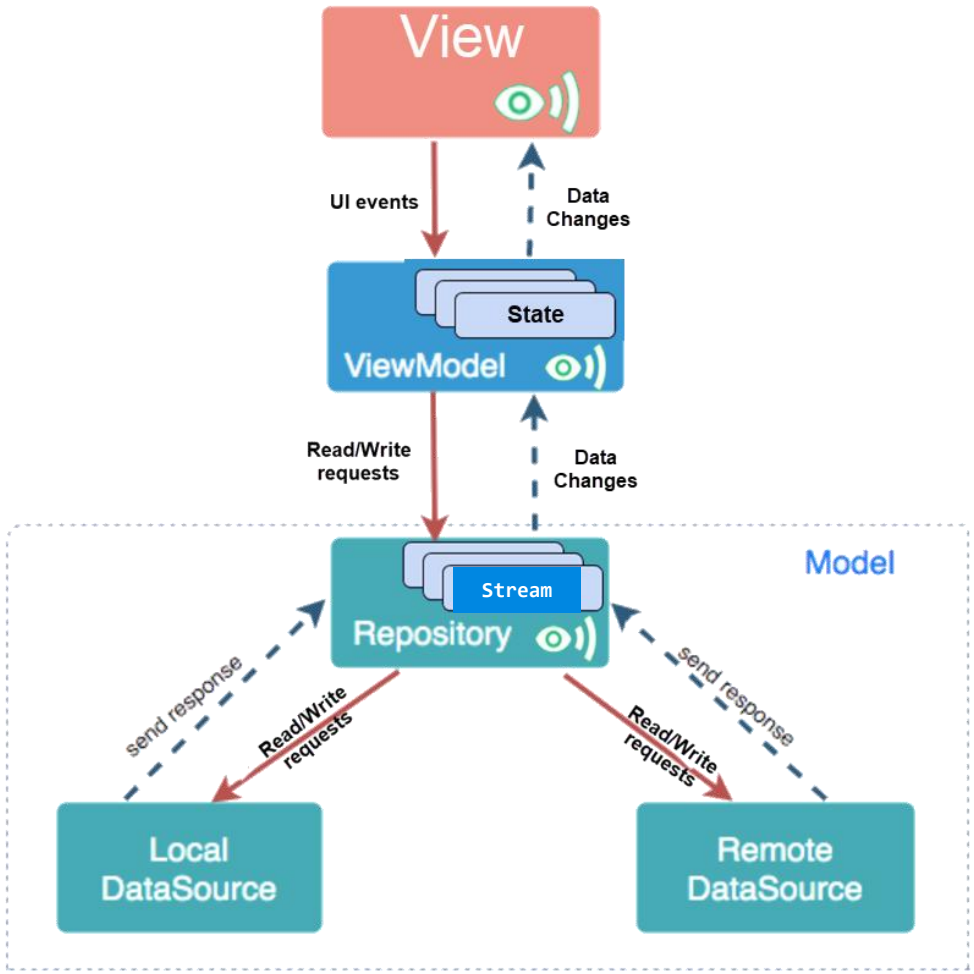
1. Model-View-ViewModel (MVVM)
2. Riverpod Providers (ViewModel)

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

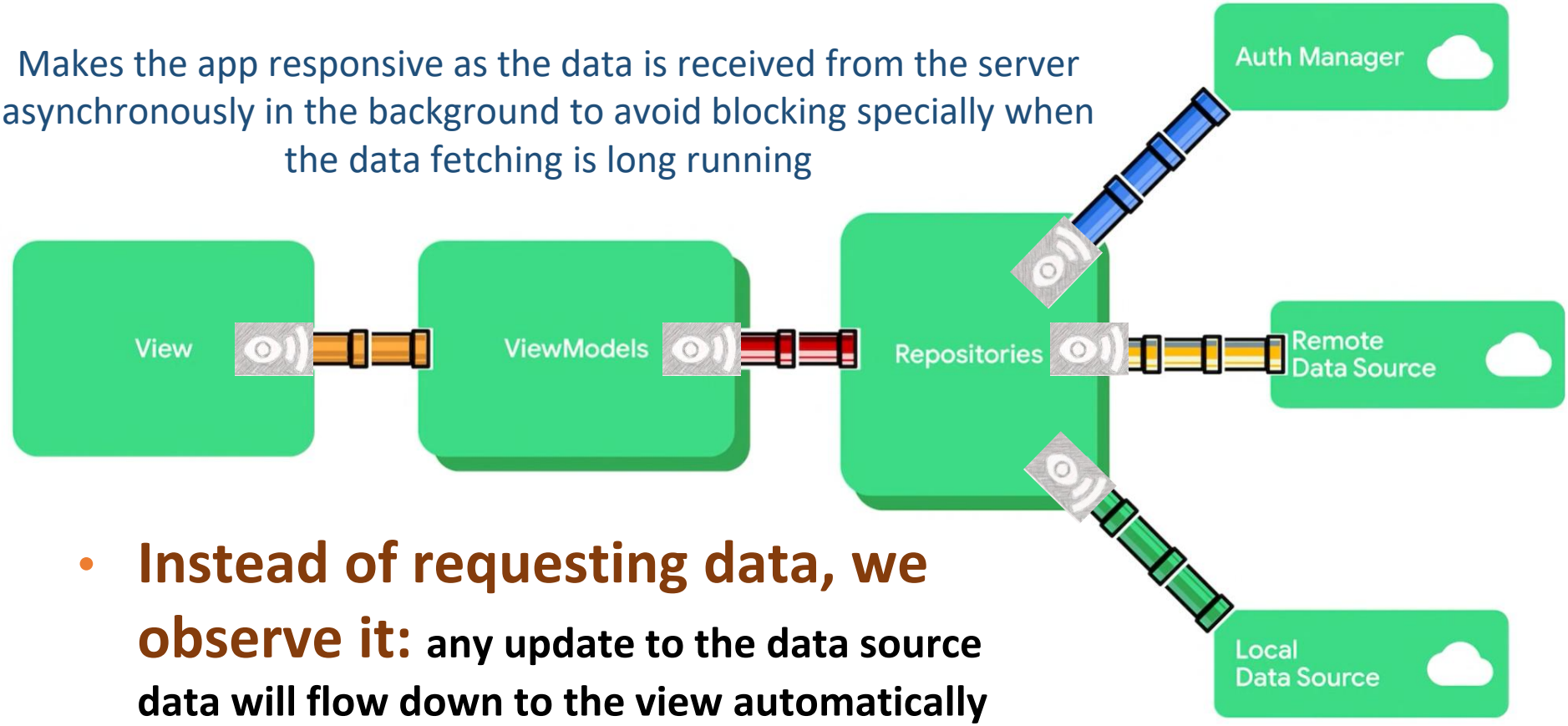
- Manages **state** (i.e., data needed by the UI)
  - Interacts with the Model to read/write data based on user input
  - Expose the state as **Observables** that the UI can subscribe-to to get data changes
- Implements UI logic / computation (e.g., Filtering or Sorting Data, Validate user input, check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

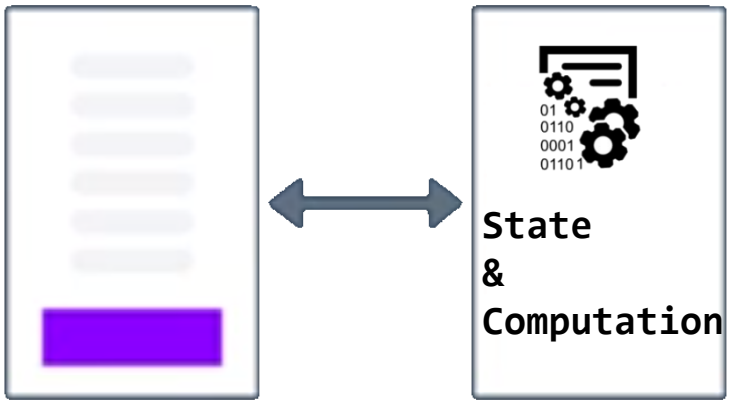
Riverpod Providers (ViewModel)

Riverpod

- Riverpod state management library for Flutter
- Efficiently creates, manages, and shares state across the app
- Promotes clean architecture by **separating** business logic from UI, simplifying testing and maintenance
- Offers multiple provider types for different state management needs
- Supports data caching for improved performance

Provider

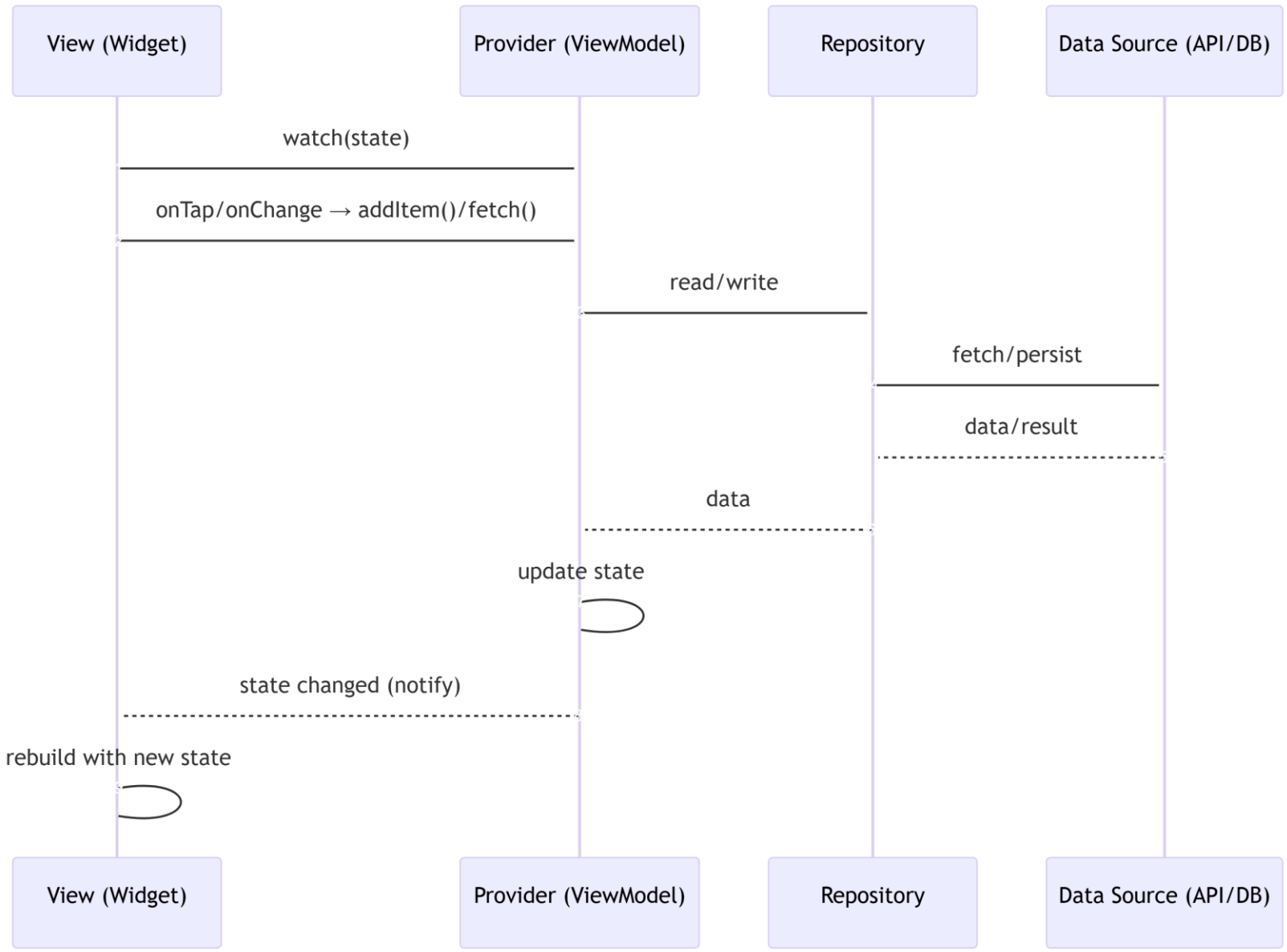
- **Provider** acts as the ViewModel, , **supplying** and **managing** the **state** required by the UI
- Provider exposes **State** variables as **observable data holder** that the View watches to trigger UI rebuild
  - Decouples app logic from the View: the Provider does NOT have any direct reference to the View
  - The View listens to Provider state changes and updates the UI accordingly



Provider responsibilities:

- Manage and update state
- Read/write data from a Repository

State Update Flow in MVVM



“ViewModels should not reference the View” rule

⚠️ ViewModel should **not be aware of the View**
=> It should be decoupled from the View to enforce the principle of separating UI from app logic for better testability and maintainability

- ViewModel should not hold a reference to Widgets
- Should not have any Flutter framework–specific code

- **Risks of violating this rule:**
  - Breaks the MVVM architecture by coupling UI and logic
  - Can cause **memory leaks** and **null pointer exceptions** as the ViewModel outlives the View
    - Example: Rotating the screen creates multiple View instances, but the same ViewModel persists, leading to stale references and crashes

Main Providers in Riverpod

Provider Type	Description	Key Features	Typical Usage
`Provider`	Provides immutable, read-only data	- No state changes - Lightweight, no reactivity	- App config, constants, API URLs, theme settings - Use when data never changes after initialization
`NotifierProvider`	Manages complex, mutable state	- Uses Notifier<T> for state logic - Centralized updates	- App-level state such as Shopping cart, authentication state
`FutureProvider`	Handles asynchronous data	- Auto rebuild UI on completion - Supports loading/error states	- Fetching data from an API (list of products, weather data)
`StreamProvider`	Handles live continuous async data streams	- Auto rebuild UI on data updates - Supports loading/error states	- Continuous data streams such as chat messages, stock price updates

Provider

- Provider provides a shared **read-only value** to the parts of your app that need it
  - Used to provide a value that doesn't change, such as configuration data, API URLs, theme settings
  - It does not rebuild UI when the value changes
- Can't we just use simple static variable?
  - Provider is lazily initialized
  - Static variable is **globally** accessible vs. Provider can scope data to a specific part of the widget tree
    - Promoting better state management and avoiding unnecessary data exposure
  - Static variable remains in memory for the entire duration of the app vs. `Provider.autoDispose` automatically releases resources when the state is no longer needed (e.g., when the widget using it is removed from the widget tree), helping optimize memory usage

Provider Example

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

This Provider exposes a read-only String value, the URL https://api.example.com
Vs. `static apiUrlProvider = "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 Text('API URL: $apiUrl');
  }
}
```

The value can be accessed by any **consumer** widget that needs it using `ref.read`

Consuming Providers from the UI

- To allow widgets to read or watch providers, the root widget must be wrapped in a **`ProviderScope`** widget
  - The ProviderScope serves as the **container** for all providers' states, allowing widgets to read and watch those providers

```
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
  - Use **`ref.read`** / **`ref.watch`** for 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()`: Rebuilds the widget whenever the provider's state changes, ensuring a reactive UI
- `ref.read()`: Accesses the provider's current state without listening to future updates
  - typically used in event handlers such as `onPressed`
- Best Practice: Prefer using `ref.watch()` over `ref.read()` to maintain a reactive UI whenever state changes
  - Use ref.read() for one-time access, like in event handlers

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
- Consumer widgets can call public methods of the Notifier class 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());
```

NotifierProvider creates an instance of **CounterNotifier** to allow widgets to listen for state changes

```
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'),
      ); ...
```

Consumer widget can call public methods of the Notifier class

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
  - 🌊 It returns a stream of values produced incrementally over time, allowing for live updates (e.g., receiving updates from a database or Web API to refresh the UI)
  - It provides the latest emitted value from the stream to update widgets when new data arrives
  - Ideal 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(
          loading: () => const CircularProgressIndicator(),
          error: (err, stack) => Text("Error: $err"),
          data: (price) => Text("Stock Price: \$${price}"),
    );
}}
```

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
});
```

Provider destruction using ref.invalidate

- Sometimes, you may want to force the destruction of a provider using ref.invalidate

```
class MyWidget extends ConsumerWidget {
  @override
  Widget build(BuildContext context, WidgetRef ref) {
    return ElevatedButton(
      onPressed: () {
        // On click, destroy the provider.
        ref.invalidate(someProvider);
      },
      child: const Text('dispose a provider'),
    );
  }
}
```

Combining Providers

- The **`ref`** object is accessible to all providers, allowing them to read or watch other providers
  - Use **`ref.watch`** to get the current state of a provider. Whenever the listened provider updates, the consumer provider will be invalidated and recomputed

```
final otherValue = ref.watch(otherProvider);
```

- e.g., a provider that listens to the user's location and fetches nearby restaurants

```
// We use "ref.watch" to get the latest location
final location = await ref.watch(locationProvider);
// Then get the nearby restaurants based on that location
```

Summary

- Provider-based State Management: Enables a clear separation between state and UI components
- Reactivity: Automatically rebuilds widgets when the state changes, ensuring the UI remains in sync with the data
- Provider Types: Supports various provider types (e.g., Provider, NotifierProvider, FutureProvider, StreamProvider) for different use cases and state management needs
  - NotifierProvider: Supplies an instance of a Notifier class to app Widgets that require it
  - Supports Asynchronous Data: Easily handles asynchronous operations through FutureProvider and StreamProvider

Resources

- Riverpod Documentation

https://riverpod.dev/docs/introduction/getting_started

- Riverpod complete guide

https://resocoder.com/2022/04/22/riverpod-2-0-complete-guide-flutter-tutorial/