Rendering & Responsive UI

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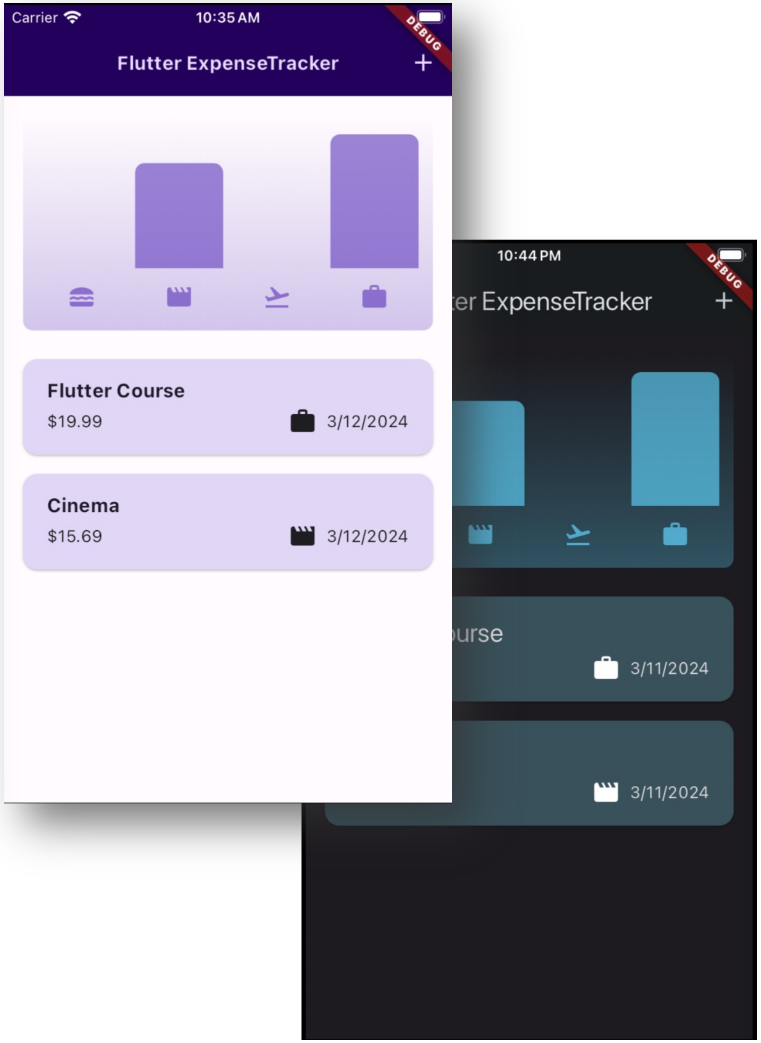
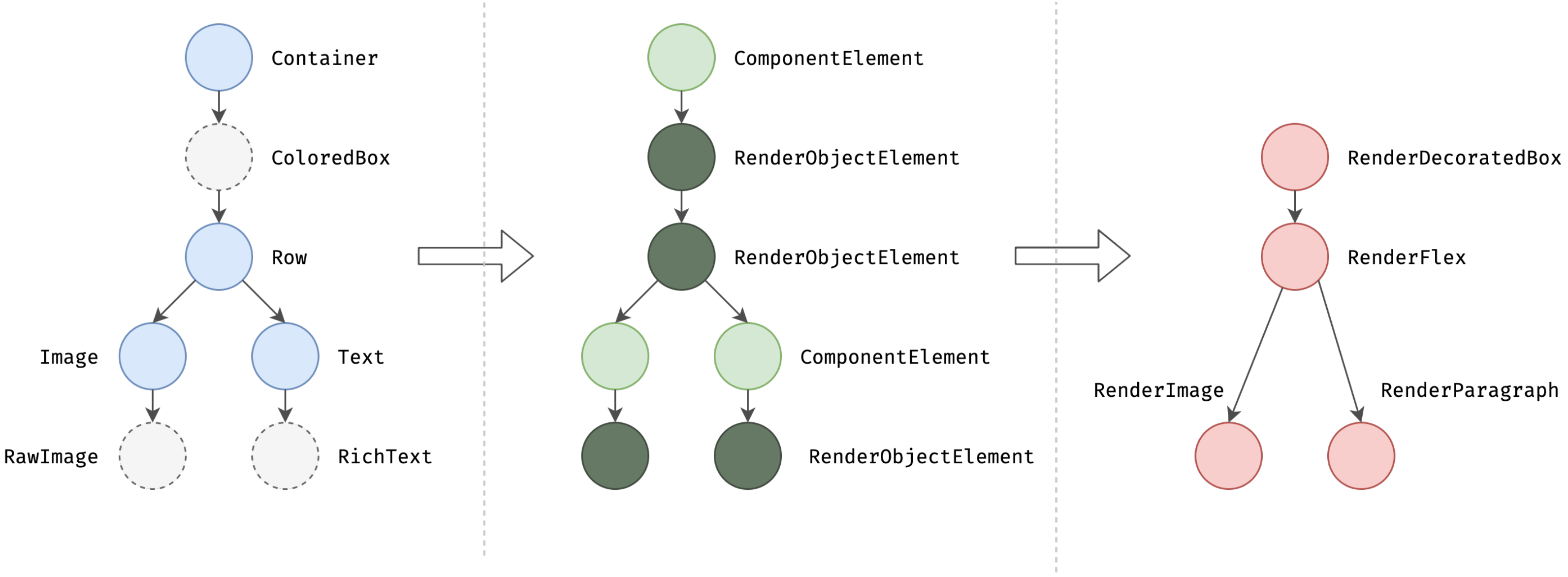
Today’s Topics

- Build & rendering
- Element tree
- Render tree
- Responsive layout
- Custom painting & parallax scrolling



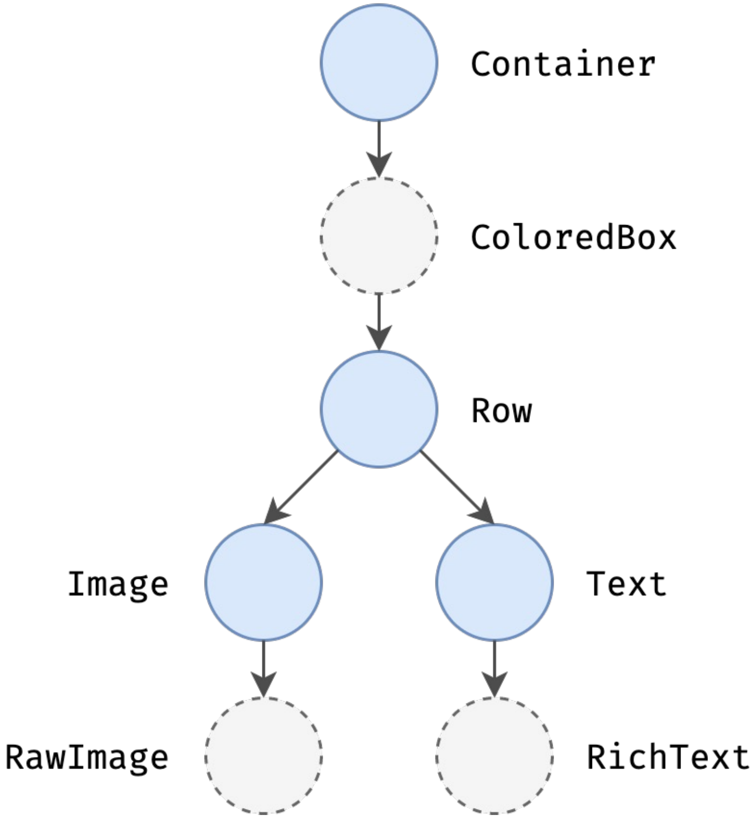
Build & Rendering Process

- ***Widget tree***: UI declaration
- ***Element tree***: states & build context
- ***Render tree***: layout & rendering



Widget Tree

- For each stateful widget, its child widgets tree are reconstructed whenever state changes
- Keep your stateful widget as small as needed
    - Extract stateful subtree to new stateful widget
    - Favor composition over inheritance



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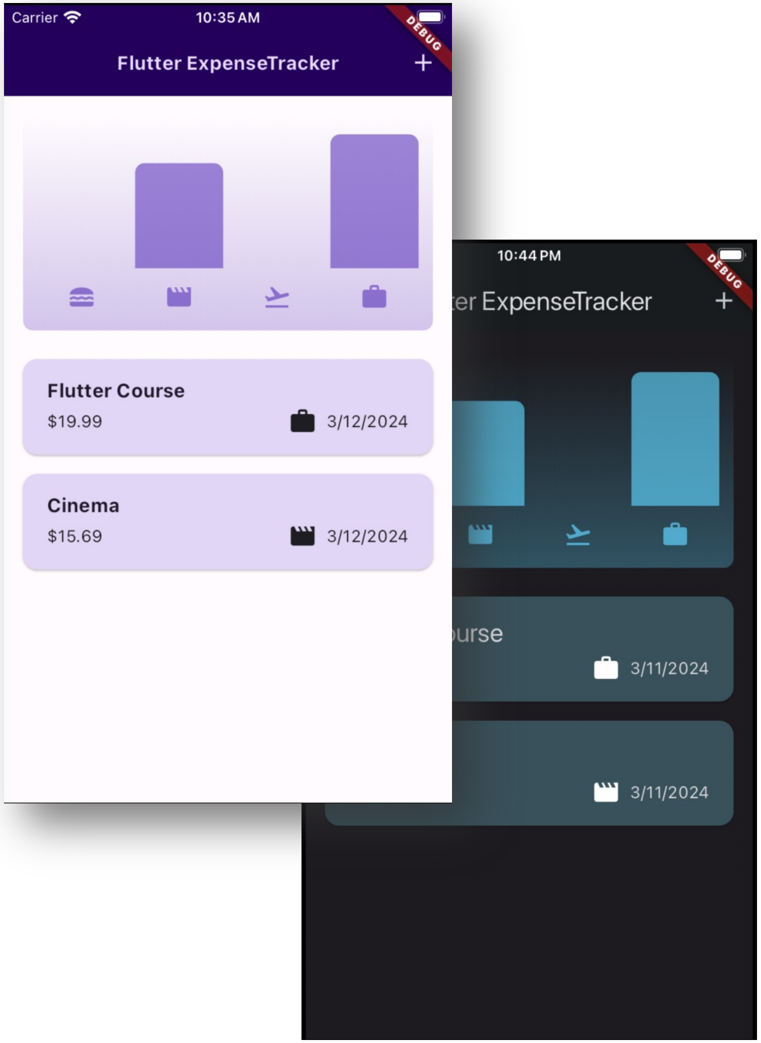

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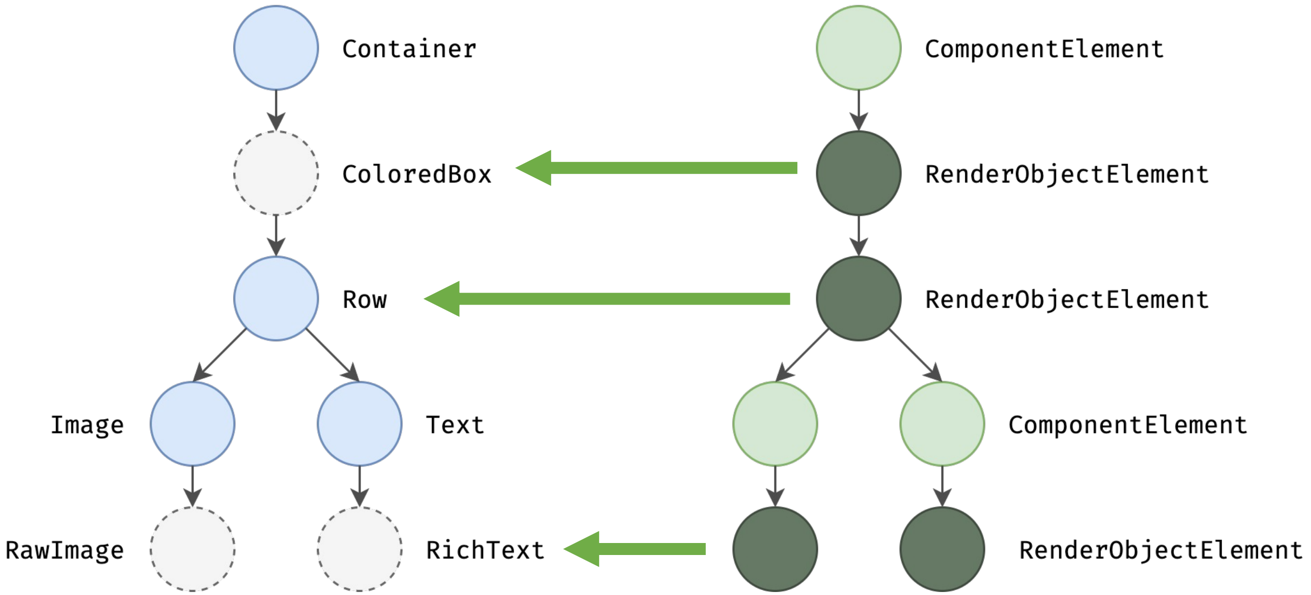
Element Tree & Node

- Every widget has `createElement()` method
- Each element node "points to" corresponding widget
- Provides ***build context*** and ***state*** for the widget



Accessing Inherited Widgets

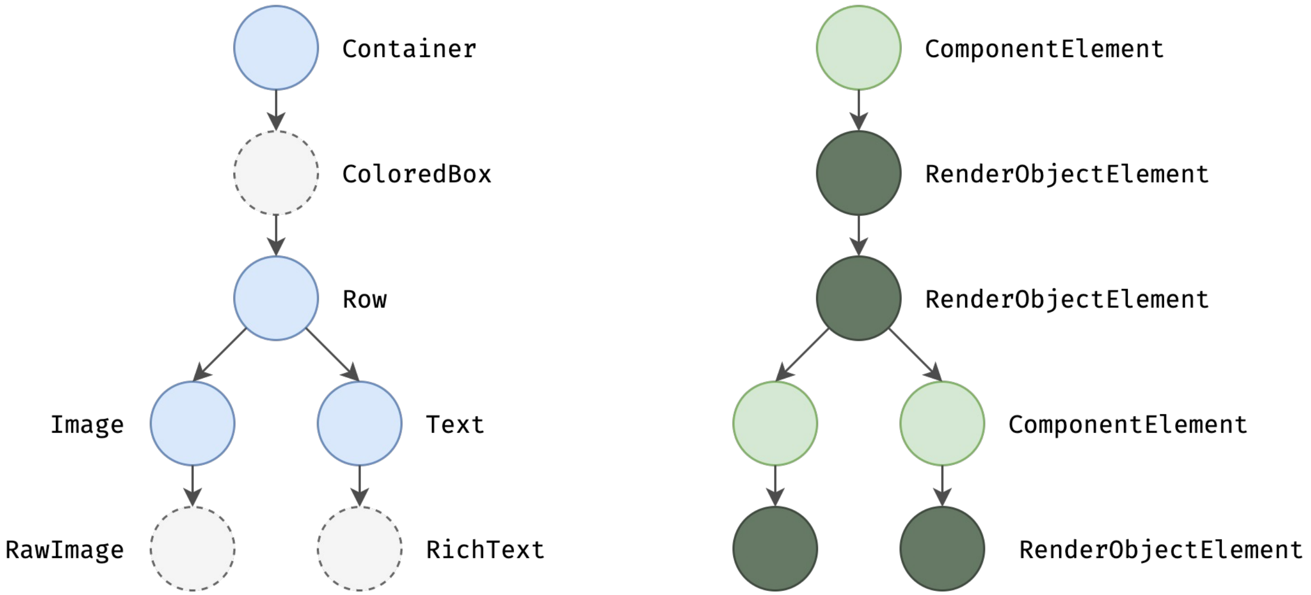
- What happens below?

```
Theme.of(context)

MediaQuery.of(context)

Navigator.of(context)
```

1. Start from element associated with context
2. Moving up along element tree to find nearest inherited widget of ***matching type***

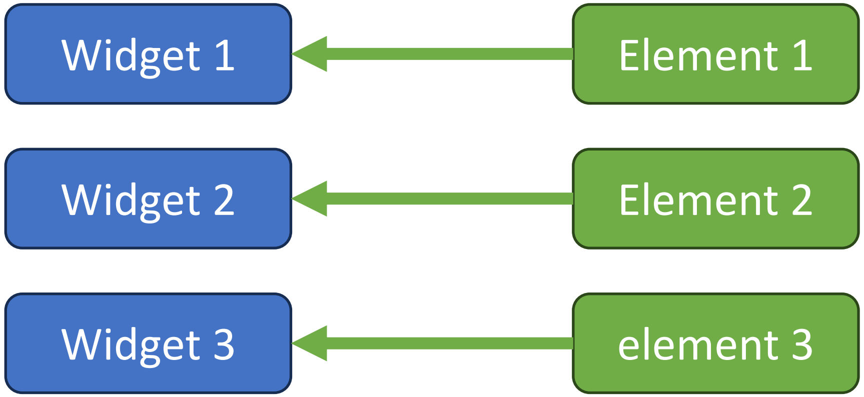
Element Nodes are Long-lived

- `initState()` and `dispose()` ***not*** called on every widget reconstruction
- How to map widget node to element node?



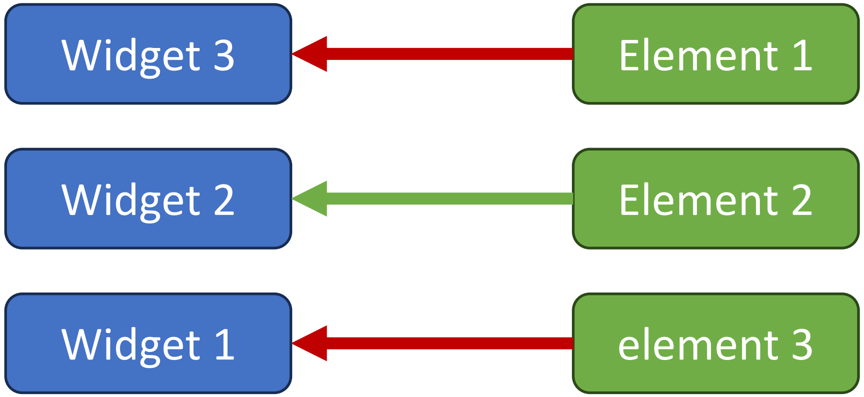
Node Mapping

- By default, element node checks the ***class*** of widget node to detect changes



Node Mapping

- By default, element node checks the ***class*** of widget node to detect changes
- Not ideal for changing list items of the same type
- If `Key` available, element node use it to detect changes



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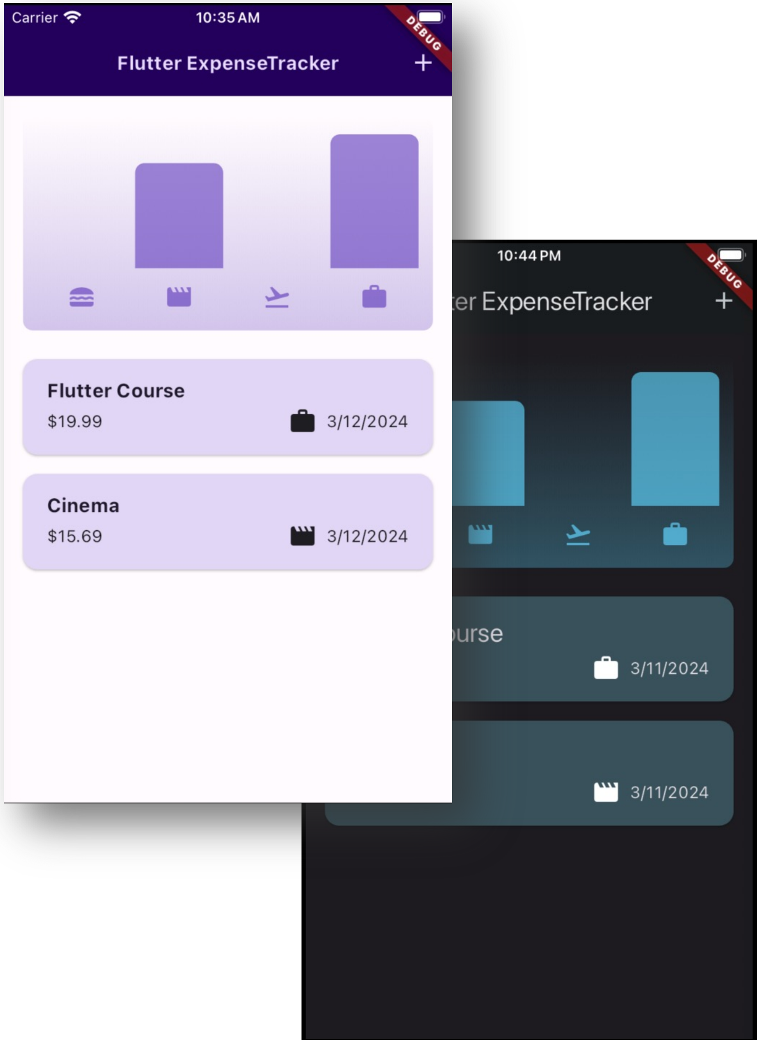
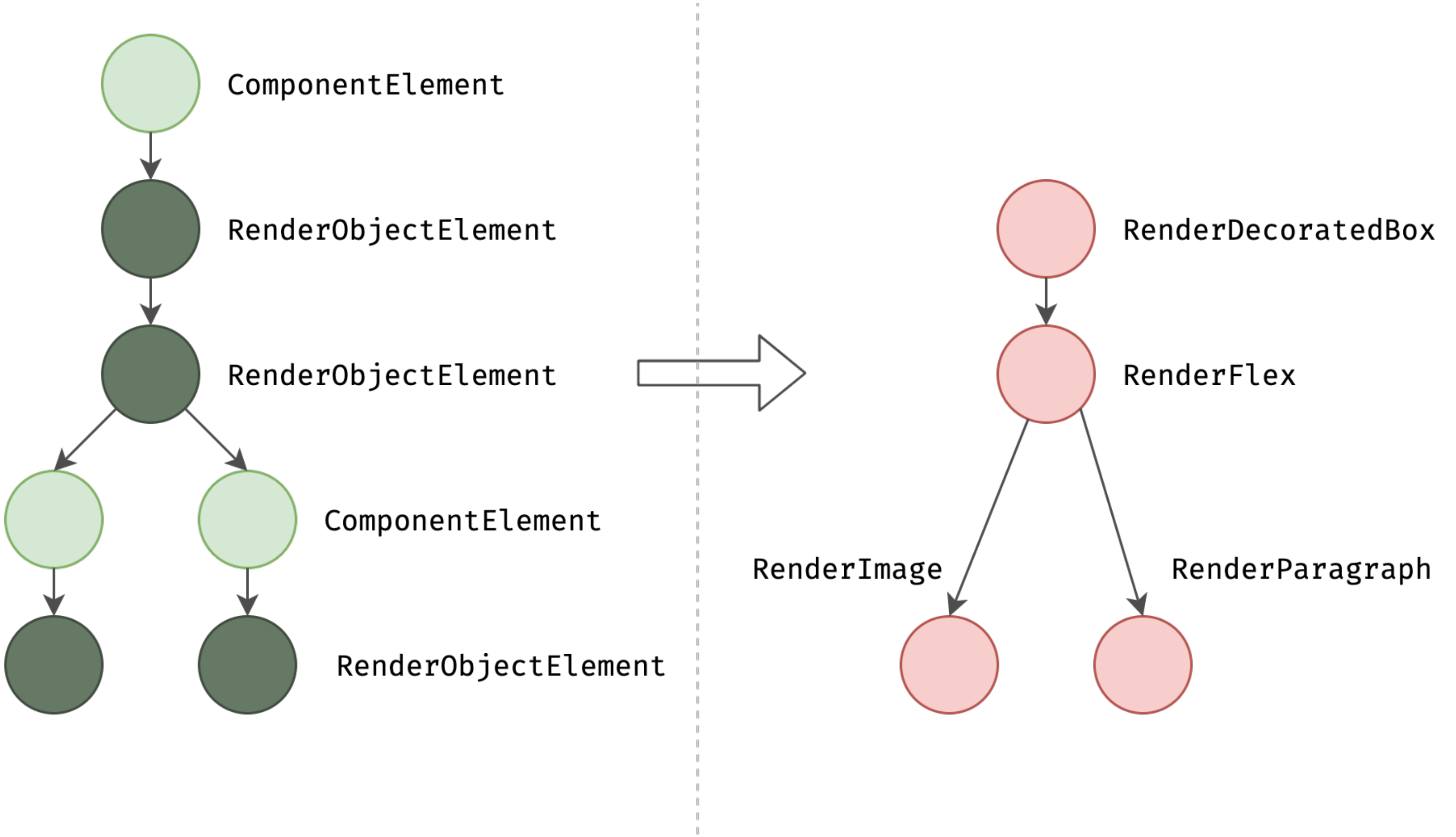
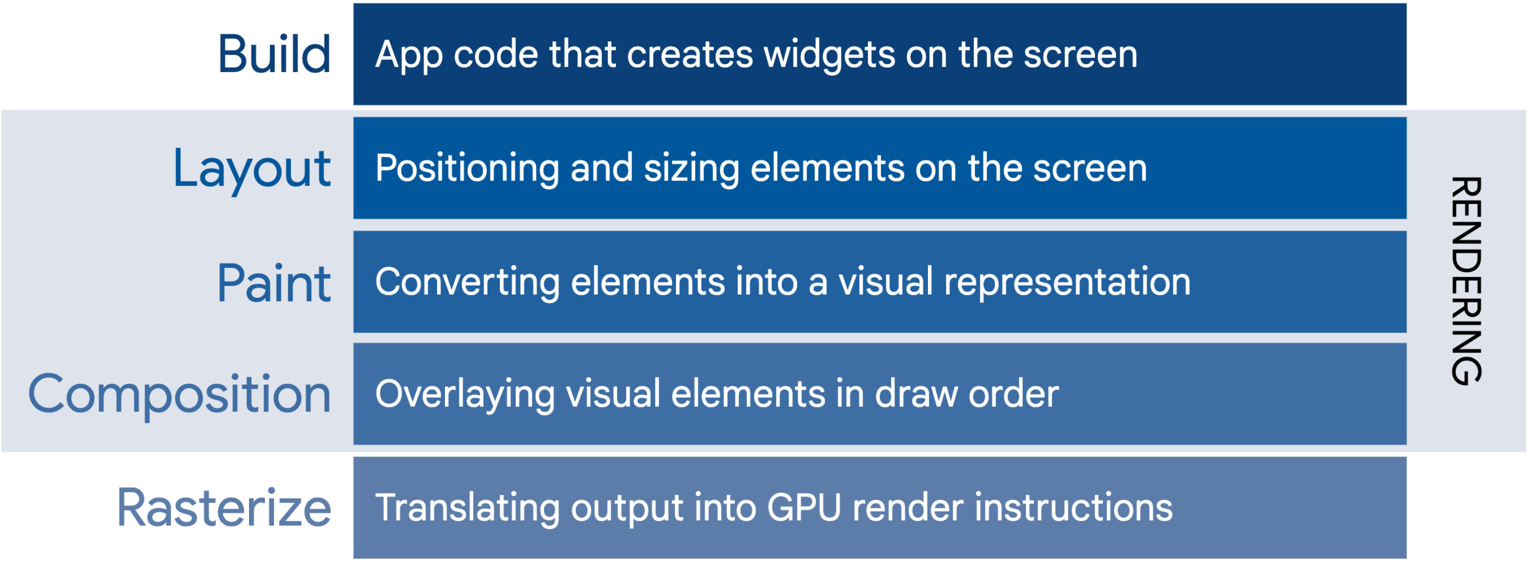


Render Tree



- Map element to **`RenderObject`** to perform actual rendering

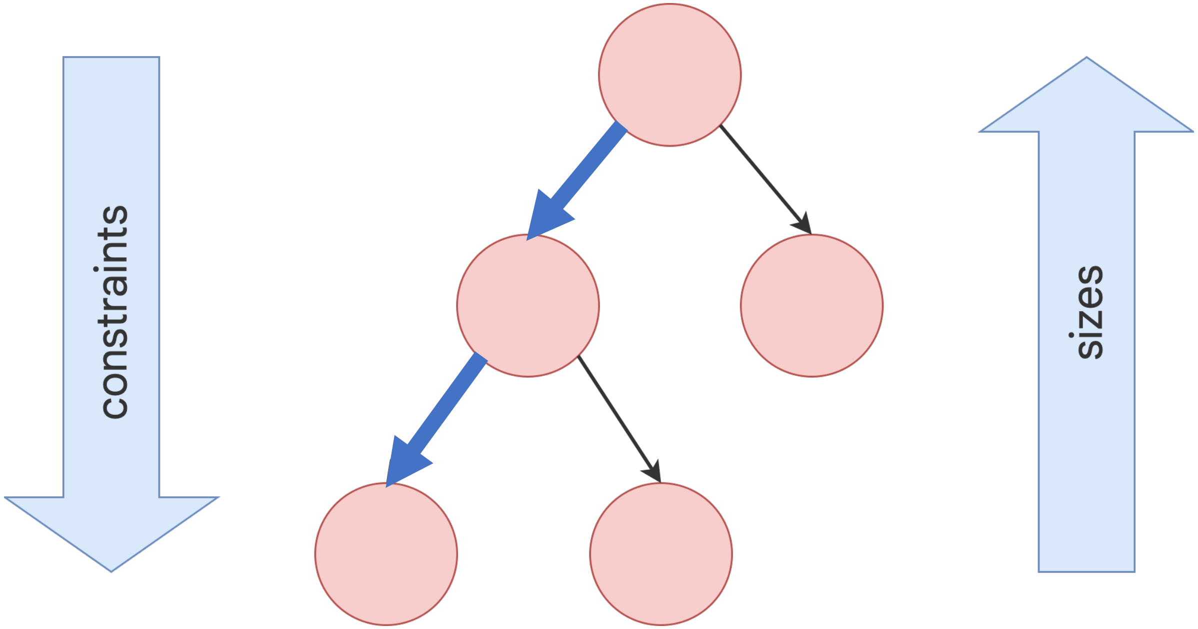
Rendering Process



Build	App code that creates widgets on the screen	
Layout	Positioning and sizing elements on the screen	RENDERING
Paint	Converting elements into a visual representation	
Composition	Overlaying visual elements in draw order	
Rasterize	Translating output into GPU render instructions	

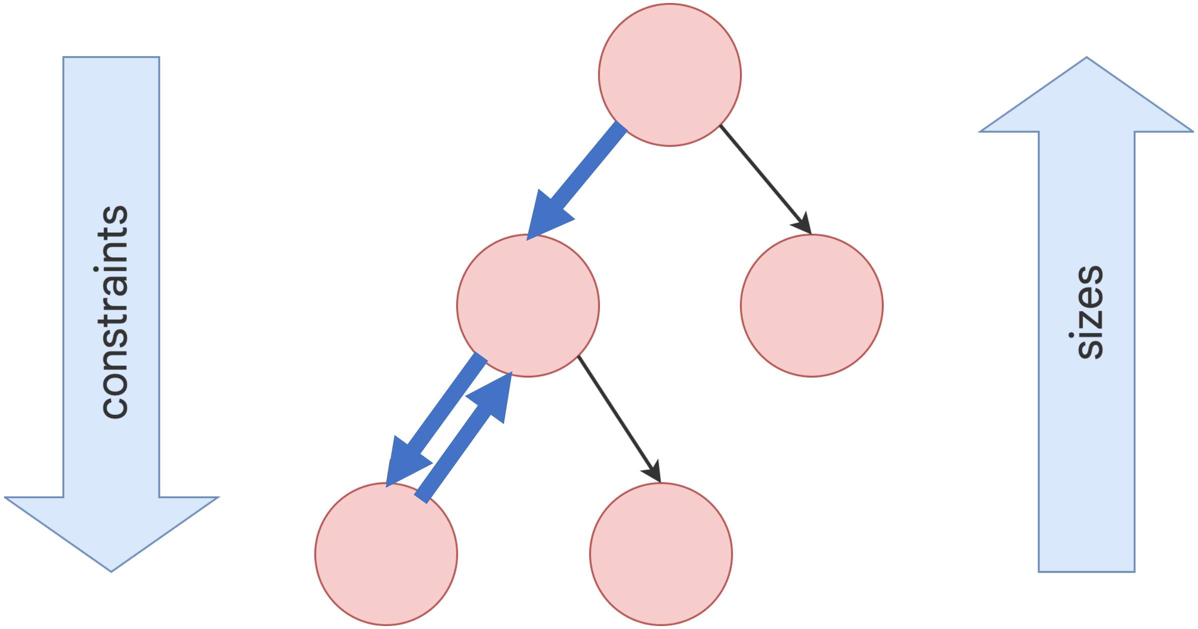
- We focus on ***layout*** and ***painting*** here

Layout: Constraints, Sizes, Positions



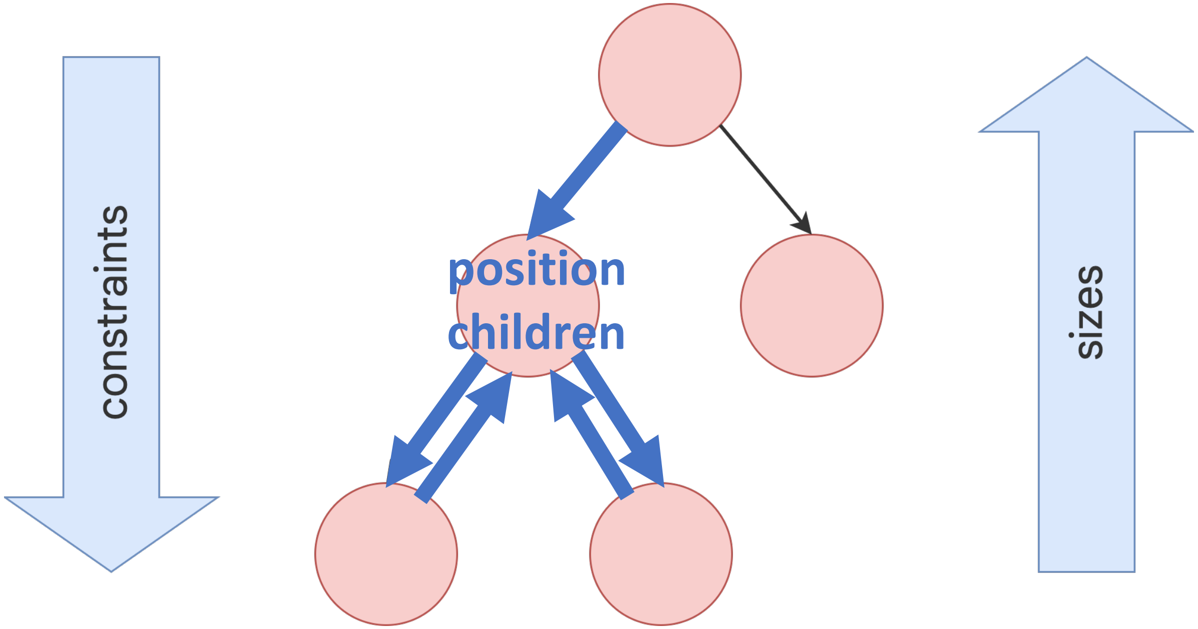
- Constraints go down (depth-first)
    - Parents tell children min/max width/height

Layout: Constraints, Sizes, Positions



- Sizes go up (depth-first)
    - Children pass sizes up to their parents

Layout: Constraints, Sizes, Positions



- Parents set positions (breadth-first)
  1. Position children based on layout concept
  2. Then, bubble up sizes to grand-parents

Constraints

- Tight constraints (min = max)
  - `App` and `Expanded` (`Flexible` with tight `fit`)

- Loose constraints (min < max)
  - `Center` transforms tight constraints from parent to loose constraints for its child, allowing “centering”
  - `Flexible` with loose `fit`

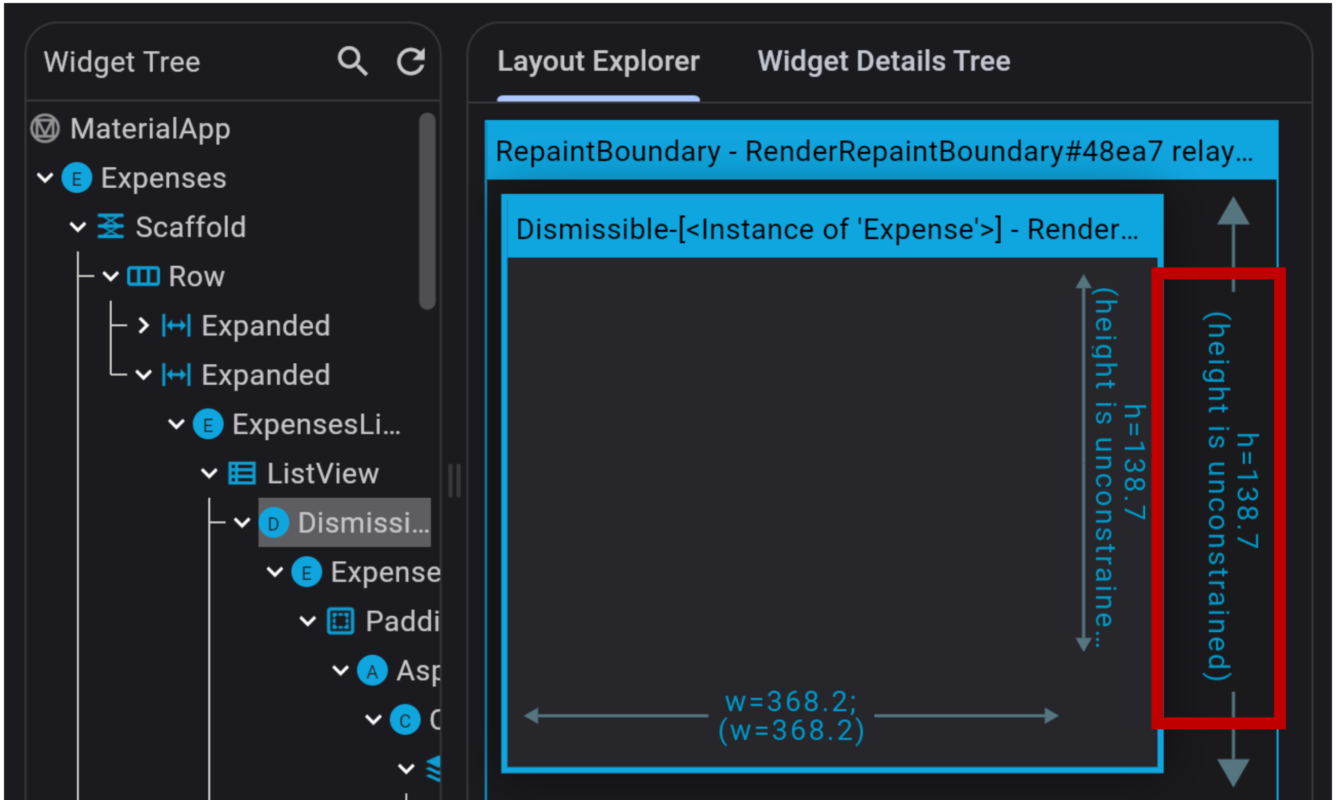
- Unbounded constraints
  - Flex box (`Row` or `Column`) unless `Flexible` presents
  - Scrollable widgets (`ListView` or Sliver widgets)

Sizing

- Be as big as possible:
  - `Center` and `ListView`, etc.
- Fit to children size:
  - `Transform` and `Opacity`, etc.
- Be a particular size:
  - `Image` and `Text`, etc.
- It depends:
- `Container`: as big as possible, but fits children if it or its children has `width` / `height`
- Flex box (`Row` or `Column`): fit children if unbounded in primary direction; otherwise as big as possible
  - No nested `ListVew` in former case

Inspecting Layouts

- Children of `ListView` have no constraints
- In `Row`, `Expanded` wraps `Chart` (with infinite width) to avoid layout problems



Challenge for You!

Why some widget with `width: 100` isn't 100 pixels wide?

Why that `Column` is overflowing?

What `IntrinsicWidth` is supposed to be doing?

Why some `FittedBox` isn't working?

- Try explain layout examples by yourself

Why Position Late?

- Different from Android and iOS layout process

- Benefits:
  - Predictable & consistent widgets/ layout behavior
  - Fast: ***single pass***; good for animations/transitions
  - Flexible for different screen sizes
  - Easy to understood and simplifies development process
- Example: fast scrollable Sliver widgets

Limitations

- Widget usually can’t have any size it wants
  - Constraints from parent
- Widget can’t know and doesn’t decide its own position in the screen
  - Position determined only after layout of entire tree
- Be specific when defining alignment
  - Otherwise, some children’s sizes may be ignored

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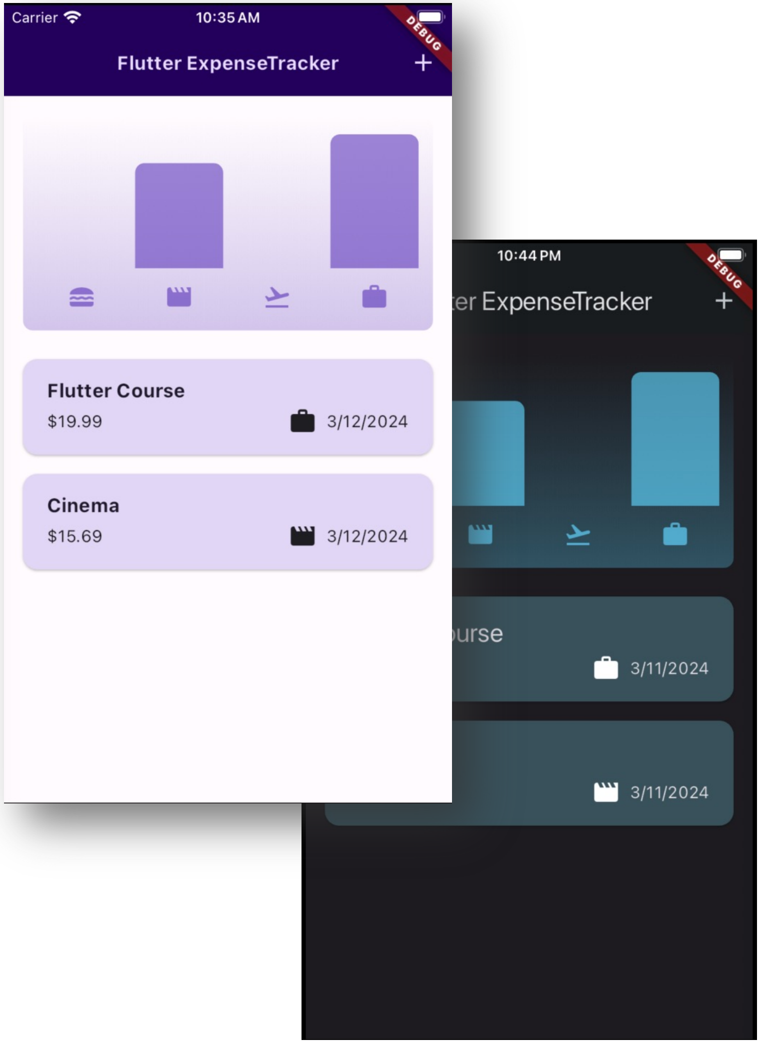

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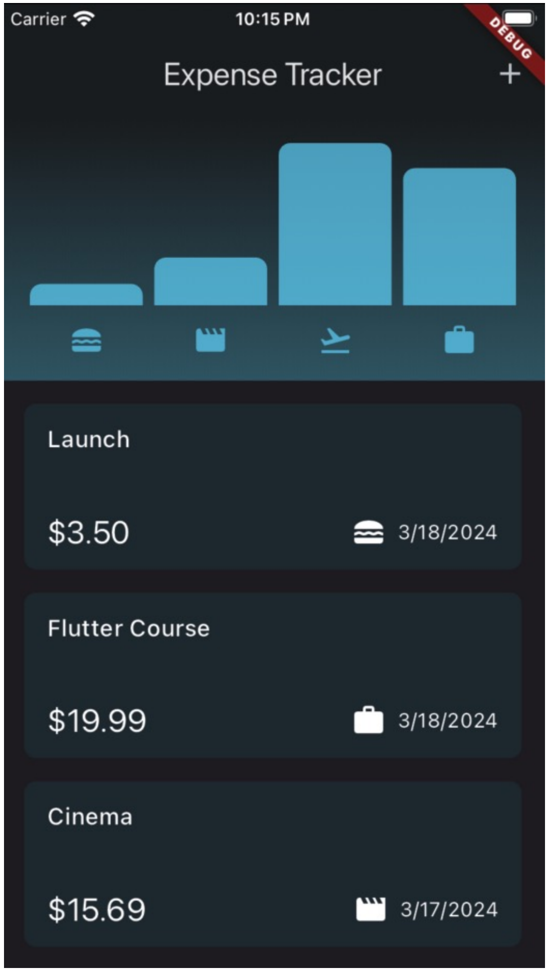
Making Expense App Responsive



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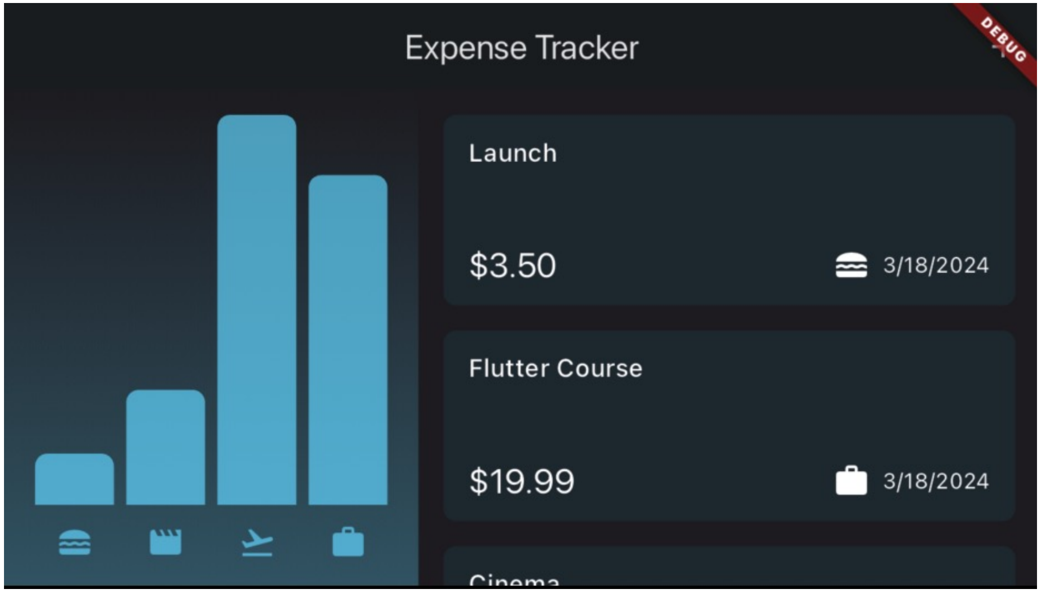

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Locking Device Orientation

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

void main() async {
  // Ensure Flutter framework is initialized
  WidgetsFlutterBinding.ensureInitialized();

  await SystemChrome.setPreferredOrientations([
    DeviceOrientation.portraitUp,
  ]);

  ...
}
```

- For some apps, this could be the best solution

Dynamic Layout

- At top of widget tree, use `MediaQuery` to trigger layout change
  - E.g., `Column` → `Row` when screen width > 600
  - See predefined layout breakpoints

- At lower part of tree, use `LayoutBuilder`
  - ***Get constraints from parent*** programmably
  - Then, build widget dynamically
  - See `new_expense.dart`

Handling Keyboard Inset (1/2)

- Dynamic sizing:

- With `Scaffold`
  - `resizeToAvoidBottomInset` set to `true` by default
  - No further action needed

- Without `Scaffold` (e.g., in modal)
  - Use `MediaQuery.viewInsets.bottom` to detect KB
  - Add bottom padding dynamically

Handling Keyboard Inset (2/2)

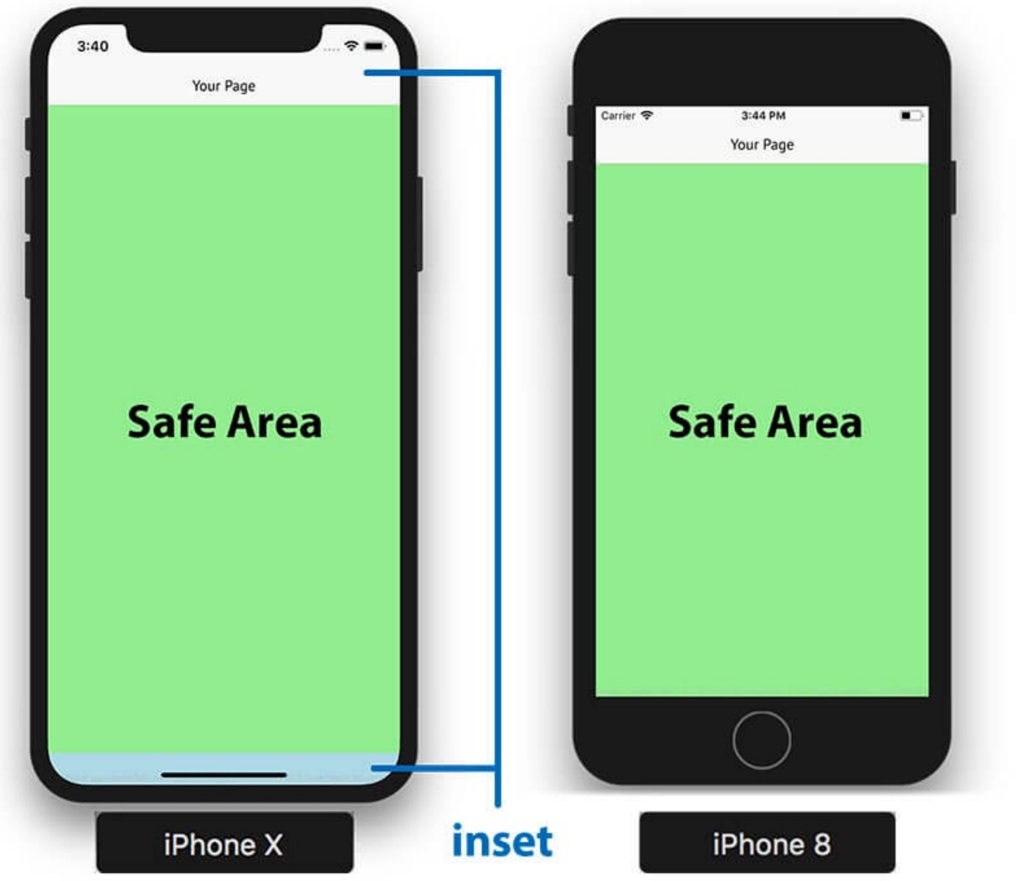
- Avoiding obscuration:

- With `Scaffold`
  - Auto-scrolling available
  - But need conditional padding for `body` to create space between input widget (`TextField`) and KB

- Without `Scaffold` (e.g., in modal)
  - Wrap root widget with `SingleChildScrollView`
  - Implement manual scrolling
  - See `new_expense.dart`

Safe Area

- Different across devices



- Use `SafeArea` widget
- For modal, set `useSafeArea` argumentm to `true` when calling `showModalBottomSheet()`

Responsiveness ≠ Adaptiveness

- ***Responsiveness***: UI renders well across different screen sizes and orientations

- ***Adaptiveness***: different layouts and functionalities for different platforms
- Example iOS adaptation:
  - `Platform.isIOS`
  - `showCupertinoAlert()` in `new_expenses.dart`

Automatic Platform Adaptation

- Theming
  - On iOS, title in `AppBar` is centered by default
- Platform-specific (Cupertino) widgets
- Adaptive constructors
  - E.g., `Icon.adaptive.share`, `AdaptiveDialog`

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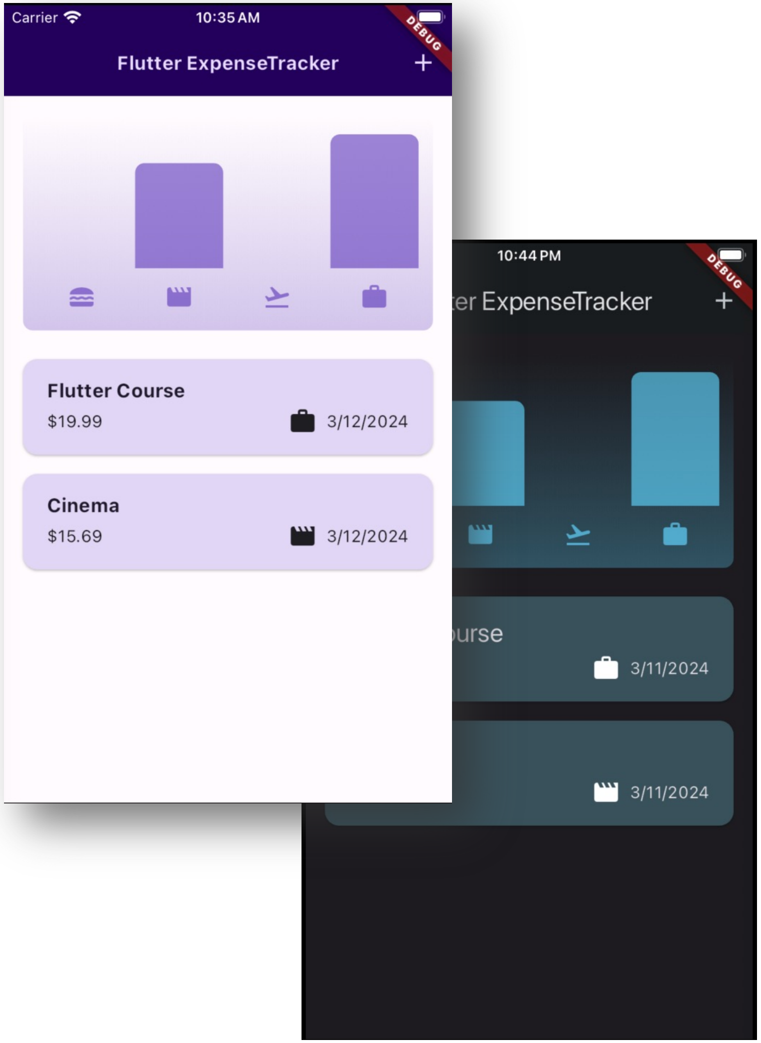

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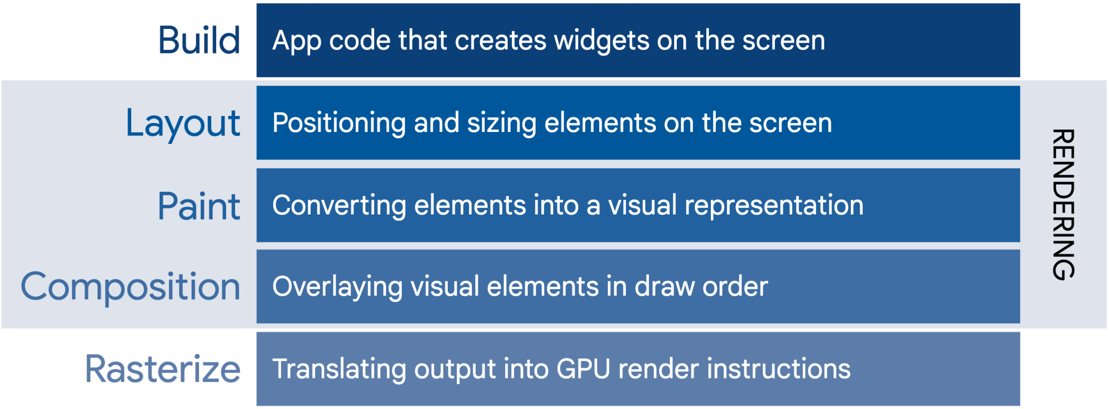
Painting



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RENDERING

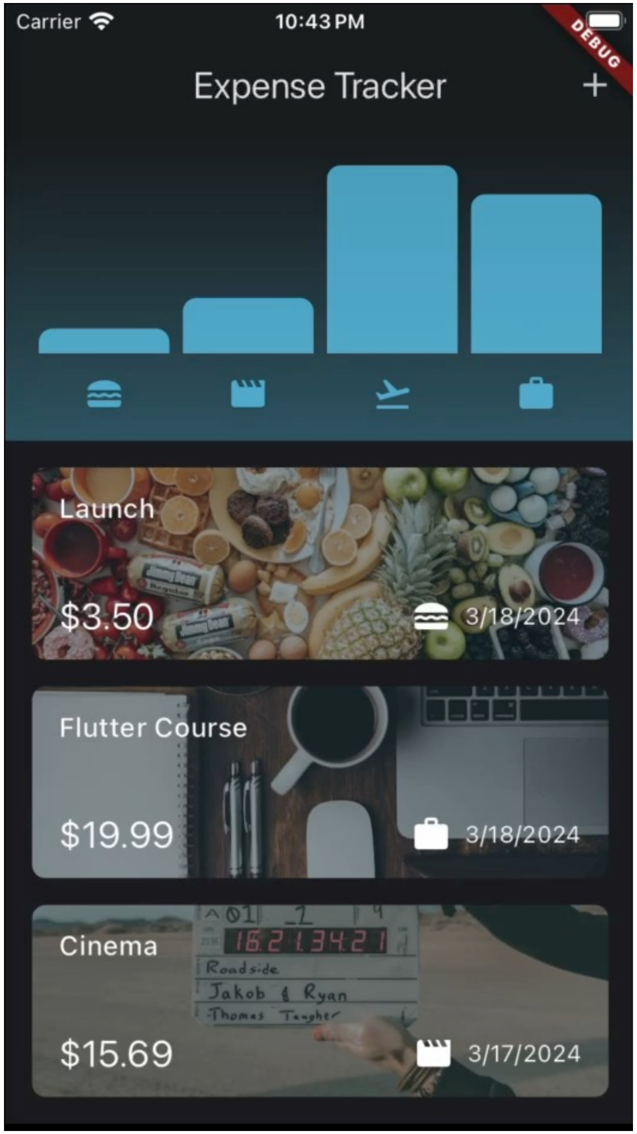
- In painting phase, we can still apply ***matrix transformations*** to `RenderObject`
  - Translation, rotation, scaling, skewing, etc.
- `Transform`: for single widget
- `Flow`: for multiple widgets or custom layout

`Flow` Widget

- Does not pass constraints down to children
  - So, children retain their intrinsic sizes
- `FlowDelegate` offers you control on:
  - Layout: `getSize()` and `setChildParentData()`
  - ***Paint***: `paintChildren()` and `shouldRepaint()`

Demo: Efficient Parallax Scrolling

- No rebuild & re-layout costs while scrolling



Suggested Reading

- Take layout examples as a challenge
- Transform widget

- Sliver Widgets
  - Short intro (`CustomScrollView` + `SliverAppBar`)
  - Longer hands-on tutorial
- Automatic Platform Adaptation
- Flutter Internals*