Mobile Applications for Sensing and Control

Sep Makhsous

Week 8

Topics

- Networking
  - Ways to get stuff from over the network
- Introduce briefly:
  - Async tasks
  - Handlers
- App Testing

Networking

Networking Overview: 4 ways to “use the network

- Viewing content by opening a browser
- Viewing content by embedding a web view
- Getting data from a web service
    - By analogy, sending data to a web service
- Managing network connections on Android
    - Power-aware data transfer design strategies
    - Using Volley, Cronet
    - DownloadManager
        - https://androidclarified.com/android-downloadmanager-example

Providing content to your users, Strategy 1

- Open a web page in a browser using an intent
- Pros:
  - Simple!
  - Take advantage of existing content and display
  - Use a browser the user is familiar with
- Cons:
  - You’re sending users out of your app
  - You have no control over the experience

Providing content to your users, Strategy 2

- Embed a WebView within your app.
- Pros:
  - Relatively simple
  - It’s easy to build a website– there are many existing tools and technologies to support it
  - You keep users within your app
- Cons:
  - Little control within your app over how the information is displayed
- Also, web content management is now out of the app developer’s control.

Working with Web Services

- Data transfer strategy
    - Pulling data from the web
    - Pushing data to the web
- Uses HTTP connection
    - Android has included traditional, common HTTP networking classes
- Must be done off the main thread
    - Can either use an AsyncTask or new Thread

Working with Web Services, cont. (2/2)

- Pros:
  - Developer has great control over when to transfer data
  - Developer has great control over display of data
  - Many sources– this is a common way to access/save data now
  - Super flexible
- Cons:
  - More responsibility for the developer
  - More code to manage
  - More ways to make the experience slower, drain the battery

Understanding Network Management on Android

- Differences between Wi-Fi and Cellular networks
- How to check the network status
- How to store user preferences
- How to respond to network changes

Wi-Fi vs Cellular Networks

	Wi-Fi	Cellular
Power Consumption	Uses less power for data transfer	Uses more power, especially with 4G Usually automatically disabled when connected to Wi-Fi (by the device)
Speed	Typically faster than cellular (greater bandwidth)	Typically slower than Wi-Fi; network speed depends on carrier and network type (3G, 4G, LTE, …)
Cost	Usually free	Metered (user has a plan; network carriers usually throttle data after a certain limit)
Availability	It tends to be more private, familiar locations (home, work, school, cafés) Useful when in one place for a while Smaller area of service	Available in public, places where there isn't Wi-Fi (e.g., a park), more remote locations. Stays connected while traveling Larger area of service

How to check network status

- Using ConnectivityManager
- There’s a difference between before Android 21 (Lollipop) and after
- Generally:
  - Ask the ConnectivityManager about the current network
  - If connected to a network:
    - Decide on network/data transfer operations based on the network type that you are connected to.

User Preferences around Networking

- A best practice is to let your user specify preferences of using different networks
- Can use a nifty thing called PreferenceActivity
  - This is deprecated; the new approach is to use the AndroidX Preference Library (https://developer.android.com/reference/androidx/preference/package-summary)
  - It’s way more complicated than we want to get to in this class– check it out when you’re ready to go deeper!
- Basically, want to:
  - Identify the types of data transfer you do in the app
  - Allow the user to specify which network to use for each type of data transfer

Reacting to changes in the network connection

- Challenge:
  - Network changes after you check network status & user preferences
- Scenario:
  - User launches your app at home
  - Your app checks and sees that it is on wi-fi, and the user has said you can download data on wi-fi but not cellular
  - User leaves home and transitions to cellular
  - Does your app keep downloading? Or stop?

Reacting to changes in the network connection

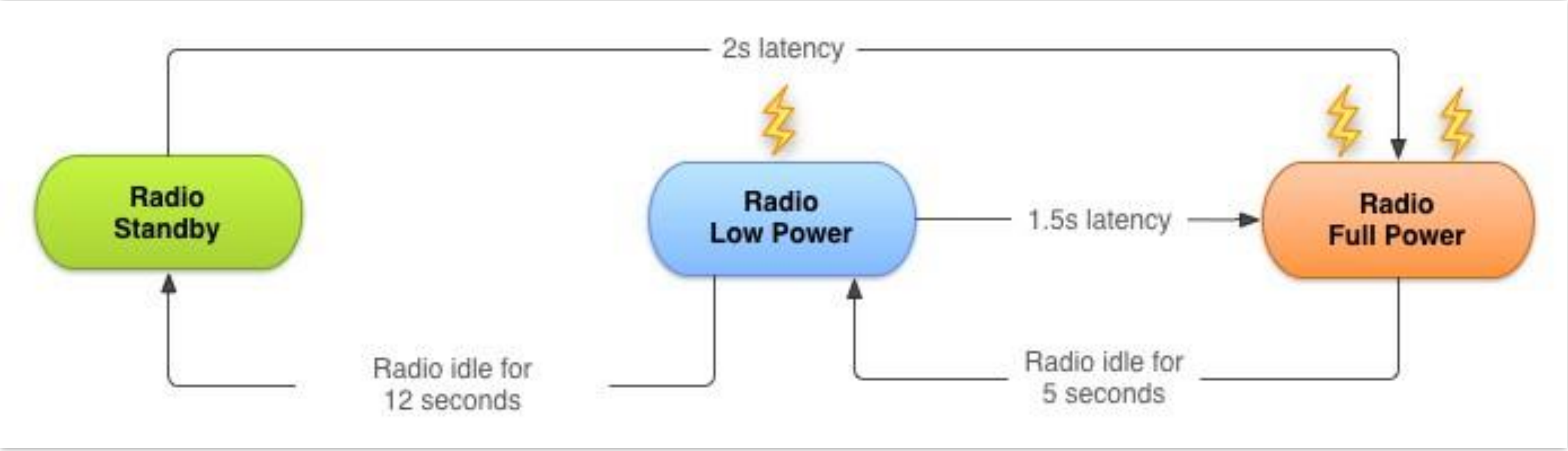
- Use a BroadcastReciever
- BUT:
    - Declaring in the manifest means….:
- Goal:
    - When the network changes:
        - Check the new network
        - Check the user preferences
        - If they are consistent, continue.
        - Otherwise, stop.

Optimizing Data Transfer

- Radio state machine
- Approaches:
    - Bundling network requests
    - Prefetching
    - Reducing Connections

Radio State Machine (example: AT&T 3G)

- Standby is lowest power state
- Full Power is highest power draw state, but is required for data transfer
- Low Power state draws less power, but has a quick transition to full power state/data transfer mode



Bundling Network Requests

- Goal:
  - Transfer as much data as possible during each transfer session in an effort to limit the number of sessions you require.
- How:
  - Create a pending transfer queue of data transfers that can be delayed
  - When a data transfer that can’t be delayed is requested, request all the data transfers in the queue at the same time

Approaches to minimize battery drain

- Optimize Downloads
  - Prefetching
  - Batch transfers
  - Reduce connections
  - Use Network Profiler to monitor
- Minimize effect of regular updates
- Avoid redundant downloads
- Modify downloads based on connectivity types

Prefetching Data

- Download all the data you are likely to need for a given time period in a single burst, over a single connection, at full capacity.
- Pros:
  - Reduce the number of radio activations needed to download the data
    - Conserve battery life
    - Improve latency
    - Lower required bandwidth
    - Reduce download times
    - Improves User Experience by avoiding a wait during long download times
- Cons:
  - If too aggressive, can increase battery drain and bandwidth use

Prefetching Data

- Cons:
  - If too aggressive, can increase battery drain and bandwidth use
- Prefetch depends on:
  - size of the data being downloaded
  - likelihood of it being used.
- As a rough guide: (based on above state machine)
  - for data that has a 50% chance of being used within the current user session, prefetch for around 6 seconds (approximately 1-2 Mb)
  - After that, the potential cost of downloading unused data matches the potential savings of not downloading that data to begin with.

Prefetching Data

- Generally speaking, it's good practice to prefetch data such that you will only need to initiate another download every 2 to 5 minutes, and in the order of 1 to 5 megabytes.
- Following this principle, large downloads—such as video files—should be downloaded in chunks at regular intervals (every 2 to 5 minutes), effectively prefetching only the video data likely to be viewed in the next few minutes.

Reducing Connections

- It’s more efficient to reuse a connection than to create a new one
  - Also enables network to react to congestion and other network data issues.
- Challenge:
  - It’s better to actively close the connection than to wait for a timeout
  - But closing the connection too early prevents you from being able to reuse it
  - More details for the developer to be aware of

Other approaches we’re not covering:

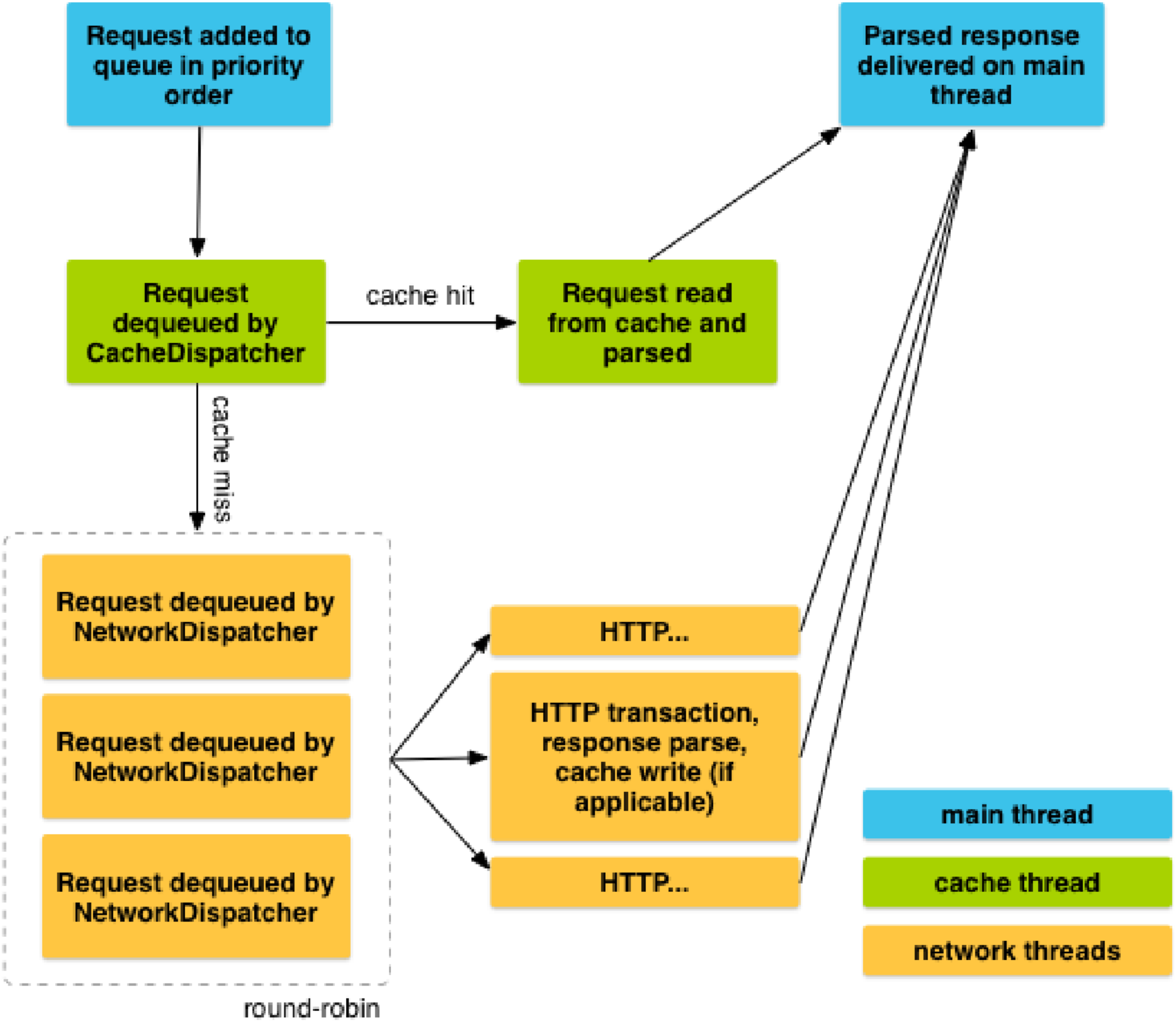
- Using Push Notifications versus polling to notify of updates
- Data Saver
  - New in Android 23
  - User specifies data preferences on the device
  - Data Saver blocks background data transfer
  - Apps can ask to be whitelisted for exemptions
- Download Manager, helping apps

Other Networking Tools

Volley

Volley excels at RPC-type operations used to populate a UI, such as fetching a page of search results as structured data.

- Automatic scheduling of network requests.
- Multiple concurrent network connections.
- Transparent disk and memory response caching with standard HTTP cache coherence.
- Support for request prioritization.
- Cancellation request API. You can cancel a single request, or you can set blocks or scopes of requests to cancel.
- More appropriate for small network requests, not large data requests



Request added to queue in priority order

Request dequeued by CacheDispatcher

cache hit

Request read from cache and parsed

Parsed response delivered on main thread

cache miss

Request dequeued by NetworkDispatcher

Request dequeued by NetworkDispatcher

Request dequeued by NetworkDispatcher

round-robin

HTTP...

HTTP transaction, response parse, cache write (if applicable)

HTTP...

main thread

cache thread

network threads

Cronet

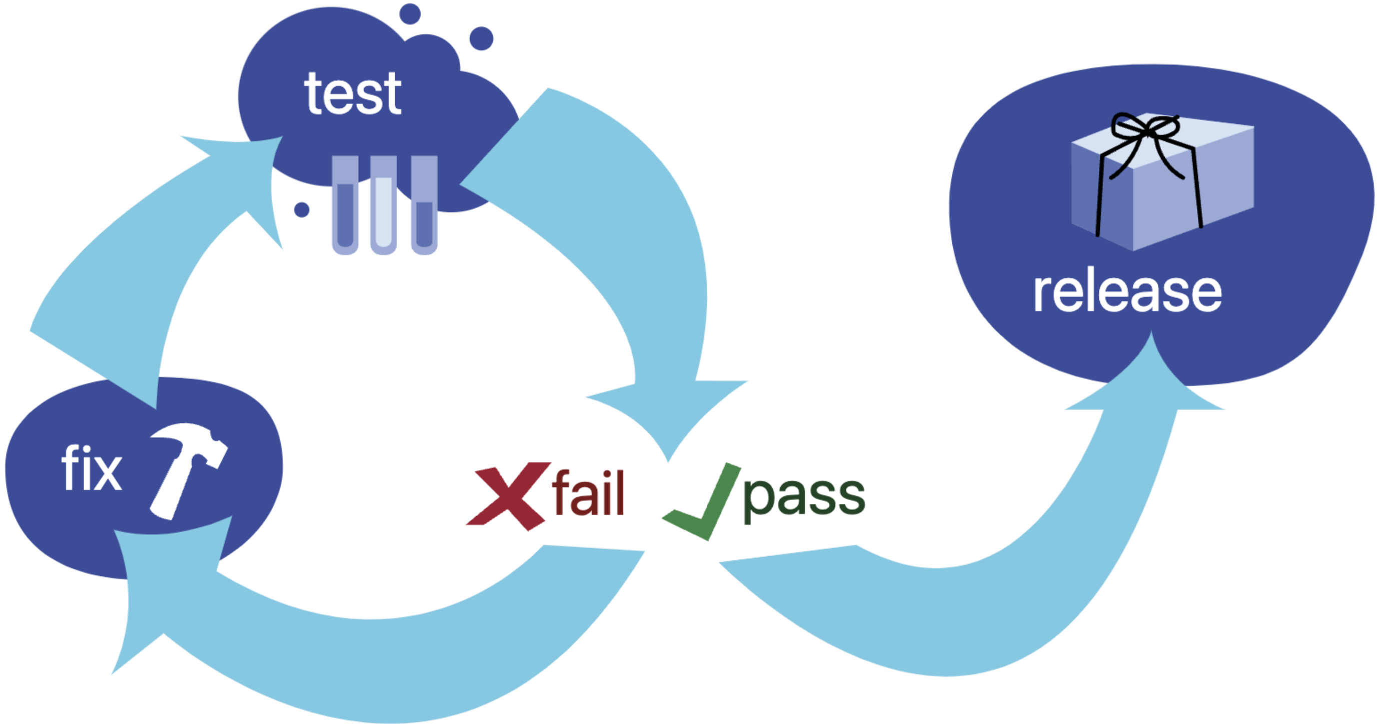
- Chromium Network stack, provided to Android
- Incorporates technology to reduce latency and increase throughput
- To use:
  - Create a Cronet Engine
  - Create a UrlRequest.Callback to handle the response of your request
  - Create an executor to manage network tasks
  - Create a URL request
    - Pass it to the executor, which asynchronously executes the request and notifies your callback with the response when completed

Sync Adapter

- Provides framework for communication between your app and a server
  - As opposed to, e.g., requesting a URL/webpage
- You can specify triggers and scheduling for syncing to happen

Work Manager

- Makes it easy to schedule tasks to be run “deferrable, asynchronous” tasks
  - On a schedule
  - E.g.: do a big data request when the user is on wifi and not doing something else



Testing Your Android App: A Comprehensive Guide

Introduction

- Why Testing?
  - In software development, testing is a crucial aspect that ensures the quality and reliability of the code. It helps us identify and fix bugs, improve performance, and make sure the application works as expected.
- What to Expect
  - Setting up a testing environment
  - Writing and running tests
  - Generating test reports, and best practices.
- What Tools:
  - Detox
  - TestGrid
  - Calabash
  - Selendroid
  - etc.

Static Analysis

To start with tests, you first need to write code that is testable.

- Instead of writing one large file, write code in small, testable modules.
- Separate the view part of your app (components) from functional logic and app state.
- Consider moving all logic and data fetching out of your components.

Understanding Different Types of Testing

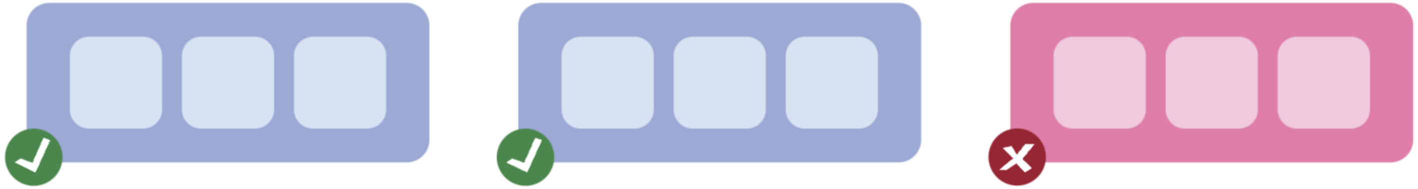
Types of Testing

1. Unit Testing

- Unit testing involves testing individual components or functions in isolation to ensure they work as expected.
- Helps to catch low-level bugs and issues, making it easier to pinpoint problems.

Understanding Different Types of Testing

Types of Testing:



2. Integration

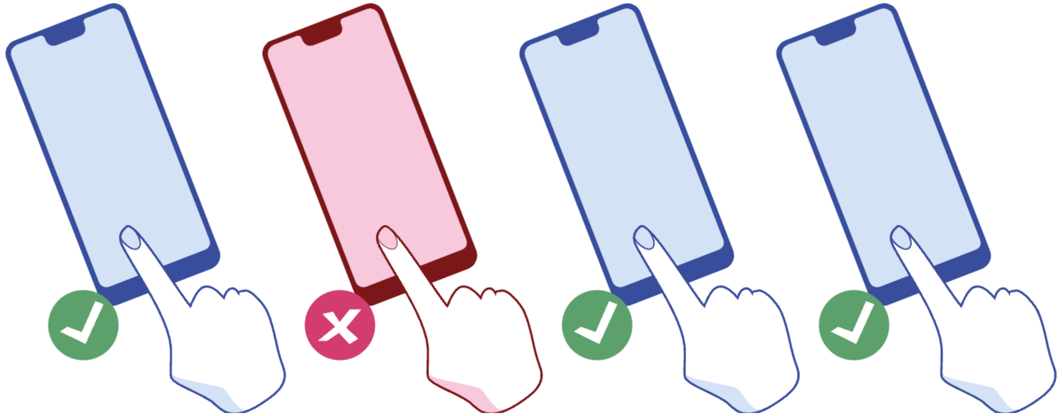
- Integration testing involves testing how multiple components or modules work together.
- Helps to catch issues that arise from the interaction between different parts of the application.

Component Tests

- Layout Components are responsible for rendering your app, and users will directly interact with their output.
- For testing components, there are two things you may want to test:
  - Interaction: to ensure the component behaves correctly when interacted with by a user (eg. when user presses a button)
  - Rendering: to ensure the component render output used by Kotlin is correct (eg. the button's appearance and placement in the UI)
  - For example:
    - if you have a button that has an onPress listener, you want to test that the button both appears correctly and that tapping the button is correctly handled by the component.

Understanding Different Types of Testing

Types of Testing:



3. End-to-End Testing

- End-to-end testing involves testing the entire application from start to finish, mimicking real user scenarios.
- Ensures the overall system functionality and helps catch issues that could affect the user experience.
- **Tools**: Detox is commonly used for end-to-end testing in Kotlin due to its stability and ability to test user flows across the entire application.

End-to-End Tests

- In end-to-end (E2E) tests, you verify your app is working as expected on a device (or a simulator / emulator) from the user perspective.
- E2E tests give you the highest possible confidence that part of your app is working. The tradeoffs include:
  - Writing them is more time consuming compared to the other types of tests
  - They are slower to run
  - They are more prone to flakiness (a "flaky" test is a test which randomly passes and fails without any change to code)