Tutorial: Setup for Android Development

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CSE 5236: Mobile Application Development

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Based on material from C. Horstmann [1], J. Bloch [2], C. Collins et al. [4], M.L. Sichitiu (NCSU), V. Janjic (Imperial College London), CSE 2221 (OSU), and other sources

Outline

- **Getting Started**
- Android Programming

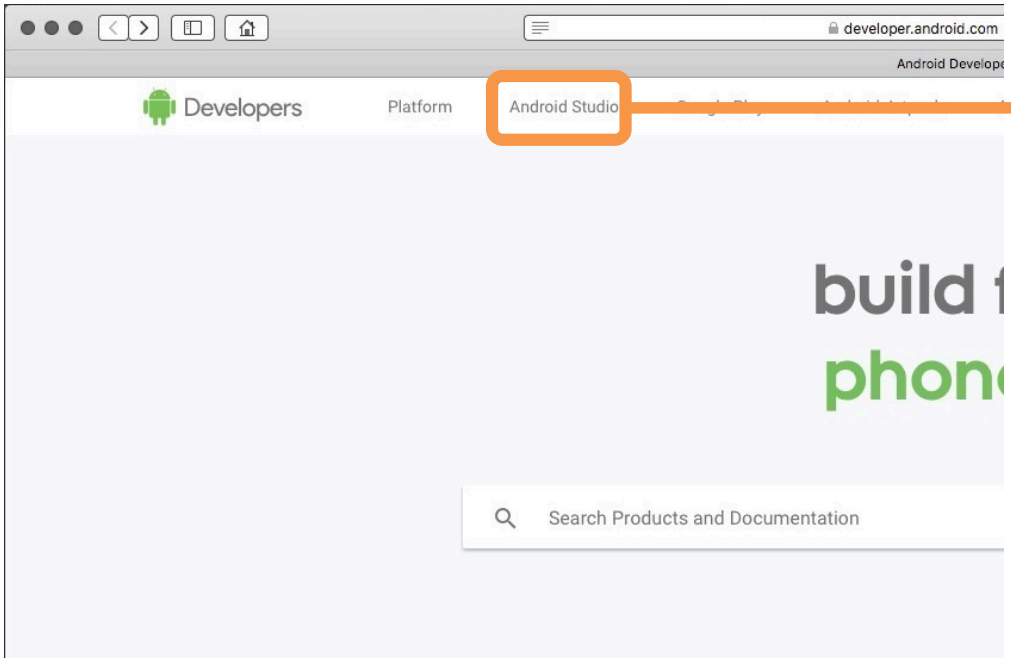
Getting Started (1)

- Need to install Java Development Kit (JDK) (**not** Java Runtime Environment (JRE)) to write Android programs
- Download JDK for your OS: https://adoptopenjdk.net/ *
- Alternatively, for OS X, Linux:
  - OS X: Install Homebrew (http://brew.sh) via Terminal,
  - Linux:
    - Debian/Ubuntu: `sudo apt install openjdk-8-jdk`
    - Fedora/CentOS: `yum install java-1.8.0-openjdk-devel`

* Why OpenJDK 8? Oracle changed Java licensing (commercial use costs $$$); Android SDK tools require version 8.

Getting Started (2)

- After installing JDK, download Android SDK from http://developer.android.com
- Simplest: download and install Android Studio bundle (including Android SDK) for your OS
- Alternative: `brew cask install android-studio` (Mac/Homebrew)
- We'll use Android Studio with SDK included (easiest)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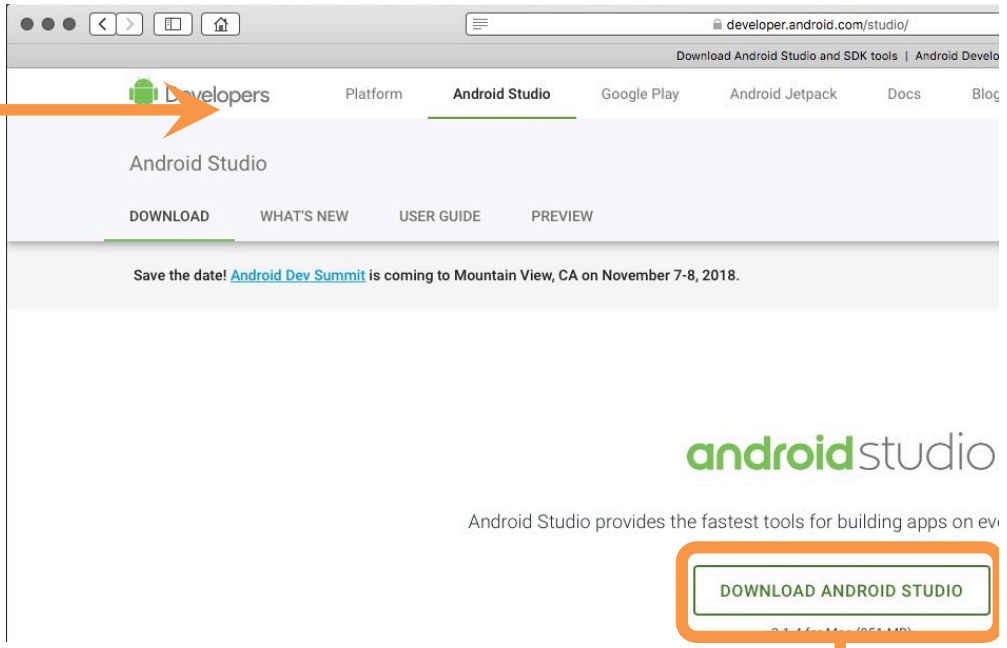
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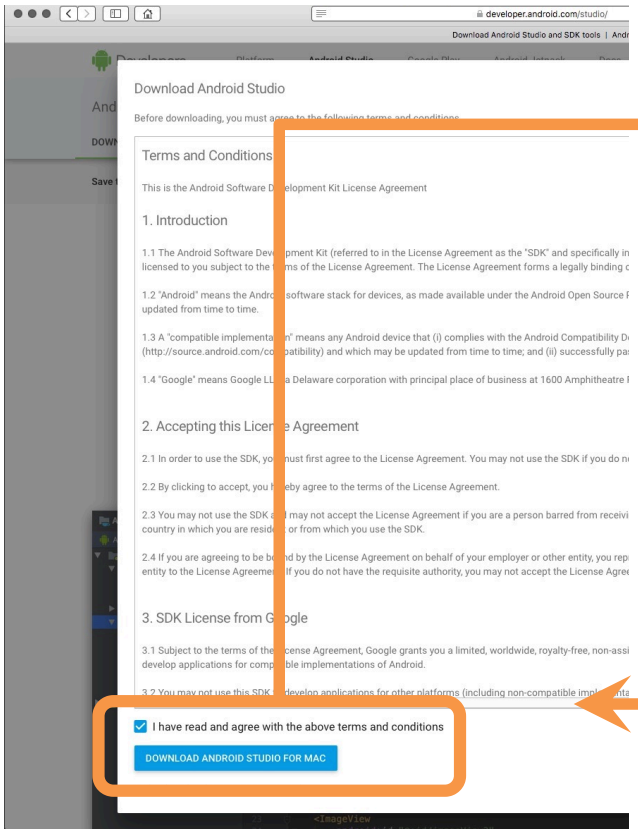
Save the date! Android Dev Summit is coming to Mountain View, CA on November 7-8, 2018.
android studio
Android Studio provides the fastest tools for building apps on ev
DOWNLOAD ANDROID STUDIO

Install!


Download Android Studio
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1. Introduction
2. Accepting this License Agreement
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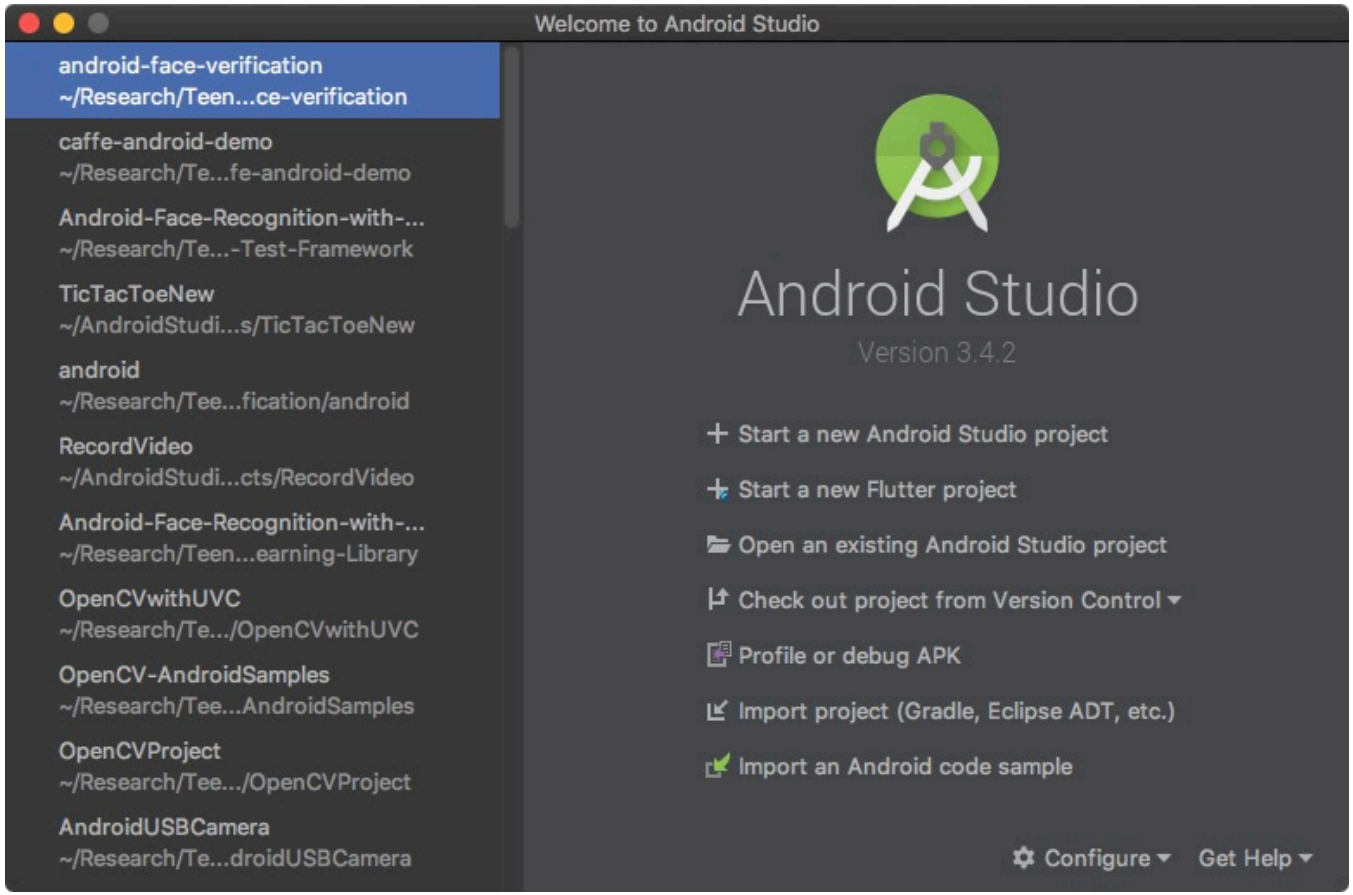
DOWNLOAD ANDROID STUDIO FOR MAC

Getting Started (3)

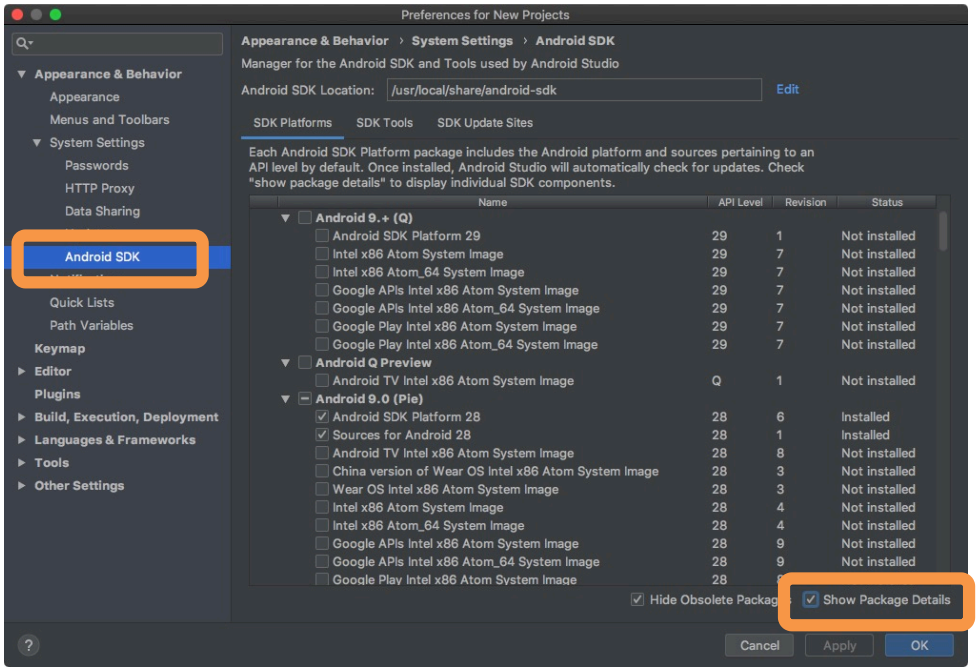
- Install Android Studio directly (Windows, Mac); unzip to directory `android-studio`, then run `./android-studio/bin/studio64.sh` (Linux)



Getting Started (4)

- Strongly recommend testing with real Android device
  - Android emulator: *slow*
  - Faster emulator: Genymotion [14], [15]
  - Install USB drivers for your Android device!
- Bring up Android SDK Manager
  - Install Android 5.x–8.x APIs, Google support repository, Google Play services
  - Don't worry about non-x86 system images

Android Studio menu → *Preferences…* or *File → Settings…*



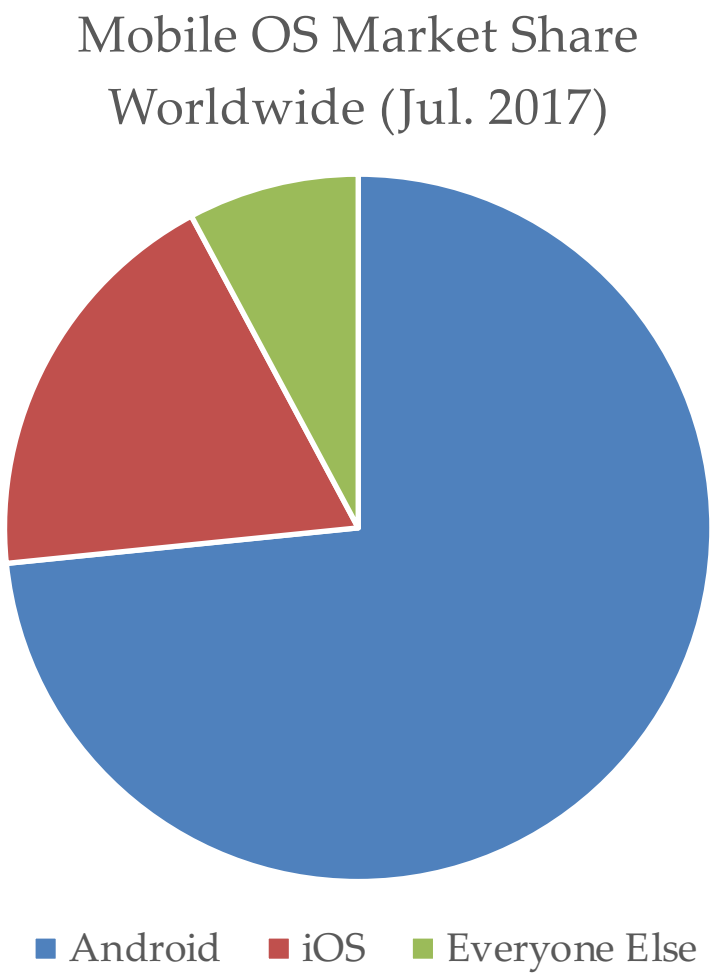
Now you're ready for Android development!

Outline

- Getting Started
- **Android Programming**

Introduction to Android

- Popular mobile device OS: 73% of worldwide smartphone market [8]
- Developed by Open Handset Alliance, led by Google
- Google claims 2 billion Android devices in use worldwide [9]



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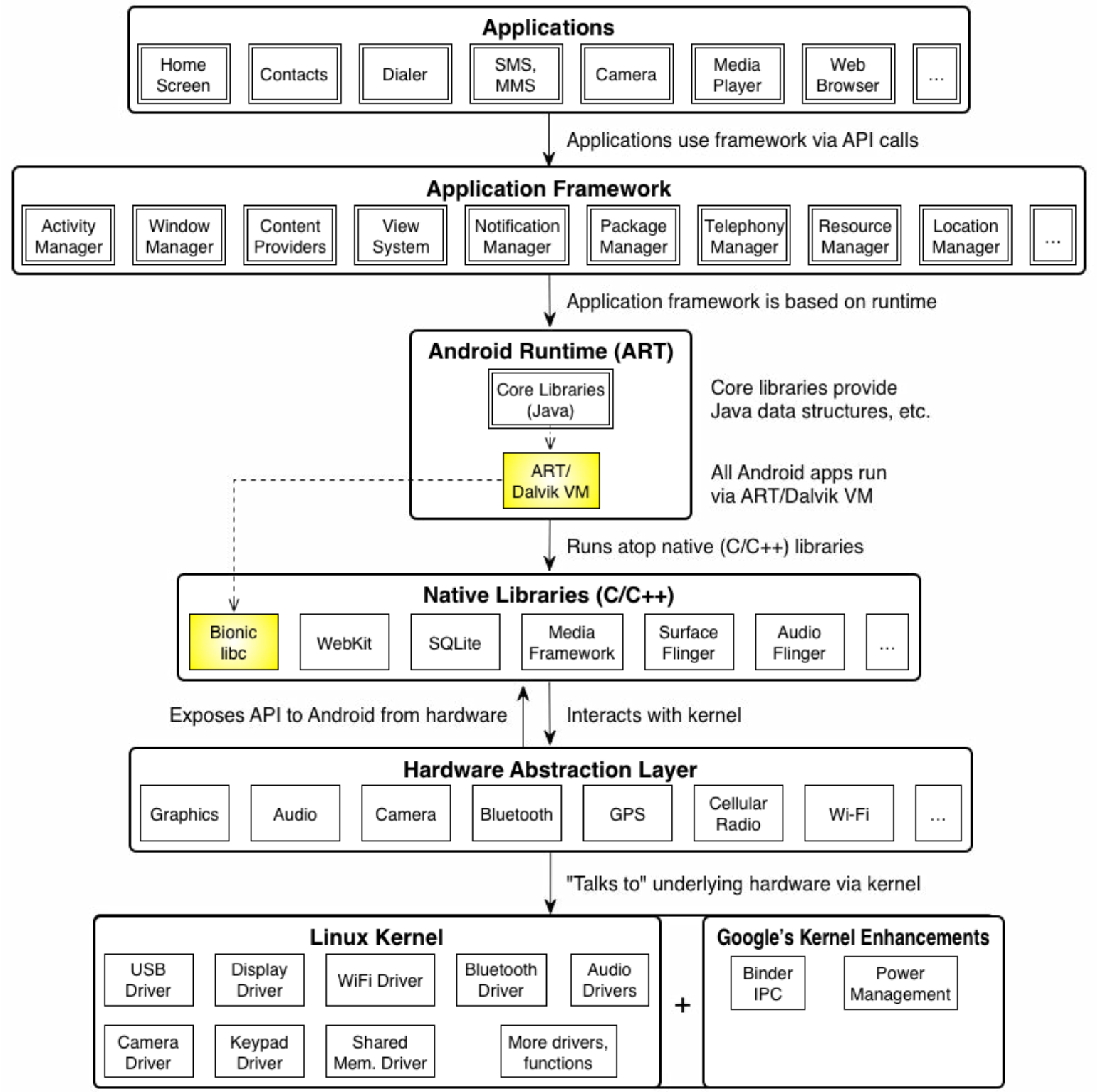
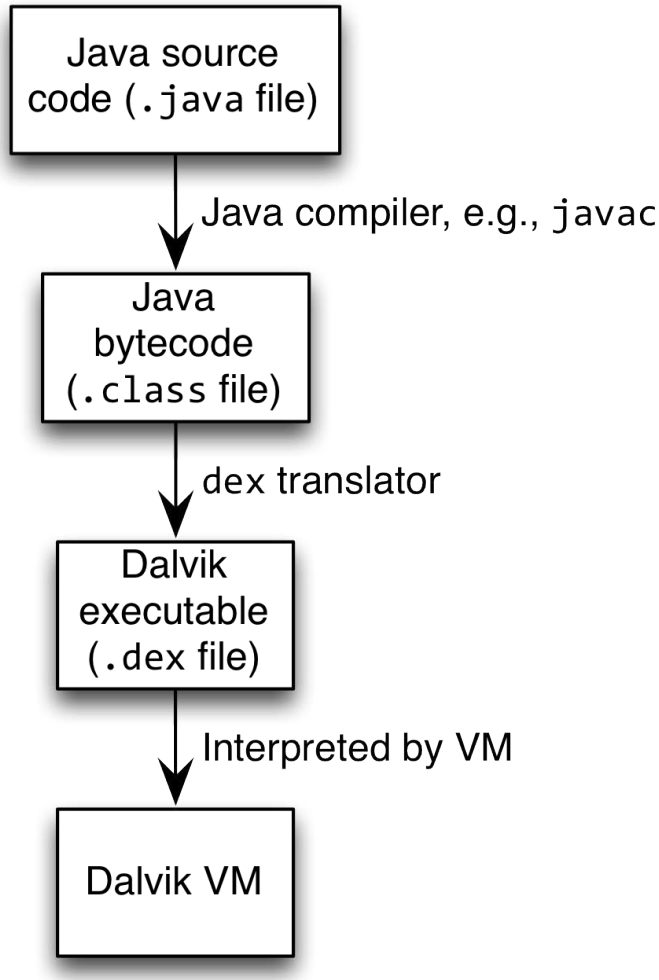

Applications
Home Screen
Contacts
Dialer
SMS, MMS
Camera
Media Player
Web Browser
…
Applications use framework via API calls
Application Framework
Activity Manager
Window Manager
Content Providers
View System
Notification Manager
Package Manager
Telephony Manager
Resource Manager
Location Manager
…
Application framework is based on runtime
Android Runtime (ART)
Core Libraries (Java)
ART/ Dalvik VM
Core libraries provide Java data structures, etc.
All Android apps run via ART/Dalvik VM
Runs atop native (C/C++) libraries
Native Libraries (C/C++)
Bionic libc
WebKit
SQLite
Media Framework
Surface Flinger
Audio Flinger
…
Exposes API to Android from hardware
Interacts with kernel
Hardware Abstraction Layer
Graphics
Audio
Camera
Bluetooth
GPS
Cellular Radio
Wi-Fi
…
"Talks to" underlying hardware via kernel
Linux Kernel
USB Driver
Display Driver
WiFi Driver
Bluetooth Driver
Audio Drivers
Camera Driver
Keypad Driver
Shared Mem. Driver
More drivers, functions
+
Google's Kernel Enhancements
Binder IPC
Power Management

Android Highlights (1)

- Android apps execute on Android Runtime (ART) (version of JVM)
  - Optimized for efficiency
  - Register-based VM, unlike Oracle's stack-based JVM
  - Java `.class` bytecode translated to Dalvik EXecutable (DEX) bytecode that ART interprets
  - Android 5+: ART with ahead-of-time, just-in-time compilation at *install* time



Android Highlights (2)

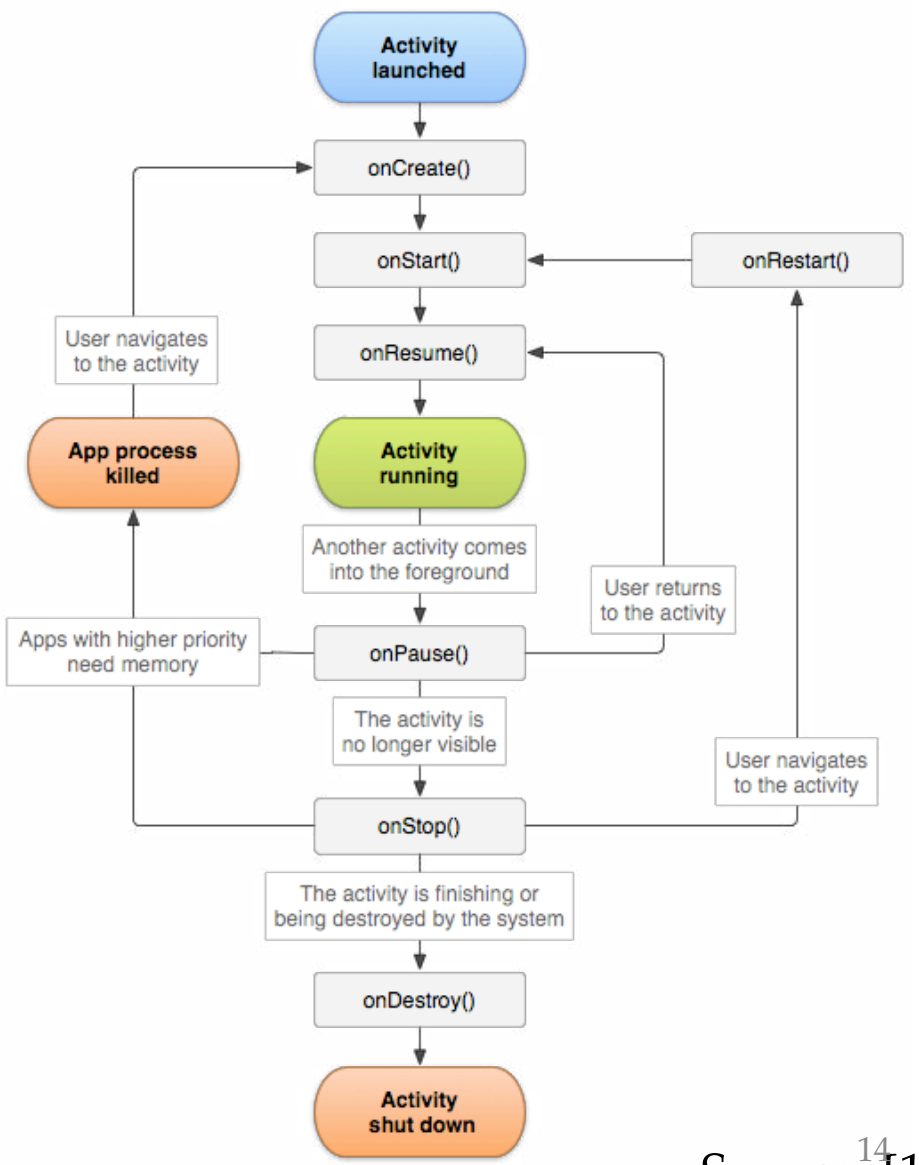
- Android apps written in Java 7+, Kotlin
- Apps use four main components:
  - `Activity`: A "single screen" that's visible to user
  - `Service`: Long-running background "part" of app (*not* separate process or thread)
  - `ContentProvider`: Manages app data (usually stored in database) and data access for queries
  - `BroadcastReceiver`: Component that listens for particular Android system events (*e.g.*, "found wireless device"), responds accordingly

App Manifest

- Each Android app must include an `AndroidManifest.xml` file describing functionality
- The manifest specifies:
  - App's Activities, Services, etc.
  - Permissions requested by app
  - Minimum API required
  - Hardware features required (*e.g.*, camera with autofocus)

Activity Lifecycle

- `Activity`: key building block of Android apps
- Extend `Activity` class, override `onCreate()`, `onPause()`, `onResume()` methods
- ART can stop any `Activity` without warning, so saving state is important!
- Activities must be responsive, otherwise user gets warning:
  - Place lengthy operations in `Runnables`, `AsyncTasks`



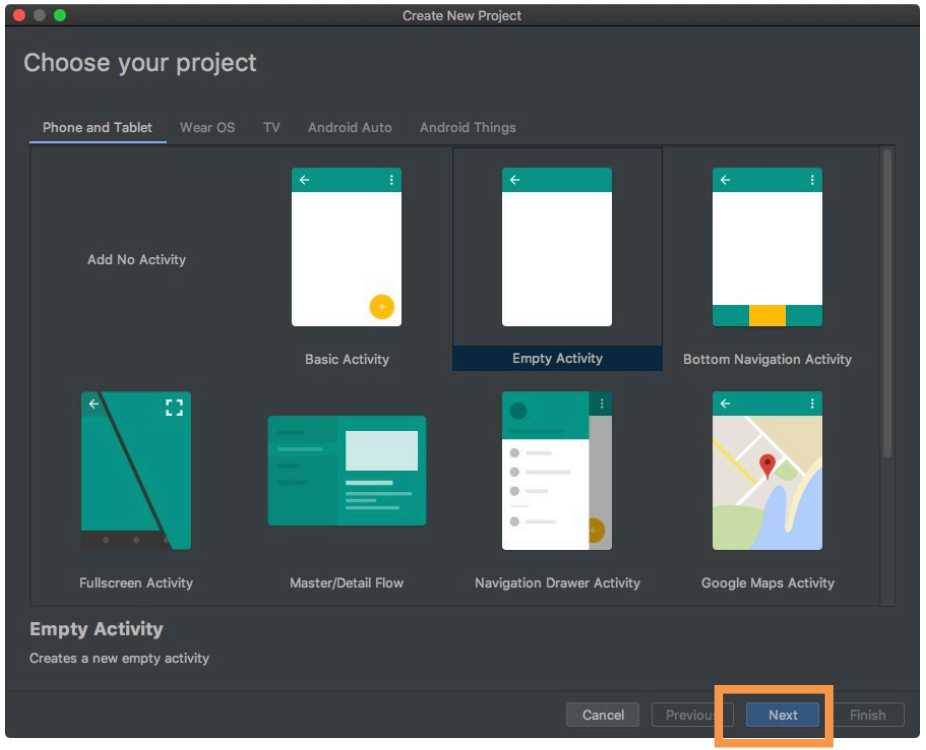
Source: [12]

App Creation Checklist

- If you own an Android device:
  - Ensure drivers are installed
  - Enable developer options on device: Go to *Settings*→ *About phone*, press *Build number* 7 times, check *USB debugging*
- For Android Studio:
  - Go to *File*→*Settings,* check "Show tool window bars" (Appearance)
  - Log state via `android.util.Log`'s `Log.d(APP_TAG_STR, "debug")`, where `APP_TAG_STR` is a `final String`
  - Other commands: `Log.e()` (error); `Log.i()` (info); `Log.w()` (warning); `Log.v()` (verbose) – same parameters

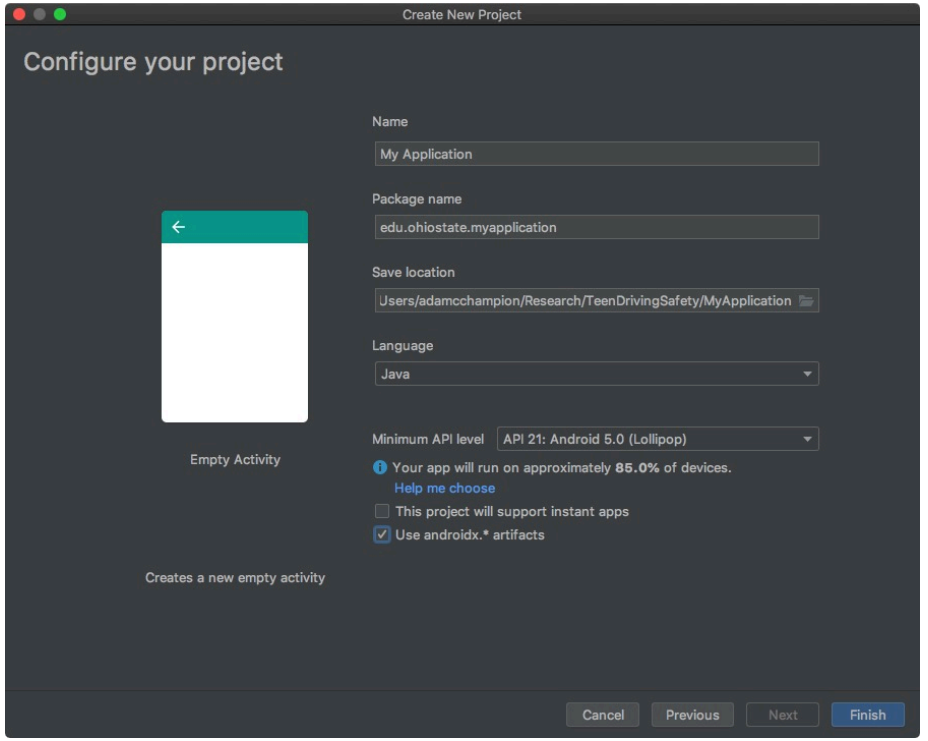
Creating Android App (1)

- Creating new project in Android Studio:
  - Go to *File→New Project*
  - Determine what kind of Activity to create (chose Empty Activity for simplicity)
  - Click *Next*



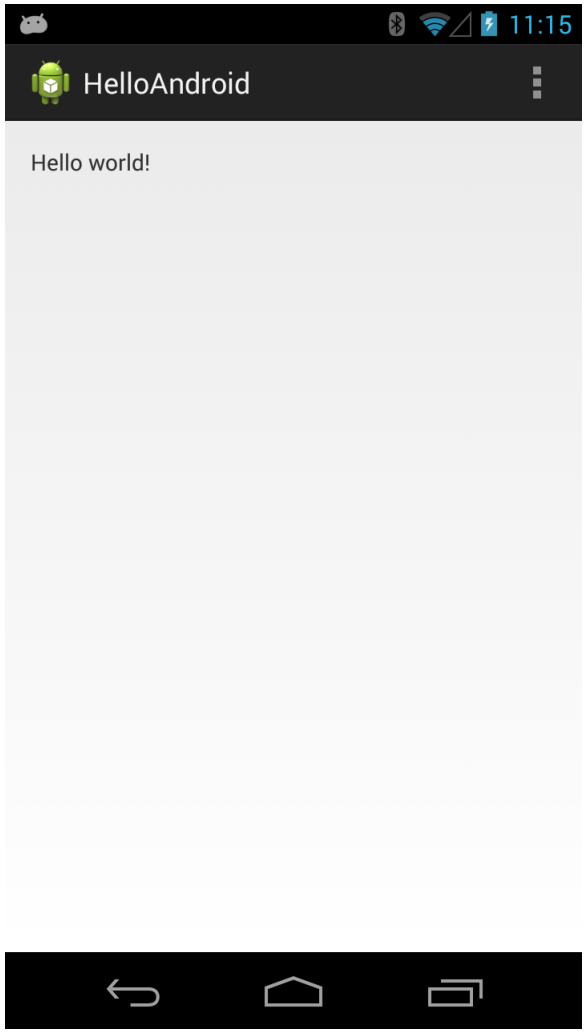
Creating Android App (2)

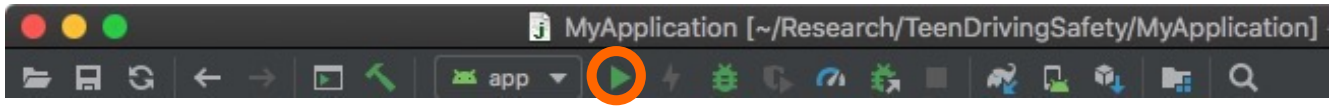
- Enter your app name (reverse DNS syntax)
- Can select:
  - Kotlin support
  - Minimum Android version (5+)
  - Using `androidx` support packages (recommend)
- This creates a "Hello World" app



Deploying the App

- Two choices for deployment:
  - Real Android device
  - Android virtual device
- Plug in your real device; otherwise, create an Android virtual device
- Emulator is slow. Try Intel accelerated one, or Genymotion
- Run the app: press “Run” button in toolbar





Underlying Source Code

src/…/MainActivity.java

```
package edu.osu.myapplication;

import androidx.appcompat.app.AppCompatActivity;

import android.os.Bundle;

public class MainActivity extends Activity {
    @Override
    protected void onCreate(Bundle savedInstanceState) {
        super.onCreate(savedInstanceState);
        setContentView(R.layout.activity_main);
    }
}
```

Underlying GUI Code

res/layout/activity_main.xml

```
<RelativeLayout
xmlns:android="http://schemas.android.com/apk/res/android"
    xmlns:tools="http://schemas.android.com/tools"
    android:layout_width="match_parent"
    android:layout_height="match_parent"
    android:paddingBottom="@dimen/activity_vertical_margin"
    android:paddingLeft="@dimen/activity_horizontal_margin"
    android:paddingRight="@dimen/activity_horizontal_margin"
    android:paddingTop="@dimen/activity_vertical_margin"
    tools:context=".MainActivity" >

    <TextView
        android:layout_width="wrap_content"
        android:layout_height="wrap_content"
        android:text="@string/hello_world" />
</RelativeLayout>
```

– `RelativeLayouts` are complicated; see [13] for details

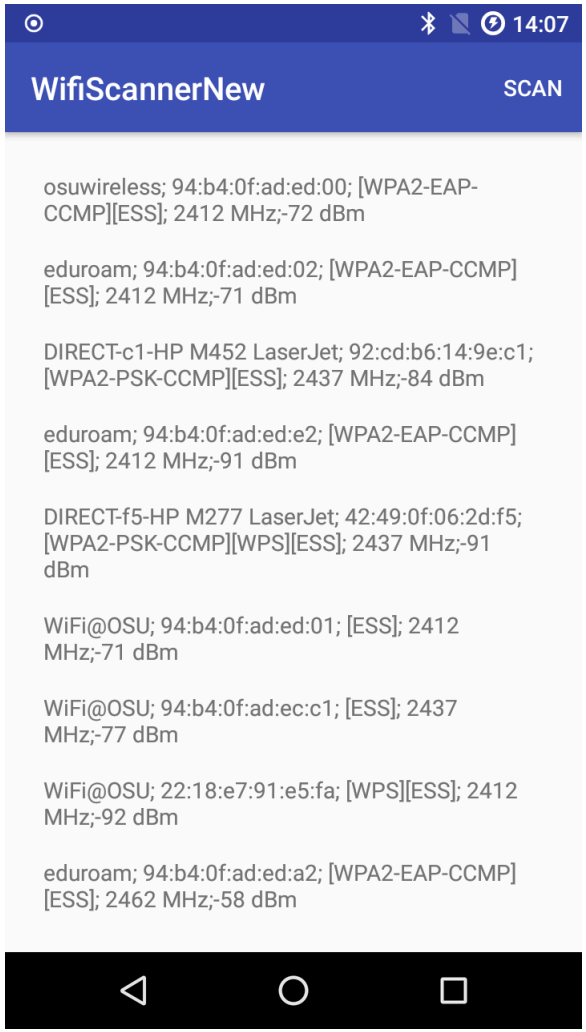
The App Manifest

AndroidManifest.xml

```
<?xml version="1.0" encoding="utf-8"?>
<manifest package="edu.ohiostate.myapplication"
  xmlns:android="http://schemas.android.com/apk/res/android">
  <application
    android:allowBackup="true"
    android:icon="@mipmap/ic_launcher"
    android:label="@string/app_name"
    android:roundIcon="@mipmap/ic_launcher_round"
    android:supportsRtl="true"
    android:theme="@style/AppTheme">
      <activity android:name=".MainActivity">
        <intent-filter>
          <action android:name="android.intent.action.MAIN"/>
          <category android:name="android.intent.category.LAUNCHER"/>
            </intent-filter>
        </activity>
    </application>
</manifest>
```

A More Interesting App

- We'll now examine an app with more features: WiFi Scanner (code on class website)
- Press a button, scan for Wi-Fi access points (APs), display them
- Architecture: Activity creates single Fragment with app



Underlying Source Code (1)

```
// WifiScanActivity.java
public class WifiScanActivity extends SingleFragmentActivity {
    @Override
    protected Fragment createFragment() {return new WifiScanFragment(); }
}
// WifiScanFragment.java. Uses RecyclerView to display dynamic list of Wi-Fi ScanResults.
@Override
public View onCreateView(LayoutInflater inflater, ViewGroup container, Bundle savedInstanceState) {
    View v = inflater.inflate(R.layout.fragment_wifi_scan, container, false);
    mScanResultRecyclerView = (RecyclerView) v.findViewById(R.id.scan_result_recyclerview);
    mScanResultAdapter = new ScanResultAdapter(mScanResultList);
    mScanResultRecyclerView.setAdapter(mScanResultAdapter);
    mScanResultRecyclerView.setLayoutManager(new LinearLayoutManager(getActivity()));

    setupWifi();
    mIntentFilter = new IntentFilter(WifiManager.SCAN_RESULTS_AVAILABLE_ACTION);

    setHasOptionsMenu(true); setRetainInstance(true);

    return v;
}

private void setupWifi() {
    try {
        Context context = getActivity().getApplicationContext();
        if (context != null) {
            mWifiManager = (WifiManager) context.getSystemService(Context.WIFI_SERVICE);
        }
    } catch (NullPointerException npe) { /* Error handling */ }
}
```

Underlying Source Code (2)

- Get system `WifiManager`
- Register BroadcastReceiver to listen for `WifiManager`'s "finished scan" system event (`Intent WifiManager.SCAN_RESULTS_AVAILABLE_ACTION`)
- Unregister Broadcast Receiver when leaving `Fragment`

```
@Override
public void onResume() { // . . .
  super.onResume(); // . . .
  SharedPreferences sharedPreferences =
    PreferenceManager.getDefaultSharedPreferences(getActivity().getApplicationContext());
    boolean hideDialog =
      sharedPreferences.getBoolean(getResources().getString(R.string.suppress_dialog_key), false);
    if (!hideDialog) { // Show user dialog asking them to accept permission request
        FragmentManager fm = getActivity().getSupportFragmentManager();
        DialogFragment fragment = new NoticeDialogFragment();
        fragment.show(fm, "info_dialog"); }
    getActivity().registerReceiver(mReceiver, mIntentFilter);
}

@Override
public void onPause() {
    super.onPause();
    getActivity().unregisterReceiver(mReceiver);
}
```

Underlying Source Code (3)

- Register menu-item listener to perform Wi-Fi scan
- Get user permission first for "coarse" location (required in Android 6+)

```
// WifiScanFragment.java
public void onCreateOptionsMenu(Menu menu, MenuInflater inflater) { /* Call super.onCreate...() */
    inflater.inflate(R.menu.menu, menu); }

public boolean onOptionsItemSelected(MenuItem item) {
  switch (item.getItemId()) {
    case R.id.menu_scan:
      if (!hasLocationPermission()) { requestLocationPermission(); }
      else { doWifiScan(); }
    return true; }
  return false; }

private void requestLocationPermission() {
  if (Build.VERSION.SDK_INT >= Build.VERSION_CODES.M) {
    if (!hasLocationPermission()) {
      requestPermissions(new String[]{Manifest.permission.ACCESS_COARSE_LOCATION}, PERM_REQUEST_LOCATION);
}}}

public void onRequestPermissionsResult(int requestCode, String[] permissions, int[] grantResults) {
    if (requestCode == PERMISSION_REQUEST_LOCATION) {
        if (grantResults[0] == PackageManager.PERMISSION_GRANTED) { doWifiScan(); }
        else { // Error } }}}
```

The Broadcast Receiver

```
// WifiScanFragment.java
private final BroadcastReceiver mReceiver = new BroadcastReceiver() {
    // Override onReceive() method to implement our custom logic.
    @Override
    public void onReceive(Context context, Intent intent) {
        // Get the Intent action.
        String action = intent.getAction();

        // If the WiFi scan results are ready, iterate through them and
        // record the WiFi APs' SSIDs, BSSIDs, WiFi capabilities, radio
        // frequency, and signal strength (in dBm).
        if (WifiManager.SCAN_RESULTS_AVAILABLE_ACTION.equals(action)) {
            // Ensure WifiManager is not null first.
            if (mWifiManager == null) { setupWifi(); }

            List<ScanResult> scanResults = mWifiManager.getScanResults();
            mScanResultList.addAll(scanResults);
            mScanResultAdapter.notifyDataSetChanged();
        }
    }
};
```

User Interface

Updating UI in code

- Two inner classes handle `RecyclerView` items:
  - `ScanResultAdapter` (extends `RecyclerView.Adapter<ScanResultHolder>`)
  - `ScanResultHolder` (extends `RecyclerView.ViewHolder`)
- See code, Big Nerd Ranch (Chapter 8) for details

UI Layout (XML)

```
<!-- fragment_wifi_scan.xml
     (for the RecyclerView fragment) -->
<?xml version="1.0" encoding="utf-8"?>
<LinearLayout
    android:layout_width="match_parent"
    android:layout_height="match_parent" >
  <android.support.v7.widget.RecyclerView
    android:id="@+id/scan_result_recyclerview"
    android:layout_width="match_parent"
    android:layout_height="match_parent"/>
</LinearLayout>

<!-- item_wifi_scan.xml
     (for each RecyclerView item) -->
<?xml version="1.0" encoding="utf-8"?>
<LinearLayout
    android:layout_width="match_parent"
    android:layout_height="wrap_content" >

    <TextView
        android:id="@+id/scan_result_textview"
        android:layout_width="match_parent"
        android:layout_height="wrap_content"
        android:text="TextView"/>
</LinearLayout>
```

Android Programming Notes

- Android apps have multiple entry points; no `main()` method
  - Cannot "sleep" in Android
  - During each entrance, certain `Objects` may be `null`
  - Null-check programming is very useful to avoid crashes
- Java concurrency techniques are required
  - Don't block the main thread in Activities
  - Implement long-running tasks (e.g, network) as `AsyncTasks`
  - Recommendation: read [4]; chapter 20 [10]; [11]
- Logging state via `Log.d()` in app is essential when debugging
- Request only the permissions that you need; otherwise, app crash!
- Event handling in Android GUIs entails listener `Objects`

Concurrency: Threads (1)

- Thread: program unit (within process) running independently
- Basic idea: create class that implements Runnable interface
  - Runnable has one method, run(), that has code to execute
  - Example:

```
public class OurRunnable implements Runnable {
    public void run() {
        // run code
    }
}
```

- Create a Thread object from Runnable and start() Thread, e.g.,

```
Runnable r = new OurRunnable();
Thread t = new Thread(r);
t.start();
```

- Problems: cumbersome, does not reuse Thread code

Concurrency: Threads (2)

- Easier approach: anonymous inner classes, e.g.,

```
Thread t = new Thread(new Runnable( {
        public void run() {
            // code to run
        }
    });
t.start();
```

- Idiom essential for *one-time* network connections in Activities
- However, Threads are hard to synchronize, especially with UI thread; AsyncTasks beter

Concurrency: AsyncTasks

- AsyncTask handles background task, interacts with UI thread:

```
public class AsyncTask<ParamsType, ProgressType, ResultType> {
    protected Result doInBackground(ParamType param) {
        // code to run in background
        publishProgress(ProgressType progress); // UI
        …
        return Result;
    }

    protected void onProgressUpdate(ProgressType progress) {
        // invoke method in Activity to update UI
    }
}
```

- Extend AsyncTask as you like (see http://developer.android.com)

Thank You

Any questions?

References (1)

1. C. Horstmann, *Big Java Late Objects*, Wiley, 2012. Online: http://proquest.safaribooksonline.com.proxy.lib.ohio–state.edu/book/–/9781118087886
2. J. Bloch, *Effective Java*, 2nd ed., Addison–Wesley, 2008. Online: http://proquest.safaribooksonline.com.proxy.lib.ohio–state.edu/book/programming/java/9780137150021
3. S.B. Zakhour, S. Kannan, and R. Gallardo, *The Java® Tutorial: A Short Course on the Basics*, 5th ed., Addison–Wesley, 2013. Online: http://proquest.safaribooksonline.com.proxy.lib.ohio–state.edu/book/programming/java/9780132761987
4. C. Collins, M. Galpin, and M. Kaeppler, *Android in Practice*, Manning, 2011. Online: http://proquest.safaribooksonline.com.proxy.lib.ohio–state.edu/book/programming/android/9781935182924
5. M.L. Sichitiu, 2011, http://www.ece.ncsu.edu/wireless/MadeInWALAN/AndroidTutorial/PPTs/javaReview.ppt
6. Oracle, http://docs.oracle.com/javase/1.5.0/docs/api/index.html
7. Wikipedia, https://en.wikipedia.org/wiki/Vehicle_Identification_Number
8. StatCounter Global Stats, "Mobile operating system market share worldwide," Jul. 2017, http://gs.statcounter.com/os-market-share/mobile/worldwide

References (2)

10. http://bcs.wiley.com/he-bcs/Books?action=index&itemId=1118087887&bcsId=7006
11. B. Goetz, T. Peierls, J. Bloch, J. Bowbeer, D. Holmes, and D. Lea, Java Concurrency in Practice, Addison-Wesley, 2006, online at http://proquest.safaribooksonline.com/book/programming/java/0321349601
12. https://developer.android.com/guide/components/activities.html
13. https://developer.android.com/guide/topics/ui/declaring-layout.html#CommonLayouts
14. https://cloud.genymotion.com/page/doc/#collapse4
15. http://blog.zeezonline.com/2013/11/install-google-play-on-genymotion-2-0/