Android Apps Development Boot Camp

Ming Chow
Lecturer, Tufts University
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mchow@cs.tufts.edu

Overview of Android

- Released in 2008
- Over 50% market share
- Powers not only smartphones but also tablets
- *Heterogeneous* ecosystem of Android devices
- Unlike Apple's "walled garden" (i.e., for deploying apps to the App Store), Android is open

In This Boot Camp

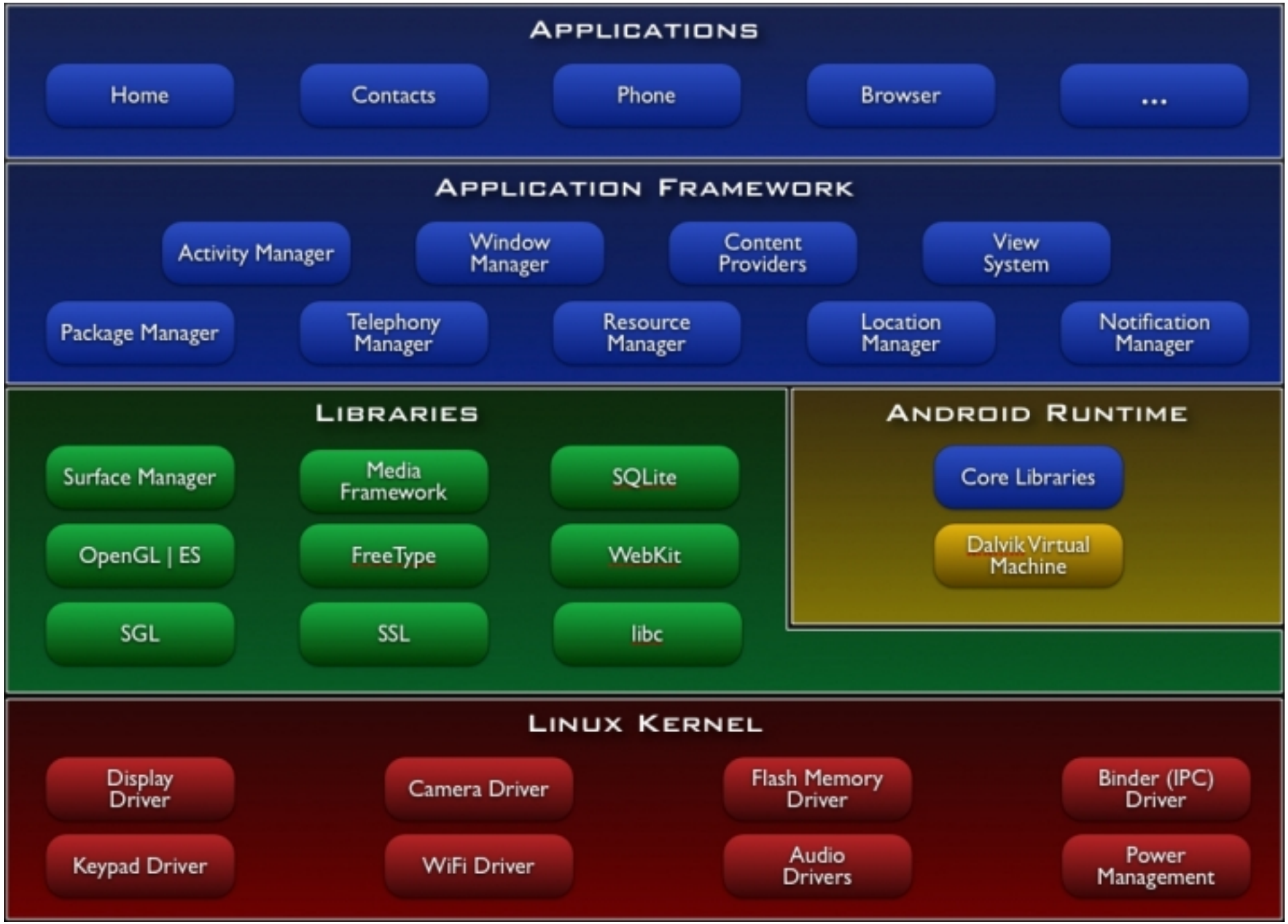
- What we will cover:
  - Android architecture
  - Creating apps using Android SDK and Eclipse
  - User interface widgets, events, and layouts
  - 2D drawing
  - Data storage
  - Using location-based services (e.g., GPS)
- What we will not cover:
  - Camera
  - Multiple views
- What we will cover if time permits:
  - Networking
  - Logging and debugging
  - Performance and response enhancements
  - Publishing to Android Market

Factors in Mobile / Tablet Development

- Limited memory
- Display capabilities (screen size limit)
- Usage fees
- App speed
- Internet access
- User input (i.e., touch, multitouch)
- Built-in capabilities (phone, GPS, camera)
- Micropayment
- Multitasking
- Services

Android Architecture

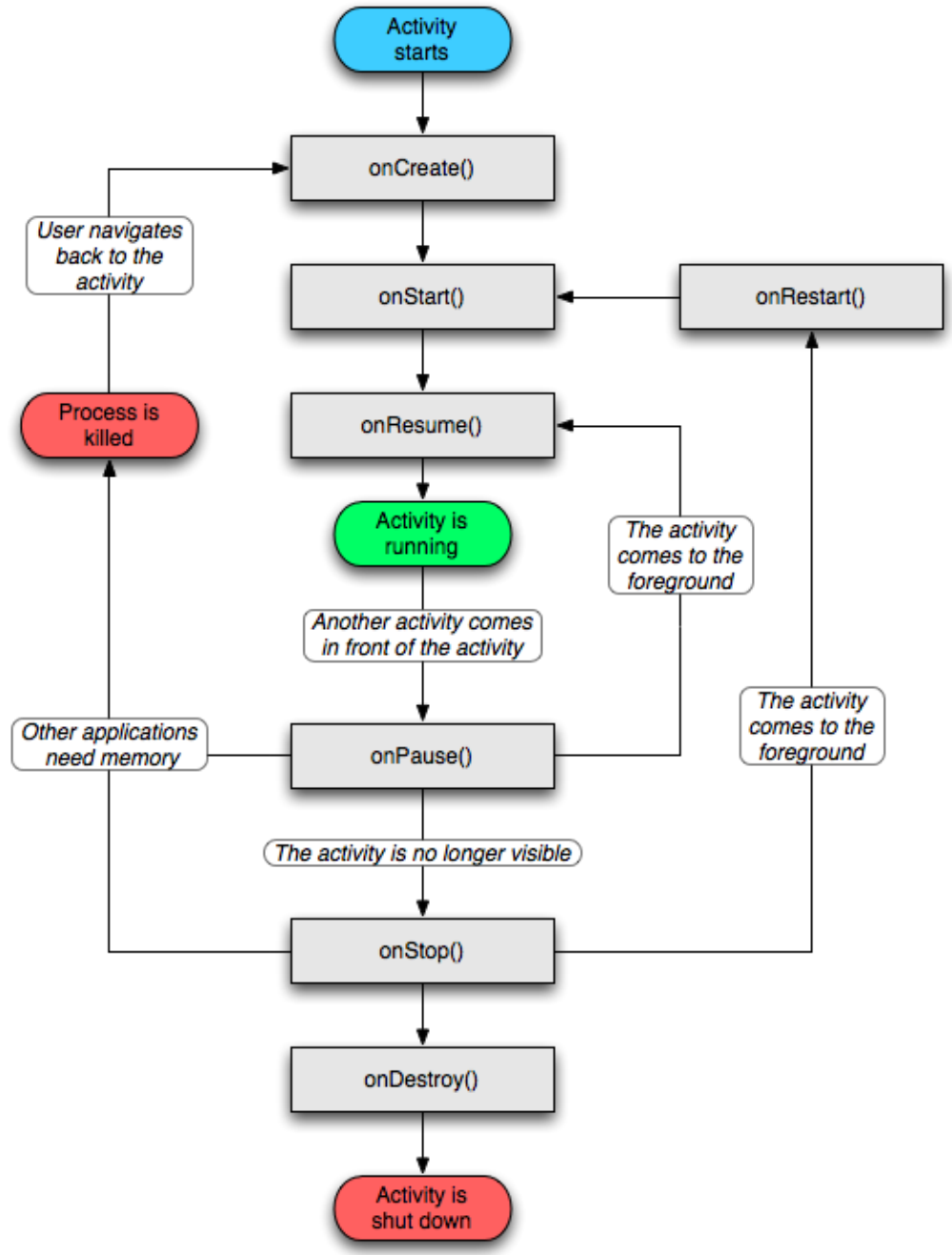
- Linux Kernel (lowest level)
  - Support for keypad, camera, Wi-Fi, power management, display, flash memory
- Android Runtime
  - Contains Dalvik VM, similar to the Java VM
- Libraries
  - Includes OpenGL, SSL, sqlite, WebKit
- Application Framework (highest level)
  - Location, view, content providers, window, activities, etc.


Applications
Home
Contacts
Phone
Browser
...
Application Framework
Activity Manager
Window Manager
Content Providers
View System
Package Manager
Telephony Manager
Resource Manager
Location Manager
Notification Manager
Libraries
Surface Manager
Media Framework
SQLite
OpenGL | ES
FreeType
WebKit
SGL
SSL
libc
Android Runtime
Core Libraries
Dalvik Virtual Machine
Linux Kernel
Display Driver
Camera Driver
Flash Memory Driver
Binder (IPC) Driver
Keypad Driver
WiFi Driver
Audio Drivers
Power Management

Components of an Android App

- *Activity* - a single screen, the user interface. While you can have multiple activities in an app, they are independent of each other!
- *Service* - runs in background without blocking an activity or deter the user experience; does not provide user interface. Example: getting your geolocation, latitude and longitude coordinates
- *Content provider* - shared set of application data; persistent storage. Examples: the file system or sqlite database
- *Broadcast receiver* - responds to system-wide announcements. Example: battery is running low
- *Intent* - asynchronous messaging system in Android; can be sent to your application or between applications. Messages are objects.
  - Example: ACTION_BATTERY_LOW

Android Activity Lifecycle



Our Development Environment

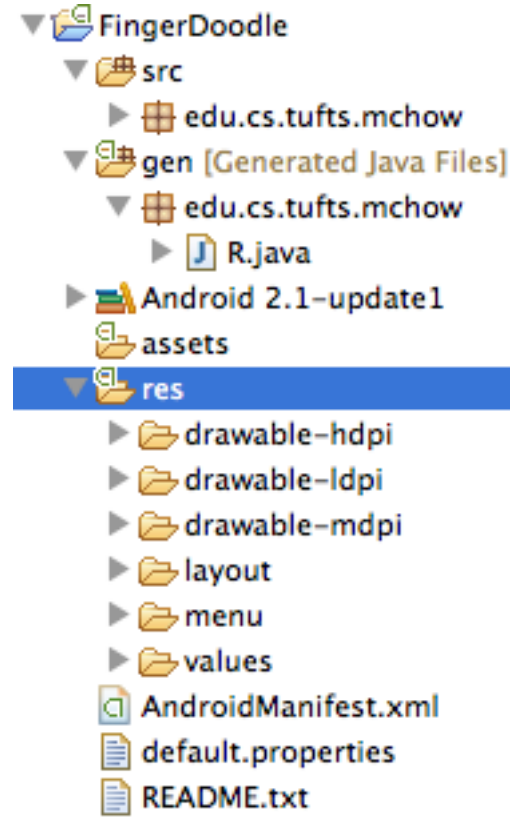
1. Eclipse (Helios)
2. Android SDK
    - In ANDROID_SDK_ROOT/tools: emulator, apkbuilder, sqlite3, etc.
3. ADT Plugin for Eclipse
4. Necessary Android OS targets for Android Virtual Device (AVD) for emulator:
    - Android 2.1-update1 - API Level 7
    - Google APIs (Google, Inc.) - API Level 7
    - Android 2.2 - API Level 8
    - Google APIs (Google, Inc.) - API Level 8

Structure of an Android App in Eclipse

- src - Your packages and source files (.java)
- gen - Generated Java Files
  - R.java - DO NOT MODIFY THIS FILE!

res - Application Resources (more next slide)

- AndroidManifest.xml - Information about the app including components of the application, permissions, linked libraries, and minimum version of Android OS and API the app requires
- Reference: http://developer.android.com/guide/topics/manifest/manifest-intro.html



Application Resources

- Images
  - HDPI, MDPI, and LDPI
  - Icon for app
- Layouts
  - Eclipse provides a drag-and-drop interface to construct layouts
- Menus
  - Define layout of menus. Example: the menu upon clicking on the "home" icon in app
- Values
  - Strings: key-value mappings of strings used in app (instead of hard-coding in source code)
- Layout, menu, and value files are XML
- Modifying or adding files to the folders under `res` will automatically modify the `gen/R.java` file!

User Interface Elements

- Views
  - In android.view package
  - Refers to the rectangular portion of screen; "container"
  - Base class for all widgets and layouts
  - Widgets
    - In android.widget package
    - The stuff to draw: TextView, Button, RadioButton, DatePicker, Spinner (drop-down), ProgressBar, etc.
  - Layouts
    - A view object
    - Determine how to lay out other objects on screen; doesn't draw stuff
    - Examples: LinearLayout, TabLayout

Hands-On: Creating Your First Android App with Eclipse and Android SDK

Assuming that you have downloaded and installed Eclipse, Android SDK, the ADT Plugin for Eclipse, and Android OS targets.

1. In Eclipse, create a new Android Virtual Device (for your emulator) in Eclipse by clicking on: 
2. In Eclipse, go to File > New > Android Project
3. Enter *Project Name*, select *Android 2.1-update1* as the Target Name, *Application Name*, *Package Name*, and *Activity Name* (i.e., the entry class). Min SDK version is optional
4. In the Package Explorer Go to your project folder > src > Package_Name > Activity_Name.java
5. Modify the source; see *next slide (what you need to modify is in **bold**)*
6. Assuming there is are no errors in source, click on the  icon to run your app in the Android emulator

Your First Android App (Source)

```
package ...;

import android.app.Activity;
import android.os.Bundle;
import android.widget.*;

public class ... extends Activity
{
  public void onCreate(Bundle savedInstanceState)
  {
    super.onCreate(savedInstanceState);
    TextView tv = new TextView(this); // A TextView is simple; used to display fixed text strngs
    tv.setText("Hey, this works!");
    tv.setHeight(50);
    setContentView(tv);
  }
}
```

User Interface Event *Listeners*

- Within widgets
- When you draw a widget, you need to customize its action. Example for a button, what to do after clicking on it?
- Most widgets in View will have a setOn*Listener method. Example for a Button: setOnClickListener(*callback method in here)*
- Reference: http://developer.android.com/guide/topics/ui/ui-events.html

Hands-On: ButtonDemo1

- ButtonDemo1 uses a widget (a button) and the *onClick* listener
- Import the ButtonDemo1 project into Eclipse:
  1. In Eclipse, File > Import...
  2. Under General, select Existing Projects into Workspace
  3. Browse to the folder where you saved the ButtonDemo1 project and click "Open..."
  4. A list of available Eclipse projects shall appear. Check the ButtonDemo1 project (and others for that matter) to import them.
  5. The projects should be available in your Package Explorer window

User Interface Event *Handlers*

- Within views (i.e., on entire screen)
- onKeyUp()
- onKeyDown()
- onTouchEvent()
- onFocusChanged()
- Reference: http://developer.android.com/guide/topics/ui/ui-events.html

User Interface Layouts

- The first Android app did not use any layouts
- Analogy: Cascading Style Sheets (CSS) in web development
- Define screen elements and layout
- Resource files stored in /res/layout
- /res/layout/main.xml sets the screen's display on application load (onCreate())
- Can also be created and modified via GUI in Eclipse
- Example:

```
<?xml version="1.0" encoding="utf-8"?>
<LinearLayout xmlns:android="http://schemas.android.com/apk/res/android"
    android:orientation="vertical"
    android:layout_width="fill_parent"
    android:layout_height="fill_parent"
    >
</LinearLayout>
```

Hands-On: ButtonDemo2

- The difference between ButtonDemo1 and ButtonDemo2: button was create programmatically using Java in ButtonDemo1 while the button in ButtonDemo2 is created using a layout.
- Import the ButtonDemo2 project into Eclipse and run

Hands-On: WidgetsDemo1

- Features:
  - Changing a checkbox from checked to unchecked, vice-versa
  - Uses a layout
- Import the WidgetsDemo1 project into Eclipse and run

2D Drawing and Images in Android

- In Java SDK and Swing, drawing can be done in a JPanel. In Android, drawing is done on a *Canvas* in a *View*
- Package of interest: android.graphics
- Similar functions compared to 2D drawing using Java SDK and Swing
- Images in Android: bitmaps
  - The android.graphics.Bitmap class provide access to the image attributes and methods for image manipulation.
- The idea:
  - Create a custom view (i.e., a subclass of View)
  - Override onDraw() method
  - Instantiate a Paint object for drawing

Hands-On: AndroidDrawingTest

- Features:
  - Custom view
  - Draw (2D) onto canvas
  - Clear background color
  - Draw anti-alias text
  - Draw shape
  - Render an image (see image in res/drawable/ directory)
- Import the AndroidDrawingTest project into Eclipse and run

Hands-On: Finger Doodle

- Released by yours truly on Android Market
- Entry class: `FingerDoodle`
- Features:
  - Options menu layout
  - {H|M|L}DPI icons
  - Strings resource file
  - One thread for drawing
  - Color picker (taken from Google)
  - One subclass of SurfaceView which provides a dedicated drawing surface embedded inside of a view hierarchy
  - Uses `onTouchEvent()` event handler

Permissioning

- Fine-grain, least-privilege, permissioning used for Android apps. That is, you have to specify what you need (allow)!
- Modify AndroidManifest.xml
- Add permissions before the </manifest>
  - Format: <uses-permission android:name="android.permission.*????*" />
- Examples:
  - ACCESS_COARSE_LOCATION - Get location via Wi-Fi, not GPS
  - ACCESS_FINE_LOCATION - Get location via GPS
  - INTERNET - Allows applications to open network sockets
  - CAMERA - Duh!
  - FLASHLIGHT - Allows access to the flashlight
  - SEND_SMS - Allows app to send SMS messages
- More: http://developer.android.com/reference/android/Manifest.permission.html

Location-Based APIs (i.e., GPS)

- Get an instance of LocationManager with a call to getSystemService() using LOCATION_SERVICE (part of Context) constant
- Implement a LocationListener class
  - Contains one method you must override: public void onLocationChanged(Location location)
- Request for location updates via requestLocationUpdates()
- Be sure to add permission to use GPS in AndroidManifest.xml file
- Reference: http://developer.android.com/guide/topics/location/obtaining-user-location.html

Example Code for Location-Based API

```
...
...
...
private LocationManager lm;
private MyLocListener myLL; // you have to write MyLocListener

private void init()
{
  lm = (LocationManager) this.getSystemService(LOCATION_SERVICE);
  lm.requestLocationUpdates(LocationManager.GPS_PROVIDER,
    DEFAULT_GPS_MIN_TIME,
    DEFAULT_GPS_MIN_DISTANCE,
    myLL);
  ...
  ...
}
```

Simulating the GPS on the Emulator

- Run your app via Eclipse (i.e., click on the green "Go" button)
- After your emulator loads your app, open a terminal (Mac OS X, Linux) or Command Prompt (Windows)
- Run `telnet localhost 5554` which will connect you to the emulator to run commands
- Run `geo fix` *lon lat*. Example: `geo fix -71.11982 42.406949`

Hands-On: GeoAppTemplate

1. Import the GeoAppTemplate project into Eclipse and run
2. After your emulator loads the app, open a terminal (Mac OS X, Linux) or Command Prompt (Windows)
3. Run telnet localhost 5554 which will connect you to the emulator to run commands
4. Run geo fix *some_lon some_lat*. Example: geo fix -71.11982 42.406949

Database and Data Storage

- Shared Preferences
  - Key-value pairs
  - Data types supported: boolean, float, integer, long, string
  - The class: android.content.SharedPreferences
  - Data stored in /data/data/*package_name*/shared_prefs/*prefs_filename.xml*
- Files and Directories
  - Application data stored in /data/data/*package_name*/
  - Context.openFileInput()
  - Context.openFileOutput()
  - Content.deleteFile()
  - Context.fileList()
  - Use standard java.io packages such as FileOutputSteam

Database and Data Storage (cont.)

- sqlite
  - The class: android.database.sqlite.SQLiteDatabase
  - Database files stored
    in /data/data/*package_name*/database/*dbasename.db*

Drawbacks of Android; Work-in-Progress

- Caveats
  - Android's openness has its drawbacks
    - Ripe for malware (e.g., many versions of Bank of America and Starbucks apps on Android Market)
  - Heterogeneous ecosystem of Android devices => *fragmentation* (too many versions Android OSs across different manufacturers and devices out there)
  - Unlike Apple, Android has many different app stores other than the Android Market (e.g., Amazon). Alas, less visibility of apps and less revenue potentials
  - User interface and experience may not be as pretty as iOS
- Android is constantly maturing

Advance Topics (if time allows)

- Networking
- Logging and debugging
- Performance and response enhancements

Networking in Android

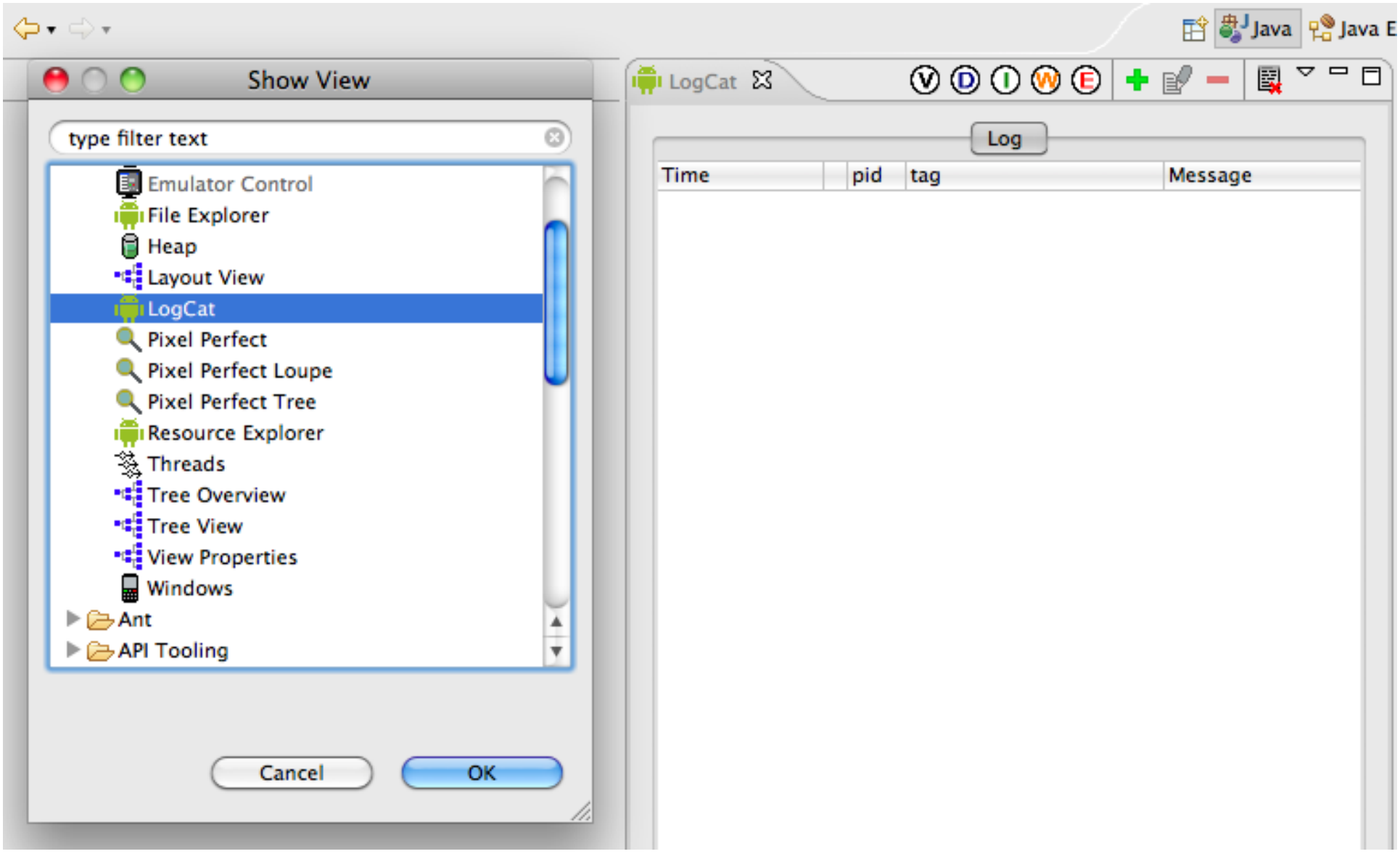
- Very similar to networking in Java SDK
- Necessary packages:
  - java.io.InputStream
  - java.net.HttpURLConnection
  - java.net.URL

Networking in Android: Working Source

```
import java.io.InputStream;
import java.net.HttpURLConnection;
import java.net.URL;
...
private String getContent (String url)
{
  try {
    URL api = new URL(url);
    HttpURLConnection conn = (HttpURLConnection)api.openConnection();
    InputStream is = conn.getInputStream();
    BufferedReader r = new BufferedReader(new InputStreamReader(is));
    StringBuilder total = new StringBuilder();
    String line;
    while ((line = r.readLine()) != null) {
      total.append(line);
    }
    r.close();
    is.close();
    return total.toString();
  }
  catch (MalformedURLException e) {
    return null;
  }
  catch (IOException e) {
    return null;
  }
}
```

Logging and Debugging

- android.util.Log - provides ability to send log output
- Verbosity levels:
  - Log.v(*tag, note*) => Verbose
  - Log.d(*tag, note*) => Debug
  - Log.i(*tag, note*) => Info
  - Log.w(*tag, note*) => Warning
  - Log.e(*tag, note*) => Error (uh oh...)
  - Log.wtf(*tag, note*) => Enough said.
- Tag: a string, private static final. Example: private static final String TAG = "***** FingerDoodle";
- Where to view log:
  - ANDROID_SDK_ROOT/platform-tools/adb (turn on AVD first)
  - Eclipse Logcat

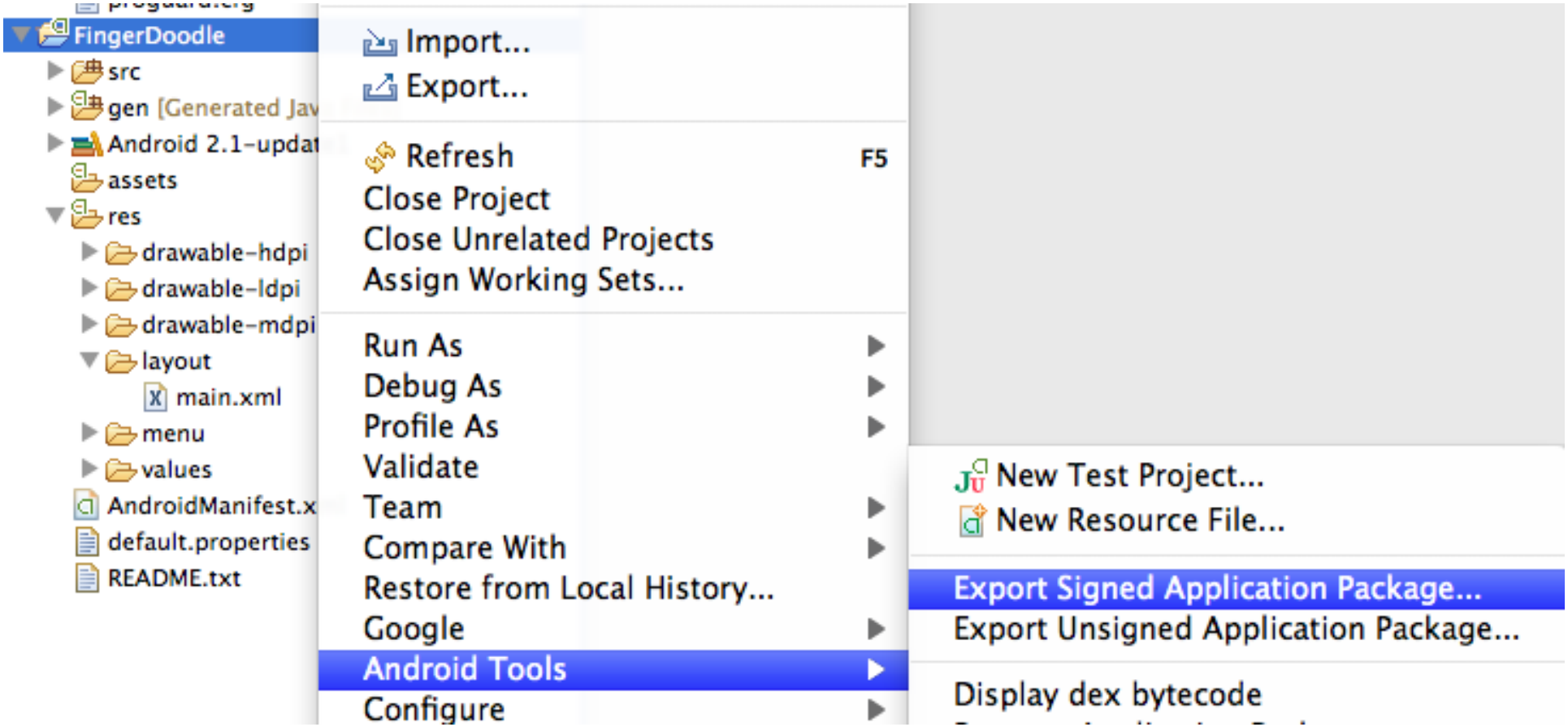

Java
Java E
Show View
type filter text
Emulator Control
File Explorer
Heap
Layout View
LogCat
Pixel Perfect
Pixel Perfect Loupe
Pixel Perfect Tree
Resource Explorer
Threads
Tree Overview
Tree View
View Properties
Windows
Ant
API Tooling
Cancel
OK
LogCat
V D I W E
Log
Time
pid
tag
Message

Performance and Responsiveness

- http://developer.android.com/guide/practices/design/performance.html
- http://developer.android.com/guide/practices/design/responsiveness.html
- Some ideas:
  - Avoid implementing and using getters and setters
  - Avoid creating unnecessary objects
  - Beware of using some libraries (which may provide functions that are woefully inefficient)
  - Use `static final` for constants
  - Never allocate memory (or release it)

Preparing Your App for the Hardware Device or Android Market

- When you test apps via emulator, Android uses a debug certificate
- Sign your app; create key and certificate for an app:
  - RTFM: http://developer.android.com/guide/publishing/app-signing.html or...
  - ...in Eclipse, right-click on project > Android Tools > Export Signed Application Package...
- To deploy your app to your hardware device (e.g., Droid Incredible):
  - Go to bin/ directory of your project and copy the .apk file (the app binary) to your hardware device (e.g., phone) via USB cable
  - Install the app onto your file via ASTRO File Manager app (free via Android Market)
- To deploy your app to the Android Market:
  - https://market.android.com/publish/Home
  - HDPI icon of app 512w x 512h PNG required!
  - If you are selling your app, a tax ID required


FingerDoodle
src
gen [Generated Jav
Android 2.1-updat
assets
res
drawable-hdpi
drawable-ldpi
drawable-mdpi
layout
main.xml
menu
values
AndroidManifest.x
default.properties
README.txt
Import...
Export...
Refresh
F5
Close Project
Close Unrelated Projects
Assign Working Sets...
Run As
Debug As
Profile As
Validate
Team
Compare With
Restore from Local History...
Google
Android Tools
Configure
New Test Project...
New Resource File...
Export Signed Application Package...
Export Unsigned Application Package...
Display dex bytecode

Acknowledgements and References

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