CS 478: Software Development for Mobile Platforms

Set 3: Activities and User Interfaces

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Android activities

- Activity = Single, focused thing that a user can do
- Main means of interaction with app user
- Each activity should support a single action
- When designing your apps, think in terms of the single actions that app should support and define one activity for each action
  - Examples of actions: Writing an email message, viewing a list of SMS messages, writing an SMS, dialing a phone number, etc.
- See http://developer.android.com/reference/android/app/Activity.html

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Tasks and the backstack

- *Task*: A sequence of activities for a given user scenario
- *Task backstack*: Stack of activities capturing user interactions
  - Activities are popped and pushed following user commands
- Multiple backstacks possibly active simultaneously
  - Jump between backstacks by going back to home screen and selecting app on top of stack
  - Or use “recents” button
- See http://developer.android.com/reference/android/app/Activity.html

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Activity lifecycle

- When app started, its main activity is usually pushed on top of stack
  - New activity is visible and in focus
  - In Java: New instance of activity’s class is created
- Activity can be deleted, e.g., because one of the following happens
  - User pushes “back” button on the device
  - Activity kills itself by calling *finish()* OS method
  - OS kills it to reclaim resources held by the activity
- If activity in focus deleted, previous activity in backstack regains focus
  - This activity is popped off stack and deleted
- Activities go through various states and state transitions in their lifetime (see next)

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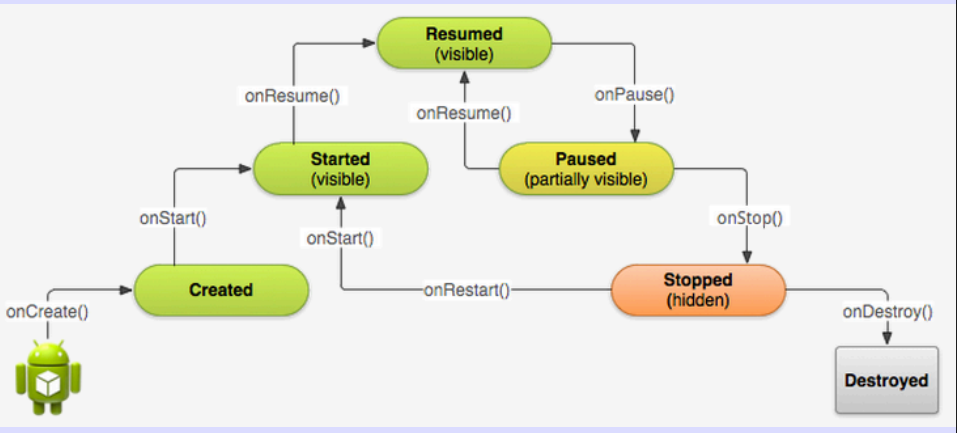
State diagram of an activity

- Source: http://developer.android.com/training/basics/activity-lifecycle/starting.html



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Activity states

- *Created* – Java object controlling activity has been created and initialized (defining content and user interactions), but not visible yet
- *Started* – Activity is visible, but not in focus (not interacting with user)
- *Resumed* (aka *running*) – Activity is visible and in focus (interacting)
- *Paused* – Visible, but not interacting (e.g., partially covered)
- *Stopped* – Not visible, but in backstack
- *Destroyed* – Activity object has been deleted

Caveat: *Created and Started* are transient states, the other 4 are permanent states

Activity could be in one of the permanent states for an indefinite time

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Activity states

- Android's app execution interleaves OS code with app code
  - App is not a standalone module with a *main()*
  - OS calls programmer-defined code when appropriate
- For activities, OS calls app code whenever a state transition occurs
- Programmer responds to state changes by defining callback methods in activity class invoked automatically by OS, e.g.,
  - *onCreate()* – Called when activity transitions to *Created* state
  - *onStart()* – Called when activity transitions to *Started* state
  - *onResume()* – etc.
  - *onPause()*
  - *onStop()*
  - *onDestroy()*

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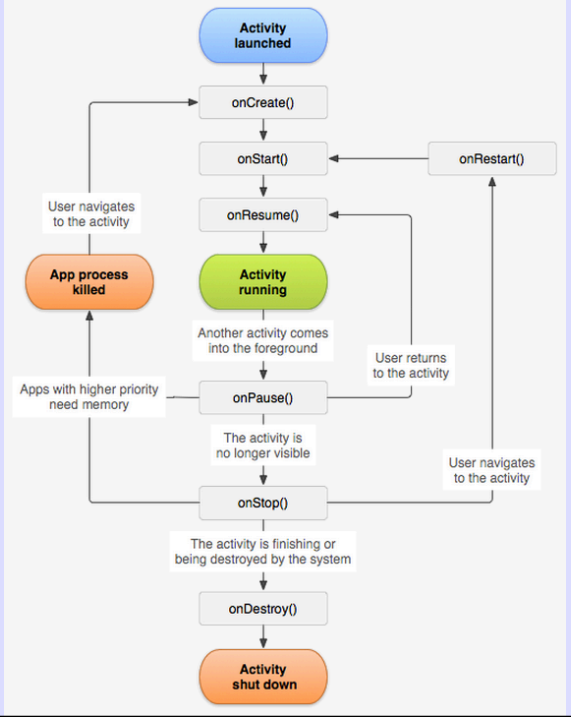
Typical lifecycle of an activity



Source: http://developer.android.com/reference/android/app/Activity.html

Activity lifecycle—The callbacks

- *onCreate()*—Initialize the new activity object
  - Think of it as an additional activity "constructor"
  - Input parameter: a *Bundle* with saved instance state (See later)
- *onStart()*—Activity about to become visible
  - Load persistent state, update content, update locations, etc.
- *onResume()*—Activity about to gain focus (interact with user)
  - Start focus-related activities (e.g., start animations, background sounds)
- *onPause()*—Activity about to lose focus
  - Save persistent state, stop animations

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Activity lifecycle—The callbacks (cont'd)

- *onStop()*—Activity about to become invisible (may not be called in Gingerbread and earlier OS)
  - Cache state
- *onDestroy()*—Activity about to go away for good
  - Caveat: *onDestroy()* may not be called at all, if OS kills activity
  - Release allocated resources
- Typically, you will not write all these methods but only those needed for your app to run
  - *onCreate()* is mandatory
  - *onPause()* is used quite frequently
  - Other callbacks are used less frequently

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Additional activity callbacks

- *onRestart()*—Called when stopped activity is started again
  - Part of activity lifecycle
  - Usually unnecessary because always followed by *onStart()*
  - Very technical, probably will never use
- *onSaveInstanceState()*—Called when OS about to kill activity because memory is low or configuration change occurred
  - Not part of lifecycle, not guaranteed to get called
  - Main goal: Create a *Bundle* instance that will be passed to *onCreate()* (and possibly *onRestoreInstanceState()*) when activity created again
  - http://developer.android.com/training/basics/activity-lifecycle/recreating.html

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Defining an activity

1. Create your own class by extending framework class *Activity*
   - In Java:
     - `public class MyActivity extends Activity ...`
   - In Kotlin:
     - `class MyActivity : Activity ...`
2. Define appropriate fields
3. Define appropriate callback methods:
   - `public void onCreate(Bundle savedInstanceState) { ...`
   - `public override fun onCreate(savedInstanceState: Bundle?) {`
4. Define additional methods as needed

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Writing method *onCreate()*

- Goal: Set up data structures + screen configuration + user interactivity
- Java source template
  1. Call *super.onCreate()*
  2. Set layout configuration for activity (call *setContentView()* on appropriate layout file)
  3. Get references to views, e.g., *findViewById(R.id.viewName)*
  4. Check saved instance state if expected, act upon it
  5. Set up listeners for interactive views (e.g., buttons, menus, etc.)
     - Listener = Code block invoked when user interacts with a view
  6. Configure views and do other initialization actions

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"Bundles"

- Groups of *(key, value)* pairs
  - Key: String
  - Value: A *Parcelable* object
- Popular methods
  - Setter methods take a *String* (the key) and value (*int, String...*): *putInt(), putString(), putDouble(), putIntArray(), putBundle(),* etc.
  - Getter methods take a string, return a value: *getBoolean(), getChar(), getByte(), getCharArray()*
- https://developer.android.com/reference/android/os/Bundle.html
- https://developer.android.com/guide/components/activities/parcelables-and-bundles.html

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Parcelable objects

- Objects meant to be passed across process boundaries
- (1) *marshalled* (flattened) into parcels, (2) shipped to another process, and (3) *unmarshalled* into their original form
- *Parcel:* Container for flattened (marshaled) data that be passed between processes through binder mechanism
- Parcelable is a Java *interface*—Familiarity with interfaces assumed
- Examples of *Parcelable* objects
  - All primitive types and primitive arrays (predefined *Parcelable*)
  - Instances of classes that implement *Parcelable* Java interface
  - You'll have to implement *Parcelable* interface for classes whose instances are passed between processes; we'll see how later on
- https://developer.android.com/reference/android/os/Parcelable.html

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A disclaimer: Activity killed by OS

- Android can kill a running process if system is low on resources
- If process being killed has activities, the activities will also be destroyed without running any more methods
  - Pre-Honeycomb (e.g., Gingerbread, Froyo, etc.)—Paused and stopped activities can be destroyed without calling activity's *onStop()* and *onDestroy()* methods
  - Honeycomb and later (e.g., ICS, JB, KK, etc.)—Only stopped activities can be destroyed
- Friendly advice: Don't count on your *onDestroy()* method being executed (*onStop()* too, if app can run on Gingerbread, etc.)
  - Save critical state in *onPause()* and *onStop()*

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Another disclaimer: Configuration changes

- **Current activity generally killed when configuration change occurs**
  - Device rotated (e.g., from portrait to landscape mode)
  - Language change, input mode change, etc.
- Why killed? Accommodate for (possible) new layout, etc.
- This means that *onPause(), onStop(), onDestroy(), onCreate(), onStart(), onResume()* will be called in sequence on old and new activity instances
  - Stopped activities destroyed and recreated when in focus again
- Two ways to avoid total destruction: (1) Use *fragments*, or (2) override callback *onConfigurationChanged()* in activity class
  - See next…

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Handling configuration changes

1. Ad-hoc methods for saving and restoring activity instance state
   - *onSaveInstanceState()* called by OS before it kills an activity
     - Save state in argument bundle
   - *onRestoreInstanceState()* called after *onStart()* when activity restarted
     - Your bundle passed back to it
     - The same bundle is also passed to *onCreate()*
2. Redefine *onConfigurationChanged()* – Not recommended
   - More complex – Programmer must handle configuration change
   - Declare type of change handled in manifest file
   - https://developer.android.com/guide/topics/resources/runtime-changes.html

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Starting an activity

Two ways to start an activity

1. *startActivity(Intent)*

   Must first create intent, describing activity to be started

   New activity created, started and put on focus, covering calling activity

2. *startActivityForResult(Intent, int)*

   Calling activity expects result (e.g., success vs. failure) back

   Add an integer identifying the call

   Called activity retrieves intent with *getIntent()*—When done, it calls *setResult(int)*

   Calling activity gets callback *onActivityResult(int, int, Intent)*; second arg is result code

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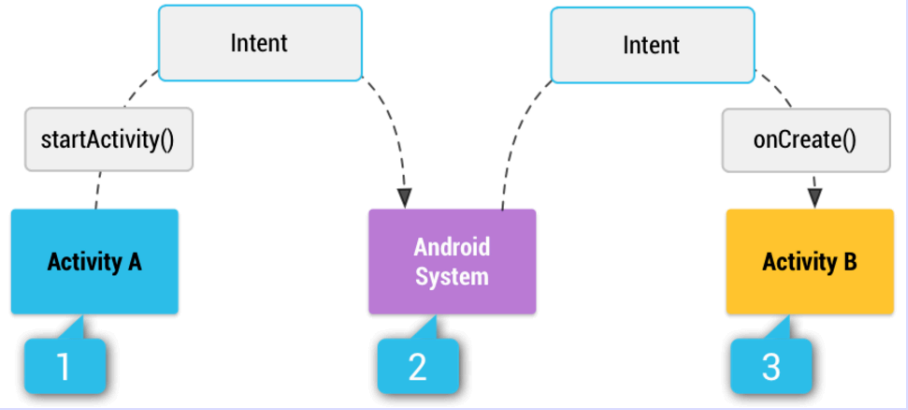
Flow of information of *startActivity()*

- Methods *startActivity()* and *startActivityForResult()* are part of Android framework (declared abstract in *Context* class and defined in *Activity*)



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About *startActivityForResult()*

The protocol of starting an activity with a result

1. Parent activity calls *startActivityForResult()* – Child activity gets focus
   - Intent argument *intent* specifies what child activity to start
   - Integer argument *requestCode* (usu symbolic) identifies call
2. Child activity sets result code (also symbolic) with *setResult(int)* or *setResult(int,Intent)* before finishing
   - Integer argument *resultCode* reports on success/failure of child activity
3. OS calls parent activity's callback *onActivityResult(int, int, Intent)*
   - Argument *requestCode* is original code identifying call
   - Argument *resultCode* is result set by child
   - Argument *intent* is original intent (presumably with new extras)

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About *onActivityResult()*

- Called right before *onResume()* in parent activity
- Intent *extras* can return additional information from child to parent activity
- Common symbolic names for integer *resultCode*: RESULT_OK, RESULT_CANCEL (public static fields of framework class *Activity*)
- If child activity did not call *setResult(),* default value RESULT_CANCEL passed to *onActivityResult()*
- Custom user codes can be defined too, e.g., RESULT_FIRST_USER (a predefined custom user code)
- Integer argument *requestCode* useful because parent activity could start multiple child activities depending on situation

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Example of *startActivityForResult()*

jellybean/packages/apps/Contacts/src/com/android/contacts/activities/PeopleActivity.java:1093-1102

- Activity showing contact list starts activity to edit a contact

```
public void onEditContactAction(Uri contactLookupUri) {
  Intent intent = new Intent(Intent.ACTION_EDIT, contactLookupUri);
  Bundle extras = getIntent().getExtras();
  if (extras != null) {
    intent.putExtras(extras);
  }
  intent.putExtra("finishActivityOnSaveCompleted", true);
  startActivityForResult(intent, SUBACTIVITY_EDIT_CONTACT);
}
```

Create new intent with action and data to start contact editor activity.

Add extra information to new intent.

Return when user saves contact info.

Launch new activity.

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Example of started activity

- Contacts app manifest file declares *ContactEditorActivity* to listen for *ACTION_EDIT* intents
- This activity will be launched in response to previous intent
- Activity uses intent extra to set result and return

```
public void onSaveFinished(Intent resultIntent) {
  if (mFinishActivityOnSaveCompleted) {
    setResult(resultIntent == null ? RESULT_CANCELED : RESULT_OK, resultIntent);
  } else if (resultIntent != null) {
    startActivity(resultIntent);
  }
  finish();
}
```

Called when user saves contact.

Field set based on intent's extra.

ContactEditorActivity sets result code.

ContactEditorActivity terminates by calling *Activity.finish()*

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Example of getting activity result

- *onActivityResult()* will first check type of request triggering this result, then check result code, finally take appropriate action
- PeopleActivity.java:1565-1587 (JB V4.1.1)

```
protected void onActivityResult(int requestCode, int resultCode, Intent data) {
 switch (requestCode) {
  case SUBACTIVITY_ACCOUNT_FILTER: {
    …
    break;
  }

  case SUBACTIVITY_NEW_CONTACT:
  case SUBACTIVITY_EDIT_CONTACT: {
    if (resultCode == RESULT_OK && … ) {
      …
    }
    break;
  }
```

First check request type.

Specify this method in parent activity.

Now check the result set by called activity.

Specify actions in response to returned code and data.

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Starting activities with intents

- Intent: A general-purpose message used for starting activities, notifying apps of some condition (e.g., low battery), starting a service, etc.
  - Goal: Allow component to signal *intention* to get something done
  - Target(s) could be an activity, a (set of) broadcast receivers or a service
  - Typically an argument to such methods as *startActivity(), broadcastIntent(),* or *startService()*
- Allow inter-app interactions
- Intent lifetime:
  - Created and sent by component (i.e., activity, service, broadcast receiver) that wants an operation done (e.g., starting an activity)
  - Received by interest parties (e.g., by activity to be started) via OS

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Two kinds of intents

1. **Explicit**

   Intent specifies exactly the component (package and class name) to be called (i.e., an activity, a receiver, or a service)

2. **Implicit**

   Intent just declares the kind of functionality expected of the target component, does not name component explicitly

   Examples of desired functionality when activity is target

   - Able to dial a phone number
   - Able to view a web page
   - Able to compose and edit an email message, etc.

- https://developer.android.com/training/basics/intents/index.html

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Intent class

- Intents are instances of framework class *Intent*
- Many fields used to pass different kinds of information from sender to receiver(s)
  - Action
  - Data
  - Category
  - Type
  - Component
  - Extras
  - Flags

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Implicit intents: *Action* and *data* fields

- Primary fields: Characterize implicit intents
- Action: String conveying operation to be performed
- Data: Operation data
- Many actions, e.g.,
  - ACTION_DIAL: Show phone number specified as data in phone dialer (part of built-in *Phone* app)
  - ACTION_CALL: Show dialer and call number specified as data
  - ACTION_VIEW: View some specified data (e.g., text file, web page...)
  - ACTION_DIAL, ACTION_VIEW, etc. are public, static, final *String* constants defined in *Intent* class

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Setting intent *action*

Two main ways to set an intent's action field

1. Directly when creating *Intent* instance (e.g., done by constructor)

```
Intent anIntent = new Intent(Intent.ACTION_MAIN) ;
```

2. Calling setter method after instance created, e.g.,

```
Intent anIntent = new Intent() ;
anIntent.setAction(Intent.ACTION_MAIN) ;
```

- Source code:

  frameworks/base/core/java/android/content/Intent.java

- Documentation:

  http://developer.android.com/reference/android/content/Intent.html

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Most popular *Action* fields

- Many action strings, public static final fields in *Intent*
  - ACTION_MAIN: Start main activity of an app – No data expected
  - ACTION_VIEW: View specified data – Data is *Uri* instance specifying what to view
  - ACTION_EDIT: Edit data specified as *Uri*
  - ACTION_DIAL: Show dialer with phone number specified as data
  - ACTION_CALL: Call phone number specified as data (restricted)
  - ACTION_SEND: Send a message or an email to someone else – Data specifies recipient (*Uri* type determines app)
  - ACTION_SYNC: Synchronize device with server
  - ACTION_PICK: Allow use to select an item – Data is directory of choices

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Intent *data*

- Expressed as Uniform Resource Identifier (URI), generalization of URL (Uniform Resource Locator) concept
- URIs have several formats, called *schemes*
- Each scheme has a tag ending in colon, and additional data
  - *http, https*—For browser data
  - *geo*—Address information (coordinates and/or address)
  - *tel*—Telephone number
  - *mailto*—Email information
  - *content*—For arbitrary content (e.g., a document file)
- Examples: "tel:(555) 555-1212" and "tel:+1-555-555-1212"

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Setting intent *data*

- Again, can use *Intent* constructor with action and data args, e.g.,

```
Intent i = new Intent(Intent.ACTION_DIAL, Uri.parse("tel:+15555551212") ;
```

  - Note: *Uri.parse()* is static *Uri* method returning new *Uri* instance
- Another way: Calling setter method after instance created, e.g.,

```
Intent anIntent = new Intent() ;
anIntent.setAction(Intent.ACTION_DIAL) ;
anIntent.setData(Uri.parse("tel:+15555551212")) ;
```

- Source code:

  frameworks/base/core/java/android/content/Intent.java
- Doc: http://developer.android.com/reference/android/content/Intent.html

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Action + *Data* combo

- Action and data are often enough to define intent target
- Assume ACTION_VIEW, then
  - *http, https* data schemes → open a browser activity
  - *geo* scheme → open a map view activity
  - *tel* scheme → open the phone dialer activity
  - *content* scheme → open a file viewer

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Intent category (cont'd)

- String giving more info about kind of activity that should handle an intent
  - Refine an intent's action
- Examples:
  - CATEGORY_LAUNCHER – Activity can be called from launcher (it appears in the launcher screen)
  - CATEGORY_BROWSABLE – Activity can be called by browser
  - CATEGORY_DEFAULT – Activity can be called by *startActivity()* even though the outstanding intent does not include a category
    - Use in intent filter (see later)
- Doc: http://developer.android.com/reference/android/content/Intent.html

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Intent category (cont'd)

- Additional category examples, asking for specific app (Combine with ACTION_MAIN):
  - CATEGORY_APP_BROWSER
  - CATEGORY_APP_CALCULATOR
  - CATEGORY_APP_CALENDAR
  - CATEGORY_APP_CONTACTS
  - CATEGORY_APP_EMAIL
  - CATEGORY_APP_GALLERY
  - CATEGORY_APP_MAPS
  - CATEGORY_APP_MARKET
  - CATEGORY_APP_MESSAGING
  - CATEGORY_APP_MUSIC
- Others CATEGORY_CAR_DOCK, CATEGORY_DESK_DOCK, etc.

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Intent MIME type

- Intent's *type* field specifies type of data in intent (a MIME type)
- Especially useful when *data* field not given
- Usually derived from intent's *data* field; specifying *type* field overrides type implicitly contained in *data* field
- Retrieved with *getType(): String*
- Set with *setType(String): Intent*
- Examples:
  - text/plain
  - text/html
  - image/jpg
  - etc.

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Explicit intents: Intent component

- Use for **explicit intents**
- Defines specific class defining target component for this intent
  - Class could belong, e.g., to an activity or service
- If set, all other intent fields are overruled
- Typically set with convenience constructor *Intent(Context, Class)*
  - Context (Global app where target class resides)
  - Actual class defining activity to be launched
- Set also from methods *setClass(Context, Class)* and *setComponent(ComponentName)*
- Example: `Intent i = new Intent(MainActivity.this, ChildActivity.class) ;`

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Intent extras

- Additional information contained in an intent
- Extras = *Bundle* instance
  - Map of (key, value) pairs, where keys must be strings
- Values can be primitive types, primitive arrays, or bundles
- Getter method *getExtras()* retrieves entire map
- Getter methods *getIntExtra(String), getIntArrayExtra(String)*, etc. retrieve value associated with arg *String* key
- Setter methods *putExtra(String, <value-type>)* places an extra in intent
- Example: Extra for adding email addresses directed to a compose message activity

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Example of useful type

- Source: https://developer.android.com/training/basics/intents/sending

Intent for sending email message with attachment.

```
Intent emailIntent = new Intent(Intent.ACTION_SEND);
// The intent does not have a URI, so declare the "text/plain" MIME type

emailIntent.setType(HTTP.PLAIN_TEXT_TYPE);
emailIntent.putExtra(Intent.EXTRA_EMAIL, new String[] {"jon@example.com"}); // recipients
emailIntent.putExtra(Intent.EXTRA_SUBJECT, "Email subject");
emailIntent.putExtra(Intent.EXTRA_TEXT, "Email message text");
emailIntent.putExtra(Intent.EXTRA_STREAM, Uri.parse(
                        "content://path/to/email/attachment"));
```

Recipient is an extra

Text +subject extras.

Specify attachment as an extra.

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Intent flags

- Metadata specifying how an intent is to be handled by OS
- Example: FLAG_ACTIVITY_NO_HISTORY, if set, will not put the child activity in the backstack
- Doc: http://developer.android.com/reference/android/content/Intent.html - setFlags(int)

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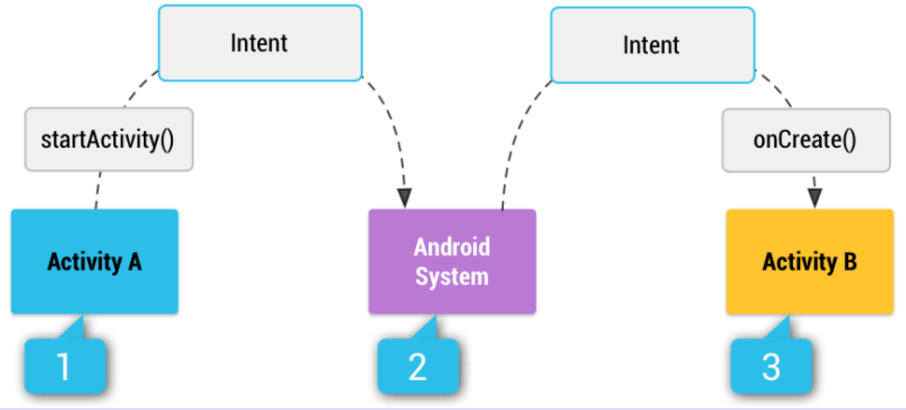
Defining intents that start an activity

- Recall *startActivity()* or *startActivityForResult()*
  - Both require intent specifying activity to be launched



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Intent resolution process

- *Intent resolution process* determines components that respond to intent
- Intent resolution works in two ways:
  1. **Explicit**

     Intent specifies component field → Explicit call to specified activity or service or broadcast receiver
  2. **Implicit**

     Intent does not specify component → Android's intent resolution process decides what activity to launch based on intent's action, data, category and type

Doc: https://developer.android.com/guide/components/intents-filters.html

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Explicitly calling an activity

- Calling activity creates intent that stores a *Context* object and a *Class* object
  - *Context* object specifies global application shared among application components
  - *Class* object specifies class to be instantiated for new activity
- Example from *SimpleCounter4*, starting tip calculator activity

```
private void switchToStateList() {
  Intent i = new Intent(SimpleCounterActivity2.this, StateListActivity.class) ;
  startActivity(i) ;
```

- Caveat: Explicit intents are much more secure than implicit intents, but implicit intents support platform extensibility

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Implicitly calling an activity

- Android looks for an activity matching that operation
- Intent *resolution*: Procedure for finding activity matching an intent
  - Activities interested in answering some intent must declare *filters* specifying intent actions
  - Activities can declare intent filters *statically* in manifest file or *programmatically* through Java statements (using class *IntentFilter)*
- OS resolves implicit intent based on 3 intent fields
  1. Action – Answering component must include this action
  2. Data – Uri data used to deduce type if intent does not have type field
  3. Categories – Answering component must include all categories in intent

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Intent filters

- *Intent filters*: Specify what intents a component should respond to
  - Components: activities, broadcast receivers and services
- Rules for matching
  - Action matches if *any* of the values in filter matches intent action
  - Data type matches if *any* of the values matches intent data
  - Data scheme matches if *any* of the values match intent's data scheme
  - Categories match if all categories in intent are contained in filter (filter may contain additional not mentioned in intent)
  - Etc.
- http://developer.android.com/reference/android/content/IntentFilter.html
- https://developer.android.com/guide/components/intents-filters.html

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Example of intent filter

- *Phone* app declares two intent filters for emergency dialing activity
- Source: jellybean/packages/apps/Phone/AndroidManifest.xml:103—116

```
<activity android:name="EmergencyDialer"
        android:label="@string/emergencyDialerIconLabel"
        android:theme="@style/EmergencyDialerTheme"
        android:screenOrientation="nosensor">
        <intent-filter>
          <action android:name="com.android.phone.EmergencyDialer.DIAL" />
          <category android:name="android.intent.category.DEFAULT" />
        </intent-filter>
        <intent-filter>
          <action android:name="com.android.phone.EmergencyDialer.DIAL" />
          <category android:name="android.intent.category.DEFAULT" />
          <data android:scheme="tel" />
        </intent-filter>
    </activity>
```

Activity tag declares activity.

First intent filter declares *DIAL* action, *DEFAULT* category.

Second intent filter declares also URI with scheme *tel.*

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Example of implicitly starting an activity

- Phone app declares activity for emergency dialing, with two intent filters
- Source: jellybean/packages/apps/Settings/src/com/android/settings/CryptKeeper.java

```
private void launchEmergencyDialer() {
    final Intent intent = new Intent(ACTION_EMERGENCY_DIAL);
    intent.setFlags(Intent.FLAG_ACTIVITY_NEW_TASK
            | Intent.FLAG_ACTIVITY_EXCLUDE_FROM_RECENTS);
    startActivity(intent);
}
```

Create intent with emergency dial action.

Start new task in history stack.

Now start activity.

Exclude activity from list of recently-started activities.

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Android tasks

- Task = Collection of related activities that support a user's workflow:
  - Activities may belong to different apps
  - Example:

    Launcher → Email activity showing message list

    → Activity showing selected message

    → Compose message activity to reply to message
- Each task is stored in its own backstack
- Task started in launcher (when user selects app) or by activity
- Task can be resumed from home screen when user selects again app that started the task, or through the "recents" menu
- https://developer.android.com/guide/components/tasks-and-back-stack.html

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Activity *singleTop* start mode

- Activity can specify a launch mode, e.g.,,

```
<activity …
    …
  launchMode=[“standard” | “singleTop” | “singleTask” | “singleInstance” ]
  … />
```

- Default is *standard; singleTop* means reuse the same instance if that instance is at top of current backstack task (both launched with *startActivity()*)
- Modes *singleTask* and *singleInstance* always begin a new task
  - *singleInstance* excludes other activity instances from task; using *startActivity()* will begin new task

http://developer.android.com/guide/topics/manifest/activity-element.html

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Android display objects

- Classes defining icons (aka UI elements, widgets…) that populate activities
- Subclasses of special *View* class
- Each instance associated with **rectangular** portion of display
- Main responsibilities of *View* and its subclasses:
  - Drawing themselves
  - Knowing their position in the window displaying them
  - Intercepting + responding to user interactions (e.g, button press)
  - Adding/accessing/removing subviews (for container views)
- Source: jellybean/frameworks/base/core/java/android/view/View.java
- Doc: http://developer.android.com/reference/android/view/View.html

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The *View* class hierarchy

- *View* is a subclass of Java *Object*
- Subclasses include
  - *TextView*
  - *ImageView*
  - *KeyboardView*
  - *ViewGroup* (a set of views—see *Composite* pattern)
- *ViewGroup* subclasses include most layouts (e.g., *LinearLayout*, *RelativeLayout, DrawerLayout*, etc.) as well as compound views such as lists, galleries, drop-down menus (aka spinners), etc.
- Straightforward implementation of *Composite* design pattern…

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Composite pattern

- Motivation:

  Support *recursive composition* in such a way that a client need not know the difference between a single and a composite object (as with *Views*)
- APIs of all display objects is declared in abstract superclass – All concrete subclasses must support that functionality
- Applicability:

  Dealing with hierarchically-organized objects (e.g., columns containing rows containing words …)
- Structure

  See class diagram next

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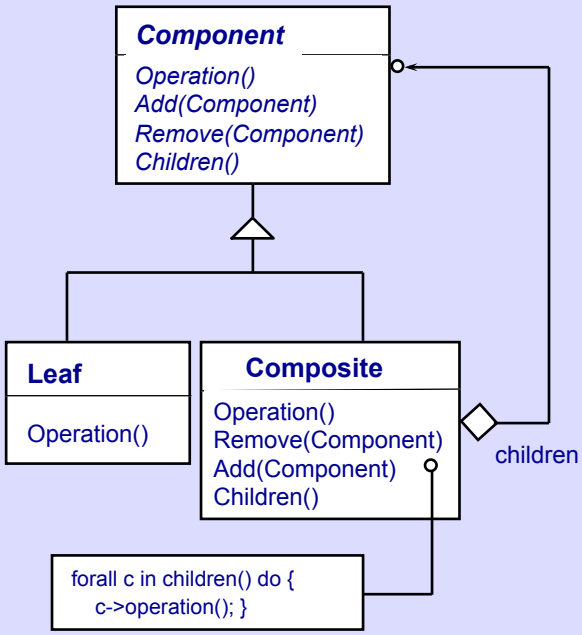
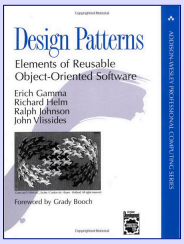


Class diagram of *Composite*

Source:
E. Gamma, Helm, Johnson, and Vlissides. *Design Patterns: Elements of Reusable Object-Oriented Design*



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Composite pattern: *Component* responsibilities

Minimally, a *Component* instance should support these APIs:

1. Know how to draw itself
2. Know and be able to change its position and size
3. If *Component* is a *Composite*, manage its children
4. If interactive component, respond to user interactions

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Composite pattern

Consequences:

1. Define class hierarchies consisting of simple and composite objects
2. Simplify clients
3. Extensibility (clients need not be modified if new components added)
4. Too general a pattern?

   (makes it difficult to to restrict functionality of concrete leaf subclasses)
5. Implementation issue: Where do you define *children* field?
   - In *Component* superclass: Leaf subclasses don't use this field
   - In *Composite* subclass: Loss of uniformity (e.g., concerning child maintenance API)

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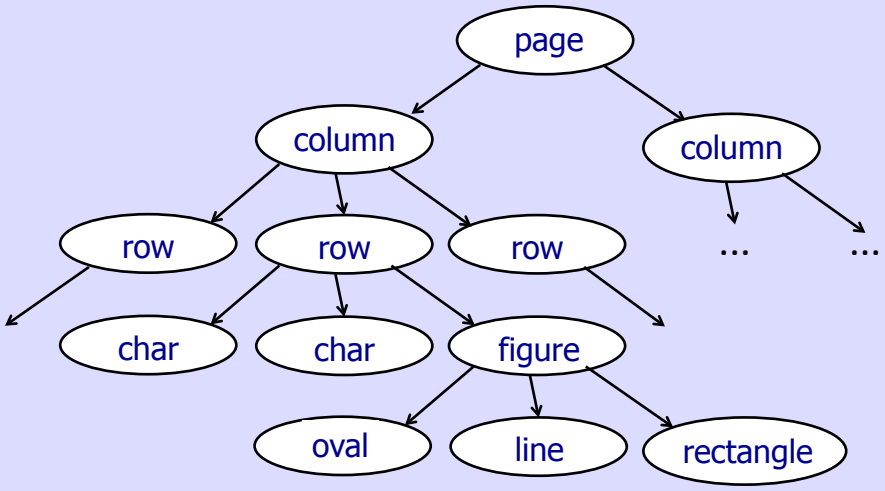
Composite pattern: An example object diagram



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The *Composite* pattern and Android views

- How Android views implement *Composite*
  - *View* class matches *Component*
  - *ViewGroup* class matches *Composite*
  - Many leaf classes, e.g., *TextView* and its subclasses including *Button*
- *ViewGroup* has lots of direct and indirect subclasses
  - E.g., *AdapterView<T>, LinearLayout, RelativeLayout, FrameLayout, Gallery, Toolbar, SlidingDrawer, TvView, ViewPager, Spinner,* etc.

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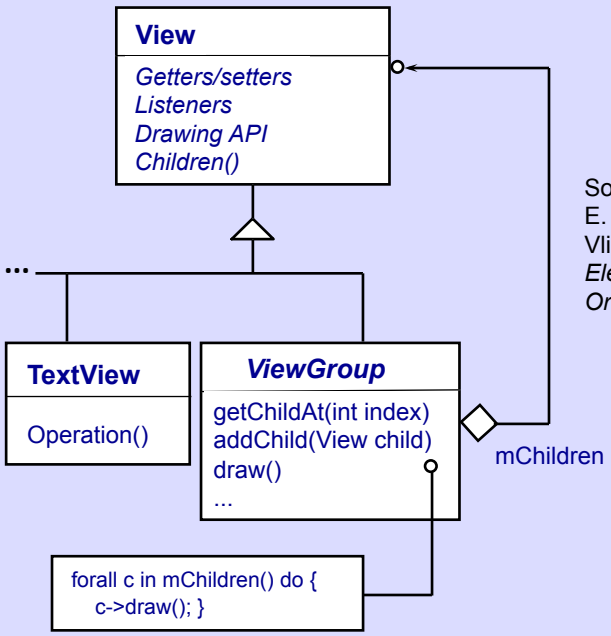
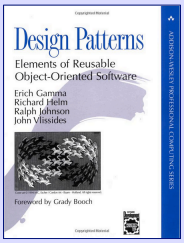


Android's take on *Composite*

Source:
E. Gamma, Helm, Johnson, and Vlissides. *Design Patterns: Elements of Reusable Object-Oriented Design*



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View's APIs

- Position API – Position determined by four factors: (1) Distance from top of parent, (2) Distance from left margin of parent, (3) height, and (4) width
- All measures in pixels (px)
- Getter methods (all no-arg + final + returning integer)
  - *getTop()*
  - *getLeft()*
  - *getHeight()*
  - *getWidth()*
- Setter methods
  - *setLeft(int)*
  - *setTop(int)*

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View's APIs (cont'd)

- Event handling APIs – Determine how *View* instances respond to user events
- Android's approach: Use Java interfaces nested in *View* class
- Each Java interface declares different abstract methods, e.g.,
  - *View.OnClickListener* → *onClick(View)*
  - *View.OnLongClickListener* → *onLongClick(View)*
  - *View.OnFocusChangeListener* → *onFocusChange(View, boolean)*
  - *View.OnKeyListener* → *onKey(View, int, KeyEvent)*
  - *View.OnLayoutChangeListener* → *onLayoutChange(View, …)*
  - *View.OnScrollChangeListener* → *onScrollChange(View, ...)*
- Handle events by creating appropriate instance of nested interface and associating instance with *View object*

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Example of listener definition

- From *SimpleCounter2* app, activity *SimpleCounterActivity2*

```
public View.OnClickListener upListener = new View.OnClickListener() {

    // Called when up button is selected
    @Override
    public void onClick(View v) {
        incrementCount() ;
    }
} ;
…
public void onCreate(Bundle savedInstanceState) {

  super.onCreate(savedInstanceState);
  …
  up = (Button) findViewById(R.id.upButton);
  up.setOnClickListener(upListener) ;
```

upListener = instance of anonymous class implementing Java interface *View.OnClickListener.*

Anonymous class must implement abstract method *onClick().*

onCreate() associates *upListener* with *Button* view.

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Comments on code

- Java interface names are legitimate type identifiers
  - Class implementing the interface can be *anonymous*
  - How defined? Give implementation (code) of abstract methods on-the-fly when declaring instance
    - Anonymous class is created automatically, along with an instance of the class
  - See earlier example
- Very convenient feature enhancing advantages of polymorphism in Java
- https://developer.android.com/reference/android/view/View
- https://developer.android.com/reference/android/view/ViewGroup

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View's APIs: Drawing views

- Three stage process
  1. Figure out dimensions (width and height) of view object
  2. Position view in container
  3. Actually draw view
- APIs
  - *onMeasure()*
  - *onLayout()*
  - *onDraw()*
- Predefined *View* subclasses have methods above; programmer must define the methods for new views

  See https://developer.android.com/guide/topics/ui/index.html

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View's additional APIs

- General properties of *View* instances have getter and setter methods
  - Visibility – *getVisibility(), setVisibility()*
  - Selected state – *isSelected(), setSelected()*
  - Clickable – *isClickable(), setClickable()*
  - Focus – *hasFocus(), requestFocus()*
  - … and many, many more

  See http://developer.android.com/reference/android/view/View.html

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Examples of popular Android views

- Button
- SeekBar
- TextView
- CheckBox
- ListView
- WebView
- etc.

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Android text views

- Root of hierarchy is class *TextView*
  - Main responsibility: Display text for user's benefit
  - Default behavior is no edit; either change default (declare attribute *android:editable="true"*) or use subclass *EditText* for editable text view
- Rich API allows user to define various fonts, color, sizes, backgrounds for the text box
- Key methods:
  - *getText()*—Returns a *CharSequence*
  - *setText()*—Overloaded, typically use with *CharSequence* arg
  - And all methods inherited from *View...*
- Doc: http://developer.android.com/reference/android/widget/TextView.html

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Declaring a *TextView* in layout xml file

- Caveat: No need to edit xml directly, can use GUI builder in SDK to set properties

```
<LinearLayout xmlns:android=http://schemas.android.com/apk/res/android
    android:orientation="vertical"
    ...

    <TextView    android:id="@+id/text"
                 android:layout_width="wrap_content"
                 android:layout_height="wrap_content"
                 android:text="This is a text view!" />

    ...
</LinearLayout>
```

Arrange views vertically in linear layout.

id attribute allows Java to find this *View*.

Declare TextView and its attributes.

Done with linear layout tag.

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Specifying an icon's width and height

- Can give exact size in density-independent pixel units (e.g., *7dp*) or use special keywords
  - *wrap_content*—size view to dimensions required by content
  - *match_parent*—as big as parent view (which directly contains this view)
- Doc: http://developer.android.com/guide/topics/ui/declaring-layout.html

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Class *TextView*'s hierarchy

- Key direct subclasses
  - *EditText* – Similar to *TextView* but editable by default
  - *TextClock* – An animated view to display time
  - *Chronometer* – A timer class counting up by default (API: *start(), stop()*)
  - *Button* – Root of button hierarchy
- Doc: http://developer.android.com/reference/android/widget/TextView.html

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Class *TextView*'s hierarchy (cont'd)

- Key indirect subclasses
  - *AutoCompleteTextView* – An *EditText* that shows completion suggestions automatically
  - *AppCompatTextView* – *EditText* with backward compatibility to older versions of Android
  - *CompoundButton* – Abstract *Button* subclass with "unchecked" and "checked" states (implements *Checkable* interface and *toggle()* method)
  - *CheckBox* – Concrete *CompoundButton* subclass showing check mark
  - *ToggleButton* – Concrete *CompoundButton* subclass with light indicator
  - *Switch* – Concrete *CompoundButton* subclass sliding right and left
  - Many "app compatibility" versions of *TextView* subclasses

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Android buttons

- Text and/or icon reacting to a "press" events
- Three kinds of buttons: (1) text, (2) icon, (3) text + icon
- Create text button with <*Button*> tag – Specify text with *android:text* attribute, a *String* (e.g., *android:text* = *@string/string_name*)
- Create icon button with <*ImageButton*> tag – Specifiy icon with *android:src* attribute, a picture file (e.g., *android:src* = *@drawable/icon_file_name*)
- Create text + image button with <*Button*> tag – Specify text with *android:text* attribute and image with *android:drawableLeft* attribute (e.g., *android:drawableLeft* = *@drawable/drawable_file_name*)
- Doc: http://developer.android.com/guide/topics/ui/controls/button.html

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Android buttons

- Must be associated with a listener to respond to clicks
  - Done programmatically or through GUI editor
  - Button listeners are instances of (classes implementing) *static* Java interface *View.OnClickListener* nested in *View* class
  - Respond to long clicks by instantiating *View.OnLongClickListener*
- *Listener*: A special kind of class that lets you specify actions in response to a user interaction with a view
- Doc: http://developer.android.com/reference/android/view/View.OnClickListener.html

  http://developer.android.com/reference/android/widget/Button.html

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Setting button's short click listener

- **Programmatically**: Implement Java interface *View.OnClickListener* and create an instance of the resulting concrete class
  - Resulting class can be anonymous—Used only for that instance
  - Implementation must define just one method—*onClick()*
- Use *Button* setter method *setOnClickListener()* to set listener
- **Statically**: Set listener in layout file (avoid pain of anonymous class…)
  - In this case, specify attribute *android:onClick* in corresponding XML layout file with name of method that will be called, e.g.,

```
<Button …
    android:onClick="someMethodName"
    …/>
```

- Doc: http://developer.android.com/reference/android/view/View.OnClickListener.html

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SimpleCounter4 button example

- Define listener (anywhere in *SimpleCounterActivity4* class)

Note *upListener*'s data type is an interface, not a class.

```
// Listener for the up button
 public View.OnClickListener upListener = new View.OnClickListener() {

   // Called when up button is selected
        @Override
        public void onClick(View v) {
             incrementCount() ;
        }
   } ;
```

Anonymous class must implement abstract method *onClick()* declared by Java interface *OnClickListener*.

Listener for up button just increments current count.

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Declaring a button

- Done in appropriate location in */res/layout/layout-file.xml* file
- Use <Button> tag for button displaying text or text and an image
- This can be done interactively by dragging button from palette in IDE
- Main attributes: id (code identifier), *layout_width, layout_height, text* (the text displayed in the button), e.g.

```
<Button
     android:id="@+id/upButton"
     android:layout_width="wrap_content"
     android:layout_height="wrap_content"
     android:text="@string/upString"
/>
```

- Doc: http://developer.android.com/guide/topics/ui/controls/button.html

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Adding a picture to a button

- Use one of attributes *drawableRight, drawableLeft, drawableTop*, and *drawableBottom* with appropriate drawable value in <Button> tag

```
<Button
    android:id="@+id/upButton"
    android:layout_width="wrap_content"
    android:layout_height="wrap_content"
    android:text="@string/upString"
    android:drawableLeft="@drawable/my_pic"
    android:drawablePadding="4dp"
/>
```

- Can also change button's background by specifying a given color or xml file containing <*selector*> tag (for default, focused and pressed state of the button)

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Image buttons

- Use <ImageButton> tag for button displaying just an image
- Include file from which button will be retrieved with attribute *android:src*, e.g.,

```
<ImageButton
    android:id="@+id/upButton"
    android:layout_width="wrap_content"
    android:layout_height="wrap_content"
    android:src="@drawable/upArrow"
/>
```

- Doc: http://developer.android.com/guide/topics/ui/controls/button.html

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CheckBox

- Class *CheckBox* defines a check box view
- Subclass of *Button* by way of *CompoundButton*
- Define a two-state button: checked and unchecked, with some text to go with it
- Again, define checkbox in layout file and let instance be created when layout is inflated, e.g.,

```
<CheckBox xmlns:android="http:// … "
      android:id=@+id/aCheckBox
      android:layout_width="wrap_content"
      android:layout_height="wrap_content"
      android:text=@string/anInitialString
/>
```

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Interacting with check boxes

- Abstract superclass *CompoundButton* defines **nested static interface** *CompoundButton.OnCheckedChangeListener* and concrete method *setOnCheckedChangedListener()*
- *OnCheckedChangeListener* declares just one abstract method, *onCheckedChanged(CompoundButton, boolean)*
  - Method called when state of button has changed, passed the button in question and the new state of the button
- Additional relevant methods
  - *isChecked() : boolean*
  - *setChecked(Boolean) : void*
  - *toggle() : void*
- http://developer.android.com/reference/android/widget/CompoundButton.html

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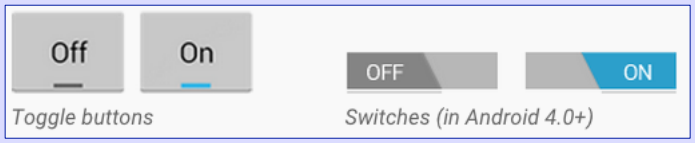
CheckBox variations

- Classes *ToggleButton* and *Switch* also define two-state buttons
- Both are subclasses of *CompoundButton*
- See http://developer.android.com/guide/topics/ui/controls/togglebutton.html



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ToggleButton class

- Automatically displays text On/Off and fills area at bottom
- Toggle button responds to *onClick* event
  - Define attribute *android:onClick* in *ToggleButton* tag in layout
  - Callback method will take a *View* (the icon that was clicked), must be *public* and return *void*
- Toggle button can also use *OnCheckedChangedListener* in way similar to *CheckButton*

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Class *ViewGroup*

- Ways to organize sets of icons
- Abstract subclass of *View*
- Main direct subclasses
  - Most layouts: *LinearLayout, RelativeLayout, ConstraintLayout, FrameLayout* (with subclass *ScrollView*), *GridLayout, DrawerLayout*
  - *AdapterView<T>*
  - *SlidingDrawer*
- Main indirect subclasses
  - *CalendarView, GridView, ListView, Spinner, TableLayout, TableRow, WebView, RadioGroup, TimePicker, DatePicker,* etc.
- https://developer.android.com/reference/android/view/ViewGroup.html

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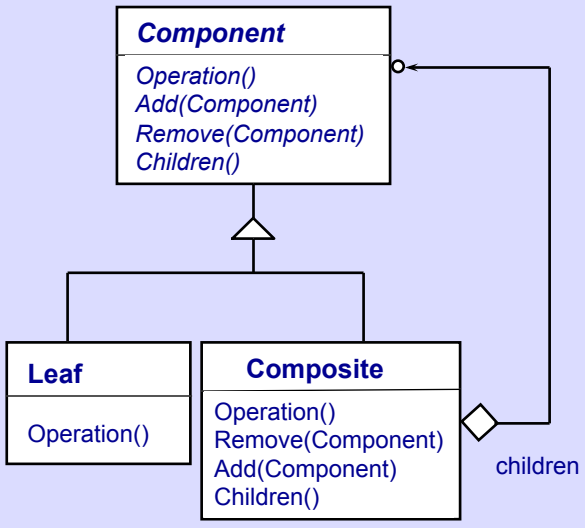
Recall *Composite* pattern…



83

ViewGroup in the *Composite* pattern

- Class *ViewGroup* plays the role of the *Composite* in the pattern
- See frameworks/base/core/java/android/view/ViewGroup.java:82,377—378

ViewGroup inherits from *View* just as *Composite* inherits from *Component*.

```
…
public abstract class ViewGroup extends View
                    implements ViewParent, ViewManager {
  …
 // Child views of this ViewGroup
  private View[] mChildren;  }
```

ViewGroup also inherites from interfaces *ViewParent* and *ViewManager*.

ViewGroup instances can contain multiple *View* instances.

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ViewGroup's child maintenance API

- *addView(View* child) : **void**
- *addView(View* child*, int* index) : **void**
- *addView(View* child*, int* index, *ViewGroup.LayoutParams* params) : **void**
- *getChildAt(int* index) : *View*
- *getChildCount()* : **int**
- *indexOfChild(View* view*)* : **int**
- *removeView(View* view*)* : **void**
- *removeAllViews()* : **void**

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Layouts

- Ways to organize sets of icons
- Many alternatives predefined in latest versions of Android
  - ➢ Use for this class
- Source code: Different layout classes are subclasses of *ViewGroup*, a subclass of *View*
- Parent-child relationship between a layout object and the views it contains

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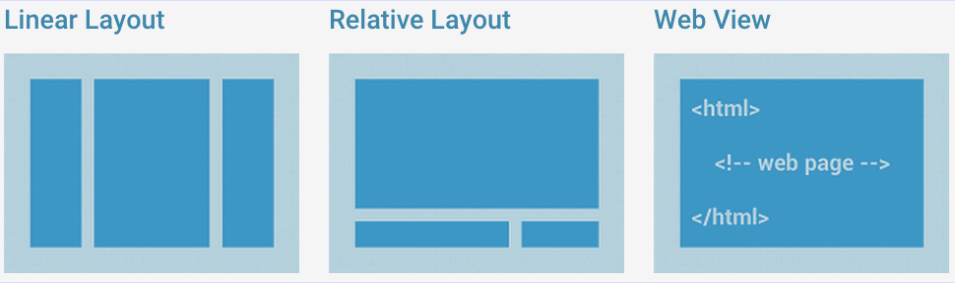
Different Layouts

- Linear layout: Items arranged in a row (horizontally or vertically)
- Relative layout: Items arranged relative to each other
- Web view: Use for web pages (may also defer to browser app)
- Source: http://developer.android.com/guide/topics/ui/declaring-layout.html



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Linear layouts

- Class *LinearLayout,* a subclass of *ViewGroup*
- Typically defined interactively using GUI builder, saved in layout.xml file (find it in "Layouts" section of palette)
  - Delimited by tags <*LinearLayout*> … </*LinearLayout*>
- Arrange items horizontally or vertically
  - Specified in *android:orientation* attribute
  - Values are "horizontal" and "vertical"
  - Can be changed programmatically with *setOrientation()*, using static fields *HORIZONTAL* and *VERTICAL*
- http://developer.android.com/reference/android/widget/LinearLayout.html

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Layout weights

- Amount to allocate to a given layout child relative to the other children
- Sometimes described as a percentage— if total weights add up to 100
  - If not, Android still computes the relative proportion of each element with respect to the total
- In this case, specify *android:height="0dp"* and *android:weight="xx"* attributes for child contained in vertical linear layout
  - Use *android:width* attribute for horizontal layout
- Can mix and match weight, *wrap_content*, and *dp* specs
  - Weights use spaces remaining after other specs accounted for
- https://developer.android.com/guide/topics/ui/layout/linear.html

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Gravity

- *Gravity*—Define position where each child will be placed in container
- Default case (no gravity specified): Top and left aligned
- Used both to define gravity of child within layout and contents of a view (e.g., the text within a text view)
- Set statically with *android:gravity* attribute in layout file or programmatically (dynamically) using *setGravity()* method, e.g.,
  - *android:gravity="bottom"* (start from bottom of linear layout)
  - *android:gravity="right|bottom"* (start from bottom right),
  - *android:gravity="center_horizontal|center_vertical"*, etc.
- Doc: http://developer.android.com/reference/android/view/Gravity.html https://developer.android.com/guide/topics/ui/layout/linear.html

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Relative layouts

- "A Layout where the positions of the children can be described in relation to each other or to the parent" [http://developer.android.com/reference/android/widget/RelativeLayout.html]
- Class *RelativeLayout*, a subclass of *ViewGroup*
- Efficient alternative to nesting *LinearLayout* views
- Positions views in relative layout are specified using boolean attributes (see next)

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Positions relative to parent

- Popular attributes (set to *"true"* or *"false"*):
  - android:layout_alignParentTop—Align with top of container
  - android:layout_alignParentBottom—Align with bottom of container
  - android:layout_alignParentLeft—Align with left side of container
  - android:layout_alignParentRight—Align with right side of container
  - android:layout_centerHorizontal—Center in container (hor.)
  - android:layout_centerVertical—Center in container (vert.)
  - android:layout_fillHorizontal—Fill container's width
  - android:layout_fillVertical—Fill container's height

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Positions relative to siblings

- Popular attributes (use view (id) reference as value):
  - android:layout_above—Place above referenced icon
  - android:layout_below—Place below referenced icon
  - android:layout_toLeftOf—Align with left side of icon
  - android:layout_toRightOf—Align with right side of icon
  - android:layout_alignTop—Align with top of referenced icon
  - android:layout_alignBottom—Align with bottom of referenced icon
  - android:layout_alignLeft—Align left sides
  - android:layout_alignRight—Align right sides
- Example: *android:layout_alignBottom="@+id/name_of_other_view"*

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Other useful layouts

- *TableLayout*—Use extends beyond tables; ability to use cell coordinates for item placement
- *ScrollView*—XML Wrapper that provides vertical scroll bar for views that are too tall to fit on screen
  - Do not use with *TextView* or *ListView*; these views already contain scrollbars
- *HorizontalScrollView*—Similar to *ScrollView* but provides horizontal scroll bar if needed
- *ConstraintLayout*—Similar to relative layout but gives system greater flexibility in arranging UI elements within layout
  - Similar to iOS approach to layout configurations
  - https://developer.android.com/training/constraint-layout/

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Constraint layouts

- "Flat" structure of display views, similar to relative layouts
- Goal: Capture typical designs produced with IDE's Layout Editor
- View positioning determined by constraints
  - Specify at least one horizontal and one vertical constraint per view
  - Constraints specify "connections" to other views, parent view or invisible guidelines
  - Use "handles" on each side of the view to define constraints relative to other views or parent container

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Constraint kinds

- Examples of constraints
  - Relative positioning
  - Margins
  - Center positioning
  - Etc.
- https://developer.android.com/reference/android/support/constraint/ConstraintLayout

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Class *AdapterView*

- View group whose children are determined by an *Adapter*
- Examples of adapter views: Lists, grids, galleries
- Adapter's main responsibilities:
  1. Store data to be displayed in view group
  2. Creating a view for each item in view group, using special layout file
- *AdapterView*'s main responsibility is to display data provided by adapter

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Class *AdapterView*

- Source code: *AdapterView* is an abstract template subclass of *ViewGroup*
  - frameworks/base/core/java/android/widget/AdapterView.java:49

    public abstract class AdapterView<T extends Adapter> extends ViewGroup
- Popular subclasses: *Spinner* (dropdown menu), *ListView, GridView,* and *Gallery*
- "Adapter" is a popular pattern from the Gang-of-Four system (see next…)

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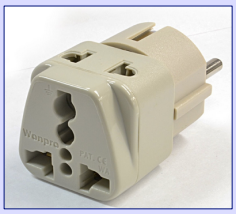
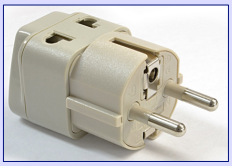
Adapter pattern

- Goal: manage incompatible interfaces between classes
- Say that client expects certain APIs of a given class *C*…
- … but that class *C* offers different methods in its API
- Adapter pattern creates a new class whose job is to fit the client's calls into the methods exposed by class *C*
  - This is similar to the adapter you use in electrical outlets when you travel abroad





Pictures of Schuko adapter from www.amazon.com.

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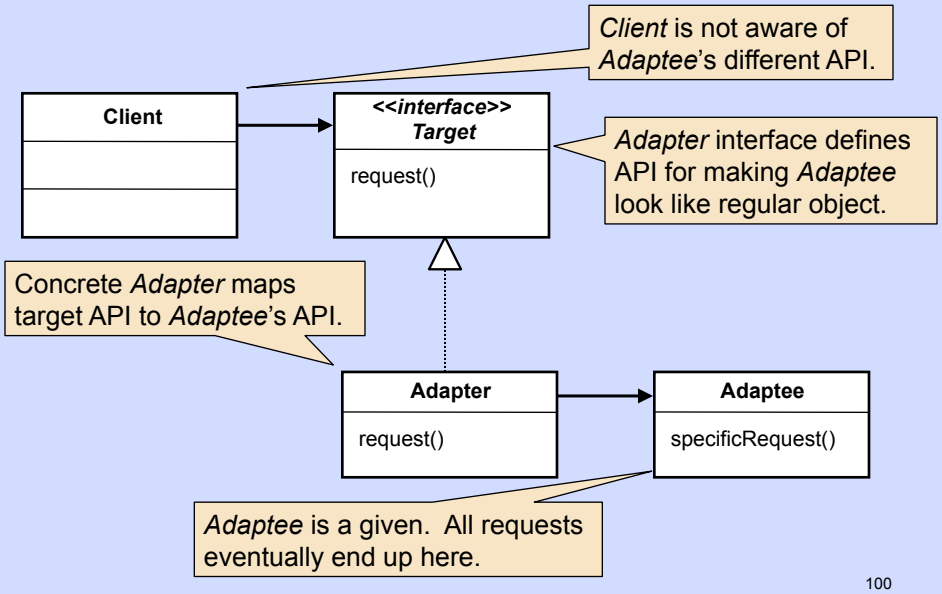
Class diagram of *Adapter*



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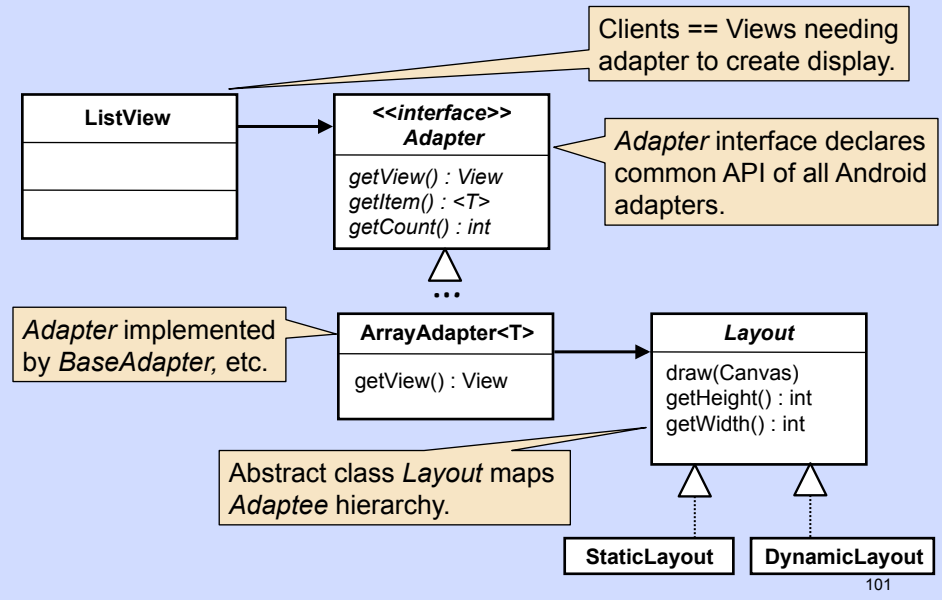
Android's implementation of *Adapter* pattern



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Creating instance of built-in adapter

- First, define layout file of each item to be shown in container
- Next, create appropriate adapter to fit each item's information into the item's format defined in a layout file in activity with *AdapterView*
- Typical actions (variations possible):
  1. Declare an adapter field, *mAdapter* in activity class
  2. In activity's *onCreate()* method instantiate *Adapter* subclass, e.g., *ArrayAdapter,* bind instance to *mAdapter*
  3. Attach adapter to view requiring it (e.g., a *ListView*), e.g., by calling *setListAdapter()*
- Key adapter method: *getView()*

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Recall adapter's two main responsibilities...

- Adapter's main responsibilities:
  1. Store data to be displayed in view group
  2. Creating a view for each item in view group, using special layout file
- *AdapterView*'s main responsibility is to display data provided by adapter

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ArrayAdapter

- Perhaps the simplest built-in adapter, convert array elements to strings (using Java's *toString()* method)
- *ArrayAdapter* converts list elements in an array to strings
- Commonly used *ArrayAdapter* constructor takes 3 args:
  1. Context (e.g., *Activity* instance)
  2. Layout resource used to inflate each list item
  3. Array of items (possibly coming from the *Strings.xml* resource)
- Normally, adapter instance holds list of items to be displayed (either as a list of resource references, or the actual items)
- http://developer.android.com/reference/android/widget/ArrayAdapter.html

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Creating a *ListView*

- Key points:
  1. Define a list widget
     - Either include a *ListView* in some layout (e.g., *LinearLayout*), or
     - Define activity as *ListActivity* subclass, no need for layout file in this case (but could still be included)
       - *ListActivity* = *Activity* subclass that hosts a *ListView* by default
       - Use *getListView()* to find *ListView* object in this case
  2. Create adapter (e.g., an *ArrayAdapter*), attach to list by calling *setListAdapter(mAdapter)*
- http://developer.android.com/reference/android/app/ListActivity.html
  http://developer.android.com/reference/android/widget/ListView.html

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Listening to list item selections

- Class *AdapterView* declares static interface *OnListItemClickListener*
- *OnListItemClickListener* declares **public void** method *onItemClick()*
  - Method signature:
    1. *AdapterView<?> parent*—Adapter view containing item clicked
    2. *View view*—Selected item
    3. *int position*—Position of item in list (starting from 0)
    4. *long id*—Resource identifier of the selected item
- Doc: http://developer.android.com/reference/android/widget/AdapterView.OnItemClickListener.html

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Java interface *AdapterView.OnItemClickListener*

1. Implement interface (perhaps using anonymous class) by defining method *onItemClick()*
2. Create class instance
3. Set listener in *ListView* instance by calling *setOnItemClickListener()*

Create new instance of interface *OnItemClickListener.*

```
listView.setOnItemClickListener(new AdapterView.OnItemClickListener() {

    public void onItemClick(AdapterView<?> parent,
                            View view, int position, long id) {

      // specify actions in response to click
    }
  }) ;
```

Must implement abstract method *onItemClick().*

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Listening to list item selections in *ListActivity*

- Class *ListActivity* defines method *onListItemClick()*
  - Parameters (similar to *onItemClick()* above):
    1. *ListView* parent—List view containing item selected
    2. *View* view—Selected item
    3. *int* position—Position of item in list (starting from 0)
    4. *long* id—Id of the selected item
- This method is an alternative to defining a listener for the *ListView*
  - No more need to call *setOnItemClickListener()* on *ListView* object
- Doc: http://developer.android.com/reference/android/app/ListActivity.html

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Creating your own adapters

- Sometimes predefined adapters don't work well for your list items
  - Grid view example: Arrange pictures in rows and columns
  - Adapter must "squeeze" a set of image files into grid tiles
- Defining your adapter, e.g., *MyAdapter*
  1. Define *MyAdapter* to extend abstract superclass *BaseAdapter*
  2. Define following methods (at least):
     - *getView()*: Creates (or Recycles) and fills view for a given grid item
     - *getItemId()*: Return the resource reference for item at position
     - *getCount()*: Returns the number of items managed by adapter
- Doc: https://developer.android.com/guide/topics/ui/binding
  https://developer.android.com/reference/android/widget/Adapter

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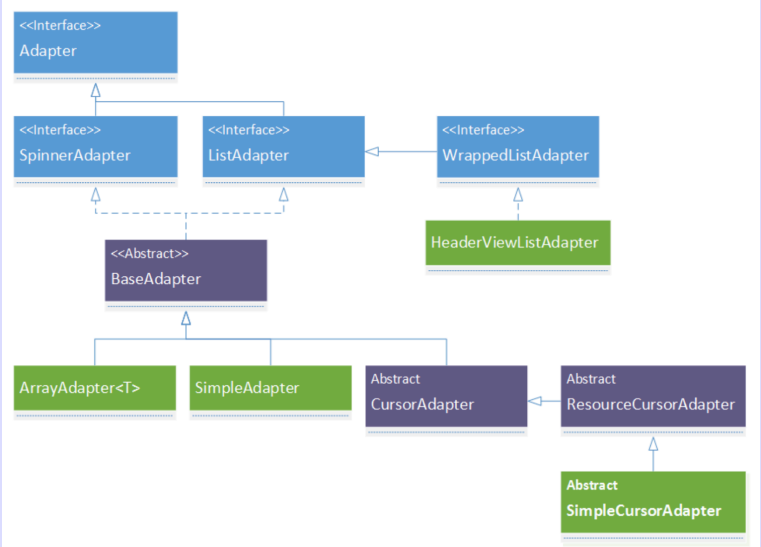
Predefined adapter hierarchy

https://www.intertech.com/Blog/wp-content/uploads/2014/06/HeirarchyOfAdapter.png



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Creating your own adapters: Details

- Pictures specified as resources
  - Place in a *drawable* folder
  - Customizable for pixel density of hosting device (e.g., *drawable-hdpi, drawable-xhdpi, drawable-xxhdpi*, etc.)
  - Default: *drawable-nodpi*
- *OnCreate()* method: Place resources in *ArrayList<Integer>*,
  - Pass list to adapter instance which will save list in appropriate field
  - Attach adapter to *GridView* instance with *setAdapter()*
  - Define listener (similar to *ListView*)
- Doc: http://developer.android.com/reference/android/widget/GridLayout.html

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Fine points about image adapters

- Use *ImageView* widget class to display picture
  - Size of picture and *ImageView* widget may differ
  - Enumeration *ImageView.ScaleType* defines options for scaling picture in *ImageView* to size of *ImageView*
  - Popular values (many more available):
    - CENTER (center picture w/o scaling)
    - CENTER_CROP (scale picture until height and width as large or larger than view while maintaining aspect ratio and center into view)
    - CENTER_INSIDE (scale until smaller than view maintaining aspect ratio and center into view)
- Doc: http://developer.android.com/reference/android/widget/ImageView.html

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Specifying *GridView* resource

```
<LinearLayout xmlns:android="http://schemas.android.com/apk/res/android"
   android:layout_width="match_parent"
   android:layout_height="match_parent"
   android:orientation="vertical" >

   <GridView
      android:id="@+id/gridview"
      android:layout_width="match_parent"
      android:layout_height="match_parent"
      android:columnWidth="80dp"
      android:gravity="center"
      android:horizontalSpacing="10dp"
      android:verticalSpacing="10dp"
      android:numColumns="auto_fit"
      android:stretchMode="columnWidth" />
</LinearLayout>
```

Use *GridView* tag.

The standard attributes.

Important: Specify column width for grid.

Space between view items.

Let grid determine number of columns.

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Main activity class

Usual declaration of an activity class.

Define images to be displayed.

```
public class GridLayoutActivity extends Activity {
  …
  private ArrayList<Integer> mThumbIdsFlowers = new ArrayList<Integer>(
      Arrays.asList(R.drawable.image1, R.drawable.image2, …));

  public void onCreate(Bundle savedInstanceState) {
    super.onCreate(savedInstanceState);
    setContentView(R.layout.main);
    GridView gridview = (GridView) findViewById(R.id.gridview);
    gridview.setAdapter(new ImageAdapter(this, mThumbIdsFlowers));
    gridview.setOnItemClickListener(new OnItemClickListener() {
      public void onItemClick(AdapterView<?> parent, View v, int position, long id) {
        Intent intent = new Intent(GridLayoutActivity.this,
            ImageViewActivity.class);
        intent.putExtra(EXTRA_RES_ID, (int) id);
        startActivity(intent);  }
    });
  } }
```

Usual *onCreate()* code.

Now instantiate special adapter.

Implement *OnItemClickListener* interface. *onItemClick()* starts new activity, passing image id.

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ImageAdapter class

Special adapter must inherit from *BaseAdapter.*

```
public class ImageAdapter extends BaseAdapter {
    private static final int PADDING = 8;
    private static final int WIDTH = 250;
    private static final int HEIGHT = 250;
    private Context mContext;
    private List<Integer> mThumbIds;

    // Store the list of image IDs
    public ImageAdapter(Context c, List<Integer> ids) {
        mContext = c;
        this.mThumbIds = ids;   }

    // Return the number of items in the Adapter
    public int getCount() {
        return mThumbIds.size();      }

    // Will get called to provide the ID that
    // is passed to OnItemClickListener.onItemClick()
    public long getItemId(int position) {
        return mThumbIds.get(position);  }
```

Constructor gets context and list of image identifiers.

Return resource identifier of i-th list item.

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ImageAdapter class (cont'd)

```
public class ImageAdapter extends BaseAdapter {
    …
    // Return an ImageView for each item referenced by the Adapter
    public View getView(int position, View convertView, ViewGroup parent) {

        ImageView imageView = (ImageView) convertView;

        // if convertView's not recycled, initialize some attributes
        if (imageView == null) {
            imageView = new ImageView(mContext);
            imageView.setLayoutParams(new GridView.LayoutParams(WIDTH, HEIGHT));
            imageView.setPadding(PADDING, PADDING, PADDING, PADDING);
            imageView.setScaleType(ImageView.ScaleType.CENTER_CROP);
        }
        imageView.setImageResource(mThumbIds.get(position));
        return imageView;
    }
}
```

Method *getView()* returns view to be displayed for grid item.

Create new *ImageView.*

Set view's params.

Crop image around center for thumbnail display.

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ImageViewActivity class

```
public class ImageViewActivity extends Activity {

  public void onCreate(Bundle savedInstanceState) {
    super.onCreate(savedInstanceState);

    // Get the Intent used to start this Activity
    Intent intent = getIntent();

    // Make a new ImageView
    ImageView imageView = new ImageView(getApplicationContext());

    // Get the ID of the image to display and set it as the image for this ImageView
    imageView.setImageResource(intent.getIntExtra(GridLayoutActivity.EXTRA_RES_ID, 0));

    setContentView(imageView);
  }
}
```

This activity is called when selected picture is displayed

Create new *ImageView.*

Set image for new *ImageView.*

setContentView() uses new *ImageView* to populate screen.

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Menus

- We consider three kinds of Android menus
  - Options menus

    Display global options for an entire activity

    User brings up by pressing "menu" soft key
  - Context menus

    Floating displays of choices pertaining to a specific view

    Usually brought up by "long click" on the view

    Example: Bring up list of options for a contact in the Contact's *PeopleActivity* listing a bunch of contacts
  - Submenus

    Menus appearing after an item was selected in previous menu
- Doc: http://developer.android.com/reference/android/view/Menu.html

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Defining menus in XML

- Use special *res* subfolder named *menu*
  - Define one XML file for each options or context menu
  - Support for different locales, configurations, devices, etc.
  - Top-level tag: <menu> … </menu>
    - When inflated, this creates an instance of *Menu* class
  - Within <menu> tag, use <item> and <item> … </item> tags to define menu options
    - When inflated, these create *MenuItem* instances
  - <menu> tag nested in <item> tag defines submenu
  - <group> … </group> tag groups common items (invisibly) sharing common properties (e.g., active state or visibility)

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Defining menus in XML (cont'd)

- Key attributes of menu items:
  - android:id — The usual
  - android:icon — Reference to drawable that is the item's icon
  - android:title — Reference to string that is the item's display text
  - android:showAsAction — Specifies whether item should appear in action bar (for options menu only)

    By default all items displayed in overflow area unless

    android:showAsAction="ifRoom" or
    android:showAsAction="always" or
    android:showAsAction="never"
- See example from http://developer.android.com/guide/topics/ui/menus.html

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Example of menu declaration: A file menu

menu tag declares main menu.

```
<menu xmlns:android="http://schemas.android.com/apk/res/android">
  <item android:id="@+id/file"
      android:title="@string/file" >
    <!-- "file" submenu -->
    <menu>
      <item android:id="@+id/create_new"
          android:title="@string/create_new" />
      <item android:id="@+id/open"
          android:title="@string/open" />
    </menu>
  </item>
</menu>
```

item tag declares item in main menu and item's attributes.

Nested menu tag creates submenu.

Items in submenu.

Source: https://developer.android.com/guide/topics/ui/menus.html

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Options menus

- Brought up (expanded) when user clicks on menu icon
  - Was a hardware button up to Gingerbread (Android 2.3)
  - Since Honeycomb (Android 3.0) different places (often bottom left or right of display, also action bar with overflow area on top right)
  - Global options for an activity, e.g., settings, search, etc.
- Doc: http://developer.android.com/guide/topics/ui/menus.html

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Defining menus in XML (cont'd)

- Options menu support in *Action Bar*
- Source: http://developer.android.com/guide/topics/ui/menus.html

Legend:
1. App icon and name
2. Action buttons
3. Overflow area

Tabs allowing user to switch views.

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Options menus (cont'd)

Three key methods in life time of options menu

1. *onCreateOptionsMenu()* –

   Set up options menu (called once only by OS)

2. *onPrepareOptionsMenu()* –

   Initialization actions (e.g., enable vs. disable items)

   Called by OS after *invalidateOptionsMenu()* called

3. *onOptionsItemSelected()* –

   Handle user interactions

   Called by OS whenever user selects a menu item

- Doc: http://developer.android.com/reference/android/app/Activity.html - onCreateOptionsMenu(android.view.Menu)

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Options menus (cont'd)

- Define an option menu by overriding *onCreateOptionsMenu()*
  - *onCreateOptionsMenu(Menu)* : *boolean*
    - — Defined in *Activity* class
    - — Create view displaying content of options menu using *inflater*
    - — Return value *true* to indicate that menu must be displayed now
    - — Called only first time menu called
  - *onPrepareOptionsMenu(Menu)* : *boolean*

    Typical *onPrepareOptionsMenu()* actions: Enable vs. disable item options, add/remove items, etc.
- Doc: http://developer.android.com/reference/android/app/Activity.html - onCreateOptionsMenu(android.view.Menu)

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Options menus (cont'd)

- Key methods (cont'd)
  - *onOptionsItemSelected(MenuItem)* : *boolean*

    Callback also defined in *Activity* class, can also be used in fragments

    Typical actions: (1) get *MenuItem*'s id and (2) switch on the id of selected item

    Default action returns *false* to let normal processing to continue, e.g., to call the *MenuItem*'s *Runnable*

    Return *true to* indicate that menu processing is done, no need to propagate further
- Doc: https://developer.android.com/guide/topics/ui/menus.html#RespondingOptionsMenu

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Creating an options menu

- Typical action for *onCreateOptionsMenu()*: Inflate XML spec
- Inflater = Android module that maps XML layout spec into a Java *View* object and displays the object
- Source: http://developer.android.com/guide/topics/ui/menus.html

onCreateOptionsMenu() callback is passed a *Menu* instance.

```
public boolean onCreateOptionsMenu(Menu menu) {
    MenuInflater inflater = getMenuInflater();
    inflater.inflate(R.menu.game_menu, menu);
    return true;
}
```

Return *MenuInflater* instance.

Inflate resource XML spec into *Menu* instance.

Display menu in host activity now.

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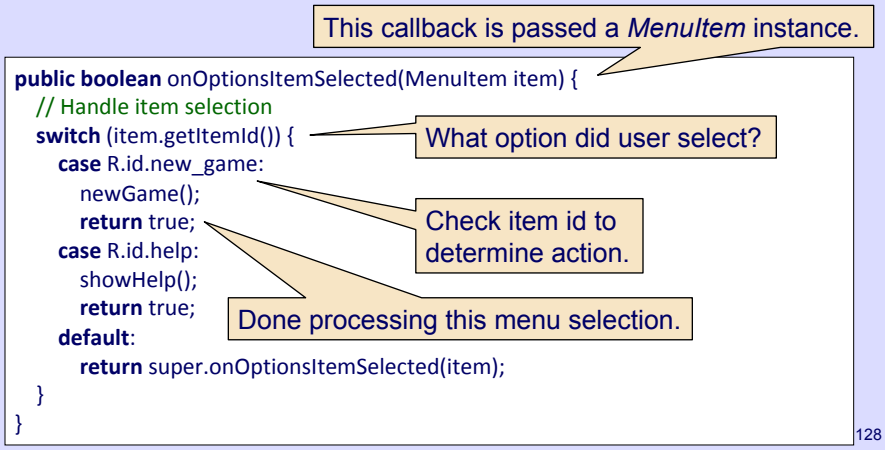
Handling options selections

- Example code for *onOptionsItemSelected()*: Figure out what to do…
- Source: http://developer.android.com/guide/topics/ui/menus.html




```
public boolean onOptionsItemSelected(MenuItem item) {
   // Handle item selection
   switch (item.getItemId()) {
      case R.id.new_game:
         newGame();
         return true;
      case R.id.help:
         showHelp();
         return true;
      default:
         return super.onOptionsItemSelected(item);
   }
}
```

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Options menus (cont'd)

- Supporting resource
  - Use special folder *menu* in project's *res* directory
  - Define an XML file for each menu in application
  - Use <menu> … </menu> tag
  - Within tag, use <item> or <item> … </item> tag to specify each menu item
  - Each item uses attributes *id, icon* (a drawable), and *title* (a string)
  - Specify submenus by nesting new <menu> … </menu> tag within an <item> … </item> tag

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Options menus (cont'd)

- Changing enabled status of menu items
  - Send message *getItem(int index)* or *findItem(int id)* to options menu to get *MenuItem* instance
  - Send message *setEnabled(boolean)* to *MenuItem* instance to change enabled status

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Context menus

- Brought up (expanded) by long click on a specific icon in a display
- Behavior is very similar to option menus, however:
  - Associate specific view with a context menu by calling *Activity* method

    ```
    registerForContextMenu(aView) ;
    ```

  - Methods are now called *onCreateContextMenu()* and *onContextItemSelected()*
  - *onCreateContextMenu()* now takes a menu, the view selected, and additional information about the menu
  - See *HelloAndroidWithMenus* app from Porter's Coursera MOOC

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Creating a context menu

- Callback *onCreateContextMenu()* inflates approprite XML spec
- Source: http://developer.android.com/guide/topics/ui/menus.html

onCreateContextMenu() callback is passed a *Menu* instance, the *View* object associated with the menu, some extra info.

```
public void onCreateContextMenu(ContextMenu menu, View v,
                    ContextMenuInfo menuInfo) {
  super.onCreateContextMenu(menu, v, menuInfo);
  MenuInflater inflater = getMenuInflater();
  inflater.inflate(R.menu.context_menu, menu);
}
```

Get *MenuInflater* instance.

Inflate appropriate XML menu resource into *Menu* instance.

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Handling context selections

- Example code for *onContextItemSelected()*: Figure out what to do…
- Source: http://developer.android.com/guide/topics/ui/menus.html

This callback is passed a *MenuItem* instance.

```
public boolean onContextItemSelected(MenuItem item) {
  AdapterContextMenuInfo info = (AdapterContextMenuInfo) item.getMenuInfo();
  switch (item.getItemId()) {
    case R.id.edit:
      editNote(info.id);
      return true;
    case R.id.delete:
      deleteNote(info.id);
      return true;
    default:
      return super.onContextItemSelected(item);
  }
}
```

Check item id and perform appropriate action.

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The *Action Bar*

- Dedicated area on top of an app's display
- Three main goals:
  1. Identify the app (e.g., by app name + icon)
  2. Access frequently-used actions, perhaps in overflow area
  3. Support navigation tabs
- Aka the *app bar*
- Doc: http://developer.android.com/training/appbar/index.html

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The *Action Bar* (cont'd)

- Recall action bar's picture below
- Source: http://developer.android.com/guide/topics/ui/menus.html

Legend:
1. App icon and name
2. Action buttons
3. Overflow area

Tabs allowing user to switch views.

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Setting up the *Action Bar*

- Traditionally managed by class *ActionBar*, constantly evolving
- Now use class *Toolbar* instead for compatibility with previous versions
- Action bar introduced in Honeycomb (V 3.0) – API level 11
- Library *v7 appcompat* and class *AppCompatActivity* provide support down to Éclair (V2.1) – API level 7
- Constant evolution through addition of new features, e.g.,

  Material design experience introduced in Lollypop
  - See http://developer.android.com/design/material/index.html
  - Beyond our scope…
- Doc: http://developer.android.com/training/appbar/setting-up.html

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Steps in setting up *Action Bar*

1. Add *v7 appcompat* library to Studio project
   - Download *Android Support Library* and *Android Support Repository* in SDK (under the *SDK Tools* tab in SDK Manager window)
   - Add *maven* repository in project *build.gradle* file

```
allprojects {
   repositories {
        google()
        // if you're using a version of Gradle lower than 4.1, you must
        // instead use
        // maven {
        //     url "https://maven.google.com"
        // }
   }
}
```

   - See http://developer.android.com/tools/support-library/setup.html

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Steps in setting up *Action Bar*

2. Add support library to *dependencies* section

```
dependencies {
   ...
   implementation "com.android.support:support-core-utils::28.0.0"
}
```

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Steps in setting up *Action Bar*

3. Define your activity as subclass of *AppCompatActivity* instead of *Activity*
   - *AppCompatActivity* == *Activity* subclass supporting latest app bar
   - Import *android.support.v7.app.ActionBar* if (7 ≤ min API ≤ 10)
   - Import *android.app.ActionBar* if (min API ≥ 11)
   - See http://developer.android.com/tools/support-library/setup.html

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Steps in setting up *Action Bar* (cont'd)

4. Manifest file: Set <application> tag to include a *NoActionBar* theme
   - Prevent use of native *ActionBar* class in device

```
<application
    android:theme="@style/Theme.AppCompat.Light.NoActionBar"
    />
```

5. Add toolbar to activity's layout file

```
<android.support.v7.widget.Toolbar
    android:id="@+id/toolbar_1"
    android:theme="@style/ThemeOverlay.AppCompat.ActionBar"
    app:popupTheme="@style/ThemeOverlay.AppCompat.Light" />
```

   - See http://android-developers.blogspot.com/2014/10/appcompat-v21-material-design-for-pre.html

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Steps in setting up *Action Bar* (cont'd)

6. In activity's *onCreate()* method, find toolbar view and set toolbar's content to be that view
   - Instruct toolbar to act as action bar with call to *setSupportActionBar()*

```
protected void onCreate() {
    super.onCreate() ;
    …
    Toolbar myToolbar = (Toolbar) findViewById(R.id.toolbar_1) ;
    setSupportActionBar(myToolbar) ;
    …
    }
```

7. Now use options menu to add shortcuts to app bar and to populate overflow area (see details in next slides…)

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Action Bar caveat

- If app contains multiple activities that must display the same action bar, avoid code duplication (tedious + error prone)
  - Define the toolbar in its own layout file, e.g., *res/layout/toolbar_1.xml*

```
<android.support.v7.widget.Toolbar
    xmlns:android="http://schemas.android.com/apk/res-auto"
    xmlns:iosched="http://schemas.android.com/apk/res/android"
    android:id="@+id/toolbar_actionbar"
    iosched:popupTheme="style/ActionBarPopupThemeOverlay"
    ioshed:theme="style/ActionBarPopupThemeOverlay"
    … />
```

  - Include layout file *toolbar_1.xml* in all layouts that want it

```
<LinearLayout …
    <include layout="@layout/toolbar_1" />
```

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Using the *Action Bar*

- Define activity's name as android:label attribute of *activity* tag (a string)
- Use *options menu* to define both action buttons and overflow area
- By default, items in *options menu* will be displayed in overflow area
  - Change by using attribute android:showAsAction

    android:showAsAction="ifRoom" or…

    android:showAsAction="never"

    Other options for attribute value: "withText" (to add text to icon), "always" (use carefully), and "never"
- Use *onOptionsItemSelected(menuItem) : boolean* to respond to item selection by user

  Doc: http://developer.android.com/training/appbar/actions.html

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Fragments

- Support for dividing activity's display into multiple panes
- Introduced in Honeycomb V3.0 (API level 11)
  - Specifically intended to support larger tablet displays
  - Still working with "1 activity = 1 screen" metaphor
- Much more screen real-estate on a table than on a phone
  - Use tablet's display more efficiently (avoid empty space)
  - Display multiple things at once, thereby avoiding needless navigation between activities

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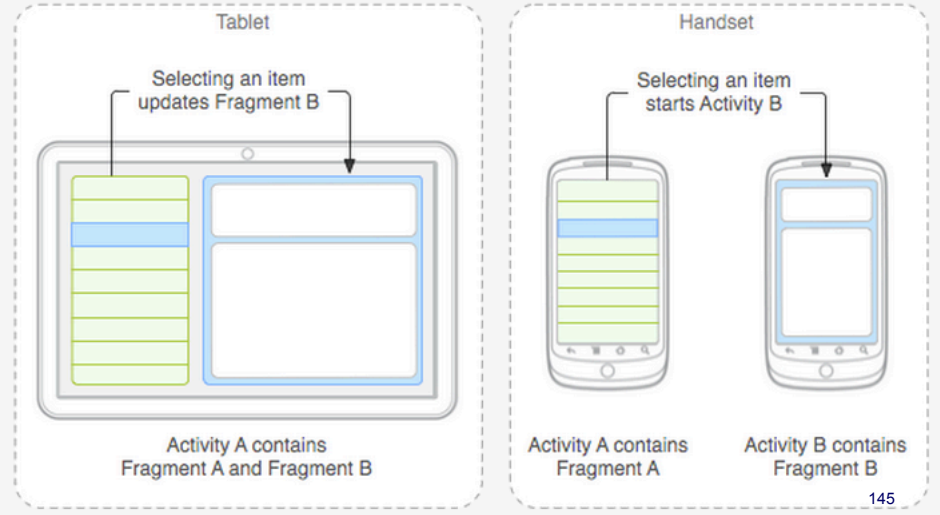
Supporting tablets and phones with fragments

- Source: http://developer.android.com/guide/components/fragments.html



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Fragments

- Fragment = Portion of an activity
  - Fragment must be hosted in activity in order to be displayed
  - Fragment defines its own layout and behavior
  - Compose multiple fragments to form an activity
  - Same fragment can be used in multiple activities
  - Simultaneous support for tablets and phones
- Doc: http://developer.android.com/guide/components/fragments.html

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Fragments

- Fragment is tied to a *containing activity*
  - Before it can be displayed, fragment must be *attached* to hosting activity
  - Lifetime of fragment is similar to an activity's, but there are additional events, when fragment is first created, attached to an activity or detached from the activity
  - When activity paused (stopped, resumed, etc.), all fragments it contains are also paused (stopped, resumed, etc.)
  - While activity running, fragments can be dynamically added and removed, etc.
  - Fragments can be added to back stack to allow navigation with device's *back* button

[http://developer.android.com/guide/components/fragments.html – Lifecycle]

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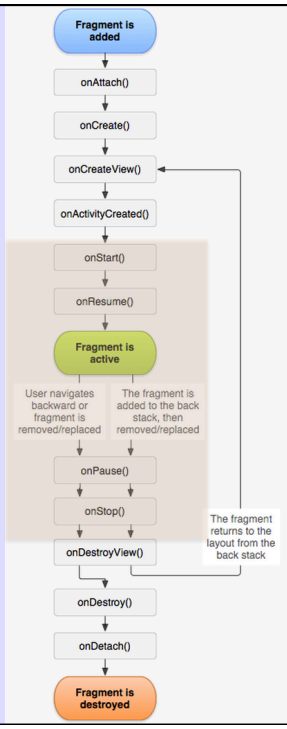

Fragment lifecycle

Mirror lifecycle events of hosting activity

Fragment will execute *onStart()*, *onResume()*, *onPause()*, *onStop()* when hosting activity does

Five additional methods:

- *onAttach()*
- *onCreateView()*
- *onActivityCreated()*
- *onDestroyView()*
- *onDetach()*

Source: http://developer.android.com/guide/components/fragments.html

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Fragment-specific callbacks

- *onAttach(Context activity)* — Called when fragment is attached to activity (record activity object)
- *onCreateView(LayoutInflater inflater, ViewGroup container, Bundle savedInstanceState): View* – Inflate content view displayed in fragment
- *onActivityCreated(Bundle savedInstanceState)* — Called when containing activity completes *onCreate()* method
- *onDestroyView()* — Called when previously created view hierarchy is deleted
- *onDetach()* — Called when fragment is no longer attached to its activity
- *onSaveInstanceState(Bundle savedState)* — Saves state in *Bundle* that will be passed to *onCreate(), onCreateView()* and *onActivityCreated()*

[http://developer.android.com/reference/android/app/Fragment.html]

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Programming fragments

Minimally, provide following callbacks

- *onAttach()*—Save the containing activity in a fragment field
- *onCreate()*—Android calls when fragment created (a constructor?)

  Initialize fragment components that must be retained when fragment is stopped, and then resumed
- *onCreateView()*—Called when fragment must generate its visual display for the first time (return a *View*)

  Gets passed a *LayoutInflater*, a *ViewGroup* (the container), and a *Bundle* (*savedInstanceState*)

  Uses inflater to create the view
- *onPause()*—Commit changes that must be saved

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Order of method execution

- Creation methods are called on containing activity first, followed by fragments
  - E.g., *onCreate(), onStart(), onResume()*
- Deletion methods are called on fragments first, followed by containing activity
  - E.g., *onPause(), onStop(), onDestroy()*

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Example order of method execution

- From fragment example we'll see later on

```
I/QuoteViewerActivity: entered onCreate()
I/TitlesFragment: entered onAttach()
I/TitlesFragment: entered onCreate()
I/TitlesFragment: entered onCreateView()
I/QuoteViewerActivity: entered onStart()
I/TitlesFragment: entered onStart()
I/QuoteViewerActivity: entered onResume()
I/TitlesFragment: entered onResume()
I/TitlesFragment: entered onPause()
I/QuoteViewerActivity: entered onPause()
I/TitlesFragment: entered onStop()
I/QuoteViewerActivity: entered onStop()
I/TitlesFragment: entered onDestroyView()
I/TitlesFragment: entered onDestroy()
I/TitlesFragment: entered onDetach()
I/QuoteViewerActivity: entered onDestroy()
```

Activity does "creation" callbacks first

Now activity is visible and interacting.

Fragment does "deletion" callbacks first.

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Java and fragments

- Fragments are subclasses of app framework's class *Fragment*
  - Fragment's code: Define fragment class as a subclass of *Fragment*

    Similar to activities being subclasses of *Activity*
  - Defining fragment's instance either
    1. Statically – In XML layout file of containing activity
    2. Programmatically – Java code of containing activity

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Static fragment definition

- Defining fragment instance *statically*:
  - Activity's layout file defines fragments explicitly
  - Use <fragment … /> tag, e.g., in linear layout
  - Attribute android:name identifies class defining fragment, e.g.,
    - android:name="edu.uic.cs478.examples.MyFragment"
  - Also, need android:id to identify fragment programmatically
  - Can differentiate between *layout, layout-land, layout-large*, etc.
  - See http://developer.android.com/guide/practices/screens_support.html
  - Example is next…

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Example of XML fragment specification

- Example XML layout file for activity containing fragments

  From http://developer.android.com/guide/practices/screens_support.html

```
<LinearLayout xmlns:android="http://schemas.android.com/apk/res/android"
  android:orientation="horizontal"
  android:layout_width="match_parent"
  android:layout_height="match_parent">
  <fragment android:name="com.example.news.ArticleListFragment"
       android:id="@+id/list"
       android:layout_weight="1"
       android:layout_width="0dp"
       android:layout_height="match_parent" />
  <fragment android:name="com.example.news.ArticleReaderFragment"
       android:id="@+id/viewer"
       android:layout_weight="2"
       android:layout_width="0dp"
       android:layout_height="match_parent" />
</LinearLayout>
```

Usual *LinearLayout* attributes.

Width defined by weights.

The class name

The second fragment in this layout.

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Dynamic fragment definition

- Define fragment programmatically
  - Activity hosting a fragment must make room for it
  - Typically reserve some space with a *FrameLayout* in containing activity
  - Then, use *fragment transaction* to create, add and remove fragment instance dynamically

    http://developer.android.com/reference/android/widget/FrameLayout.html:

    > FrameLayout is designed to block out an area on the screen to display a single item. Generally, FrameLayout should be used to hold a single child view, because it can be difficult to organize child views in a way that's scalable to different screen sizes without the children overlapping each other. …
    >
    > Child views are drawn in a stack, with the most recently added child on top.

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XML layout of activity with dynamic fragments

```
<LinearLayout xmlns:android="blah! blah! blah!"
   android:id="@+id/someName"
   android:orientation="horizontal"
   etc. >
   <FrameLayout
      android:id="@+id/someFrame"
      android:width="0dp"
      android:height="matchParent"
      android:weight="1">
   </FrameLayout>
   <FrameLayout
      android:id="@+id/someOtherFrame"
      android:width="0dp"
      android:height="matchParent"
      android:weight="3">
   </FrameLayout>
</LinearLayout>
```

Usual spec of a *LinearLayout*.

This *FrameLayout* takes 25% of *LinearLayout*'s width.

This *FrameLayout* takes remaining 75% of *LinearLayout*'s width.

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Defining a fragment's layout

- Once more, define fragment layouts either:
  1. Statically – Use XML layout file for fragment
  2. Programmatically – Java code in *onCreateView()* callback
- Setup fragment transactions (e.g., add to an activity) for inclusion in back stack by calling *addToBackStack()* whenever fragment is added to view

  Activity events are included in back stack automatically, fragments events are not

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Generating fragment's display

- Done in fragment callback *onCreateView()*, which returns root *View*
- *inflate()* takes: (1) layout file, (2) parent view (optional), and (3) boolean indicating whether returned view is attached to parent (use *false*)

  See http://developer.android.com/reference/android/view/LayoutInflater.html

Method must create view that contains fragment's visual display.

```
public View onCreateView(LayoutInflater inflater,
                         ViewGroup container, Bundle savedState)  {

  return inflater.inflate(R.layout.myFragment, container, false) ;

}
```

Assume fragment spec in file res/layout/myFragment.xml.

Do not attach to parent *ViewGroup*.

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Fragment and activity communication

- No direct communication between fragments
  - Intended receiver (activity or fragment) may or may not exist
  - Containing activity mediates communication
  - Fragment gets containing activity by calling *getActivity()*, after fragment attached, or from *onAttach()*
  - Activity gets fragment reference with *fragment manager* and fragment's ID
- Examples
  - Button aButton = (Button) getActivity.findViewById(R.id.upButton) ;
  - MyFragment aFragment = getFragmentManager().findFragmentById(R.id…) ;

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Fragment and activity communication (cont'd)

- Fragment may enforce communication with activity via a *Java interface*
  - Fragment defines nested interface with named method(s)
  - Activity containing fragment must *implement* interface
  - Fragment calls method(s) in activity to share information with activity

Fragment class definition.

```
public class MyFragment extends Fragment {
    …
    // Containing activity will implement this interface
    public interface OnSomeEventListener {
        public void onSomeEvent(…) ;
    }
    …
};
```

Nested interface declares method that containing activity must implement.

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Fragment and activity communication (cont'd)

- Activity must implement interface nested in fragment for all this to work

Containing activity must implement Java interface *OnSomeEventListener.*

```
public class MyActivity extends FragmentActivity
                        implements OnSomeEventListener {
    …
    // Implement methods declared by OnSomeEventLlistener
    public void OnSomeEvent ( … ) {

    }
    …
};
```

Activity gives code for method declared by *OnSomeEventListener* in order to implement *OnSomeEventListener.*

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Fragment and activity communication (cont'd)

- Fragment wants to make sure that activity has implemented the interface
  - But how? Fragment defines reference to activity **but uses interface type in declaration**
  - Declaration works only if activity implements interface

```
public class MyFragment extends Fragment {
    OnSomeEventListener mContainingActivity ;
    public void onAttach(Context activity) {
        try (
            mContainingActivity = (OnSomeEventListener) activity ;
        } catch (ClassCastException ex) {
            …
        } …
```

This activity must respond to fragment events, implement *OnSomeEventListener.*

This cast will succeed only if activity implements interface.

Catch block executed if cast fails.

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Structure of fragment static layout app

- One activity, two fragments (titles and quotes)
- Titles fragment is subclass of *ListFragment* (implicitly contains a *ListView*)
- Three layout resources: One each for activity and quotes fragment, one for list item (just a simple *TextView,* no layout needed for *ListFragment*, similar to *ListActivity*)
- Activity layout statically defines two fragments
- Three Java source files, one each for activity and two fragments
- Communication between fragment and activity:
  1. Fragment declares Java interface that activity must implement, and
  2. Fragment sets its event listener to be that activity
- Source: Porter's Coursera MOOC, example app *FragmentsStaticLayout*

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Static layout app: *QuoteViewerActivity*

- *QuoteViewerActivity* acts as conduit between between *TitlesFragment* and *QuotesFragment*
  - Declares static arrays with titles and quotes
  - Obtains reference to quotes fragment through *FragmentManager*
  - Implements Java interface *ListSelectionListener* by defining function *onListSelection()* that will be called by titles fragment whenever user selects an item in the list
    - Java interface defined in fragment class *TitlesFragment*
  - Calls *getShownIndex()* and *showQuoteAtIndex()* in details fragment to find out what quote currently displayed and to change quote

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Static layout app: the titles fragment

- Subclass of *ListFragment*
- Declares interface *ListSelectionListener* implemented by quotes viewer activity (method *onListSelection()*)
- Declares listener field of type *ListSelectionListener*
- Defines method *onListItemClick()* (part of *ListFragment* API)
  - This method calls *onListSelection()* on listener (i.e., containing activity)
- *onAttach()* method sets listener to containing activity (passed as arg)
- *onActivityCreated()* sets array adapter, using resource file and quotes array

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Static layout app: the quotes fragment

- Subclass of *Fragment*
- Method *onCreateView()* method inflates layout resource
- Method *onActivityCreated()* gets quote view defined in fragment's layout
  - Must wait for activity to be created in order to get view object
- Define methods *getShownIndex()* and *showViewAtIndex()*, called by quote viewer activity

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Defining fragments programmatically: Summary

Use following steps in *onCreate()* of containing activity :

1. Retrieve the *fragment manager* – Call method *getFragmentManager()*
2. Begin a *fragment transaction – fragmentManager.beginTransaction()*
3. Add/Remove/Replace fragment wrt container view –
   transaction.add(container_id, fragment)
   transaction.replace(container_id, fragment)
   transaction.remove(container_id, fragment)
4. (optional) Add this transaction to the back stack –
   transaction.addToBackStack(null)
5. Commit the transaction – *transaction.commit()*
6. (optional) Force transaction to be performed now – Call
   executePendingTransactions()

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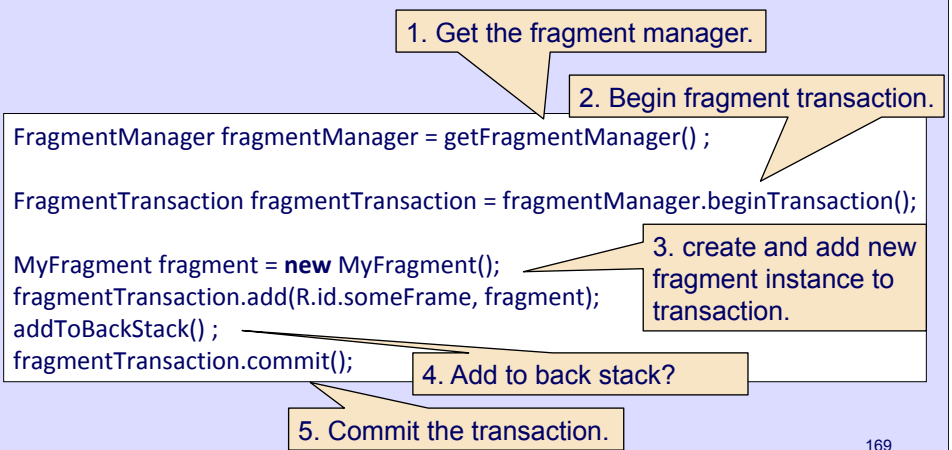
Defining fragments programmatically

- Example code

  http://developer.android.com/guide/components/fragments.html



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Why this complexity?

- Two complications:
  1. Must call fragment manager to add and remove fragments
  2. Fragment operations must be part of a fragment transaction
- A plausible reason?
  - Different threads could execute fragment operations simultaneously
  - Coordination among threads needed to avoid conflicting changes
  - In general, only UI thread can modify interface
  - *commit()* executed by UI thread regardless of requesting thread
  - Fragment transactions enforce *atomicity*
- *FragmentTransaction* class to provide atomicity?
- Doc: https://developer.android.com/guide/components/fragments

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Defining fragments programmatically

- Fragment manager can usefully "find" fragments in a display, e.g., if a fragment was defined statically in layout file

  getFragmentManager().findFragmentById(R.id.theFragment)
- Call *addToBackStack()* multiple times during same transaction to add different actions to the back stack

  See Porter's *FragmentsProgrammaticLayout* example

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Fragments programmatic layout

- Dynamic fragment creation alone does not improve user experience
  - Reconfigure fragments programmatically to improve experience
- Activity's layout file defines 2 frame layouts instead of 2 fragments
- Activity's *onCreate()* method adds titles fragment and quotes fragment in single fragment manager transaction
- Nothing else changed; user experience is identical to static layout case

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Adding fragments dynamically to an activity

- Suppose fragment *F* should be added and removed dynamically from an activity
- Activity can use these steps
  1. Activity creates fragment instance, does not add to display
  2. Activity uses method *isAdded()* to check status of fragment
  3. Activity uses fragment manager's transactions to add and remove fragment instance from display
  4. Activity can set up an *OnBackStackChangedListener* to reset layout programmatically when user navigates back from fragment action

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OnBackStackChangedListener

- Static interface nested in class *FragmentManager*
- One abstract no-arg method, *onBackStackChanged() : void*
- Associate instance with fragment manager by sending message *addBackStackChangedListener()*

  May use anonymous class when instantiating interface, e.g.,

Send message adding listener to fragment manager.

```
// Add a OnBackStackChangedListener to reset the layout when the back stack changes
mFragmentManager.addOnBackStackChangedListener(
        new FragmentManager.OnBackStackChangedListener() {
                public void onBackStackChanged() {
                    // Blah! Blah! Blah!
                }
}) ;
```

Create anonymous class and its (only) instance.

Don't forget to define method *onBackStackChanged()*.

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executePendingTransactions()

- Force the fragment manager to executed current transactions immediately
- Call after you commit a transaction
- Prevent fragment manager from "optimizing" screen updates

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Fragments dynamic layout

- Activity's layout file defines frame layouts without weights as width will be determined dynamically
  - Width is `match_parent` for first frame layout and `0dp` for second frame layout
  - Titles fragment's *TextView* width is `match_parent`, quotes fragment's is `wrap_content`
- Activity's *onCreate()* method adds only titles fragment, sets up back stack changed listener to call *setLayout()*
- Method *setLayout()* checks whether quotes fragment added; sets layout configurations programmatically
- *onListSelection()* listener adds quotes fragment (if not added), adds transaction to back stack (triggering *setLayout()*)

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Reusing fragments across activities

- Avoid recreating fragment when an activity is destroyed
- Potential savings:
  - Deleting and creating the fragment objects (e.g., less garbage)
  - Fragment's *onDestroy()* and *onCreate()* methods
  - Creating the fragment's view
- To keep fragment around, call *setRetainInstance(true)* in fragment's class *onCreate()* method
- Retrieve retained fragment through fragment manager (See next…)

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Finding retained fragment

- https://developer.android.com/guide/topics/resources/runtime-changes.html#RetainingAnObject

```
private RetainedFragment dataFragment;

public void onCreate(Bundle savedInstanceState) {
    ....
    // find the retained fragment on activity restarts
    FragmentManager fm = getFragmentManager();
    dataFragment = (DataFragment) fm.findFragmentByTag("data");

    // create the fragment and data the first time
    if (dataFragment == null) {
       // add the fragment
       dataFragment = new DataFragment();
       fm.beginTransaction().add(dataFragment, "data").commit();
       // load the data from the web
       dataFragment.setData(loadMyData());
    }
```

Field holding fragment reference.

Does fragment manager have retained instance?

No. Then create new fragment instance and add to display.

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Fragment static config layout

- New version with distinct layouts for phone/tablet
- Default layout is similar to programmatic layout (2 frame layouts)
  - Now used for portrait mode
  - Titles reduced to one line in portrait mode
  - Font size reduced to 24sp from 32sp
- Layout-land redefines layout of both fragments to use bigger 32sp font size
- Default layout uses ellipses for titles items
- Java code similar to previous static layout example
- Source: Porter's Coursera MOOC

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