# Services and Threads

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## SERVICES

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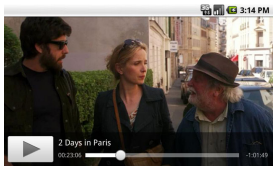
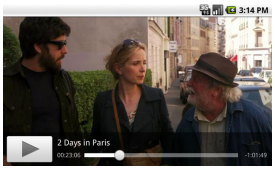
```xml
<?xml version="1.0" encoding="utf-8"?>
<manifest xmlns:android=http://schemas.android.com/apk/res/android ...>

    <uses-permission android:name="android.permission.INTERNET" />
    <uses-permission android:name="android.permission.WIFI" />
    <uses-permission android:name="android.permission.WRITE_EXTERNAL_STORAGE" />

    <application
        android:icon="@drawable/ic_launcher"
        android:label="@string/app_name" >
        <activity ...> ... </activity>
        <provider ...> ... </provider>

        <service
            android:name=".ChatService"
            android:exported="false">
        </service>

        <receiver android:name=".ChatApp.Receiver">
            <intent-filter>
                <action android:name="android.action.intent.PROVIDER_CHANGED”/>
            </intent-filter>
        </receiver>

    </application>
</manifest>
```



## Activity



## Activity





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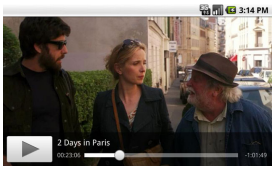
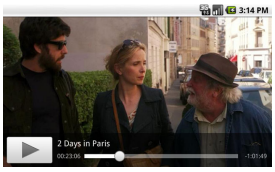
## Activity





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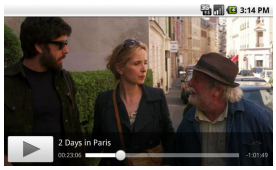
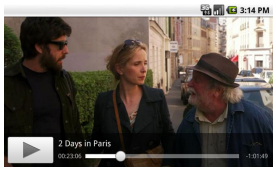
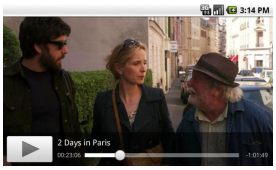
## Activity




## Service

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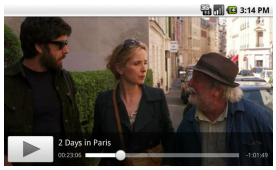
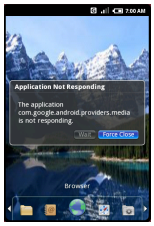
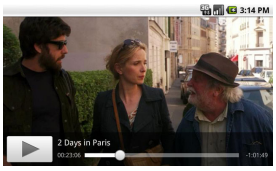
## Activity




## Service

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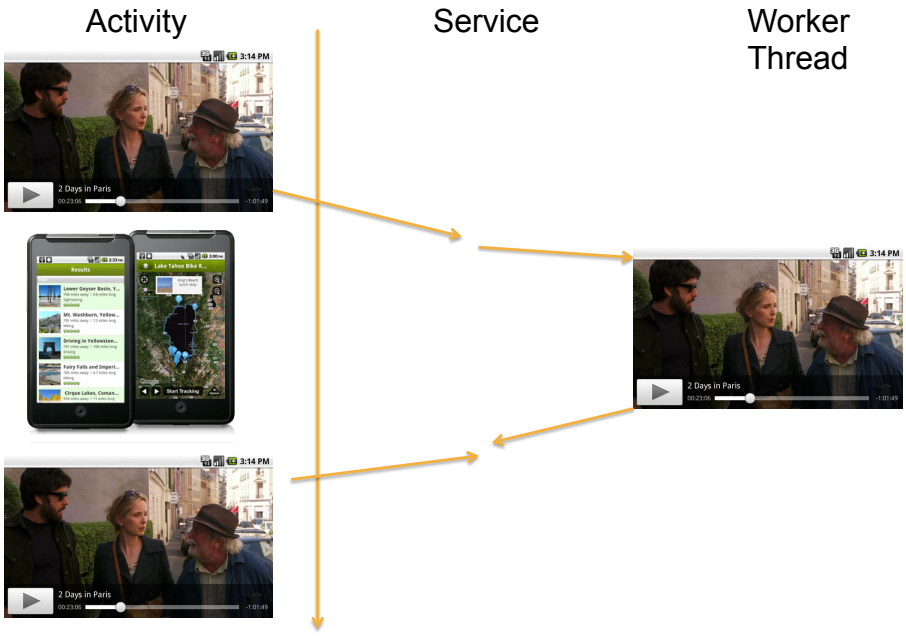


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# Services

- Motivation: Manage background work
  - I/O (databases, files)
  - Network
  - Music player
  - Image processing (camera)
- Service: framework manages task resources
  - Life cycle: background thread termination

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# Service Design Issues

- Starting/stopping vs binding/unbinding
  - Perform background request
  - Maintain background activity
  - Communicate with UI
- Local vs remote
- Communication with UI client
  - Passing arguments
  - Receiving intermediate results
  - Receiving final results

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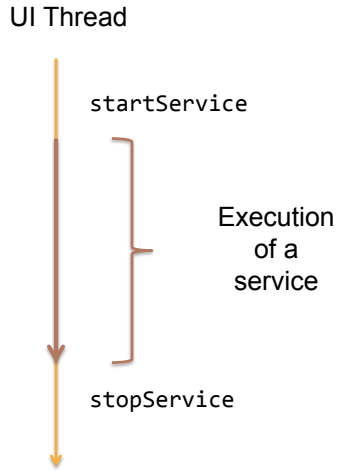
# Services and Threads

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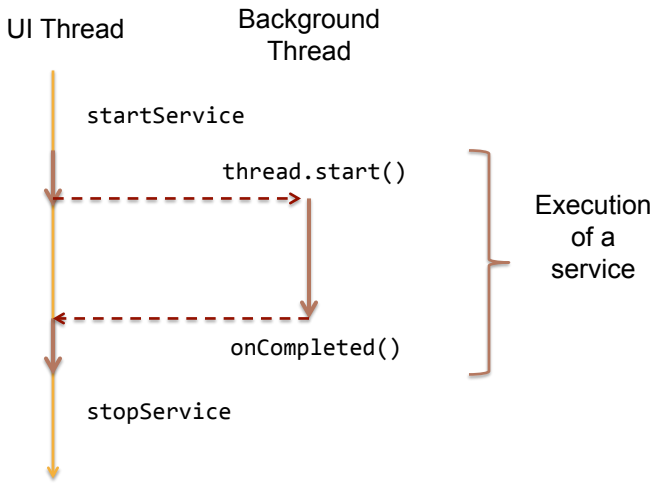
# Services and Threads

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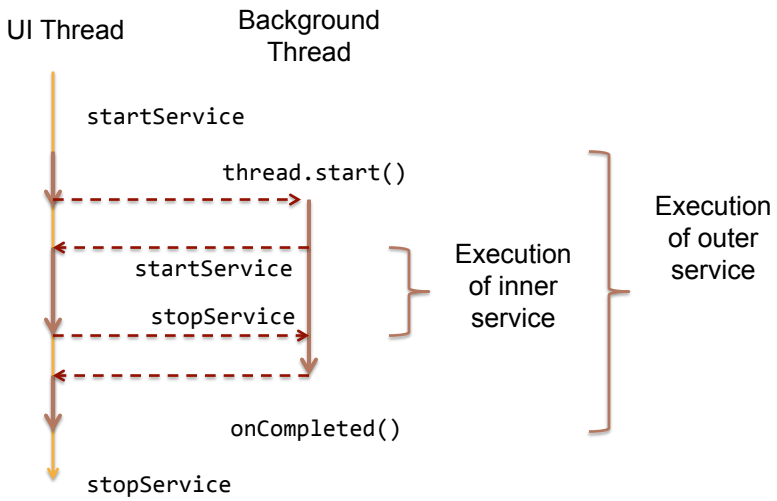
# Services and Threads

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## INTENT SERVICE

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## Intent Service

- Simple request-driven service
- Request = intent to start service
- Performed on background thread
- All requests serialized on one thread

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# Intent Service

- Perform request on background thread
- Client: send service request

```
Intent request = new Intent(this, SendService.class);

request.setAction(SendService.SEND_ACTION);

request.putExtra(...DESTINATION, destinationAddress);
request.putExtra(...SOURCE, mySenderId);
request.putExtra(...MESSAGE, “Hello!”);

startService(request);
```

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# Intent Service

- Service: receive and perform request

```
public class SendService extends IntentService {

  public SendService() { super(“SendService”); }

  public static void SEND_ACTION =
      “org.example.messages.SEND”;
  public static void MESSAGE = “message”;
  public static void DESTINATION = “destination”;
  public static void SOURCE = “source”;

  ...
}
```

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# Intent Service

- Service: receive and perform request

```
public class SendService extends IntentService {
  public void onHandleIntent(Intent request) {
    if (request.getAction().equals(SEND_ACTION) {
      String dest =
        request.getStringExtra(DESTINATION);
      String source = request.getStringExtra(SOURCE);
      String message = request.getStringExtra(MESSAGE);
      Socket socket;
      ...
      socket.send(packet);
    }
  }
}
```

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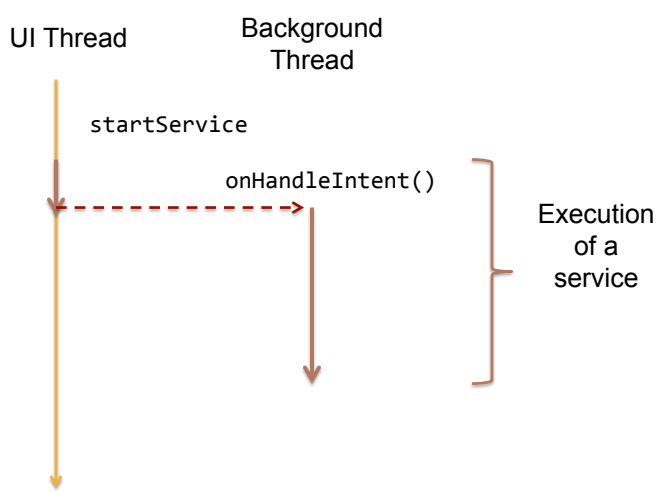
# Intent Service

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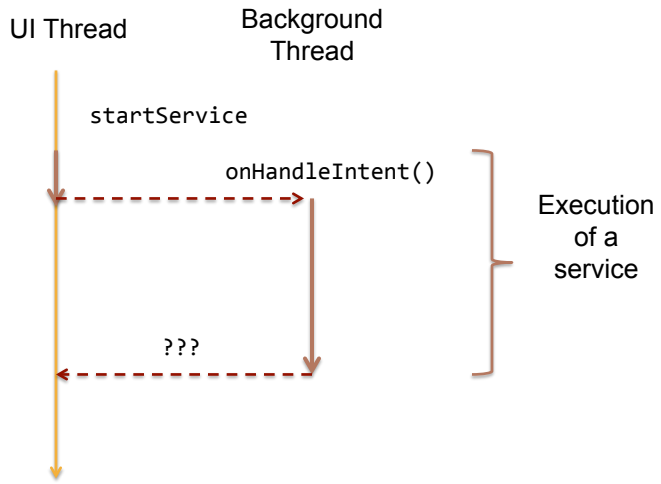
# Intent Service with Result

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# RESULT RECEIVER

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# Result Receiver

- Client-side receiver
  - Define callback via inheritance:

```
public AckReceiver extends ResultReceiver {
  void onReceiveResult(int resultCode,
                       Bundle result) { ... }
}
request.putExtra(RECEIVER, new AckReceiver(...));
```

- Server-side receiver
  - Proxy for sending reply

```
ResultReceiver resultReceiver =
      intent.getExtraParcelable(RECEIVER);
Bundle result = new Bundle();
result.put(ACK, ...);
resultReceiver.send(resultCode, result);
```

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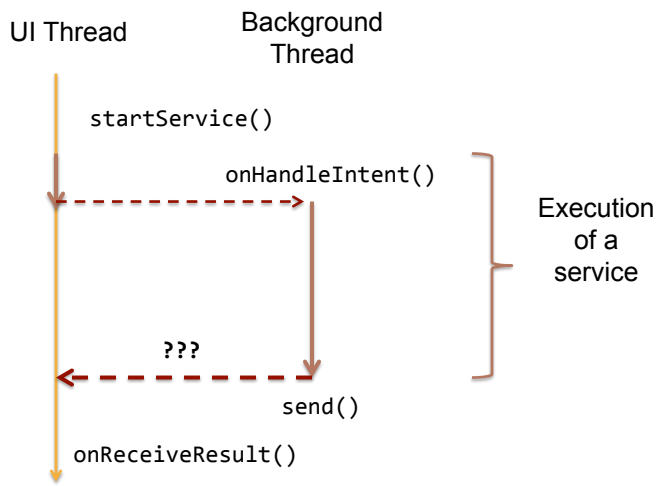
# Intent Service with Result Receiver

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# Result Receiver

- Client-side receiver
  - Define callback via inheritance:

```
public AckReceiver extends ResultReceiver {
  void onReceiveResult(int resultCode,
                       Bundle result) { ... }
}
request.putExtra(RECEIVER, new AckReceiver(...));
```

- Server-side receiver
  - Proxy for sending reply

```
ResultReceiver resultReceiver;
Bundle result = new Bundle();
result.put(ACK, ...);
resultReceiver.send(resultCode, result);
```

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# Result Receiver

- Client-side receiver
  - Define callback via inheritance:

```
Public AckReceiver extends ResultReceiver {
  void onReceiveResult(int resultCode,
                       Bundle result) { ... }
}
request.putExtra(RECEIVER,
                 new AckReceiver(new Handler()));
```

- Server-side receiver
  - Proxy for sending reply

```
ResultReceiver resultReceiver;
Bundle result = new Bundle();
Result.put(ACK, ...);
resultReceiver.send(resultCode, result);
```

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# Handlers and ResultReceiver

- Handler
  - Per-thread message queue
  - Post messages
  - Post tasks (`Runnable` objects)
- Bind receiver to **current** thread handler:

```
request.putExtra(RECEIVER,
                 new AckReceiver(new Handler()));
```

- Post reply to **requester** handler:

```
resultReceiver.send(resultCode, result);
```

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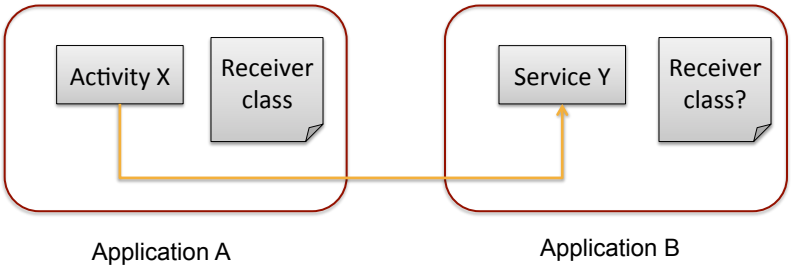
# Receiver Wrapper

- Issues with `ResultReceiver`
- What if client activity is destroyed?
- Client-specific `ResultReceiver` class in service process?

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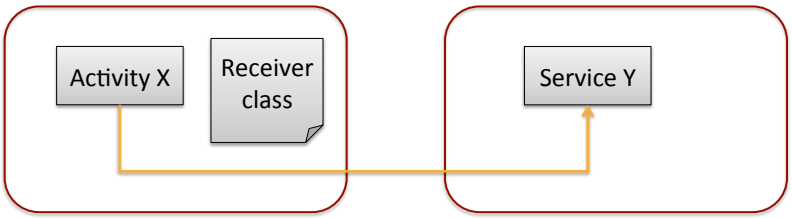
# Receiver Wrapper

```
public class ResultReceiverWrapper
       extends ResultReceiver {

  public ResultReceiverWrapper(Handler handler) {
    super(handler);
  }
```




Application A

Application B

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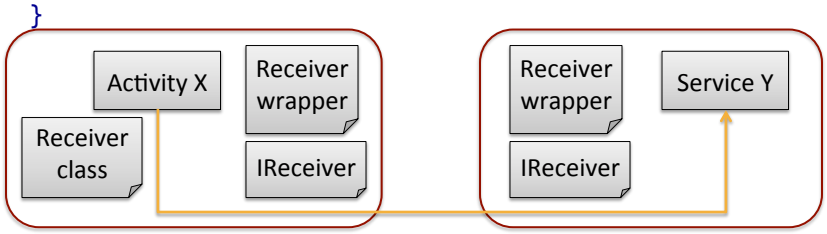
# Receiver Wrapper

```
public class ResultReceiverWrapper
       extends ResultReceiver {

  private IReceiver receiver;

  public interface IReceiver {
    public void onReceiveResult(int resultCode,
                                Bundle resultData);
  }
```




Application A

Application B

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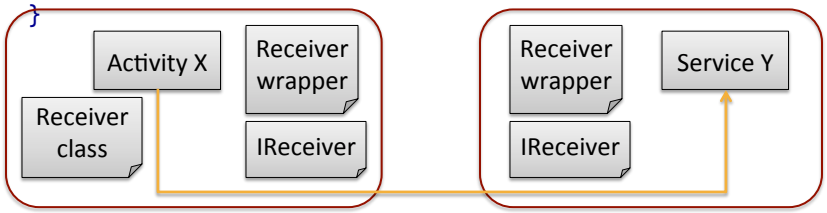
# Receiver Wrapper

```
public class ResultReceiverWrapper
       extends ResultReceiver {
  public void setReceiver(Ireceiver receiver) {
    this.receiver = receiver;
  }
  protected void onReceiveResult(int resultCode, Bundle data) {
    if (receiver != null) {
      receiver.onReceiveResult(resultCode, resultData);
    }
  }
```




Application A

Application B

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# Activity

- Declarations

```
IReceiver receiver;
ResultReceiverWrapper wrapper;
```

- Enable receiver

```
public void onResume() {
  super.onResume();
  wrapper.setReceiver(receiver);
}
```

- Disable receiver:

```
public void onDestroy() {
  super.onDestroy();
  wrapper.setReceiver(null);
}
```

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# BINDING SERVICE

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# Service

```
public class MyService extends Service {

  @Override
  public void onCreate() {
    // Actions to perform when service is created.
  }

  @Override
  public IBinder onBind(Intent intent) {
    // Replace with service binding implementation.
  }

  @Override
  public int onStartCommand(Intent intent, int flags, int start) {
    // Launch a background thread to do processing.
  }
}
```

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## Types of Service

- Bound service
  - Defined by connections from clients (activities)
- Started service
  - Explicitly started and stopped
  - Special case: `IntentService`
- Combination

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## Bound Service

- Started when first client connects
- Ended when last client disconnects
- Binder: client side of connection
  - RPC interface

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# Bound Service Applications

- Network service
  - Turn on radio when WIFI required
  - Turn off when no clients
- File locking service
  - Start for first lock request
  - Turn off when all locks released

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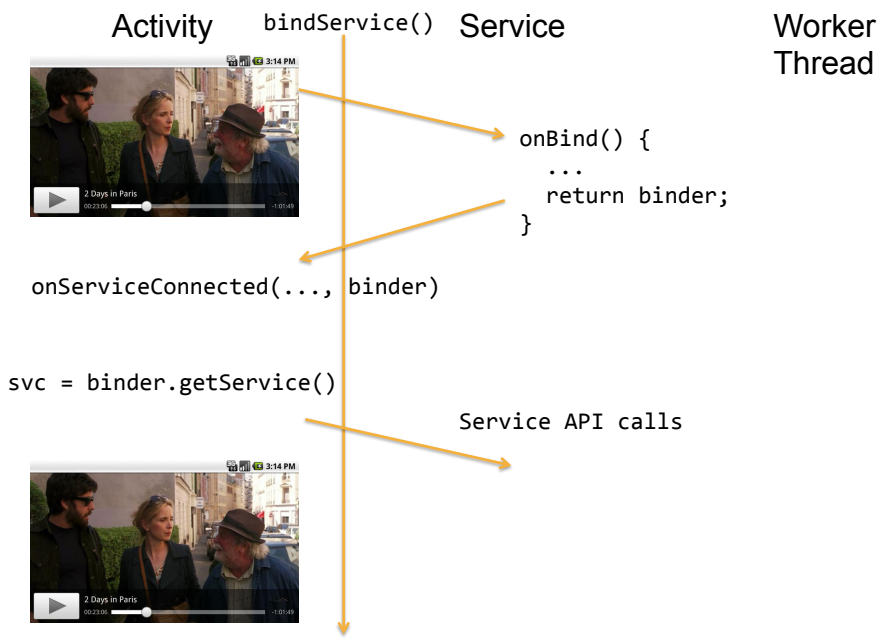


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# Implementing a Binding: Activity

```
private MyService service;

…

@Override
public void onCreate(Bundle savedState) {
  super.onCreate(savedState);

  // Bind to the service
  Intent bindIntent =
       new Intent(this, MyService.class);
  bindService
       (bindIntent, connection, Context.BIND_AUTO_CREATE);
}
```

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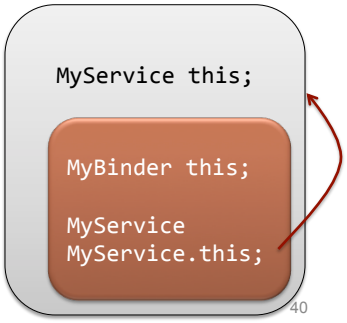
# Implementing a Binding: Service

```
class MyService extends Service {

  private final IBinder binder = new MyBinder();

  @Override
  public IBinder onBind(Intent intent) {
    return binder;
  }

  public class MyBinder extends Binder {
    MyService getService() {
      return MyService.this;
    }
  }

}
```

```
onBind() {
  ...
  return binder;
}
```

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# Implementing a Binding: Activity

```
private MyService service;

// Handles the connection between the service and activity
private ServiceConnection connection = new ServiceConnection() {
  public void onServiceConnected
              (ComponentName className, IBinder binder) {
    // Called when the connection is made.
    service = ((MyService.MyBinder)binder).getService();
  }

  public void onServiceDisconnected(ComponentName className) {
    // Received when the service unexpectedly disconnects.
    service = null;
  }
};
```

Service API calls

```
onServiceConnected(..., binder)

service =
((MyService.MyBinder)binder).getService()
```

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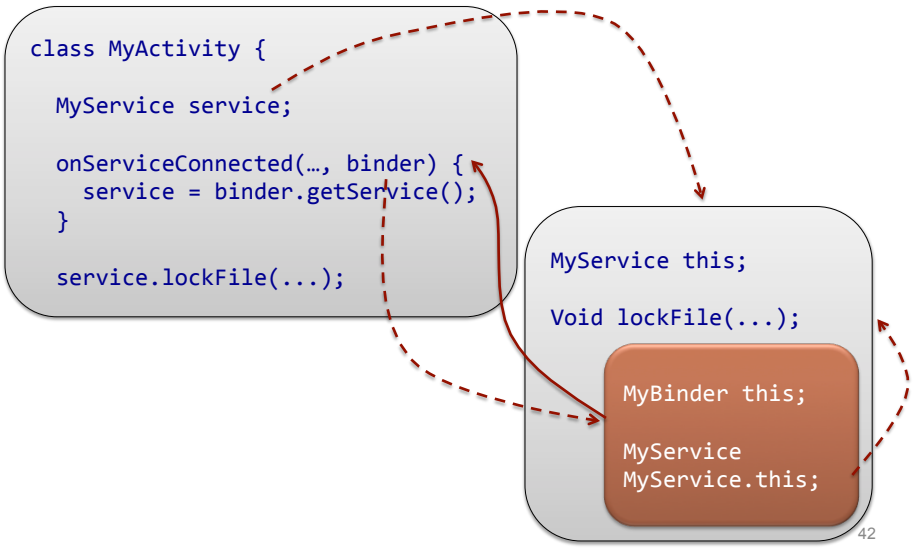
# Bound Service

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# BINDING ACROSS PROCESSES

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## Binding Across Processes

```
class MyActivity {

  MyService service;

  onServiceConnected(…, binder) {
    service = binder.getService();
  }

  service.lockFile(...);
```

```
MyService this;

void lockFile(...);

onBind()
  return new Binder() {
    getService() {
      return
        MyService.this;
    }
  }
```

# Binding Across Processes

- AIDL interface
  - AIDL language for interfaces
  - Client stubs from interface
- Message channels
  - Less complexity
  - Manual marshalling

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# Binding Across Processes

```
class MyActivity {

  Messenger messenger;

  onServiceConnected(…, binder) {
    messenger =
      new Messenger(binder);
  }

  messenger.send(message);
```

```
messenger =
  new Messenger(handler);


onBind()
  return
    messenger.getBinder()
```

# Binding Across Processes: Client

```
Messenger messenger;

public void onServiceConnected(ComponentName name,
                               IBinder binder) {
  this.messenger = new Messenger(binder);
}

void sendRequest() {
  Message message = Message.obtain(null, action, 0, 0);
  Bundle args = new Bundle();
  ... Add arguments to args bundle ...
  message.setData(args);
  try {
    messenger.send(message);
  } catch (RemoteException e) {
  }
}
```

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# Binding Across Processes: Service

```
Messenger messenger;

@Override
public void onCreate() {
  super.onCreate();
  messenger = new Messenger(... messenger handler ...);
}

public IBinder onBind(Intent intent) {
  return messenger.getBinder();
}
```

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# Binding Across Processes: Service

```
Messenger messenger;

@Override
public void onCreate() {
  super.onCreate();
  messenger = new Messenger(new MessageHandler());
}

class MessageHandler extends Handler {
  public void handleMessage(Message message) {
    Bundle data = message.getData();
    ResultReceiver resultReceiver = data.getParcelable(…);
    switch (message.what) {
      resultReceiver.send(...);
    }
  }
}
```

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# HANDLERS

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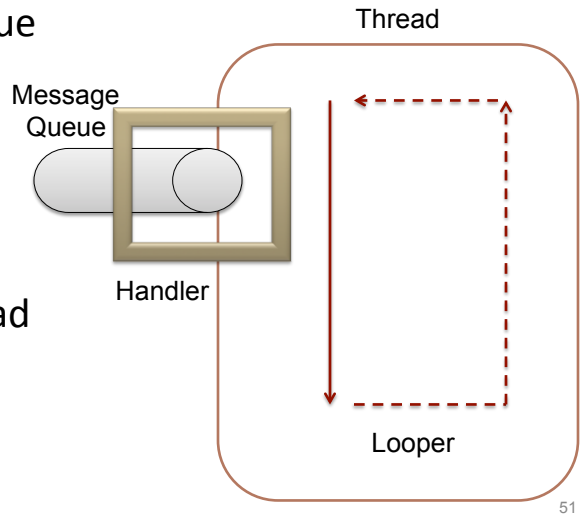
# Handler Abstractions

- MessageQueue
  - Message
  - Runnable
- Looper
- Handler
- Handler thread

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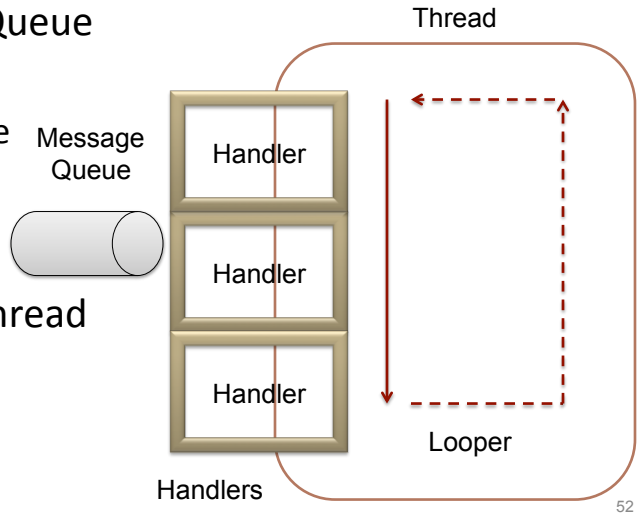
# Handler Abstractions

- MessageQueue
  - Message
  - Runnable
- Looper
- Handler
- Handler thread

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## Using Handlers

- Define a handler class for processing:

```
class MessageHandler extends Handler {
  void handleMessage(Message message) {
    ...
  }
```

- Instantiate on a looper (thread):

```
Handler handler = new MessageHandler();
```

- Post a message to a handler:

```
handler.sendMessage(…);
```

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## Using Handlers

- Define a handler class for processing:

```
class MessageHandler extends Handler {
  void handleMessage(Message message) {
    ...
  }
```

- Instantiate on a looper (thread):

```
messenger = new Messenger(new MessageHandler());
```

- Post a message (remotely) to a handler:

```
messenger.send(…);
```

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## Problem

- Instantiate on a looper (thread):

```
Handler handler = new MessageHandler();
```

- Instantiates on the current thread
- How to instantiate on background thread?
- Define a thread with:
  - Message queue
  - Looper

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## Handler on Background Thread

- Define a **handler class** for processing:

```
class MessageHandler extends Handler { ... }
```

- Create a background **handler thread**:

```
messengerThread = new HandlerThread(TAG,
          Process.THREAD_PRIORITY_BACKGROUND);
messengerThread.start();
```

- Instantiate handler on background thread **looper**:

```
Looper messengerLooper =
          messengerThread.getLooper();
handler = new MessageHandler(this,
                              messengerLooper);
```

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## Binding Across Processes: Service

```
Messenger messenger;

public void onCreate() {
  super.onCreate();
  messenger = new Messenger(new MessageHandler());
}

public void onCreate() {
  super.onCreate();
  messengerThread = new HandlerThread(TAG,
                        Process.THREAD_PRIORITY_BACKGROUND);
  messengerThread.start();
  Looper messengerLooper = messengerThread.getLooper();
  handler = new MessageHandler(this, messengerLooper);
  messenger = new Messenger(handler);
}
```

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## EXPLICITLY STARTED/STOPPED SERVICES

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# Binding and Disconnecting

- Binding to a Service

```
Intent intent = new Intent(this, MyService.class);
bindService(intent,
            connection,
            flags /* Context.BIND_AUTO_CREATE */ );
```

- Use the Service

```
service.doSomething(...);
/* or messenger.send(...) */
```

- Disconnect:

```
unbindService(connection);
```

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# Service

```
public class MyService extends Service {

  @Override
  public void onCreate() {
    // Actions to perform when service is created.
  }

  @Override
  public IBinder onBind(Intent intent) {
    // Replace with service binding implementation.
  }

  @Override
  public int onStartCommand(Intent intent, int flags,
                            int startId) {
    // Launch a background thread to do processing.
  }
}
```

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## Connection-Oriented vs Connectionless

- Connection-oriented
  - Bound service
  - Intent just starts service
  - *Data extras not transmitted to onBind!*
- Connectionless
  - Started service
  - Intent starts service and transmits data

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## Service

```
public class MyService extends Service {

  @Override
  public void onCreate() {
    // Actions to perform when service is created.
  }

  @Override
  public IBinder onBind(Intent intent) {
    // Replace with service binding implementation.
  }

  @Override
  public int onStartCommand(Intent intent, int flags,
                            int startId) {
    // Launch a background thread to do processing.
  }
}
```

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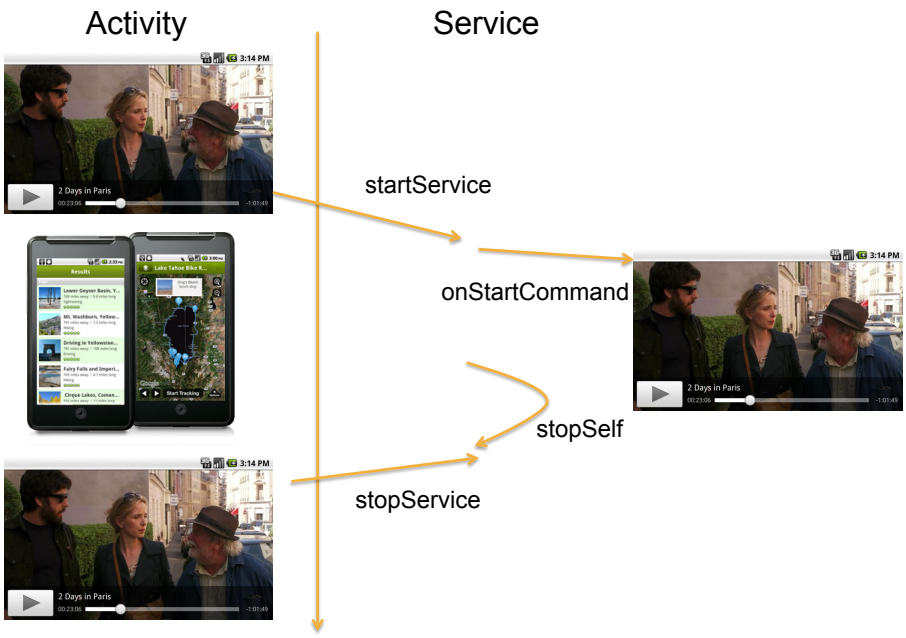


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# Stopping & Starting

- Starting a Service

```
// Explicitly start a Service
startService(new Intent(this, MyService.class)
             flags,
             requestID);
```

- Stopping a Service

```
stopService(new Intent(this, MyService.class));
```

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## Service Operations

- On creation
```
void onCreate()
```
- On starting
```
int onStartCommand(Intent intent,
                   int flags,
                   int requestID)
```
- Stopping the service
```
stopSelf()

stopSelfResult(requestID);  /* Maintain order! */
```

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## Service Operations

- On starting
```
int onStartCommand(Intent intent, int flags,
                   int requestID)
```
- Start Flags
  - `START_FLAG_REDELIVERY`: restarting killed service
  - `START_FLAG_RETRY`: restarting killed during start
- Return flags
  - `START_STICKY`: leave "started" if killed
  - `START_NOT_STICKY`: don't restart without request
  - `START_REDELIVER_INTENT`: restart with intent if killed

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# Example: IntentLikeService

```
public class IntentLikeService extends Service {

  private Looper looper;
  private ServiceHandler handler;

  private final class ServiceHandler extends Handler {
      public ServiceHandler(Looper looper) {
          super(looper);
      }
      @Override
      public void handleMessage(Message msg) { }
          ... do stuff ...
          // Stop the service using the startId, so that we don't
          // stop the service in the middle of handling another job
          stopSelf(msg.arg1);
      }
  }
```

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# Example: IntentLikeService

```
public class IntentLikeService extends Service {

  public void onCreate() {
     HandlerThread thread = new HandlerThread(...,
            Process.THREAD_PRIORITY_BACKGROUND);
     thread.start();
     looper = thread.getLooper();
     handler = new ServiceHandler(looper);
  }

  public int onStartCommand(Intent intent, int flags, int startId){
     Message msg = handler.obtainMessage();
     msg.arg1 = startId;
     handler.sendMessage(msg);
     return START_STICKY;
  }
```

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## BACKGROUND TASKS

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## APIs for Background Threads

- Java threads
- Handler API
- AsyncTask
- `Activity.runOnUiThread()`

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## APIs for Background Threads

- Java threads

```
Runnable code = new Runnable() {
  public void run() {
    ... do work ...
  }
}
new Thread(code).start();
```

- Handler API
- AsyncTask
- `Activity.runOnUiThread()`

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## APIs for Background Threads

- Java threads
- Handler API

```
class MyHandler extends Handler { ... }
handlerThread = new HandlerThread(...);
handlerThread.start();
Looper looper = handlerThread.getLooper();
handler = new MyHandler(this, looper);
handler.sendMessage(...);
```

- AsyncTask
- `Activity.runOnUiThread()`

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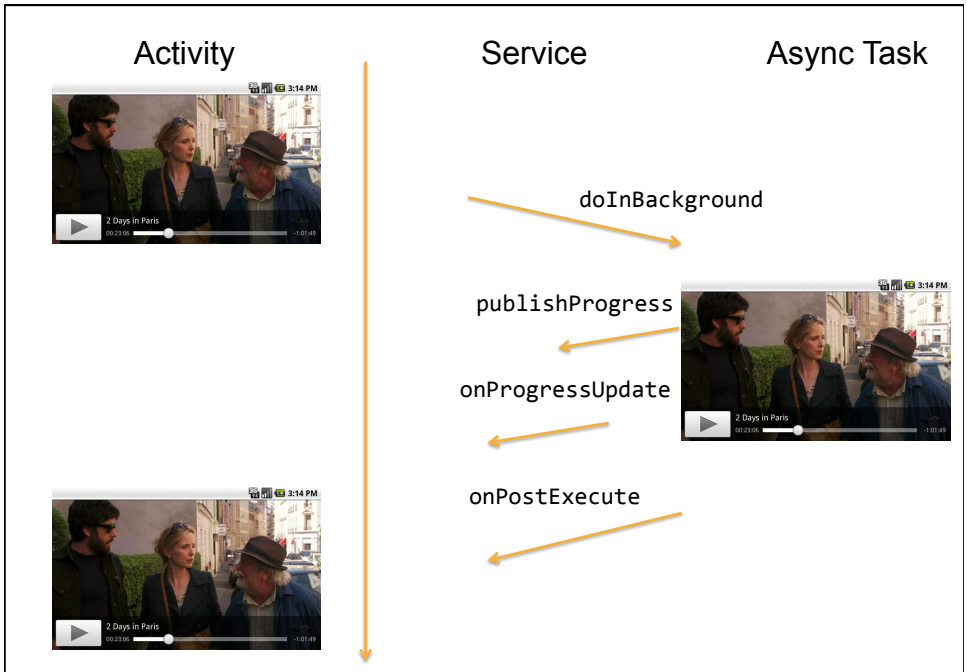


# Asynchronous Task

```
private class MyAsyncTask extends AsyncTask<String,Integer,Integer>
{
  @Override
  protected void onProgressUpdate(Integer... progress) {
    // Update progress bar, Notification, or other UI element
  }

  @Override
  protected void onPostExecute(Integer... result) {
    // Report results via UI update, Dialog, or notification
  }

  ...

}
```

Input parameter type

Progress report type

Result type

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# Asynchronous Task

```
private class MyAsyncTask extends AsyncTask<String,Integer,Integer>
{

  @Override
  protected Integer doInBackground(String... parameter) {
    int myProgress = 0;

    // Perform background processing task, update myProgress

    publishProgress(myProgress)

    // Continue performing background processing task

    // Return the value to be passed to onPostExecute
    return result;
  }
}
```

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# Asynchronous Task

```
private class MyAsyncTask extends AsyncTask<String,Integer,Integer>
{
  @Override
  protected Integer doInBackground(String...) {
    ...
    publishProgress(myProgress)
    ...
  }
  @Override
  protected void onProgressUpdate(Integer...) { ... }

  @Override
  protected void onPostExecute(Integer...) { ... }
}
```

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# APIs for Background Threads

- Java threads
- Handler API
- AsyncTask

```
AsyncTask<Void,Void,Integer> task =
  new AsyncTask<Void,Void,Integer>() {
    Integer doInBackground(Void ...params) {
      ... do work on background thread ... return 3;
    }
    void onPostExecute(Integer result) {
      ... post-processing on UI thread ...
    }
  };
task.start();
```

- `Activity.runOnUiThread()`

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# APIs for Background Threads

- Java threads
- Handler API
- AsyncTask
- `Activity.runOnUiThread()`

```
public class MyActivity extends Activity
      implements LoaderManager.LoaderCallbacks<Cursor>{
  public void onLoadFinished(Loader<Cursor> loader,
                             Cursor cursor) {
    MyActivity.this.runOnUiThread(new Runnable(){
      public void run() {
        ... perform UI updates on the UI thread ...
      }
    }
  }
}
```

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# BROADCAST RECEIVER

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```
<?xml version="1.0" encoding="utf-8"?>
<manifest xmlns:android=http://schemas.android.com/apk/res/android ...>

    <uses-permission android:name="android.permission.INTERNET" />
    <uses-permission android:name="android.permission.WIFI" />
    <uses-permission android:name="android.permission.WRITE_EXTERNAL_STORAGE" /
>

    <application
        android:icon="@drawable/ic_launcher"
        android:label="@string/app_name" >
        <activity android:name=".ChatApp" ...>
        <provider ...>
        <service ...>

        <receiver android:name=".ChatApp.Receiver">
            <intent-filter>
               <action android:name="android.action.intent.PROVIDER_CHANGED”/>
            </intent-filter>
        </receiver>
    </application>

</manifest>
```

# Background Processing

```
public static final String NEW_MESSAGE_BROADCAST =
      "edu.stevens.cs522.chat.NewMessageBroadcast";

private class ReceiveMessageTask extends
               AsyncTask<Void, MessageInfo, Void> {

   protected Void doInBackground(Void... params) {

      while (true) {
         MessageInfo msg = nextMessage();
         addReceivedMessage(msg);
         ...
      }
   }

}
```

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# Background Processing

```
private class ReceiveMessageTask extends
               AsyncTask<Void, MessageInfo, Void> {

   private Intent msgUpdateBroadcast =
                  new Intent(NEW_MESSAGE_BROADCAST);

   public void addReceivedMessage(MessageInfo msg) {
      ContentResolver cr = getContentResolver();
      cr.insert(ChatContract.CONTENT_URI, ...);

      /*
       * Logic for updating the Messages cursor
       * is done on the UI thread.
       */
      sendBroadcast(msgUpdateBroadcast);
   }
```

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# Foreground Update

- Define broadcast receiver
  - Notification for UI updates
- Register when activity becomes active
- Unregister when activity becomes inactive

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# Broadcast Receiver

```
public class ChatApp extends Activity {

   CursorAdapter messageAdapter;

   public static class Receiver
                  extends BroadcastReceiver {
      public void onReceive (Context ctxt, Intent intent) {
         messageAdapter.swapCursor(...);
      };
   }

   Receiver receiver;

   public void onStart() { registerReceiver(receiver, filter); }

   public void onStop() { unregisterReceiver(receiver); }
```

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# NOTIFICATIONS

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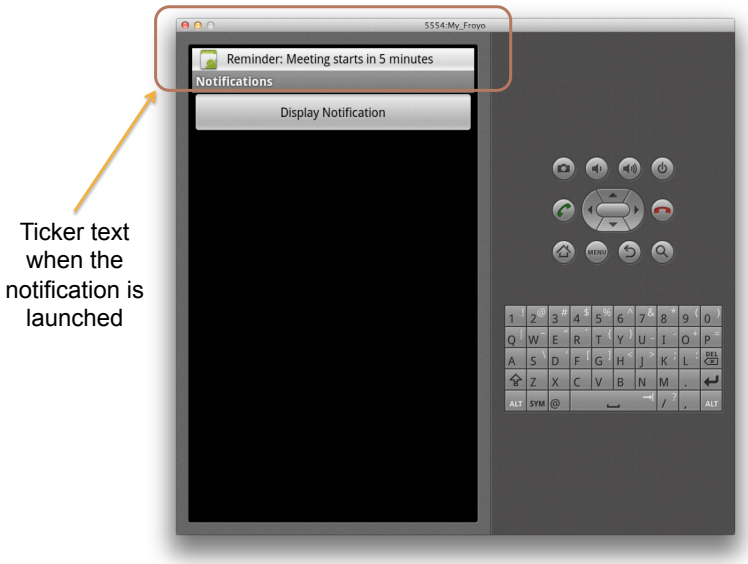


Ticker text when the notification is launched

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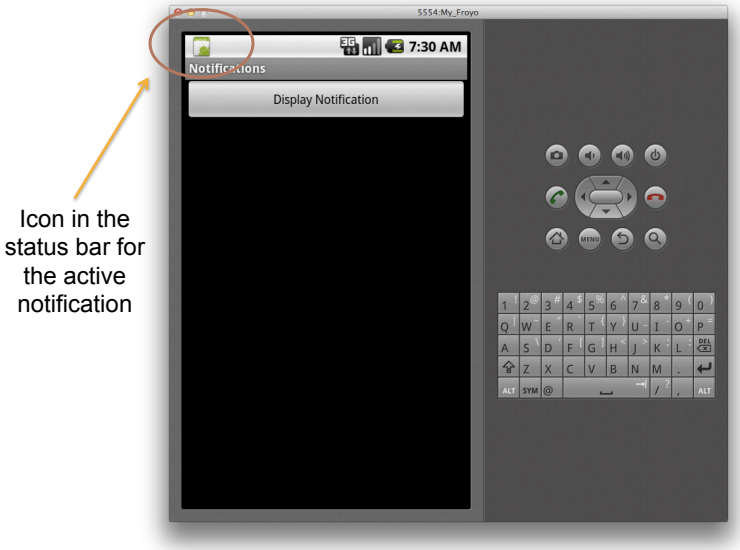


Icon in the status bar for the active notification

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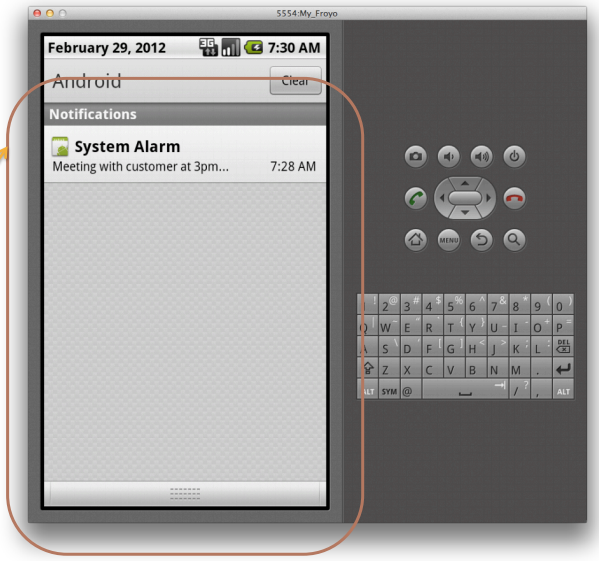


Extended status bar with further details

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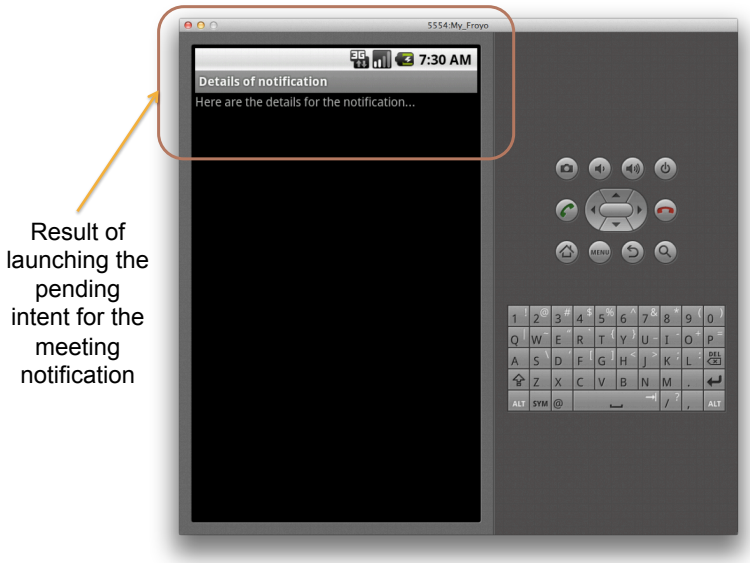


Result of launching the pending intent for the meeting notification

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# Notifications

- Creating a Notification

```
// Choose a drawable to display as the status bar icon
int icon = R.drawable.icon;

// Text to display in status bar when notify launched
String tickerText = "Notification";

// The extended status bar orders notification in time order
long when = System.currentTimeMillis();

Notification notification =
      new Notification(icon, tickerText, when);
```

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# Notifications

- Getting the Notification Manager

```
String svcName = Context.NOTIFICATION_SERVICE;

NotificationManager notificationManager;

notificationManager =
      (NotificationManager)getSystemService(svcName);
```

- Firing the notification

```
int notificationRef = 1;  // App-specific notify identifier
notificationManager.notify
      (notificationRef, notification);
```

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# Setting Notification Values

```
Context context = getApplicationContext();
// Text to display in the extended status window
String expandedText = "Extended status text";
// Title for the expanded status
String expandedTitle = "Notification Title";

// Intent to launch activity when extended text is clicked
Intent intent = new Intent(this, MyActivity.class);
PendingIntent launchIntent =
      PendingIntent.getActivity(context, 0, intent, 0);

notification.setLatestEventInfo(context,
                                expandedTitle,
                                expandedText,
                                launchIntent);
```

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## CONCLUSIONS

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# Conclusions

- Services
  - Started
  - Bound
- Thread management
  - Handlers
  - `AsyncTask` and `runOnUiThread`
- UI updates
  - Loader manager (last week)
  - Broadcast receiver
  - Notification

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