App Development for Smart Devices

CS 495/595 – Fall 2012

Lec #4: Services and Broadcast Receivers

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Objective

• Working in Background
  • Services
  • BroadcastReceiver
  • AsyncTask

• Student Presentations
  – Calling All Cars: Cell Phone Networks and the Future of Traffic
    • Presenter: Scott Corey
  – Mobile Crowdsensing: Current State and Future Challenges
    • Presenter: Anitam Das
  – Pocket, Bag, Hand, etc. -- Automatically Detecting Phone Context through Discovery
    • Presenter: Lulwah Alkwai
Android Application Components

- Activity
- Views
- Service
- Broadcast Receiver
- Content Provider
- Intents
- Widgets
Services
Services

• A Service is an application component that runs in the background, not interacting with the user, for an **indefinite** period of time.

• Higher priority than inactive Activities, so less likely to be killed
  • If killed, they can be configured to re-run automatically (when resources available)

• Each service class must have a corresponding `<service>` declaration in its package's `AndroidManifest.xml`
Services

• Services can be started with `Context.startService()` and `Context.bindService()`

• Execute in the main thread of the application’s process.
  • CPU intensive tasks must be offloaded to background threads using `Thread` or `AsyncTask`

• Alarms can be used to fire Intents at set times. These can start services, open Activities, or broadcast Intents
Services Lifecycle

- A Service has three lifecycle methods:

1. `void onCreate()`
2. `void onStartCommand()`
3. `void onDestroy()`
Creating a Service

```java
import android.app.Service;
import android.content.Intent;
import android.os.IBinder;

public class MyService extends Service {
    @Override
    public void onCreate() {
        // TODO: Actions to perform when service is created.
    }

    @Override
    public IBinder onBind(Intent intent) {
        // TODO: Replace with service binding implementation.
        return null;
    }

    @Override
    public int onStartCommand(Intent intent, int flags, int startId) {
        // TODO Launch a background thread to do processing.
        return Service.START_STICKY;
    }

    @Override
    public void onDestroy() {
        // TODO: Actions to perform when service is ended.
    }
}
```
onStartCommand

• Called whenever the Service is started with startService call
  
  – So beware: may be executed several times in Service’s lifetime!
  
  – Controls how system will respond if Service restarted (START_STICKY)
  
  – Run from main GUI thread, so standard pattern is to create a new Thread from onStartCommand to perform processing and stop Service when complete
Starting a Service

• Call startService

```
// Implicitly start a Service
Intent myIntent = new Intent(MyService.ORDER_PIZZA);
myIntent.putExtra("TOPPING", "Margherita");
startService(myIntent);

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

(To use this example, would need to include a ORDER_PIZZA constant in MyService class and use an Intent Filter to register the Service as a provider of ORDER_PIZZA)
Stopping a Service

• Call stopService

```java
ComponentName service = startService(new Intent(this, BaseballWatch.class));

// Stop a service using the service name.
stopService(new Intent(this, service.getClass()));

// Stop a service .
// try {
//    Class serviceClass = Class.forName(service.getClassName());
//    stopService(new Intent(this, serviceClass));
// } catch (ClassNotFoundException e) {}
```
Binding Activities to Services

• Activity maintains reference to a Service
• Activity can make calls on the Service just as any other instantiated class
• To support this, implement onBind for the Service

```java
private final IBinder binder = new MyBinder();

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

public class MyBinder extends Binder {
    MyService getService() {
        return MyService.this;
    }
}
```
Binding Activities to Services

- Once Service is bound, all public methods and properties are available through the `serviceBinder` object obtained from the `onServiceConnected` handler.
Binding Activities to Services

private MyService serviceBinder; // Reference to the service

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

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

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

    // Bind to the service
    Intent bindIntent = new Intent(MyActivity.this, MyService.class);
    bindService(bindIntent, mConnection, Context.BIND_AUTO_CREATE);
}
AsyncTask
Background threads

• To make app responsive, move all time-consuming operations off main app thread to child thread. **Very important!**

• Two options:
  – AsyncTask
  – Write own Threads
AsyncTask<Params, Progress, Result>

• Execution of asynchronous task goes through following main steps:
  
  • `doInBackground(Params...)`: used to perform background computation that can take a long time. The parameters of the asynchronous task are passed to this step. The result will be passed to `onPostExecute()`. `publishProgress(Progress...)` is used to publish one or more units of progress by calling `onProgressUpdate(Progress...)`.
  
  • `onProgressUpdate(Progress...)`: invoked after a call to `publishProgress(Progress...)`. Used to display any form of progress in the user interface while the background computation is still executing. For instance, it can be used to animate a progress bar or show logs in a text field.
  
  • `onPostExecute(Result)`: invoked after the background computation finishes. The result of the background computation is passed to this step as a parameter.
Creating AsyncTask

```java
private class DownloadFilesTask extends AsyncTask<URL, Integer, Long> {
    @Override
    protected Long doInBackground(URL... urls) { //Background thread. Do not interact with UI
        int myProgress = 0; long result=0;
        // [... Perform background processing task, update myProgress ...]
        PublishProgress(myProgress)
        // [... Continue performing background processing task ...]

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

    @Override
    protected void onProgressUpdate(Integer... progress) { //Post interim updates to UI thread; access UI
        // [... Update progress bar, Notification, or other UI element ...]
    }

    @Override
    protected void onPostExecute(Long result) { //Run when doInBackground completed; access UI
        // [... Report results via UI update, Dialog, or notification ...]
        showDialog("Downloaded " + result + " bytes");
    }
}

new DownloadFilesTask().execute(url1, url2, url3); //this call in onStartCommand()
```
BroadcastReceivers
BroadcastReceiver

• Component that responds to system-wide broadcast announcements.

• Example system broadcasts: screen has turned off, the battery is low, user is present using phone, or a picture was captured.

• Applications can initiate broadcasts—e.g., to let other applications know that some data has been downloaded to the device and is available for them to use.

• Don’t display a UI, but can create a status bar notification to alert the user when a broadcast event occurs.
BroadcastReceiver

• Usually, a broadcast receiver is just a "gateway" to other components and is intended to do a very minimal amount of work. For instance, it might initiate a service to perform some work based on the event.

  – Important: you must complete tasks in a BroadcastReceiver within <10s. If you have a task that will take longer, you must start a new thread to avoid app assassin OS.
The system delivers a broadcast Intent to all interested broadcast receivers, which handle the Intent sequentially.
BroadcastReceiver Lifecycle

A broadcast receiver has a single callback method:

```java
void onReceive(Context curContext, Intent broadcastMsg)
```

1. When a broadcast message arrives to a receiver, Android calls its onReceive() method and passes it the Intent object containing the message.

2. The broadcast receiver is considered to be active only while it is executing this method.

3. When onReceive() returns, it is inactive.
Example

• Starting Broadcast

```java
public static final String NEW_LIFEFORM_DETECTED = "com.paad.action.NEW_LIFEFORM";

Intent intent = new Intent(NEW_LIFEFORM_DETECTED);
intent.putExtra("lifeformName", lifeformType);
sendBroadcast(intent);
```

• BroadcastReceiver

```java
import android.content.BroadcastReceiver;
import android.content.Intent;
import android.content.Context;

public class MyBroadcastReceiver extends BroadcastReceiver {

    @Override
    public void onReceive(Context context, Intent intent) {
        // TODO: React to the Intent received.
    }
}
```
Manifest

The manifest of applications using Android Services must include:

If the application defines a BroadcastReceiver as an independent class, it must include a `<receiver>` clause identifying the component. In addition an `<intent-filter>` entry is needed to declare the actual filter the service and the receiver use.
<?xml version="1.0" encoding="utf-8"?>
<manifest xmlns:android="http://schemas.android.com/apk/res/android"
    package="cs495.demos" android:versionCode="1" android:versionName="1.0.0">
    <uses-sdk android:minSdkVersion="4" /></uses-sdk>

<application android:icon="@drawable/icon" android:label="@string/app_name">
    <activity android:name=".MyServiceDriver2"
        <intent-filter>
            <action android:name="android.intent.action.MAIN" />
            <category android:name="android.intent.category.LAUNCHER" />
        </intent-filter>
    </activity>

    <service android:name=".MyService2" />

    <receiver android:name=".MyBroadcastReceiver"
        <intent-filter>
            <action android:name="com.paad.action.NEW_LIFEFORM" />
        </intent-filter>
    </receiver>
</application>
</manifest>
Native Broadcasts

- ACTION_BOOT_COMPLETED
- ACTION_CAMERA_BUTTON
- ACTION_DATE_CHANGED and ACTION_TIME_CHANGED
- ACTION_MEDIA_BUTTON
- ACTION_MEDIA_EJECT
- ACTION_MEDIA_MOUNTED and ACTION_MEDIA_UNMOUNTED
- ACTION_SCREEN_OFF and ACTION_SCREEN_ON
- ACTION_TIMEZONE_CHANGED

For comprehensive list:
http://code.google.com/android/reference/android/content/Intent.html
WakeLock
Device Power

• Just because you have code in a BroadcastReceiver or Service doesn’t mean it will run if the phone goes into a low-power state

• Common problem: create a Broadcast receiver. Create a thread from within it to run code....

• All works fine when phone is on and plugged into computer during development

• Fails under normal use because phone shuts down quickly in power management state

• Need to use a WakeLock!
WakeLock

• Control the power state on device (somewhat)

• Used to
  – Keep the CPU running
  – Prevent screen dimming or going off
  – Prevent backlight from turning on

• Only use when necessary and release as quickly as possible

• Need to request the `android.permission.WAKE_LOCK` permission in the `<uses-permission>` element of the manifest file.
Creating a WakeLock

PowerManager pm = (PowerManager)getSystemService(Context.POWER_SERVICE);
WakeLock wakeLock = pm.newWakeLock(PowerManager.PARTIAL_WAKE_LOCK,
"MyWakeLock");
wakeLock.acquire();
[ ... Do things requiring the CPU stay active ... ]
wakeLock.release();

PARTIAL_WAKE_LOCK keeps the CPU running without the screen on

<table>
<thead>
<tr>
<th>Flag Value</th>
<th>CPU</th>
<th>Screen</th>
<th>Keyboard</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTIAL_WAKE_LOCK</td>
<td>On*</td>
<td>Off</td>
<td>Off</td>
</tr>
<tr>
<td>SCREEN_DIM_WAKE_LOCK</td>
<td>On</td>
<td>Dim</td>
<td>Off</td>
</tr>
<tr>
<td>SCREEN_BRIGHT_WAKE_LOCK</td>
<td>On</td>
<td>Bright</td>
<td>Off</td>
</tr>
<tr>
<td>FULL_WAKE_LOCK</td>
<td>On</td>
<td>Bright</td>
<td>Bright</td>
</tr>
</tbody>
</table>
Project Ideas
Project’s Idea

• Security
  • ODU Secure App

• Localization
  • Taking random pictures from your cell at home when it is on a table. Could you locate the phone using the ceiling feature?

• Medical/health/activity monitoring
  • Parkin's disease detection
  • EEG Set

• Transportation
  • Detecting and identifying whether group of people are on the same transport unit using correlation of accelerometer, gyro, …
Project’s Idea

• Education
  • Engineering management game

• Misc
  • Understanding Interface activities power consumption
  • Extension of MagnoTricoder
  • Bird Sound Detection

• Last Year Projects:
  • http://www.cs.odu.edu/~nadeem/classes/cs495-F11/projects.htm
Questions?
To Do

• Find Your Team
• Think of your project

• Example 1 (in this slides)
• Example 2 (in this slides)
Example 1. A very Simple Service

- The main application starts a service. The service prints lines on the DDMS LogCat until the main activity stops the service.

```java
// a simple service is started & stopped
package cs495.demos;
import android.app.Activity;
import android.content.ComponentName;
import android.content.Intent;
import android.content.Intent;
import android.os.Bundle;
import android.view.View;
import android.view.View.OnClickListener;
import android.widget.*;
public class ServiceDriver1 extends Activity {
    TextView txtMsg;
    Button btnStopService;
    ComponentName service;
    Intent intentMyService;
```
Example 1. cont’d

```java
@Override
public void onCreate(Bundle savedInstanceState) {
    super.onCreate(savedInstanceState);
    setContentView(R.layout.main);
    txtMsg = (TextView) findViewById(R.id.txtMsg);

    intentMyService = new Intent(this, MyService1.class);
    service = startService(intentMyService);

    btnStopService = (Button) findViewById(R.id.btnStopService);
    btnStopService.setOnClickListener(new OnClickListener() {
        public void onClick(View v) {
            try {
                stopService(intentMyService);
                txtMsg.setText("After stoppingService: \n" + service.getClassName());
            } catch (Exception e) {
                Toast.makeText(getApplicationContext(), e.getMessage(), 1).show();
            }
        }
    });
}
```
Example 1. cont’d - Service

//non CPU intensive service running the main task in its main thread
package cs495.demos;
Import android.app.Service;
Import android.content.Intent;
Import android.os.IBinder;
Import android.util.Log;

public class MyService1 extends Service {
    @Override
    public IBinder onBind(Intent arg0) {
        return null;
    }
    @Override
    public void onCreate() {
        super.onCreate();
        Log.i("<<MyService1-onStart>>", "I am alive-1!");
    }
    @Override
    public void onStart(Intent intent, intstartId) {
        super.onStart(intent, startId);
        Log.i("<<MyService1-onStart>>", "I did something very quickly");
    }
    @Override
    public void onDestroy() {
        super.onDestroy();
        Log.i("<<MyService1-onDestroy>>", "I am dead-1");
    }
} //MyService1
Example 1. cont’d - Manifest

```xml
<?xml version="1.0" encoding="utf-8"?>
<manifest xmlns:android="http://schemas.android.com/apk/res/android"
    package="cs495.demos"
    android:versionCode="1"
    android:versionName="1.0">

    <application android:icon="@drawable/icon"
        android:label="@string/app_name">
        <activity android:name=".ServiceDriver1"
            android:label="@string/app_name">
            <intent-filter>
                <action android:name="android.intent.action.MAIN" />
                <category android:name="android.intent.category.LAUNCHER" />
            </intent-filter>
        </activity>
        <service android:name=".MyService1" />
    </application>

    <uses-sdk android:minSdkVersion="4" />
</manifest>
```
Example 1. cont’d - Layout

```xml
<?xml version="1.0" encoding="utf-8"?>

<AbsoluteLayout
    android:id="@+id/widget32"
    android:layout_width="fill_parent"
    android:layout_height="fill_parent"
    xmlns:android="http://schemas.android.com/apk/res/android"
/>

<EditText
    android:id="@+id/txtMsg"
    android:layout_width="fill_parent"
    android:layout_height="120px"
    android:textSize="18sp"
    android:layout_x="0px"
    android:layout_y="57px"
/>

<Button
    android:id="@+id/btnStopService"
    android:layout_width="151px"
    android:layout_height="wrap_content"
    android:text="Stop Service"
    android:layout_x="43px"
    android:layout_y="200px">
</Button>
</AbsoluteLayout>
```
Example 1. cont’d - Running

According to the Log
1. Main Activity is started (no displayed yet)
2. Service is started (onCreate, onStart)
3. Main Activity UI is displayed
4. User stops Service
Example 2. Realistic Activity-Service Interaction

1. The main activity starts the service and registers a receiver.

2. The service is slow, therefore it runs in a parallel thread its time consuming task.

3. When done with a computing cycle, the service adds a message to an intent.

4. The intents broadcasted using the filter: cs495.action.DEMO2

5. A BroadcastReceiver(defined inside the main Activity) uses the previous filter and catches the message (displays the contents on the main UI).

6. At some point the main activity stops the service and finishes executing.
Example 2. cont’d - Layout

```xml
<?xml version="1.0" encoding="utf-8"?>
<LinearLayout
    android:id="@+id/widget32"
    android:layout_width="fill_parent"
    android:layout_height="fill_parent"
    android:orientation="vertical"
    xmlns:android="http://schemas.android.com/apk/res/android">
    <EditText
        android:id="@+id/txtMsg"
        android:layout_width="fill_parent"
        android:layout_height="120px"
        android:textSize="12sp"/>
    <Button
        android:id="@+id/btnStopService"
        android:layout_width="151px"
        android:layout_height="wrap_content"
        android:text="Stop Service"/>
</LinearLayout>
```
Example 2. cont’d - Manifest

```xml
<?xml version="1.0" encoding="utf-8"?>
<manifest xmlns:android="http://schemas.android.com/apk/res/android"
    package="cis493.demos"
    android:versionCode="1"
    android:versionName="1.0.0">
    <uses-sdk android:minSdkVersion="4"></uses-sdk>
    <application android:icon="@drawable/icon" android:label="@string/app_name">
        <activity android:name=".MyServiceDriver"
            android:label="@string/app_name">
            <intent-filter>
                <action android:name="android.intent.action.MAIN"/>
                <category android:name="android.intent.category.LAUNCHER"/>
            </intent-filter>
        </activity>
        <service android:name="MyService"/>
    </application>
</manifest>
```
Example 2. cont’d – Main Activity

// Application logic and its BroadcastReceiver in the same class
package cs495.demos;
import java.util.Date;
import android.app.Activity;
import android.content.BroadcastReceiver;
import android.content.ComponentName;
import android.content.Context;
import android.content.Intent;
import android.content.IntentFilter;
import android.os.Bundle;
import android.os.SystemClock;
import android.util.Log;
import android.view.View;
import android.view.View.OnClickListener;
import android.widget.*;

public class MyServiceDriver extends Activity {
    TextView txtMsg;
    Button btnStopService;
    Component Nameservice;
    Intent intentMyService;
    BroadcastReceiver receiver;
}
Example 2. cont’d – Main Activity

```java
@override
public void onCreate(Bundle savedInstanceState) {
    super.onCreate(savedInstanceState);
    setContentView(R.layout.main);
    txtMsg = (TextView) findViewById(R.id.txtMsg);

    intentMyService = new Intent(this, MyService.class);
    service = startService(intentMyService);

    txtMsg.setText("MyService started -(see DDMS Log)");
    btnStopService = (Button) findViewById(R.id.btnStopService);
    btnStopService.setOnClickListener(new OnClickListener() {
        public void onClick(View v) {
            try {
                stopService(new Intent(intentMyService));
                txtMsg.setText("After stopingService: 
" + service.getClassName());
            } catch (Exception e) {
                e.printStackTrace();
            }
        }
    });
} }
```
Example 2. cont’d – Main Activity

// register & define filter for local listener
IntentFilter mainFilter = new IntentFilter("cs495.action.DEMO2");
receiver = new MyMainLocalReceiver();
registerReceiver(receiver, mainFilter);
} //onCreate

@override
protected void onDestroy() {
    super.onDestroy();
    try {
        stopService(intentMyService);
        unregisterReceiver(receiver);
    } catch (Exception e) {
        Log.e("MAIN-DESTROY>>>", e.getMessage());
    }
    Log.e("MAIN-DESTROY>>>", "Adios");
} //onDestroy

register
unregister
Example 2. cont’d – Main Activity

////////////////////////////////////////////////////////////////////
// local (embedded) RECEIVER

public class MyMainLocalReceiver extends BroadcastReceiver{
    @Override
    public void onReceive(Context localContext, Intent callerIntent) {
        String serviceData = callerIntent.getStringExtra("serviceData");
        Log.e("MAIN>>>", serviceData + " -receiving data ", SystemClock.elapsedRealtime());

        String now = "\n" + serviceData + " ---" + new Date().toLocaleString();
        txtMsg.append(now);
    }
} //MyMainLocalReceiver

} //MyServiceDriver
Example 2. cont’d – The Service

// Service uses a thread to run slow operation
package cs495.demos;

import android.app.Service;
import android.content.Intent;
import android.os.IBinder;
import android.util.Log;

public class MyService extends Service {
    boolean isRunning = true;

    @Override
    public IBinder onBind(Intent arg0) {
        return null;
    }

    @Override
    public void onCreate() {
        super.onCreate();
    }
}
Example 2. cont’d – The Service

```java
@override
public void onStart(Intent intent, int startId) {
    super.onStart(intent, startId);
    Log.e("<<MyService-onStart>>", "I am alive!");
    // we place the slow work of the service in its own thread
    // so the caller is not hung up waiting for us
    Thread triggerService = new Thread (new Runnable() {
        long startingTime = System.currentTimeMillis();
        long tics = 0;
        public void run() {
            for (int i=0; (i< 120) & isRunning; i++) { //at most 10 minutes
                try {
                    //fake that you are very busy here
                    tics = System.currentTimeMillis() - startingTime;
                    Intent myFilteredResponse = new Intent("cs495.action.DEMO2");
                    String msg = i+ " value: " + tics;
                    myFilteredResponse.putExtra("serviceData", msg);
                    sendBroadcast(myFilteredResponse);
                    Thread.sleep(1000); //five seconds
                } catch(Exception e) { e.printStackTrace(); }
            } //for
        } //run
    });
    triggerService.start();
} //onStart
```
Example 2. cont’d – The Service

```java
@Override
public void onDestroy() {
    super.onDestroy();
    Log.e("<<MyService-onDestroy>>", "I am dead");
    isRunning = false;
} //onDestroy

} //MyService
```

Stop thread