Component Technologies on Google Android

Master Seminar

Michael Eckel

University of Applied Sciences Gießen-Friedberg
Department of Mathematics, Natural Sciences and Computing

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ANDROID

Outline

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What is Android?

- Mobile Operating System
- Developed by Google
- First version released in 2008
- Largely open-source
- Based on Linux 2.6
- Programming is done in Java

System Architecture

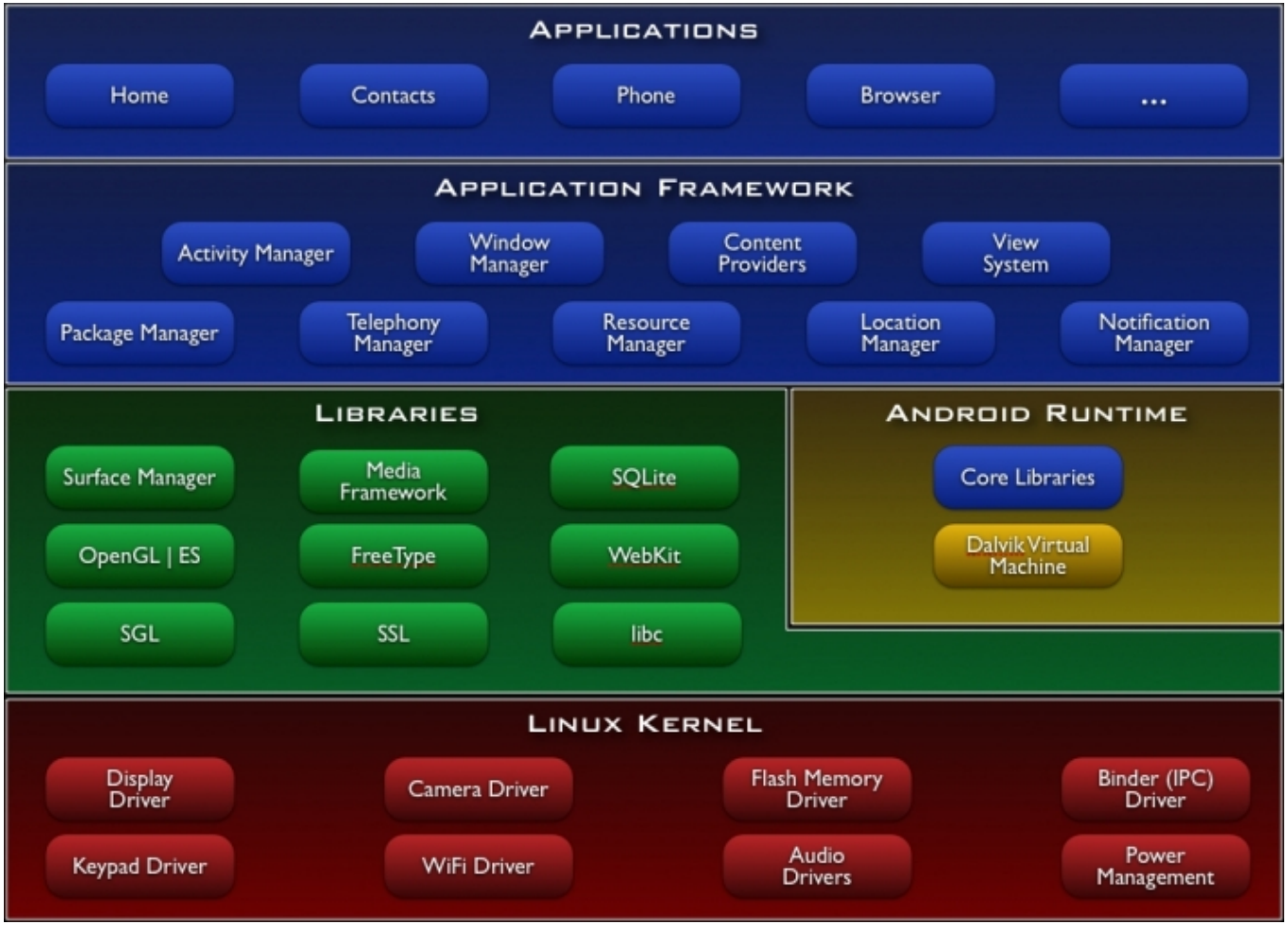

Figure: System architecture of Android

Source: `http://developer.android.com/images/system-architecture.jpg`

What is the Dalvik Virtual Machine (DVM)?

- Developed by Google
- Based on Apache Harmony
- Optimized for mobile devices
- Makes use of processor registers (unlike the JVM)
  - Register machine vs. Pushdown automaton
- Executes DEX bytecode (*Not Java bytecode!*)

DEX bytecode

- Much more compact than Java bytecode
- But does *not* support
  - all Java language features (e. g. *Reflection*)
  - the whole Java framework (e. g. Swing, AWT, . . .)

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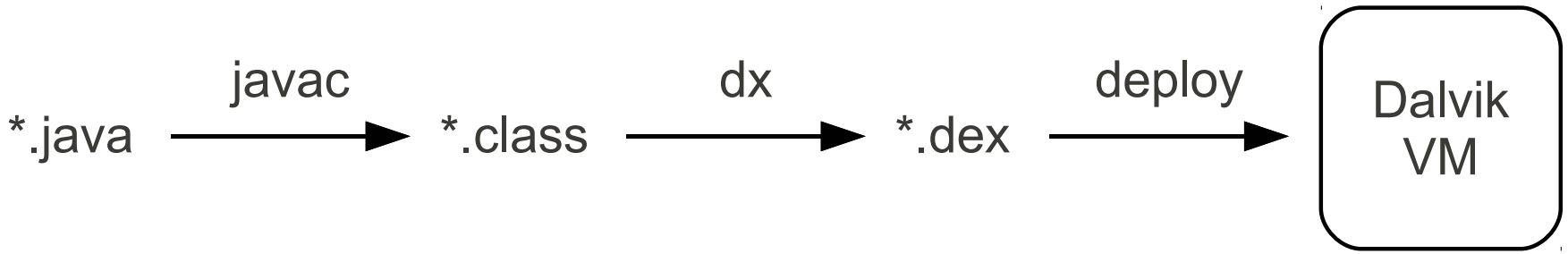

Figure: How to create DEX bytecode from Java sourcecode

Android Applications

- Android applications consist of
  - DEX bytecode
  - Ressources (e. g. images, sounds, . . .)
  - Data (e. g. SQLite databases, XML files, . . .)
- They are subject to a lifecycle
- . . . and are executed in a *sandbox*
- One Linux process per application
- One DVM per application
- Own UID and GID

Outline

Definition of a Software Component

Definition by the European Conference on Object-Oriented Programming (ECOOP) in 1996:

> *"A software component is a unit of composition with contractually specified interfaces and explicit context dependencies only. A software component can be deployed independently and is subject to composition by third parties."*

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In short:

1. Contractually specified interface
2. Explicit context dependencies
3. Independent deployment

What is a Component Model?

Components must conform to a component model!

A component model specifies the following:

- Form and properties of components
- How components interact with each other
- How components can be combined

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Components in Android

- Activities
  - Interaction with the user
  - Presentation of the user interface
- Services
  - Used to run background tasks
  - They do not have an user interface
- Content Providers
  - Providing data to other applications
  - "Break out" from the sandbox
- Broadcast Receivers
  - Receive broadcasts (from Android system or other applications)

Outline

Communication between Components

- Is done via *Intents* and *Intent Filters*
- Intent announces wish for communication
- Intent Filter receives this wish
- Intent must match conditions of the Intent Filter

Intent Filters

- Are *explicitly* defined in the Android manifest (`AndroidManifest.xml`)
- That complies to point 1 of the definition of a component

```
...
<receiver android:name="org.example.MyReceiver">
  <intent-filter>
    <action android:name="org.example.TEST" />
  </intent-filter>
</receiver>
...
```

Intents

- Are *not explicitly* defined anywhere
  - Only in the Java code
  - (Maybe) violates point 2 of the definition of a component
  - It is up to the programmer to document the interface
  - Would be nice to see all dependencies explicitly
- Explicit vs. implicit Intents

```
/* explicit intent */
Intent ei = new Intent(org.example.MyReceiver.class);

/* implicit intent */
Intent ii = new Intent("org.example.TEST");
```

Sending an Intent

- Equipping additional data

```
Intent i = new Intent(Intent.ACTION_SENDTO);
i.setData(Uri.parse("mailto:you@mail.com"));
i.putExtra(Intent.EXTRA_SUBJECT, "Lottery");
i.putExtra(Intent.EXTRA_TEXT, "You won the Jackpot!");
startActivity(i);
```

- An appropriate application is being invoked

Outline

Realization of a Plugin System in Android

Involved Components

- Basic Application
- Plugins

Every component is realized as an own application!

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Communication

- **Basic Application**
  - Sends a broadcast on startup
  - Waits for answer from plugins
- **Plugins**
  - Wait for broadcast from basic application
  - Send answer broadcast to basic application

Basic Application

Request all plugins on startup...

```
...
public class BasicApplication extends Activity {
  @Override
  public void onCreate(Bundle savedInstanceState) {
    ...
    /* request all plugins */
    Intent i = new Intent("org.example.REQUEST_PLUGIN");
    sendBroadcast(i);
    ...
  }
  ...
}
...
```

Basic Application

Intent Filter for receiving response from plugins

```
...
<receiver android:name=".BasicApplicationResponseReceiver">
  <intent-filter>
    <action android:name="org.example.PLUGIN_RESPONSE" />
  </intent-filter>
</receiver>
...
```

Basic Application

Broadcast Receiver for receiving response from plugins

```
...
public class BasicApplicationResponseReceiver extends
     BroadcastReceiver {
  @Override
  public void onReceive(Context context, Intent intent) {
    /* process plugin answer */
    String packageName = intent.getStringExtra("package_name");
    ...
  }
}
...
```

Plugins

Intent Filter and Broadcast Receiver for plugins

```
...
<receiver android:name=".Plugin1RequestReceiver">
  <intent-filter>
    <action android:name="org.example.REQUEST_PLUGIN" />
  </intent-filter>
</receiver>
...
```

```
...
public class Plugin1RequestReceiver extends BroadcastReceiver {
@Override
  public void onReceive(Context context, Intent intent) {
    /* send broadcast response to basic application */
    Intent i = new Intent("org.example.PLUGIN_RESPONSE");
    i.putExtra("package_name", context.getPackageName());
    context.sendBroadcast(i);
  }
}
...
```

Android's Component System
Conclusion

- Plugin systems are easy to realize
- Plugins can be deployed independently
- So point 3 of the definition of a component is fulfilled

WebSMS

- Realizes a similiar plugin system
- Is open-source
- Text messages can be sent over online services
- Instead of the cellular phone network
- `https://github.com/felixb/websms/`

Outline

What is OSGi?

OSGi is a dynamic module system for Java and is specified by the OSGi Alliance.

> *"OSGi technology is Universal Middleware. OSGi technology provides a service-oriented, component-based environment for developers and offers standardized ways to manage the software lifecycle. These capabilities greatly increase the value of a wide range of computers and devices that use the Java™ platform."*

No further explanation will be given at this point.

Why running OSGi on Android?

There are several advantages:

- OSGi specific features are needed
- Porting an existing OSGi application to Android
- Reusing an already existing OSGi component/bundle

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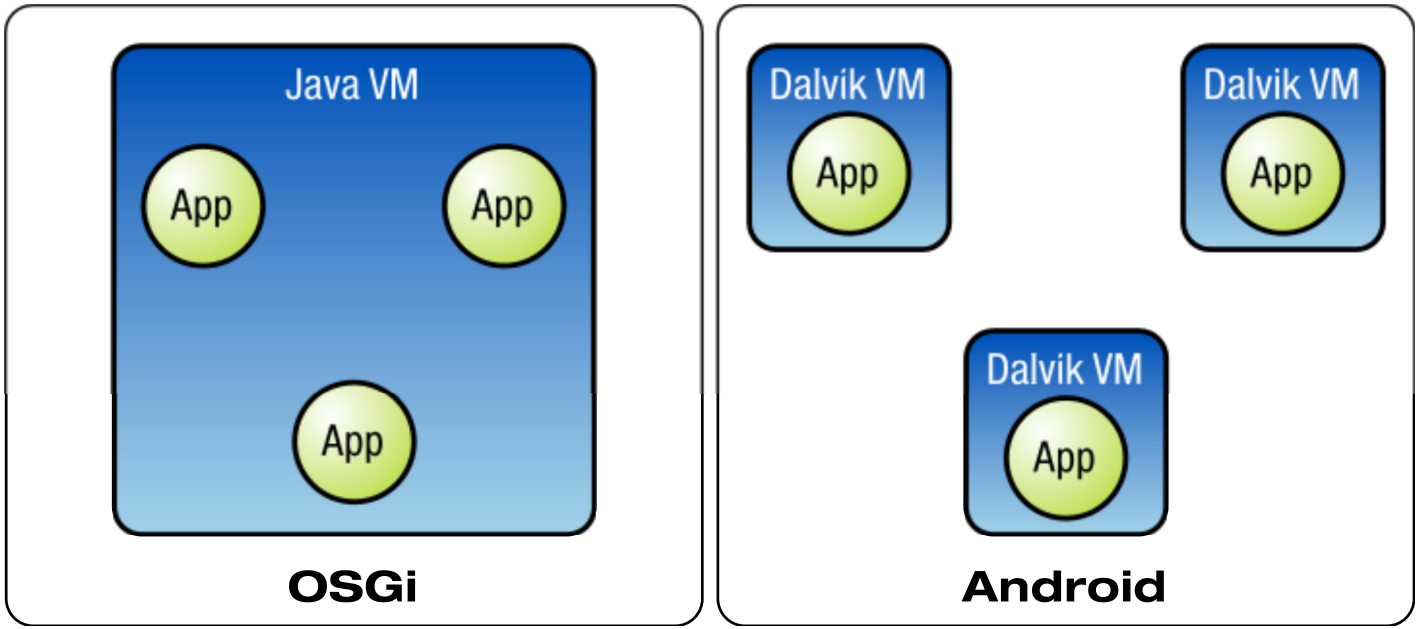
OSGi vs. Android's Component System



- No need for IPC (overhead)
- On crash only one application crashes

Source: http://felix.apache.org/site/presentations.data/OSGi%20on%20Google%20Android%20using%20Apache%20Felix.pdf

Outline

OSGi Components on Android

OSGi frameworks for Android

- Apache Felix successfully ported to Android
- R-OSGi is also available

Running OSGi components on Android (I)

There are two simple steps to follow:

1. Create a normal OSGi bundle, e. g. `Dummy.jar` with following contents:
   - `META-INF/MANIFEST.MF`
   - `org/example/Dummy.class`
   - `org/example/impl/DummyImpl.class`

   The interface `org.example.Dummy` must be exposed in the manifest file
2. Convert the bundle to Dalvik format using *dx* tool:

   ```
   dx --dex --output=DummyDex.jar Dummy.jar
   ```

   The contents now should be as follows:
   - `META-INF/MANIFEST.MF`
   - `classes.dex`

Running OSGi components on Android (II)

R-OSGi needs exposed interfaces to be available as `.class` file:

- `META-INF/MANIFEST.MF`
- `classes.dex`
- `org/example/Dummy.class`

Now the JAR is ready for deployment

Outline

ROCS

What is ROCS?

ROCS (Remote OSGi Caching Service) is a remotely provisioned OSGi framework for ambient/mobile systems.

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Why ROCS?

For providing OSGi bundles to mobile devices by directly loading them from network into the devices main memory.

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Why ROCS?

For providing OSGi bundles to mobile devices by directly loading them from network into the devices main memory.

Advantages

- Administrators need to manage only one application repository
- Security constraints can be checked/enforced at a single point
- No need for installing software
- ...

Outline

ROCS on OSGi

- ROCS uses Java's remote class loading mechanisms
- Resources are directly loaded into memory
- Loading resources from network is similar to loading from a slow flash drive

Outline

OSGi Issues

- OSGi has one drawback:
  - Bundles are deployed into a local cache before they are loaded into the device's memory
- Normally done by using a local file system cache
- Cache stores all currently installed bundles
- Remote bundles are loaded as follows:
  - Bundle Repository $\rightarrow$ Device's Local Cache $\rightarrow$ Device's Main Memory

Outline

The ROCS Architecture

Consists of:

- Mobile devices (with ROCS OSGi frameworks)
- Remote cache servers (ROCS servers)

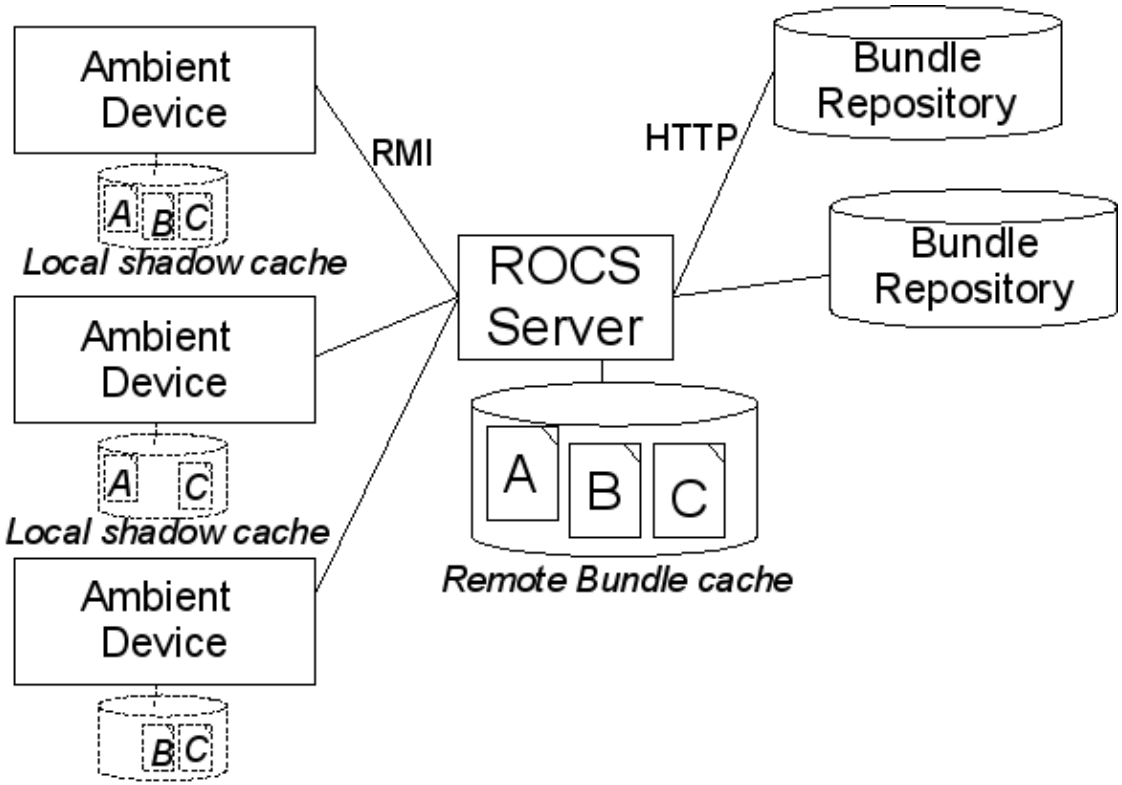

Figure: The ROCS Architecture [OP08]

ROCS Bundle Loading

- With ROCS bundles are loaded as follows:
  - Bundle Repository → ROCS Server's Local Cache → Device's Main Memory

Outline

Conclusion

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   - Communication between Components
   - Realization of a Plugin System in Android

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3. **OSGi on Android**
   - Differences between OSGi and Android's Component System
   - OSGi Components on Android

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3. **OSGi on Android**
   - Differences between OSGi and Android's Component System
   - OSGi Components on Android
4. **ROCS: a Remotely Provisioned OSGi Framework**
   - ROCS on OSGi
   - OSGi Issues
   - The ROCS Solution

Conclusion

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Thank you for listening!

Source: http://commons.wikimedia.org/wiki/File:Android_robot_skateboarding.svg

Questions?