UNIVERSAL SIM CARD USING TSM

Project Report submitted in partial fulfillment of the requirement for the degree

of

Bachelor of Technology

in

Computer Science & Engineering

Under the Supervision of

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By

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To

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CERTIFICATE

This is to certify that project report entitled “UNIVERSAL SIM CARD USING TSM”, submitted by GAURAV ROY (111299) in partial fulfillment for the award of degree of Bachelor of Technology in Computer Science & Engineering to Jaypee University of Information Technology, Waknaghat, Solan has been carried out under my supervision.

This work has not been submitted partially or fully to any other University or Institute for the award of this or any other degree or diploma.

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ACKNOWLEDGEMENT

I would like to express my gratitude to all those who gave us the possibility to complete this project. I want to thank the Department of CSE & IT in JUIT for giving us the permission to commence this project in the first instance, to do the necessary research work.

I am deeply indebted to my project guide **Ms. Nishtha Ahuja**, whose help, stimulating suggestions and encouragement helped me in all the time of research on this project. I feel motivated and encouraged every time I get his encouragement. For her coherent guidance throughout the tenure of the project, I feel fortunate to be taught by her, who gave me her unwavering support.

I am also grateful to **Mr. Amit Singh (CSE Project lab**) for his practical help and guidance

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ABSTRACT

This application is a generic free stash application using Smart Card API implementation. It allows the user to store his basic details on secure element (SE) which can be used in case of emergency.

SE is found on the UICC (Universal Integrated Circuit Card) of every Android phone, but the platform currently doesn't allow access to it. Recent devices come with NFC support, which is often combined with an embedded secure element chip, usually in the same package and can access SE using TSM (trusted service manager). Also the SE can be accessed after taking permission from mobile network operators directly but it is expensive. A TSM is a role in a near field communication ecosystem. It acts as a neutral broker that sets up business agreements and technical connections with mobile network operators, phone manufacturers or other entities controlling the secure element on mobile phones. The objective is to read and write data on the secure element located on a NFC Chip with the help of TSM.

PROBLEM STATEMENT

To develop a Storage application which allows users to store their basic and secure information on a portable storage which in future can be used by others/himself in case of any emergency especially life-death situation.

MOTIVATION

Main motivation of creating this application is to allow users to share their basic information's and make call to their emergency contacts at the time of emergency with just a click. Also an SMS will be sent on the emergency contact numbers about the location and coordinates of the user. This may be extremely helpful in life-death situation.

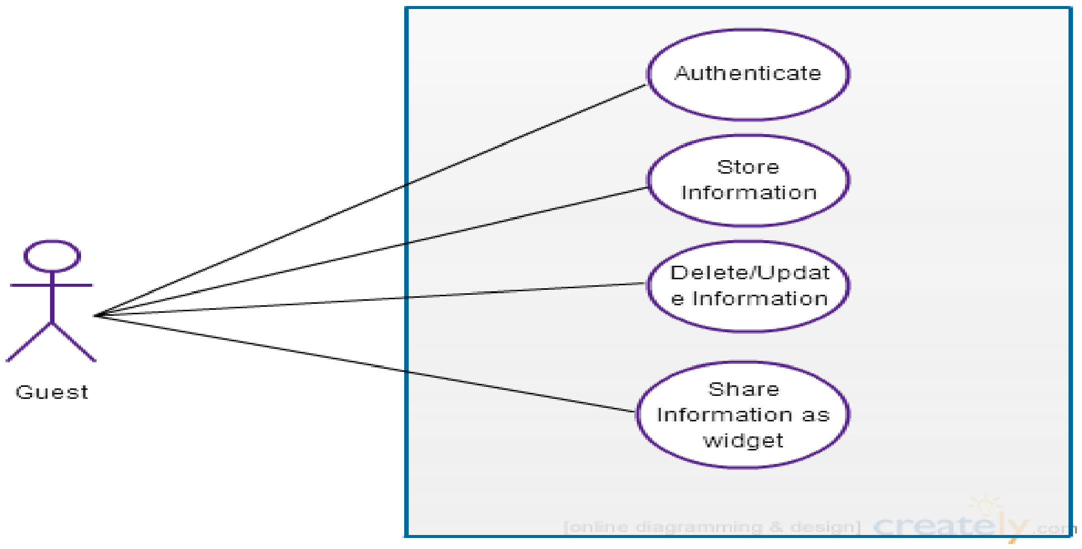
Authenticate
Store Information
Delete/Update Information
Share Information as widget
Guest
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Fig I - Use Case for Universal SIM Card

CHAPTER 1

INTRODUCTION TO ANDROID DEVELOPMENT

Android provides a rich application framework that allows you to build innovative apps and games for mobile devices in a Java language environment. The documents listed in the left navigation provide details about how to build apps using Android's various APIs.

If you're new to Android development, it's important that you understand the following fundamental concepts about the Android app framework.

- **Applications provide multiple entry points**

  Android apps are built as a combination of distinct components that can be invoked individually. For instance, an individual activity provides a single screen for a user interface, and a service independently performs work in the background.

  From one component you can start another component using an intent. You can even start a component in a different app, such an activity in a maps app to show an address. This model provides multiple entry points for a single app and allows any app to behave as a user's "default" for an action that other apps may invoke.

- **Applications adapt to different devices**

  Android provides an adaptive app framework that allows you to provide unique resources for different device configurations. For example, you can create different XML layout files for different screen sizes and the system determines which layout to apply based on the current device's screen size.

  You can query the availability of device features at runtime if any app features require specific hardware such as a camera. If necessary, you can also declare features your app requires so app markets such as Google Play Store do not allow installation on devices that do not support that feature.

1.1 Application Fundamentals

Android apps are written in the Java programming language. The Android SDK tools compile your code—along with any data and resource files—into an APK: an Android package, which is an archive file with an .apk suffix. One APK file contains all the contents of an Android app and is the file that Android-powered devices use to install the app.

Once installed on a device, each Android app lives in its own security sandbox:

The Android operating system is a multi-user Linux system in which each app is a different user.

By default, the system assigns each app a unique Linux user ID (the ID is used only by the system and is unknown to the app). The system sets permissions for all the files in an app so that only the user ID assigned to that app can access them.

Each process has its own virtual machine (VM), so an app's code runs in isolation from other apps.

By default, every app runs in its own Linux process. Android starts the process when any of the app's components need to be executed, then shuts down the process when it's no longer needed or when the system must recover memory for other apps.

In this way, the Android system implements the principle of least privilege. That is, each app, by default, has access only to the components that it requires to do its work and no more. This creates a very secure environment in which an app cannot access parts of the system for which it is not given permission.

However, there are ways for an app to share data with other apps and for an app to access system services:

It's possible to arrange for two apps to share the same Linux user ID, in which case they are able to access each other's files. To conserve system resources, apps with the same user ID can also arrange to run in the same Linux process and share the same VM (the apps must also be signed with the same certificate).

An app can request permission to access device data such as the user's contacts, SMS messages, the mountable storage (SD card), camera, Bluetooth, and more. All app permissions must be granted by the user at install time.

That covers the basics regarding how an Android app exists within the system. The rest of this document introduces you to:

The core framework components that define your app.

The manifest file in which you declare components and required device features for your app.

Resources that are separate from the app code and allow your app to gracefully optimize its behavior for a variety of device configurations.

1.2 Application Components

App components are the essential building blocks of an Android app. Each component is a different point through which the system can enter your app. Not all components are actual entry points for the user and some depend on each other, but each one exists as its own entity and plays a specific role—each one is a unique building block that helps define your app's overall behavior.

There are four different types of app components. Each type serves a distinct purpose and has a distinct lifecycle that defines how the component is created and destroyed.

Here are the four types of app components:

1.2.1 Activities

An activity represents a single screen with a user interface. For example, an email app might have one activity that shows a list of new emails, another activity to compose an email, and another activity for reading emails. Although the activities work together to form a cohesive user experience in the email app, each one is independent of the others. As such, a different app can start any one of these activities (if the email app allows it). For example, a camera app can start the activity in the email app that composes new mail, in order for the user to share a picture.

An activity is implemented as a subclass of Activity and you can learn more about it in the Activitiesdeveloper guide.

1.2.2 Services

A service is a component that runs in the background to perform long-running operations or to perform work for remote processes. A service does not provide a user interface. For example, a service might play music in the background while the user is in a different app, or it might fetch data over the network without blocking user interaction with an activity. Another component, such as an activity, can start the service and let it run or bind to it in order to interact with it.

A service is implemented as a subclass of Service and you can learn more about it in the Servicesdeveloper guide.

1.2.3 Content providers

A content provider manages a shared set of app data. You can store the data in the file system, SQLite database, on the web, or any other persistent storage location your app can access. Through the content provider, other apps can query or even modify the data (if the content provider allows it). For example, the Android system provides a content provider that manages the user's contact information. As such, any app with the proper permissions can query part of the content provider (such as ContactsContractData) to read and write information about a particular person.

Content providers are also useful for reading and writing data that is private to your app and not shared. For example, the Note Pad sample app uses a content provider to save notes.

A content provider is implemented as a subclass of ContentProvider and must implement a standard set of APIs that enable other apps to perform transactions. For more information, see the Content Providersdeveloper guide.

1.2.4 Broadcast receivers

A broadcast receiver is a component that responds to system-wide broadcast announcements. Many broadcasts originate from the system—for example, a broadcast announcing that the screen has turned off, the battery is low, or a picture was captured. Apps can also initiate broadcasts—for example, to let other apps know that some data has been downloaded to the device and is available for them to use. Although broadcast receivers don't display a user interface, they may create a status bar notification to alert the user when a broadcast event occurs. More commonly, though, 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.

A broadcast receiver is implemented as a subclass of BroadcastReceiver and each broadcast is delivered as an Intent object. For more information, see the BroadcastReceiver class.

A unique aspect of the Android system design is that any app can start another app’s component. For example, if you want the user to capture a photo with the device camera, there's probably another app that does that and your app can use it, instead of developing an activity to capture a photo yourself. You don't need to incorporate or even link to the code from the camera app. Instead, you can simply start the activity in the camera app that captures a photo. When complete, the photo is even returned to your app so you can use it. To the user, it seems as if the camera is actually a part of your app.

When the system starts a component, it starts the process for that app (if it's not already running) and instantiates the classes needed for the component. For example, if your app starts the activity in the camera app that captures a photo, that activity runs in the process that belongs to the camera app, not in your app's process. Therefore, unlike apps on most other systems, Android apps don't have a single entry point (there's no main() function, for example).

Because the system runs each app in a separate process with file permissions that restrict access to other apps, your app cannot directly activate a component from another app. The Android system, however, can. So, to activate a component in another app, you must deliver a message to the system that specifies your intent to start a particular component. The system then activates the component for you.

1.3 The Manifest File

Before the Android system can start an app component, the system must know that the component exists by reading the app's AndroidManifest.xml file (the "manifest" file). Your app must declare all its components in this file, which must be at the root of the app project directory.

The manifest does a number of things in addition to declaring the app's components, such as:

- Identify any user permissions the app requires, such as Internet access or read-access to the user's contacts.
- Declare the minimum API Level required by the app, based on which APIs the app uses.
- Declare hardware and software features used or required by the app, such as a camera, Bluetooth services, or a multi-touch screen.
- API libraries the app needs to be linked against (other than the Android framework APIs), such as the Google Maps library.
- And more

1.3.1 Declaring components

The primary task of the manifest is to inform the system about the app's components. For example, a manifest file can declare an activity as follows:

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

<manifest ... >

  <applicationandroid:icon="@drawable/app_icon.png" ... >

    <activityandroid:name="com.example.project.ExampleActivity"

          android:label="@string/example_label" ... >

    </activity>

    ...

  </application>

</manifest>
```

In the <application> element, the android:icon attribute points to resources for an icon that identifies the app.

In the <activity> element, the android:name attribute specifies the fully qualified class name of the Activitysubclass and the android:label attributes specifies a string to use as the user-visible label for the activity.

You must declare all app components this way:

<activity> elements for activities

<service> elements for services

<receiver> elements for broadcast receivers

<provider> elements for content providers

Activities, services, and content providers that you include in your source but do not declare in the manifest are not visible to the system and, consequently, can never run. However, broadcast receivers can be either declared in the manifest or created dynamically in code (as BroadcastReceiver objects) and registered with the system by callingregisterReceiver().

For more about how to structure the manifest file for your app, see The AndroidManifest.xml Filedocumentation.

1.3.2 Declaring component capabilities

As discussed above, in Activating Components, you can use an Intent to start activities, services, and broadcast receivers. You can do so by explicitly naming the target component (using the component class name) in the intent. However, the real power of intents lies in the concept of implicit intents. An implicit intent simply describes the type of action to perform (and, optionally, the data upon which you'd like to perform the action) and allows the system to find a component on the device that can perform the action and start it. If there are multiple components that can perform the action described by the intent, then the user selects which one to use.

The way the system identifies the components that can respond to an intent is by comparing the intent received to the intent filters provided in the manifest file of other apps on the device.

When you declare an activity in your app's manifest, you can optionally include intent filters that declare the capabilities of the activity so it can respond to intents from other apps. You can declare an intent filter for your component by adding an <intent-filter> element as a child of the component's declaration element.

For example, if you've built an email app with an activity for composing a new email, you can declare an intent filter to respond to "send" intents (in order to send a new email) like this:

```
<manifest ... >
    ...
    <application ... >
        <activityandroid:name="com.example.project.ComposeEmailActivity">
            <intent-filter>
            <actionandroid:name="android.intent.action.SEND"/>

            <dataandroid:type="*/*"/>

            <categoryandroid:name="android.intent.category.DEFAULT"/>

          </intent-filter>

        </activity>

    </application>

</manifest>
```

Then, if another app creates an intent with the ACTION_SEND action and pass it to startActivity(), the system may start your activity so the user can draft and send an email.

For more about creating intent filters, see the Intents and Intent Filters document.

1.3.3 Declaring app requirements

There are a variety of devices powered by Android and not all of them provide the same features and capabilities. In order to prevent your app from being installed on devices that lack features needed by your app, it's important that you clearly define a profile for the types of devices your app supports by declaring device and software requirements in your manifest file. Most of these declarations are informational only and the system does not read them, but external services such as Google Play do read them in order to provide filtering for users when they search for apps from their device.

For example, if your app requires a camera and uses APIs introduced in Android 2.1 (API Level 7), you should declare these as requirements in your manifest file like this:

```
<manifest ... >

    <uses-featureandroid:name="android.hardware.camera.any"

                  android:required="true"/>

    <uses-sdkandroid:minSdkVersion="7"android:targetSdkVersion="19"/>

    ...

</manifest>
```

Now, devices that do NOT have a camera and have an Android version LOWER than 2.1 cannot install your app from Google Play.

However, you can also declare that your app uses the camera, but does not REQUIRE it. In that case, your app must set the required attribute to "false" and check at runtime whether the device has a camera and disable any camera features as appropriate.

1.4 Activities

An Activity is an application component that provides a screen with which users can interact in order to do something, such as dial the phone, take a photo, send an email, or view a map. Each activity is given a window in which to draw its user interface. The window typically fills the screen, but may be smaller than the screen and float on top of other windows.

An application usually consists of multiple activities that are loosely bound to each other. Typically, one activity in an application is specified as the "main" activity, which is presented to the user when launching the application for the first time. Each activity can then start another activity in order to perform different actions. Each time a new activity starts, the previous activity is stopped, but the system preserves the activity in a stack (the "back stack"). When a new activity starts, it is pushed onto the back stack and takes user focus. The back stack abides to the basic "last in, first out" stack mechanism, so, when the user is done with the current activity and presses the Back button, it is popped from the stack (and destroyed) and the previous activity resumes. (The back stack is discussed more in the Tasks and Back Stack document.)

When an activity is stopped because a new activity starts, it is notified of this change in state through the activity's lifecycle callback methods. There are several callback methods that an activity might receive, due to a change in its state—whether the system is creating it, stopping it, resuming it, or destroying it—and each callback provides you the opportunity to perform specific work that's appropriate to that state change. For instance, when stopped, your activity should release any large objects, such as network or database connections. When the activity resumes, you can reacquire the necessary resources and resume actions that were interrupted. These state transitions are all part of the activity lifecycle.

The rest of this document discusses the basics of how to build and use an activity, including a complete discussion of how the activity lifecycle works, so you can properly manage the transition between various activity states.

1.4.1 Creating an Activity

To create an activity, you must create a subclass of Activity (or an existing subclass of it). In your subclass, you need to implement callback methods that the system calls when the activity transitions between various states of its lifecycle, such as when the activity is being created, stopped, resumed, or destroyed. The two most important callback methods are:

onCreate() - You must implement this method. The system calls this when creating your activity. Within your implementation, you should initialize the essential components of your activity. Most importantly, this is where you must call setContentView() to define the layout for the activity's user interface.

onPause() - The system calls this method as the first indication that the user is leaving your activity (though it does not always mean the activity is being destroyed). This is usually where you should commit any changes that should be persisted beyond the current user session (because the user might not come back).

There are several other lifecycle callback methods that you should use in order to provide a fluid user experience between activities and handle unexpected interuptions that cause your activity to be stopped and even destroyed. All of the lifecycle callback methods are discussed later, in the section about Managing the Activity Lifecycle.

1.4.2 Implementing a user interface

The user interface for an activity is provided by a hierarchy of views—objects derived from the View class. Each view controls a particular rectangular space within the activity's window and can respond to user interaction. For example, a view might be a button that initiates an action when the user touches it.

Android provides a number of ready-made views that you can use to design and organize your layout. "Widgets" are views that provide a visual (and interactive) elements for the screen, such as a button, text field, checkbox, or just an image. "Layouts" are views derived from ViewGroup that provide a unique layout model for its child views, such as a linear layout, a grid layout, or relative layout. You can also subclass the View and ViewGroup classes (or existing subclasses) to create your own widgets and layouts and apply them to your activity layout.

The most common way to define a layout using views is with an XML layout file saved in your application resources. This way, you can maintain the design of your user interface separately from the source code that defines the activity's behavior. You can set the layout as the UI for your activity with setContentView(), passing the resource ID for the layout. However, you can also create new Views in your activity code and build a view hierarchy by inserting new Views into a ViewGroup, then use that layout by passing the root ViewGroup to setContentView().

For information about creating a user interface, see the User Interface documentation.

1.4.3 Declaring the activity in the manifest

You must declare your activity in the manifest file in order for it to be accessible to the system. To declare your activity, open your manifest file and add an <activity> element as a child of the <application> element. For example:

```
<manifest ... >
  <application ... >
      <activity android:name=".ExampleActivity" />
      ...
  </application ... >
  ...
```

```
</manifest >
```

There are several other attributes that you can include in this element, to define properties such as the label for the activity, an icon for the activity, or a theme to style the activity's UI. The android:name attribute is the only required attribute—it specifies the class name of the activity. Once you publish your application, you should not change this name, because if you do, you might break some functionality, such as application shortcuts (read the blog post, Things That Cannot Change).

See the <activity> element reference for more information about declaring your activity in the manifest.

1.4.4 Using intent filters

An <activity> element can also specify various intent filters—using the <intent-filter> element—in order to declare how other application components may activate it.

When you create a new application using the Android SDK tools, the stub activity that's created for you automatically includes an intent filter that declares the activity responds to the "main" action and should be placed in the "launcher" category. The intent filter looks like this:

```
<activity android:name=".ExampleActivity" android:icon="@drawable/app_icon">

    <intent-filter>

        <action android:name="android.intent.action.MAIN" />

        <category android:name="android.intent.category.LAUNCHER" />

    </intent-filter>

</activity>
```

The <action> element specifies that this is the "main" entry point to the application. The <category> element specifies that this activity should be listed in the system's application launcher (to allow users to launch this activity).

If you intend for your application to be self-contained and not allow other applications to activate its activities, then you don't need any other intent filters. Only one activity should have the "main" action and "launcher" category, as in the previous example. Activities that you don't want to make available to other applications should have no intent filters and you can start them yourself using explicit intents (as discussed in the following section).

However, if you want your activity to respond to implicit intents that are delivered from other applications (and your own), then you must define additional intent filters for your activity. For each type of intent to which you want to respond, you must include an <intent-filter> that includes an <action> element and, optionally, a <category> element and/or a <data> element. These elements specify the type of intent to which your activity can respond.

For more information about how your activities can respond to intents, see the Intents and Intent Filters document.

1.4.5 Starting an Activity

You can start another activity by calling startActivity(), passing it an Intent that describes the activity you want to start. The intent specifies either the exact activity you want to start or describes the type of action you want to perform (and the system selects the appropriate activity for you, which can even be from a different application). An intent can also carry small amounts of data to be used by the activity that is started.

When working within your own application, you'll often need to simply launch a known activity. You can do so by creating an intent that explicitly defines the activity you want to start, using the class name. For example, here's how one activity starts another activity named SignInActivity:

```
Intent intent = new Intent(this, SignInActivity.class);

startActivity(intent);
```

However, your application might also want to perform some action, such as send an email, text message, or status update, using data from your activity. In this case, your application might not have its own activities to perform such actions, so you can instead leverage the activities provided by other applications on the device, which can perform the actions for you. This is where intents are really valuable—you can create an intent that describes an action you want to perform and the system launches the appropriate activity from another application. If there are multiple activities that can handle the intent, then the user can select which one to use. For example, if you want to allow the user to send an email message, you can create the following intent:

```
Intent intent = new Intent(Intent.ACTION_SEND);

intent.putExtra(Intent.EXTRA_EMAIL, recipientArray);

startActivity(intent);
```

The EXTRA_EMAIL extra added to the intent is a string array of email addresses to which the email should be sent. When an email application responds to this intent, it reads the string array provided in the extra and places them in the "to" field of the email composition form. In this situation, the email application's activity starts and when the user is done, your activity resumes.

1.4.6 Starting an activity for a result

Sometimes, you might want to receive a result from the activity that you start. In that case, start the activity by calling startActivityForResult() (instead of startActivity()). To then receive the result from the subsequent activity, implement the onActivityResult() callback method. When the subsequent activity is done, it returns a result in an Intent to your onActivityResult() method.

For example, perhaps you want the user to pick one of their contacts, so your activity can do something with the information in that contact. Here's how you can create such an intent and handle the result:

```
private void pickContact() {
    // Create an intent to "pick" a contact, as defined by the content provider URI
    Intent intent = new Intent(Intent.ACTION_PICK, Contacts.CONTENT_URI);
    startActivityForResult(intent, PICK_CONTACT_REQUEST);
}
@Override
protected void onActivityResult(int requestCode, int resultCode, Intent data) {
    // If the request went well (OK) and the request was PICK_CONTACT_REQUEST
    if (resultCode == Activity.RESULT_OK && requestCode ==
PICK_CONTACT_REQUEST) {
        // Perform a query to the contact's content provider for the contact's name
        Cursor cursor = getContentResolver().query(data.getData(),
        new String[] {Contacts.DISPLAY_NAME}, null, null, null);
        if (cursor.moveToFirst()) { // True if the cursor is not empty
            int columnIndex = cursor.getColumnIndex(Contacts.DISPLAY_NAME);
            String name = cursor.getString(columnIndex);
            // Do something with the selected contact's name...
        }
    }
}
```

This example shows the basic logic you should use in your onActivityResult() method in order to handle an activity result. The first condition checks whether the request was successful—if it was, then the resultCode will be RESULT_OK—and whether the request to which this result is responding is known—in this case, the requestCode matches the second parameter sent with startActivityForResult(). From there, the code handles the activity result by querying the data returned in an Intent (the data parameter).

What happens is, a ContentResolver performs a query against a content provider, which returns a Cursor that allows the queried data to be read. For more information, see the Content Providers document.

For more information about using intents, see the Intents and Intent Filters document.

1.4.7 Shutting Down an Activity

You can shut down an activity by calling its finish() method. You can also shut down a separate activity that you previously started by calling finishActivity().

Note: In most cases, you should not explicitly finish an activity using these methods. As discussed in the following section about the activity lifecycle, the Android system manages the life of an activity for you, so you do not need to finish your own activities. Calling these methods could adversely affect the expected user experience and should only be used when you absolutely do not want the user to return to this instance of the activity.

1.4.8 Managing the Activity Lifecycle

Managing the lifecycle of your activities by implementing callback methods is crucial to developing a strong and flexible application. The lifecycle of an activity is directly affected by its association with other activities, its task and back stack.

An activity can exist in essentially three states:

- Resumed - The activity is in the foreground of the screen and has user focus. (This state is also sometimes referred to as "running".)
- Paused - Another activity is in the foreground and has focus, but this one is still visible. That is, another activity is visible on top of this one and that activity is partially transparent or doesn't cover the entire screen. A paused activity is completely alive (the Activity object is retained in memory, it maintains all state and member information, and remains attached to the window manager), but can be killed by the system in extremely low memory situations.
- Stopped - The activity is completely obscured by another activity (the activity is now in the "background"). A stopped activity is also still alive (the Activity object is retained in memory, it maintains all state and member information, but is not attached to the window manager). However, it is no longer visible to the user and it can be killed by the system when memory is needed elsewhere.

If an activity is paused or stopped, the system can drop it from memory either by asking it to finish (calling its finish() method), or simply killing its process. When the activity is opened again (after being finished or killed), it must be created all over.

1.4.9 Implementing the lifecycle callbacks

When an activity transitions into and out of the different states described above, it is notified through various callback methods. All of the callback methods are hooks that you can override to do appropriate work when the state of your activity changes. The following skeleton activity includes each of the fundamental lifecycle methods:

```
public class ExampleActivity extends Activity {
    @Override
    public void onCreate(Bundle savedInstanceState) {
        super.onCreate(savedInstanceState);
        // The activity is being created.
    }
    @Override
    protected void onStart() {
        super.onStart();
        // The activity is about to become visible.
    }
    @Override
    protected void onResume() {
        super.onResume();
        // The activity has become visible (it is now "resumed").
    }
    @Override
    protected void onPause() {
        super.onPause();
        // Another activity is taking focus (this activity is about to be "paused").
    }
    @Override
    protected void onStop() {
        super.onStop();
        // The activity is no longer visible (it is now "stopped")
    }
    @Override
    protected void onDestroy() {

        super.onDestroy();

        // The activity is about to be destroyed.

    }

}
```

Note: Your implementation of these lifecycle methods must always call the superclass implementation before doing any work, as shown in the examples above.

Taken together, these methods define the entire lifecycle of an activity. By implementing these methods, you can monitor three nested loops in the activity lifecycle:

The entire lifetime of an activity happens between the call to onCreate() and the call to onDestroy(). Your activity should perform setup of "global" state (such as defining layout) in onCreate(), and release all remaining resources in onDestroy(). For example, if your activity has a thread running in the background to download data from the network, it might create that thread in onCreate() and then stop the thread in onDestroy().

The visible lifetime of an activity happens between the call to onStart() and the call to onStop(). During this time, the user can see the activity on-screen and interact with it. For example, onStop() is called when a new activity starts and this one is no longer visible. Between these two methods, you can maintain resources that are needed to show the activity to the user. For example, you can register a BroadcastReceiver in onStart() to monitor changes that impact your UI, and unregister it in onStop() when the user can no longer see what you are displaying. The system might call onStart() and onStop() multiple times during the entire lifetime of the activity, as the activity alternates between being visible and hidden to the user.

The foreground lifetime of an activity happens between the call to onResume() and the call to onPause(). During this time, the activity is in front of all other activities on screen and has user input focus. An activity can frequently transition in and out of the foreground—for example, onPause() is called when the device goes to sleep or when a dialog appears. Because this state can transition often, the code in these two methods should be fairly lightweight in order to avoid slow transitions that make the user wait.

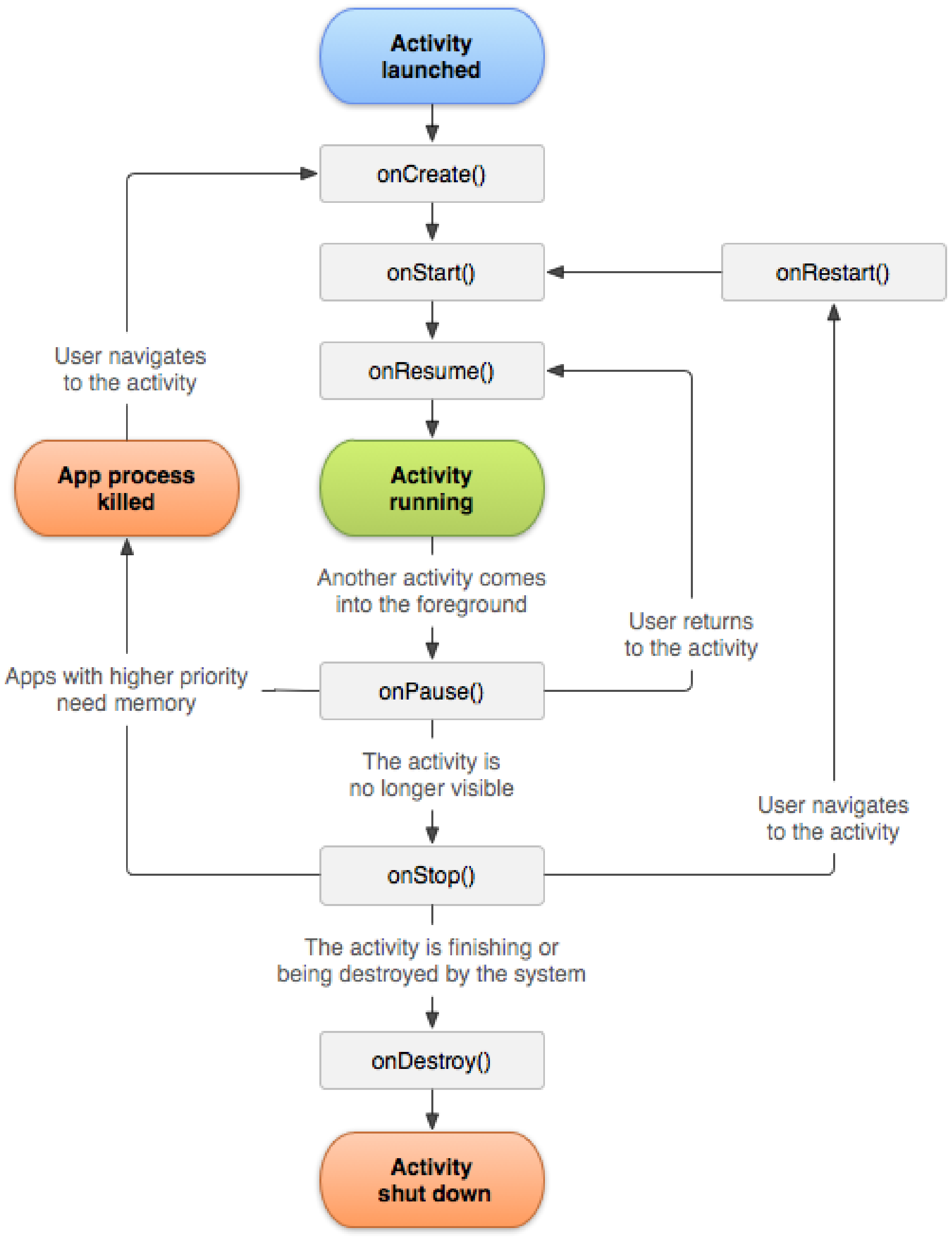

Activity launched
onCreate()
onStart()
onRestart()
User navigates to the activity
onResume()
App process killed
Activity running
Another activity comes into the foreground
User returns to the activity
Apps with higher priority need memory
onPause()
The activity is no longer visible
User navigates to the activity
onStop()
The activity is finishing or being destroyed by the system
onDestroy()
Activity shut down

Fig 1.1 - The activity lifecycle

Figure 1 illustrates these loops and the paths an activity might take between states. The rectangles represent the callback methods you can implement to perform operations when the activity transitions between states.

The same lifecycle callback methods are listed in table 1, which describes each of the callback methods in more detail and locates each one within the activity's overall lifecycle, including whether the system can kill the activity after the callback method completes.

Method	Description	Killable after?	Next
<u>onCreate( )</u>	Called when the activity is first created. This is where you should do all of your normal static set up — create views, bind data to lists, and so on. This method is passed a Bundle object containing the activity's previous state, if that state was captured (see Saving Activity State, later). Always followed by onStart().	**No**	**onStart( )**
<u>onRestart( )</u>	Called after the activity has been stopped, just prior to it being started again. Always followed by onStart()	**No**	**onStart( )**

<u>onStart( )</u>	Called just before the activity becomes visible to the user.
	Followed by onResume() if the activity comes to the foreground, or onStop() if it becomes hidden.
		No	**onResume()
			or
			onStop( )**

<u>onResume( )</u>	Called just before the activity starts interacting with the user. At this point the activity is at the top of the activity stack, with user input going to it. Always followed by onPause().	**No**	**onPause( )**

<u>onPause( )</u>	Called when the system is about to start resuming another activity. This method is typically used to commit unsaved changes to persistent data, stop animations and other things that may be consuming CPU, and so on. It should do whatever it does very quickly, because the next activity will	**Yes**	**onResume()
			or
			onStop( )**

	not be resumed until it returns. Followed either by onResume() if the activity returns back to the front, or by onStop() if it becomes invisible to the user.		
onStop( )	Called when the activity is no longer visible to the user. This may happen because it is being destroyed, or because another activity (either an existing one or a new one) has been resumed and is covering it. Followed either by onRestart() if the activity is coming back to interact with the user, or by onDestroy() if this activity is going away.	**Yes**	**onRestart( ) or onDestroy( )**
onDestroy( )	Called before the activity is destroyed. This is the final call that the activity will receive. It could be called either because the activity is finishing (someone called finish() on it), or because the system is temporarily destroying this instance of the activity to save space. You can distinguish between these two scenarios with the isFinishing() method.	**Yes**	**nothing**

Table 1.1 A summary of the activity lifecycle's callback methods.

The column labeled "Killable after?" indicates whether or not the system can kill the process hosting the activity at any time after the method returns, without executing another line of the activity's code. Three methods are marked "yes": (onPause(), onStop(), and onDestroy()). Because onPause() is the first of the three, once the activity is created, onPause() is the last method that's guaranteed to be called before the process can be killed—if the system must recover memory in an emergency, then onStop() and onDestroy() might not be called. Therefore, you should use onPause() to write crucial persistent data (such as user edits) to storage. However, you should be selective about what information must be retained during onPause(), because any blocking procedures in this method block the transition to the next activity and slow the user experience.

Methods that are marked "No" in the Killable column protect the process hosting the activity from being killed from the moment they are called. Thus, an activity is killable from the time onPause() returns to the time onResume() is called. It will not again be killable until onPause() is again called and returns.

Note: An activity that's not technically "killable" by this definition in table 1 might still be killed by the system—but that would happen only in extreme circumstances when there is no other recourse. When an activity might be killed is discussed more in the Processes and Threading document.

1.4.10 Saving activity state

The introduction to Managing the Activity Lifecycle briefly mentions that when an activity is paused or stopped, the state of the activity is retained. This is true because the Activity object is still held in memory when it is paused or stopped—all information about its members and current state is still alive. Thus, any changes the user made within the activity are retained so that when the activity returns to the foreground (when it "resumes"), those changes are still there.

However, when the system destroys an activity in order to recover memory, the Activity object is destroyed, so the system cannot simply resume it with its state intact. Instead, the system must recreate the Activity object if the user navigates back to it. Yet, the user is unaware that the system destroyed the activity and recreated it and, thus, probably expects the activity to be exactly as it was. In this situation, you can ensure that important information about the activity state is preserved by implementing an additional callback method that allows you to save information about the state of your activity: onSaveInstanceState().

The system calls onSaveInstanceState() before making the activity vulnerable to destruction. The system passes this method a Bundle in which you can save state information about the activity as name-value pairs, using methods such as putString() and putInt(). Then, if the system kills your application process and the user navigates back to your activity, the system recreates the activity and passes the Bundle to both onCreate() and onRestoreInstanceState(). Using either of these methods, you can extract your saved state from the Bundle and restore the activity state. If there is no state information to restore, then the Bundle passed to you is null (which is the case when the activity is created for the first time).

Note: There's no guarantee that onSaveInstanceState() will be called before your activity is destroyed, because there are cases in which it won't be necessary to save the state (such as when the user leaves your activity using the Back button, because the user is explicitly closing the activity). If the system calls onSaveInstanceState(), it does so before onStop() and possibly before onPause().

However, even if you do nothing and do not implement onSaveInstanceState(), some of the activity state is restored by the Activity class's default implementation of onSaveInstanceState(). Specifically, the default implementation calls the corresponding onSaveInstanceState() method for every View in the layout, which allows each view to provide information about itself that should be saved. Almost every widget in the Android framework implements this method as appropriate, such that any visible changes to the UI are automatically saved and restored when your activity is recreated. For example, the EditText widget saves any text entered by the user and the CheckBox widget saves whether it's checked or not. The only work required by you is to provide a unique ID (with the android:id attribute) for each widget you want to save its state. If a widget does not have an ID, then the system cannot save its state.

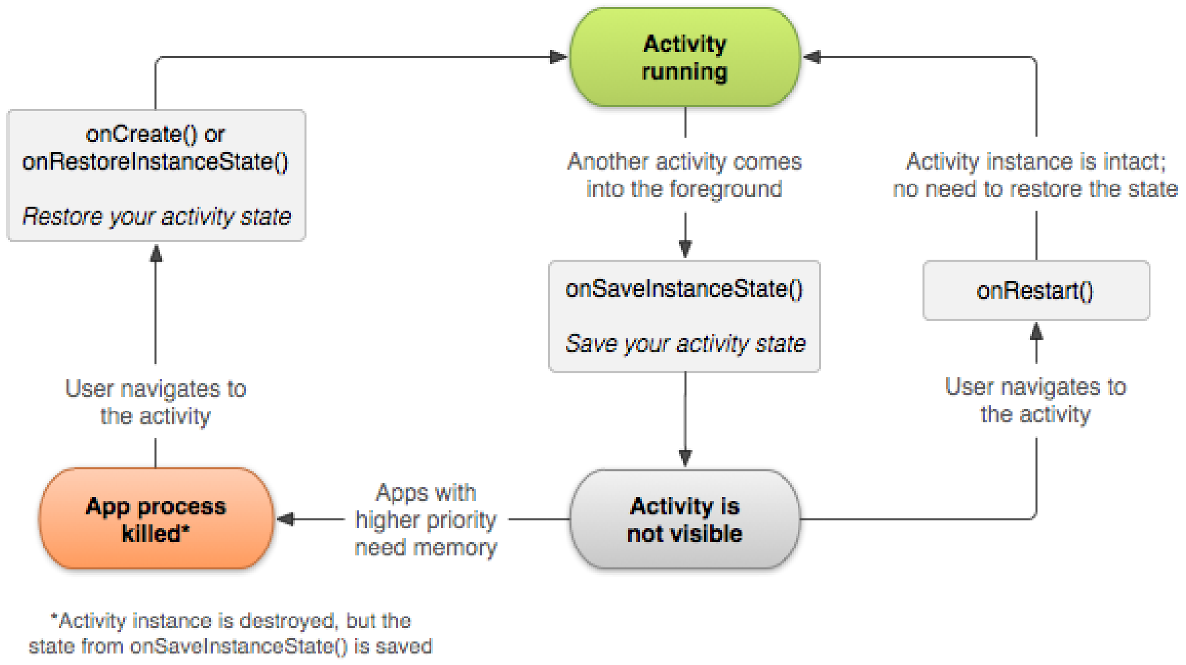

Activity running
onCreate() or onRestoreInstanceState()
Restore your activity state
Another activity comes into the foreground
Activity instance is intact; no need to restore the state
onSaveInstanceState()
Save your activity state
onRestart()
User navigates to the activity
User navigates to the activity
App process killed*
Apps with higher priority need memory
Activity is not visible
*Activity instance is destroyed, but the state from onSaveInstanceState() is saved

Figure 1.2 - The two ways in which an activity returns to user focus with its state intact: either the activity is destroyed, then recreated and the activity must restore the previously saved state, or the activity is stopped, then resumed and the activity state remains intact.

Although the default implementation of onSaveInstanceState() saves useful information about your activity's UI, you still might need to override it to save additional information. For example, you might need to save member values that changed during the activity's life (which might correlate to values restored in the UI, but the members that hold those UI values are not restored, by default).

Because the default implementation of onSaveInstanceState() helps save the state of the UI, if you override the method in order to save additional state information, you should always call the superclass implementation of onSaveInstanceState() before doing any work. Likewise, you should also call the superclass implementation of onRestoreInstanceState() if you override it, so the default implementation can restore view states.

Note: Because onSaveInstanceState() is not guaranteed to be called, you should use it only to record the transient state of the activity (the state of the UI)—you should never use it to store persistent data. Instead, you should use onPause() to store persistent data (such as data that should be saved to a database) when the user leaves the activity.

A good way to test your application's ability to restore its state is to simply rotate the device so that the screen orientation changes. When the screen orientation changes, the system destroys and recreates the activity in order to apply alternative resources that might be available for the new screen configuration. For this reason alone, it's very important that your activity completely restores its state when it is recreated, because users regularly rotate the screen while using applications.

1.4.11 Handling configuration changes

Some device configurations can change during runtime (such as screen orientation, keyboard availability, and language). When such a change occurs, Android recreates the running activity (the system calls onDestroy(), then immediately calls onCreate()). This behavior is designed to help your application adapt to new configurations by automatically reloading your application with alternative resources that you've provided (such as different layouts for different screen orientations and sizes).

If you properly design your activity to handle a restart due to a screen orientation change and restore the activity state as described above, your application will be more resilient to other unexpected events in the activity lifecycle.

The best way to handle such a restart is to save and restore the state of your activity using onSaveInstanceState() and onRestoreInstanceState() (or onCreate()), as discussed in the previous section.

For more information about configuration changes that happen at runtime and how you can handle them, read the guide to Handling Runtime Changes.

1.4.12 Coordinating activities

When one activity starts another, they both experience lifecycle transitions. The first activity pauses and stops (though, it won't stop if it's still visible in the background), while the other activity is created. In case these activities share data saved to disc or elsewhere, it's important to understand that the first activity is not completely stopped before the second one is created. Rather, the process of starting the second one overlaps with the process of stopping the first one.

- The order of lifecycle callbacks is well defined, particularly when the two activities are in the same process and one is starting the other. Here's the order of operations that occur when Activity A starts Acivity B:
- Activity A's onPause() method executes.
- Activity B's onCreate(), onStart(), and onResume() methods execute in sequence. (Activity B now has user focus.)

Then, if Activity A is no longer visible on screen, its onStop() method executes.

This predictable sequence of lifecycle callbacks allows you to manage the transition of information from one activity to another. For example, if you must write to a database when the first activity stops so that the following activity can read it, then you should write to the database during onPause() instead of during onStop().

1.5 Intents and Intent Filters

An Intent is a messaging object you can use to request an action from another app component. Although intents facilitate communication between components in several ways, there are three fundamental use-cases:

1.5.1 To start an activity:

An Activity represents a single screen in an app. You can start a new instance of an Activity by passing an Intent to startActivity(). The Intent describes the activity to start and carries any necessary data.

If you want to receive a result from the activity when it finishes, call startActivityForResult(). Your activity receives the result as a separate Intent object in your activity's onActivityResult() callback. For more information, see the Activities guide.

1.5.2 To start a service:

A Service is a component that performs operations in the background without a user interface. You can start a service to perform a one-time operation (such as download a file) by passing an Intent to startService(). The Intent describes the service to start and carries any necessary data.

If the service is designed with a client-server interface, you can bind to the service from another component by passing an Intent to bindService(). For more information, see the Services guide.

1.5.3 To deliver a broadcast:

A broadcast is a message that any app can receive. The system delivers various broadcasts for system events, such as when the system boots up or the device starts charging. You can deliver a broadcast to other apps by passing an Intent to sendBroadcast(), sendOrderedBroadcast(), or sendStickyBroadcast().

1.5.4 Intent Types

There are two types of intents:

- Explicit intents specify the component to start by name (the fully-qualified class name). You'll typically use an explicit intent to start a component in your own app, because you know the class name of the activity or service you want to start. For example, start a new activity in response to a user action or start a service to download a file in the background.
- Implicit intents do not name a specific component, but instead declare a general action to perform, which allows a component from another app to handle it. For example, if you want to show the user a location on a map, you can use an implicit intent to request that another capable app show a specified location on a map.

When you create an explicit intent to start an activity or service, the system immediately starts the app component specified in the Intent object.

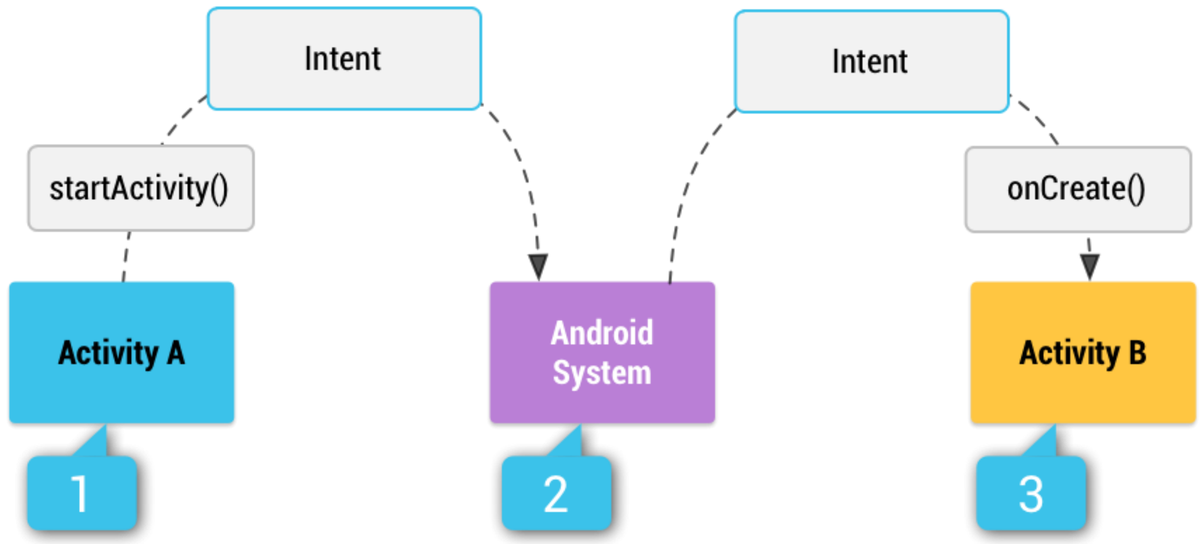


Figure 1.3 - Illustration of how an implicit intent is delivered through the system to start another activity: (1) Activity A creates an Intent with an action description and passes it to startActivity(). (2) The Android System searches all apps for an intent filter that matches the intent. When a match is found, (3) the system starts the matching activity (Activity B) by invoking its onCreate() method and passing it the Intent.

When you create an implicit intent, the Android system finds the appropriate component to start by comparing the contents of the intent to the intent filters declared in the manifest file of other apps on the device. If the intent matches an intent filter, the system starts that component and delivers it the Intent object. If multiple intent filters are compatible, the system displays a dialog so the user can pick which app to use.

An intent filter is an expression in an app's manifest file that specifies the type of intents that the component would like to receive. For instance, by declaring an intent filter for an activity, you make it possible for other apps to directly start your activity with a certain kind of intent. Likewise, if you do not declare any intent filters for an activity, then it can be started only with an explicit intent.

Caution: To ensure your app is secure, always use an explicit intent when starting a Service and do not declare intent filters for your services. Using an implicit intent to start a service is a security hazard because you cannot be certain what service will respond to the intent, and the user cannot see which service starts. Beginning with Android 5.0 (API level 21), the system throws an exception if you call bindService() with an implicit intent.

1.5.5 Building an Intent

An Intent object carries information that the Android system uses to determine which component to start (such as the exact component name or component category that should receive the intent), plus information that the recipient component uses in order to properly perform the action (such as the action to take and the data to act upon).

The primary information contained in an Intent is the following:

- **Component name**

  The name of the component to start.

  This is optional, but it's the critical piece of information that makes an intent explicit, meaning that the intent should be delivered only to the app component defined by the component name. Without a component name, the intent is implicit and the system decides which component should receive the intent based on the other intent information (such as the action, data, and category—described below). So if you need to start a specific component in your app, you should specify the component name.

  Note: When starting a Service, you should always specify the component name. Otherwise, you cannot be certain what service will respond to the intent, and the user cannot see which service starts.

  This field of the Intent is a ComponentName object, which you can specify using a fully qualified class name of the target component, including the package name of the app. For example, com.example.ExampleActivity. You can set the component name with setComponent(), setClass(), setClassName(), or with the Intent constructor.

- **Action**

  A string that specifies the generic action to perform (such as view or pick).

  In the case of a broadcast intent, this is the action that took place and is being reported. The action largely determines how the rest of the intent is structured—particularly what is contained in the data and extras.

  You can specify your own actions for use by intents within your app (or for use by other apps to invoke components in your app), but you should usually use action constants defined by the Intent class or other framework classes. Here are some common actions for starting an activity:

  - **ACTION_VIEW**
    Use this action in an intent with startActivity() when you have some information that an activity can show to the user, such as a photo to view in a gallery app, or an address to view in a map app.

- **ACTION_SEND**
  Also known as the "share" intent, you should use this in an intent with startActivity() when you have some data that the user can share through another app, such as an email app or social sharing app.

See the Intent class reference for more constants that define generic actions. Other actions are defined elsewhere in the Android framework, such as in Settings for actions that open specific screens in the system's Settings app.

You can specify the action for an intent with setAction() or with an Intent constructor.

If you define your own actions, be sure to include your app's package name as a prefix. For example:

```
static final String ACTION_TIMETRAVEL = "com.example.action.TIMETRAVEL";
```

- **Data**

  The URI (a Uri object) that references the data to be acted on and/or the MIME type of that data. The type of data supplied is generally dictated by the intent's action. For example, if the action is ACTION_EDIT, the data should contain the URI of the document to edit.

  When creating an intent, it's often important to specify the type of data (its MIME type) in addition to its URI. For example, an activity that's able to display images probably won't be able to play an audio file, even though the URI formats could be similar. So specifying the MIME type of your data helps the Android system find the best component to receive your intent. However, the MIME type can sometimes be inferred from the URI—particularly when the data is a content: URI, which indicates the data is located on the device and controlled by a ContentProvider, which makes the data MIME type visible to the system.

  To set only the data URI, call setData(). To set only the MIME type, call setType(). If necessary, you can set both explicitly with setDataAndType().

  Caution: If you want to set both the URI and MIME type, do not call setData() and setType() because they each nullify the value of the other. Always use setDataAndType() to set both URI and MIME type.

- **Category**

  A string containing additional information about the kind of component that should handle the intent. Any number of category descriptions can be placed in an intent, but most intents do not require a category. Here are some common categories:

  - **CATEGORY_BROWSABLE**
    The target activity allows itself to be started by a web browser to display data referenced by a link—such as an image or an e-mail message.

- **CATEGORY_LAUNCHER**
  The activity is the initial activity of a task and is listed in the system's application launcher.
  See the Intent class description for the full list of categories.
  You can specify a category with addCategory().

These properties listed above (component name, action, data, and category) represent the defining characteristics of an intent. By reading these properties, the Android system is able to resolve which app component it should start.

However, an intent can carry additional information that does not affect how it is resolved to an app component. An intent can also supply:

- **Extras**

  Key-value pairs that carry additional information required to accomplish the requested action. Just as some actions use particular kinds of data URIs, some actions also use particular extras.

  You can add extra data with various putExtra() methods, each accepting two parameters: the key name and the value. You can also create a Bundle object with all the extra data, then insert the Bundle in the Intent with putExtras().

  For example, when creating an intent to send an email with ACTION_SEND, you can specify the "to" recipient with the EXTRA_EMAIL key, and specify the "subject" with the EXTRA_SUBJECT key.

  The Intent class specifies many EXTRA_* constants for standardized data types. If you need to declare your own extra keys (for intents that your app receives), be sure to include your app's package name as a prefix. For example:

```
static final String EXTRA_GIGAWATTS = "com.example.EXTRA_GIGAWATTS";
```

- **Flags**

  Flags defined in the Intent class that function as metadata for the intent. The flags may instruct the Android system how to launch an activity (for example, which task the activity should belong to) and how to treat it after it's launched (for example, whether it belongs in the list of recent activities).

  For more information, see the setFlags() method.

  - **Example explicit intent**
    An explicit intent is one that you use to launch a specific app component, such as a particular activity or service in your app. To create an explicit intent, define the component name for the Intent object—all other intent properties are optional.

For example, if you built a service in your app, named DownloadService, designed to download a file from the web, you can start it with the following code:

```
// Executed in an Activity, so 'this' is the Context


// The fileUrl is a string URL, such as "http://www.example.com/image.png"

Intent downloadIntent = new Intent(this, DownloadService.class);

downloadIntent.setData(Uri.parse(fileUrl));

startService(downloadIntent);
```

The Intent(Context, Class) constructor supplies the app Context and the component a Class object. As such, this intent explicitly starts the DownloadService class in the app.

For more information about building and starting a service, see the Services guide.

- **Example implicit intent**
  An implicit intent specifies an action that can invoke any app on the device able to perform the action. Using an implicit intent is useful when your app cannot perform the action, but other apps probably can and you'd like the user to pick which app to use.

For example, if you have content you want the user to share with other people, create an intent with the ACTION_SEND action and add extras that specify the content to share. When you call startActivity() with that intent, the user can pick an app through which to share the content.

Caution: It's possible that a user won't have any apps that handle the implicit intent you send to startActivity(). If that happens, the call will fail and your app will crash. To verify that an activity will receive the intent, call resolveActivity() on your Intent object. If the result is non-null, then there is at least one app that can handle the intent and it's safe to call startActivity(). If the result is null, you should not use the intent and, if possible, you should disable the feature that issues the intent.

```
// Create the text message with a string

Intent sendIntent = new Intent();

sendIntent.setAction(Intent.ACTION_SEND);

sendIntent.putExtra(Intent.EXTRA_TEXT, textMessage);
sendIntent.setType(HTTP.PLAIN_TEXT_TYPE); // "text/plain" MIME type


// Verify that the intent will resolve to an activity
if (sendIntent.resolveActivity(getPackageManager()) != null) {
    startActivity(sendIntent);
}
```

Note: In this case, a URI is not used, but the intent's data type is declared to specify the content carried by the extras.

When startActivity() is called, the system examines all of the installed apps to determine which ones can handle this kind of intent (an intent with the ACTION_SEND action and that carries "text/plain" data). If there's only one app that can handle it, that app opens immediately and is given the intent. If multiple activities accept the intent, the system displays a dialog so the user can pick which app to use..

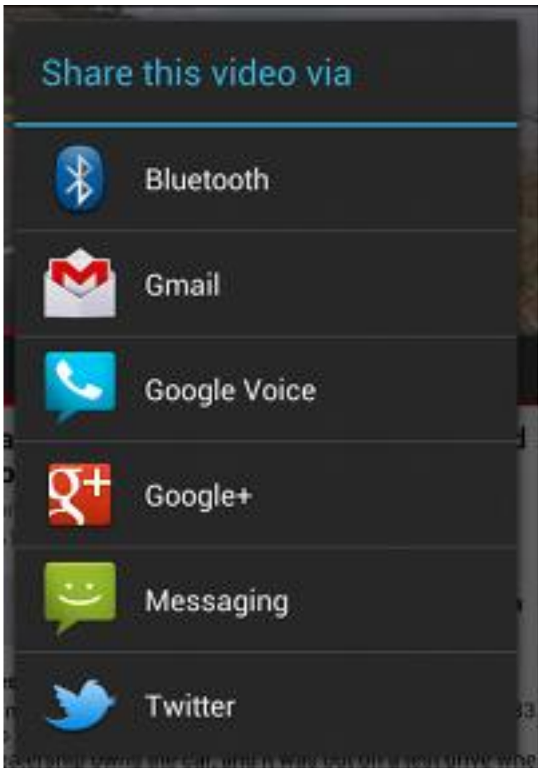


Figure 1.4 - A chooser dialog.

1.5.6 Forcing an app chooser

When there is more than one app that responds to your implicit intent, the user can select which app to use and make that app the default choice for the action. This is nice when performing an action for which the user probably wants to use the same app from now on, such as when opening a web page (users often prefer just one web browser) .

However, if multiple apps can respond to the intent and the user might want to use a different app each time, you should explicitly show a chooser dialog. The chooser dialog asks the user to select which app to use for the action every time (the user cannot select a default app for the action). For example, when your app performs "share" with the ACTION_SEND action, users may want to share using a different app depending on their current situation, so you should always use the chooser dialog, as shown in figure 2.

To show the chooser, create an Intent using createChooser() and pass it to startActivity(). For example:

```
Intent sendIntent = new Intent(Intent.ACTION_SEND);

...

// Always use string resources for UI text.

// This says something like "Share this photo with"

String title = getResources().getString(R.string.chooser_title);

// Create intent to show the chooser dialog

Intent chooser = Intent.createChooser(sendIntent, title);

// Verify the original intent will resolve to at least one activity

if (sendIntent.resolveActivity(getPackageManager()) != null) {

    startActivity(chooser);

}
```

This displays a dialog with a list of apps that respond to the intent passed to the createChooser() method and uses the supplied text as the dialog title.

1.5.7 Receiving an Implicit Intent

To advertise which implicit intents your app can receive, declare one or more intent filters for each of your app components with an <intent-filter> element in your manifest file. Each intent filter specifies the type of intents it accepts based on the intent's action, data, and category. The system will deliver an implicit intent to your app component only if the intent can pass through one of your intent filters.

Note: An explicit intent is always delivered to its target, regardless of any intent filters the component declares.

An app component should declare separate filters for each unique job it can do. For example, one activity in an image gallery app may have two filters: one filter to view an image, and another filter to edit an image. When the activity starts, it inspects the Intent and decides how to behave based on the information in the Intent (such as to show the editor controls or not).

Each intent filter is defined by an <intent-filter> element in the app's manifest file, nested in the corresponding app component (such as an <activity> element). Inside the <intent-filter>, you can specify the type of intents to accept using one or more of these three elements.

- **<action>**
  Declares the intent action accepted, in the name attribute. The value must be the literal string value of an action, not the class constant.
- **<data>**
  Declares the type of data accepted, using one or more attributes that specify various aspects of the data URI (scheme, host, port, path, etc.) and MIME type.
- **<category>**
  Declares the intent category accepted, in the name attribute. The value must be the literal string value of an action, not the class constant.

Note: In order to receive implicit intents, you must include the CATEGORY_DEFAULT category in the intent filter. The methods startActivity() and startActivityForResult() treat all intents as if they declared the CATEGORY_DEFAULT category. If you do not declare this category in your intent filter, no implicit intents will resolve to your activity.

For example, here's an activity declaration with an intent filter to receive an ACTION_SEND intent when the data type is text:

```
<activity android:name="ShareActivity">

   <intent-filter>

      <action android:name="android.intent.action.SEND"/>

      <category android:name="android.intent.category.DEFAULT"/>

      <data android:mimeType="text/plain"/>

   </intent-filter>

</activity>
```

It's okay to create a filter that includes more than one instance of <action>, <data>, or <category>. If you do, you simply need to be certain that the component can handle any and all combinations of those filter elements.

When you want to handle multiple kinds of intents, but only in specific combinations of action, data, and category type, then you need to create multiple intent filters.

1.5.8 Restricting access to components

Using an intent filter is not a secure way to prevent other apps from starting your components. Although intent filters restrict a component to respond to only certain kinds of implicit intents, another app can potentially start your app component by using an explicit intent if the developer determines your component names. If it's important that only your own app is able to start one of your components, set the exported attribute to "false" for that component.

An implicit intent is tested against a filter by comparing the intent to each of the three elements. To be delivered to the component, the intent must pass all three tests. If it fails to match even one of them, the Android system won't deliver the intent to the component. However, because a component may have multiple intent filters, an intent that does not pass through one of a component's filters might make it through on another filter. More information about how the system resolves intents is provided in the section below about Intent Resolution.

Caution: To avoid inadvertently running a different app's Service, always use an explicit intent to start your own service and do not declare intent filters for your service.

Note: For all activities, you must declare your intent filters in the manifest file. However, filters for broadcast receivers can be registered dynamically by calling registerReceiver(). You can then unregister the receiver with unregisterReceiver(). Doing so allows your app to listen for specific broadcasts during only a specified period of time while your app is running.

1.5.9 Example filters

To better understand some of the intent filter behaviors, look at the following snippet from the manifest file of a social-sharing app.

```
<activity android:name="MainActivity">

   <!-- This activity is the main entry, should appear in app launcher -->

   <intent-filter>

      <action android:name="android.intent.action.MAIN" />

      <category android:name="android.intent.category.LAUNCHER" />
```

```
    </intent-filter>
</activity>
<activity android:name="ShareActivity">
    <!-- This activity handles "SEND" actions with text data -->
    <intent-filter>
        <action android:name="android.intent.action.SEND"/>
        <category android:name="android.intent.category.DEFAULT"/>
        <data android:mimeType="text/plain"/>
    </intent-filter>
    <!-- This activity also handles "SEND" and "SEND_MULTIPLE" with media data -->
    <intent-filter>
        <action android:name="android.intent.action.SEND"/>
        <action android:name="android.intent.action.SEND_MULTIPLE"/>
        <category android:name="android.intent.category.DEFAULT"/>
        <data android:mimeType="application/vnd.google.panorama360+jpg"/>
        <data android:mimeType="image/*"/>
        <data android:mimeType="video/*"/>
    </intent-filter>
</activity>
```

The first activity, MainActivity, is the app's main entry point—the activity that opens when the user initially launches the app with the launcher icon:

The ACTION_MAIN action indicates this is the main entry point and does not expect any intent data.

The CATEGORY_LAUNCHER category indicates that this activity's icon should be placed in the system's app launcher. If the <activity> element does not specify an icon with icon, then the system uses the icon from the <application> element.

These two must be paired together in order for the activity to appear in the app launcher.

The second activity, ShareActivity, is intended to facilitate sharing text and media content. Although users might enter this activity by navigating to it from MainActivity, they can also enter ShareActivity directly from another app that issues an implicit intent matching one of the two intent filters.

Note: The MIME type, application/vnd.google.panorama360+jpg, is a special data type that specifies panoramic photos, which you can handle with the Google panorama APIs.

1.5.10 Using a Pending Intent

A PendingIntent object is a wrapper around an Intent object. The primary purpose of a PendingIntent is to grant permission to a foreign application to use the contained Intent as if it were executed from your app's own process.

Major use cases for a pending intent include:

Declare an intent to be executed when the user performs an action with your Notification (the Android system's NotificationManager executes the Intent).

Declare an intent to be executed when the user performs an action with your App Widget (the Home screen app executes the Intent).

Declare an intent to be executed at a specified time in the future (the Android system's AlarmManager executes the Intent).

Because each Intent object is designed to be handled by a specific type of app component (either an Activity, a Service, or a BroadcastReceiver), so too must a PendingIntent be created with the same consideration. When using a pending intent, your app will not execute the intent with a call such as startActivity(). You must instead declare the intended component type when you create the PendingIntent by calling the respective creator method:

- PendingIntent.getActivity() for an Intent that starts an Activity.
- PendingIntent.getService() for an Intent that starts a Service.
- PendingIntent.getBroadcast() for a Intent that starts an BroadcastReceiver.

Unless your app is receiving pending intents from other apps, the above methods to create a PendingIntent are the only PendingIntent methods you'll probably ever need.

Each method takes the current app Context, the Intent you want to wrap, and one or more flags that specify how the intent should be used (such as whether the intent can be used more than once).

More information about using pending intents is provided with the documentation for each of the respective use cases, such as in the Notifications and App Widgets API guides.

1.5.11 Intent Resolution

When the system receives an implicit intent to start an activity, it searches for the best activity for the intent by comparing the intent to intent filters based on three aspects:

- The intent action
- The intent data (both URI and data type)
- The intent category

The following sections describe how an intents are matched to the appropriate component(s) in terms of how the intent filter is declared in an app's manifest file.

- **Action test**

  To specify accepted intent actions, an intent filter can declare zero or more <action> elements. For example:

```
<intent-filter>
    <action android:name="android.intent.action.EDIT" />
    <action android:name="android.intent.action.VIEW" />
    ...
</intent-filter>
```

  To get through this filter, the action specified in the Intent must match one of the actions listed in the filter.

  If the filter does not list any actions, there is nothing for an intent to match, so all intents fail the test. However, if an Intent does not specify an action, it will pass the test (as long as the filter contains at least one action).

- **Category test**

  To specify accepted intent categories, an intent filter can declare zero or more <category> elements. For example:

```
<intent-filter>
    <category android:name="android.intent.category.DEFAULT" />
    <category android:name="android.intent.category.BROWSABLE" />
    ...
</intent-filter>
```

  For an intent to pass the category test, every category in the Intent must match a category in the filter. The reverse is not necessary—the intent filter may declare more categories than are specified in the Intent and the Intent will still pass. Therefore, an intent with no categories should always pass this test, regardless of what categories are declared in the filter.

Note: Android automatically applies the the CATEGORY_DEFAULT category to all implicit intents passed to startActivity() and startActivityForResult(). So if you want your activity to receive implicit intents, it must include a category for "android.intent.category.DEFAULT" in its intent filters (as shown in the previous <intent-filter> example.

- **Data test**

To specify accepted intent data, an intent filter can declare zero or more <data> elements. For example:

```
<intent-filter>
   <data android:mimeType="video/mpeg" android:scheme="http" ... />
   <data android:mimeType="audio/mpeg" android:scheme="http" ... />
   ...
</intent-filter>
```

Each <data> element can specify a URI structure and a data type (MIME media type). There are separate attributes — scheme, host, port, and path — for each part of the URI:

<scheme>://<host>:<port>/<path>

For example:

content://com.example.project:200/folder/subfolder/etc

In this URI, the scheme is content, the host is com.example.project, the port is 200, and the path is folder/subfolder/etc.

Each of these attributes is optional in a <data> element, but there are linear dependencies:

- If a scheme is not specified, the host is ignored.
- If a host is not specified, the port is ignored.
- If both the scheme and host are not specified, the path is ignored.
- When the URI in an intent is compared to a URI specification in a filter, it's compared only to the parts of the URI included in the filter. For example:
- If a filter specifies only a scheme, all URIs with that scheme match the filter.

- If a filter specifies a scheme and an authority but no path, all URIs with the same scheme and authority pass the filter, regardless of their paths.
- If a filter specifies a scheme, an authority, and a path, only URIs with the same scheme, authority, and path pass the filter.

Note: A path specification can contain a wildcard asterisk (*) to require only a partial match of the path name.

The data test compares both the URI and the MIME type in the intent to a URI and MIME type specified in the filter. The rules are as follows:

- An intent that contains neither a URI nor a MIME type passes the test only if the filter does not specify any URIs or MIME types.
- An intent that contains a URI but no MIME type (neither explicit nor inferable from the URI) passes the test only if its URI matches the filter's URI format and the filter likewise does not specify a MIME type.
- An intent that contains a MIME type but not a URI passes the test only if the filter lists the same MIME type and does not specify a URI format.
- An intent that contains both a URI and a MIME type (either explicit or inferable from the URI) passes the MIME type part of the test only if that type matches a type listed in the filter. It passes the URI part of the test either if its URI matches a URI in the filter or if it has a content: or file: URI and the filter does not specify a URI. In other words, a component is presumed to support content: and file: data if its filter lists only a MIME type.

This last rule, rule (d), reflects the expectation that components are able to get local data from a file or content provider. Therefore, their filters can list just a data type and do not need to explicitly name the content: and file: schemes. This is a typical case. A <data> element like the following, for example, tells Android that the component can get image data from a content provider and display it:

```
<intent-filter>

   <data android:mimeType="image/*" />

   ...

</intent-filter>
```

Because most available data is dispensed by content providers, filters that specify a data type but not a URI are perhaps the most common.

Another common configuration is filters with a scheme and a data type. For example, a <data> element like the following tells Android that the component can retrieve video data from the network in order to perform the action:

```
<intent-filter>
    <data android:scheme="http" android:type="video/*" />
    ...
</intent-filter>
```

1.5.12 Intent matching

Intents are matched against intent filters not only to discover a target component to activate, but also to discover something about the set of components on the device. For example, the Home app populates the app launcher by finding all the activities with intent filters that specify the ACTION_MAIN action and CATEGORY_LAUNCHER category.

Your application can use intent matching in a similar way. The PackageManager has a set of query...() methods that return all components that can accept a particular intent, and a similar series of resolve...() methods that determine the best component to respond to an intent. For example, queryIntentActivities() returns a list of all activities that can perform the intent passed as an argument, and queryIntentServices() returns a similar list of services. Neither method activates the components; they just list the ones that can respond. There's a similar method, queryBroadcastReceivers(), for broadcast receivers.

CHAPTER 2

USING THE SIM CARD AS A SECURE ELEMENT IN ANDROID

Mobile devices can include some form of a Secure Element (SE), but a smart card based UICC (usually called just 'SIM card') is almost universally present. Virtually all SIM cards in use today are programmable and thus can be used as a SE. Continuing the topic of hardware-backed security, we will now look into how SIMs can be programmed and used to enhance the security of Android applications.

2.1 Secure Element

A Secure Element (SE) is a tamper resistant smart card chip capable of running smart card applications (called applets or cardlets) with a certain level of security and features. A smart card is essentially a minimalistic computing environment on single chip, complete with a CPU, ROM, EEPROM, RAM and I/O port. Recent cards also come equipped with cryptographic co-processors implementing common algorithms such as DES, AES and RSA. Smart cards use various techniques to implement tamper resistance, making it quite hard to extract data by disassembling or analyzing the chip. They come pre-programmed with a multi-application OS that takes advantage of the hardware's memory protection features to ensure that each application's data is only available to itself. Application installation and (optionally) access is controlled by requiring the use of cryptographic keys for each operation.

The SE can be integrated in mobile devices in various form factors: UICC (commonly known as a SIM card), embedded in the handset or connected to a SD card slot. If the device supports NFC the SE is usually connected to the NFC chip, making it possible to communicate with the SE wirelessly.

Smart cards have been around for a while and are now used in applications ranging from pre-paid phone calls and transit ticketing to credit cards and VPN credential storage. Since an SE installed in a mobile device has equivalent or superior capabilities to that of a smart card, it can theoretically be used for any application physical smart cards are currently used for. Additionally, since an SE can host multiple applications, it has the potential to replace the bunch of cards people use daily with a single device. Furthermore, because the SE can be controlled by the device's OS, access to it can be restricted by requiring additional authentication (PIN or passphrase) to enable it.

So a SE is obviously a very useful thing to have and with a lot of potential, but why would you want to access one from your apps? Aside from the obvious payment applications, which you couldn't realistically build unless you own a bank and have a contract with Visa and friends, there is the possibility of storing other cards you already have (access cards, loyalty cards, etc.) on your phone, but that too is somewhat of a gray area and may requiring contracting the relevant issuing entities. The main application for third party apps would be implementing and running a critical part of the app, such as credential storage or license verification inside the SE to guarantee that it is impervious to reversing and cracking. Other apps that can benefit from being implemented in the SE are One Time Password (OTP) generators and, of course PKI credential (i.e., private keys) storage. While implementing those apps is possible today with standard tools and technologies, using them in practice on current commercial Android devices is not that straightforward.

2.2 SIM cards

First, a few words about terminology: while the correct term for modern mobile devices is UICC (Universal Integrated Circuit Card), since the goal of this post is not to discuss the differences between mobile networks, we will usually call it a 'SIM card' and only make the distinction when necessary.

So what is a SIM card? 'SIM' stands for Subscriber Identity Module and refers to a smart card that securely stores the subscriber identifier and the associated key used to identify and authenticate to a mobile network. It was originally used on GSM networks and standards were later extended to support 3G and LTE. Since SIMs are smart cards, they conform to ISO-7816 standards regarding physical characteristics and electrical interface. Originally they were the same size as 'regular' smart cards (Full-size, FF), but by far the most popular sizes nowadays are Mini-SIM (2FF) and Micro-SIM (3FF), with Nano-SIM (4FF) introduced in 2012.

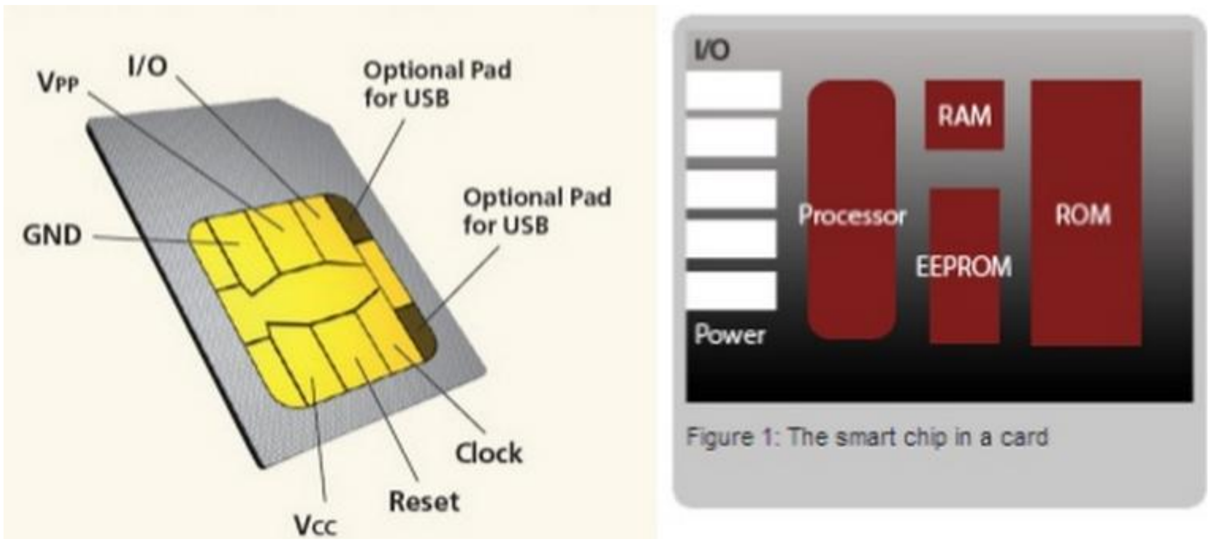


Fig 2.1 - SIM Card structure

Of course, not every smart that fits in the SIM slot can be used in a mobile device, so the next question is: what **makes a smart card a SIM card?** Technically, it's conformance to mobile communication standards such 3GPP TS 11.11 and certification by the SIMalliance. In practice it is the ability to run an application that allows it to communicate with the phone (referred to as 'Mobile Equipment', ME, or 'Mobile Station', MS in related standards) and connect to a mobile network. While the original GSM standard did not make a distinction between the physical smart card and the software required to connect to the mobile network, with the introduction of 3G standards, a clear distinction has been made. The physical smart card is referred to as Universal Integrated Circuit Card (UICC) and different mobile network applications than run on it have been defined: GSM, CSIM, USIM, ISIM, etc. A UICC can host and run more than one network application (hence 'universal'), and thus can be used to connect to different networks. While network application functionality depends on the specific mobile network, their core features are quite similar: store network parameters securely and identify to the network, as well as authenticate the user (optionally) and store user data.

2.2.1 SIM card applications

Let's take GSM/3G as an example and briefly review how a network application works. For GSM the main network parameters are network identity (International Mobile Subscriber Identity, IMSI; tied to the SIM), phone number (MSISDN, used for routing calls and changeable) and a shared network authentication key Ki. To connect to the network the MS needs to authenticate itself and negotiate a session key. Both authentication and session key derivation make use of Ki, which is also known to the network and looked up by IMSI. The MS sends a connection request and includes its IMSI, which the network uses to find the corresponding Ki. The network then uses the Ki to generate a challenge (RAND), expected challenge response (SRES) and session key Kc and sends RAND to the MS. Here's where the GSM application running on the SIM card comes into play: the MS passes the RAND to the SIM card, which in turn generates its own SRES and Kc. The SRES is sent to the network and if it matches the expected value, encrypted communication is established using the session key Kc. As you can see, the security of this protocol hinges solely on the secrecy of the Ki. Since all operations involving the Ki are implemented inside the SIM and it never comes with direct contact with neither the MS or the network, the scheme is kept reasonably secure. Of course, security depends on the encryption algorithms used as well, and major weaknesses that allow intercepted GSM calls to be decrypted using off-the shelf hardware were found in the original versions of the A3/A5 algorithms (which were initially secret). Jumping back to Android for a moment, all of this is implemented by the baseband software (more on this later) and network authentication is never directly visible to the main OS.

We've shown that SIM cards need to run applications, let's now say a few words about how those applications are implemented and installed. Initial smart cards were based on a file system model, where files (elementary files, EF) and directories (dedicated files, DF) were named with a two-byte identifier. Thus developing 'an application' consisted mostly of selecting an ID for the DF that hosts its files (called ADF), and specifying the formats and names of EFs that store data. For example, the GSM application is under the '7F20' ADF, and the USIM ADF hosts the EF_imsi,EF_keys, EF_sms, etc. files. Practically all SIMs used today are based on Java Card technology and implement GlobalPlatform card specifications. Thus all network applications are implemented as Java Card applets and emulate the legacy file-based structure for backward compatibility. Applets are installed according to GlobalPlatform specifications by authenticating to the Issuer Security Domain (Card Manager) and issuing LOAD and INSTALLcommands.

One application management feature specific to SIM cards is support for OTA (Over-The-Air) updates via binary SMS. This functionality is not used by all carries, but it allows them to remotely install applets on SIM cards they have issued. OTA is implemented by wrapping card commands (APDUs) in SMS T-PDUs, which the ME forwards to the SIM (ETSI TS 102 226). In most SIMs this is actually the only way to load applets on the card, even during initial personalization. That is why most of the common GlobalPlatform-compliant tools cannot be used as is for managing SIMs. One needs to either use a tool that supports SIM OTA, such as the SIMalliance Loader, or implement APDU wrapping/unwrapping, including any necessary encryption and integrity algorithms (ETSI TS 102 225). Incidentally, problems with the implementation of those secured packets on some SIMs that use DES as the encryption and integrity algorithm have been used to crack OTA update keys. The major use of the OTA functionality is to install and maintain SIM Toolkit (STK) applications which can interact with the handset via standard 'proactive' (in reality implemented via polling) commands and display menus or even open Web pages and send SMS. While STK applications are almost unheard of in the US and Asia, they are still heavily used in some parts of Europe and Africa for anything from mobile banking to citizen authentication. Android also supports STK with a dedicated STK system app, which is automatically disabled if the SIM card has not STK applets installed.

2.2.2 Accessing the SIM card

As mentioned above, network related functionality is implemented by the baseband software and what can be done from Android is entirely dependent on what features the baseband exposes. Android supports STK applications, so it does have internal support for communicating to the SIM, but the OS security overview explicitly states that '*low level access to the SIM card is not available to third-party apps*'. So how can we use it as an SE then? Some Android builds from major vendors, most notably Samsung, provide an implementation of the SIMalliance Open Mobile API on some handsets and an open source implementation (for compatible devices) is available from the SEEK for Android project. The Open Mobile API aims to provide a unified interface for accessing SEs on Android, including the SIM. To understand how the Open Mobile API works and the cause of its limitations, let's first review how access to the SIM card is implemented in Android.

On Android devices all mobile network functionality (dialing, sending SMS, etc.) is provided by the baseband processor (also referred to as 'modem' or 'radio'). Android applications and system services communicate to the baseband only indirectly via the Radio Interface Layer (RIL) daemon (rild). It in turn talks to the actual hardware by using a manufacturer-provided RIL HAL library, which wraps the proprietary interface the baseband provides. The SIM card is typically connected only to baseband processor (sometimes also to the NFC controller via SWP), and thus all communication needs to go through the RIL. While the proprietary RIL implementation can always access the SIM in order to perform network identification and authentication, as well as read/write contacts and access STK applications, support for transparent APDU exchange is not always available. The standard way to provide this feature is to use extended AT commands such AT+CSIM (Generic SIM access) and AT+CGLA (Generic UICC Logical Channel Access), as defined in 3GPP TS 27.007, but some vendors implement it using proprietary extensions, so support for the necessary AT commands does not automatically provide SIM access.

SEEK for Android provides patches that implement a resource manager service (SmartCardService) that can connect to any supported SE (embedded SE, ASSD or UICC) and extensions to the Android telephony framework that allow for transparent APDU exchange with the SIM. As mentioned above, access through the RIL is hardware and proprietary RIL library dependent, so you need both a compatible device and a build that includes the SmartCardService and related framework extensions. Thanks to some work by they u'smile project, UICC access on most variants of the popular Galaxy S2 and S3 handsets is available using a patched CyanogenMod build, so you can make use of the latest SEEK version. Even if you don't own one of those devices, you can use the SEEK emulator extension which lets you use a standard PC/SC smart card reader to connect a SIM to the Android emulator. Note that just any regular Java card won't work out of the box because the emulator will look for the GSM application and mark the card as not usable if it doesn't find one. You can modify it to skip those steps, but a simple solution is to install a dummy GSM application that always returns the expected responses.

Once you have managed to get a device or the emulator to talk to the SIM, using the OpenMobile API to send commands is quite straightforward:

```
// connect to the SE service, asynchronous

SEService seService = new SEService(this, this);

// list readers

Reader[] readers = seService.getReaders();

// assume the first one is SIM and open session

Session session = readers[0].openSession();

// open logical (or basic) channel

Channel channel = session.openLogicalChannel(aid);

// send APDU and get response

byte[] rapdu = channel.transmit(cmd);
```

You will need to request the org.simalliance.openmobileapi.SMARTCARD permission and add the org.simalliance.openmobileapi extension library to your manifest for this to work.

```
<manifest ...>
<uses-permission android:name="org.simalliance.openmobileapi.SMARTCARD" />
<application ...>
<uses-library
        android:name="org.simalliance.openmobileapi"
        android:required="true" />
  ...
</application>
</manifest>
```

2.2.3 SE-enabled Android applications

Now that we can connect to the SIM card from applications, what can we use it for? Just as regular smart cards, an SE can be used to store data and keys securely and perform cryptographic operations without keys having to leave the card. One of the usual applications of smart cards is to store RSA authentication keys and certificates that are used from anything from desktop logon to VPN or SSL authentication. This is typically implemented by providing some sort of middleware library, usually a standard cryptographic service provider (CSP) module that can plug into the system CSP or be loaded by a compatible application. As the Android security model does not allow system extensions provided by third party apps, in order to integrate with the system key management service, such middleware would need to be implemented as a key master module for the system credential store (keystore) and be bundled as a system library. This can be accomplished by building a custom ROM which installs our custom key master module, but we can also take advantage of the SE without rebuilding the whole system. The most straightforward way to do this is to implement the security critical part of an app inside the SE and have the app act as a client that only provides a user-facing GUI. One such application provided with the SEEK distribution is an SE-backed one-time password (OTP)Google Authenticator app. Since the critical part of OTP generators is the seed (usually a symmetric cryptographic key), they can easily be cloned once the seed is obtained or extracted. Thus OTP apps that store the seed in a regular file (like the official Google Authenticator app) provide little protection if the device OS is compromised. The SEEK GoogleOtpAuthenticator app both stores the seed and performs OTP generation inside the SE, making it impossible to recover the seed from the app data stored on the device.

The Java Card API provides a subset of the JCA classes, with an interface optimized towards using pre-allocated, shared byte arrays, which is typical on a memory constrained platform such as a smart card. A basic encryption example would look something like this:

```
byte[] buff = apdu.getBuffer();

//..

DESKey deskey =

 (DESKey)KeyBuilder.buildKey(KeyBuilder.TYPE_DES_TRANSIENT_DESELECT,

            KeyBuilder.LENGTH_DES3_2KEY, false);

deskey.setKey(keyBytes, (short)0);

Cipher cipher = Cipher.getInstance(Cipher.ALG_DES_CBC_PKCS5, false);

cipher.init(deskey, Cipher.MODE_ENCRYPT);

cipher.doFinal(data, (short) 0, (short) data.length,

             buff, (short) 0);
```

As you can see, a dedicated key object, that is automatically cleared when the applet is deselected, is first created and then used to initialize a Cipher instance. Besides the unwieldy number of casts to short (necessary because 'classic' Java Card does not support int, but it is still the default integer type) the code is very similar to what you would find in a Java SE or Android application. Hashing uses the MessageDigest class and follows a similar routine. Using the system-provided Cipher and MessageDigest classes as building blocks it is fairly straightforward to implement CBC mode encryption and HMAC for data integrity. However as it happens, our low end SIM card does not provide usable implementations of those classes (even though the spec sheet claims they do), so we would need to start from scratch. Fortunately, since Java cards can execute arbitrary programs (as long as they fit in memory), it is also possible to include our own encryption algorithm implementation in the applet. Even better, a Java Card optimized AES implementation is freely available. This implementation provides only the basic pieces of AES -- key schedule generation and single block encryption, so some additional work is required to match the Java Cipher class functionality. The bigger downside is that by using an algorithm implemented in software we cannot take advantage of the specialized crypto co-processor most smart cards have. With this implementation our SIM (8-bit CPU, 6KB RAM) card takes about 2 seconds to process a single AES block with a 128-bit key. The performance can be improved slightly by reducing the number of AES round to 7 (10 are recommended for 128-bit keys), but that will both lower the security level of the system and result in an non-standard cipher, making testing more difficult. Another disadvantage is that native key objects are usually stored in a secured memory area that is better protected from side channel attacks, but by using our own cipher we are forced to store keys in regular byte arrays. With those caveats, this AES implementation should give us what we need for our demo application. Using the JavaCardAES class as a building block, our AES CBC encryption routine would look something like this:

```
aesCipher.RoundKeysSchedule(keyBytes, (short) 0, roundKeysBuff);

short padSize = addPadding(cipherBuff, offset, len);

short paddedLen = (short) (len + padSize);

short blocks = (short) (paddedLen / AES_BLOCK_LEN);

for (short i = 0; i < blocks; i++) {

  short cipherOffset = (short) (i * AES_BLOCK_LEN);

  for (short j = 0; j < AES_BLOCK_LEN; j++) {

    cbcV[j] ^= cipherBuff[(short) (cipherOffset + j)];

  }

  aesCipher.AESEncryptBlock(cbcV, OFFSET_ZERO, roundKeysBuff);

  Util.arrayCopyNonAtomic(cbcV, OFFSET_ZERO, cipherBuff,

                          cipherOffset, AES_BLOCK_LEN);

}
```

Not as concise as using the system crypto classes, but gets the job done. Finally (not shown), the IV and cipher text are copied to the APDU buffer and sent back to the caller. Decryption follows a similar pattern. One thing that is obviously missing is the MAC, but as it turns out a hash algorithm implemented in software is prohibitively slow on our SIM (mostly because it needs to access large tables stored in the slow card EEPROM). While a MAC can be also implemented using the AES primitive, we have omitted it from the sample applet. In practice tampering with the cipher text of encrypted passwords would only result in incorrect passwords, but it is still a good idea to use a MAC when implementing this on a fully functional Java Card.

2.3 Near field communication (NFC)

NFC is a set of standards for smartphones and similar devices to establish radio communication with each other by touching them together or bringing them into proximity, typically a distance of 10 cm (3.9 in) or less.

As with proximity card technology, near-field communication uses electromagnetic induction between two loop antennas located within each other's near field, effectively forming an air-core transformer. It operates within the globally available and unlicensed radio frequency ISM band of 13.56 MHz on ISO/IEC 18000-3 air interface and at rates ranging from 106 kbits/s to 424 kbit/s. NFC involves an initiator and a target; the initiator actively generates an RF field that can power a passive target, an unpowered chip called a "tag". This enables NFC targets to take very simple form factors such as tags, stickers, key fobs, or cards that do not require batteries. NFC peer-to-peer communication is possible, provided both devices are powered. NFC tags contain data (currently between 96 and 4,096 bytes of memory) and are typically read-only, but may be rewriteable. The tags can securely store personal data such as debit and credit card information, loyalty program data, PINs and networking contacts, among other information. They can be custom-encoded by their manufacturers or use the specifications provided by the NFC Forum, an industry association with more than 160 members founded in 2004 by Nokia, Philips Semiconductors (became NXP Semiconductors since 2006) and Sony charged with promoting the technology and setting key standards. The NFC Forum defines four types of tags that provide different communication speeds and capabilities in terms of configurability, memory, security, data retention and write endurance.

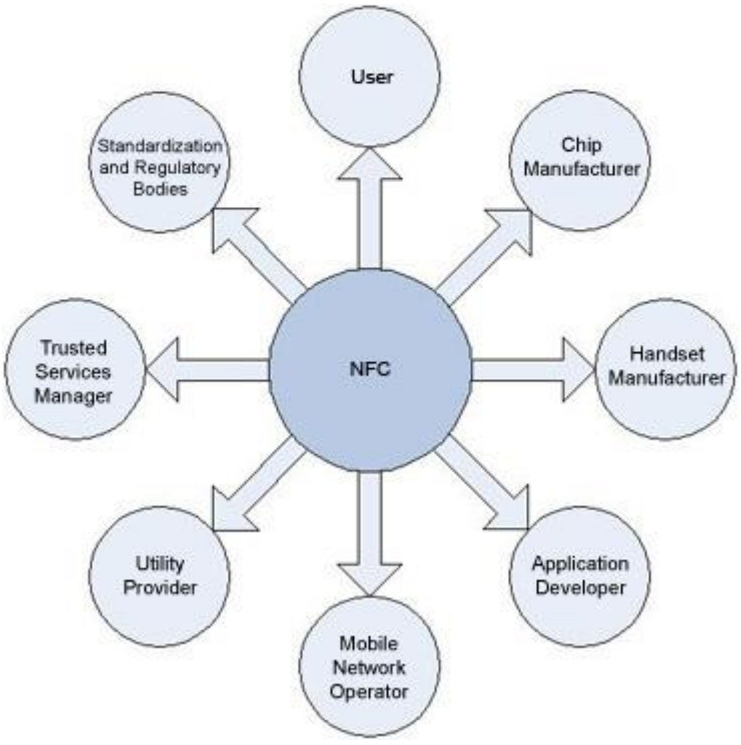


Fig 2.2 - NFC Features

NFC standards cover communications protocols and data exchange formats, and are based on existing radio-frequency identification(RFID) standards including ISO/IEC 14443 and FeliCa. The standards include ISO/IEC 18092[5] and those defined by the NFC Forum. In addition to the NFC Forum, the GSMA has also worked to define a platform for the deployment of "GSMA NFC Standards" within mobile handsets. GSMA's efforts include Trusted Services Manager,Single Wire Protocol, testing and certification, secure element.

A patent licensing program for NFC is currently under deployment by France Brevets, a patent fund created in 2011. A public, platform-independent NFC library is released under the free GNU Lesser General Public License by the name libnfc.

CHAPTER 3

TRUSTED SERVICE MANAGER: THE TRUSTED INTERMEDIARY

3.1 Trusted Service Manager(TSM)

A **trusted service manager (TSM)** is a role in a near field communication ecosystem. It acts as a neutral broker that sets up business agreements and technical connections with mobile network operators, phone manufacturers or other entities controlling the secure element on mobile phones. The trusted service manager enables service providers to distribute and manage their contactless applications remotely by allowing access to the secure element in NFC-enabled handsets.

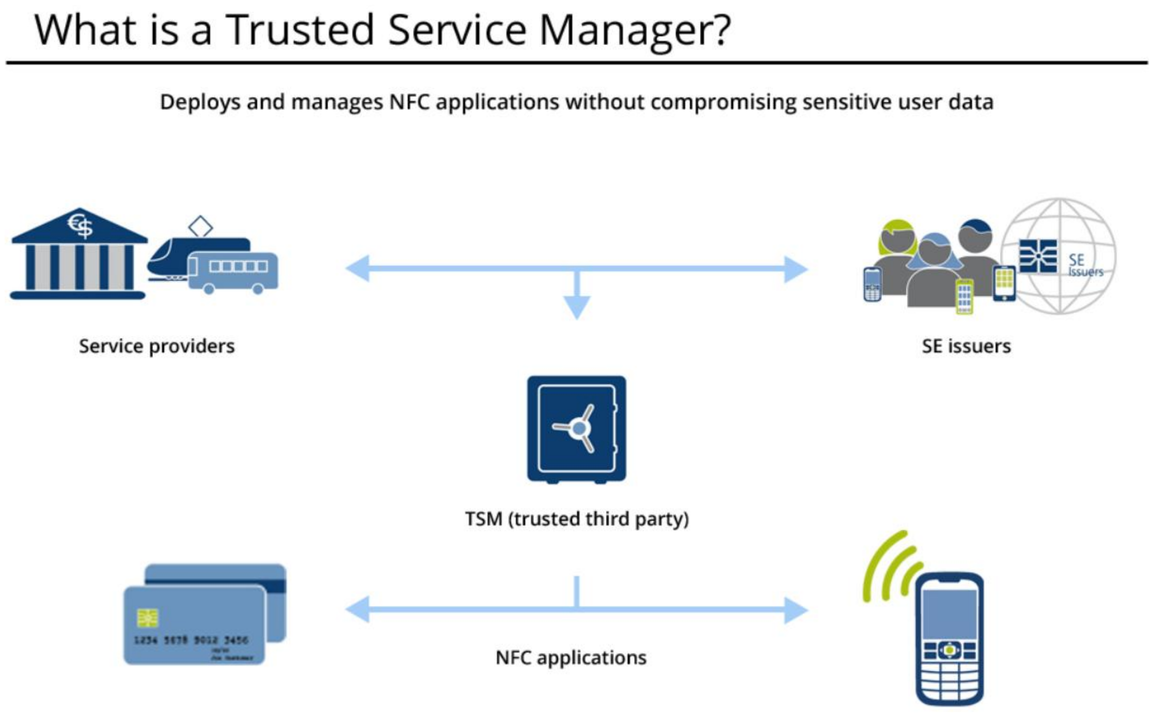

What is a Trusted Service Manager?
Deploys and manages NFC applications without compromising sensitive user data
Service providers
SE issuers
SE issuers
TSM (trusted third party)
NFC applications
1234 5678 9012 3456

Fig 3.1 - Trusted Service Manager Overview

3.1.1 Types of TSM

There are two types of TSM – the secure element issuer TSM (SEI TSM) and the service provider TSM (SP TSM). The SEI TSM manages secure element lifecycles and security domains for SPs, while the SP TSM manages the service provider's application provisioning to the SE and its application lifecycles. Collaboration and messaging between the two TSMs is standardized by the industry association "GlobalPlatform", which supports the use of any secure element type. The TSM acts as a bridge between the various service providers and the final customers.

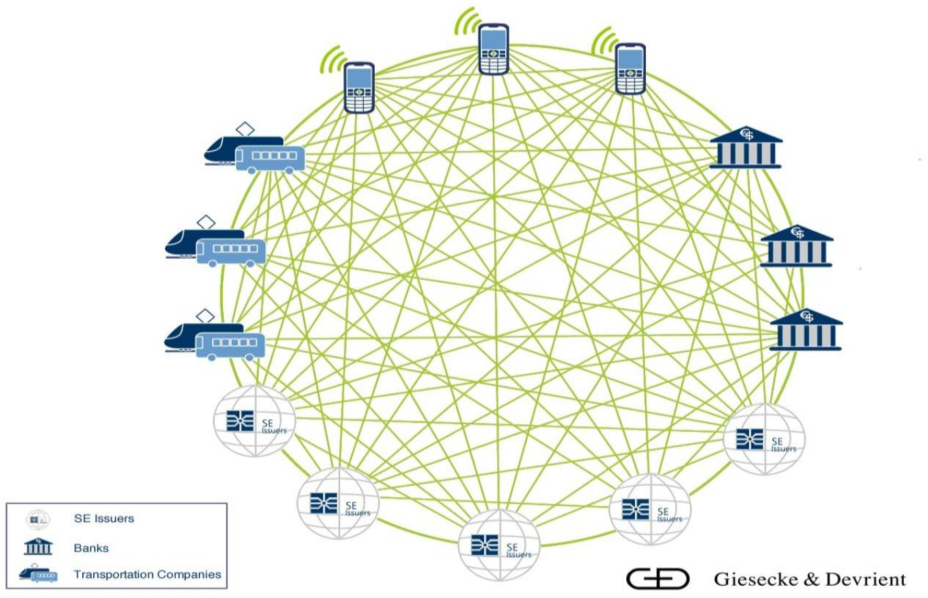


Fig 3.2 - NFC Eco-System without TSM

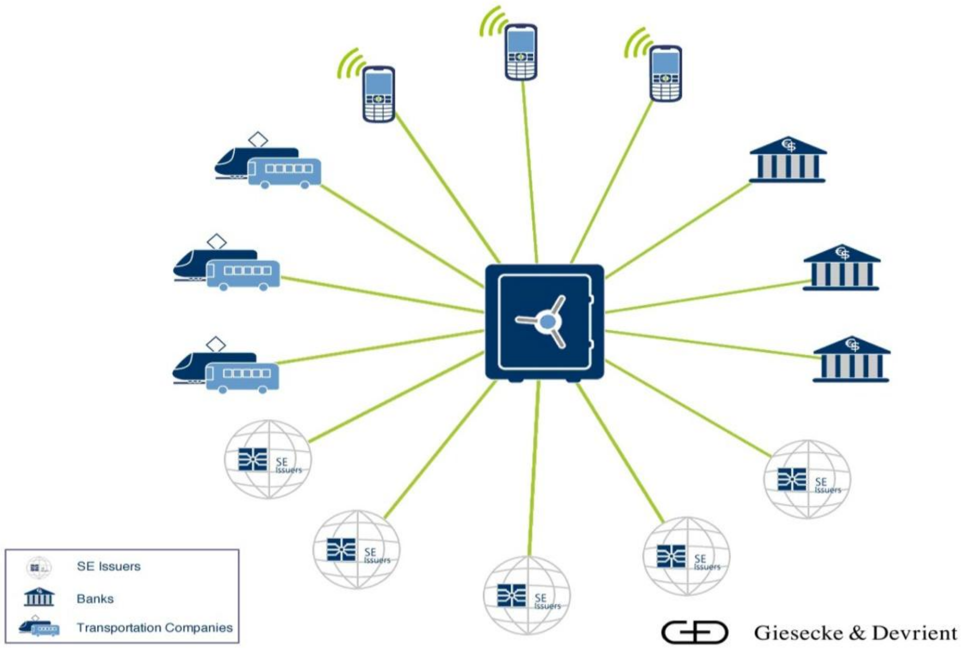


Fig 3.3 - NFC Eco-System with TSM

It is also worth noting that the TSM infrastructure can be utilized to provision and manage SE applications that are not NFC-based too – a good example being an online authentication application that can be deployed in the context of online or mobile banking services.

3.1.2 Highest security requirements

As the term implies, both TSMs need to be trusted and hence highly secure. This entails secure physical premises, high-quality processes, and security built into the systems and solutions deployed, including secure key storage. This is particularly essential in relation to payment applications, and payment schemes such as Visa and MasterCard therefore require stringent TSM certification. Due to these security requirements and the necessary know-how of both mobile and payment technologies, TSM (especially of the open, aggregating SP variety) is most often provided as a managed service by a trusted expert – and that is where G&D comes in.

CHAPTER 4

SYSTEM DESIGN

4.1 Overall Diagram

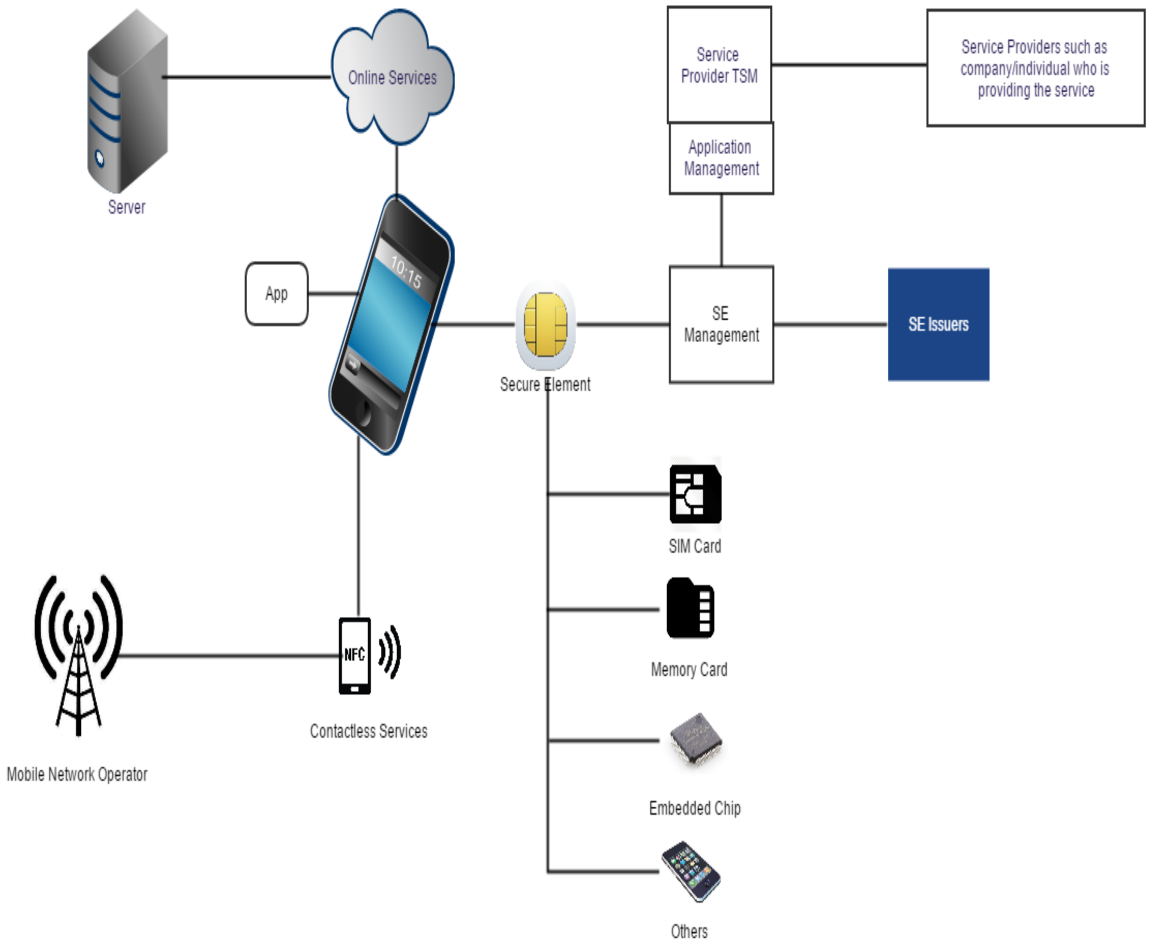


Fig 4.1 - Overall Structure

4.2 Flow Diagram

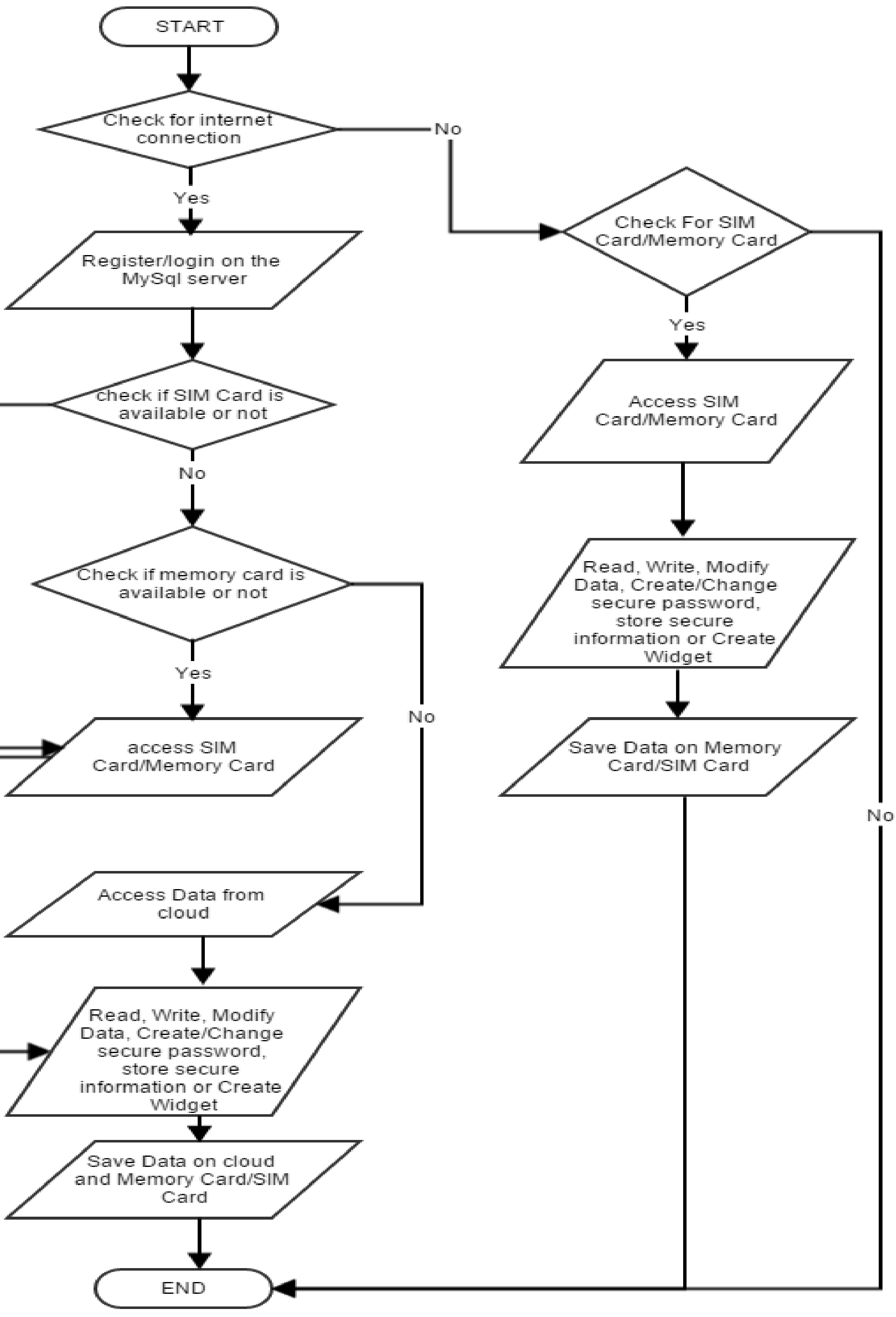

START
Check for internet connection
No
Yes
Register/login on the MySql server
check if SIM Card is available or not
Yes
No
Check if memory card is available or not
Yes
No
access SIM Card/Memory Card
Access Data from cloud
Read, Write, Modify Data, Create/Change secure password, store secure information or Create Widget
Save Data on cloud and Memory Card/SIM Card
END
Check For SIM Card/Memory Card
Yes
Access SIM Card/Memory Card
Read, Write, Modify Data, Create/Change secure password, store secure information or Create Widget
Save Data on Memory Card/SIM Card
No

Fig 4.2 - Flow Diagram

4.3 Use Case

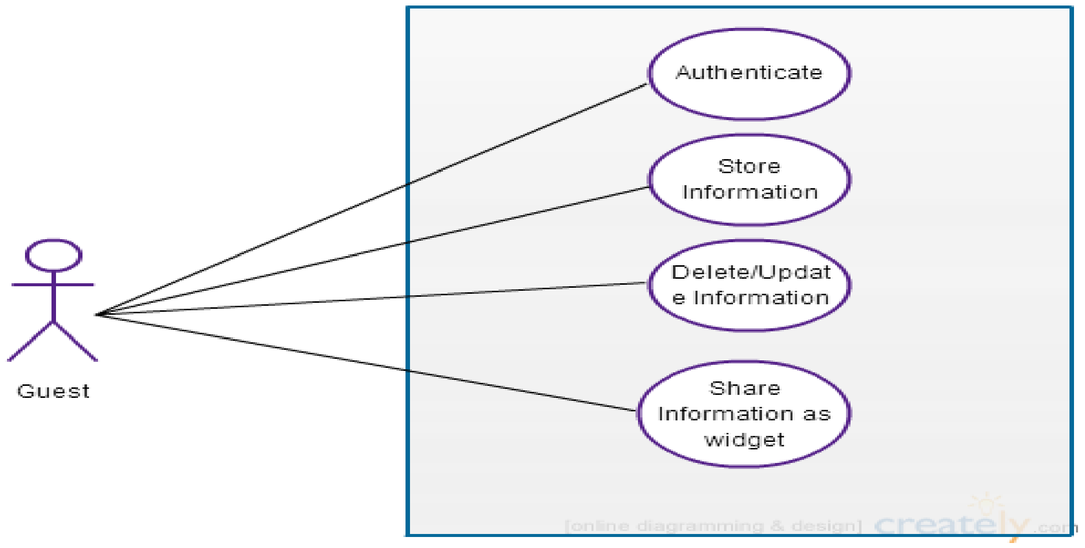

Authenticate
Store Information
Delete/Update Information
Share Information as widget
Guest
[online diagramming & design] creately.com

Fig 4.3 - Use Case for Universal SIM Card

4.4 System Requirements:

1. Hardware Requirements**:**

- Android Phone

CPU	: 768MHz
RAM	: 512 MB
Display	: Any
SD Card Slot	: 1GB
SIM Card	

- NFC

2. Software Requirements:

• OS	: Android 4.0 and above
• Software	: Eclipse, Android Development Tool

CHAPTER 5

IMPLEMENTATION

(Proposed Methodology and Algorithm)

The following things were done in sequence to achieve an executable version of the project:

- A MySQL database is created to maintain user's online account. This store user's information and the data stored by him on SIM Card/Memory Card.
- A "Secure Computation API" is used for the creation of TSM through which SIM Card can be accessed.
- An android default library is used for accessing Memory Card.
- After setting up TSM and checking whether SIM/Memory Card is accessible or not various file handling techniques are used to read, write and store data.
- Since user can store secure data secure password is created by the user. And this password is hashed using HMAC (keyed-hashed message authentication code).
- Also, secured contents stored by the user are encrypted using RSA algorithm to prevent unauthorized access.
- The basic data stored by the user are fetched from the SIM Card/Memory Card and a widget is created to display this data on home screen. The widget is created using android app widget provider library.
- The widget also has a one-touch button which enables user to contact emergency contacts.
- The one-touch button does two things:
    - Firstly, it sends SMS's to the emergency contact numbers about user's location and a default emergency message as set by the user. The SMS feature is implemented using android telephony library.
    - Secondly, it makes calls to the first emergency number. This is also implemented using android's telephony library.
- For fetching the user's location Google Map API is used which returns the co-ordinates and other location details.

CHAPTER 6

OUTPUT (SCREENSHOTS)

Screenshot 1 - App Login Screen

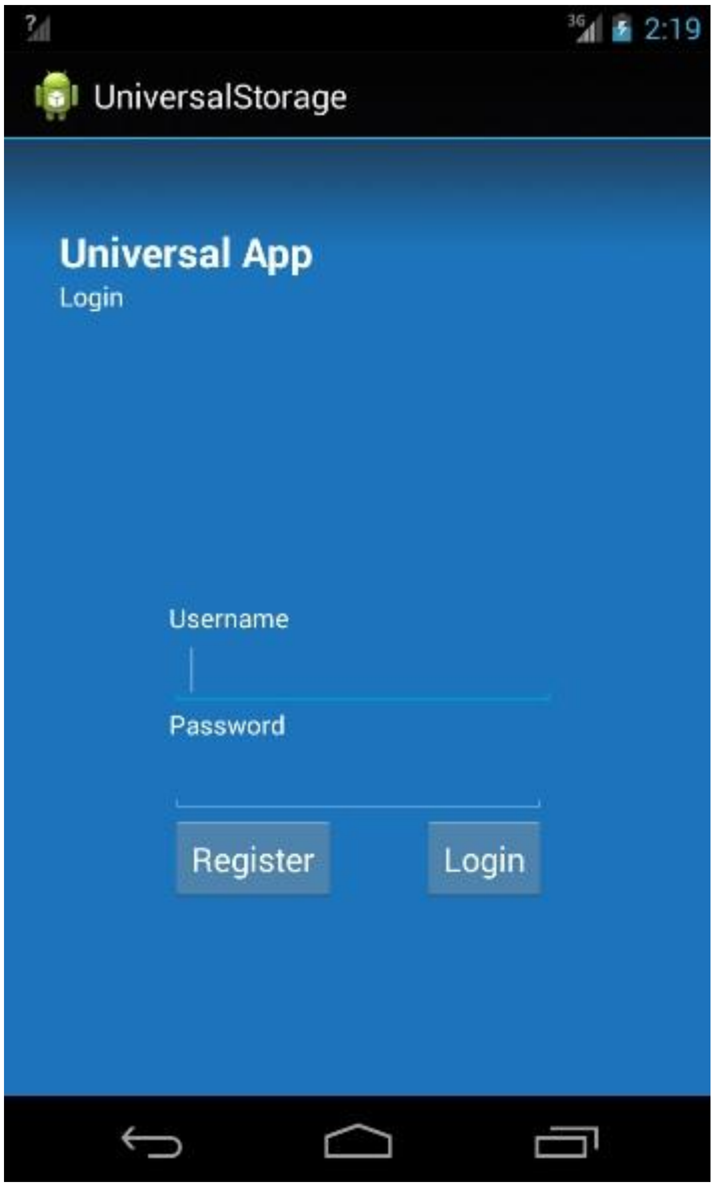


Fig 6.1 - Application login screen

It allows the user to input his username and password and login into the system using login button if he is already registered else he can register himself using the register button.

Screenshot 2- App Register Screen

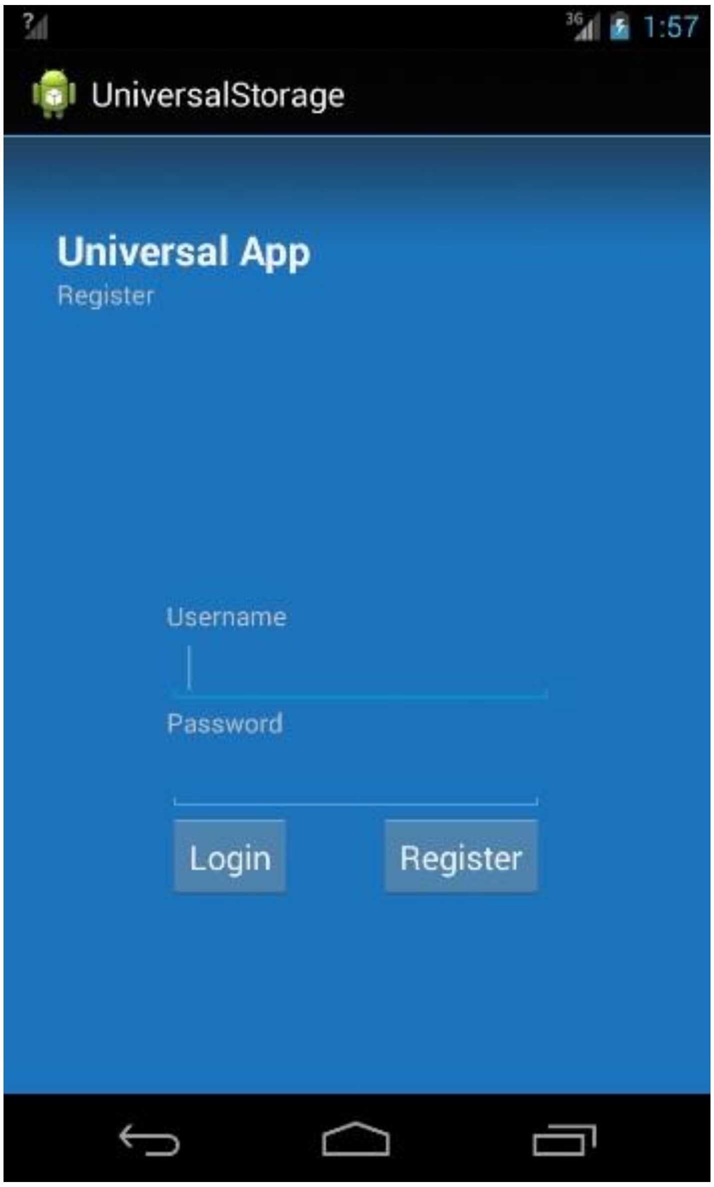


Fig 6.2 - Application register screen

It allows the user to input his desired username and password and then register himself on the server using the register button. If he is already registered then he can go to the login screen by using the login button.

Screenshot 3 - App Menu Screen

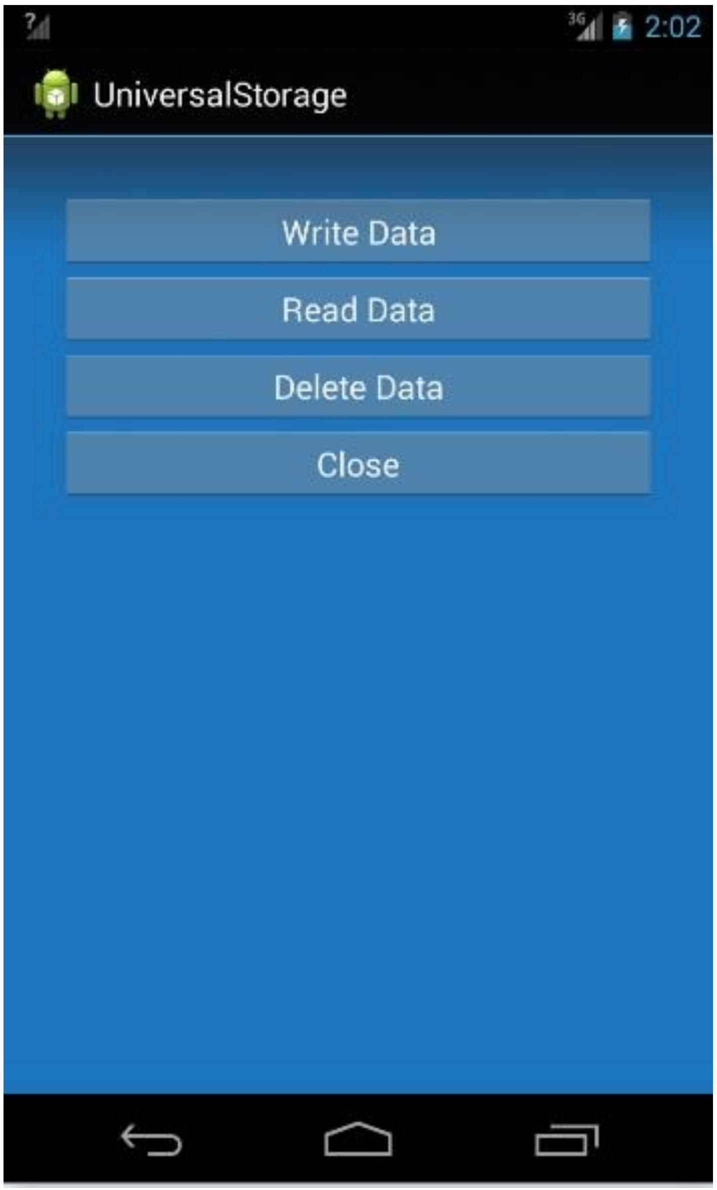
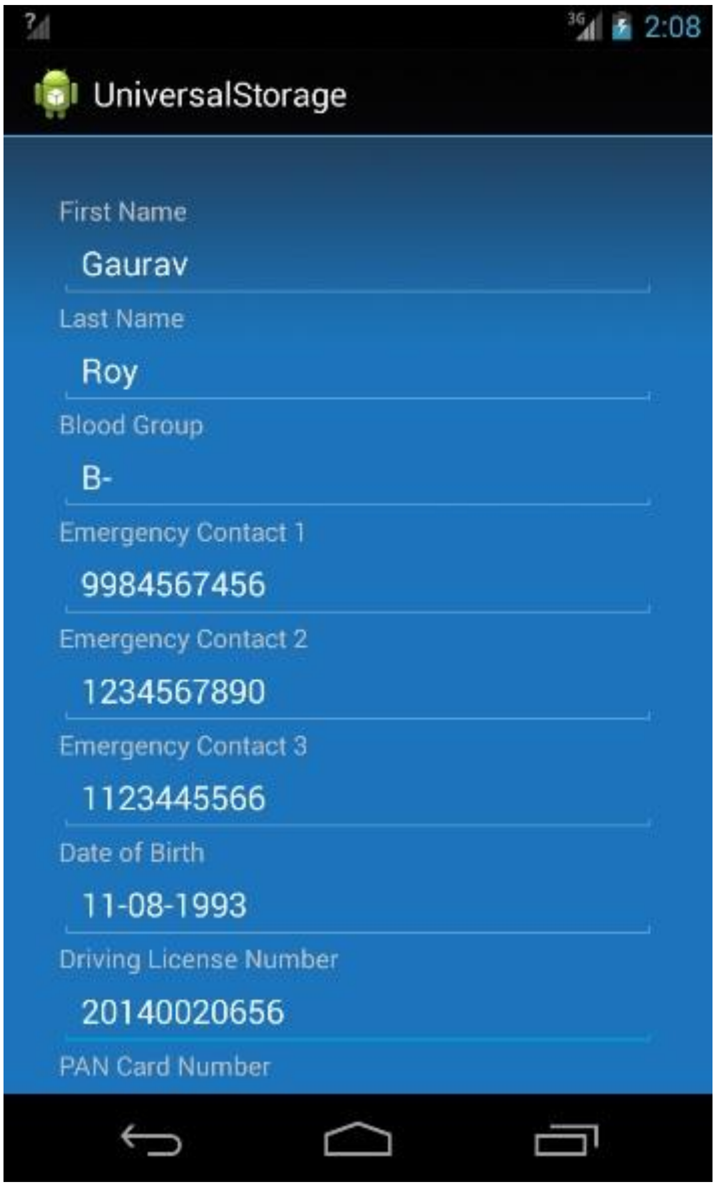


Fig 6.3 - Application menu screen

This menu screen provides the user an option to insert his details, read the details previously stored, delete the data and close the application

Screenshot 4 - App Write/Update screen


2:08

UniversalStorage

First Name
Gaurav

Last Name
Roy

Blood Group
B-

Emergency Contact 1
9984567456

Emergency Contact 2
1234567890

Emergency Contact 3
1123445566

Date of Birth
11-08-1993

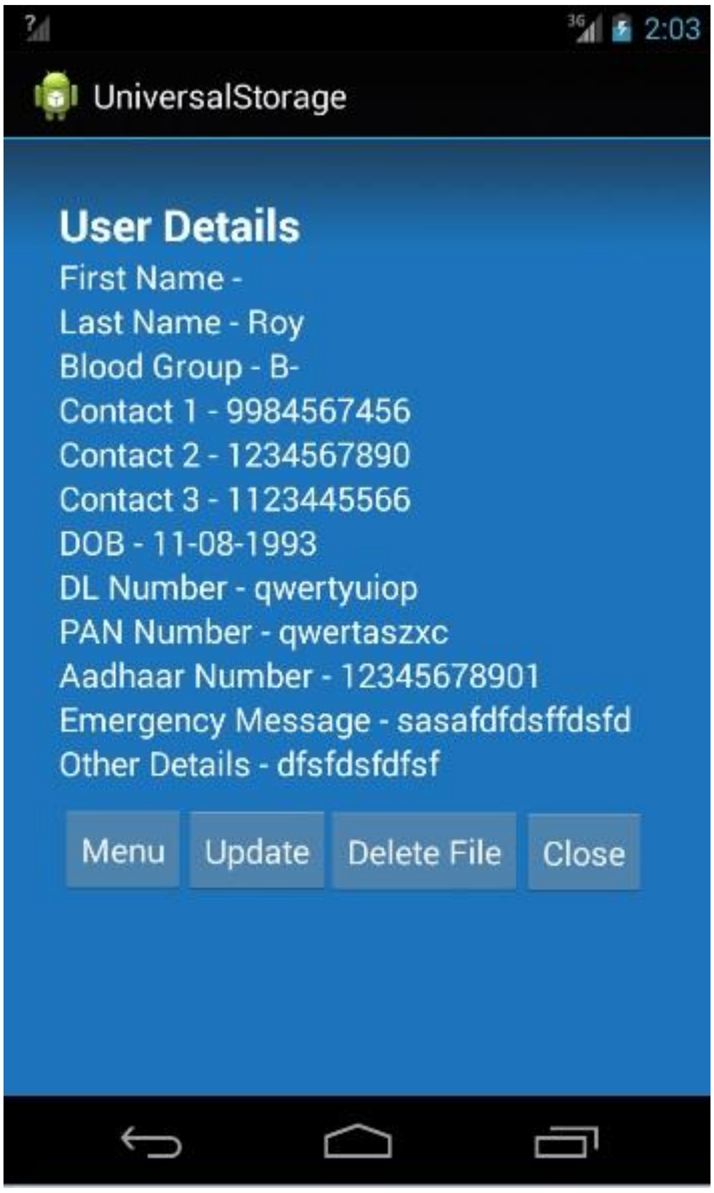
Driving License Number
20140020656

PAN Card Number

Fig 6.4 - Application write/update screen

This screen allows the user to input and save all his basic details. Also this activity validates the input data as per pre-specified format before it is saved.

Screenshot 5 - App User Details Screen



UniversalStorage

User Details

First Name -
Last Name - Roy
Blood Group - B-
Contact 1 - 9984567456
Contact 2 - 1234567890
Contact 3 - 1123445566
DOB - 11-08-1993
DL Number - qwertyuiop
PAN Number - qwertaszxc
Aadhaar Number - 12345678901
Emergency Message - sasafdfdsffdsfd
Other Details - dfsfdsfdfsf

Fig 6.5 - Application user details screen

This screen displays all the data saved by the user. Also the user can update/delete the data, go to the menu screen or go to previous screen by using the buttons present at the bottom of the screen.

Screenshot 6 - App Widget

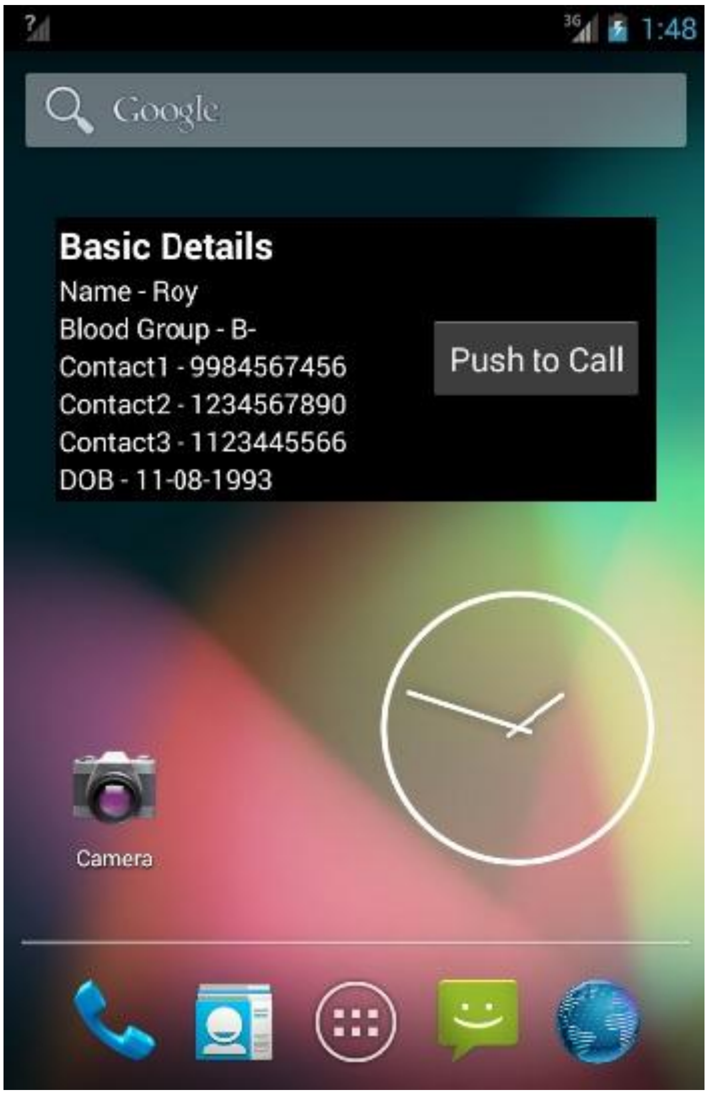

Basic Details
Name - Roy
Blood Group - B-
Contact1 - 9984567456
Contact2 - 1234567890
Contact3 - 1123445566
DOB - 11-08-1993

Fig 6.6 - Application widget

This widget displays the information stored by the user on the homepage. The user can also make call to the first emergency contact number stored by using the push to call in case of emergency.

Screenshot 7 - App call screen

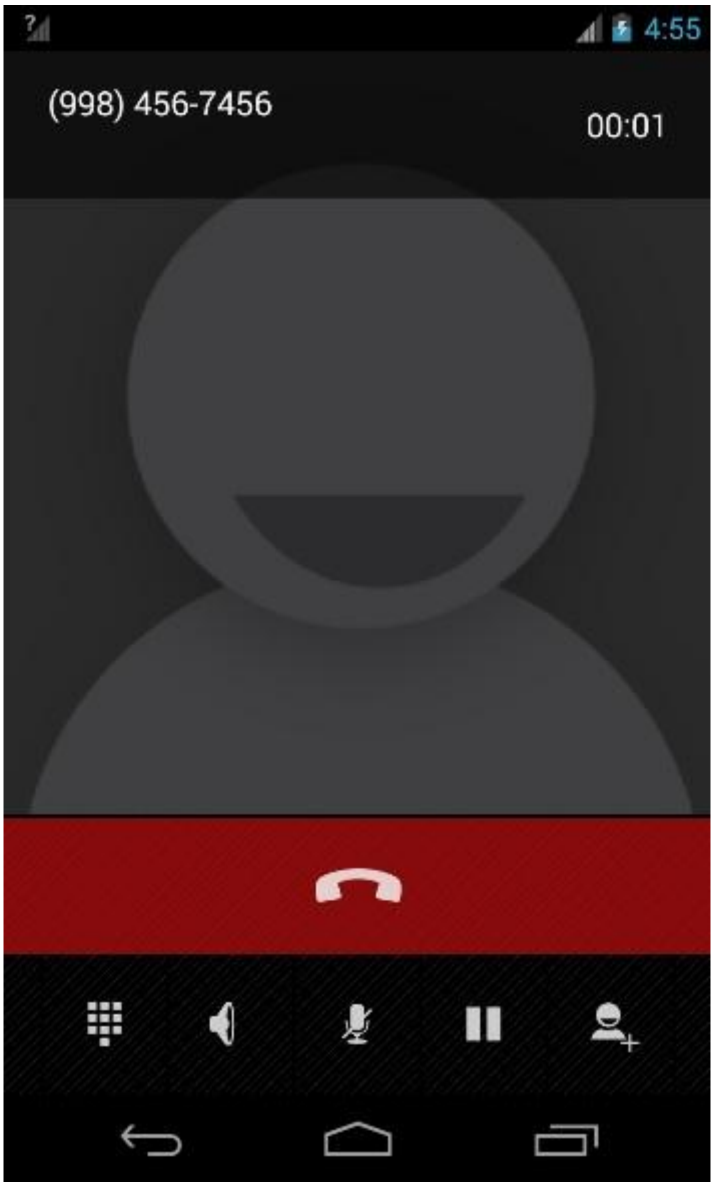


Fig 6.7 - Application call screen

This is the call screen where the user is redirected after he/she clicks on the push to call button present in the widget.

FUTURE WORK

Several approaches can be followed to improvise the current system:

- If integrated with the Police Control Room/ Emergency Control Room this app can be helpful in providing help in very short time in an event of emergency.
- The whole concept of accessing SIM Card can be used in the creation of wallet apps like Google Wallet.

CONCLUSION

Based on the implementation, it can be inferred that, this system can prove to be a promising system. It can be extremely helpful in various emergency situations. Also the data stored on Secure Element (SIM Card/Memory Card) are portable and can be used on any device meeting minimum requirements. And there is no need for user to store same data again and again on different devices.

A secure element is a tamper resistant execution environment on a chip that can execute applications and store data in a secure manner. An SE is found on the UICC of every Android phone, but the platform currently doesn't allow access to it. Thus, TSM implementation is limited as it is a very new concept and the mobile network operator holds the right to ban any TSM any time it wants or if there is a conflict of interest.

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