Android Packer

facing the challenges, building solutions

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What is Android Packer?

Android packers are able to
encrypt an original classes.dex file,
decrypt the dex file to memory at runtime,
and then execute via **DexClassLoader**.

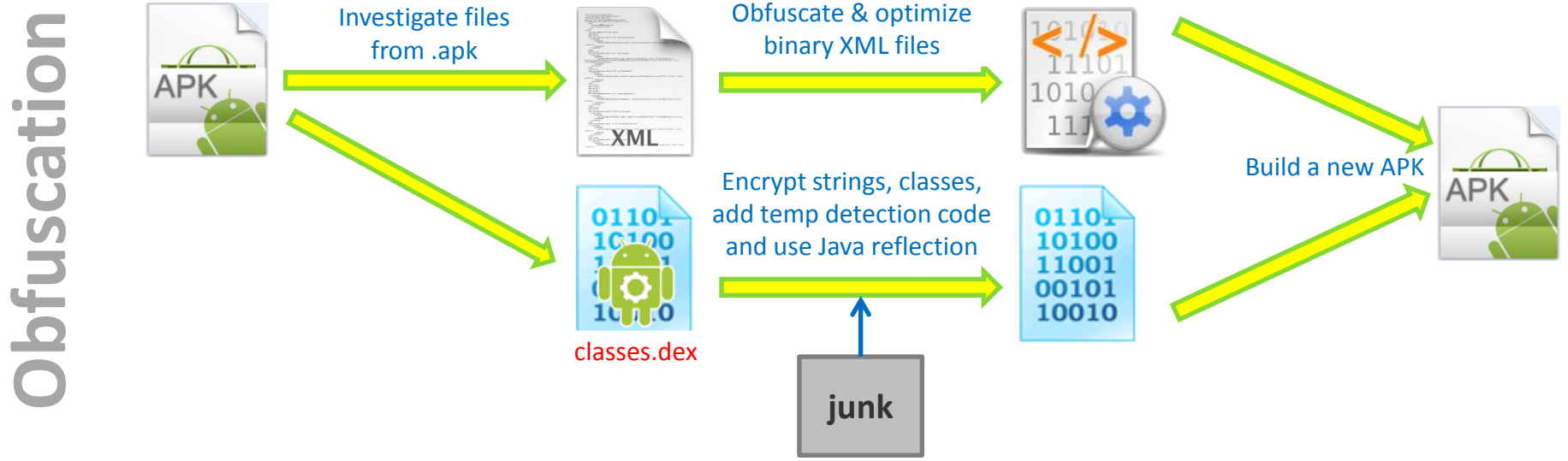
What is Particular about Android Packer?

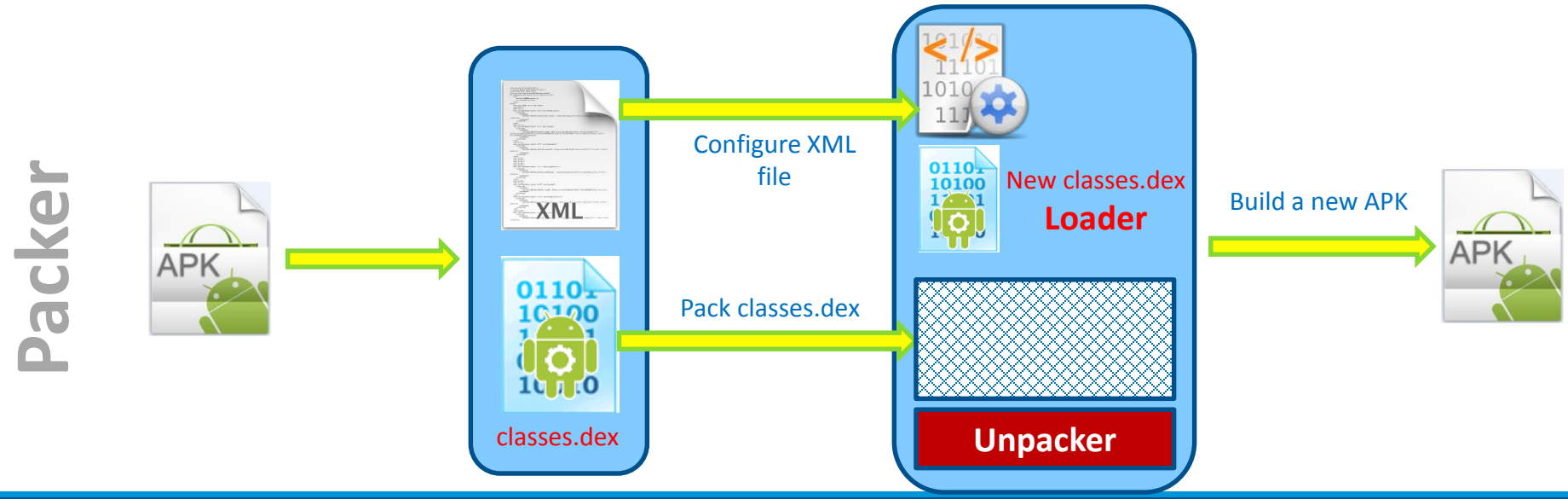
- Difference between Obfuscation and Packer
- Popular packer services
- Growth of packed threats
- Opening the black box of Android Packers

How to Evade Android Packer?

- Challenges
- Solutions
- Demonstration
- Summary
- The Future

Difference between Obfuscation and Packer

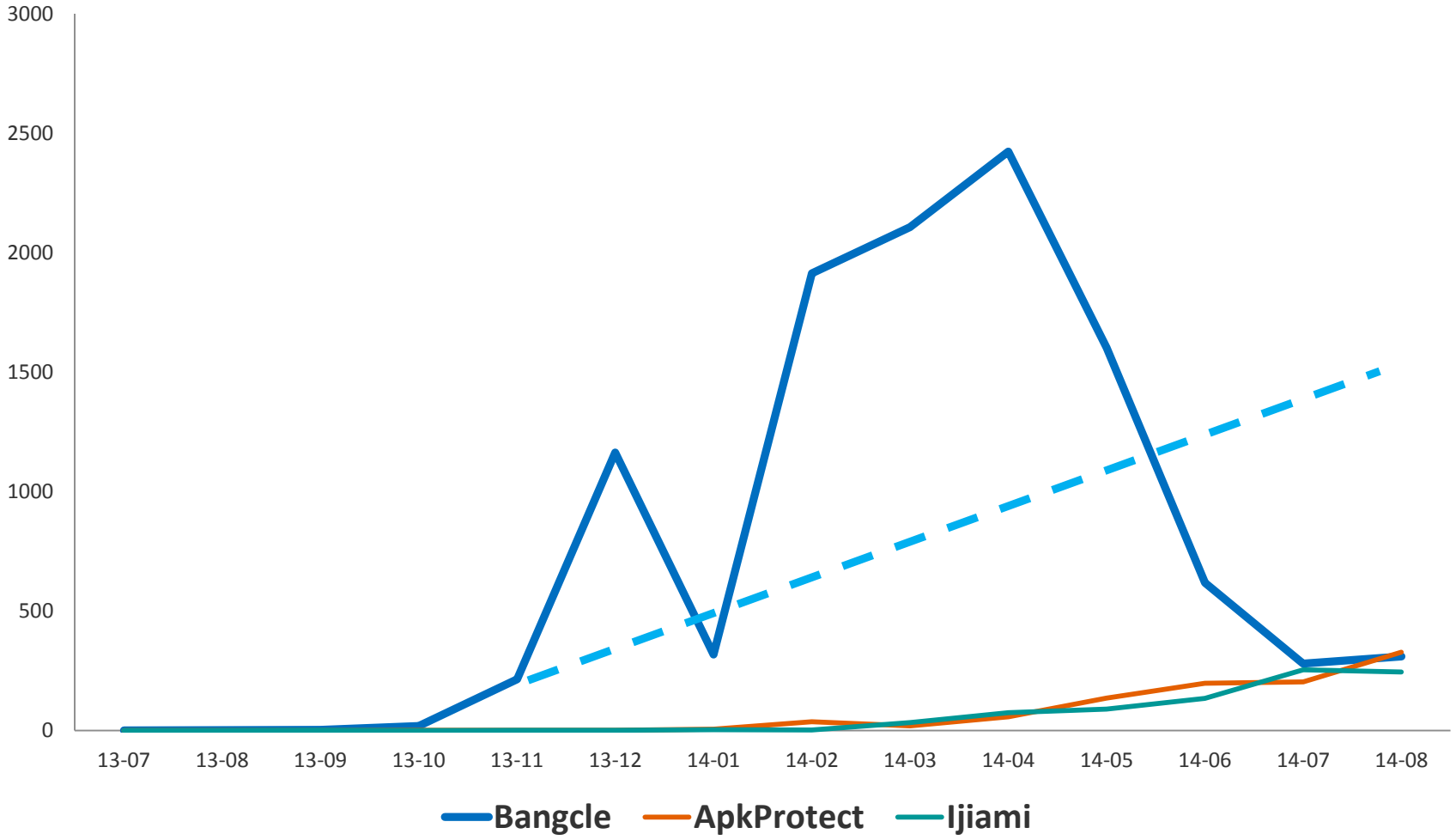




Popular packer services

- Protecting legitimate applications in loss of intellectual property
- Online Android packing services
- Anti-Tamper, Anti-Decompiler, Anti-Runtime injection, and Anti-Debug
- Employing virus scan engines to prevent malware being packed

Growth of Packed Threats



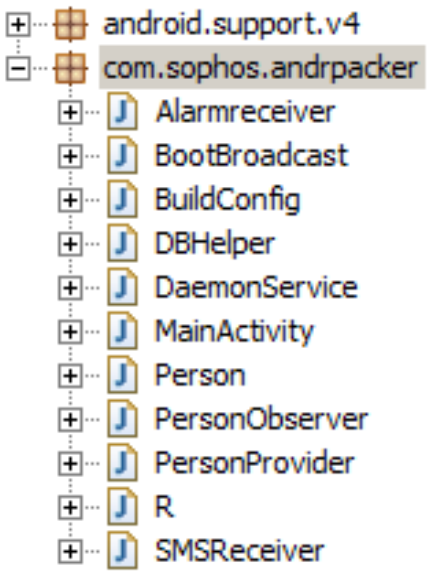
Opening the Black Box of Android Packers

Pack Provider	Added File	Comments
ApkProtect	lib/armeabi/libapkprotect2.so	// ARM shared native library binary
Bangcle	assets/meta-data/manifest.mf	// APK manifest file
	assets/meta-data/rsa.pub	// Signature file
	assets/meta-data/rsa.sig	// The real signature file with certificate
	assets/bangcle_classes.jar	// Encrypted original classes.dex file
	assets/bangcleplugin/collector.dex	// Bangcle information collector plugin
	assets/bangcleplugin/container.dex	// Bangcle Implementation plugin
	assets/bangcleplugin/dgc	// Bangcle plugin logfile
	assets/com.sophos.andrpacker	// ARM executable file
	assets/com.sophos.andrpacker.x86	// x86 executable file
	assets/libsecexe.x86.so	// x86 shared native library binary
	assets/libsecmain.x86.so	// x86 native main binary
	lib/armeabi/libsecexe.so	// ARM shared native library binary
	lib/armeabi/libsecmain.so	// ARM native main binary
Ijiami	META-INF/signed.bin	// Ijiami signed binary file
	META-INF/af.bin	// Ijiami binary file
	META-INF/sdata.bin	// Ijiami RSA signature file
	assets/ijiami.dat	// Encrypted original Apk file
	lib/armeabi/libexecmain.so	// ARM JNI load/unload native binary
	lib/armeabi/libexec.so	// ARM shared native library binary

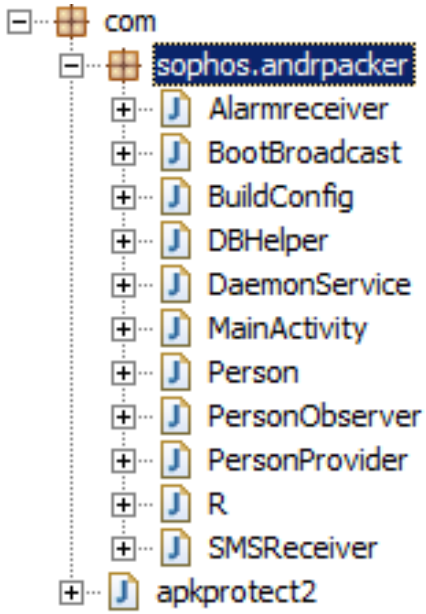
Opening the Black Box of Android Packer

Pack Provider	Modified/Replaced File	Comments
ApkProtect	classes.dex	// Modified original classes.dex file
Bangcle	AndroidManifest.xml classes.dex	// Configure to implement Bangcle class // classes.dex replaced by Bangcle
Ijiami	AndroidManifest.xml classes.dex	// Configure to implement Ijiami class // classes.dex replaced by Ijiami

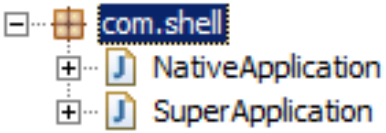
Code Tree of Decompiled `classes.dex`



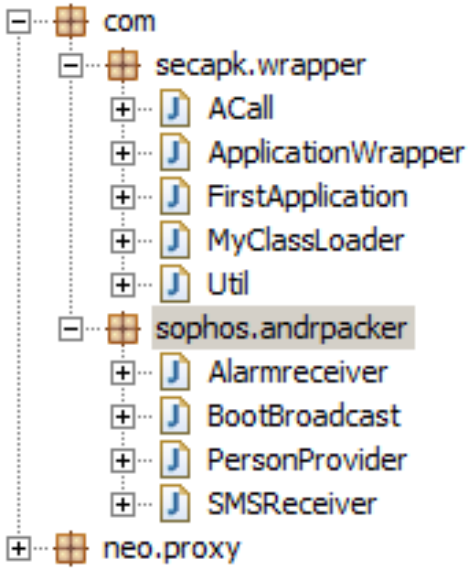
Original classes.dex



ApkProtect



Ijiami



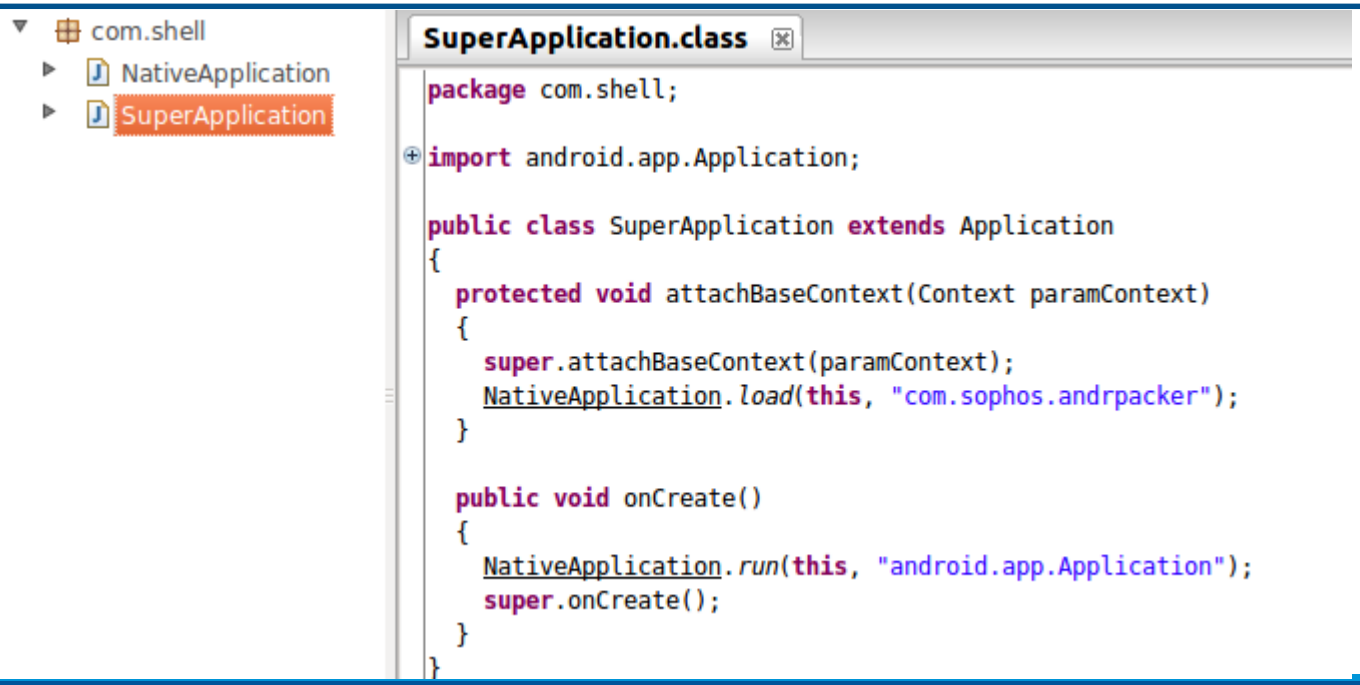
Bangcle

Investigation on Ijiami – entrypoint

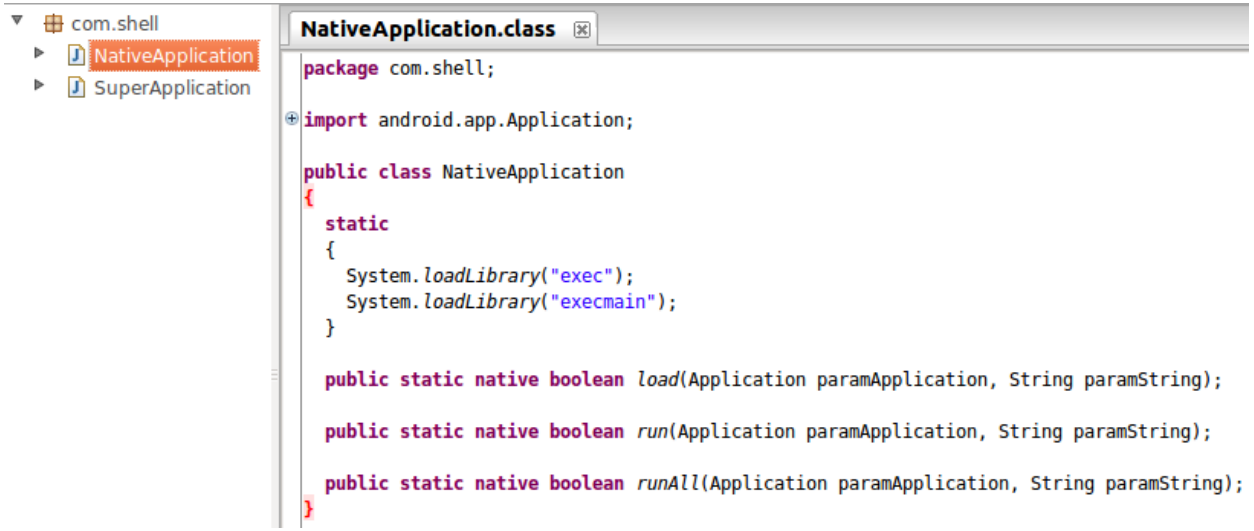
`Application` class – the start point to execute unpacker

```
<application android:allowBackup="true" android:debuggable="true" android:icon="@drawable/ic_launcher"
android:label="@string/app_name" android:theme="@style/AppTheme">
```

```
<application android:allowBackup="true" android:debuggable="true" android:icon="@drawable/ic_launcher"
android:label="@string/app_name" android:name="com.shell.SuperApplication"
android:theme="@style/AppTheme">
```



Investigation on Ijiami – working process



- libexec.so
  - Its the main code is `deinit`.
  - It verifies the signature and integrity of encrypted data.
  - It decrypts `assets/ijiami.dat` to original `classes.dex`.
- libexecmain.so
  - It calls `deinit` and starts`load` and `run` functions in Dalvik layer.

Investigation on Ijiami – dex header modification

Modify original dex header in memory

The modification starts from the beginning of dex file to 0x28 bytes

Additional studies on BANGCLE梆梆

Entrypoint of Bangcle source code – `ApplicationWrapper` class

```
public void onCreate()
{
  super.onCreate();
  if (Util.getCustomClassLoader() == null) {
    Util.runAll(this);
  }
  String str = FirstApplication;
  try
  {
    this.cl = ((DexClassLoader)Util.getCustomClassLoader());
    realApplication = (Application)getClassLoader().loadClass(str).newInstance();
    if (realApplication != null)
    {
      localACall = ACall.getACall();
      localACall.at1(realApplication, getBaseContext());
      localACall.set2(this, realApplication, this.cl, getBaseContext());
    }
}…
```

Additional studies on BANGCLE梆梆

`runall` method of Bangcle `Util` class

```
public static void runAll(Context paramContext)
  {
    x86Ctx = paramContext;
    doCheck(paramContext); // checking integrity of classes.jar
    checkUpdate(paramContext);
    try
    {
      File localFile = new File("/data/data/" + paramContext.getPackageName() +
"/.cache/");
      if (!localFile.exists()) {
        localFile.mkdir();
      }
      checkX86(paramContext); // If it is x86 platform, copy related library binary
      CopyBinaryFile(paramContext); // copy encrypted classes.jar and JNI binary
      createChildProcess(paramContext); // create child processes
      tryDo(paramContext);
      runPkg(paramContext, paramContext.getPackageName()); // call MyClassLoader
      return;
}…
```

Additional studies on BANGCLE梆梆

- the `ACall` class of Bangcle deals with binary such as `libsecexe.so` in the Library layer of Android
- `libsecexe.so` is responsible for JNI call

```
public native void a1(byte[] paramArrayOfByte1, byte[] paramArrayOfByte2);

public native void at1(Application paramApplication, Context paramContext);

public native void at2(Application paramApplication, Context paramContext);

public native void c1(Object paramObject1, Object paramObject2);

public native void c2(Object paramObject1, Object paramObject2);

public native Object c3(Object paramObject1, Object paramObject2);

public native void r1(byte[] paramArrayOfByte1, byte[] paramArrayOfByte2);

public native void r2(byte[] paramArrayOfByte1, byte[] paramArrayOfByte2, byte[] paramArrayOf

public native ClassLoader rc1(Context paramContext);

public native void s1(Object paramObject1, Object paramObject2, Object paramObject3);

public native Object set1(Activity paramActivity, ClassLoader paramClassLoader);

public native Object set2(Application paramApplication1, Application paramApplication2, Class
```

pA226AD0639E094643D446D114B40A4F7	0001072C
p14285A16A9AD09C58C6229A0216C2BCE	00009E6C
pFBC0F628D4A0CEDB94B22B8AF32C6449	0000E1C0
pFFB607FCF6C8C78DF1B93B14618C1170	00021E60
p48661E70C9925A280F22F90CE1DD9FBC	0000A100
p6543834C664025CDB9CC8865EA4F5D21	00008744
pBAE09FC1D43B26EF272F4502C9B9A761	00021E64
p614EBEA527F7CFE77711182EACCBC3CE	00021E68
p2D656B85C816001EDC4DBA95AD2B1451	0000BBB4
p9E0BA5F141B271A7182A3D7E36F3B98C	00021B00
p59E15566C42CB17277A9BC11BD48E66D	00021E6C
p6681D68CA8B7E8F086ECE19A06ED13D0	0000B238
pA3E4F5DB10866DA44836DD6A227D7FE5	000216EC
p261362038FFCD16031F67682A01C2B16	0000F9A0
p92B745BE458923D2EFA4F4E95A0A5A51	0000E0A4
p6C5C888FDD1835CEC733F97BBA04B9B2	00021C00
p654E3EE0BCC4136DD6A880AF954A8AC0	0000E118
p403FB1BE0452ED04B365494693196D2F	00021AFC
pF0F81B20C6DEDD307E414D3004F853B6	00021C04
pC0B5AC27AB6DC40D0C0A378EC7ED634B	0000FC5C
p5F7D25555384803B7DEE6F72B840DCFB	00005304
JNI_OnLoad	00007278

Additional studies on BANGCLE梆梆

Mutually tracing in three Bangcle processes to block analysis from debugging tools

```
u0_a46    1552  57    203288 22432 ffffffff 40063ebc S a.hello
u0_a46    1568  1552  6d944  1592  ffffffff 40038d5c S a.hello
u0_a46    1570  1568  2076   372   c00c2e10 40037d50 S a.hello
```

```
dmesg | grep -i ptrace
<4>anti-ptrace kernel module loaded with pid=[1398]
<4>PTRACE: pid=[1568] uid=[10046], [16,1552,  (null),  (null) ==> 0 ]
<4>PTRACE: pid=[1568] uid=[10046], [16,1570,  (null),  (null) ==> 0 ]
<4>PTRACE: pid=[1568] uid=[10046], [07,1570,  (null),  (null) ==> 0 ]
<4>PTRACE: pid=[1570] uid=[10046], [07,1568,  (null),  (null) ==> -3 ]
<4>PTRACE: pid=[1568] uid=[10046], [05,1552,4a8446f0,12345678 ==> 0 ]
<4>PTRACE: pid=[1568] uid=[10046], [05,1552,4a8446f4,563ffbcf ==> 0 ]
<4>PTRACE: pid=[1568] uid=[10046], [05,1552,4a8446f8,5c745a41 ==> 0 ]
<4>PTRACE: pid=[1568] uid=[10046], [05,1552,4a8446fc,c5f094b7 ==> 0 ]
<4>PTRACE: pid=[1568] uid=[10046], [05,1552,4a844700,4495deba ==> 0 ]
<4>PTRACE: pid=[1568] uid=[10046], [05,1552,4a844704,f689a279 ==> 0 ]
<4>PTRACE: pid=[1568] uid=[10046], [05,1552,4a844708,55e102c3 ==> 0 ]
<4>PTRACE: pid=[1568] uid=[10046], [05,1552,4a84470c,a3b885d5 ==> 0 ]
<4>PTRACE: pid=[1568] uid=[10046], [05,1552,4a844710,6b6d5841 ==> 0 ]
<4>PTRACE: pid=[1568] uid=[10046], [05,1552,4a844714,f689a279 ==> 0 ]
<4>PTRACE: pid=[1568] uid=[10046], [05,1552,4a844718,55e102c3 ==> 0 ]
<4>PTRACE: pid=[1568] uid=[10046], [05,1552,4a84471c,a3b885d5 ==> 0 ]
<4>PTRACE: pid=[1568] uid=[10046], [05,1552,4a844720,6b6d5841 ==> 0 ]
<4>PTRACE: pid=[1568] uid=[10046], [07,1552,  (null),  (null) ==> 0 ]
```

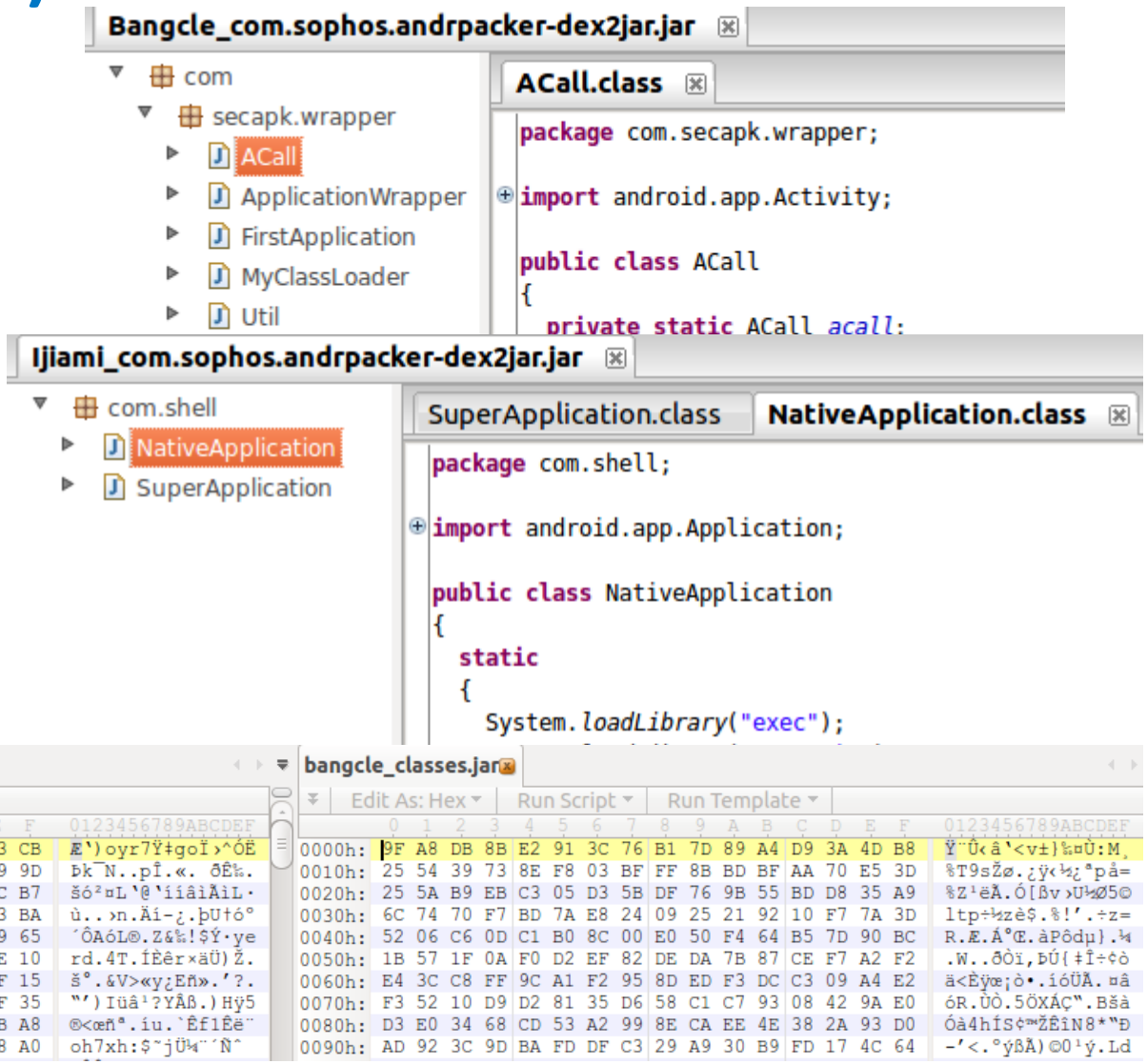
Technology Review of Bangcle and Ijiami

- Anti-Temper – checks the integrity check of encrypted dex.
- Anti-Decompiler – decrypts the encrypted dex in memory and employs `MyClassLoader` to load decrypted original dex in runtime.
- Anti-Runtime injection – It is impossible to establish relationship between `ACall` class with `libsecexe.so` due to the encryption.
- Anti-Debug – Both packers use techniques to block analysis from debugging tools

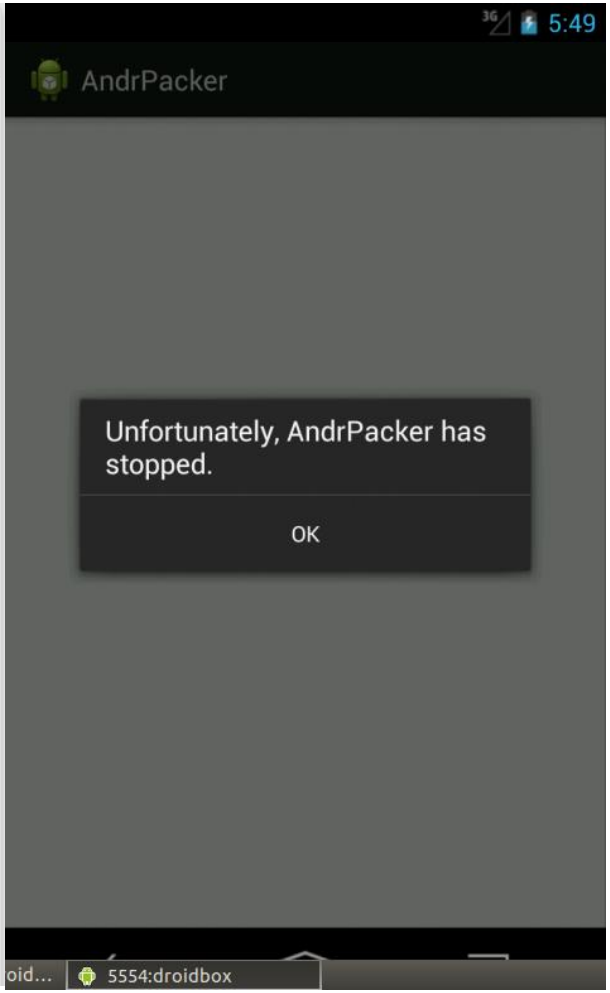
PART 2

Facing Challenges - Ineffective reverse engineering (RE) tools

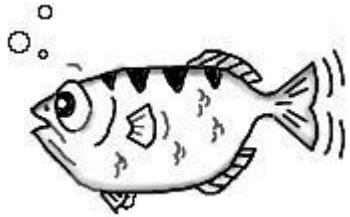
- IDA Pro
- Dex2jar
- Apktool
- BakSmali/Smali
- JEB



Facing Challenges - Failure of dynamic analysis systems



Facing Challenges - Runtime Anti-Debug



- gdb, gcore, memory searching, dd
- Anti-ptrace technique to block analysis from debugging tools

Facing Challenges - Difficult to detect by security solutions

- Certificate
- Package name
- AndroidManifest.xml
- ……

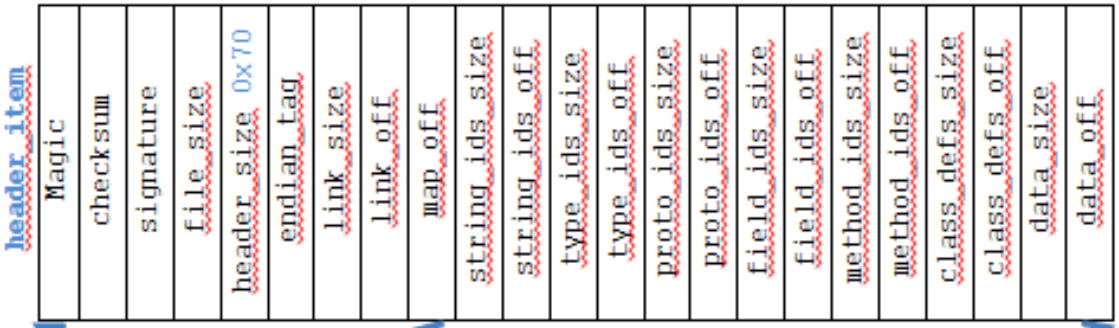
Building Solutions – Acquire Memory

1. Initialize an Android build environment including path and required package on either Linux or OSX system.
2. Download the Android SDK and NDK.
3. Download the Android Kernel Source Code.
4. Cross Compile the Kernel.
5. Create AVD then Emulate the Custom Kernel with the AVD.
6. Download and Cross Compile `LiME`.
7. Load LiME on the Android Device/Emulator.
8. Acquire Memory.

Building Solutions – Memory forensics with Volatility plugins

- `linux_pslist` – gathers active tasks by walking the task_struct.
- `linux_proc_maps` – gathers process maps for Linux.
- `linux_dump_map` – writes selected process memory mappings to disk.

Building Solutions – Memory forensics with Volatility plugins



map_list

item_num DWORD				
TYPE_HEADER_ITEM	0x0000	unused	size 0x0001	offset 0x0000
TYPE_STRING_ID_ITEM	0x0001	unused	size	offset 0x0070
TYPE_TYPE_ID_ITEM	0x0002	unused	size	offset
TYPE		unused	size	offset
TYPE		unused	size	offset
TYPE		unused	size	offset
TYPE		unused	size	offset
TYPE		unused	size	offset
TYPE		unused	size	offset
TYPE		unused	size	offset
TYPE		unused	size	offset
TYPE		unused	size	offset
TYPE		unused	size	offset
TYPE_MAP_LIST	0x1000	unused	size	map_list_offset
TYPE		unused	size	offset
TYPE		unused	size	offset
TYPE		unused	size	offset

Building Solutions – Memory forensics with Volatility plugins `apk_packer_find_dex`

```
signatures = {
 'map_header' : 'rule map_header { \
    strings: \
    $hex = {00 00 ?? ?? 01 00 00 00 00 00 00 00 01 00 ?? ?? ?? ?? ?? ?? 70
00 00 00 02 00} \
    condition: $hex }'
}

class apk_packer_find_dex(linux_common.AbstractLinuxCommand):
 """Gather information about the dex Dump in Memory running in the
system"""

 def __init__(self, config, *args, **kwargs):
  linux_common.AbstractLinuxCommand.__init__(self, config, *args, **kwargs)
  self._config.add_option('PID', short_option='p', default=None,
   help='Operate on a specific Android application Process ID',
   action='store', type='str')
```

```
def calculate(self):
  """ Required: Runs YARA search to find hits """
  rules = yara.compile(sources = signatures)

  proc_maps = linux_proc_maps.linux_proc_maps(self._config).calculate()
   for task, vma in proc_maps:
   if not vma.vm_file:
….
     proc_as = task.get_process_address_space()
     maxlen = vma.vm_end - vma.vm_start
     data = proc_as.zread(vma.vm_start, maxlen - 1)

     if data:
      for match in rules.match(data = data):
       for moffset, _name, _value in match.strings:
        (usize,) = struct.unpack('I', data[moffset - 4 : moffset])

        i = 0
        offset = moffset
        while  i < usize:

         (maptype,) = struct.unpack('H', data[offset: offset+2])
         (mapoffset,) = struct.unpack('I', data[offset+8: offset+12])

         if maptype == 0x1000:
          yield task, vma, moffset - 4 - mapoffset, moffset
          break
         i += 1
         offset += 12
```

Building Solutions – Memory forensics with Volatility plugins `apk_packer_find_dex`

```
def render_text(self, outfd, data):
  self.table_header(outfd, [("Task", "10"),
          ("VM Start", "[addrpad]"),
          ("VM End", "[addrpad]"),
          ("Dex Offset", "[addr]"),
          ("Map Offset", "[addr]")])
  for (task, vma, offset, moffset) in data:
    self.table_row(outfd, task.pid, vma.vm_start,
vma.vm_end, offset, moffset - 4)
```

Demonstration – Memory Acquisition

```
emulator -wipe-data -avd myavd -kernel ~/android-
kernal/arch/arm/boot/zImage -show-kernel -verbose

adb push ~/lime-forensics/src/lime-goldfish.ko /sdcard/lime.ko

adb shell

root@android:/ #

  insmod /sdcard/lime.ko "path=/sdcard/lime.dump format=lime"

root@android:/ #

ls -al /sdcard/lime.dump

fls ~/.android/avd/myavd.avd/sdcard.img

icat ~/.android/avd/myavd.avd/sdcard.img 27  > ~/lime.dmp
```

Demonstration – Bangcle

1. Find PID:

```
python ~/android-volatility/vol.py --profile=LinuxGolfish-
2_6_29ARM -f Bangcle_lime.dmp linux_pslist
```

```
0xf2f90c00 phos.andrpacker      876             10046           10046  0x263b8000 2014-04-14 02:40:37 UTC+0
0xe9159c00 com.sophos.andr      891             10046           10046  0x2add0000 2014-04-14 02:40:38 UTC+0
0xe631f000 com.sophos.andr      893             10046           10046  0x2af14000 2014-04-14 02:40:38 UTC+0
```

2. Find original dex in memory:

```
python ~/android-volatility/vol.py --profile=LinuxGolfish-
2_6_29ARM -f Bangcle_lime.dmp apk_packer_find_dex -p876
```

```
Volatility Foundation Volatility Framework 2.3.1
Task       VM Start   VM End     Dex Offset Map Offset
---------- ---------- ---------- ---------- ----------
       876 0x4c10d000 0x4c1a4000       0x28    0x8ffc8
```

Demonstration – Bangcle

3. Dump memory map:

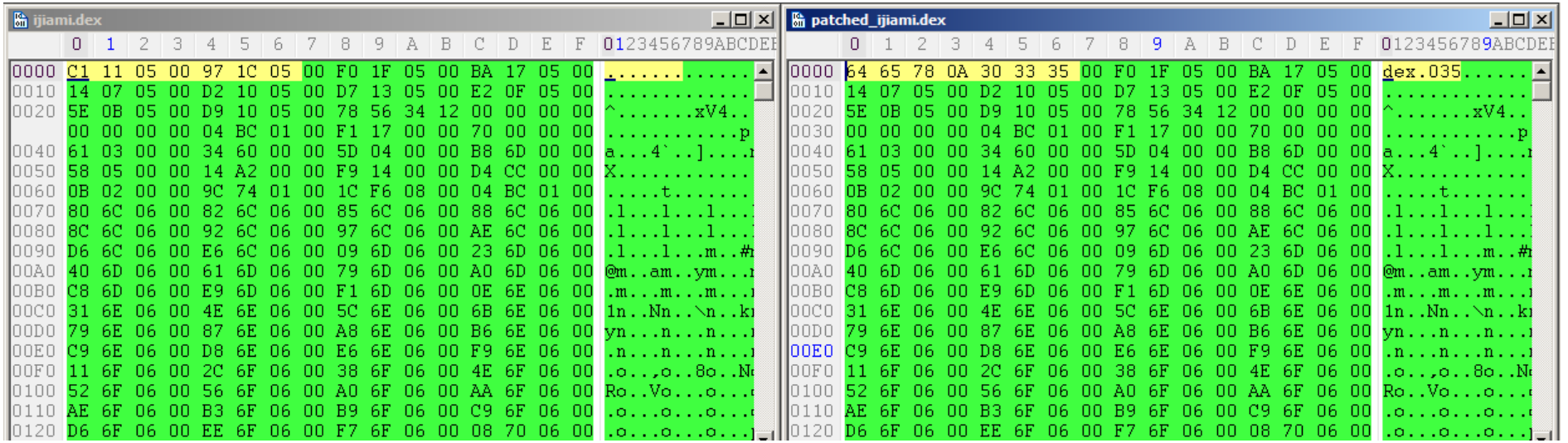
```
python ~/android-volatility/vol.py --profile=LinuxGolfish-2_6_29ARM -f Bangcle_lime.dmp linux_dump_map -p876 -s 0x4c10d000 --dump-dir ~/Downloads/
```

```
Volatility Foundation Volatility Framework 2.3.1
Task       VM Start   VM End         Length Path
---------- ---------- ---------- ---------- ----
       876 0x4c10d000 0x4c1a4000    0x97000 /home/labrat/Downloads/task.876.0x4c10d000.vma
```

4. Truncate to get 'original' dex:

Demonstration – Ijiami

Patch `DEX_FILE_MAGIC` header



Detection Solution

- AndroidManifest.xml
- Classname in Bangcle
- Size of encrypted payload
- Resource files
- `resources.arsc`
- ……

Summary

- Popular Android packing service – Ijiami and Bangcle
- Explosive growth of packed malware
- Anti-Temper, Anti-Decompiler, Anti-Runtime injection and Anti-Debug
- Challenges to security threat researchers
- Solutions Memory forensics with Volatility plugins
- Demonstration

The Future

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Q&A