安卓Chrome沙箱逃逸的一种姿势

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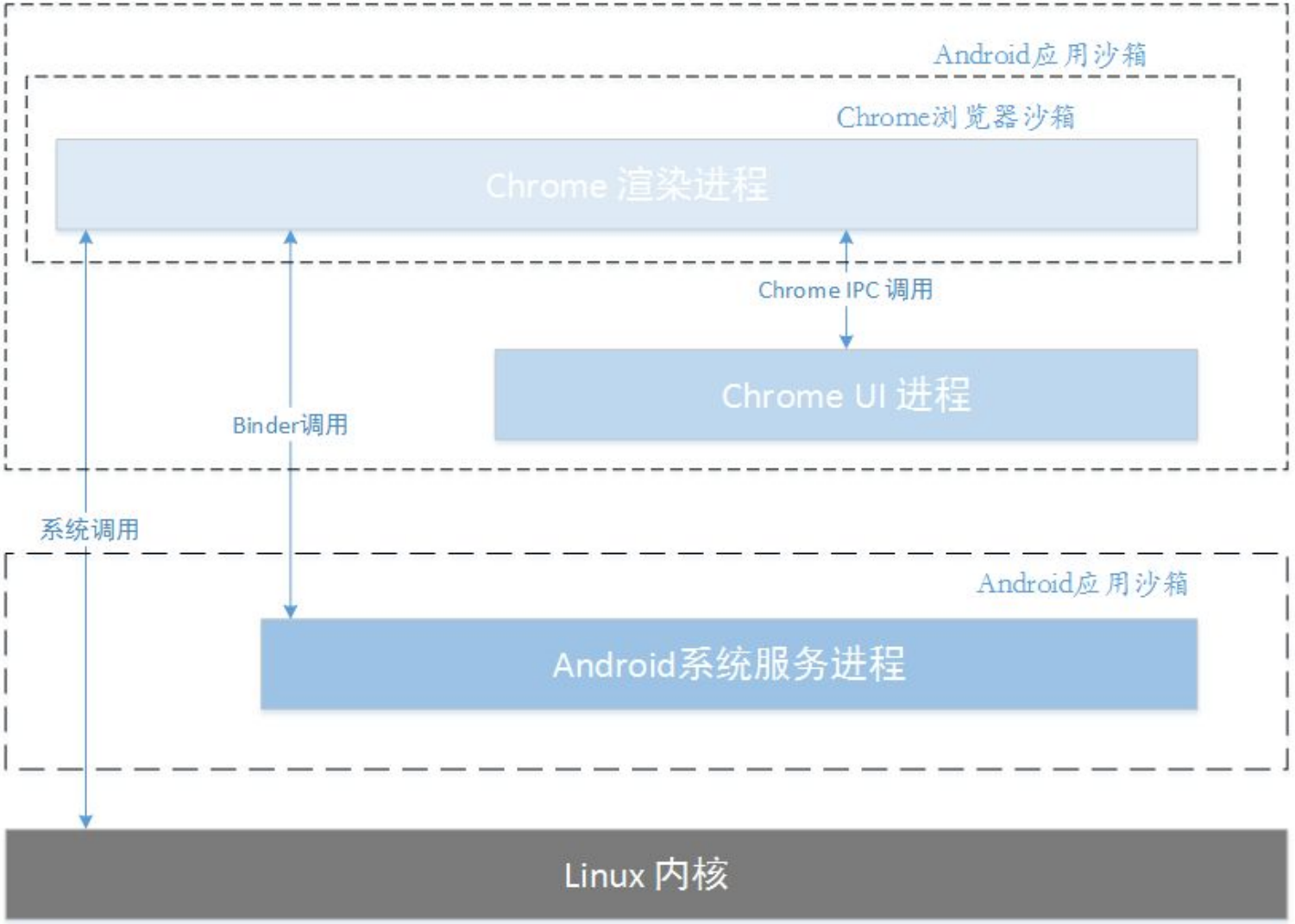
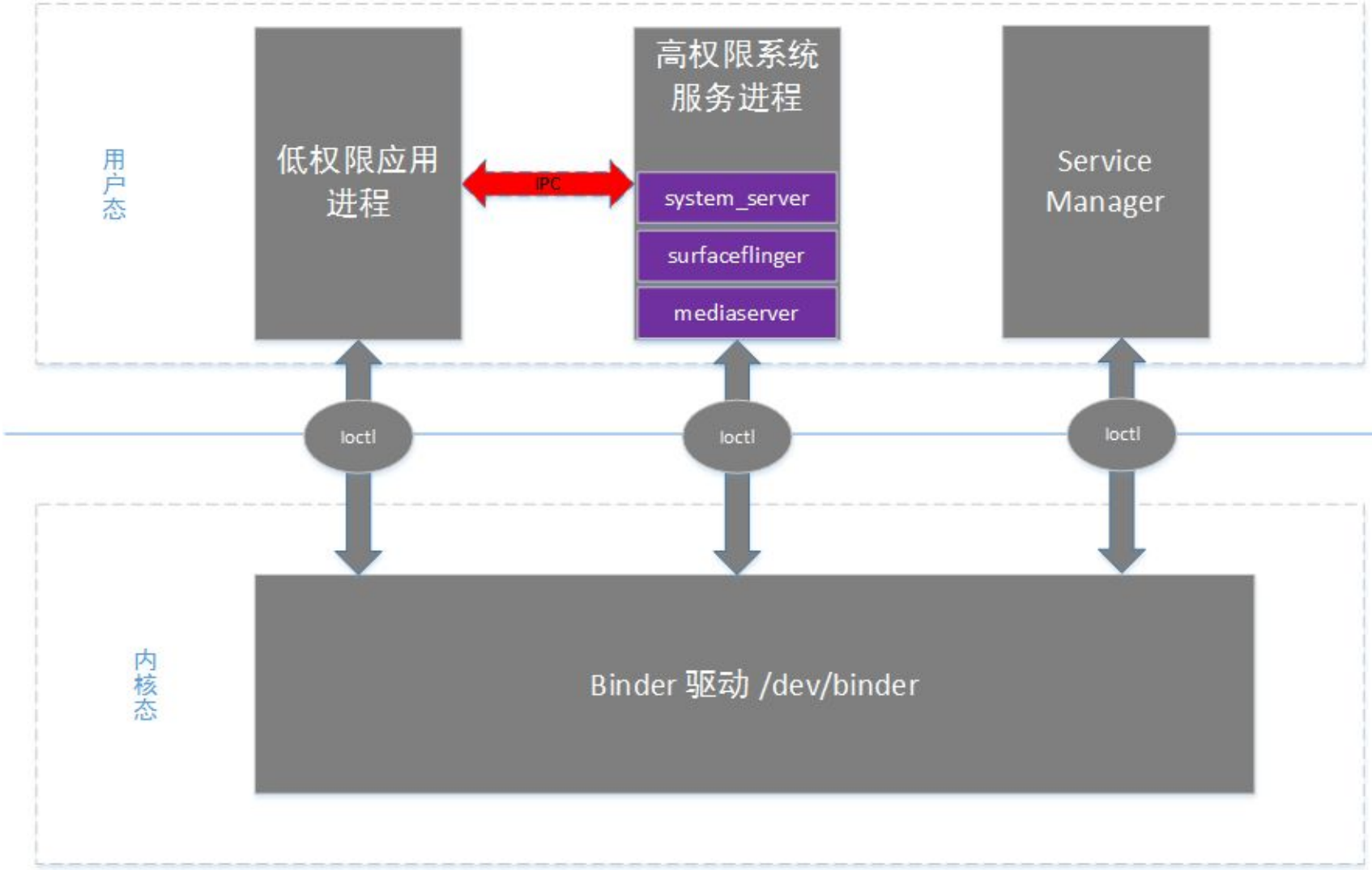
主要内容

- 沙箱攻击面分析
- Chrome 沙箱与安卓系统服务的交互
- Bundle的设计缺陷
- 一些过沙箱漏洞
- 一个漏洞具体利用

沙箱攻击面分析


Android应用沙箱
Chrome浏览器沙箱
Chrome 渲染进程
Chrome IPC 调用
Chrome UI 进程
Binder调用
系统调用
Android应用沙箱
Android系统服务进程
Linux 内核

安卓系统服务


用户态
低权限应用进程
IPC
高权限系统服务进程
system_server
surfaceflinger
mediaserver
Service Manager
Ioctl
Ioctl
Ioctl
内核态
Binder 驱动 /dev/binder

安卓系统服务

```
ggong@ggong-pc:~$ adb shell service list
Found 104 services:
0 sip: [android.net.sip.ISipService]
1 carrier_config: [com.android.internal.telephony.ICarrierConfigLoader]
2 phone: [com.android.internal.telephony.ITelephony]
3 telecom: [com.android.internal.telecom.ITelecomService]
4 isms: [com.android.internal.telephony.ISms]
5 iphonesubinfo: [com.android.internal.telephony.IPhoneSubInfo]
6 simphonebook: [com.android.internal.telephony.IIccPhoneBook]
......
99 media.player: [android.media.IMediaPlayerService]
100 media.audio_flinger: [android.media.IAudioFlinger]
101 android.security.keystore: [android.security.IKeystoreService]
102 drm.drmManager: [drm.IDrmManagerService]
103 android.service.gatekeeper.IGateKeeperService: []
```

SeLinux对沙箱进程的限制

- Chrome进程

```
ggong@ggong-pc:~$ adb shell ps -Z | grep chrome
u:r:untrusted_app:s0:c512,c768 u0_a65    7706  214   com.android.chrome
u:r:untrusted_app:s0:c512,c768 u0_a65    7776  214   com.android.chrome:privileged_process0
u:r:isolated_app:s0:c512,c768  u0_i3     7871  214   com.android.chrome:sandboxed_process1
```

- Isolated_app域

/external/sepolicy/isolated_app.te

```
allow isolated_app activity_service:service_manager find;
allow isolated_app display_service:service_manager find;
neverallow isolated_app {
        service_manager_type
        -activity_service
        -display_service
}:service_manager find;
```

SeLinux对沙箱进程的限制

在isolated_app域中获取系统服务	返回结果
getSystemService(WINDOW_SERVICE)	null
getSystemService(LOCATION_SERVICE)	null
getSystemService(CONNECTIVITY_SERVICE)	null
getSystemService(...)	null
getSystemService(ACTIVITY_SERVICE)	ActivityManager
getSystemService(DISPLAY_SERVICE)	DisplayManager

SeLinux对沙箱进程的限制

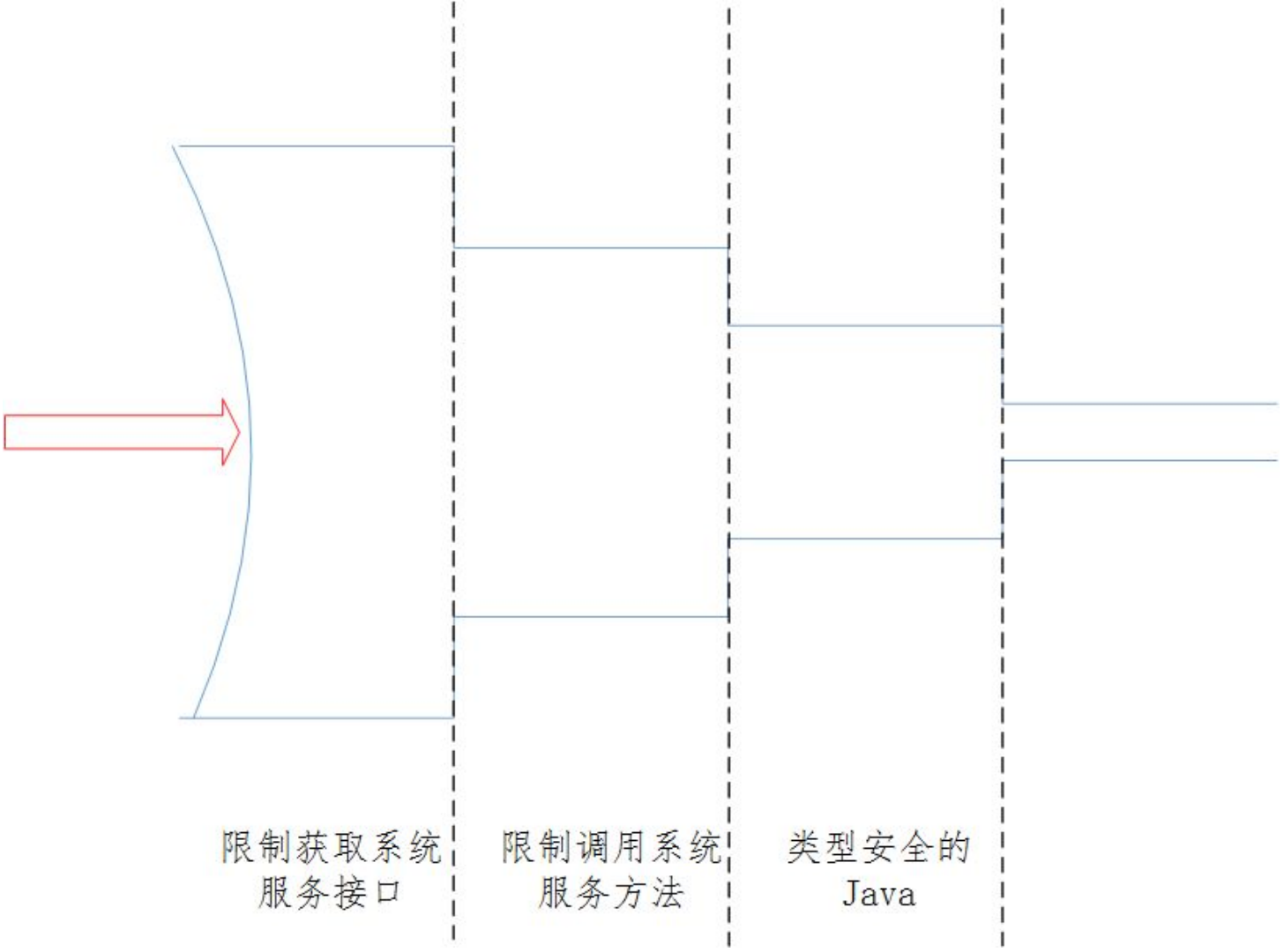
startActivity ------> **startActivityAsUser**

```
public final int startActivityAsUser(IApplicationThread caller, String callingPackage,
        Intent intent, String resolvedType, IBinder resultTo, String resultWho, int requestCode,
        int startFlags, ProfilerInfo profilerInfo, Bundle options, int userId) {
    enforceNotIsolatedCaller("startActivity");-------------------------->检查调用进程是否位于isolate_app域
    userId = handleIncomingUser(Binder.getCallingPid(), Binder.getCallingUid(), userId,
            false, ALLOW_FULL_ONLY, "startActivity", null);
    // TODO: Switch to user app stacks here.
    return mStackSupervisor.startActivityMayWait(caller, -1, callingPackage, intent,
            resolvedType, null, null, resultTo, resultWho, requestCode, startFlags,
            profilerInfo, null, null, options, false, userId, null, null);
}
```

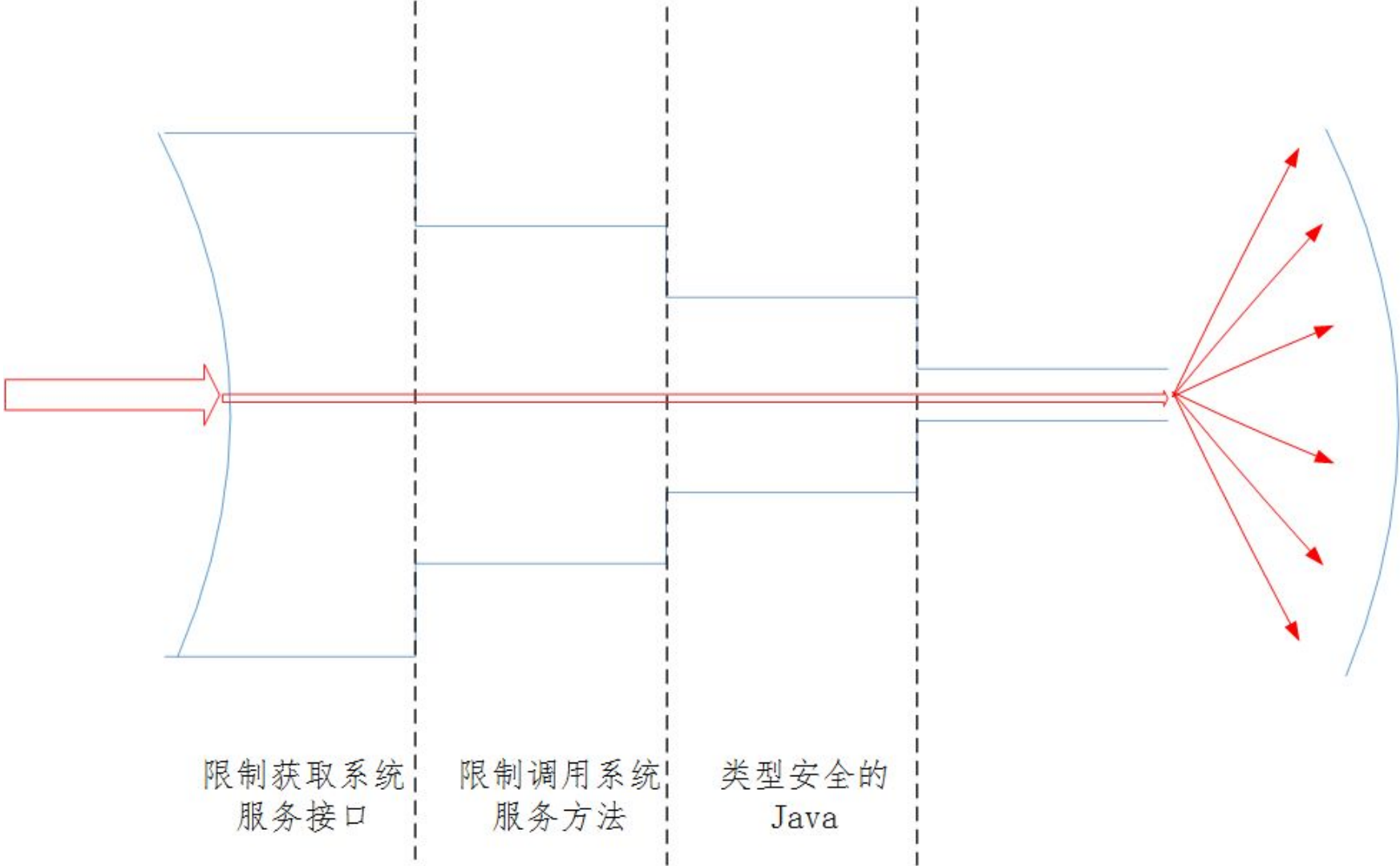
SeLinux对沙箱进程的限制

```
    void enforceNotIsolatedCaller(String caller) {
        if (UserHandle.isIsolated(Binder.getCallingUid())) {
            throw new SecurityException("Isolated process not
allowed to call " + caller);
        }
    }
```

攻击面变化示意图



攻击面变化示意图



奇点

```
case ONVERT_TO_TRANSLUCENT_TRANSACTION: {
data.enforceInterface(IActivityManager.descriptor);
    IBinder token = data.readStrongBinder();
    final Bundle bundle;
    if (data.readInt() == 0) {
        bundle = null;
    } else {
        bundle = data.readBundle();
    }
    final ActivityOptions options = bundle == null ? null :
new ActivityOptions(bundle);---------------->
    boolean converted = convertToTranslucent(token,
options);
    reply.writeNoException();
    reply.writeInt(converted ? 1 : 0);
    return true;
}
```

```
case START_IN_PLACE_ANIMATION_TRANSACTION: {
    data.enforceInterface(IActivityManager.descriptor);
    final Bundle bundle;
    if (data.readInt() == 0) {
        bundle = null;
    } else {
        bundle = data.readBundle();
    }
    final ActivityOptions options = bundle == null ? null : new
ActivityOptions(bundle);------------------>
   startInPlaceAnimationOnFrontMostApplication(options);
    reply.writeNoException();
    return true;
 }
```

奇点

```
  public ActivityOptions(Bundle opts) {
      mPackageName = opts.getString(KEY_PACKAGE_NAME);
      try {
          mUsageTimeReport = opts.getParcelable(KEY_USAGE_TIME_REPORT);
      } catch (RuntimeException e) {
          Slog.w(TAG, e);
      }
      mAnimationType = opts.getInt(KEY_ANIM_TYPE);
      ......
}
```

什么是Bundle

putByte(String key, byte value)
putChar(String key, char value)
putBoolean(String key, boolean value)
putDouble(String key, double value)
putInt(String key, int value)
putLong(String key, long value)
putString(String key, String value)
putFloat(String key, float value)
putShort(String key, short value)
putParcelable(String key, Parcelable value)
putSerializable(String key, Serializable value)

getByte(String key)
getChar(String key)
getBoolean(String key)
getDouble(String key)
getInt(String key)
getLong(String key)
getString(String key)
getFloat(String key)
getShort(String key)
getParcelable(String key)
getSerializable(String key)

Bundle的一个特性

ArrayMap<String, Object> **mMap** = null;

```
public String getString(@Nullable String key) {
    unparcel();---------->会从二进制流中重构整个mMap结果，导致很多无关代码被执行
    final Object o = mMap.get(key);
    try {
        return (String) o;
    } catch (ClassCastException e) {
        typeWarning(key, o, "String", e);
        return null;
    }
}
```

温故知新(Serializable)

两个很有名的Serializable相关的漏洞

- CVE-2014-7911

  Jann Horn
  java.io.ObjectInputStream 没有校验输入对象是否真正可以被序列化，即是否实现了Serializable接口。

- CVE-2015-3825

  USENIX 2015
  ONE CLASS TO RULE THEM ALL 0-DAY DESERIALIZATION VULNERABILITIES IN ANDROID
  mContext成员变量忘记加上关键字transient

温故知新(Parcelable)

```
public interface Parcelable {
    ……
    public void writeToParcel(Parcel dest, int flags);
    public interface Creator<T> {
        public T createFromParcel(Parcel source);
        public T[] newArray(int size);
    }
    ……
}
```

大概有600个类实现了Parcelable接口，这些类的createFromParcel方法都能在chrome沙箱中被调用。

温故知新(Parcelable)

我们发现的Parcelable相关的沙箱逃逸漏洞

CVE	描述
CVE-2016-2412	Elevation of Privilege Vulnerability in System_server
CVE-2015-3849	Elevation of Privilege Vulnerability in Region
CVE-2015-1474	Integer overflow leading to heap corruption while unflattening GraphicBuffer
CVE-2015-3875（first reportor Daniel Micay）	Remote Code Execution Vulnerabilities in libutils

CVE-2015-3849

```
        SkASSERT(count >= SkRegion::kRectRegionRuns);

-       RunHead* head = (RunHead*)sk_malloc_throw(sizeof(RunHead) + count * sizeof(RunType));
+       const int64_t size = sk_64_mul(count, sizeof(RunType)) + sizeof(RunHead);
+       if (count < 0 || !sk_64_isS32(size)) { SK_CRASH(); }
+
+       RunHead* head = (RunHead*)sk_malloc_throw(size);
        head->fRefCnt = 1;
        head->fRunCount = count;
```

CVE-2016-2412

```
#    define SK_CRASH() __debugbreak()
 #  else
 #    if 1   // set to 0 for infinite loop, which can help connecting gdb
-#      define SK_CRASH() do { SkNO_RETURN_HINT(); *(int *)(uintptr_t)0xbbadbeef = 0; } while (false)
+#       define SK_CRASH() do { SkNO_RETURN_HINT(); abort(); } while (false)
 #    else
 #      define SK_CRASH() do { SkNO_RETURN_HINT(); } while (true)
 #    endif
```

CVE-2015-3875

```
SharedBuffer* SharedBuffer::alloc(size_t size)
 {
+    // Don't overflow if the combined size of the buffer / header is larger than
+    // size_max.
+    LOG_ALWAYS_FATAL_IF((size >= (SIZE_MAX - sizeof(SharedBuffer))),
+                        "Invalid buffer size %zu", size);
+
     SharedBuffer* sb = static_cast<SharedBuffer *>(malloc(sizeof(SharedBuffer) + size));
     if (sb) {
         sb->mRefs = 1;
@@ -52,7 +60,7 @@
         memcpy(sb->data(), data(), size());
         release();
     }
-    return sb;
+    return sb;
 }
```

CVE-2015-3875触发栈(Java层)

F/ActivityManager(1685): at android.view.MotionEvent.nativeReadFromParcel(Native Method)
F/ActivityManager(1685): at android.view.MotionEvent.createFromParcelBody(MotionEvent.java:3198)
F/ActivityManager(1685): at android.view.MotionEvent$1.createFromParcel(MotionEvent.java:3187)
F/ActivityManager(1685): at android.view.MotionEvent$1.createFromParcel(MotionEvent.java:3184)
F/ActivityManager(1685): at android.os.Parcel.readParcelable(Parcel.java:2252)
F/ActivityManager(1685): at android.os.Parcel.readValue(Parcel.java:2152)
F/ActivityManager(1685): at android.os.Parcel.readArrayMapInternal(Parcel.java:2485)
F/ActivityManager(1685): at android.os.BaseBundle.unparcel(BaseBundle.java:221)
F/ActivityManager(1685): at android.os.BaseBundle.getString(BaseBundle.java:918)
F/ActivityManager(1685): at android.app.ActivityOptions.<init>(ActivityOptions.java:570)
F/ActivityManager(1685): at android.app.ActivityManagerNative.onTransact(ActivityManagerNative.java:1671)
F/ActivityManager(1685): at com.android.server.am.ActivityManagerService.onTransact(ActivityManagerService.java:2208)
F/ActivityManager(1685): at android.os.Binder.execTransact(Binder.java:446)

CVE-2015-3875触发栈(Native层)

(gdb) bt
#0 android::SharedBuffer::alloc (size=4294967280) at system/core/libutils/SharedBuffer.cpp:28 ------>size = 0xfffffff0
#1 0xb6d362a6 in android::VectorImpl::setCapacity (this=this@entry=0xaed5fe4c, new_capacity=new_capacity@entry=536870910) at system/core/libutils/VectorImpl.cpp:334
#2 0xb6792c72 in setCapacity (size=536870910, this=0xaed5fe4c) at system/core/include/utils/Vector.h:81 ------> size = 0x1ffffffe
#3 android::MotionEvent::readFromParcel (this=this@entry=0xaed5fe00, parcel=0x9f5ad7f0) at frameworks/native/libs/input/Input.cpp:444
#4 0xb6e91f1e in android::android_view_MotionEvent_nativeReadFromParcel (env=0x9f439ac0, clazz=<optimized out>, nativePtr=<optimized out>, parcelObj=0x99f5c220) at frameworks/base/core/jni/android_view_MotionEvent.cpp:701

(gdb) l
27 SharedBuffer* SharedBuffer::alloc(size_t size)
28 {
29   SharedBuffer* sb = static_cast<SharedBuffer *>(malloc(sizeof(SharedBuffer) + size));
30   if (sb) {
31   sb->mRefs = 1;
32   sb->mSize = size;
(gdb) p sizeof(SharedBuffer)
$19 = 16
(gdb) p sizeof(SharedBuffer) + size
$20 = 0

越界内存写

```
(gdb) bt
#0  android::MotionEvent::readFromParcel (this=this@entry=0xaefca680, parcel=0xaec2f490) at
frameworks/native/libs/input/Input.cpp:459
#1  0xb6e91f1e in android::android_view_MotionEvent_nativeReadFromParcel (env=0xaec306a0, clazz=<optimized out>,
nativePtr=<optimized out>,
    parcelObj=0x9fdf6220) at frameworks/base/core/jni/android_view_MotionEvent.cpp:701
(gdb) l
455     while (sampleCount-- > 0) {   ---------->sampleCount初始值0x1ffffffe
456         mSampleEventTimes.push(parcel->readInt64());  ---------->越界写的位置，写的内容也是来自于parcel
457         for (size_t i = 0; i < pointerCount; i++) {
458             mSamplePointerCoords.push();
459             status_t status = mSamplePointerCoords.editTop().readFromParcel(parcel);
460             if (status) {  ---------->长度控制的关键
461                 return status;
462             }
463         }
```

堆喷射方法

沙箱中能调用的系统服务方法很少，一个很巧妙的内存泄漏Bug是很宝贵的。

```
public class GraphicBuffer implements Parcelable{...}
status_t GraphicBuffer::unflatten(...){
        native_handle* h = native_handle_create(
        static_cast<int>(numFds), static_cast<int>(numInts));
        handle = h;
        status_t err = mBufferMapper.registerBuffer(handle);
        if (err != NO_ERROR) {
            handle = NULL;---------->没有free，内存泄漏
            return err;
        }
}
```

重写结构

public class ***KeyCharacterMap*** **implements** Parcelable {.....} ------>确保能从沙箱里分配

static jlong **nativeReadFromParcel**(JNIEnv ***env**, jobject **clazz**, jobject **parcelObj**) {
.....
    NativeKeyCharacterMap* **map** = **new** NativeKeyCharacterMap(deviceId, kcm);
    return reinterpret_cast<jlong>(map);
}

(gdb) pt /m NativeKeyCharacterMap ---------->大小为8个字节，与SharedBuffer溢出后分配的大小相同
type = class android::NativeKeyCharacterMap {
  private:
    int32_t mDeviceId;
    android::sp<android::KeyCharacterMap> mMap;   --------->重写指向喷射得到的固定地址,GC时会调用sp<.....>的析构函数
}

class android::KeyCharacterMap : public android::RefBase {}

在喷射的堆内存中构造一些结构

```
(gdb) pt /m android::RefBase
type = class android::RefBase {
   hide void * vptr;
  private:
    android::RefBase::weakref_impl * const mRefs;
}

(gdb) pt /m android::RefBase::weakref_impl
type = class android::RefBase::weakref_impl : public android::RefBase::weakref_type {
  public:
    volatile int32_t mStrong;
    volatile int32_t mWeak;
    android::RefBase * const mBase;    ---------->指向喷射得到的固定地址(g_fixedAddress = 0x9010100c)
    volatile int32_t mFlags;
}
```

堆喷射后的内存布局

```
0x90101000: 0x000003fd 0x000003fe 0x000003ff 0x90101014
0x90101010: 0x90101024 0x00000001 0x90101034 0xb6e6f709
0x90101020: 0xb6e84cbb 0x00000001 0x00000001 0x9010100c
0x90101030: 0x00000000 0x00000004 0x00000005 0x00000006
0x90101040: 0x00000007 0xb6e901cb 0xb6e901cb 0x0000dead
0x90101050: 0x0000dead 0xb6e909f1 0x0000dead 0x0000dead
0x90101060: 0x90101000 0x00001000 0x00000007 0x00000003
0x90101070: 0x00000004 0x00000007 0xb6da325c 0x00000000
0x90101080: 0x00000001 0x00000002 0x00000003 0x00000004
0x90101090: 0x00000007 0x901010a8 0xb6ef3f4d 0xb6ef3f55
0x901010a0: 0xffffffff 0x0001462c 0xe59f0004 0xe59f1004
0x901010b0: 0xea000001 0x90101098 0x00200000 0xe92d4ff0
0x901010c0: 0xe3a0b02d 0xeddf1ba8 0xe24ddf4f 0xe3a0a060
0x901010d0: 0xeddf0ba7 0xe3a08067 0xe3a0e020 0xe58d0018
0x901010e0: 0xe3a00078 0xe3a03000 0xe5cdb0f4 0xe3a0b070
0x901010f0: 0xe3a0206c 0xe3a0c074 0xe3a0506f 0xe5cd80f2
```

红：RefBase对象

橙：RefBase的虚表

绿：weakref_impl对象

蓝：ROP栈

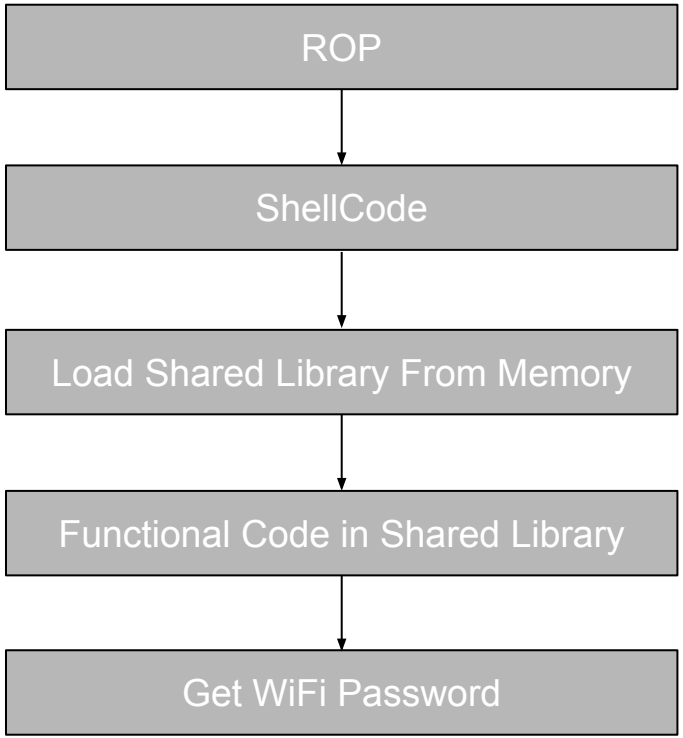
黑：shellcode

触发ROP

```
(gdb) bt
#0  android::RefBase::decStrong (this=0x9010100c, id=0x9c80bcbc) at system/core/libutils/RefBase.cpp:343
#1  0xb6e8a6ba in android::sp<android::Looper>::~sp (this=0x9c80bcbc, __in_chrg=<optimized out>)
    at system/core/include/utils/StrongPointer.h:143
#2  0xb6ea314c in ~NativeKeyCharacterMap (this=0x9c80bcb8, __in_chrg=<optimized out>)
    at frameworks/base/core/jni/android_view_KeyCharacterMap.cpp:53
#3  android::nativeDispose (env=<optimized out>, clazz=<optimized out>, ptr=<optimized out>)
    at frameworks/base/core/jni/android_view_KeyCharacterMap.cpp:112
```

```
341void RefBase::decStrong(const void* id) const
342{
324    weakref_impl* const refs = mRefs; ...
350    if (c == 1) {
351        refs->mBase->onLastStrongRef(id);   ---------->mBase的虚表可控，跳转后r0为mBase地址，即g_fixedAddress
           ...
354        }
357}
```

获取Wifi密码



/data/misc/wifi/wpa_supplicant.conf

DEMO

总结与建议

- 总结:
  - Bundle的缺陷
  - 一些能利用Bundle缺陷的漏洞
  - CVE-2015-3875的具体利用
- 建议:
  - unparcel时不要自动创建复杂对象

招贤纳才

领域：

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Chrome浏览器安全

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