前言

在了解了正常环境下 app 的 activity 是如何被启动的以后，接下來我们希望能够了解一下 VirtualApp 中是如何启动目标 app 的。不过整个流程涉及到了对部分 Service 的 Hook，但这些内容却不是本节我们重点关心的内容，因此会有相应的介绍，但或许并不全面。

容器内 APP 启动流程

点击启动应用时发生了啥

当用户点击了视图上目标应用的图标后，触发点击事件并向下调用，在 blackbox 中将来到 `launchApk` 函数：

```java
public boolean launchApk(String packageName, int userId) {
  Intent launchIntentForPackage =
      getBPackageManager().getLaunchIntentForPackage(packageName, userId);
  if (launchIntentForPackage == null) {
    return false;
  }
  startActivity(launchIntentForPackage, userId);
  return true;
}

public void startActivity(Intent intent, int userId) {
  if (mClientConfiguration.isEnableLauncherActivity()) {
    LauncherActivity.launch(intent, userId);
  } else {
    getBActivityManager().startActivity(intent, userId);
  }
}

public static void launch(Intent intent, int userId) {
  Intent splash = new Intent();
  splash.setClass(SandBoxCore.getContext(), LauncherActivity.class);
  splash.addFlags(Intent.FLAG_ACTIVITY_NEW_TASK);

  splash.putExtra(LauncherActivity.KEY_INTENT, intent);
  splash.putExtra(LauncherActivity.KEY_PKG, intent.getPackage());
  splash.putExtra(LauncherActivity.KEY_USER_ID, userId);
  SandBoxCore.getContext().startActivity(splash);
}
```

`mClientConfiguration.isEnableLauncherActivity` 是恒真的，因此最终会调用 `LauncherActivity.launch` ，在该函数中， `blackbox` 初始化了一个 `Intent` ，然后调用原生的 `startActivity` 函数来进入 `LauncherActivity` ，在进入时，会调用该对象的 `onCreate` 函数：

```
@Override
protected void onCreate(@Nullable Bundle savedInstanceState) {
  super.onCreate(savedInstanceState);
  // 获取启动当前 Activity 的 Intent
  Intent intent = getIntent();
  if (intent == null) {
    finish();
    return;
  }
  // 获取需要启动的对于 APP 的相关信息
  Intent launchIntent = intent.getParcelableExtra(KEY_INTENT);
  String packageName = intent.getStringExtra(KEY_PKG);
  int userId = intent.getIntExtra(KEY_USER_ID, 0);

  PackageInfo packageInfo =
      SandBoxCore.getBPackageManager().getPackageInfo(packageName, 0, userId);
  if (packageInfo == null) {
    Slog.e(TAG, packageName + " not installed!");
    finish();
    return;
  }
  Drawable drawable =
packageInfo.applicationInfo.loadIcon(SandBoxCore.getPackageManager());
  setContentView(R.layout.activity_launcher);
  findViewById(R.id.iv_icon).setBackgroundDrawable(drawable);
  // 调用 BActivityManager.startActivity 在 Blackbox 中启动应用
  new Thread(() ->
SandBoxCore.getBActivityManager().startActivity(launchIntent,
userId)).start();
}
```

函数首先获取之前那个 splash ，然后从中读取出需要启动的目标应用的包名和用户 ID，并通过包名来读取包的相关信息，最后调用 `BActivityManager.startActivity` 来在 Blackbox 中启动应用。

```
public void startActivity(Intent intent, int userId) {
  try {
    getService().startActivity(intent, userId);
  } catch (RemoteException e) {
    e.printStackTrace();
  }
}

public Service getService() {
  if (mService != null
      && mService.asBinder().pingBinder()
      && mService.asBinder().isBinderAlive()) {
    return mService;
  }
  try {
    mService =
        Reflector.on(getTClass().getName() + "$Stub")
            .method("asInterface", IBinder.class)
            .call(SandBoxCore.get().getService(getServiceName()));
    mService
        .asBinder()
        .linkToDeath(
            new IBinder.DeathRecipient() {
              @Override
              public void binderDied() {
                mService.asBinder().unlinkToDeath(this, 0);
                mService = null;
              }
            },
            0);
    return getService();
  } catch (Throwable e) {
    e.printStackTrace();
    return null;
  }
}
```

`getService` 函数会返回对应的 Service ，在这个函数中将会返回 `BActivityManagerService` ，这里涉及到了一个我们尚且没有关注过的问题，VirtualApp 是如何伪造各种系统 Service 的?

那些系统服务如何被 Hook

在应用的 `Manifest` 里声明了这么一段：

```
<provider
  android:name=".core.system.SystemCallProvider"
  android:authorities="${applicationId}.blackbox.SystemCallProvider"
  android:exported="false"
  android:process="@string/black_box_service_name" />
```

在启动 Blackbox 的时候，`handleBindApplication` 中会主动调用对应 `ContentProvider` 下的 `onCreate` 函数：

```
@Override
public boolean onCreate() {
  return initSystem();
}

private boolean initSystem() {
  BlackBoxSystem.getSystem().startup();
  return true;
}

public void startup() {
  // 如果已经启动过了，则直接返回即可
  if (isStartup.getAndSet(true)) return;
  BEnvironment.load();

  // 将需要 hook 的系统 Service 代理放入 mServices
  mServices.add(BPackageManagerService.get());
  mServices.add(BUserManagerService.get());
  mServices.add(BActivityManagerService.get());
  mServices.add(BJobManagerService.get());
  mServices.add(BStorageManagerService.get());
  mServices.add(BPackageInstallerService.get());
  mServices.add(BXposedManagerService.get());
  mServices.add(BProcessManagerService.get());
  mServices.add(BAccountManagerService.get());
  mServices.add(BLocationManagerService.get());
  mServices.add(BNotificationManagerService.get());
  // 遍历每个 Service 并调用 systemReady 完成准备工作
  for (ISystemService service : mServices) {
    service.systemReady();
  }
  // 遍历 blackbox 中每个预先安装的应用，如果有哪个尚未安装完成，重新恢复安装
  List<String> preInstallPackages = AppSystemEnv.getPreInstallPackages();
  for (String preInstallPackage : preInstallPackages) {
    try {
      if (!BPackageManagerService.get().isInstalled(preInstallPackage,
BUserHandle.USER_ALL)) {
        PackageInfo packageInfo =
            SandBoxCore.getPackageManager().getPackageInfo(preInstallPackage,
0);
        BPackageManagerService.get()
            .installPackageAsUser(
                packageInfo.applicationInfo.sourceDir,
                InstallOption.installBySystem(),
                BUserHandle.USER_ALL);
      }
    } catch (PackageManager.NameNotFoundException ignored) {
    }
  }
  initJarEnv();
}
```

我们重点关注的是 `mServices` 这个成员，在注意到它将 `BActivityManagerService` 放入了数组，并调用对应的 `systemReady` ：

```
public BActivityManagerService() {
  mBroadcastManager = BroadcastManager.startSystem(this, mPms);
}

@Override
public void systemReady() {
  mBroadcastManager.startup();
}
public void startup() {
  mPms.addPackageMonitor(this);
  List<BPackageSettings> bPackageSettings = mPms.getBPackageSettings();
  for (BPackageSettings bPackageSetting : bPackageSettings) {
    BPackage bPackage = bPackageSetting.pkg;
    registerPackage(bPackage);
  }
}
```

最终会为每个包注册一个 `BroadcastReceiver` ：

```
private void addReceiver(String packageName, BroadcastReceiver receiver) {
  List<BroadcastReceiver> broadcastReceivers = mReceivers.get(packageName);
  if (broadcastReceivers == null) {
    broadcastReceivers = new ArrayList<>();
    mReceivers.put(packageName, broadcastReceivers);
  }
  broadcastReceivers.add(receiver);
}
```

而这个 `SystemCallProvider` 本身也作为一个 IBinder，将它管理的这些 Service 暴露给其他应用使用：

```
@Nullable
@Override
public Bundle call(@NonNull String method, @Nullable String arg, @Nullable
Bundle extras) {
  Slog.d(TAG, "call: " + method + ", " + extras);
  if ("VM".equals(method)) {
    Bundle bundle = new Bundle();
    if (extras != null) {
      String name = extras.getString("_B_|_server_name_");
      BundleCompat.putBinder(bundle, "_B_|_server_",
ServiceManager.getService(name));
    }
    return bundle;
  }
  return super.call(method, arg, extras);
}
```

`ServiceManager.getService` 可以能够根据参数来返回对应的 Service：

```
public static IBinder getService(String name) {
  return get().getServiceInternal(name);
}
public static ServiceManager get() {
  if (sServiceManager == null) {
    synchronized (ServiceManager.class) {
      if (sServiceManager == null) {
        sServiceManager = new ServiceManager();
      }
    }
  }
  return sServiceManager;
}
private ServiceManager() {
  mCaches.put(ACTIVITY_MANAGER, BActivityManagerService.get());
  mCaches.put(JOB_MANAGER, BJobManagerService.get());
  mCaches.put(PACKAGE_MANAGER, BPackageManagerService.get());
  mCaches.put(STORAGE_MANAGER, BStorageManagerService.get());
  mCaches.put(USER_MANAGER, BUserManagerService.get());
  mCaches.put(XPOSED_MANAGER, BXposedManagerService.get());
  mCaches.put(ACCOUNT_MANAGER, BAccountManagerService.get());
  mCaches.put(LOCATION_MANAGER, BLocationManagerService.get());
  mCaches.put(NOTIFICATION_MANAGER, BNotificationManagerService.get());
}
public IBinder getServiceInternal(String name) {
  return mCaches.get(name);
}
```

如果 `ServiceManager` 没初始化的话就先创建并初始化，将所有的 Service 都放入 `mCaches` ，并在需要的时候返回该对象。最终其他需要使用这些服务的应用就都能够通过 Binder 拿到这些对应的对象了。

对这些获取 Service 的对象来说，他们本该获取到原生的 `ActivityManagerService` ，却被 `BActivityManagerService` 替换掉了，对应的去调用那些本该调用的方法时，自然这些方法也就一起被 Hook 掉了。

一般来说我们都是通过 `getSystemService` 来获取对应的服务的：

```
@Override
public Object getSystemService(String name) {
    // this 是 ContextImpl
    return SystemServiceRegistry.getSystemService(this, name);
}
```

而在 Blackbox 的 HookManager 中注册了对各种对象的钩子：

```
public void init() {
  if (SandBoxCore.get().isBlackProcess() ||
SandBoxCore.get().isServerProcess()) {
    addInjector(new IDisplayManagerProxy());
    addInjector(new OsStub());
    addInjector(new IActivityManagerProxy());
    addInjector(new IPackageManagerProxy());
    addInjector(new ITelephonyManagerProxy());
    addInjector(new HCallbackProxy());
    addInjector(new IAppOpsManagerProxy());
    addInjector(new INotificationManagerProxy());
    addInjector(new IAlarmManagerProxy());
    addInjector(new IAppWidgetManagerProxy());
    addInjector(new ContentServiceStub());
    addInjector(new IWindowManagerProxy());
    addInjector(new IUserManagerProxy());
    addInjector(new RestrictionsManagerStub());
    addInjector(new IMediaSessionManagerProxy());
    addInjector(new ILocationManagerProxy());
    addInjector(new IStorageManagerProxy());
    addInjector(new ILauncherAppsProxy());
```

```
      addInjector(new IJobServiceProxy());
      addInjector(new IAccessibilityManagerProxy());
      addInjector(new ITelephonyRegistryProxy());
      addInjector(new IDevicePolicyManagerProxy());
      addInjector(new IAccountManagerProxy());
      addInjector(new IConnectivityManagerProxy());
      addInjector(new IClipboardManagerProxy());
      addInjector(new IPhoneSubInfoProxy());
      addInjector(new IMediaRouterServiceProxy());
      addInjector(new IPowerManagerProxy());
      addInjector(new IContextHubServiceProxy());
      addInjector(new IVibratorServiceProxy());
      addInjector(new IPersistentDataBlockServiceProxy());
      addInjector(AppInstrumentation.get());
      /*
       * It takes time to test and enhance the compatibility of WifiManager
  * (only tested in Android 10).     * commented by BlackBoxing at 2022/03/08
  * */    addInjector(new IWifiManagerProxy());
      addInjector(new IWifiScannerProxy());
      // 12.0
      if (BuildCompat.isS()) {
        addInjector(new IActivityClientProxy(null));
        addInjector(new IVpnManagerProxy());
      }
      // 11.0
      if (BuildCompat.isR()) {
        addInjector(new IPermissionManagerProxy());
      }
      // 10.0
      if (BuildCompat.isQ()) {
        addInjector(new IActivityTaskManagerProxy());
      }
      // 9.0
      if (BuildCompat.isPie()) {
        addInjector(new ISystemUpdateProxy());
      }
      // 8.0
      if (BuildCompat.isOreo()) {
        addInjector(new IAutofillManagerProxy());
        addInjector(new IDeviceIdentifiersPolicyProxy());
        addInjector(new IStorageStatsManagerProxy());
      }
      // 7.1
      if (BuildCompat.isN_MR1()) {
        addInjector(new IShortcutManagerProxy());
      }
      // 7.0
      if (BuildCompat.isN()) {
        addInjector(new INetworkManagementServiceProxy());
      }
      // 6.0
      if (BuildCompat.isM()) {
        addInjector(new IFingerprintManagerProxy());
        addInjector(new IGraphicsStatsProxy());
      }
      // 5.0
      if (BuildCompat.isL()) {
        addInjector(new IJobServiceProxy());
      }
    }
    injectAll();
  }
```

我们主要看 `IActivityManagerProxy` 是如何对 `ActivityManager` 进行 hook 的：

```
@Override
protected void inject(Object base, Object proxy) {
  Object iActivityManager = null;
  if (BuildCompat.isOreo()) {
    iActivityManager =
BRActivityManagerOreo.get().IActivityManagerSingleton();
  } else if (BuildCompat.isL()) {
    iActivityManager = BRActivityManagerNative.get().gDefault();
  }
  BRSingleton.get(iActivityManager)._set_mInstance(proxy);
}
```

这里有一个 `_set_mInstance` 实际上是 `blackreflection` 的语法糖，它通过反射的方式来修改 `gDefault().mInstance` 。我们在上一节中提到过启动应用时会通过 `ActivityManagerNative.getDefault` 来得到 `ActivityManagerProxy` ，这里会将结果给改成 `Proxy` ，也就是用 `IActivityManagerProxy` 来代理原本的返回对象。

比如说 `getServices` 函数会被 hook 为：

```
@ProxyMethod("getServices")
public static class GetServices extends MethodHook {
  @Override
  protected Object hook(Object who, Method method, Object[] args) throws
Throwable {
    RunningServiceInfo runningServices =
          BActivityManager.get()
              .getRunningServices(BActivityThread.getAppPackageName(),
BActivityThread.getUserId());
    if (runningServices == null) {
      return new ArrayList<>();
    }
    return runningServices.mRunningServiceInfoList;
  }
}
```

> 可以注意到，在注入 Service Hook 的时候是有做进程判断的，因为主进程肯定还是需要和 Service 进行正常沟通的，如果全都 Hook 掉的话，主进程也无法正常通信了。所以在满足 `isBlackProcess` 或 `isServerProcess` 时才会注入那些代理，也就是那些需要启动的内部应用或是服务进程才会注入。

顺带一提，ServerProcess 中包含了这么几个：

```
<provider
  android:name=".core.system.SystemCallProvider"
  android:authorities="${applicationId}.blackbox.SystemCallProvider"
  android:exported="false"
  android:process="@string/black_box_service_name" />
<receiver
  android:name=".proxy.ProxyBroadcastReceiver"
  android:enabled="true"
  android:exported="true"
  android:process="@string/black_box_service_name">
  <intent-filter>    <action android:name="${applicationId}.stub_receiver" />
  </intent-filter></receiver>
<service
  android:name=".core.system.DaemonService"
  android:exported="false"
  android:process="@string/black_box_service_name" />
<service
  android:name=".core.system.DaemonService$DaemonInnerService"
  android:exported="false"
  android:process="@string/black_box_service_name" />
```

BActivityManagerService.startActivity 如何启动应用

接下来我们回到 `BActivityManagerService.startActivity` 来看看它如何启动应用。

```
@Override
public void startActivity(Intent intent, int userId) {
  UserSpace userSpace = getOrCreateSpaceLocked(userId);
  synchronized (userSpace.mStack) {
    userSpace.mStack.startActivityLocked(userId, intent, null, null, null, -1,
-1, null);
  }
}
```

这里向下继续调用 `startActivityLocked`，不过这个函数有点长，这里主要关注两个几个关键步骤即可：

```
public int startActivityLocked(
      int userId,
      Intent intent,
      String resolvedType,
      IBinder resultTo,
      String resultWho,
      int requestCode,
      int flags,
      Bundle options) {
    synchronized (mTasks) {
      synchronizeTasks();
    }

    ResolveInfo resolveInfo =
        BPackageManagerService.get().resolveActivity(intent, GET_ACTIVITIES,
resolvedType, userId);
    if (resolveInfo == null || resolveInfo.activityInfo == null) {
      return 0;
    }
    Log.d(TAG, "startActivityLocked : " + resolveInfo.activityInfo);
    ActivityInfo activityInfo = resolveInfo.activityInfo;

    ActivityRecord sourceRecord = findActivityRecordByToken(userId, resultTo);
    if (sourceRecord == null) {
      resultTo = null;
    }
    TaskRecord sourceTask = null;
    if (sourceRecord != null) {
      sourceTask = sourceRecord.task;
    }

    String taskAffinity = ComponentUtils.getTaskAffinity(activityInfo);

    int launchModeFlags = 0;
    boolean singleTop =
        containsFlag(intent, Intent.FLAG_ACTIVITY_SINGLE_TOP)
            || activityInfo.launchMode == ActivityInfo.LAUNCH_SINGLE_TOP;
    boolean newTask = containsFlag(intent, Intent.FLAG_ACTIVITY_NEW_TASK);
    boolean clearTop = containsFlag(intent, Intent.FLAG_ACTIVITY_CLEAR_TOP);
    boolean clearTask = containsFlag(intent, Intent.FLAG_ACTIVITY_CLEAR_TASK);

    TaskRecord taskRecord = null;
    switch (activityInfo.launchMode) {
      case ActivityInfo.LAUNCH_SINGLE_TOP:
      case ActivityInfo.LAUNCH_MULTIPLE:
      case ActivityInfo.LAUNCH_SINGLE_TASK:
        taskRecord = findTaskRecordByTaskAffinityLocked(userId, taskAffinity);
        if (taskRecord == null && !newTask) {
          taskRecord = sourceTask;
        }
        break;
      case ActivityInfo.LAUNCH_SINGLE_INSTANCE:
        taskRecord = findTaskRecordByTaskAffinityLocked(userId, taskAffinity);
        break;
    }

    // 如果还没有task则新启动一个task
    if (taskRecord == null || taskRecord.needNewTask()) {
      return startActivityInNewTaskLocked(userId, intent, activityInfo,
  resultTo, launchModeFlags);
    }
    // 移至前台
    mAms.moveTaskToFront(taskRecord.id, 0);

    boolean notStartToFront = false;
    if (clearTop || singleTop || clearTask) {
      notStartToFront = true;
    }

    boolean startTaskToFront =
        !notStartToFront
            && ComponentUtils.intentFilterEquals(taskRecord.rootIntent, intent)
            && taskRecord.rootIntent.getFlags() == intent.getFlags();

    if (startTaskToFront) return 0;

    ActivityRecord topActivityRecord = taskRecord.getTopActivityRecord();
    ActivityRecord targetActivityRecord =
        findActivityRecordByComponentName(userId,
  ComponentUtils.toComponentName(activityInfo));
    ActivityRecord newIntentRecord = null;
```

```java
  boolean ignore = false;

  if (clearTop) {
    if (targetActivityRecord != null) {
      // 目标栈上面所有activity出栈
      synchronized (targetActivityRecord.task.activities) {
        for (int i = targetActivityRecord.task.activities.size() - 1; i >= 0;
i--) {
          ActivityRecord next = targetActivityRecord.task.activities.get(i);
          if (next != targetActivityRecord) {
            next.finished = true;
            Log.d(TAG, "makerFinish: " + next.component.toString());
          } else {
            if (singleTop) {
              newIntentRecord = targetActivityRecord;
            } else {
              // clearTop并且不是singleTop，目标也finish，重建。
              targetActivityRecord.finished = true;
            }
            break;
          }
        }
      }
    }
  }

  if (singleTop && !clearTop) {
    if (ComponentUtils.intentFilterEquals(topActivityRecord.intent, intent)) {
      newIntentRecord = topActivityRecord;
    } else {
      synchronized (mLaunchingActivities) {
        for (ActivityRecord launchingActivity : mLaunchingActivities) {
          if (!launchingActivity.finished
              && launchingActivity.component.equals(intent.getComponent())) {
            // todo update onNewIntent from intent
            ignore = true;
          }
        }
      }
    }
  }

  if (activityInfo.launchMode == ActivityInfo.LAUNCH_SINGLE_TASK && !clearTop)
{
    if (ComponentUtils.intentFilterEquals(topActivityRecord.intent, intent)) {
      newIntentRecord = topActivityRecord;
    } else {
      ActivityRecord record =
          findActivityRecordByComponentName(userId,
ComponentUtils.toComponentName(activityInfo));
      if (record != null) {
        // 需要调用目标onNewIntent
        newIntentRecord = record;
        // 目标栈上面所有activity出栈
        synchronized (taskRecord.activities) {
          for (int i = taskRecord.activities.size() - 1; i >= 0; i--) {
            ActivityRecord next = taskRecord.activities.get(i);
            if (next != record) {
              next.finished = true;
            } else {
              break;
            }
          }
        }
      }
    }
  }

  if (activityInfo.launchMode == ActivityInfo.LAUNCH_SINGLE_INSTANCE) {
    newIntentRecord = topActivityRecord;
  }

  // clearTask finish All
  if (clearTask && newTask) {
    for (ActivityRecord activity : taskRecord.activities) {
      activity.finished = true;
    }
  }

  finishAllActivity(userId);

  if (newIntentRecord != null) {
    // 通知onNewIntent
    deliverNewIntentLocked(newIntentRecord, intent);
    return 0;
  } else if (ignore) {
    return 0;
  }

  if (resultTo == null) {
    ActivityRecord top = taskRecord.getTopActivityRecord();
    if (top != null) {
      resultTo = top.token;
    }
  } else if (sourceTask != null) {
    ActivityRecord top = sourceTask.getTopActivityRecord();
    if (top != null) {
      resultTo = top.token;
    }
  }
  return startActivityInSourceTask(
      intent,
      resultType,
      resultTo,
      resultWho,
      requestCode,
      flags,
      options,
      userId,
      topActivityRecord,
      activityInfo,
      launchModeFlags);
}
```

首先我们关注 `startActivityInNewTaskLocked` ，对于那些需要新启动的情况，使用该函数创建对应的任务：

```
private int startActivityInNewTaskLocked(
    int userId, Intent intent, ActivityInfo activityInfo, IBinder resultTo,
int launchMode) {
  ActivityRecord record = newActivityRecord(intent, activityInfo, resultTo,
userId);
  Intent shadow = startActivityProcess(userId, intent, activityInfo, record);

  shadow.addFlags(Intent.FLAG_ACTIVITY_MULTIPLE_TASK);
  shadow.addFlags(Intent.FLAG_ACTIVITY_NEW_DOCUMENT);
  shadow.addFlags(Intent.FLAG_ACTIVITY_NEW_TASK);
  shadow.addFlags(launchMode);

  SandBoxCore.getContext().startActivity(shadow);
  return 0;
}
```

该函数创建了一个 `shadow` ，它实际上是用来创建一个虚假的 `Intent` 的，我们往下跟踪 `startActivityProcess` ：

```
private Intent startActivityProcess(
    int userId, Intent intent, ActivityInfo info, ActivityRecord record) {
  ProxyActivityRecord stubRecord = new ProxyActivityRecord(userId, info,
intent, record);
  ProcessRecord targetApp =
      BProcessManagerService.get()
          .startProcessLocked(
              info.packageName, info.processName, userId, -1,
Binder.getCallingPid());
  if (targetApp == null) {
    throw new RuntimeException("Unable to create process, name:" + info.name);
  }
  return getStartStubActivityIntentInner(intent, targetApp.bpid, userId,
stubRecord, info);
}
```

`targetApp` 初始化了我们将要启动的目标应用的相关信息：

```
public ProcessRecord startProcessLocked(
    String packageName, String processName, int userId, int bpid, int
callingPid) {
  ApplicationInfo info =
BPackageManagerService.get().getApplicationInfo(packageName, 0, userId);
  if (info == null) return null;
  ProcessRecord app;
  int buid = BUserHandle.getUid(userId,
BPackageManagerService.get().getAppId(packageName));
  synchronized (mProcessLock) {
    Map<String, ProcessRecord> bProcess = mProcessMap.get(buid);

    if (bProcess == null) {
      bProcess = new HashMap<>();
    }
    if (bpid == -1) {
      app = bProcess.get(processName);
      if (app != null) {
        if (app.initLock != null) {
          app.initLock.block();
        }
        if (app.bActivityThread != null) {
          return app;
        }
      }
      bpid = getUsingBPidL();
      Slog.d(TAG, "init bUid = " + buid + ", bPid = " + bpid);
    }
    if (bpid == -1) {
      throw new RuntimeException("No processes available");
    }
    app = new ProcessRecord(info, processName);
    app.uid = Process.myUid();
    app.bpid = bpid;
    app.buid = BPackageManagerService.get().getAppId(packageName);
    app.callingBUid = getBUidByPidOrPackageName(callingPid, packageName);
    app.userId = userId;

    bProcess.put(processName, app);
    mPidsSelfLocked.add(app);

    synchronized (mProcessMap) {
      mProcessMap.put(buid, bProcess);
    }
    if (!initAppProcessL(app)) {
      // init process fail
      bProcess.remove(processName);
      mPidsSelfLocked.remove(app);
      app = null;
    } else {
      app.pid = getPid(SandBoxCore.getContext(),
ProxyManifest.getProcessName(app.bpid));
    }
  }
  return app;
}
```

可以看到主要就是一些 ID 的初始化，不过注意，其中 bpid 指的其实是对 Blackbox 来说的进程 ID ， 因为对系统来说只有 Blackbox 这一个进程，但是对 Blackbox 来说却需要管理其中启动的不同应用。

其中还包括了一个 `initAppProcessL` 用来初始化 app：

```
  private boolean initAppProcessL(ProcessRecord record) {
    Log.d(TAG, "initProcess: " + record.processName);
    AppConfig appConfig = record.getClientConfig();
    Bundle bundle = new Bundle();
    bundle.putParcelable(AppConfig.KEY, appConfig);
    Bundle init =
        ProviderCall.callSafely(
            record.getProviderAuthority(), "_Black_|_init_process_", null,
  bundle);
```

```
    IBinder appThread = BundleCompat.getBinder(init, "_Black_|_client_");
    if (appThread == null || !appThread.isBinderAlive()) {
      return false;
    }
    attachClientL(record, appThread);

    createProc(record);
    return true;
  }
```

这是一个通过 Binder 来调用 `initprocess` 函数的接口函数，对应调用为：

```
@Nullable
@Override
public Bundle call(@NonNull String method, @Nullable String arg, @Nullable
Bundle extras) {
  if (method.equals("_Black_|_init_process_")) {
    assert extras != null;
    extras.setClassLoader(AppConfig.class.getClassLoader());
    AppConfig appConfig = extras.getParcelable(AppConfig.KEY);
    BActivityThread.currentActivityThread().initProcess(appConfig);

    Bundle bundle = new Bundle();
    BundleCompat.putBinder(bundle, "_Black_|_client_",
BActivityThread.currentActivityThread());
    return bundle;
  }
  return super.call(method, arg, extras);
}
```

向下调用 `initProcess` 函数：

```
public void initProcess(AppConfig appConfig) {
  synchronized (mConfigLock) {
    if (this.mAppConfig != null &&
!this.mAppConfig.packageName.equals(appConfig.packageName)) {
      // 该进程已被attach
      throw new RuntimeException(
          "reject init process: "
              + appConfig.processName
              + ", this process is : "
              + this.mAppConfig.processName);
    }
    this.mAppConfig = appConfig;
    IBinder iBinder = asBinder();
    try {
      iBinder.linkToDeath(
          new DeathRecipient() {
            @Override
            public void binderDied() {
              synchronized (mConfigLock) {
                try {
                  iBinder.linkToDeath(this, 0);
                } catch (RemoteException ignored) {
                }
                mAppConfig = null;
              }
            }
          },
          0);
    } catch (RemoteException e) {
      e.printStackTrace();
    }
  }
}
```

这里将 `appConfig` 设置到了 `BActivityThread` 对象里去。

然后再调用 `getStartStubActivityIntentInner` ，不过参数其实只有刚才的 `bpid` ，对应参数中的 `vpid` ：

```
private Intent getStartStubActivityIntentInner(
    Intent intent, int vpid, int userId, ProxyActivityRecord target,
ActivityInfo activityInfo) {
  Intent shadow = new Intent();
  TypedArray typedArray = null;
  try {
    Resources resources =
        PackageManagerCompat.getResources(SandBoxCore.getContext(),
activityInfo.applicationInfo);
    int id;
    if (activityInfo.theme != 0) {
      id = activityInfo.theme;
    } else {
      id = activityInfo.applicationInfo.theme;
    }
    assert resources != null;
    typedArray = resources.newTheme().obtainStyledAttributes(id,
BRRstyleable.get().Window());
```

```
    boolean windowIsTranslucent =
        typedArray.getBoolean(BRRstyleable.get().Window_windowIsTranslucent(),
false);
    if (windowIsTranslucent) {
    // 使用 vpid 查找
      shadow.setComponent(
          new ComponentName(
              SandBoxCore.getHostPkg(),
ProxyManifest.TransparentProxyActivity(vpid)));
    } else {
    // 使用 vpid 查找
      shadow.setComponent(
          new ComponentName(SandBoxCore.getHostPkg(),
ProxyManifest.getProxyActivity(vpid)));
    }
    Slog.d(TAG, activityInfo + ", windowIsTranslucent: " +
windowIsTranslucent);
  } catch (Throwable e) {
    e.printStackTrace();
    shadow.setComponent(
        new ComponentName(SandBoxCore.getHostPkg(),
ProxyManifest.getProxyActivity(vpid)));
  } finally {
    if (typedArray != null) {
      typedArray.recycle();
    }
  }
  ProxyActivityRecord.saveStub(
      shadow, intent, target.mActivityInfo, target.mActivityRecord,
target.mUserId);
  return shadow;
}
```

这个 vpid 参数会用来查找 Blackbox 提前在 Manifest 中占坑的 Activity：

```
<activity
  android:name=".proxy.ProxyActivity$P0"

android:configChanges="mcc|mnc|locale|touchscreen|keyboard|keyboardHidden|navigation|orientation|screenLayout|uiMode|screenSize|smallestScreenSize|fontScale
"
  android:exported="true"
  android:process=":p0"
  android:supportsPictureInPicture="true"
  android:taskAffinity="com.hello.sandbox.task_affinity"
```

```
    android:theme="@style/BTheme" />
  <activity
    android:name=".proxy.ProxyActivity$P1"

  android:configChanges="mcc|mnc|locale|touchscreen|keyboard|keyboardHidden|navi
  gation|orientation|screenLayout|uiMode|screenSize|smallestScreenSize|fontScale
  "
    android:exported="true"
    android:process=":p1"
    android:supportsPictureInPicture="true"
    android:taskAffinity="com.hello.sandbox.task_affinity"
    android:theme="@style/BTheme" />
```

这样的 Activity 总共有 50 个，相当于 Blackbox 最多能支持同时启动 50 个内部应用。

这个操作相当于构造了一个用于启动 `ProxyActivity` 的 `Intent` ，最终再将这个对象传给系统 AMS 来启动它：

```
SandBoxCore.getContext().startActivity(shadow);
```

AMS 收到这个请求后自然是正常启动这个 Activity 了，因为所有行为都合法。但是当 AMS 完成了相关启动后，在前文我们提到过，会给这个新的 Activity 发一个 `H.EXECUTE_TRANSACTION` 命令，而这个命令会被 `handleLaunchActivity` 处理，但是这个函数其实在之前是被 Hook 掉了的：

```
addInjector(new HCallbackProxy());
```

这个 HCallbackProxy 中是这样注入的：

```
private Handler getH() {
  Object currentActivityThread = SandBoxCore.mainThread();
  return BRActivityThread.get(currentActivityThread).mH();
}
private Handler.Callback getHCallback() {
  return BRHandler.get(getH()).mCallback();
}

@Override
public void injectHook() {
  mOtherCallback = getHCallback();
  if (mOtherCallback != null
      && (mOtherCallback == this
          ||
mOtherCallback.getClass().getName().equals(this.getClass().getName()))) {
    mOtherCallback = null;
  }
  BRHandler.get(getH())._set_mCallback(this);
}
```

最终是把 `mCallback` 对象用 `HCallbackProxy` 给替换掉了，从而把下面的消息处理函数 `handleMessage` 给换掉了。不过如果不是我们需要处理的消息，会重新调用原本的函数来处理。

最终调用自己实现的 `handleLaunchActivity` 函数：

```
public synchronized void handleBindApplication(String packageName, String
processName) {
    if (isInit()) return;
    try {
      CrashHandler.create();
    } catch (Throwable ignored) {
    }

    PackageInfo packageInfo =
        SandBoxCore.getBPackageManager()
            .getPackageInfo(packageName, PackageManager.GET_PROVIDERS,
BActivityThread.getUserId());
    ApplicationInfo applicationInfo = packageInfo.applicationInfo;
    if (packageInfo.providers == null) {
      packageInfo.providers = new ProviderInfo[] {};
    }
    mProviders.addAll(Arrays.asList(packageInfo.providers));
    Slog.d(TAG, "handleBindApplication mProviders=" + mProviders);

    Object boundApplication =
BRActivityThread.get(SandBoxCore.mainThread()).mBoundApplication();

    Context packageContext = createPackageContext(applicationInfo);
    Object loadedApk = BRContextImpl.get(packageContext).mPackageInfo();
    BRLoadedApk.get(loadedApk)._set_mSecurityViolation(false);
    // fix applicationInfo
    BRLoadedApk.get(loadedApk)._set_mApplicationInfo(applicationInfo);

    int targetSdkVersion = applicationInfo.targetSdkVersion;
    if (targetSdkVersion < Build.VERSION_CODES.GINGERBREAD) {
      StrictMode.ThreadPolicy newPolicy =
          new
StrictMode.ThreadPolicy.Builder(StrictMode.getThreadPolicy()).permitNetwork().
```

```
build();
    StrictMode.setThreadPolicy(newPolicy);
  }
  if (Build.VERSION.SDK_INT >= Build.VERSION_CODES.N) {
    if (targetSdkVersion < Build.VERSION_CODES.N) {
      StrictModeCompat.disableDeathOnFileUriExposure();
    }
  }
  if (Build.VERSION.SDK_INT >= Build.VERSION_CODES.P) {
    WebView.setDataDirectorySuffix(getUserId() + ":" + packageName + ":" +
processName);
  }

  VirtualRuntime.setupRuntime(processName, applicationInfo);

  BRVMRuntime.get(BRVMRuntime.get().getRuntime())
      .setTargetSdkVersion(applicationInfo.targetSdkVersion);
  if (BuildCompat.isS()) {

BRCompatibility.get().setTargetSdkVersion(applicationInfo.targetSdkVersion);
  }

  NativeCore.init(Build.VERSION.SDK_INT);
  assert packageContext != null;
  IOCore.get().enableRedirect(packageContext);

  AppBindData bindData = new AppBindData();
  bindData.appInfo = applicationInfo;
  bindData.processName = processName;
  bindData.info = loadedApk;
  bindData.providers = mProviders;

  ActivityThreadAppBindDataContext activityThreadAppBindData =
      BRActivityThreadAppBindData.get(boundApplication);
  activityThreadAppBindData._set_instrumentationName(
      new ComponentName(bindData.appInfo.packageName,
Instrumentation.class.getName()));
  activityThreadAppBindData._set_appInfo(bindData.appInfo);
  activityThreadAppBindData._set_info(bindData.info);
  activityThreadAppBindData._set_processName(bindData.processName);
  activityThreadAppBindData._set_providers(bindData.providers);

  mBoundApplication = bindData;

  // ssl适配
  if (BRNetworkSecurityConfigProvider.getRealClass() != null) {
```

```java
      Security.removeProvider("AndroidNSSP");
      BRNetworkSecurityConfigProvider.get().install(packageContext);
    }
    Application application;
    try {
      onBeforeCreateApplication(packageName, processName, packageContext);
      if (BuildCompat.isT()){
        BEnvironment.getAllDex(packageName).forEach(new Consumer<String>() {
          @Override
          public void accept(String s) {
            new File(s).setReadOnly();
          }
        });
      }
      application = BRLoadedApk.get(loadedApk).makeApplication(false, null);
      mInitialApplication = application;

  BRActivityThread.get(SandBoxCore.mainThread())._set_mInitialApplication(mIniti
  alApplication);
      ContextCompat.fix(
          (Context)
  BRActivityThread.get(SandBoxCore.mainThread()).getSystemContext());
      ContextCompat.fix(mInitialApplication);

      installProviders(mInitialApplication, bindData.processName,
  bindData.providers);
      try {
        fixAiLiaoPhoto(mInitialApplication);
      } catch (Throwable e) {
        e.printStackTrace();
      }
      onBeforeApplicationOnCreate(packageName, processName, application);
      AppInstrumentation.get().callApplicationOnCreate(application);
      onAfterApplicationOnCreate(packageName, processName, application);
      NativeCore.init_seccomp();
      HookManager.get().checkEnv(HCallbackProxy.class);

      if (BuildConfig.DEBUG) {
        Log.d(
            TAG,
            "Instrumentation class name "
                + 
  AppInstrumentation.get().getCurrInstrumentation().getClass().getName());
      }
    } catch (Exception e) {
      e.printStackTrace();
      throw new RuntimeException("Unable to makeApplication", e);
    }
  }
```

看起来似乎有些复杂，这里稍微总结一下。

首先 `handleLaunchActivity` 这个函数会有多次调用，不只是收到 `LAUNCH_ACTIVITY` 时，还有 `EXECUTE_TRANSACTION` 的时候也一样会调用（似乎是兼容版本），因此看着流程里会有多次提前返回，是因为时机还没到。

以及我们知道，一个 APP 在启动时有可能会创建多个 Activity，第一个创建的 `Activity` 需要额外的调用 `bindApplication` 去绑定 `Application` 对象，这个也是我们前文正常流程里提到过的。

```
public synchronized void handleBindApplication(String packageName, String
processName) {
  if (isInit()) return;
  try {
    CrashHandler.create();
  } catch (Throwable ignored) {
  }

  PackageInfo packageInfo =
      SandBoxCore.getBPackageManager()
          .getPackageInfo(packageName, PackageManager.GET_PROVIDERS,
BActivityThread.getUserId());
  ApplicationInfo applicationInfo = packageInfo.applicationInfo;
  if (packageInfo.providers == null) {
    packageInfo.providers = new ProviderInfo[] {};
  }
  mProviders.addAll(Arrays.asList(packageInfo.providers));
  Slog.d(TAG, "handleBindApplication mProviders=" + mProviders);

  Object boundApplication =
BRActivityThread.get(SandBoxCore.mainThread()).mBoundApplication();

  Context packageContext = createPackageContext(applicationInfo);
  Object loadedApk = BRContextImpl.get(packageContext).mPackageInfo();
  BRLoadedApk.get(loadedApk)._set_mSecurityViolation(false);
  // fix applicationInfo
  BRLoadedApk.get(loadedApk)._set_mApplicationInfo(applicationInfo);

  int targetSdkVersion = applicationInfo.targetSdkVersion;
  if (targetSdkVersion < Build.VERSION_CODES.GINGERBREAD) {
    StrictMode.ThreadPolicy newPolicy =
        new
StrictMode.ThreadPolicy.Builder(StrictMode.getThreadPolicy()).permitNetwork().
build();
    StrictMode.setThreadPolicy(newPolicy);
  }
  if (Build.VERSION.SDK_INT >= Build.VERSION_CODES.N) {
    if (targetSdkVersion < Build.VERSION_CODES.N) {
      StrictModeCompat.disableDeathOnFileUriExposure();
    }
  }
  if (Build.VERSION.SDK_INT >= Build.VERSION_CODES.P) {
    WebView.setDataDirectorySuffix(getUserId() + ":" + packageName + ":" +
processName);
  }

  VirtualRuntime.setupRuntime(processName, applicationInfo);

  BRVMRuntime.get(BRVMRuntime.get().getRuntime())
      .setTargetSdkVersion(applicationInfo.targetSdkVersion);
  if (BuildCompat.isS()) {

BRCompatibility.get().setTargetSdkVersion(applicationInfo.targetSdkVersion);
  }

  NativeCore.init(Build.VERSION.SDK_INT);
  assert packageContext != null;
  IOCore.get().enableRedirect(packageContext);

  AppBindData bindData = new AppBindData();
  bindData.appInfo = applicationInfo;
  bindData.processName = processName;
  bindData.info = loadedApk;
  bindData.providers = mProviders;

  ActivityThreadAppBindDataContext activityThreadAppBindData =
      BRActivityThreadAppBindData.get(boundApplication);
  activityThreadAppBindData._set_instrumentationName(
      new ComponentName(bindData.appInfo.packageName,
Instrumentation.class.getName()));
  activityThreadAppBindData._set_appInfo(bindData.appInfo);
  activityThreadAppBindData._set_info(bindData.info);
  activityThreadAppBindData._set_processName(bindData.processName);
  activityThreadAppBindData._set_providers(bindData.providers);

  mBoundApplication = bindData;
```

```
    // ssl适配
    if (BRNetworkSecurityConfigProvider.getRealClass() != null) {
      Security.removeProvider("AndroidNSSP");
      BRNetworkSecurityConfigProvider.get().install(packageContext);
    }
    Application application;
    try {
      onBeforeCreateApplication(packageName, processName, packageContext);
      if (BuildCompat.isT()){
        BEnvironment.getAllDex(packageName).forEach(new Consumer<String>() {
          @Override
          public void accept(String s) {
            new File(s).setReadOnly();
          }
        });
      }
      application = BRLoadedApk.get(loadedApk).makeApplication(false, null);
      mInitialApplication = application;

  BRActivityThread.get(SandBoxCore.mainThread())._set_mInitialApplication(mIniti
  alApplication);
      ContextCompat.fix(
          (Context)
  BRActivityThread.get(SandBoxCore.mainThread()).getSystemContext());
      ContextCompat.fix(mInitialApplication);
```

函数一样很长，总结一下内容：

1. 获取 APK 信息 `packageInfo`
2. 修改 `LoadedApk` 中的 `mSecurityViolation` 和 `mApplicationInfo` 为目标应用
3. 设置进程名和命令行中的参数名为目标函数 `VirtualRuntime.setupRuntime`
4. 设置 `TargetSdkVersion`
5. 初始化 Blackbox 自己的 sdk 动态库 `NativeCore.init`
6. 路径重定向 `IOCore.get().enableRedirect`
7. 调用 `makeApplication` 以构建子程序包的 `Application` 对象，并且替换原来通过 Host Stub 生成的 `mInitialApplication` 。注意，这个时候新生成的 `LoadedApk` 代表了目标应用，其中的很多资源路径全都被替换为目标应用的路径了，加载资源时将会从被替换后的路径去查找。
8. 注册 Providers
9. 通过 `callApplicationOnCreate` 调用 `Application` 下的 `OnCreate` ，这会创建或初始化对应的上下文、 `Instrumentation` 、 `Application` ，目标应用生命周期开始
10. 初始化 seccomp，这是 Blackbox 后续提供的新功能，Virtualbox 是没有这个的 `NativeCore.init_seccomp`

在 `handleBindApplication` 完成后我们回到 `handleLaunchActivity` 继续往下：

```
int taskId =
    BRIActivityManager.get(BRActivityManagerNative.get().getDefault())
        .getTaskForActivity(token, false);
SandBoxCore.getBActivityManager()
    .onActivityCreated(taskId, token, stubRecord.mActivityRecord);
```

这里有一个 `onActivityCreated` ：

```
public void onActivityCreated(
    ProcessRecord processRecord, int taskId, IBinder token, ActivityRecord
record) {
  synchronized (mLaunchingActivities) {
    mLaunchingActivities.remove(record);
    mHandler.removeMessages(LAUNCH_TIME_OUT, record);
  }
  synchronized (mTasks) {
    synchronizeTasks();
    TaskRecord taskRecord = mTasks.get(taskId);
    if (taskRecord == null) {
      taskRecord =
          new TaskRecord(taskId, record.userId,
ComponentUtils.getTaskAffinity(record.info));
      taskRecord.rootIntent = record.intent;
      mTasks.put(taskId, taskRecord);
    }
    record.token = token;
    record.processRecord = processRecord;
    record.task = taskRecord;
    taskRecord.addTopActivity(record);
    Log.d(TAG, "onActivityCreated : " + record.component.toString());
  }
}
```

将 Activity 指定。

```
LaunchActivityItemContext launchActivityItemContext =
BRLaunchActivityItem.get(r);
launchActivityItemContext._set_mIntent(stubRecord.mTarget);
launchActivityItemContext._set_mInfo(activityInfo);
```

最后将 `mIntent` 和 `mInfo` 替换成目标应用。

这个函数从这一步结束后会返回一个 false，之前一直没注意到，但实际上当其返回 false 的时候，会回到原函数：

```java
@Override
public boolean handleMessage(@NonNull Message msg) {
  if (!mBeing.getAndSet(true)) {
    try {
      if (BuildCompat.isPie()) {
        if (msg.what == BRActivityThreadH.get().EXECUTE_TRANSACTION()) {
          final Boolean a = handleLaunchActivity(msg);
          if (a != null && a) {
            getH().sendMessageAtFrontOfQueue(Message.obtain(msg));
            return true;
          }
        }
      } else {
        if (msg.what == BRActivityThreadH.get().LAUNCH_ACTIVITY()) {
          final Boolean a = handleLaunchActivity(msg);
          if (a != null && a) {
            getH().sendMessageAtFrontOfQueue(Message.obtain(msg));
            return true;
          }
        }
      }
      if (msg.what == BRActivityThreadH.get().CREATE_SERVICE()) {
        return handleCreateService(msg.obj);
      }
      if (mOtherCallback != null) {
        return mOtherCallback.handleMessage(msg);
      }
      return false;
    } finally {
      mBeing.set(false);
    }
  }
  return false;
}
```

当 `handleLaunchActivity` 返回 false 后，程序继续往下执行 `mOtherCallback.handleMessage` ，这个 `mOtherCallback` 就是原本的那个处理对象，通过它来调用原本的那个 `handleLaunchActivity` 。

在原先的那个处理函数中：

```
public Activity handleLaunchActivity(ActivityClientRecord r,
        PendingTransactionActions pendingActions, Intent customIntent) {
    // 在创建Activity之前初始化
    if (ThreadedRenderer.sRendererEnabled
            && (r.activityInfo.flags & ActivityInfo.FLAG_HARDWARE_ACCELERATED)
!= 0) {
        HardwareRenderer.preload();
    }
    // 获取WMS服务，初始化WindowManager
    WindowManagerGlobal.initialize();
    // GraphicsEnvironment提示一个activity正在进程上启动
    GraphicsEnvironment.hintActivityLaunch();
    // 启动Activity，调用ActivityThread#performLaunchActivity()
    final Activity a = performLaunchActivity(r, customIntent);
    return a;
}
```

注意这里的 `ActivityClientRecord` 被传进了 `performLaunchActivity` ：

```
    private Activity performLaunchActivity(ActivityClientRecord r, Intent
customIntent) {
        ......
                Activity activity = null;
                try {
                    // 重点* 1. 通过Instrumentation 反射创建 Activity
                    java.lang.ClassLoader cl = appContext.getClassLoader();
                    activity = mInstrumentation.newActivity(
                            cl, component.getClassName(), r.intent);
                    ......
                }
                try {
                    ......
                    // 重点* 2. 执行 attach 流程
                    activity.attach(appContext, this, getInstrumentation(),
r.token,r.ident, app, r.intent, r.activityInfo, title, r.parent,r.embeddedID,
r.lastNonConfigurationInstances, config,r.referrer, r.voiceInteractor, window,
r.activityConfigCallback,r.assistToken, r.shareableActivityToken);
                    if (r.isPersistable()) {
                        mInstrumentation.callActivityOnCreate(activity,
r.state, r.persistentState);
                    } else {
                        重点* 3. OnCreate流程
                        mInstrumentation.callActivityOnCreate(activity,
r.state);
                    }
```

```
                        // 设置状态为 ON_CREATE（1）
                        r.setState(ON_CREATE);
                    } ......
            ......
        }
```

.

由于我们预先已经把相关的资源路径全部替换成目标应用了，这里会创建目标应用的内存实例对象，获取的 classloader 也都是指向目标应用的路径，使用它们创建 `Activity` 并最终调用 `callActivityOnCreate` 。以及目标的相关 dex 和动态库也都在这里被加载进内存。

```
public class Instrumentation {
    public Activity newActivity(ClassLoader cl, String className,
                                Intent intent)
            throws InstantiationException, IllegalAccessException,
            ClassNotFoundException {
        String pkg = intent != null && intent.getComponent() != null
                ? intent.getComponent().getPackageName() : null;
        return getFactory(pkg).instantiateActivity(cl, className, intent);
    }
}
```

```
public class AppComponentFactory extends android.app.AppComponentFactory {
    public @NonNull Activity instantiateActivityCompat(@NonNull ClassLoader
cl,
                                                        @NonNull String
className, @Nullable Intent intent)
            throws InstantiationException, IllegalAccessException,
ClassNotFoundException {
        try {
            // 通过mClassLoader 调用loadClass加载的。
            return (Activity)
cl.loadClass(className).getDeclaredConstructor().newInstance();
        } catch (InvocationTargetException | NoSuchMethodException e) {
            throw new RuntimeException("Couldn't call constructor", e);
        }
    }
}
```

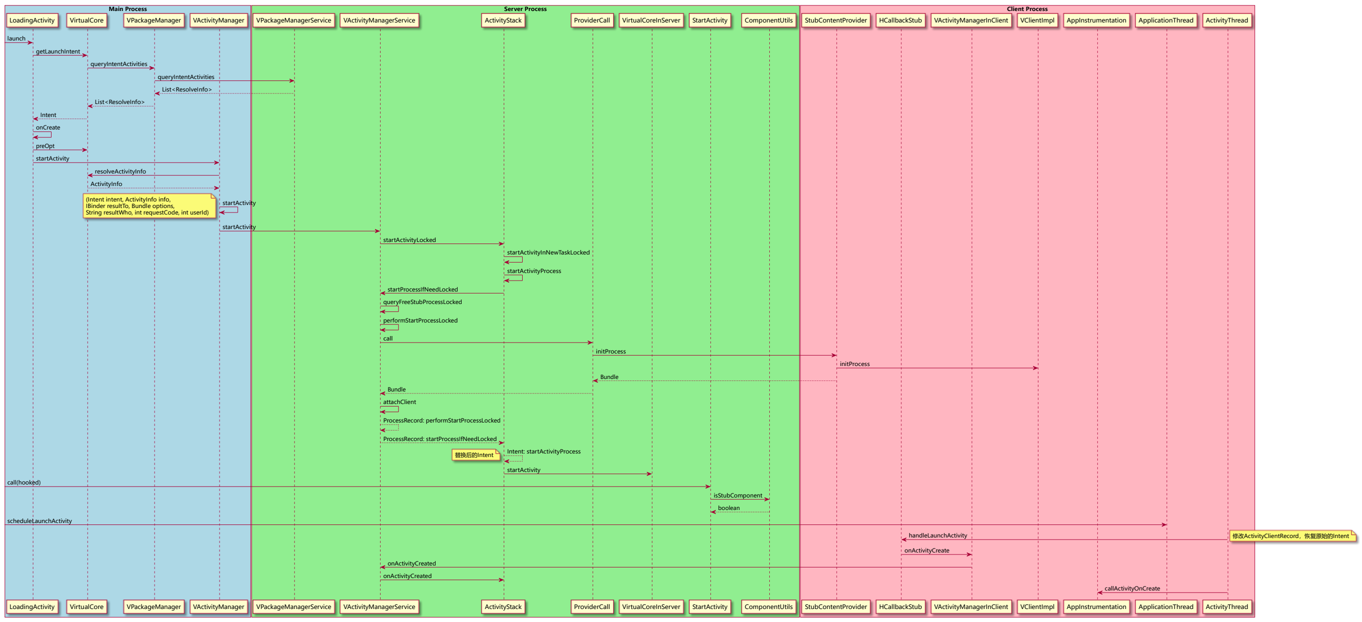
另外， `AppInstrumentation` 把这个函数做了个 Hook：

```
@Override
public void callActivityOnCreate(
        Activity activity, Bundle icicle, PersistableBundle persistentState) {
    mBaseInstrumentation.callActivityOnCreate(activity, icicle,
persistentState);
    for (AppLifecycleCallback appLifecycleCallback :
SandBoxCore.get().getAppLifecycleCallbacks()) {
        appLifecycleCallback.onActivityCreated(activity, icicle);
    }
}
```

`mBaseInstrumentation.callActivityOnCreate` 会调用原生的 `callActivityOnCreate` ，这个里面会去调用 `Activity` 的 `OnCreate` 。

流程图

最后贴一份流程图，来自于 alen17



参考文章

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