Android Services & Local IPC: Programming Bound Services with Messengers (Part 1)

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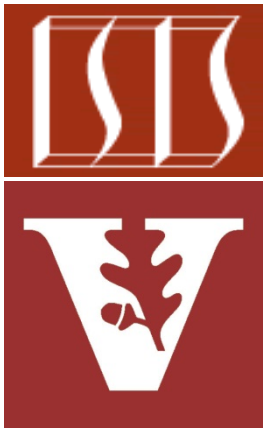

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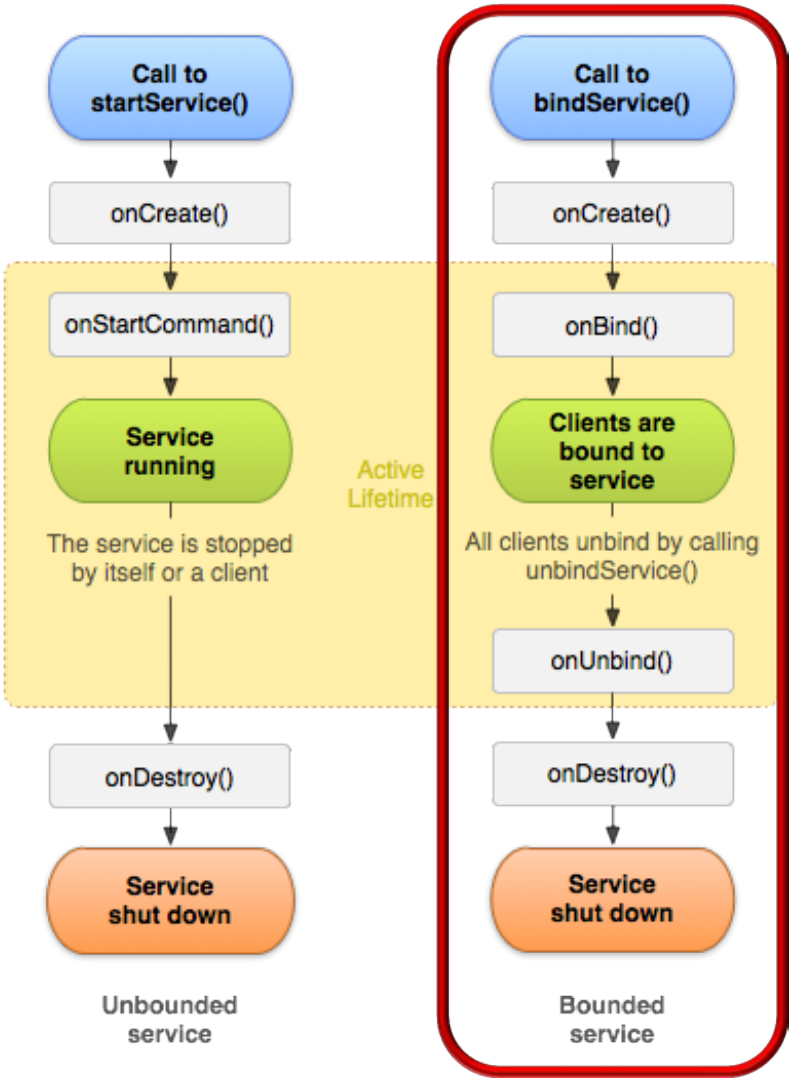
Learning Objectives in this Part of the Module

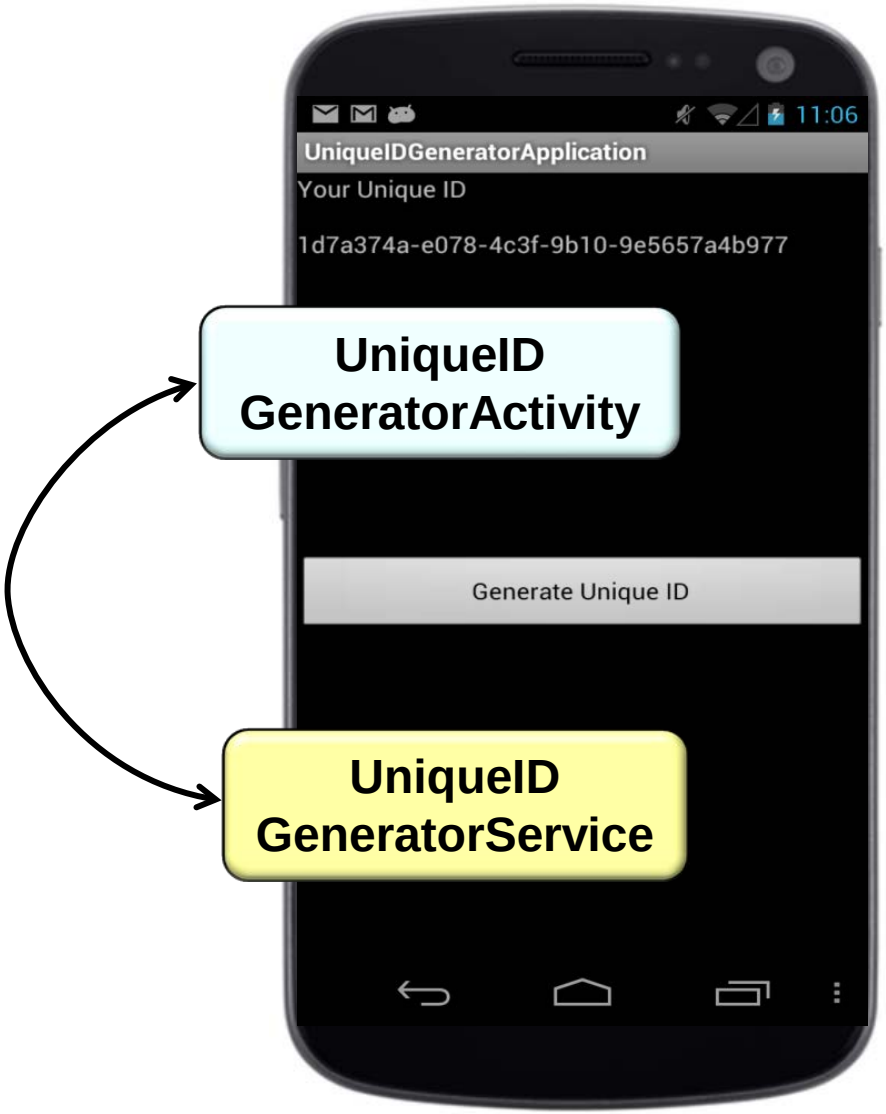
- Recognize how a Bound Service provides a Client-Server interface that allows two-way conversations between one or more Clients & the Service



See earlier part on “Overview of Android Services”

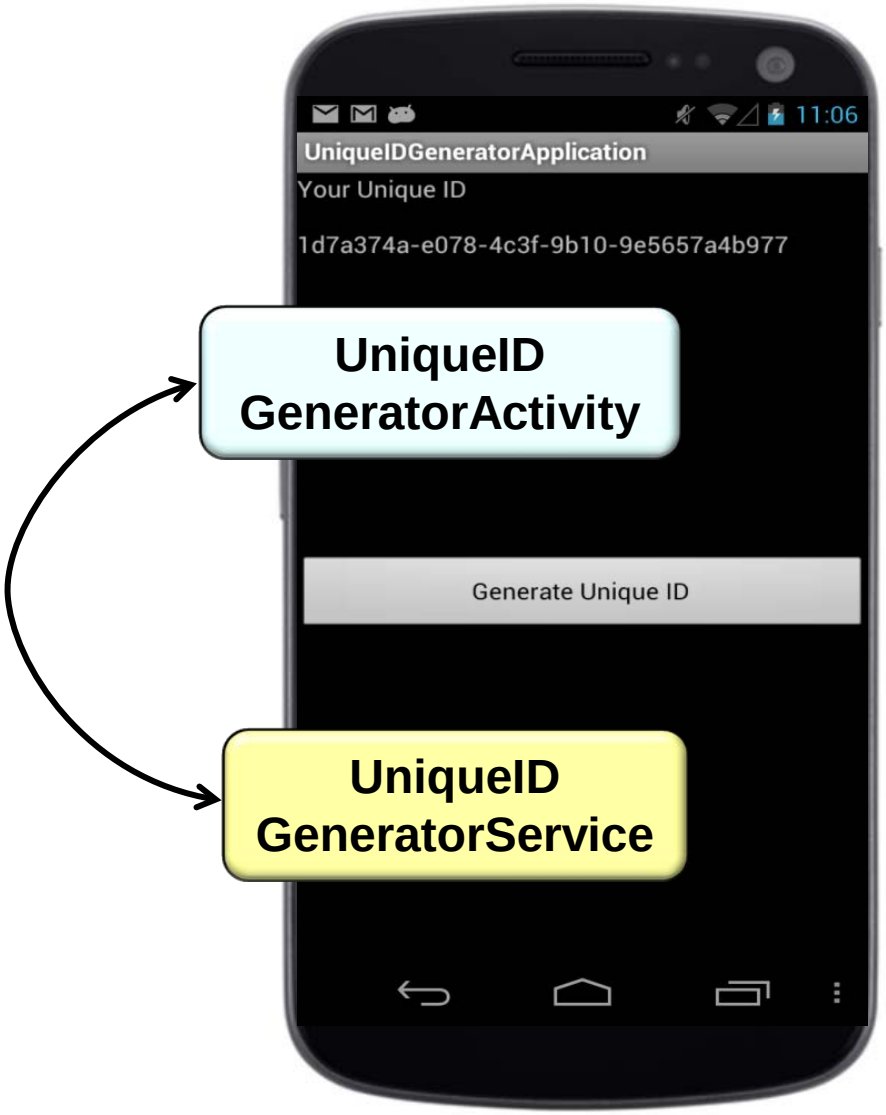
Learning Objectives in this Part of the Module

- Recognize how a Bound Service provides a Client-Server interface that allows two-way conversations between one or more Clients & the Service
- Understand how to develop a Bound Service with Messengers



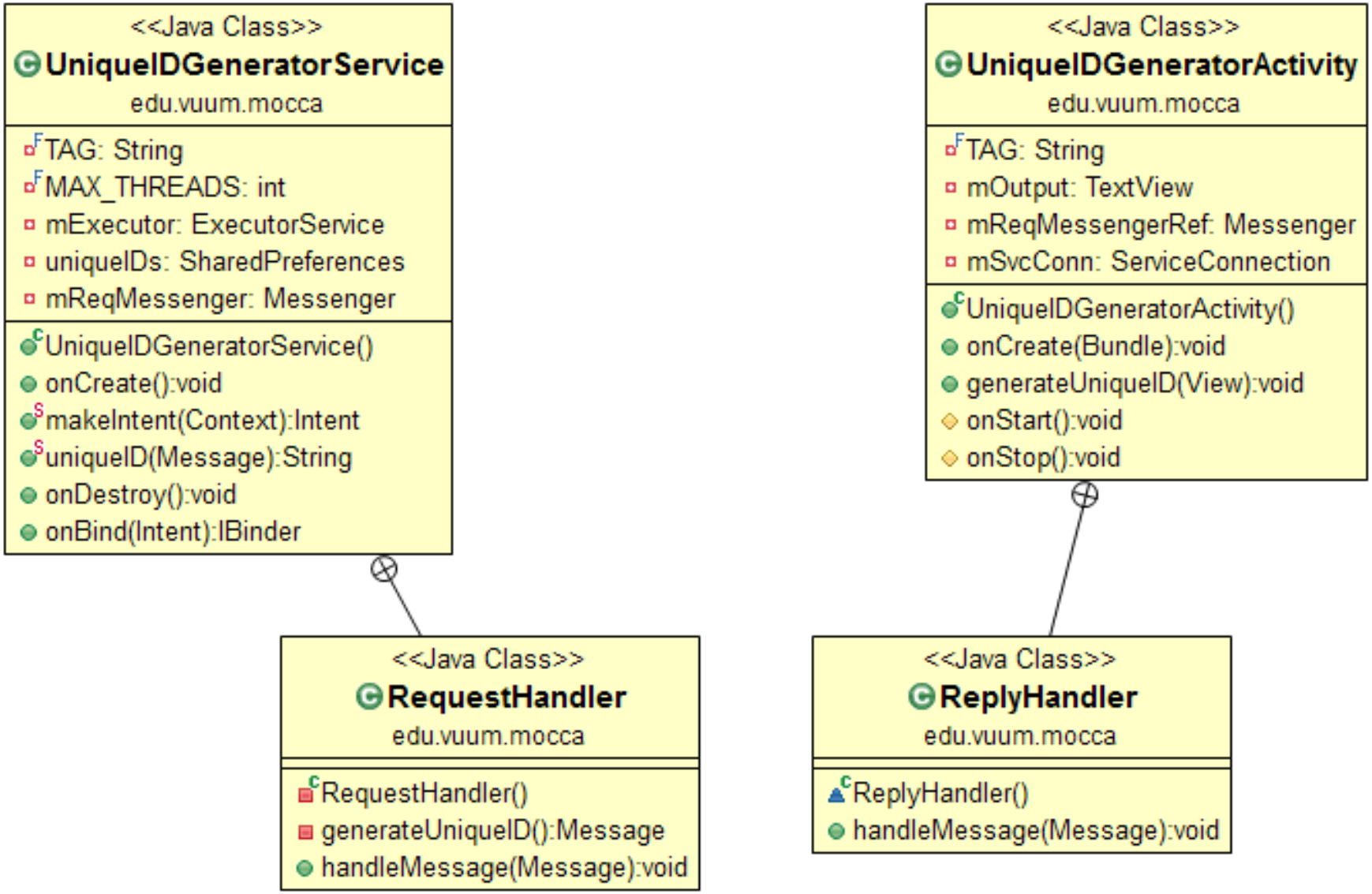
Learning Objectives in this Part of the Module

- Recognize how a Bound Service provides a Client-Server interface that allows two-way conversations between one or more Clients & the Service
- Understand how to develop a Bound Service with Messengers
  - e.g., a Unique ID generator application that uses a pair of Messengers to concurrently retrieve a system-wide persistent unique ID



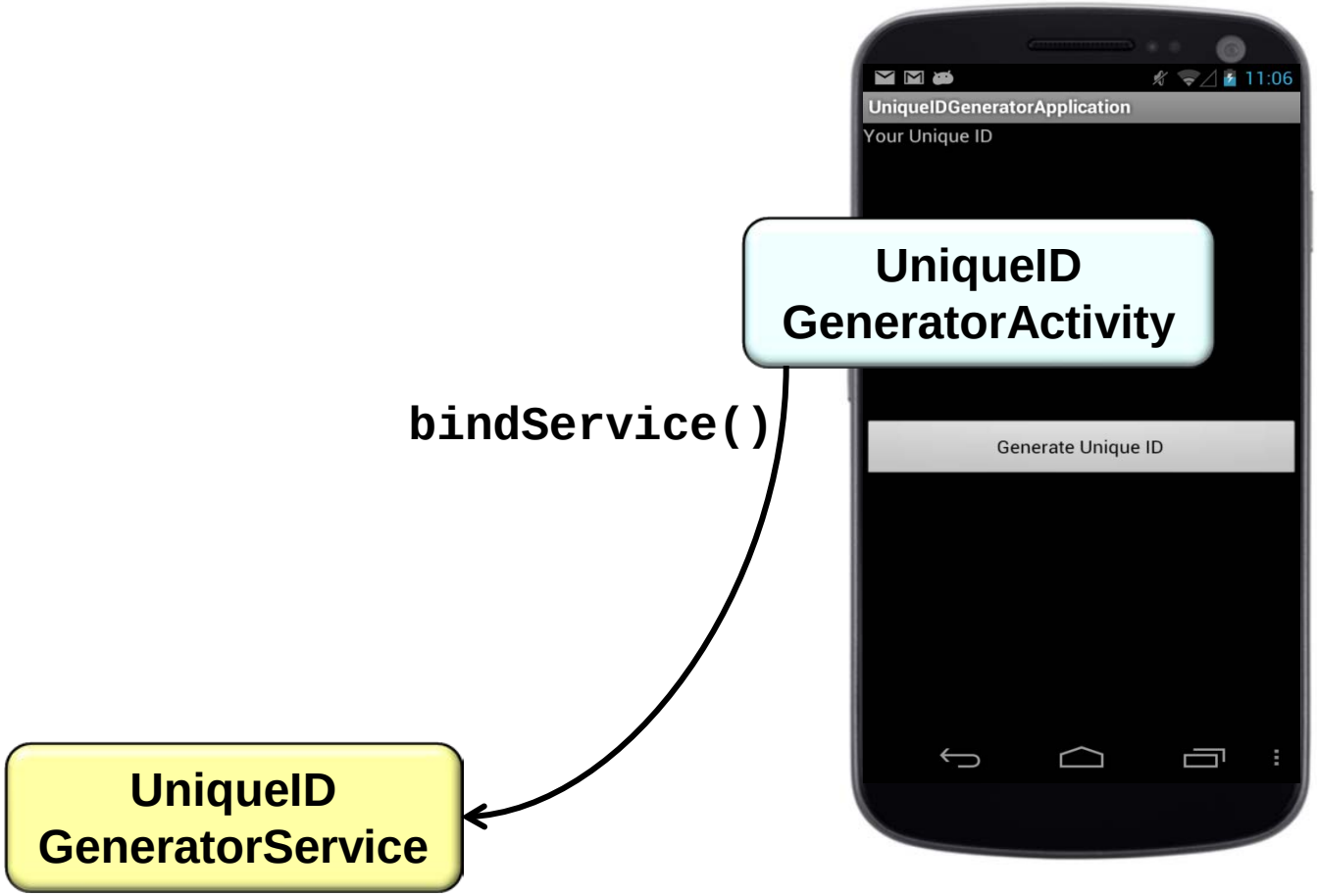
class.coursera.org/android-001/lecture/85
shows an AIDL-based version of this application

UniqueIDGeneratorApplication Overview



UniqueIDGeneratorApplication Overview

1. UniqueIDGeneratorActivity calls bindService() to launch the UniqueIDGeneratorService when its onStart() hook method is called



UniqueIDGeneratorApplication Overview

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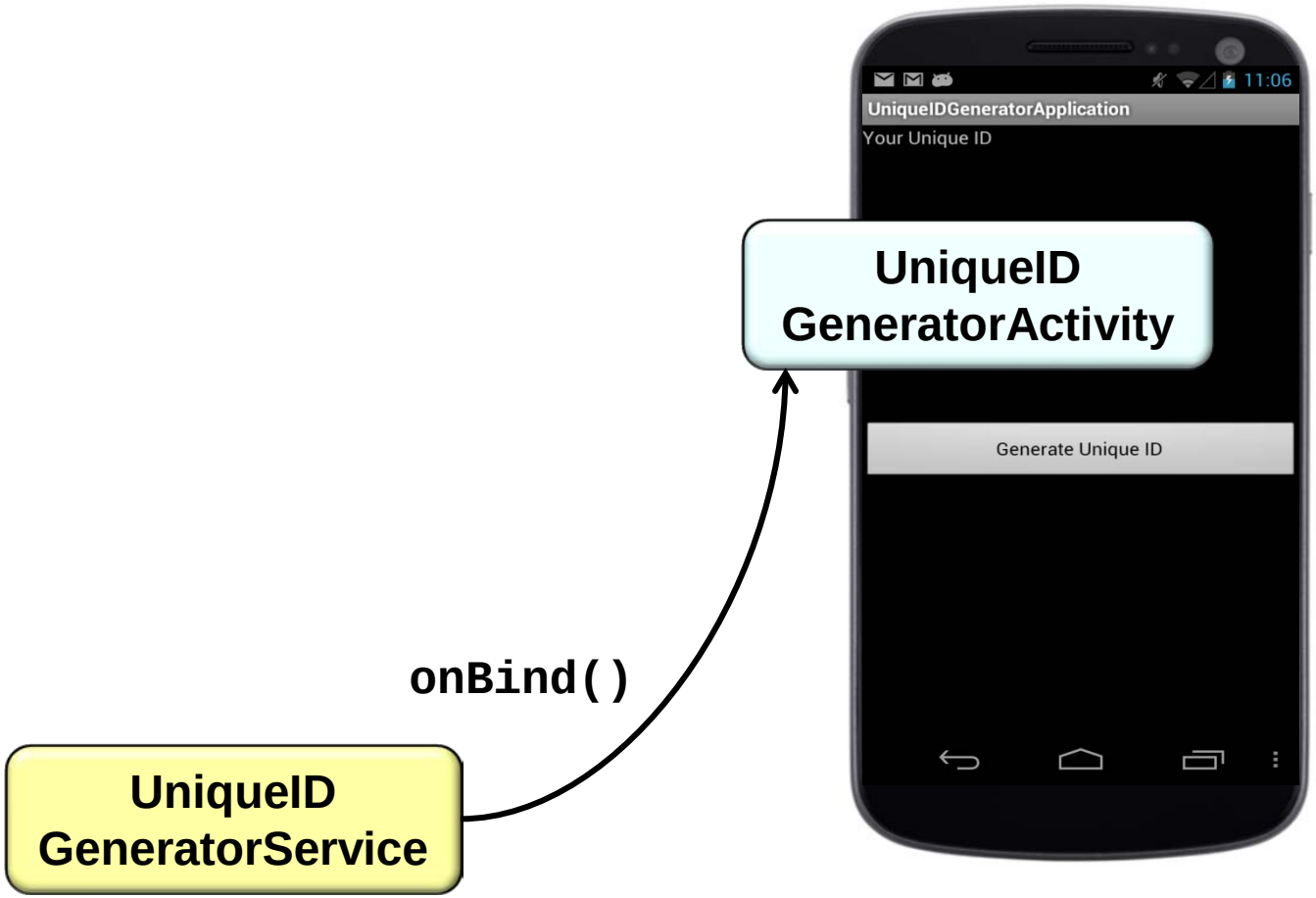
2. This Service returns a reference to a Messenger via the onBind() hook method



UniqueIDGeneratorApplication Overview

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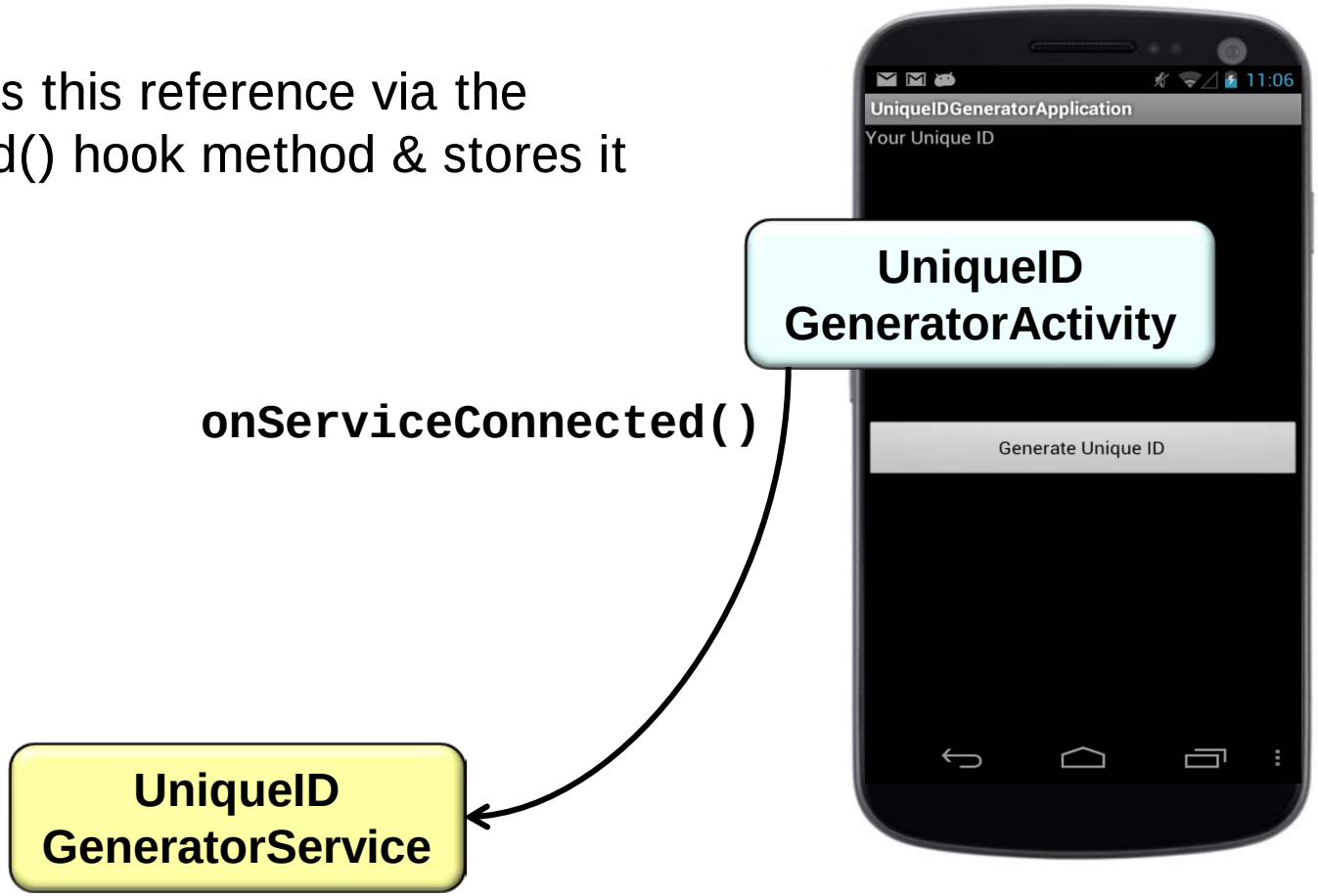
2. This Service returns a reference to a Messenger via the onBind() hook method
3. The Activity receives this reference via the onServiceConnected() hook method & stores it



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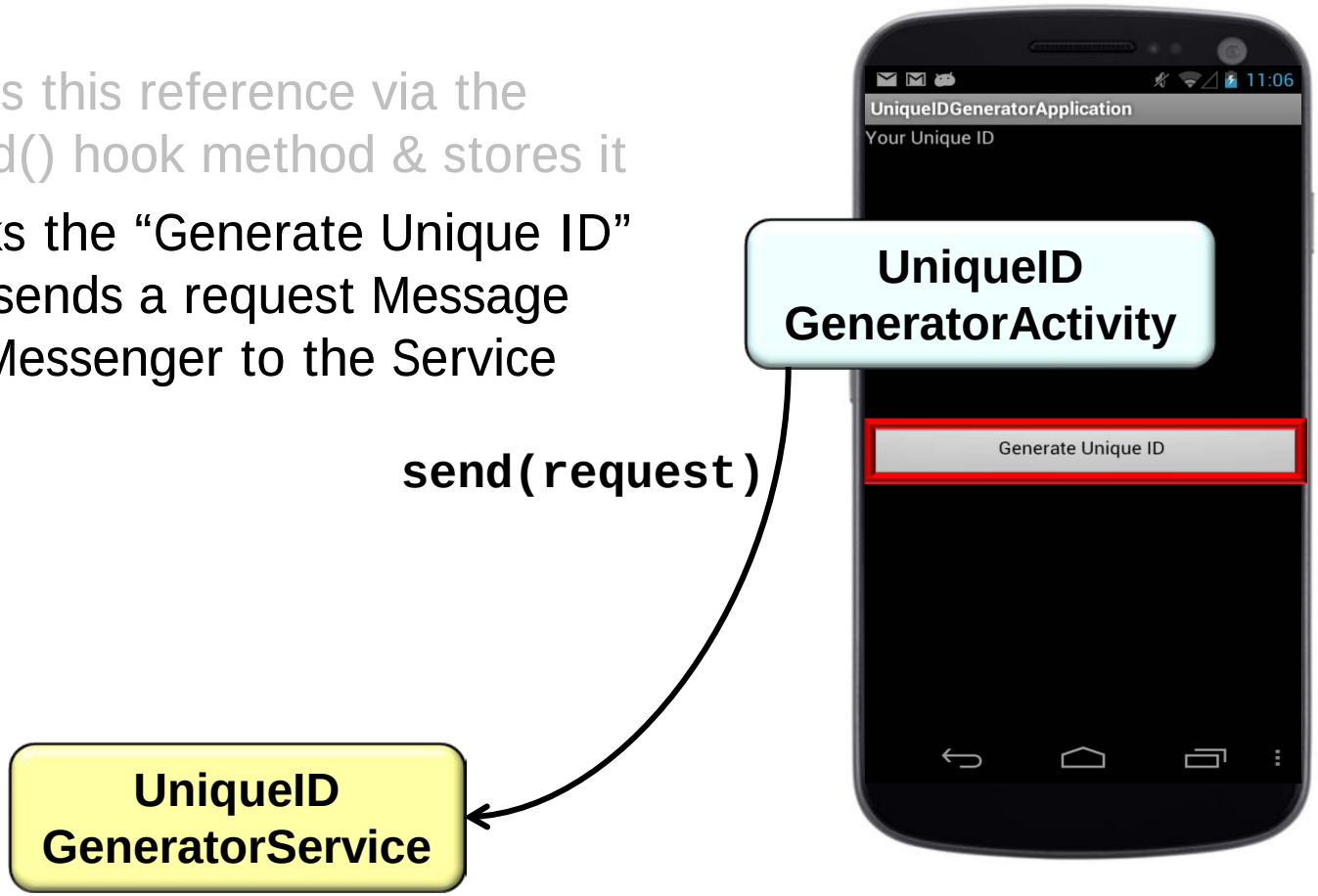
4. When the user clicks the “Generate Unique ID” button the Activity sends a request Message containing a reply Messenger to the Service



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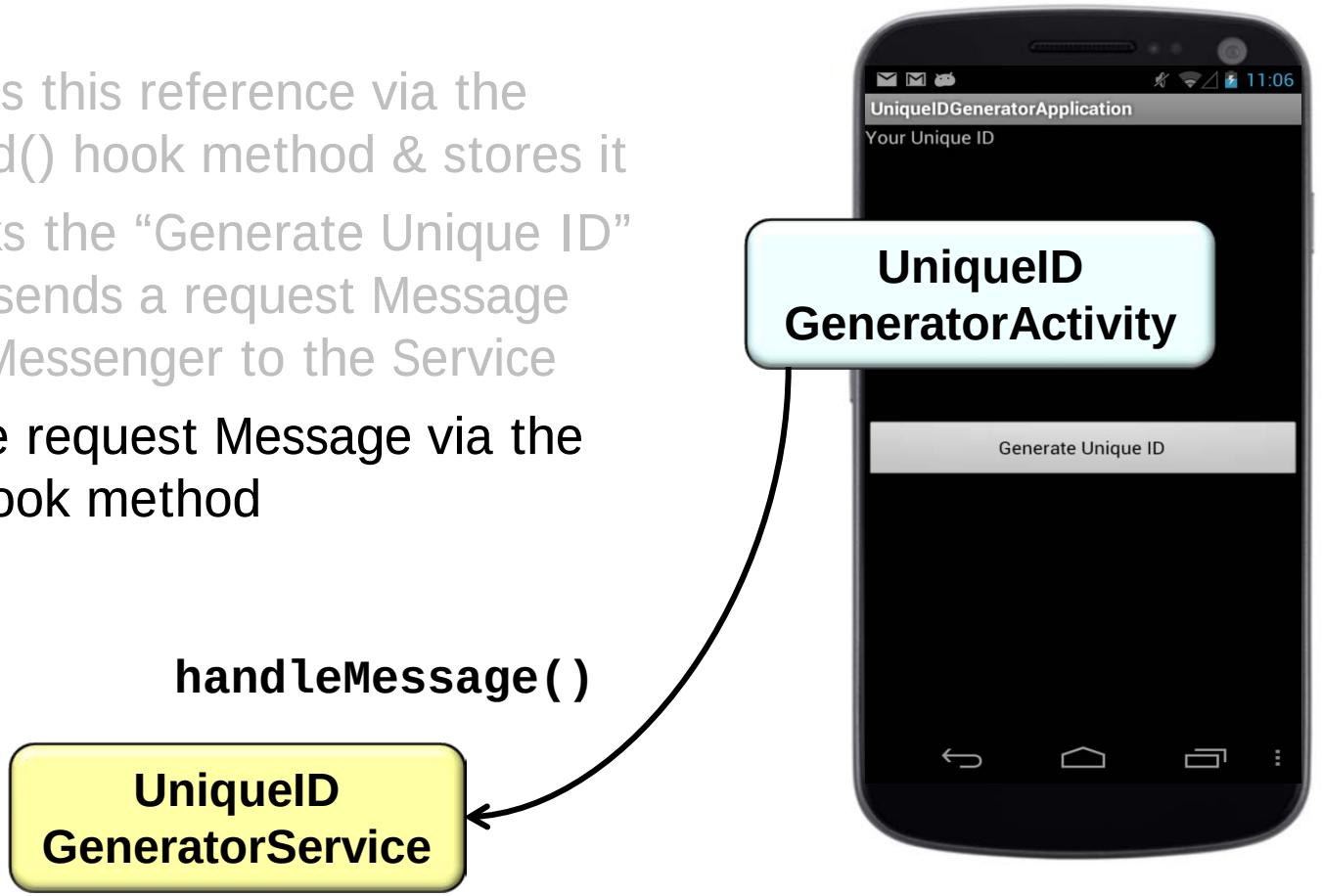
4. When the user clicks the “Generate Unique ID” button the Activity sends a request Message containing a reply Messenger to the Service
5. Service receives the request Message via the handleMessage() hook method



UniqueIDGeneratorApplication Overview

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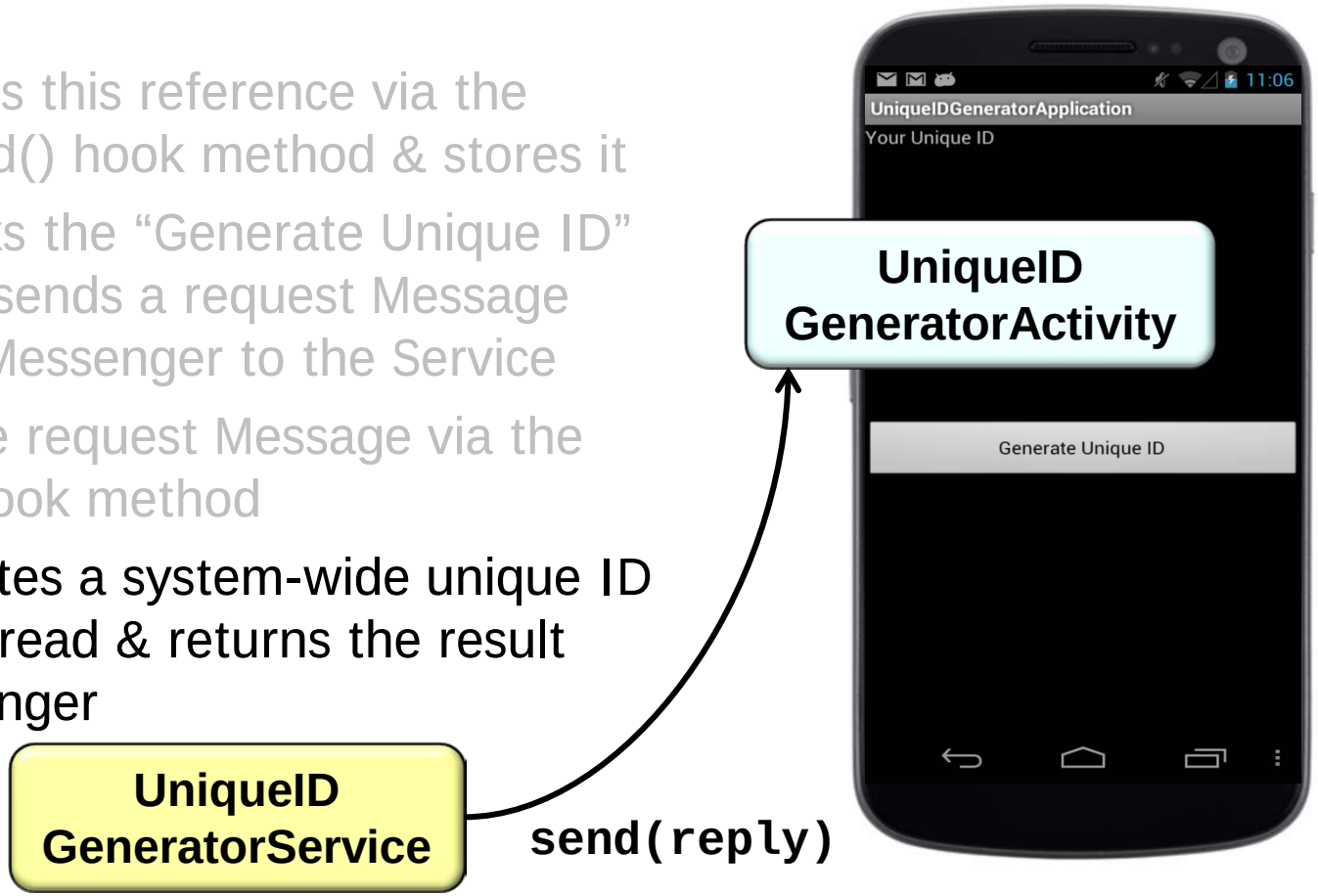
6. The Service generates a system-wide unique ID in a background Thread & returns the result via the reply Messenger



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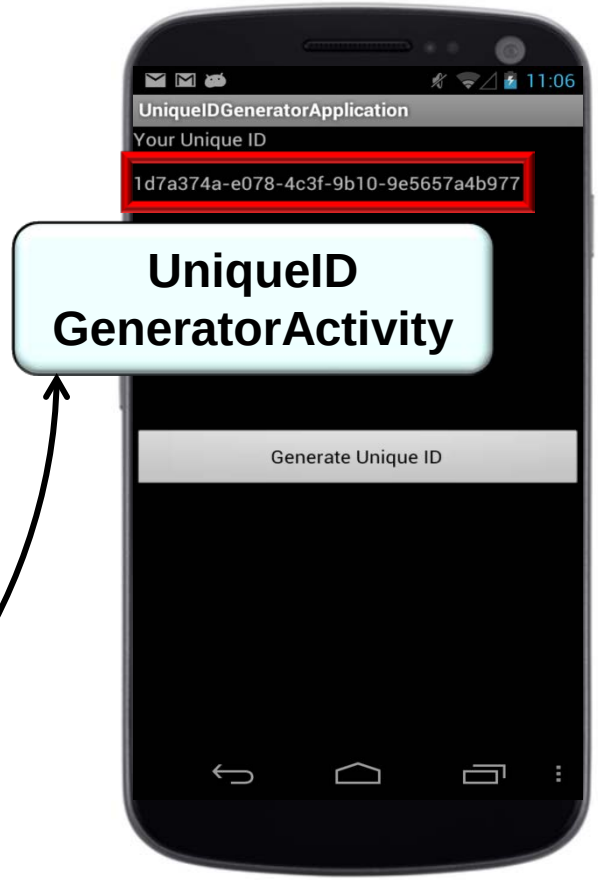
6. The Service generates a system-wide unique ID in a background Thread & returns the result via the reply Messenger
7. Activity displays the unique ID



UniqueID GeneratorActivity

UniqueID GeneratorService

Tips to Understand UniqueIDGenerator Application

- Run/read the code & watch the video carefully to understand how it works

github.com/douglascraigschmidt/POSA-14/tree/master/ex/UniqueIDGeneratorApplication

Tips to Understand UniqueIDGenerator Application

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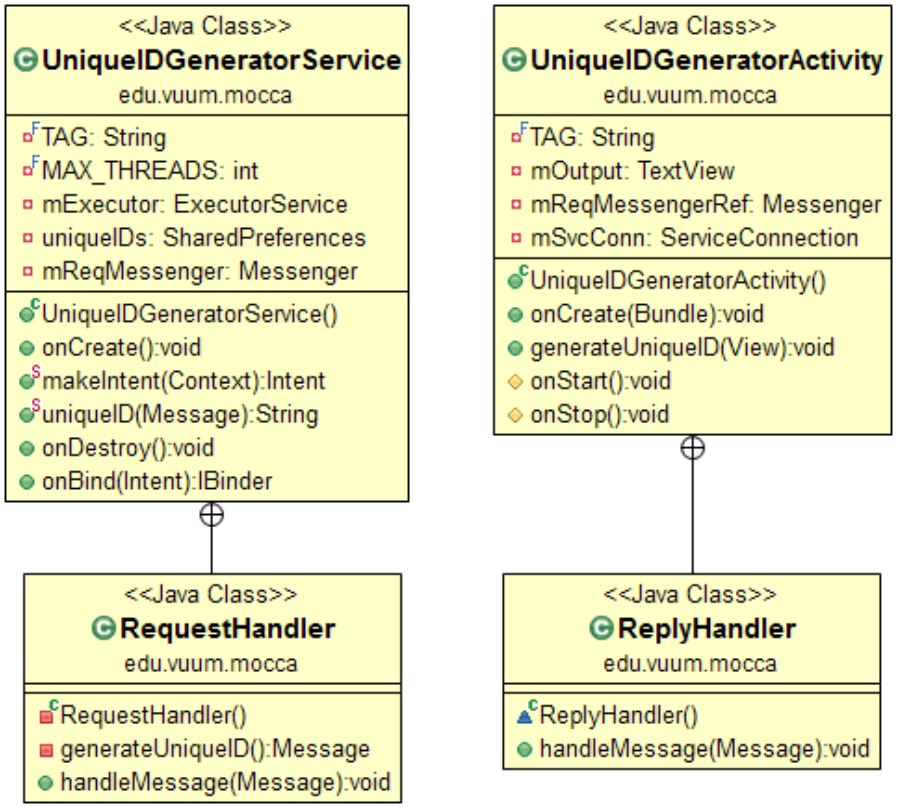
- This example is complex since many classes & Android mechanisms are used



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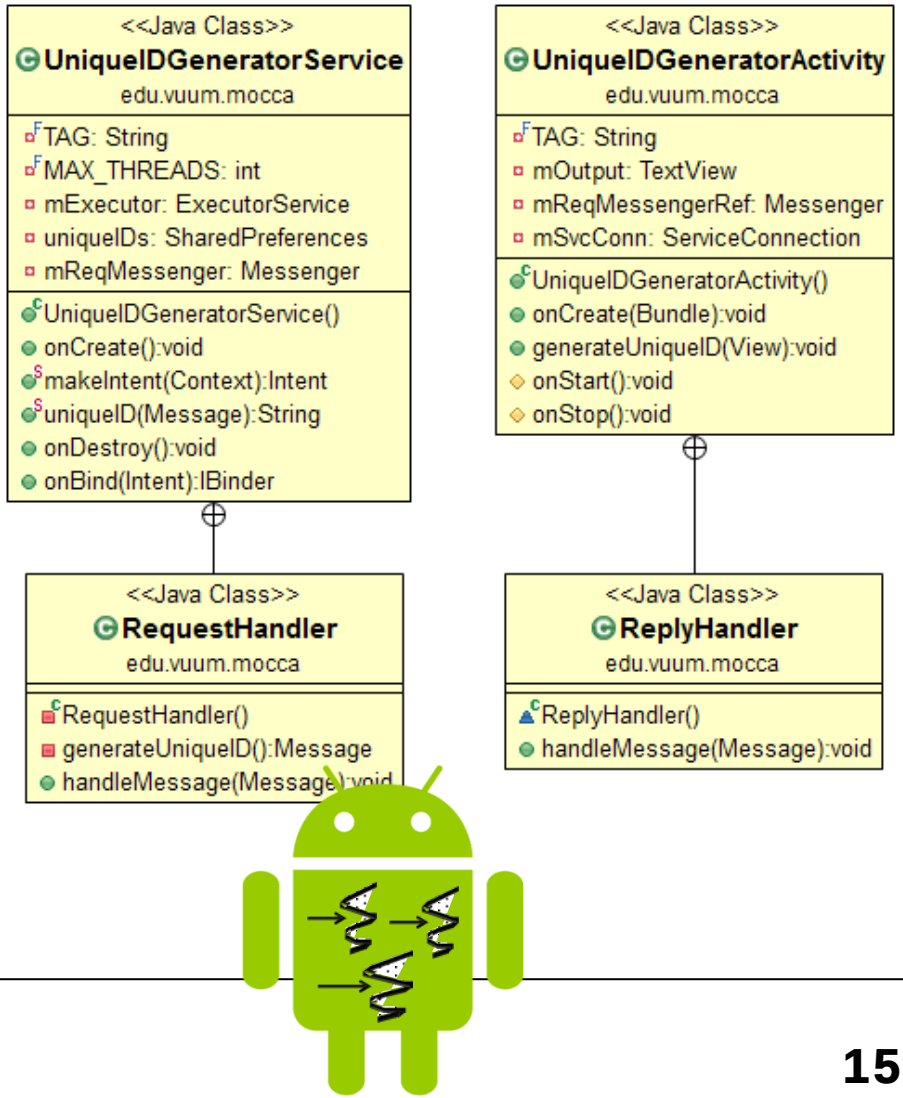
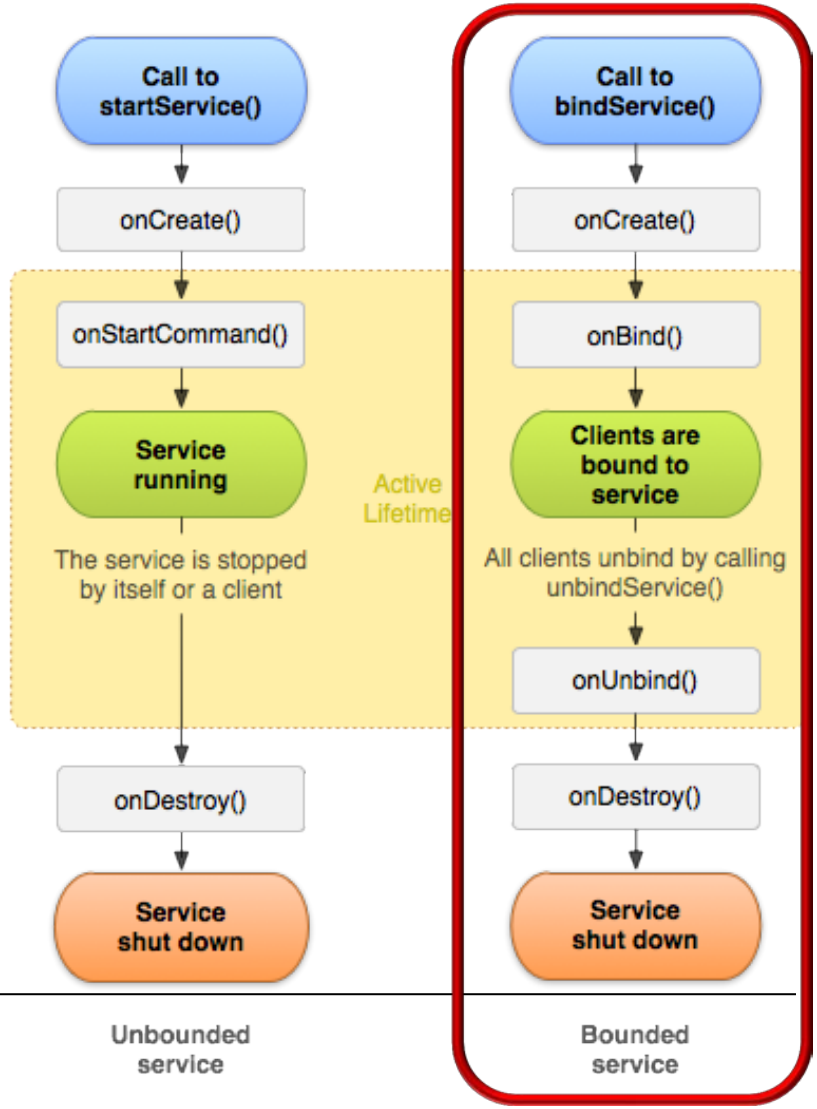


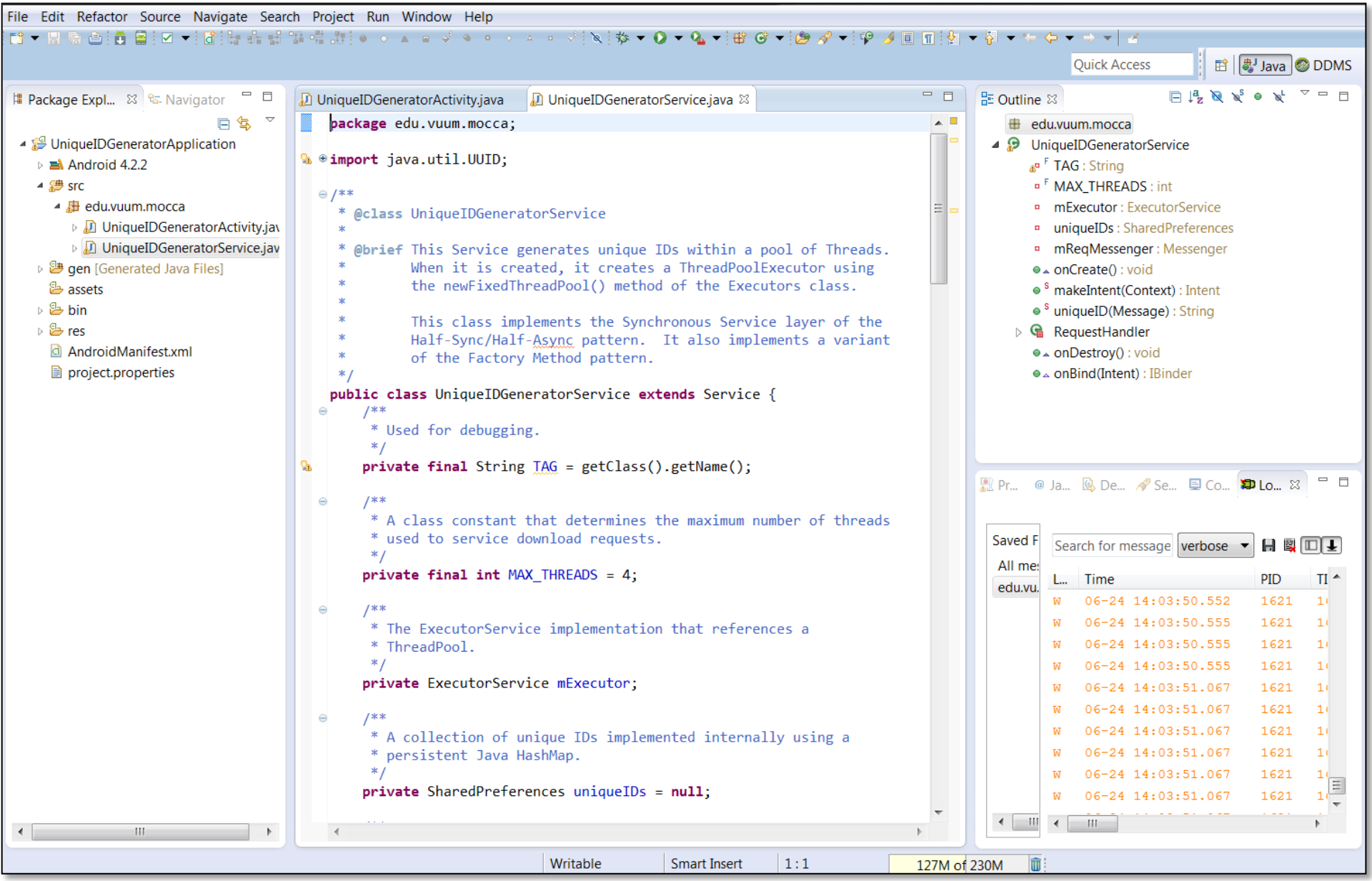


Tips to Understand UniqueIDGenerator Application

- Run/read the code & watch the video carefully to understand how it works
- This example is complex since many classes & Android mechanisms are used
  - We therefore analyze it from various perspectives

Launching & Initializing Bound Services

Programming the UniqueIDGenerator Application

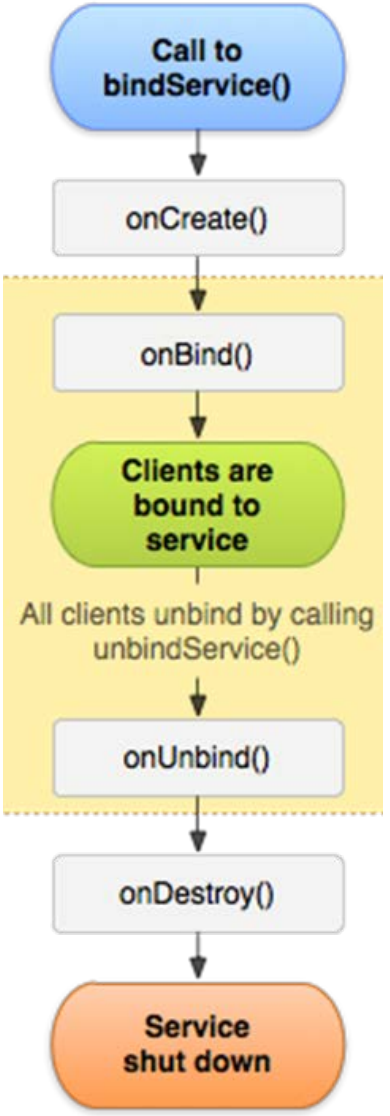


Launching a Bound Service

- A Bound Service allows components to bind to it by calling bindService() to create a “persistent” connection

```
Intent intent =
  UniqueIDGeneratorService.makeIntent(this);
bindService(intent, mSvcConn,
            Context.BIND_AUTO_CREATE);
```

UniqueID Generator Activity



developer.android.com/guide/components/services.html#CreatingBoundService

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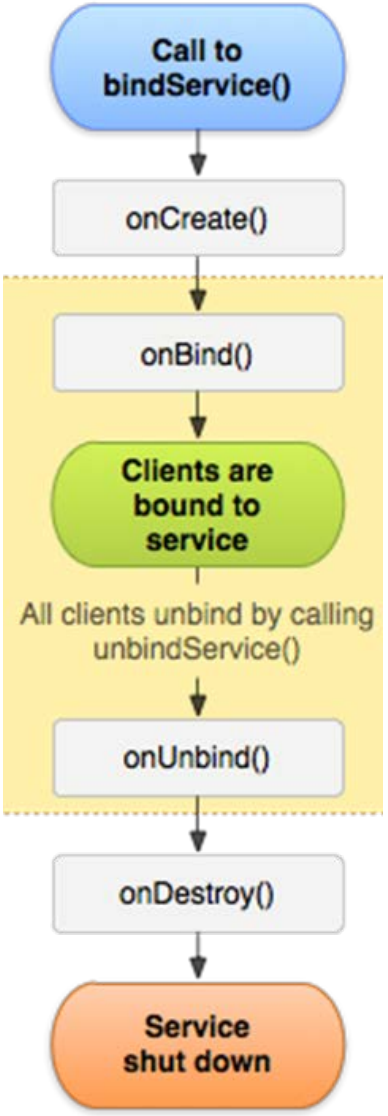
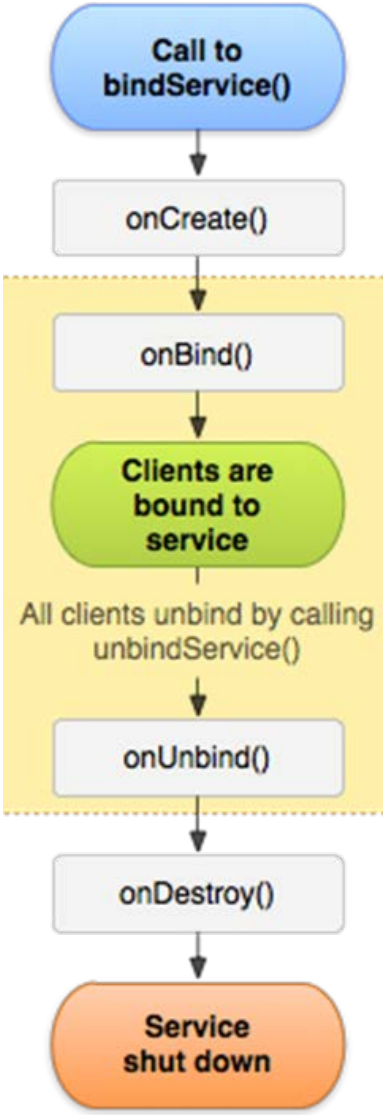
UniqueID Generator Activity



Launching a Bound Service

- A Bound Service allows components to bind to it by calling bindService() to create a “persistent” connection
  - The client must provide ServiceConnection object to monitor the connection with the Service

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UniqueID Generator Activity

developer.android.com/reference/android/content/ServiceConnection.html

Launching a Bound Service

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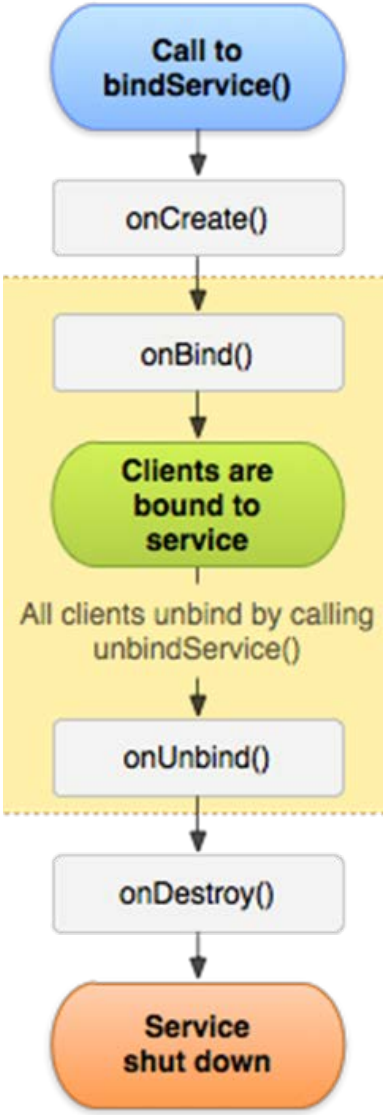
  - The client must provide ServiceConnection object to monitor the connection with the Service
  - If the Service isn't already running it will be activated

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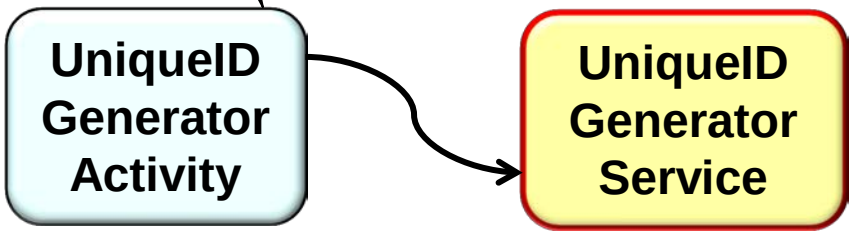

See www.dre.vanderbilt.edu/~schmidt/PDF/Activator.pdf for info on *Activator*

Launching a Bound Service

- A Bound Service allows components to bind to it by calling bindService() to create a “persistent” connection
  - The client must provide ServiceConnection object to monitor the connection with the Service
  - If the Service isn’t already running it will be activated
  - bindService() is not a blocking call

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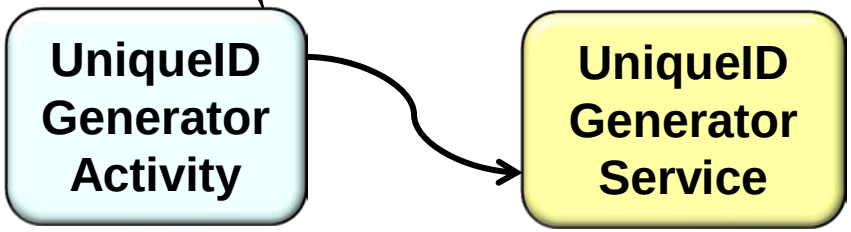
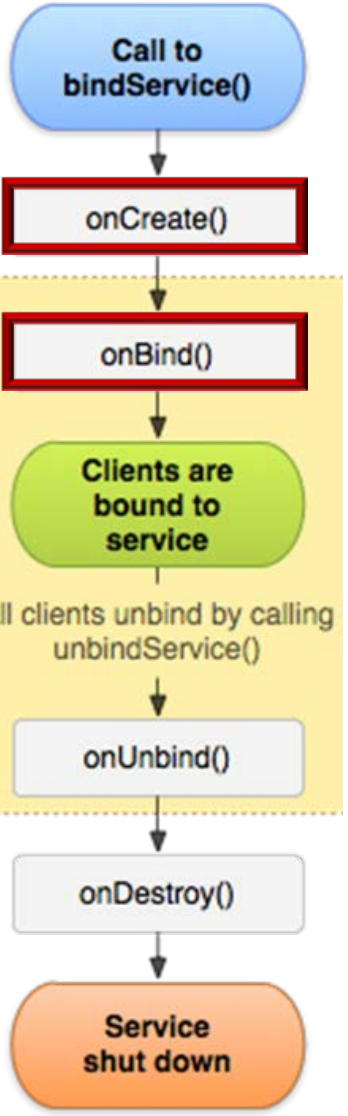


Initializing a Bound Service

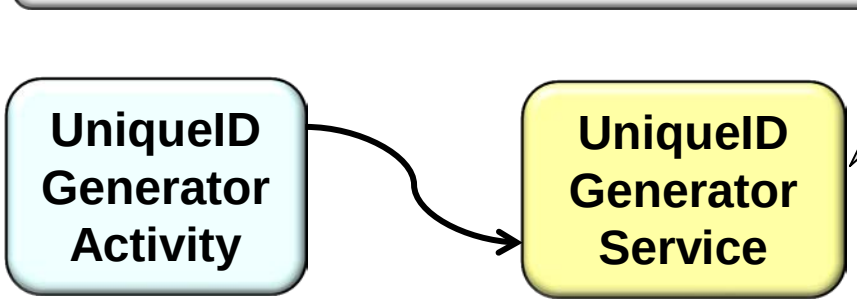
- After Service is running Android invokes its onCreate() & onBind() hook methods




```
public class UniqueIDGeneratorService
       extends Service {
  ...
  public void onCreate() { ... }

  public Ibinder onBind(Intent intent){ ... }

  ...
```



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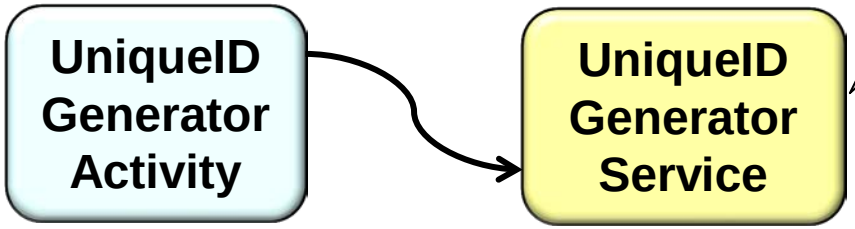

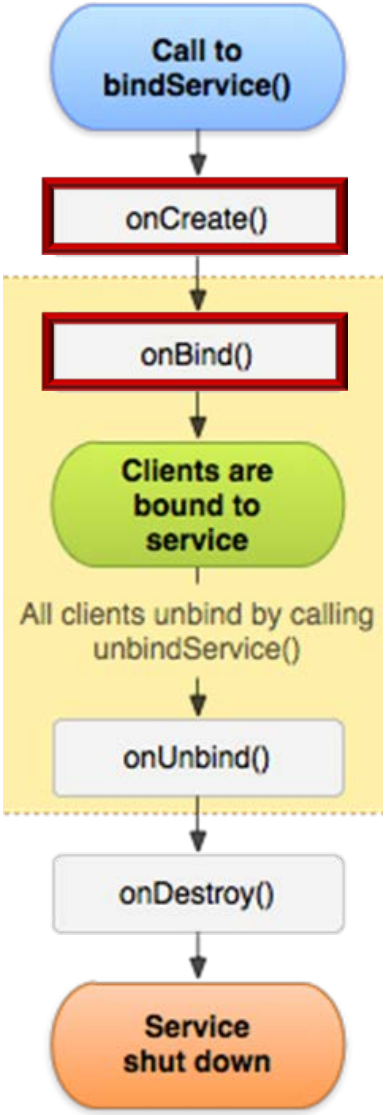

Initializing a Bound Service

- After Service is running Android invokes its onCreate() & onBind() hook methods
  - onCreate() initializes Service-level data members

```
public void onCreate() {
  mReqMessenger =
    new Messenger(new RequestHandler());

  uniqueIDs =
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  mExecutor =
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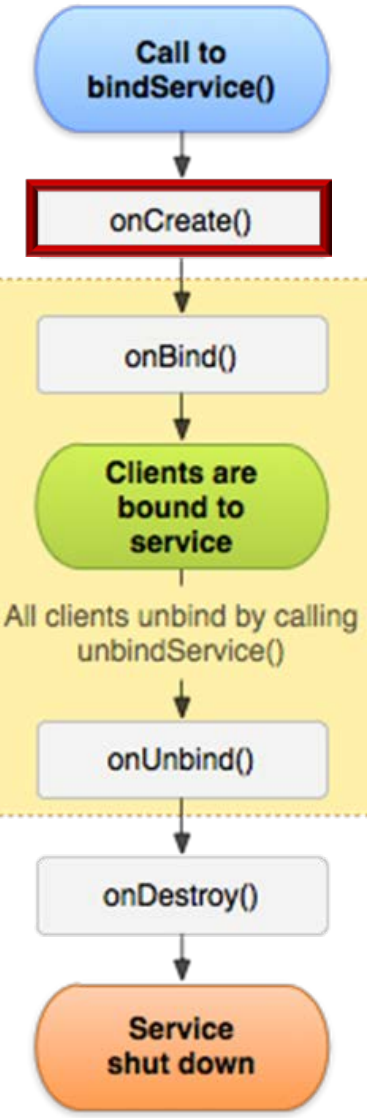

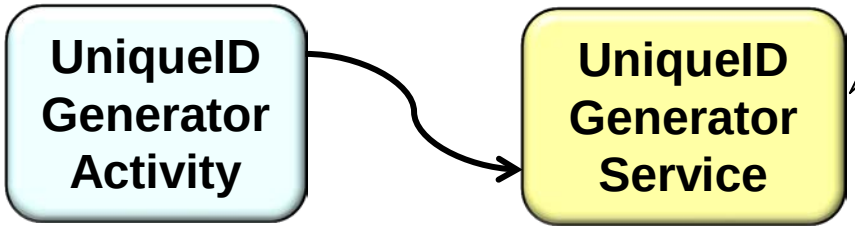

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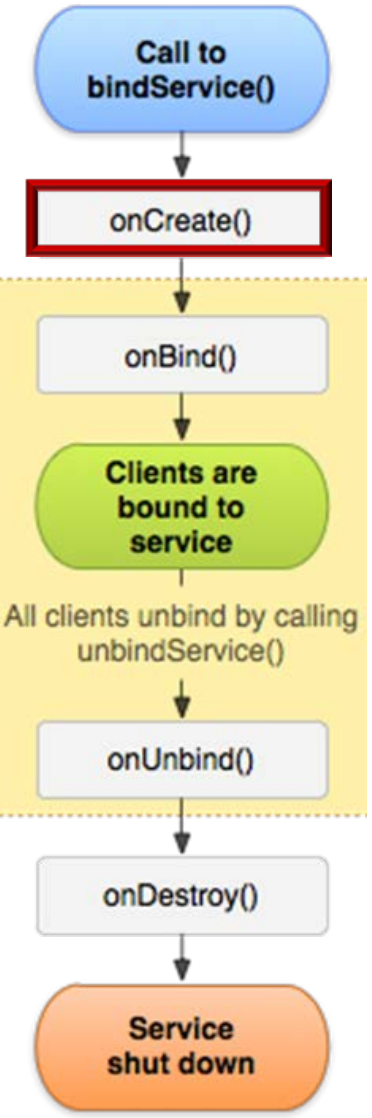

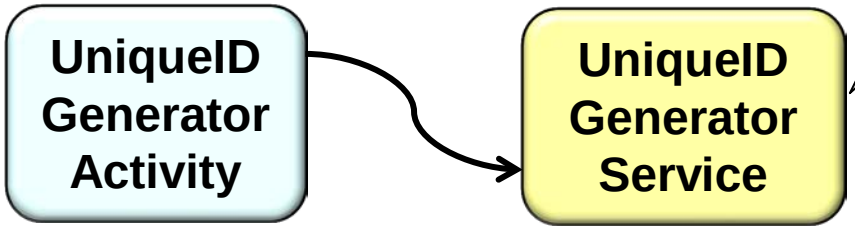

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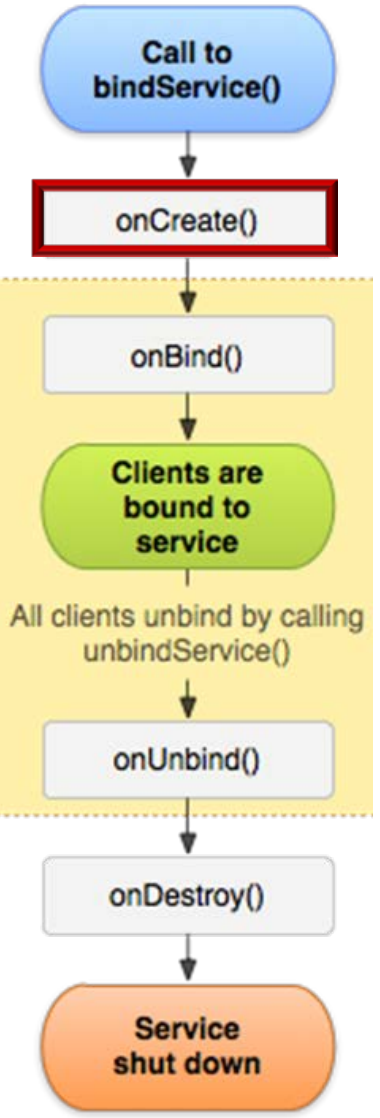

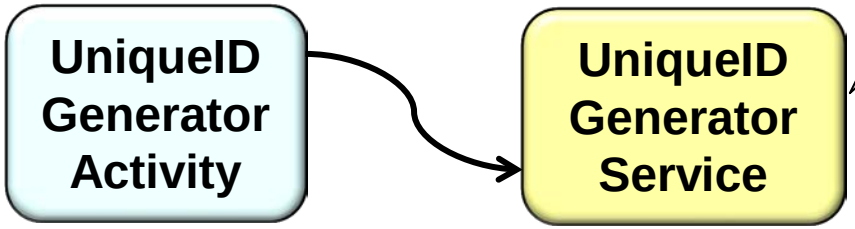

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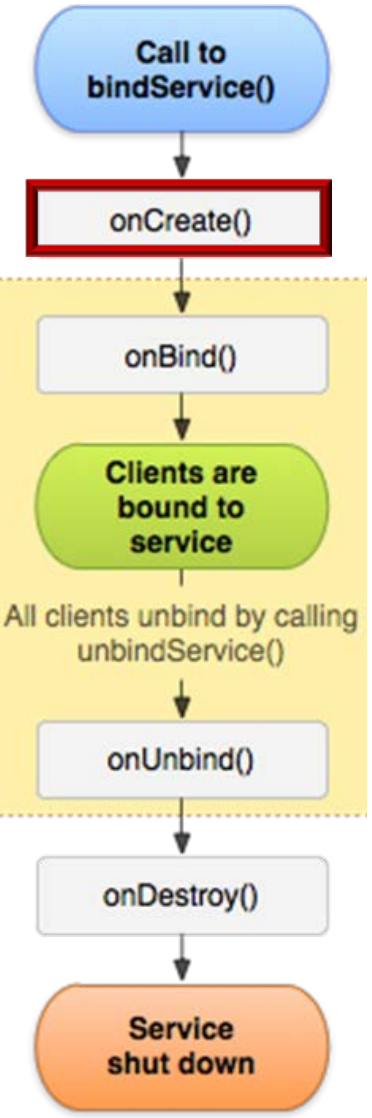
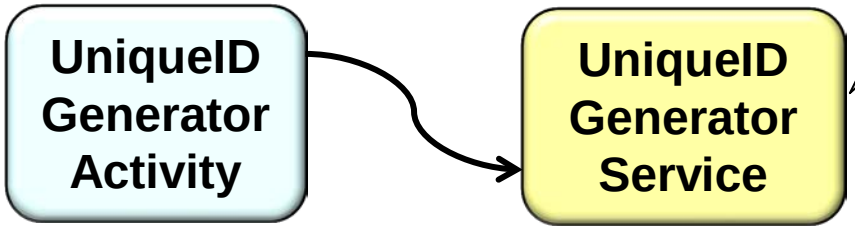
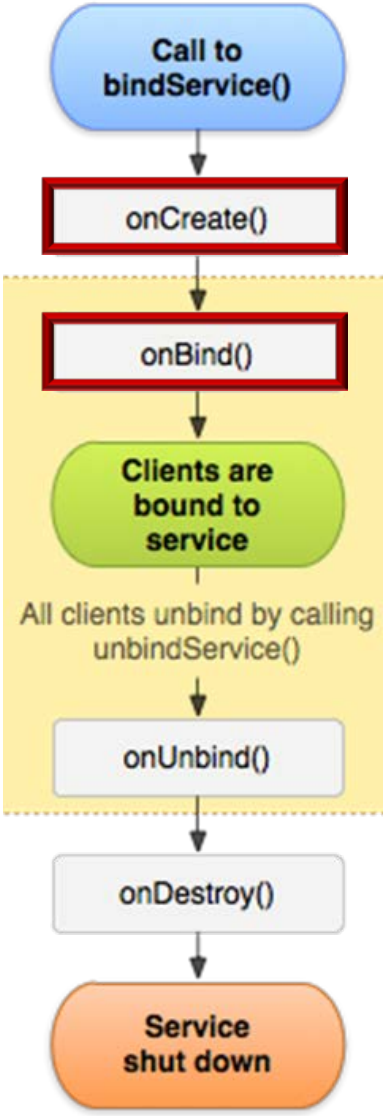


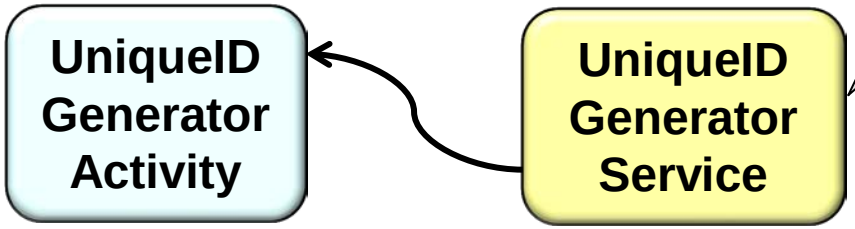


Initializing a Bound Service

- After Service is running Android invokes its onCreate() & onBind() hook methods
  - onCreate() initializes Service-level data members
  - onBind() returns an IBinder that enables the client to communication with the Bound Service




```
...
public IBinder onBind(Intent intent) {
  return mReqMessenger.getBinder();
}
...
```



Initializing a Bound Service

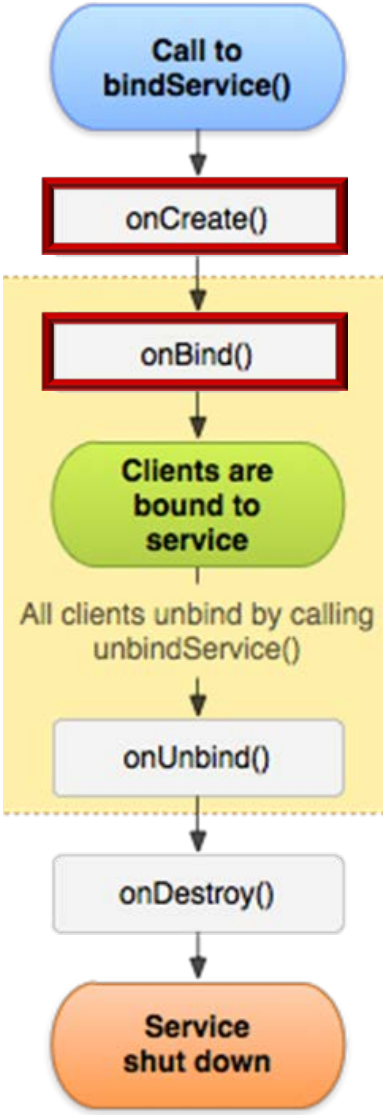
- After Service is running Android invokes its onCreate() & onBind() hook methods
  - onCreate() initializes Service-level data members
  - onBind() returns an IBinder that enables the client to communication with the Bound Service

The object returned from onBind() is typically initialized in onCreate() or as a data member

```
...
public IBinder onBind(Intent intent) {
  return mReqMessenger.getBinder();
}
...
```

UniqueID Generator Activity

UniqueID Generator Service



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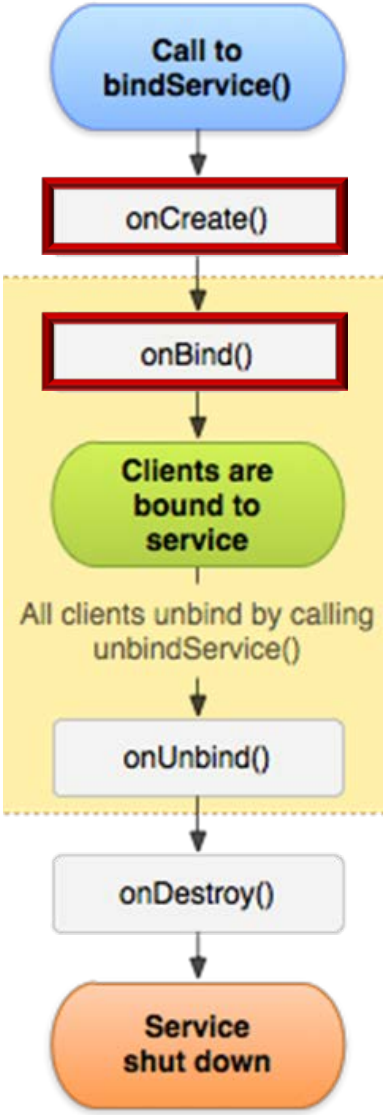


Returns Ibinder the Messenger uses to communicate with its associated request Handler

```
...
public IBinder onBind(Intent intent) {
  return mReqMessenger.getBinder();
}
...
```

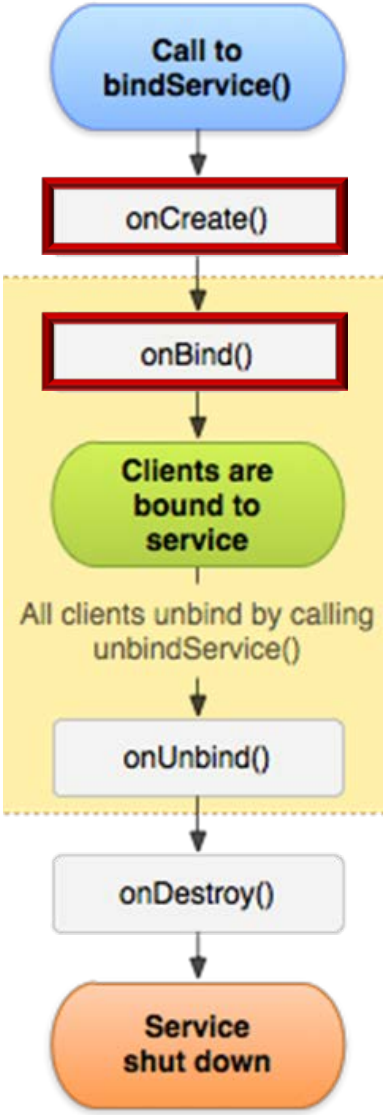
UniqueID Generator Activity

UniqueID Generator Service

developer.android.com/reference/android/os/Messenger.html#getBinder()

Initializing a Bound Service

- After Service is running Android invokes its onCreate() & onBind() hook methods
  - onCreate() initializes Service-level data members
  - onBind() returns an IBinder that enables the client to communication with the Bound Service
  - onBind() is only called to retrieve the Ibinder when the first client binds to the Service

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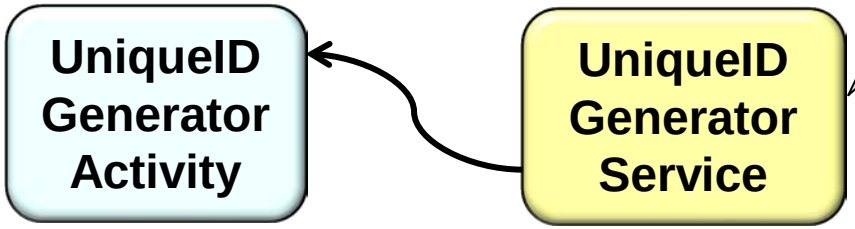

developer.android.com/guide/components/bound-services.html

Connecting & Interacting with Bound Services

Connecting to a Bound Service

- A callback-driven protocol is used to establish a connection

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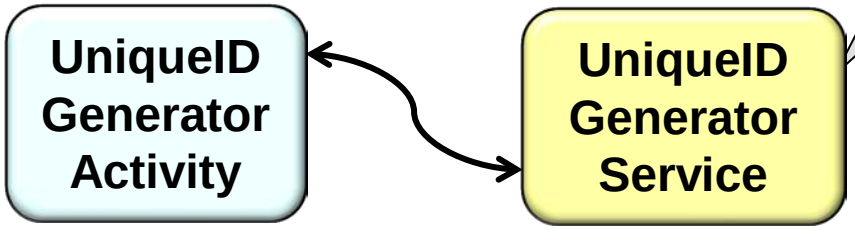

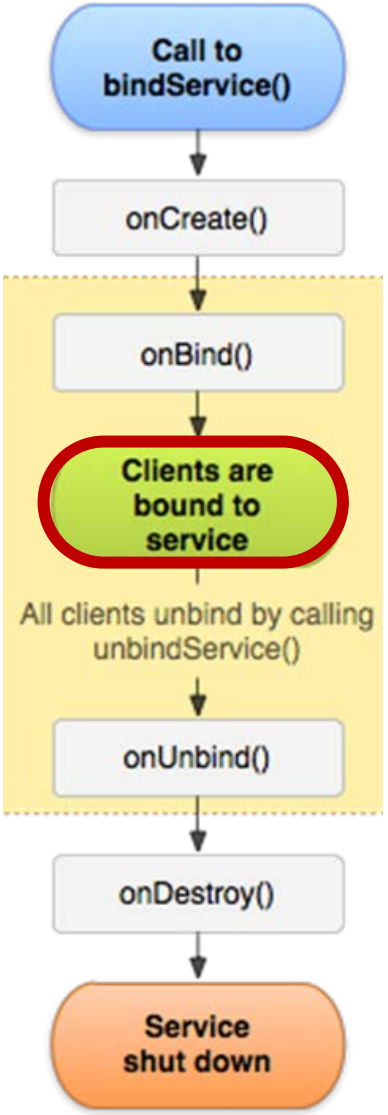

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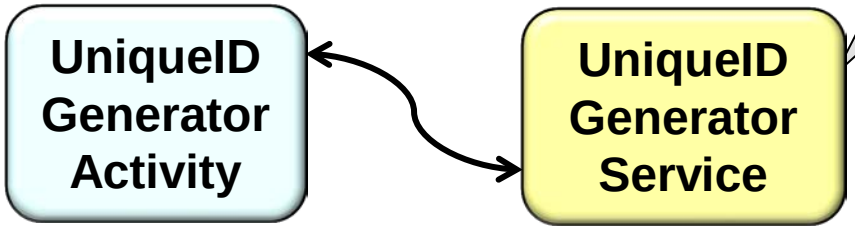

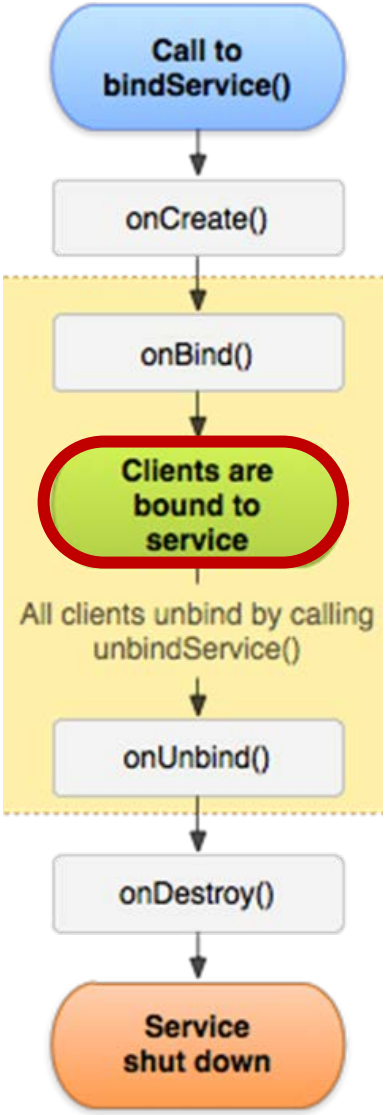

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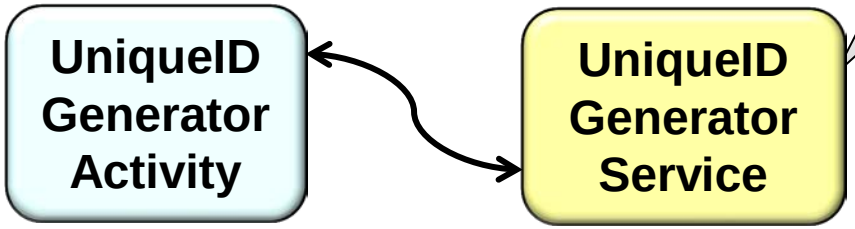

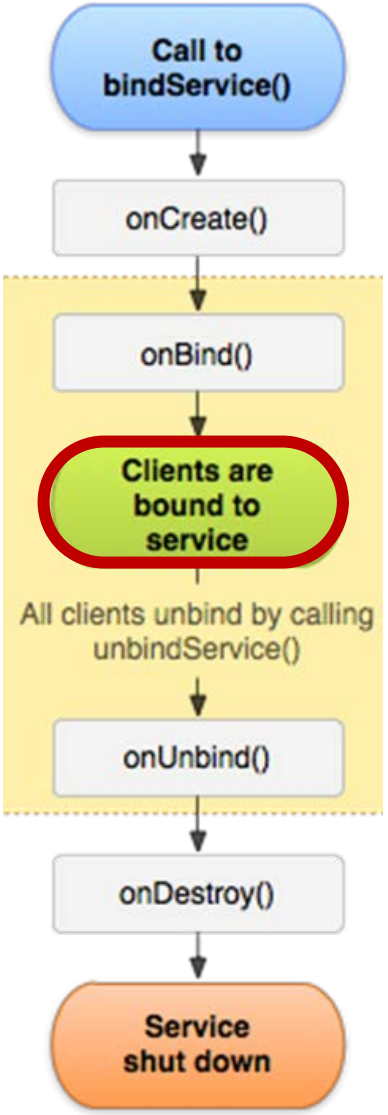

Connecting to a Bound Service

- A callback-driven protocol is used to establish a connection
  - The client implements an onServiceConnected() hook method to get a reference to an object in the Service

Store a reference to the Service's Messenger

```
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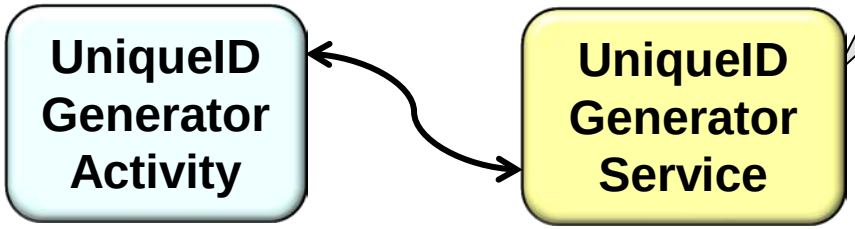

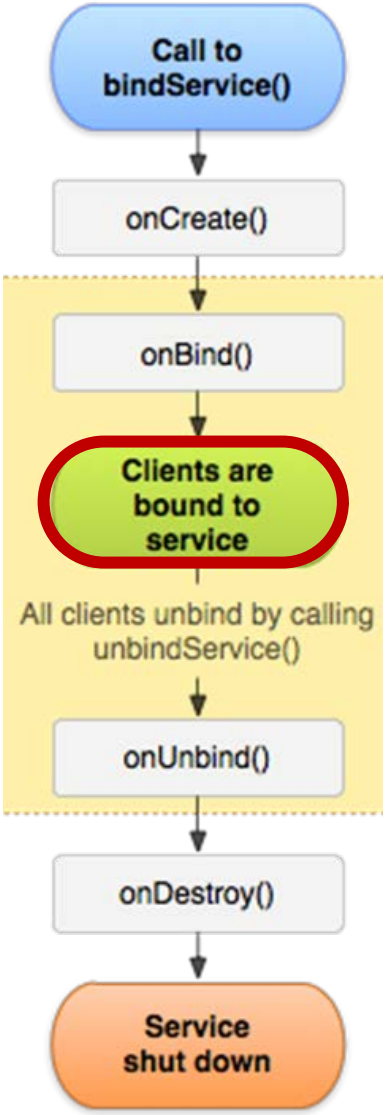

Connecting to a Bound Service

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  - The client implements an onServiceConnected() hook method to get a reference to an object in the Service

```
private Messenger mReqMessengerRef = null;

ServiceConnection mSvcConn =
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  ...
  public void onServiceDisconnected
        (ComponentName className) {
    mReqMessengerRef = null;
  }
...
```

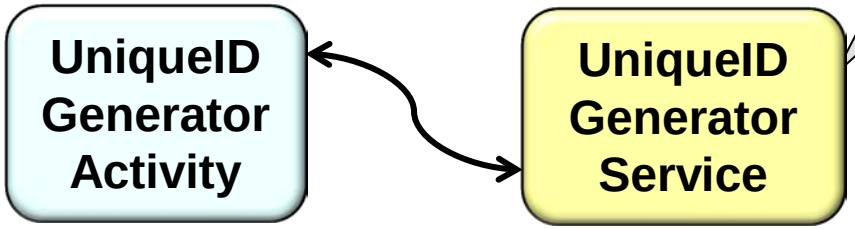

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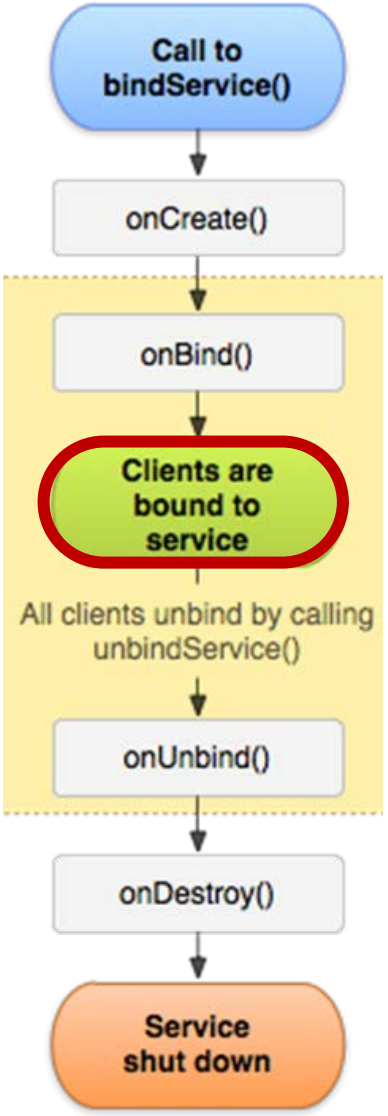
```

Called back when the process hosting the Service has crashed or is killed

UniqueID Generator Activity

UniqueID Generator Service



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  ...
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  }
...
```
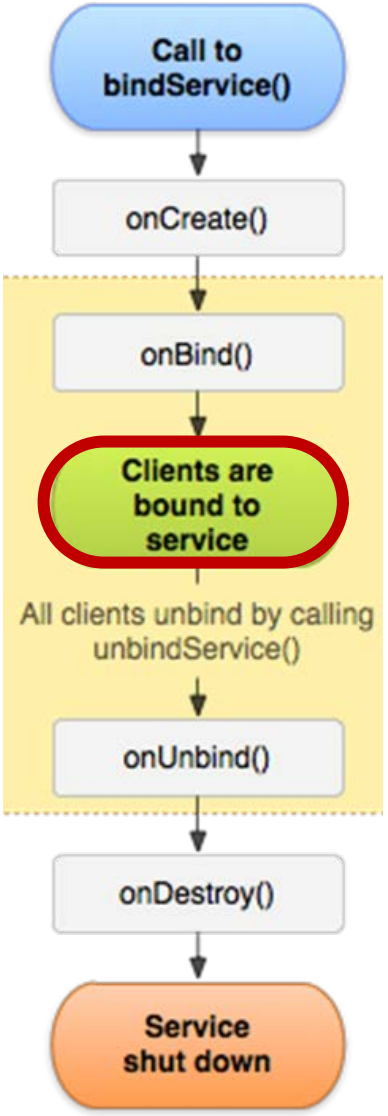

This callback does not remove the Service Connection

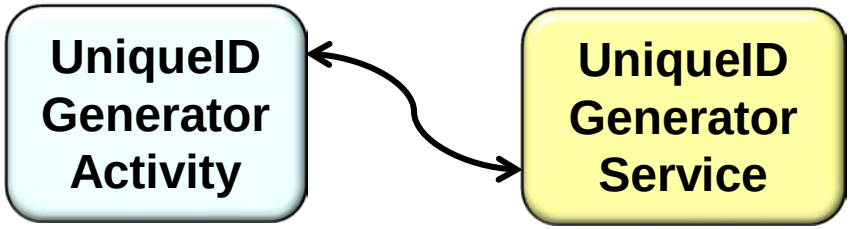
UniqueID Generator Activity

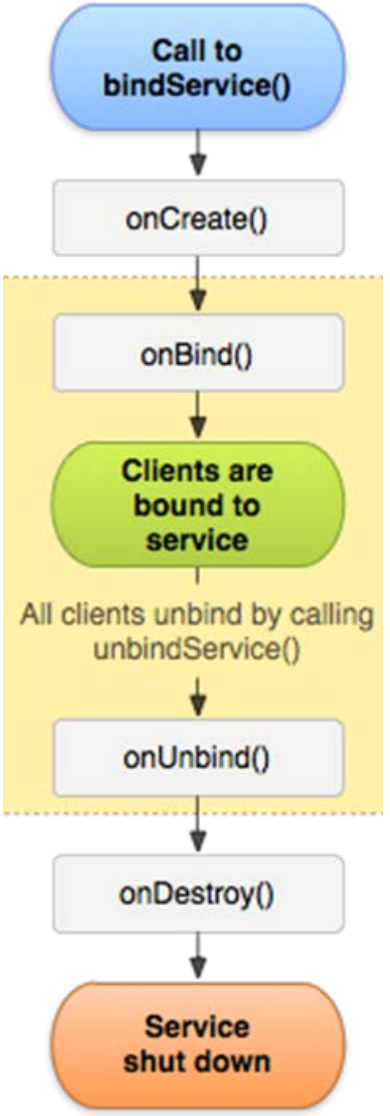
UniqueID Generator Service



Interacting with a Bound Service

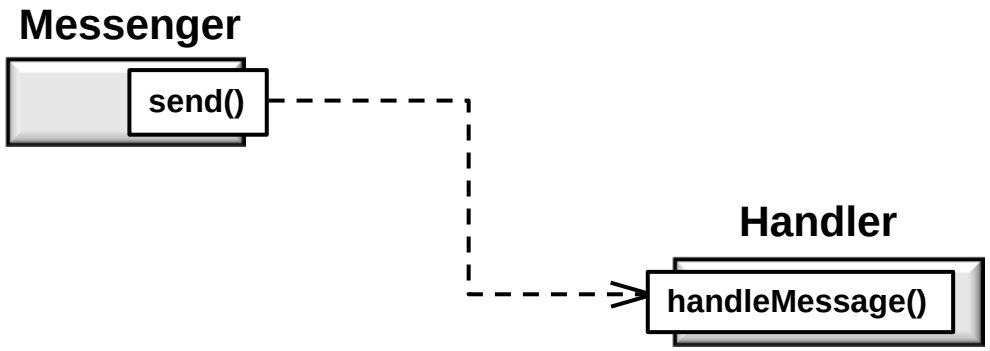
- A Bound Service offers clients an interface they can use to interact with the Service

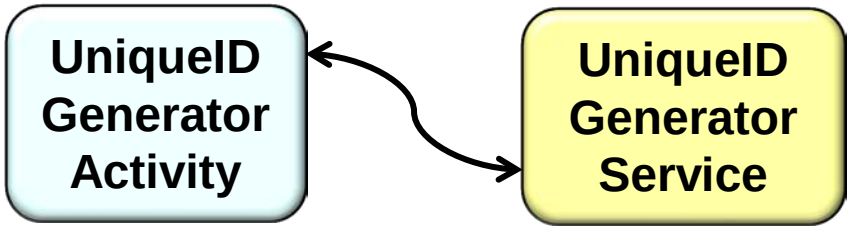




Interacting with a Bound Service

- A Bound Service offers clients an interface they can use to interact with the Service
  - This interface can be generic
    - e.g., using Messengers & Handlers for inter- or intra-process communication

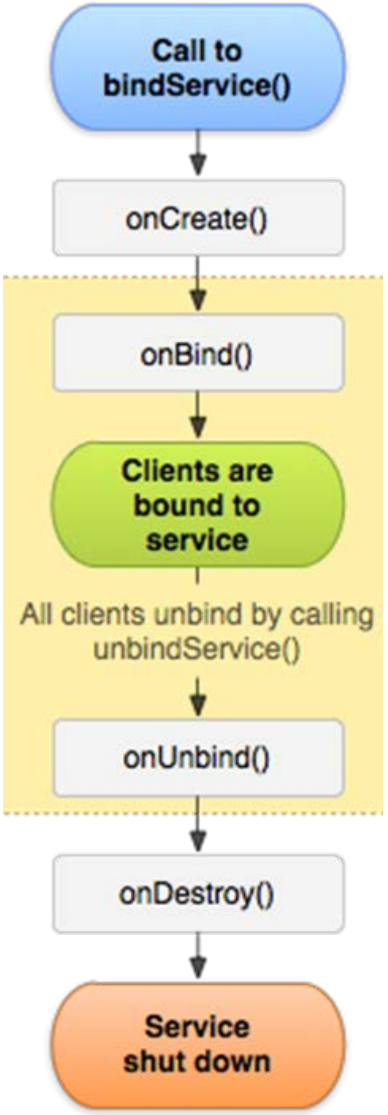


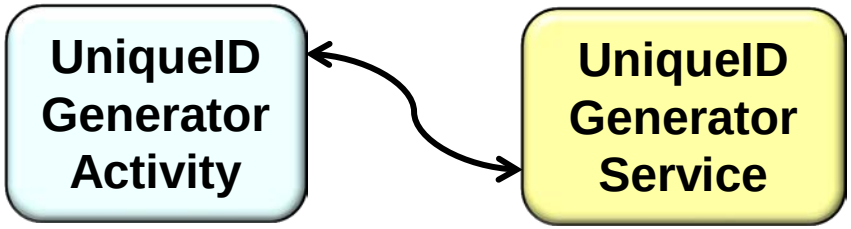


Interacting with a Bound Service

- A Bound Service offers clients an interface they can use to interact with the Service
  - This interface can be generic
  - This interface can also be type-specific
    - e.g., using the Android Interface Definition Language (AIDL) for inter- or intra-process communication

```
interface UniqueIDGenerator {
    String uniqueID();
}
```

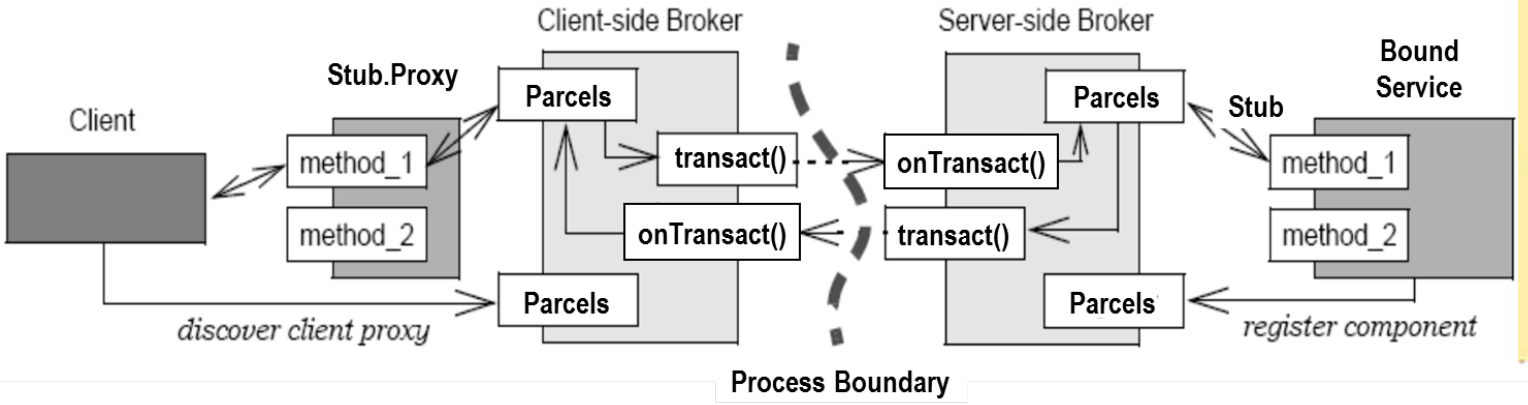


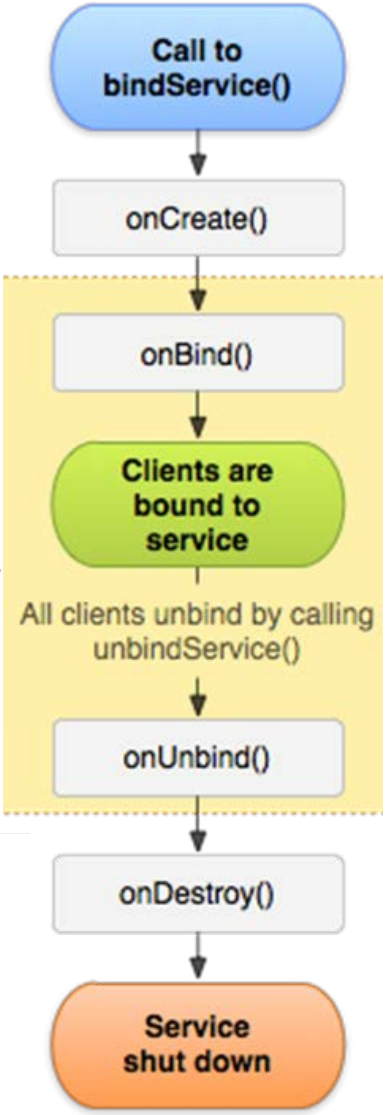


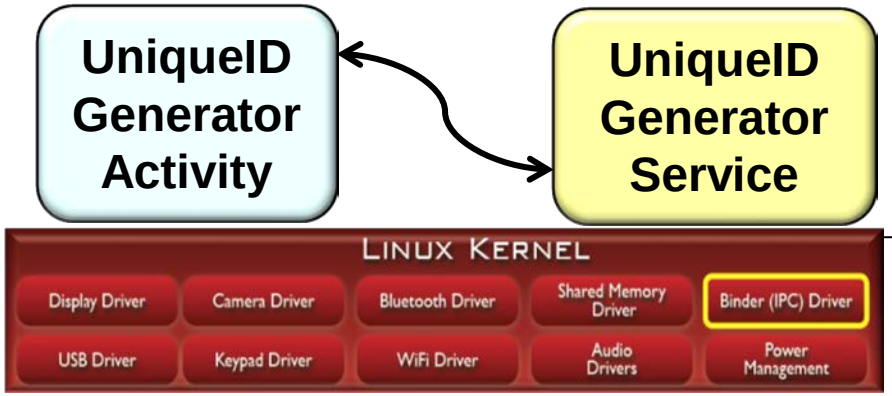
See upcoming part on “Programming Bound Services with AIDL”

Interacting with a Bound Service

- A Bound Service offers clients an interface they can use to interact with the Service
  - This interface can be generic
  - This interface can also be type-specific
  - Both approaches use the Android Binder framework
    - Implements patterns like *Broker* & *Proxy*

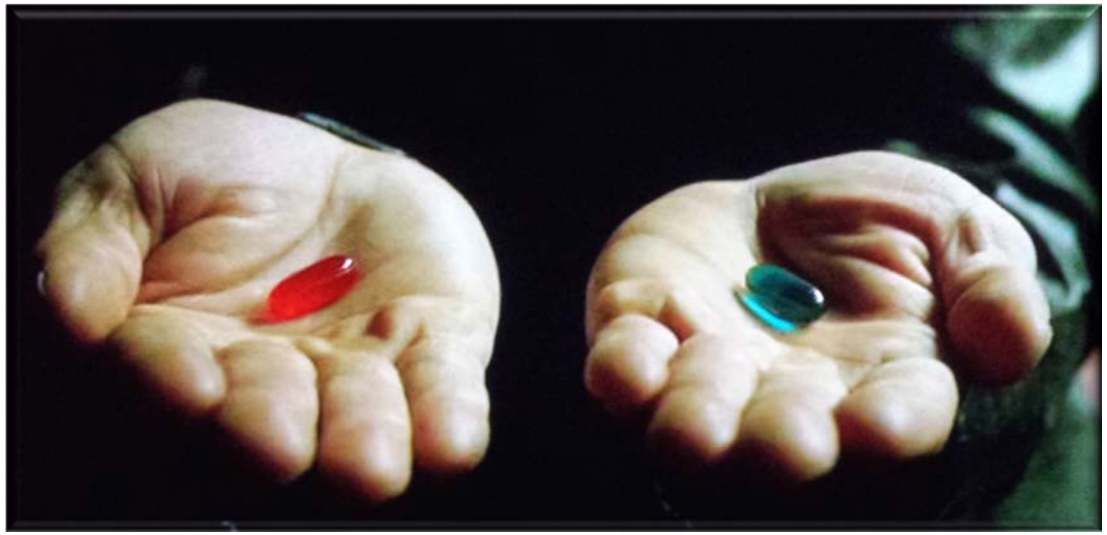


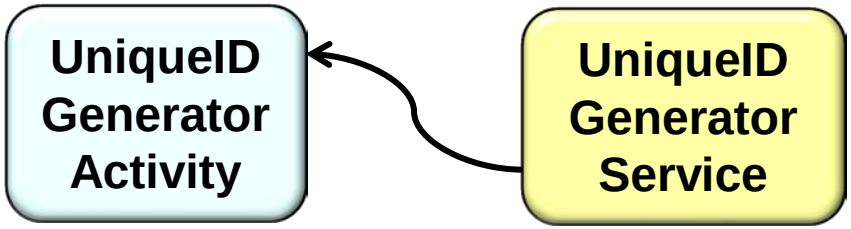




Interacting with a Bound Service

- A Bound Service offers clients an interface they can use to interact with the Service
- The UniqueIDGenerator application uses a pair of Messengers to communicate





Interacting with a Bound Service

- A Bound Service offers clients an interface they can use to interact with the Service
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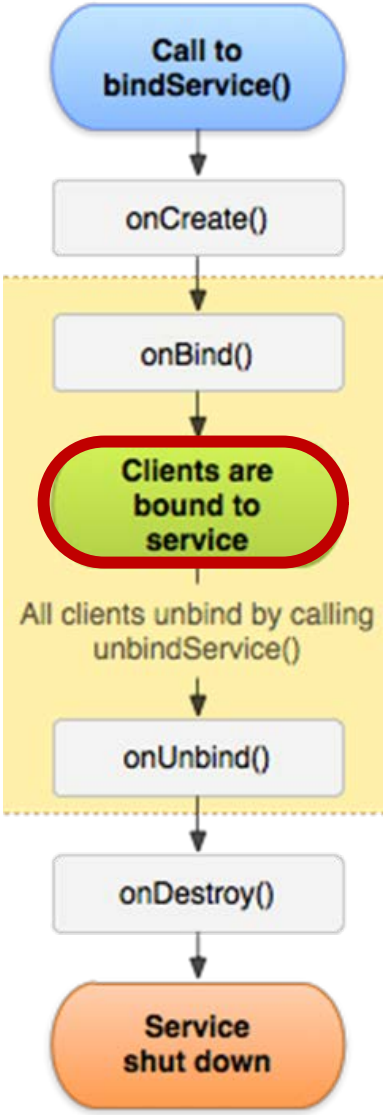
```
public void onCreate() {
  mReqMessenger =
    new Messenger(new RequestHandler());
  ...

private class RequestHandler extends Handler {
  public void handleMessage(Message request) {
    ...
    mExecutor.execute(...);
    ...
```

UniqueID Generator Activity

UniqueID Generator Service



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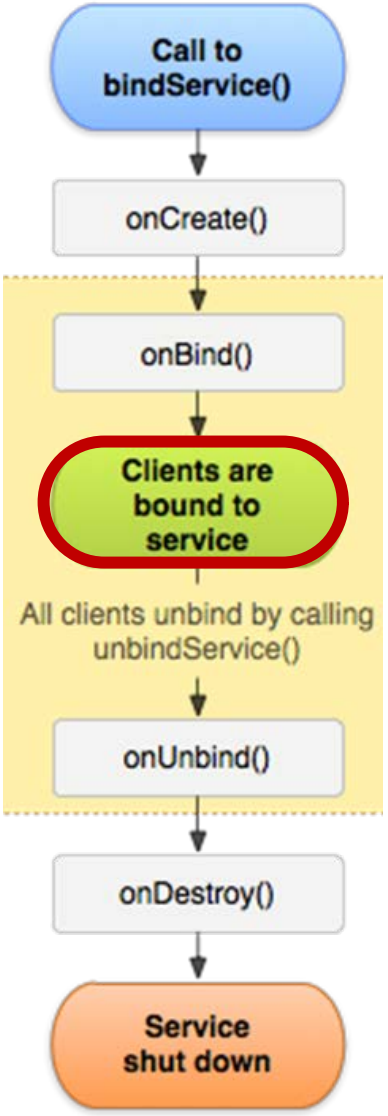

Interacting with a Bound Service

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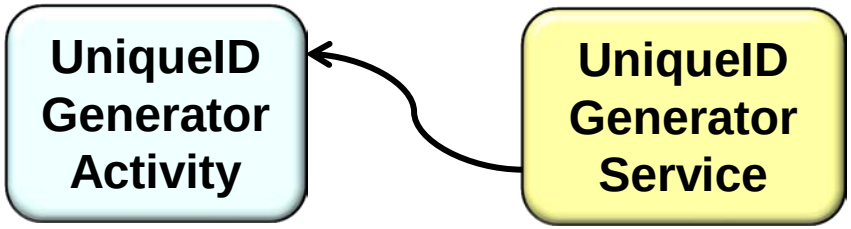
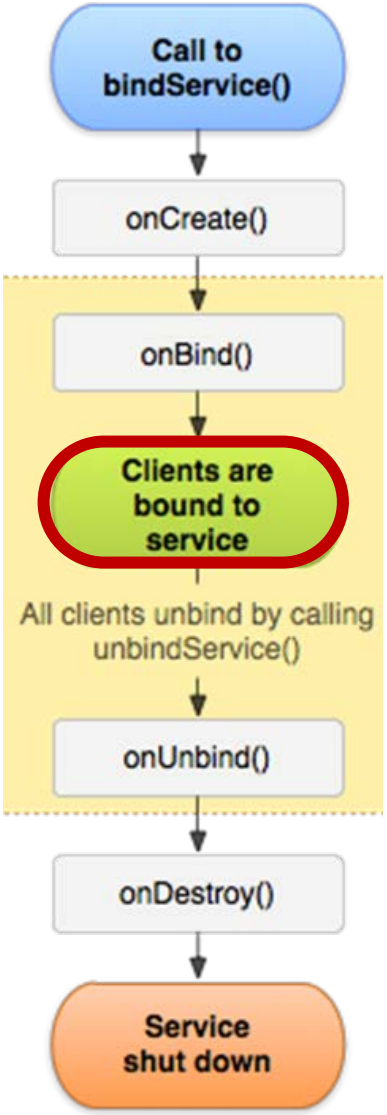
```
...
public IBinder onBind(Intent intent) {
  return mReqMessenger.getBinder();
}
...
```





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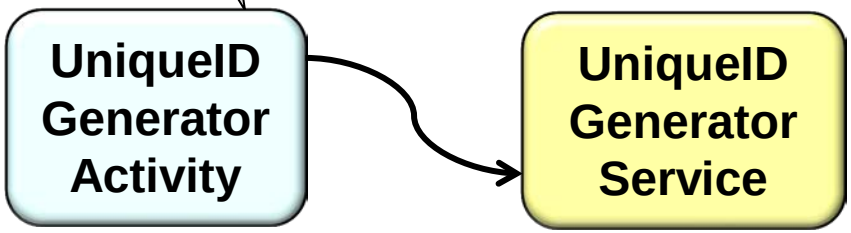

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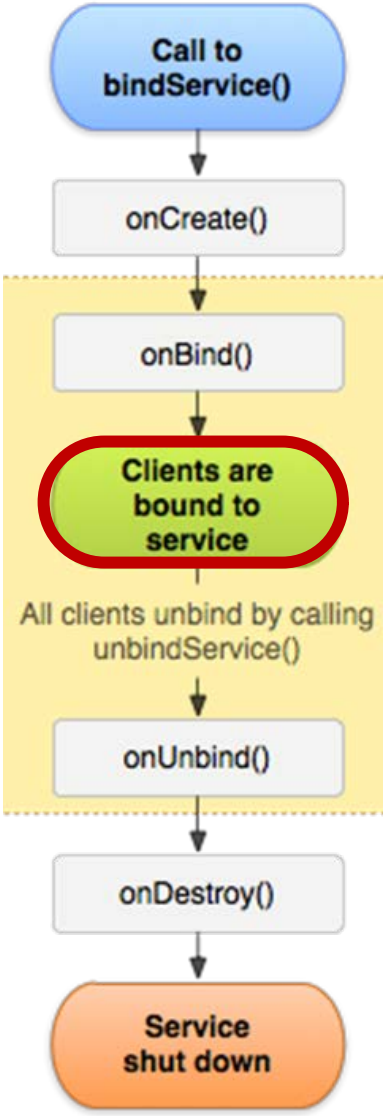
UniqueID Generator Activity → UniqueID Generator Service



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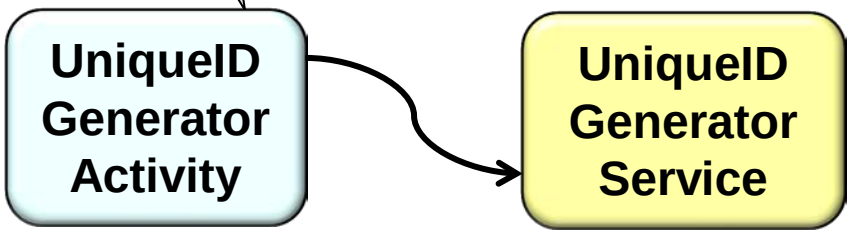
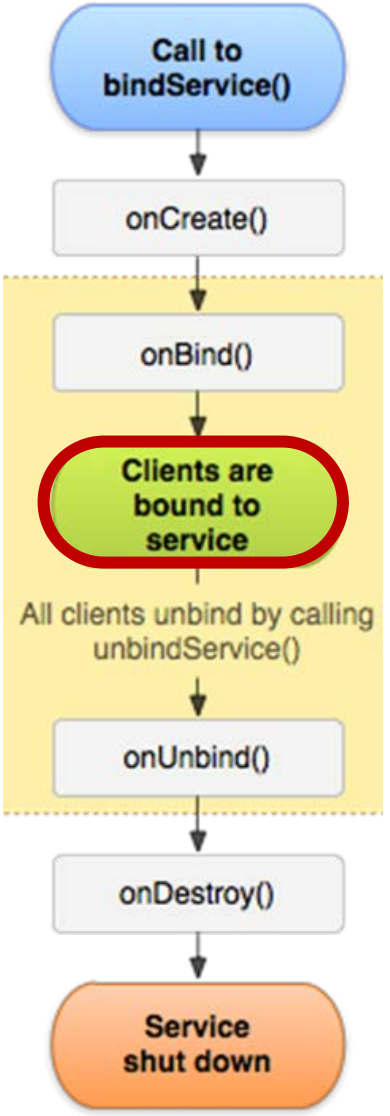
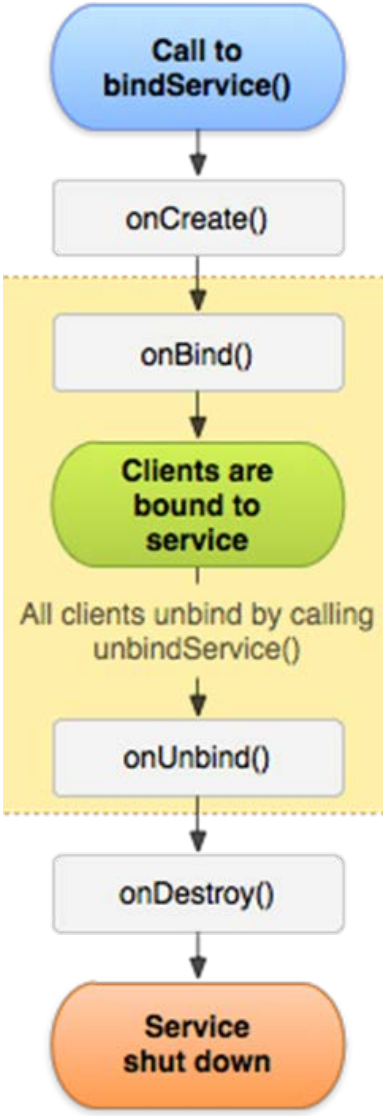


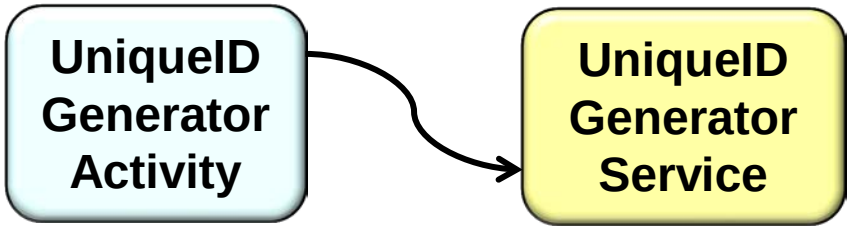


Stopping Bound Services

Stopping a Bound Service

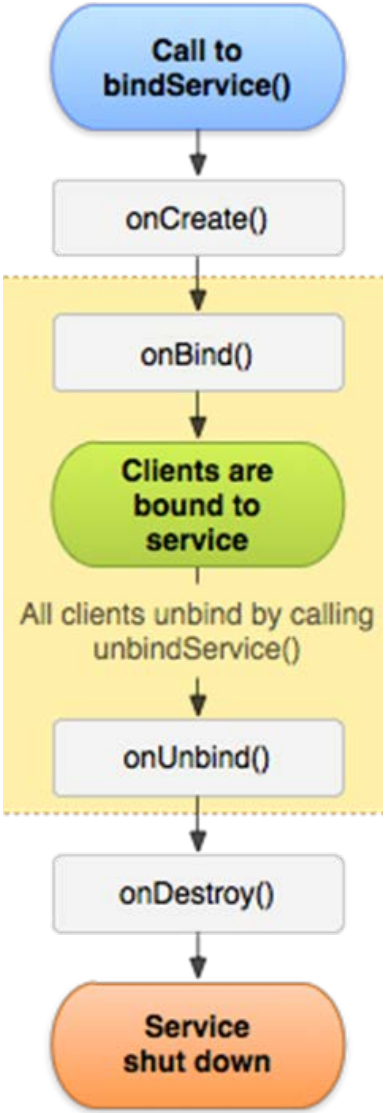
- When a Bound Service is launched, it has a lifecycle that depends on the component(s) accessing it





Stopping a Bound Service

- When a Bound Service is launched, it has a lifecycle that depends on the component(s) accessing it
  - i.e., it typically doesn't run in the background indefinitely, but instead is managed automatically



When a client is done interacting with a Bound Service, it calls unbindService() to unbind

UniqueID Generator Activity

UniqueID Generator Service

developer.android.com/guide/components/bound-services.html#Lifecycle

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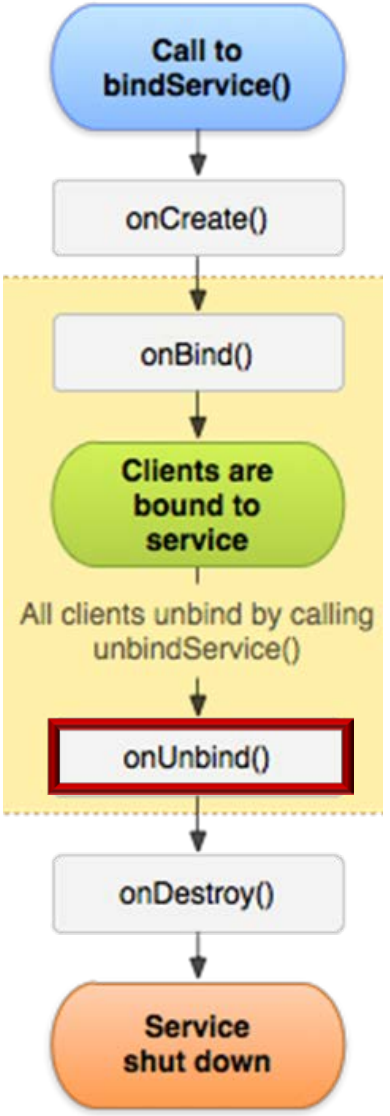


```
public abstract class Service extends ... {
  ...
  public boolean onUnbind(Intent intent) {
    return false;
  }
  ...
```

UniqueID Generator Activity → UniqueID Generator Service

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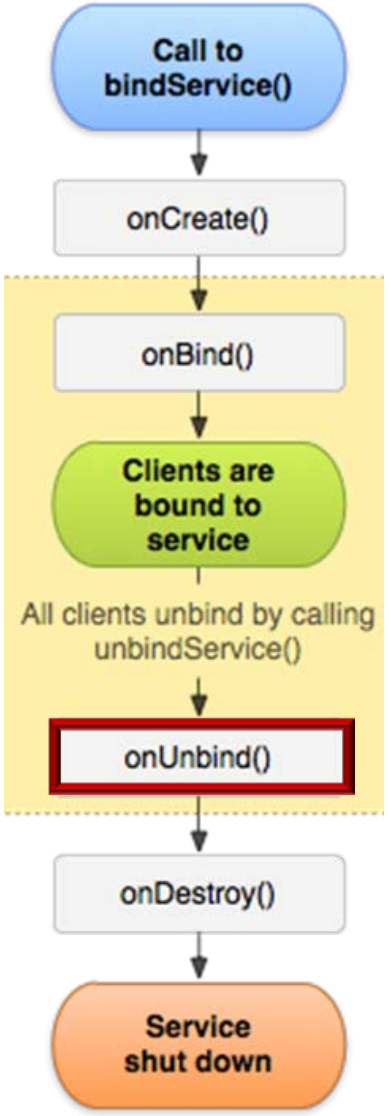


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UniqueID Generator Activity

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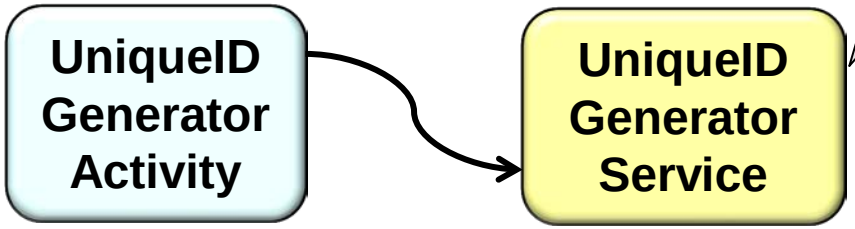
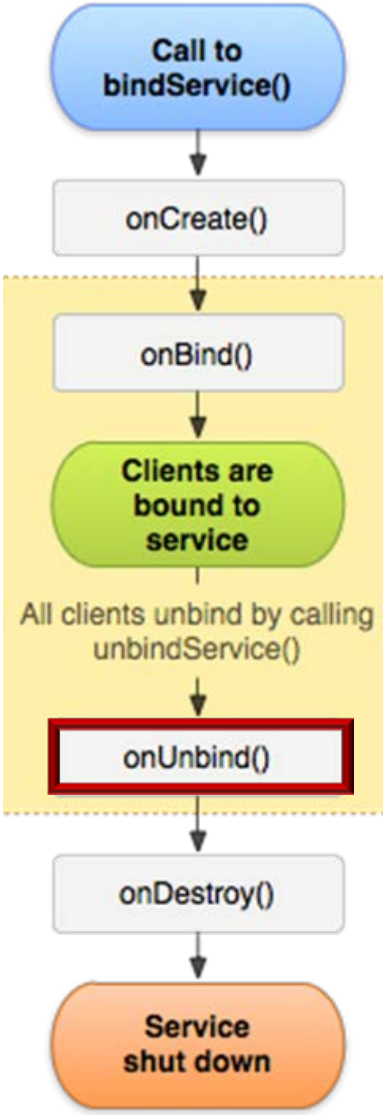
Returning true from onUnbind() enables onRebind() to be called when new clients bind to a Service

```
public class UniqueIDGenerorService
       extends Service {
  ...
  public boolean onUnbind(Intent intent) {
    return true;
  }
  ...
```





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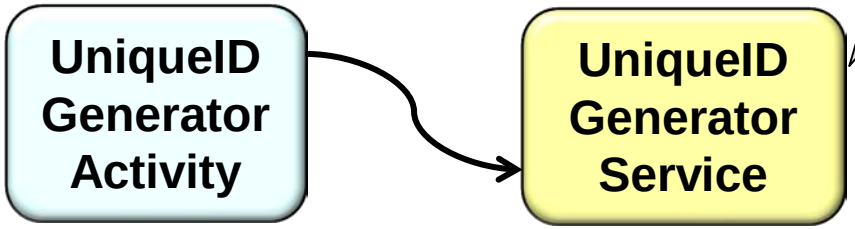
onRebind() can be used if a Bound Service is also a Started Service

```
public class UniqueIDGenerorService
       extends Service {
  ...
  public boolean onRebind(Intent intent) {
    ...
```



developer.android.com/guide/components/services.html#Lifecycle

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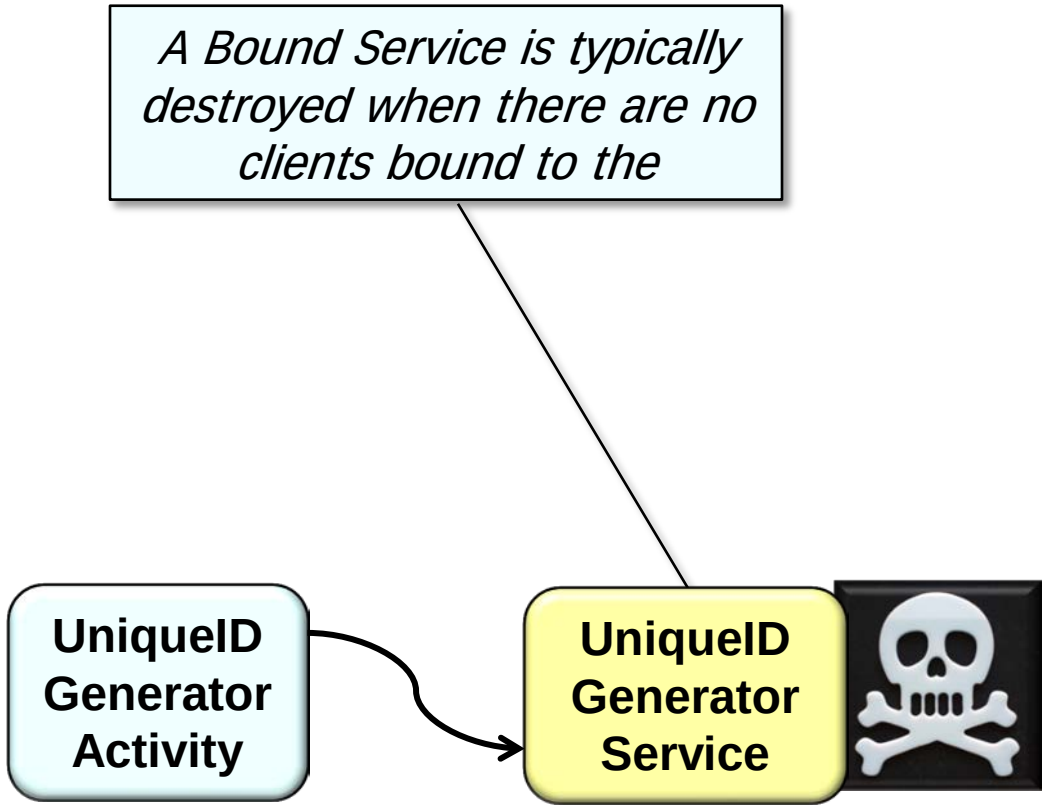

Stopping a Bound Service

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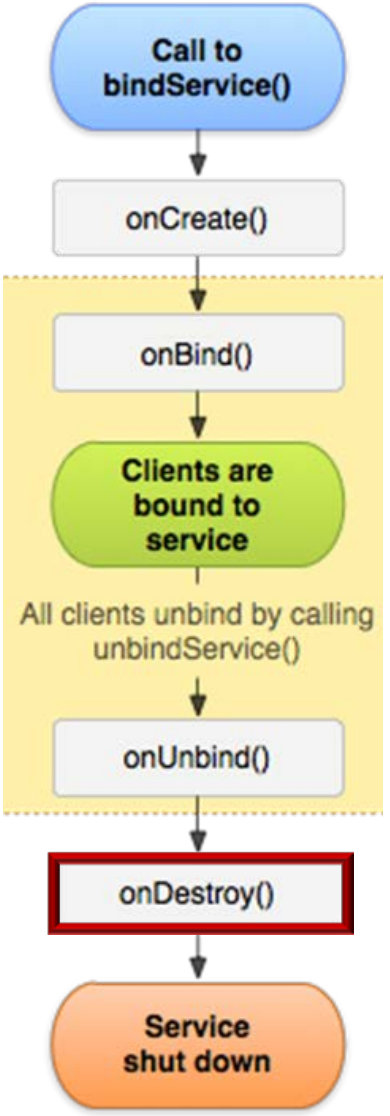
Cleanup any resources that were allocated

```
...
public void onDestory() {
    mExecutor.shutdown();
}
...
```

UniqueID Generator Activity

UniqueID Generator Service



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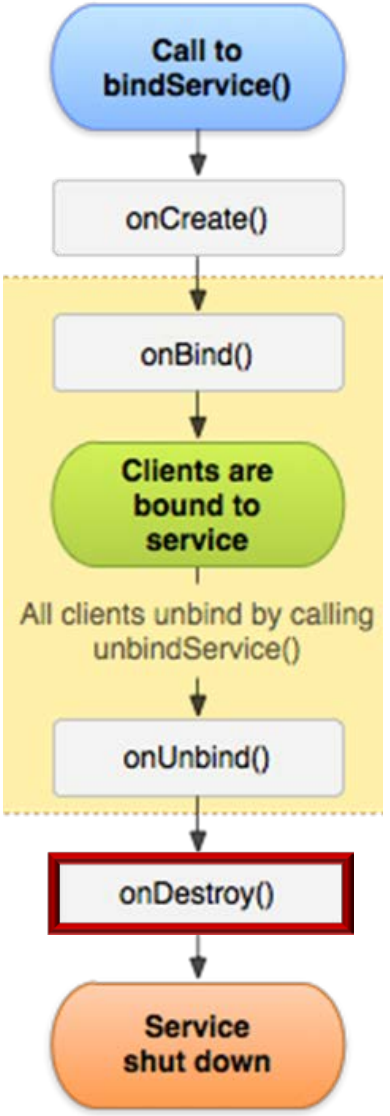
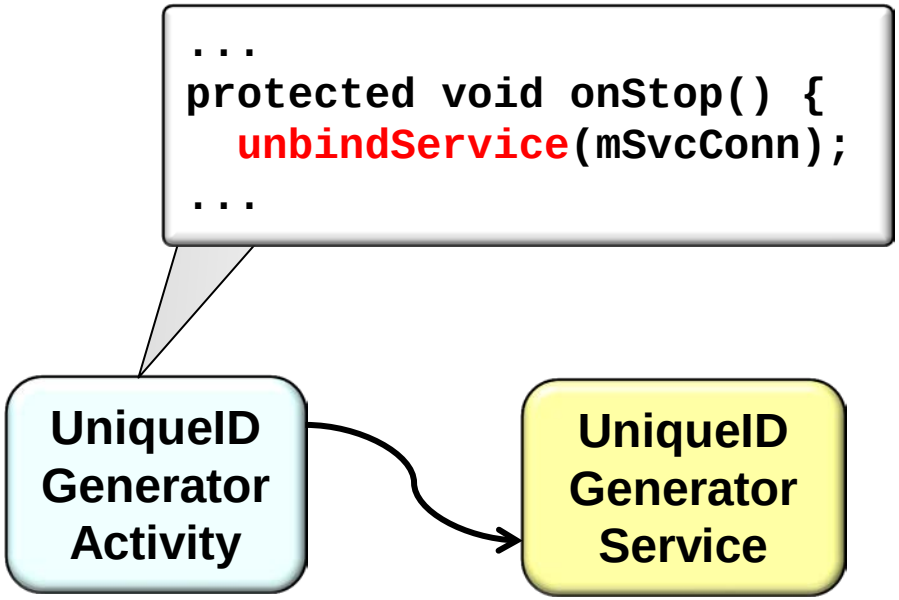


Stopping a Bound Service

- When a Bound Service is launched, it has a lifecycle that depends on the component(s) accessing it
- An Activity should call unbindService() when it stops or when it's done interacting with a Bound Service



Stopping a Bound Service

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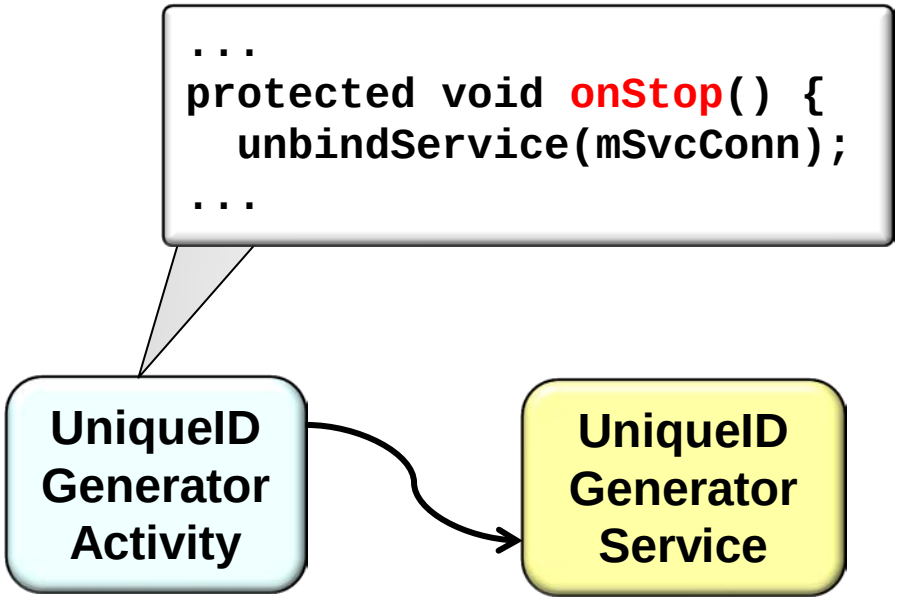

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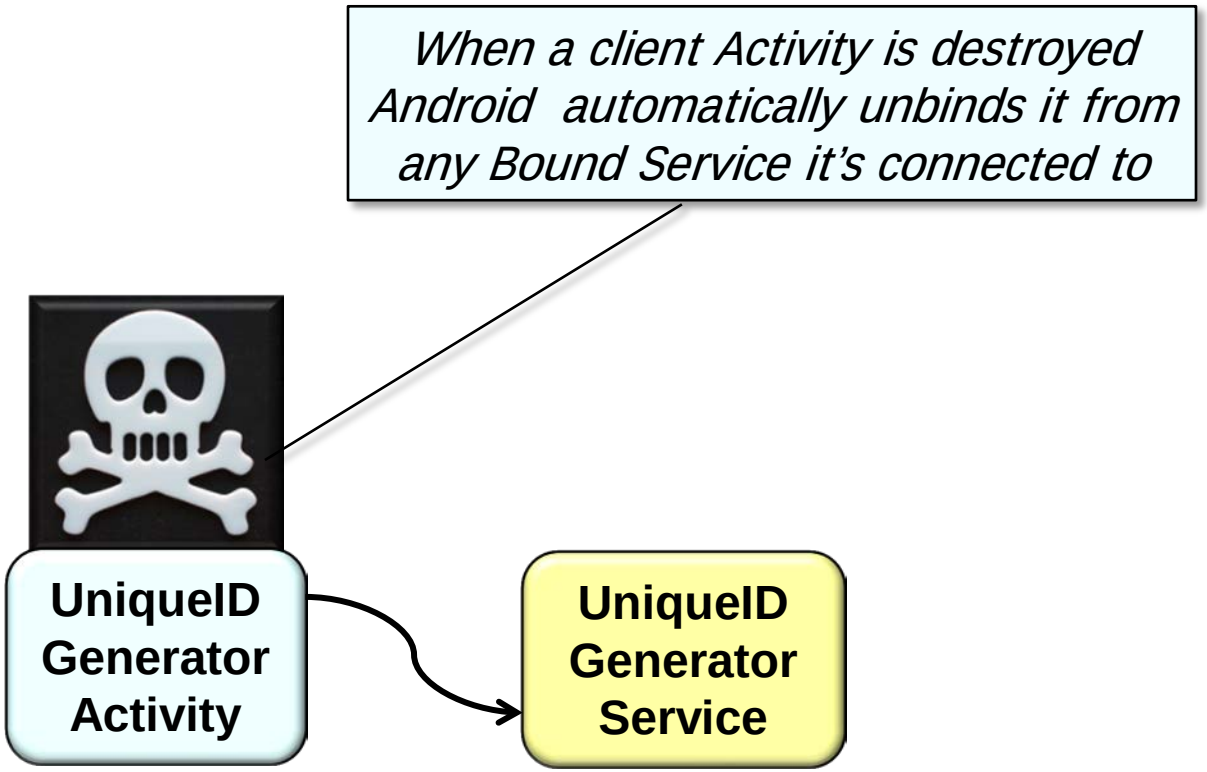
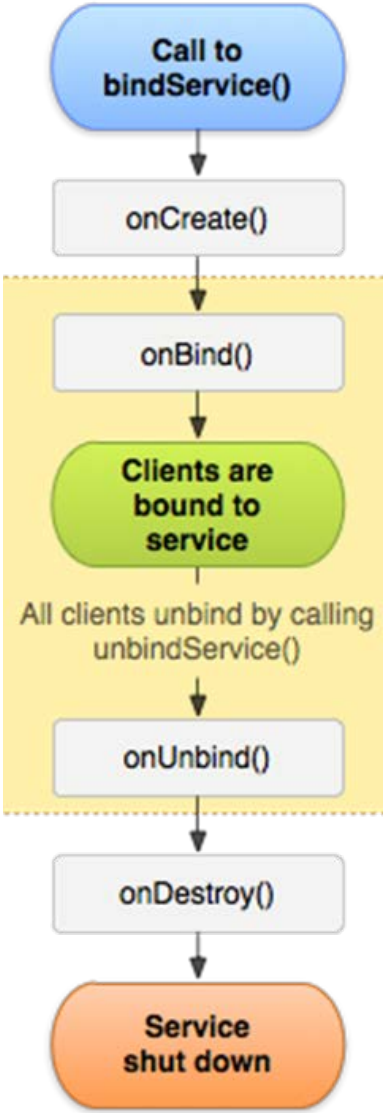
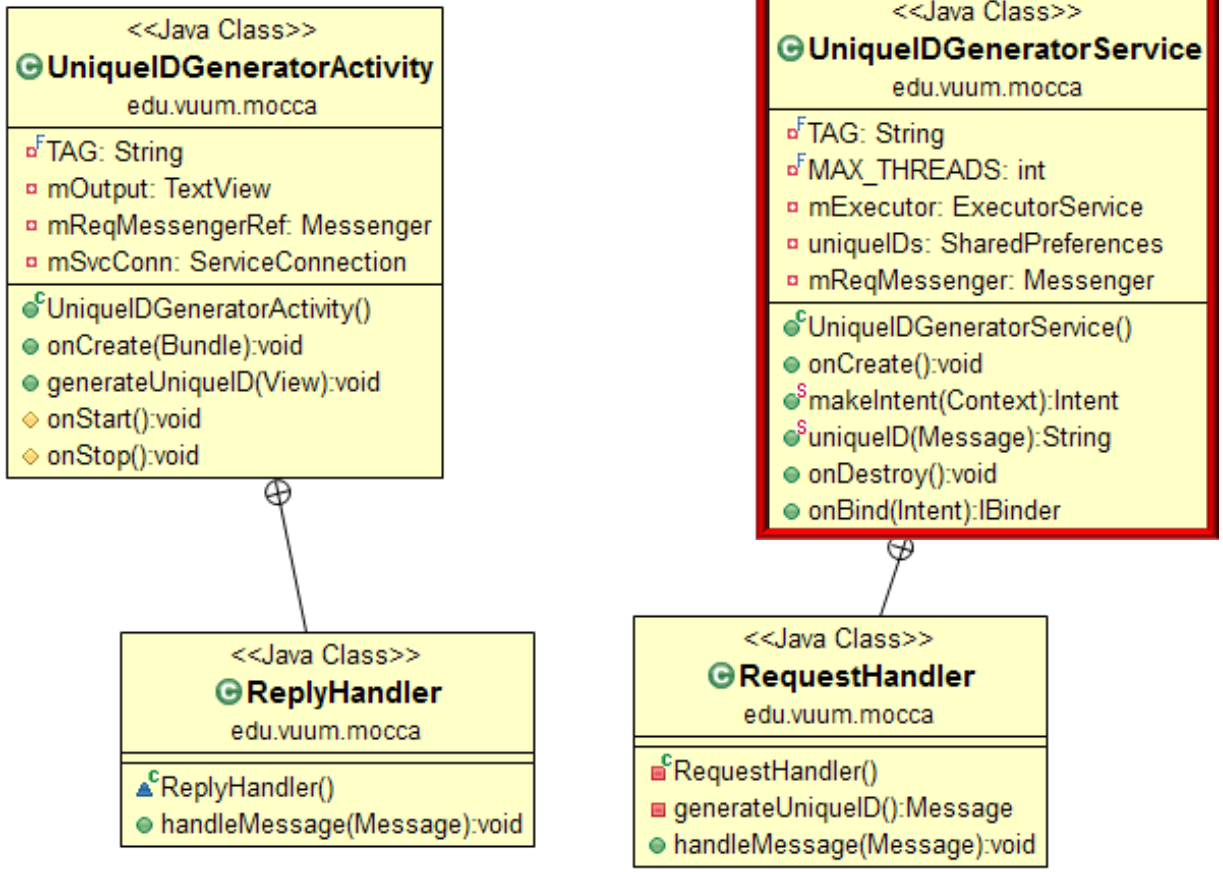




Summary

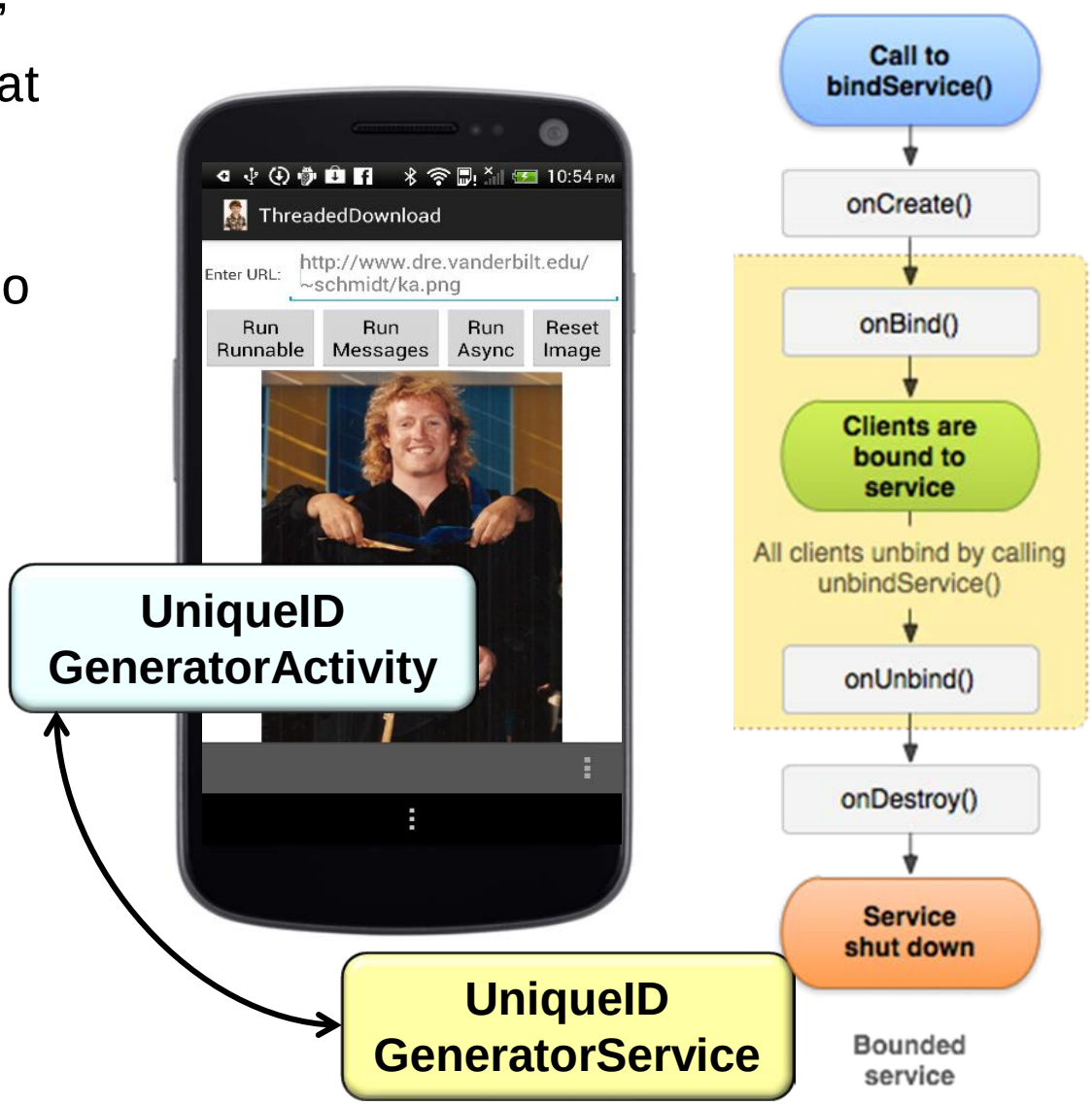
Summary

- A Bound Service is the “server” in a client-server interaction that runs on an Android device



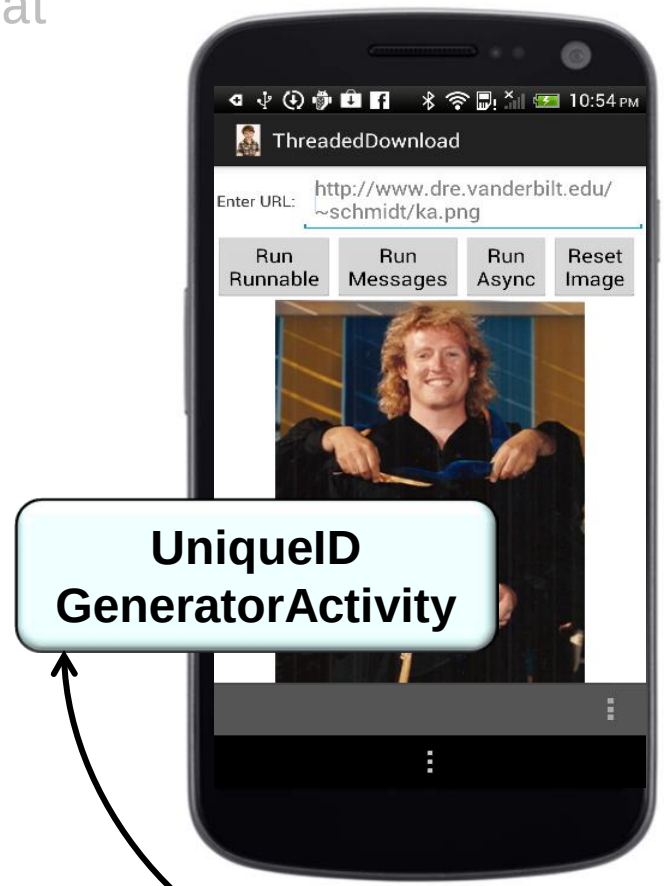
Summary

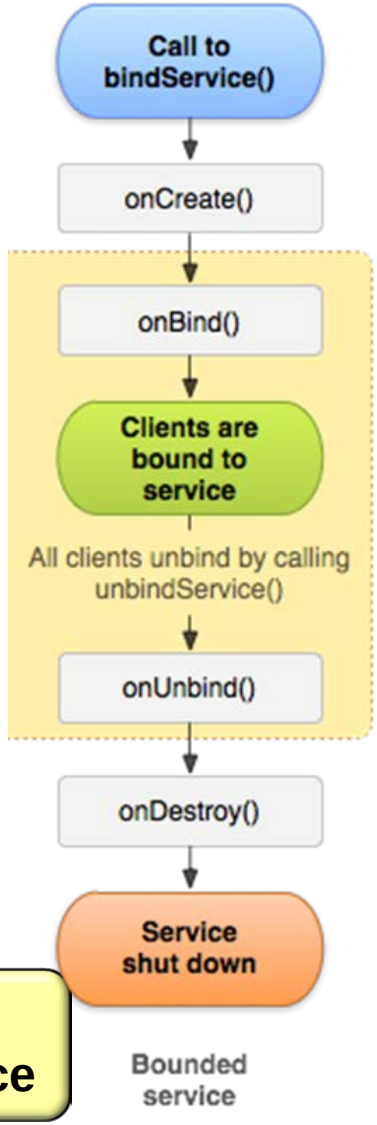
- A Bound Service is the "server" in a client-server interaction that runs on an Android device
  - e.g., the UniqueIDGenerator Application allows Activities to bind to the Service, send requests, receive replies, & perform IPC



Summary

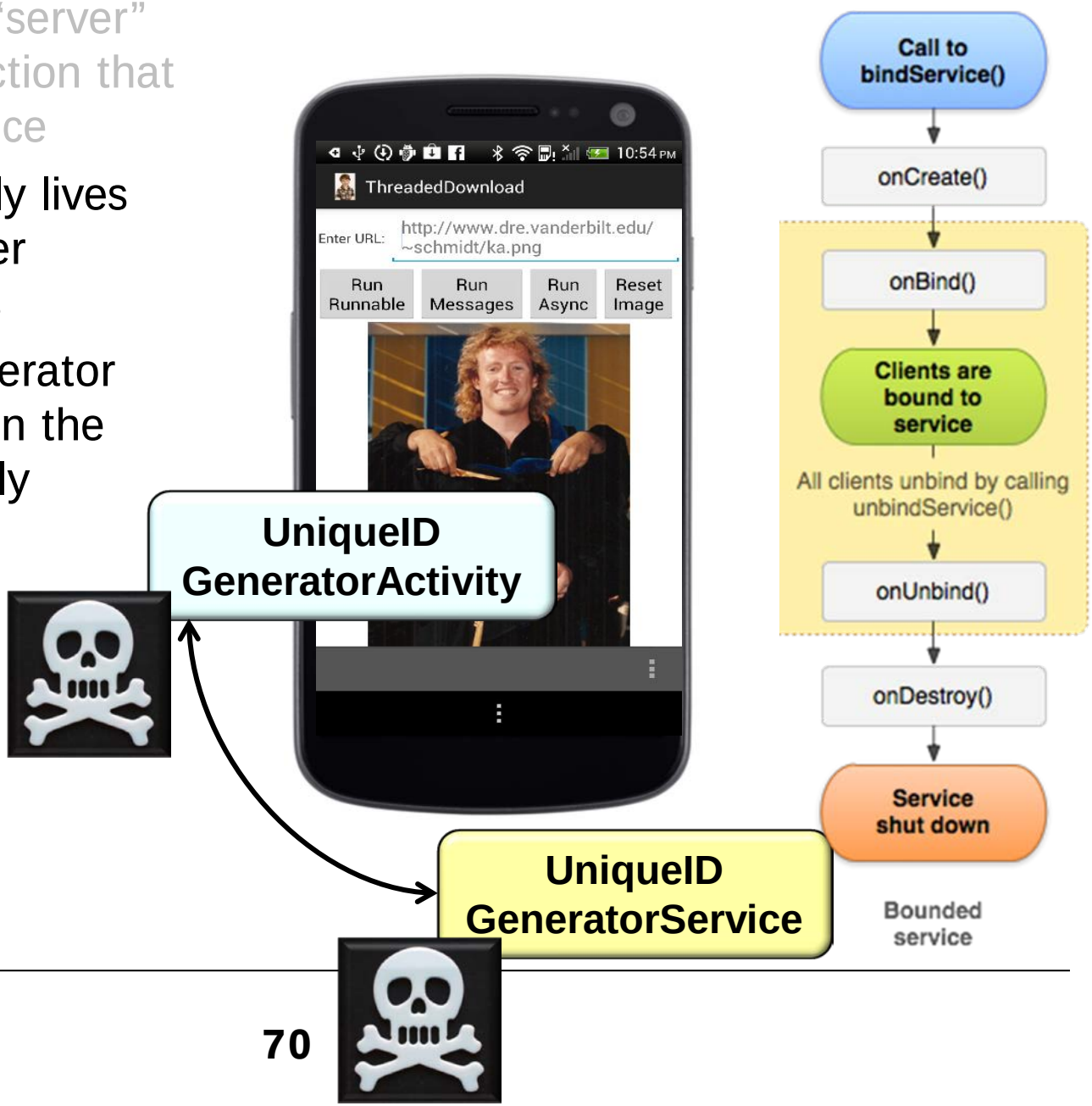
- A Bound Service is the "server" in a client-server interaction that runs on an Android device
- A Bound Service typically lives only while it serves other Application components





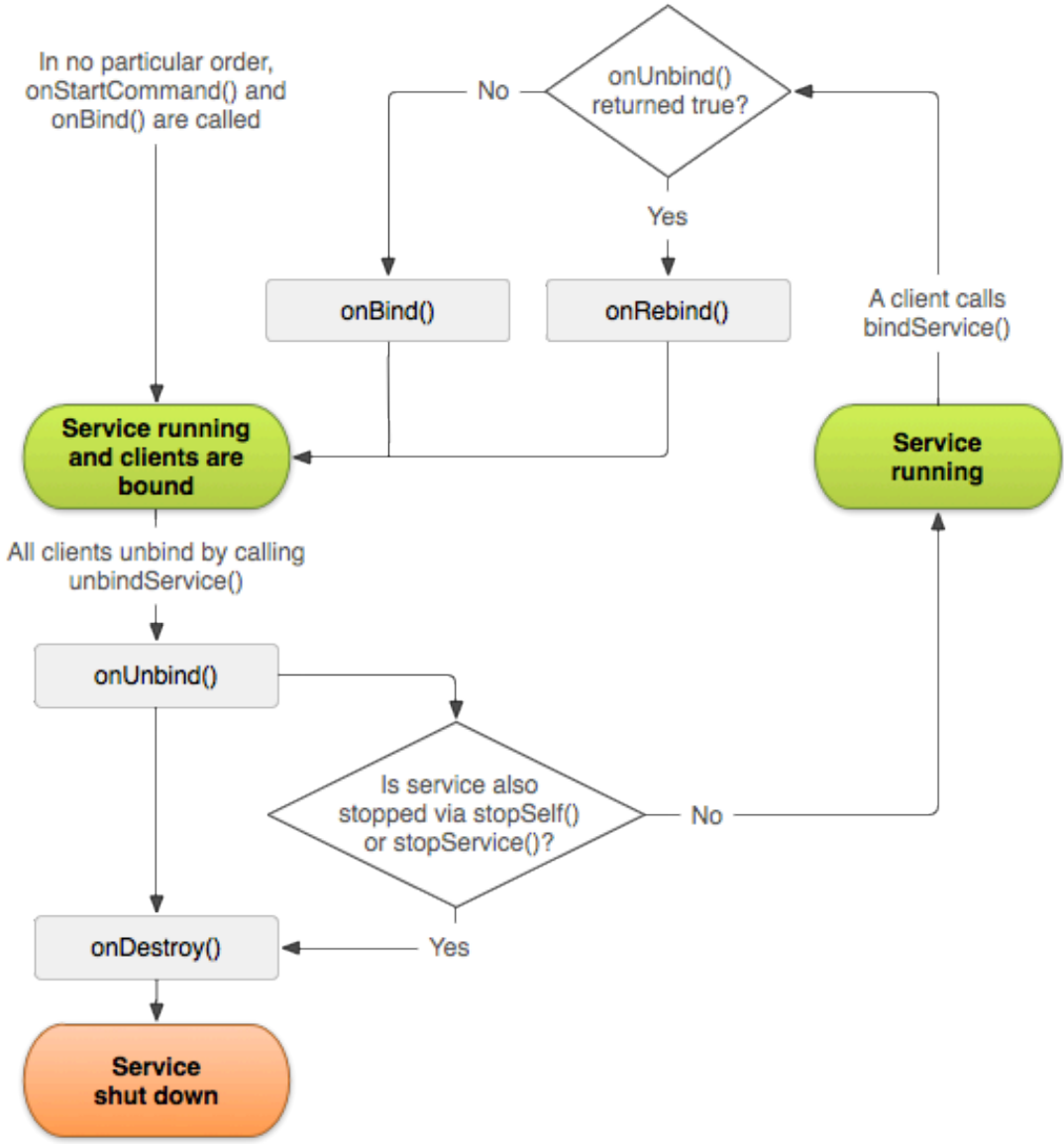
Summary

- A Bound Service is the "server" in a client-server interaction that runs on an Android device
- A Bound Service typically lives only while it serves other Application components
  - i.e., the UniqueIDGenerator Service does not run in the background indefinitely



Summary

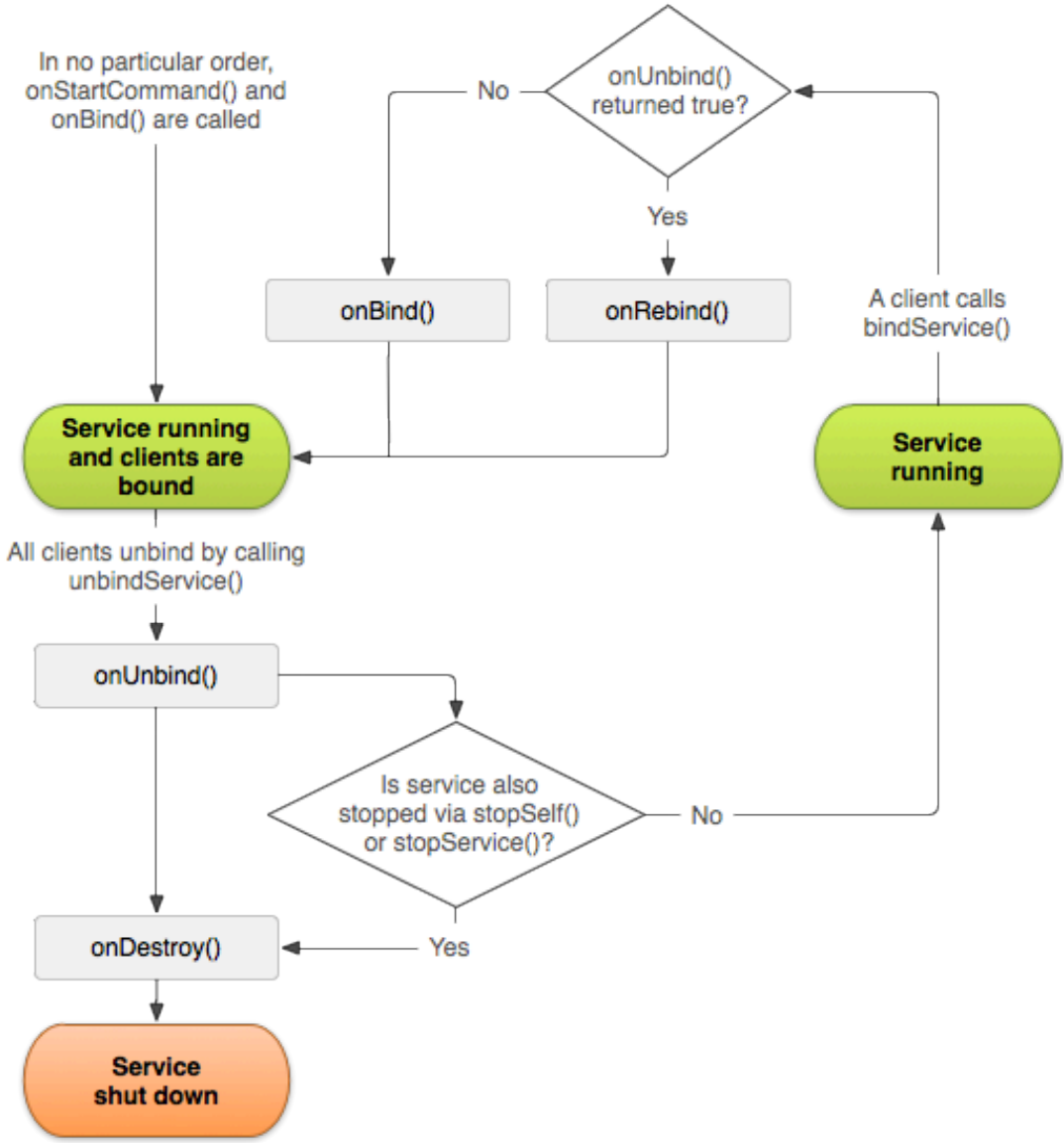
- A Bound Service is the "server" in a client-server interaction that runs on an Android device
- A Bound Service typically lives only while it serves other Application components
- It's also possible to define "hybrid" models that combine Bound & Started Services



developer.android.com/guide/components/bound-services.html#Lifecycle

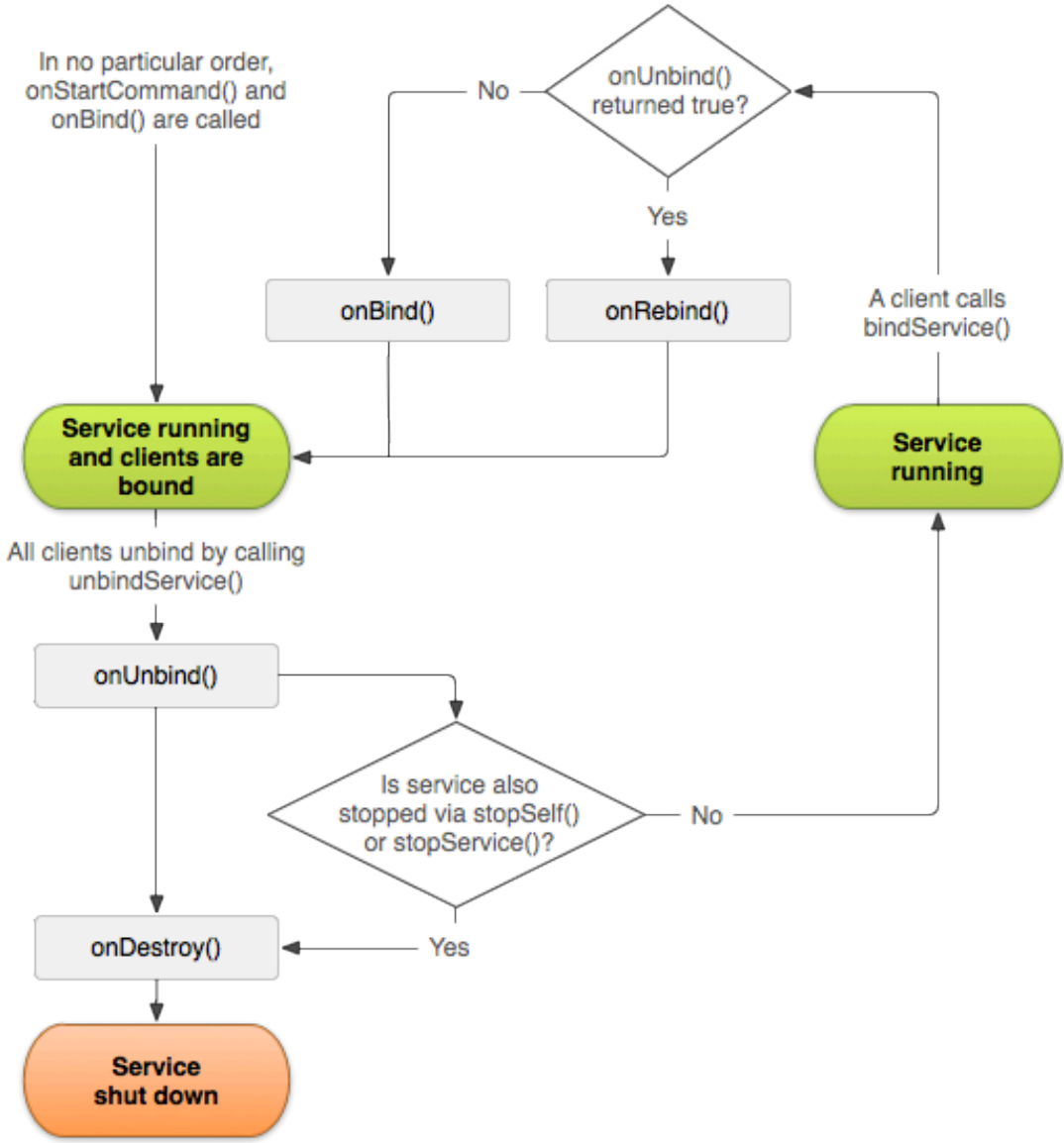
Summary

- A Bound Service is the “server” in a client-server interaction that runs on an Android device
- A Bound Service typically lives only while it serves other Application components
- It’s also possible to define “hybrid” models that combine Bound & Started Services
  - If a Bound Service implements onStartCommand() it won’t be destroyed when it’s unbound from all clients



Summary

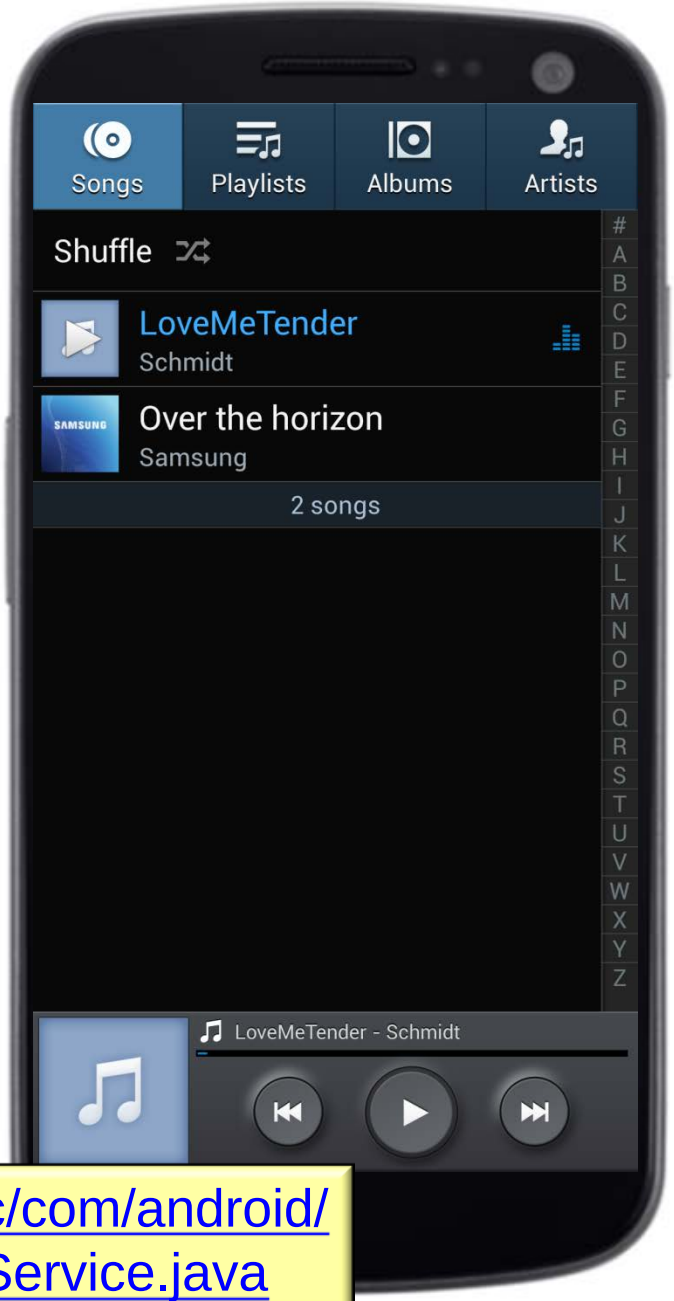
- A Bound Service is the "server" in a client-server interaction that runs on an Android device
- A Bound Service typically lives only while it serves other Application components
- It's also possible to define "hybrid" models that combine Bound & Started Services
  - If a Bound Service implements onStartCommand() it won't be destroyed when it is unbound from all clients
  - If onUnbind() returns "true" the onRebind() hook method will be called the next time a client binds to the Service



developer.android.com/reference/android/app/Service.html#onRebind(android.content.Intent)

Summary

- A Bound Service is the “server” in a client-server interaction that runs on an Android device
- A Bound Service typically lives only while it serves other Application components
- It’s also possible to define “hybrid” models that combine Bound & Started Services
- Android’s MusicPlaybackService is an example of a hybrid Service



packages/apps/Music/src/com/android/music/MusicPlaybackService.java