Android Services & Local IPC: Advanced Bound Service Communication – AIDL Syntax & Supported Data Types

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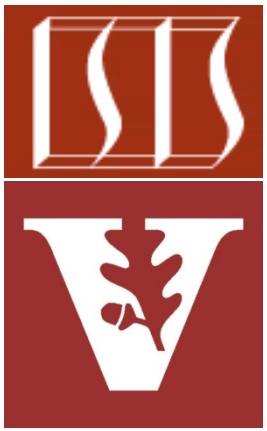

Professor of Computer Science

Institute for Software Integrated Systems

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Learning Objectives in this Part of the Module

- Understand the Android interface syntax & supported data types

```
InterfaceDeclaration:
    interface Identifier InterfaceBody
InterfaceBody:
    { { InterfaceBodyDeclaration } }
InterfaceBodyDeclaration:
    InterfaceMethodDecl
InterfaceMethodDecl:
    Type Identifier InterfaceMethodDeclaratorRest
InterfaceMethodDeclaratorRest:
    FormalParameters
```

```
                        interface IDownloadCallback {
                          oneway void sendPath(in String path);
                        }
interface Idownload {
    oneway void setCallback(in IDownloadCallback callback);
}
```

AIDL Syntax & Supported Data Types

- AIDL allows application developers to declare their "business" logic methods using a Java-like interface syntax

```
interface IDropBoxManagerService {
  void add(in DropBoxManager.Entry entry);
  ...
  DropBoxManager.Entry getNextEntry(String tag, long millis);
}
```

frameworks/base/core/java/com/android/internal/os/IDropBoxManagerService.aidl

AIDL Syntax & Supported Data Types

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```
interface IDropBoxManagerService {
  void add(in DropBoxManager.Entry entry);
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```

  - Similarities with Java interfaces
    - AIDL can declare methods with typed parameters & a return value

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  - Similarities with Java interfaces
  - Differences from Java interfaces
    - No static fields

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interface IDropBoxManagerService {
  void add(in DropBoxManager.Entry entry);
  ...
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}
```

  - Similarities with Java interfaces
  - Differences from Java interfaces
    - No static fields
    - All non-primitive parameters must be labeled by "direction"
      - **`in`** – (default/only mode for primitives) transferred to remote method
      - **`out`** – returned to the caller
      - **`inout`** – both in & out (rarely used)

Limit direction to just what's needed since marshaling parameters is expensive

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  - Similarities with Java interfaces
  - Differences from Java interfaces
    - No static fields
    - All non-primitive parameters must be labeled by "direction"
    - Methods (& AIDL interfaces themselves) can be defined as **oneway**
      - **oneway** method invocations don't block the caller

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  - Similarities with Java interfaces
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    - Methods cannot throw exceptions

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  - Similarities with Java interfaces
  - Differences from Java interfaces
    - No static fields
    - All non-primitive parameters must be labeled by "direction"
    - Methods (& AIDL interfaces themselves) can be defined as **oneway**
    - Methods cannot throw exceptions
    - Interfaces can't inherit from other interfaces

AIDL Syntax & Supported Data Types

- AIDL allows application developers to declare their "business" logic methods using a Java-like interface syntax

- Supported Java primitives
  - boolean, boolean[], byte, byte[], char[], int, int[], long, long[], float, float[], double, double[]
  - java.lang.CharSequence, java.lang.String

```
interface IEmailService {
   …
   boolean createFolder(long accountId,
                        String name);
   boolean deleteFolder(long accountId,
                        String name);
   boolean renameFolder(long accountId,
                        String oldName,
                        String newName);
```

packages/apps/Email/emailcommon/src/com/android/emailcommon/service/IEmailService.aidl

AIDL Syntax & Supported Data Types

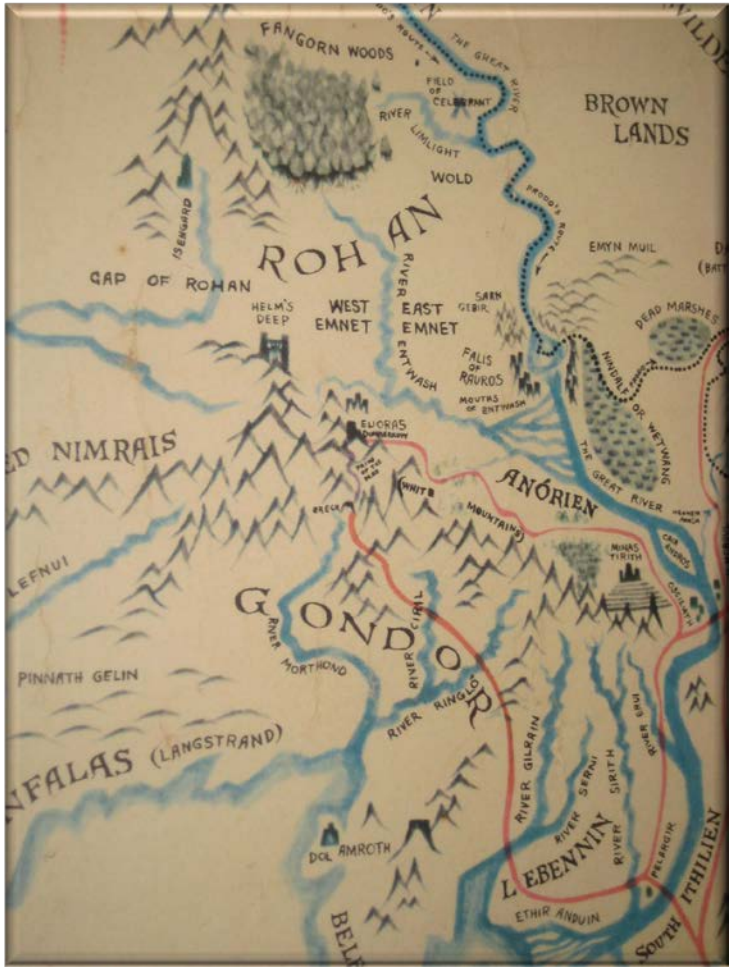
- AIDL allows application developers to declare their "business" logic methods using a Java-like interface syntax
- Supported Java primitives
- java.util.List
  - Uses java.util.ArrayList internally
  - List elements must be valid AIDL data types
  - Generic lists supported

```
oneway interface
INetworkQueryServiceCallback {
  void onQueryComplete
    (in List<OperatorInfo>
        networkInfoArray,
     int status);
}
```

packages/apps/Phone/src/com/android/phone/INetworkQueryServiceCallback.aidl

AIDL Syntax & Supported Data Types

- AIDL allows application developers to declare their "business" logic methods using a Java-like interface syntax
- Supported Java primitives
- java.util.List
- Java.util.Map
  - Uses java.util.HashMap internally
  - Map elements must be valid AIDL data types
  - Generic maps *not* supported
  - Not widely used (no use in Android)



AIDL Syntax & Supported Data Types

- AIDL allows application developers to declare their "business" logic methods using a Java-like interface syntax
- Supported Java primitives
- java.util.List
- Java.util.Map
- Classes implementing the Parcelable protocol

```
public class StatusBarIcon
             implements Parcelable {
  ...
  public void readFromParcel(Parcel in)
  { ... }
  public void writeToParcel
    (Parcel out, int flags) { ... }
}
```

Java source file

```
parcelable StatusBarIcon;

oneway interface IStatusBar {
  void setIcon(int index, in StatusBarIcon icon);
  ...
}
```

AIDL source file

developer.android.com/guide/components/aidl.html#PassingObjects has more

AIDL Syntax & Supported Data Types

- AIDL allows application developers to declare their "business" logic methods using a Java-like interface syntax
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AIDL source file

frameworks/base/core/java/com/android/internal/statusbar/IStatusBar.aidl

Summary

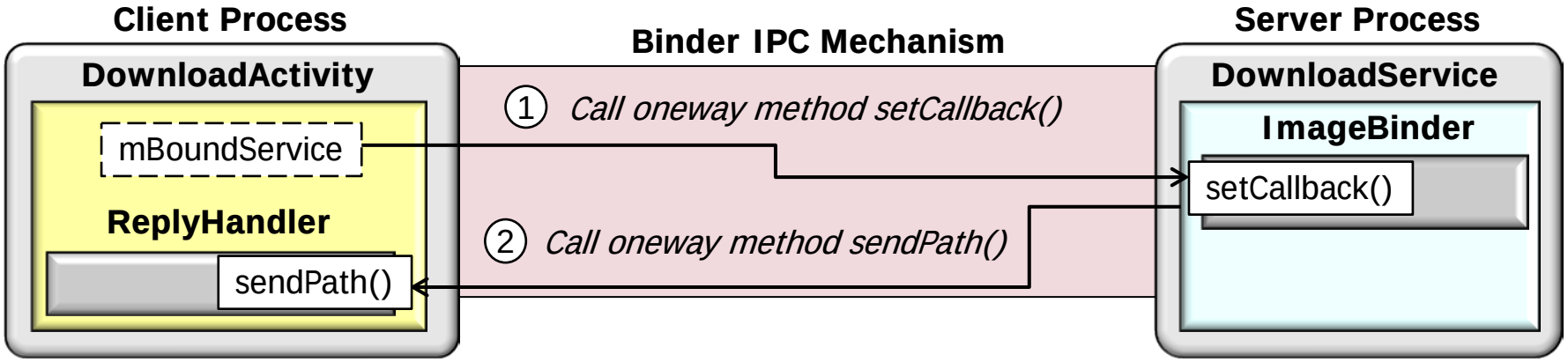
- AIDL uses a simple syntax that lets you declare an interface with one or more methods that can take parameters & return values

```
InterfaceDeclaration:
    interface Identifier InterfaceBody
InterfaceBody:
    { { InterfaceBodyDeclaration } }
InterfaceBodyDeclaration:
    ;
    InterfaceMethodDecl
InterfaceMethodDecl:
    Type Identifier InterfaceMethodDeclaratorRest
InterfaceMethodDeclaratorRest:
    FormalParameters
```

AIDL interfaces are a subset of Java interfaces

Summary

- AIDL uses a simple syntax that lets you declare an interface with one or more methods that can take parameters & return values
- The parameters & return values can be of any supported type, even other AIDL-generated interfaces
  - Interface methods that are passed parameters of other interfaces are commonly used to implement asynchronous one-way callbacks



Summary

- AIDL uses a simple syntax that lets you declare an interface with one or more methods that can take parameters & return values
- The parameters & return values can be of any supported type, even other AIDL-generated interfaces
- You must construct the .aidl file using a subset of the Java programming language
  - Each .aidl file must define a single interface & requires only the interface declaration & method signatures

```
interface Idownload {
    oneway void setCallback(in IDownloadCallback callback);
}
```

IDownload.aidl source file

IDownloadCallback.aidl source file

```
interface IDownloadCallback {
  oneway void sendPath(in String path);
}
```

Android Services & Local IPC: Advanced Bound Service Communication – Implementing AIDL Interfaces

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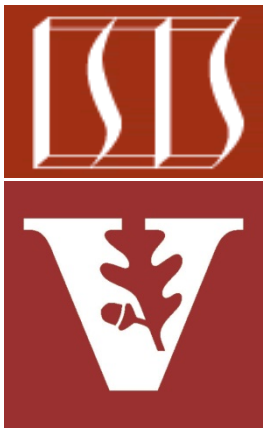

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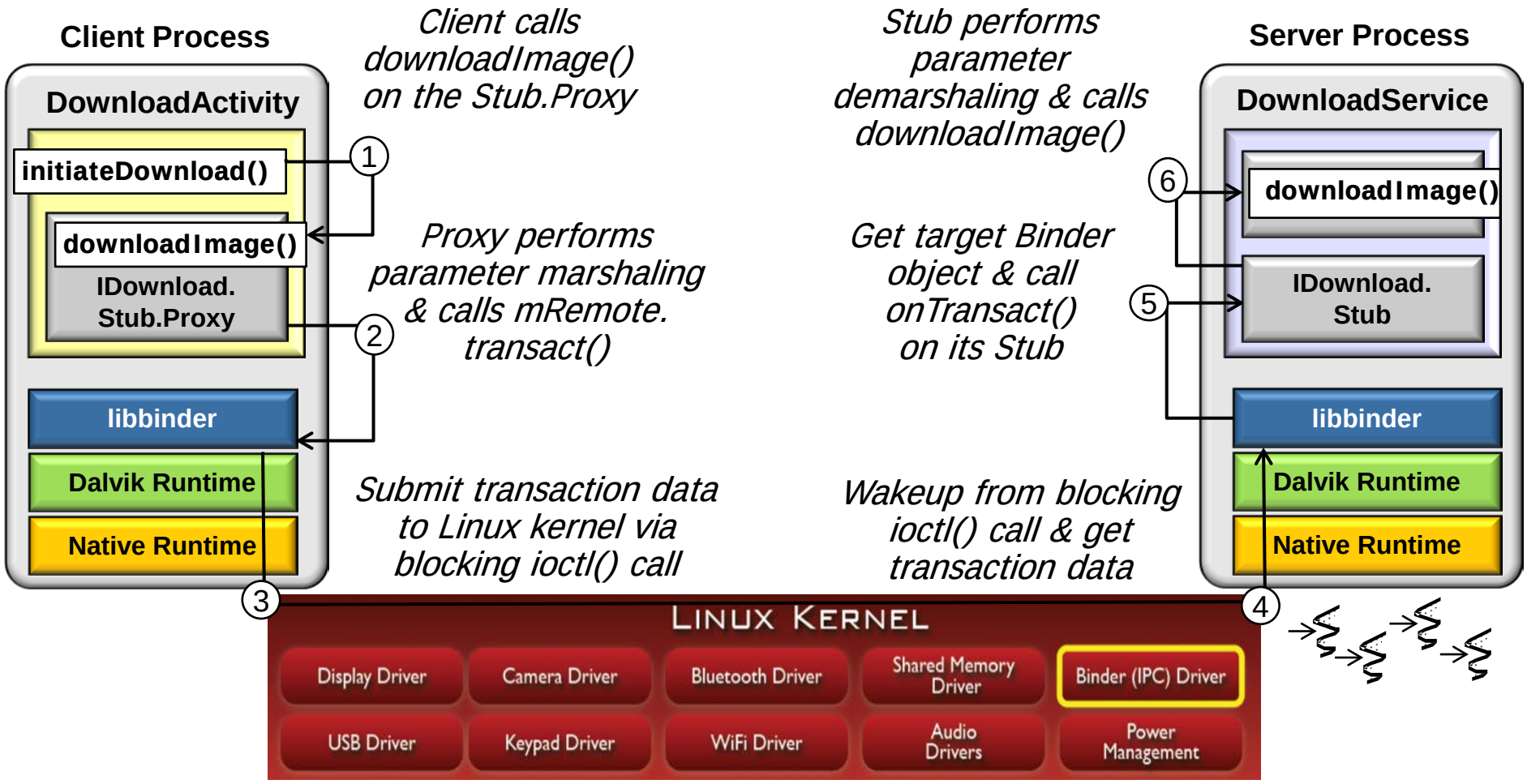
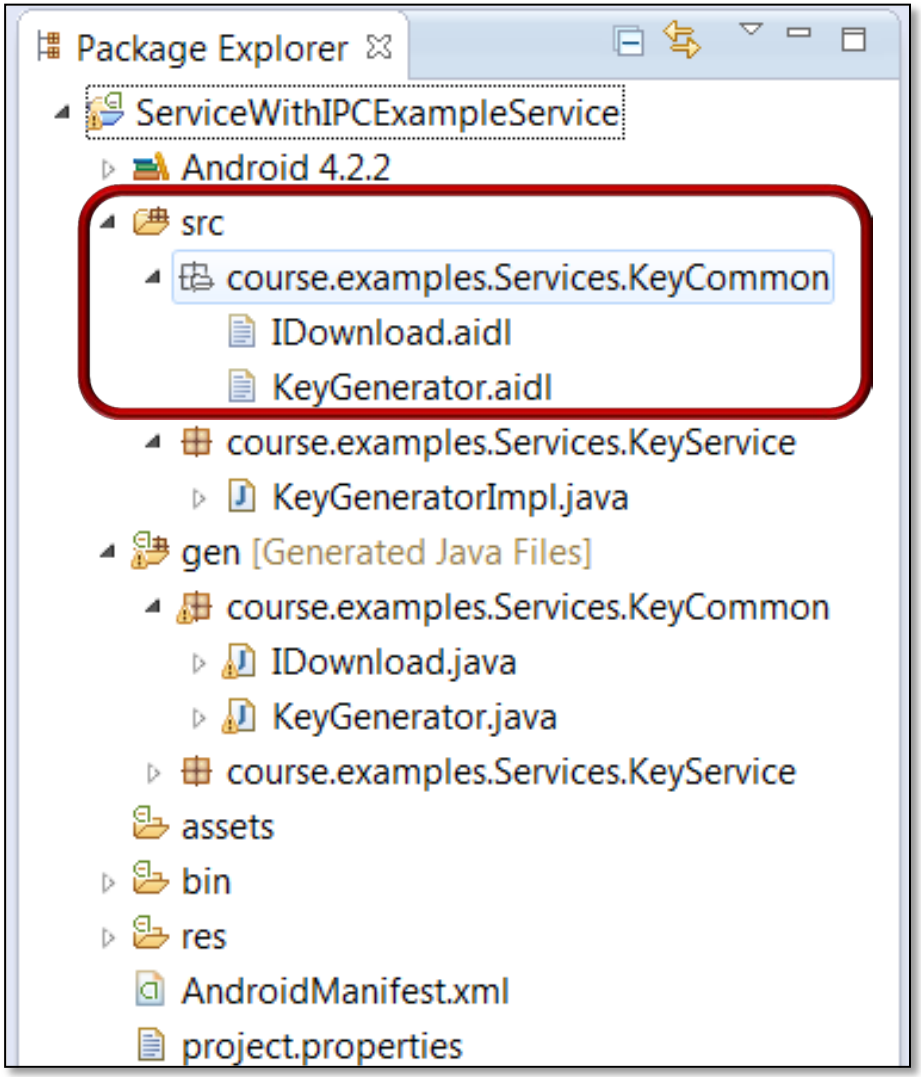
Learning Objectives in this Part of the Module

- Understand how to implement AIDL interfaces via Eclipse



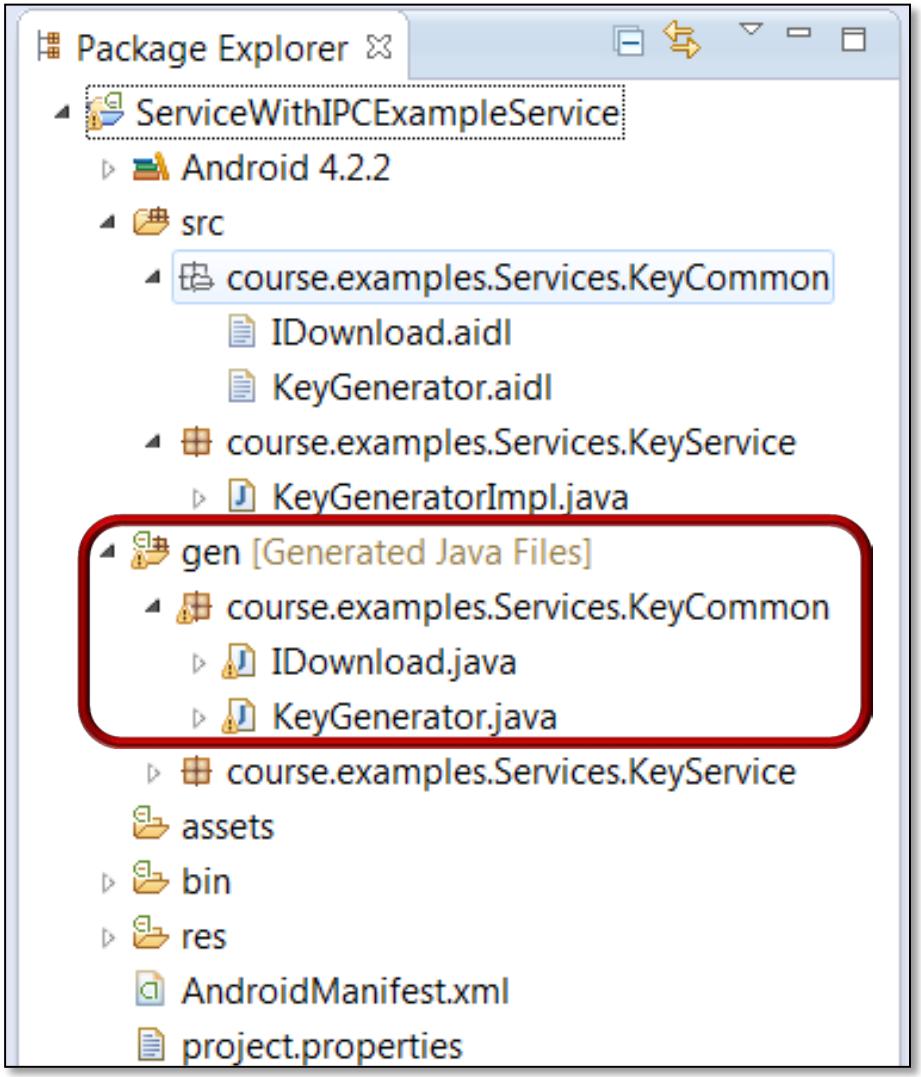
Developing with AIDL on Eclipse

- Each Binder-based service is defined in a separate .aidl file & saved in a **`src`** directory
  - Eclipse ADT automatically calls aidl for each .aidl file it finds in a **`src`** directory

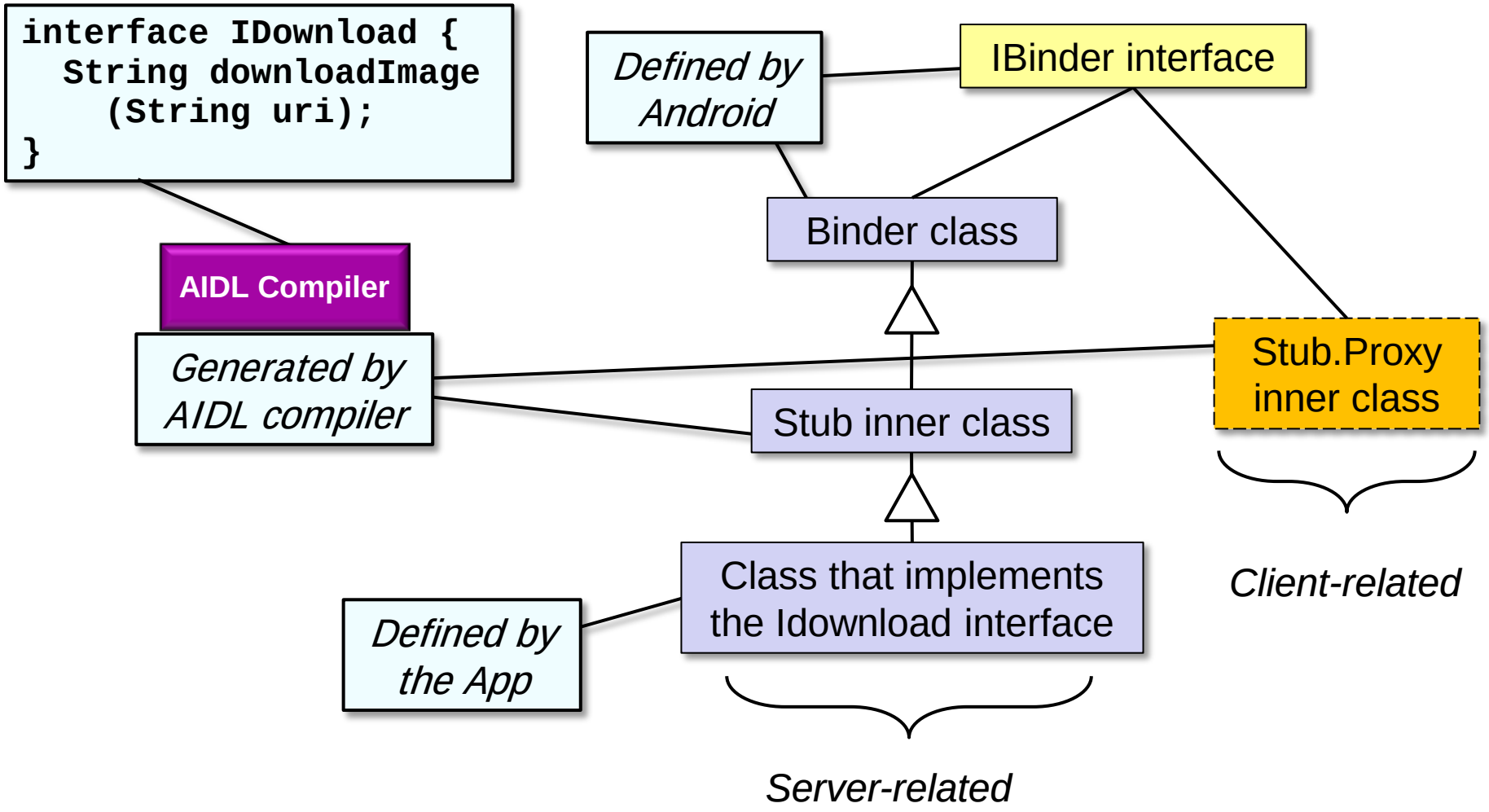


Developing with AIDL on Eclipse

- Each Binder-based service is defined in a separate .aidl file & saved in a `src` directory
- The Android aidl build tool extracts a real Java interface from each .aidl file & places it into a *.java file in the **gen** directory
  - This *.java file also contains
    - A generated Stub that extends Android's android.os.Ibinder
    - A Proxy that inherits from the AIDL interface



Structure of AIDL-based Solutions



Example of Generated Stub

```
public interface IDownload extends android.os.Iinterface {
  public static abstract class Stub extends android.os.Binder
                                    implements IDownload {

    public Stub() {
      this.attachInterface(this, DESCRIPTOR);
    }

    ...
```

Local-side IPC implementation class

Construct the stub & attach it to the interface

Example of Generated Stub

```
public interface IDownload extends android.os.Iinterface {
  public static abstract class Stub extends android.os.Binder
                                    implements IDownload {



  public static IDownload asInterface(android.os.IBinder obj) {
      if ((obj==null)) return null;
      android.os.IInterface iin = (android.os.IInterface)
        obj.queryLocalInterface(DESCRIPTOR);
      if (((iin != null) && (iin instanceof IDownload)))
        return ((IDownload)iin);
      return new IDownload.Stub.Proxy(obj);
    }

    ...
```

Cast an IBinder object into an IDownload interface, generating a proxy if needed

Example of Generated Proxy

```
public interface IDownload extends android.os.Iinterface {
  public static abstract class Stub ... {
    private static class Proxy implements IDownload {

      private android.os.IBinder mRemote;

      Proxy(android.os.IBinder remote) {
        mRemote = remote;
      }
      ...
```

Used by a client to call a remote method

Cache Binder for subsequent use by Proxy

This code fragment has been simplified a bit to fit onto the slide

Example of Generated Proxy

```
public interface IDownload extends android.os.Iinterface {
  public static abstract class Stub ... {
    private static class Proxy implements IDownload {
      ...

      public String downloadImage(String uri) ... {
        android.os.Parcel _data = android.os.Parcel.obtain();
        android.os.Parcel _reply = android.os.Parcel.obtain();
        java.lang.String _result;
        _data.writeInterfaceToken(DESCRIPTOR);
        _data.writeString(url);
        mRemote.transact(Stub.TRANSACTION_downloadImage, _data,
                         _reply, 0);
        _reply.readException();
        _result = _reply.readString();
        ...
        return _result;
   ...
```

Marshal the parameter, transmit to the remote object, & demarshal the result

This code fragment has been simplified a bit to fit onto the slide

Example of Generated Stub

```
public interface IDownload extends android.os.Iinterface {
  public static abstract class Stub extends android.os.Binder
                                    implements IDownload {

  public boolean onTransact(int code, android.os.Parcel data,
                            android.os.Parcel reply, int flags) ... {
    switch (code) {
    case TRANSACTION_downloadImage:
      data.enforceInterface(DESCRIPTOR);
      java.lang.String _arg0 = data.readString();
      java.lang.String _result = this.downloadImage(_arg0);
      reply.writeNoException();
      reply.writeString(_result);
      return true;
      ...
```

This method is dispatched by Binder RPC to trigger a callback on our downloadImage()

Demarshal the parameter, dispatch the upcall, & marshal the result

This code fragment has been simplified a bit to fit onto the slide

Implementing an AIDL Interface

- Given an auto-generated AIDL stub, you must implement certain methods

```
public interface IDownload extends android.os.Iinterface {
  public static abstract class Stub extends android.os.Binder
                                          implements IDownload {
    ...
    public String downloadImage(String uri)
                              throws android.os.RemoteException;
  }
}
```

  - Either implement downloadImage() directly in the stub or by forwarding the stub to some other implementation method

Implementing an AIDL Interface

- Given an auto-generated AIDL stub, you must implement certain methods
- Implementation steps:
  1. Create a private instance of AIDL-generated Stub class

```
public class DownloadService
             extends Service {
  private final IDownload.Stub
    binder = null;
  public void onCreate() {
    binder = new IDownload.Stub(){
      public String downloadImage
        (String uri)  {
         ...
      }
  };

  public IBinder onBind
                  (Intent intent)
  { return this.binder; }
}
```

Implementing an AIDL Interface

- Given an auto-generated AIDL stub, you must implement certain methods
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  1. Create a private instance of AIDL-generated Stub class
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Implementing an AIDL Interface

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- Implementation steps:
  1. Create a private instance of AIDL-generated Stub class
  2. Implement Java methods for each method in the AIDL file
  3. Return this private instance from your onBind() method in the Service subclass

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             extends Service {
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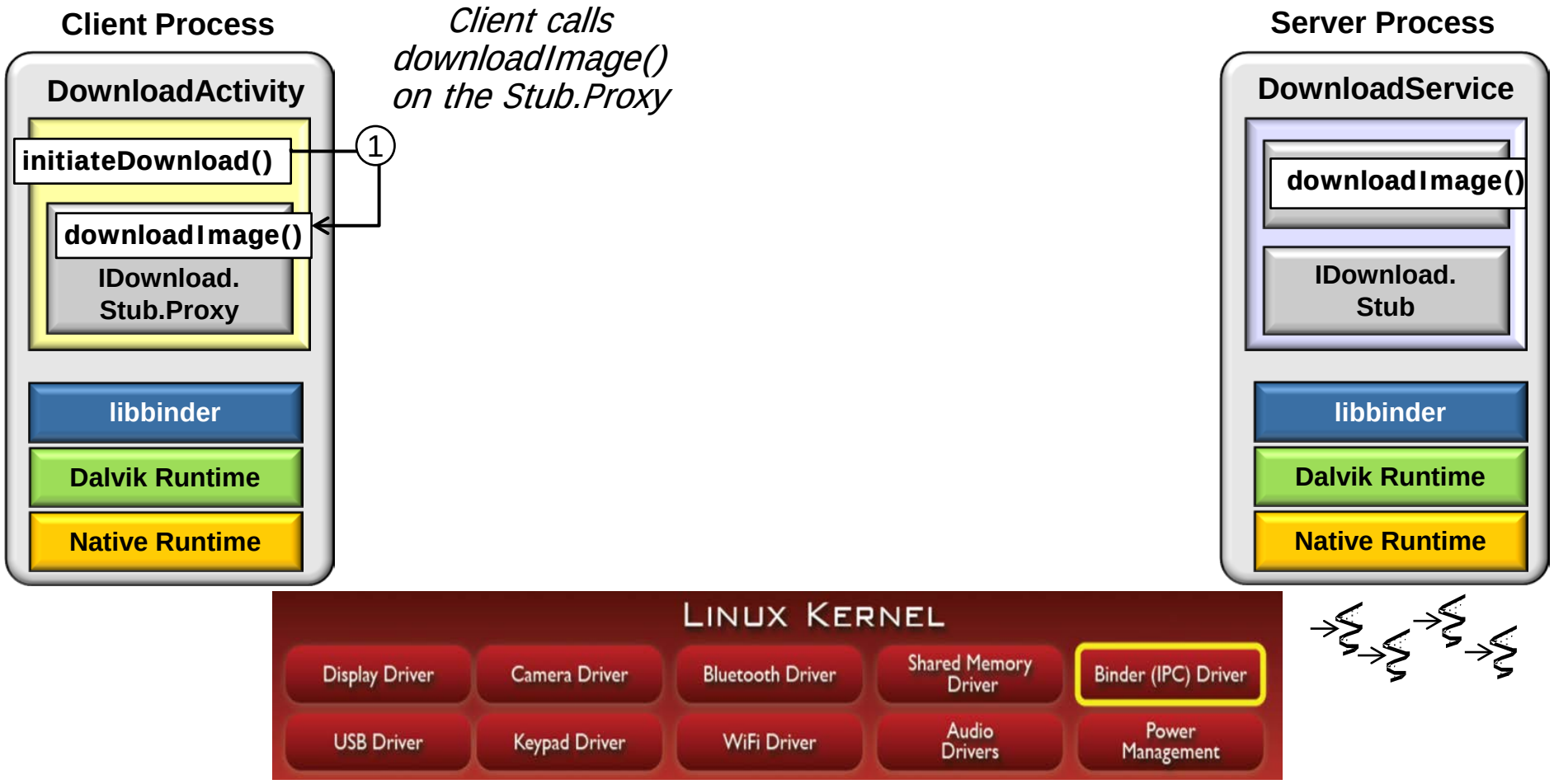
Putting the Pieces Together End-to-End



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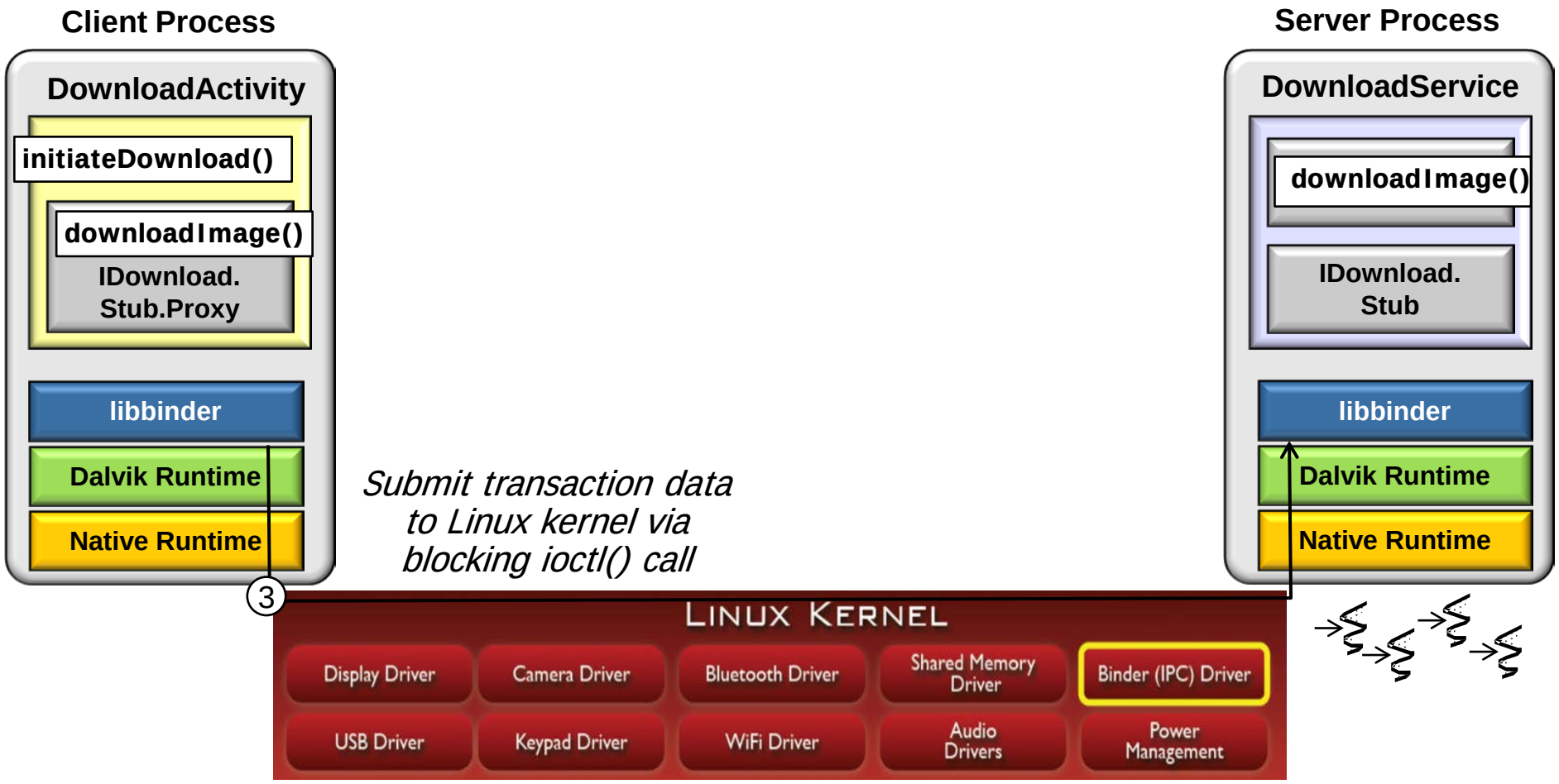

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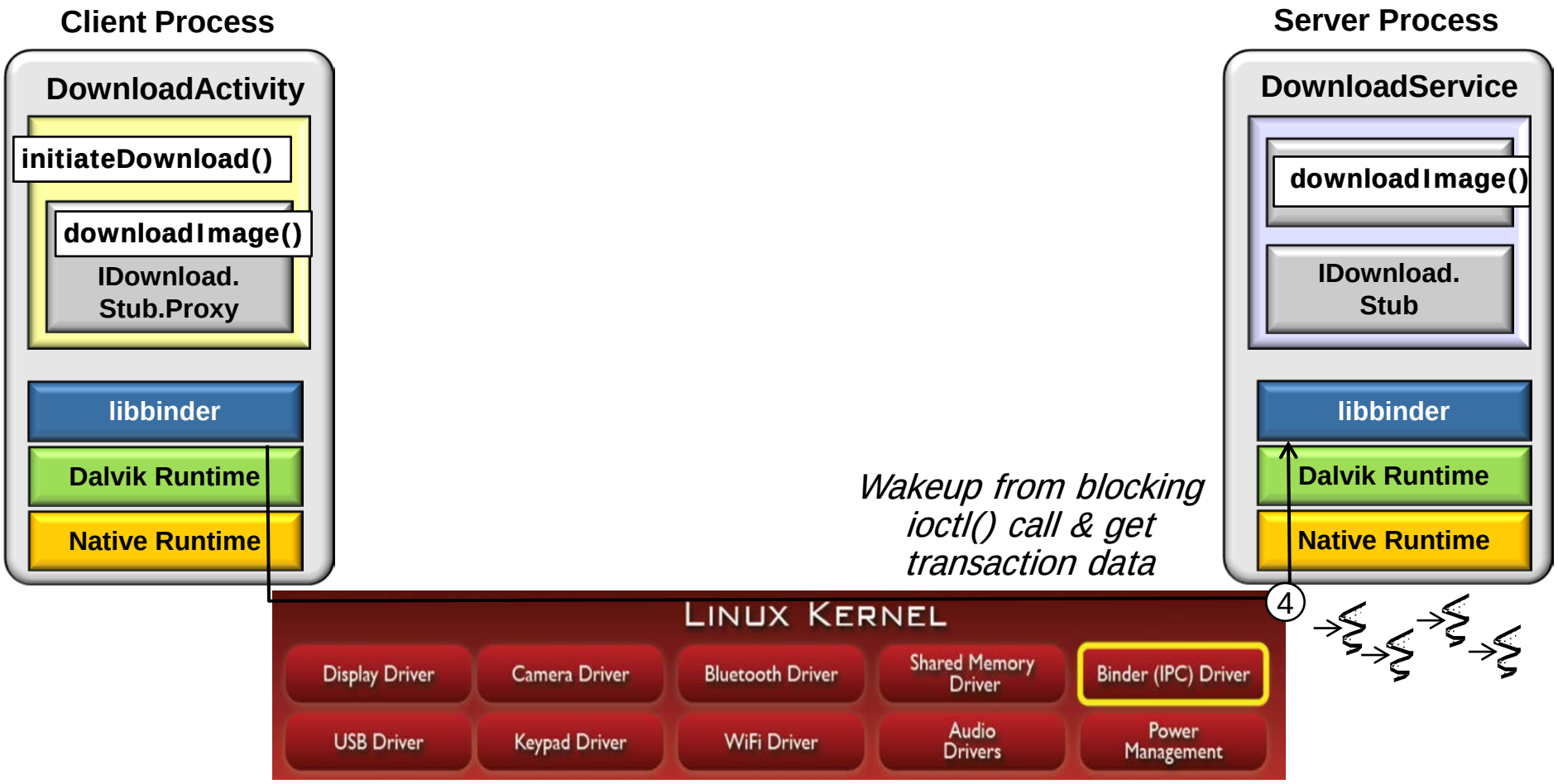

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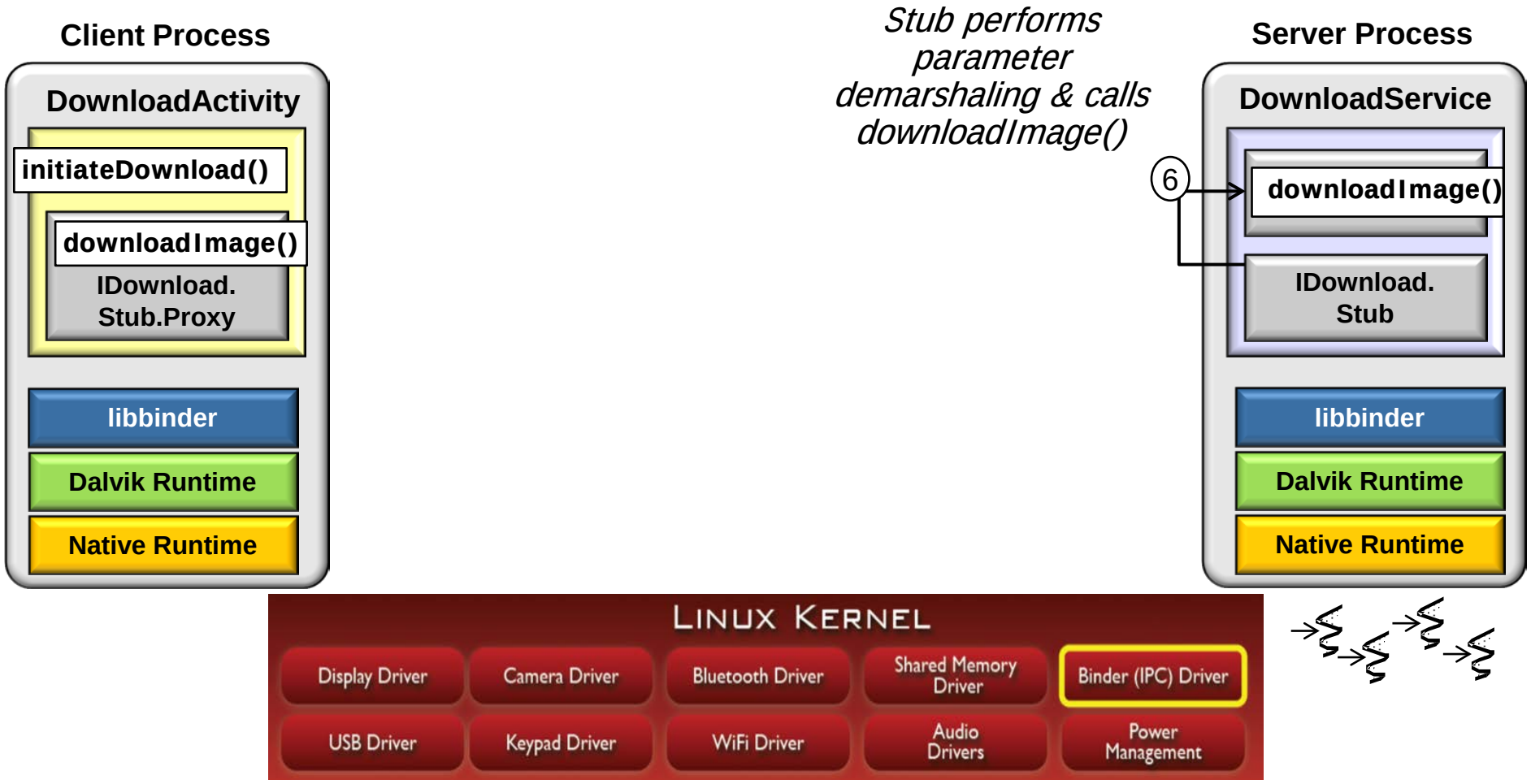

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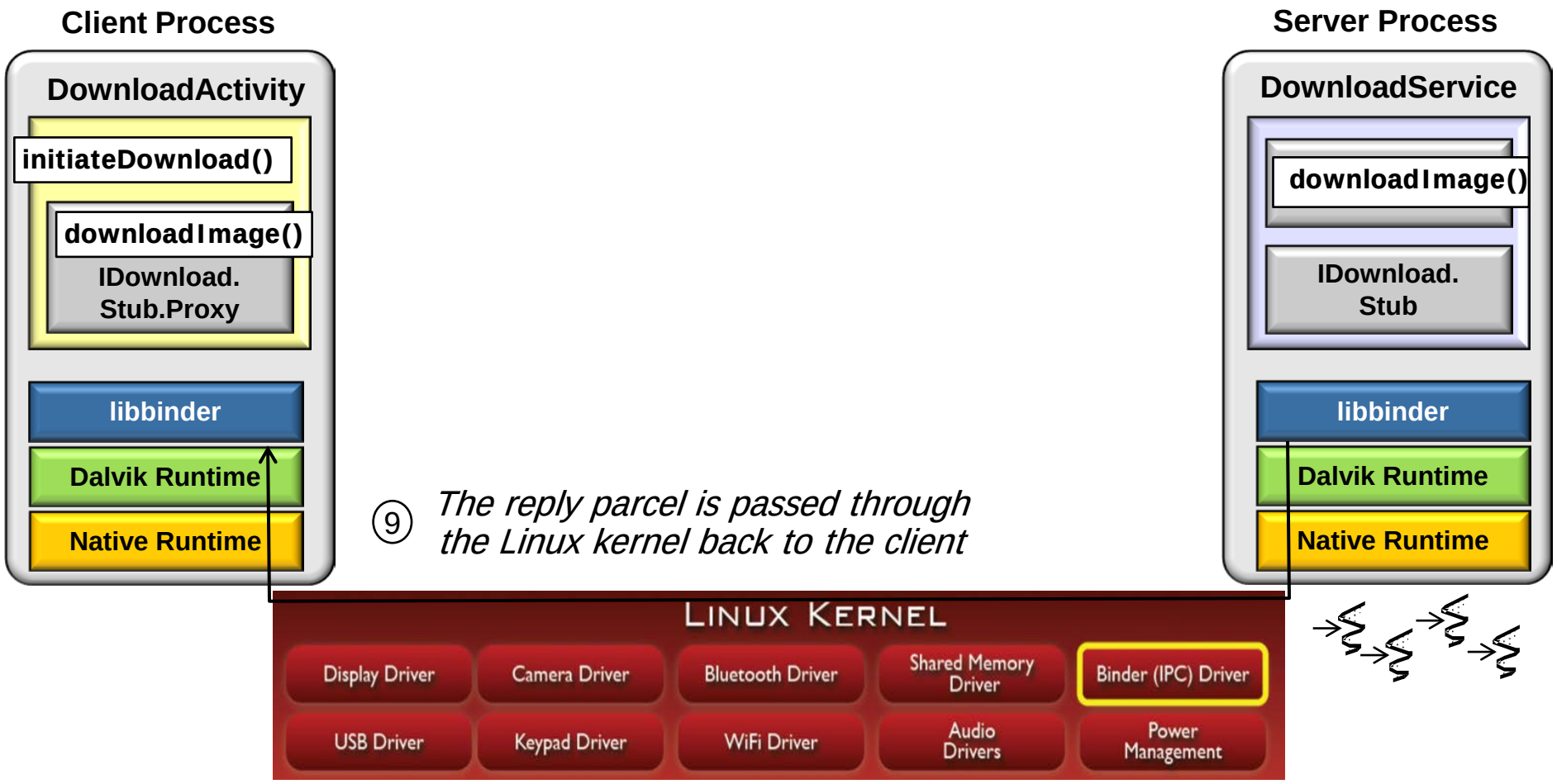

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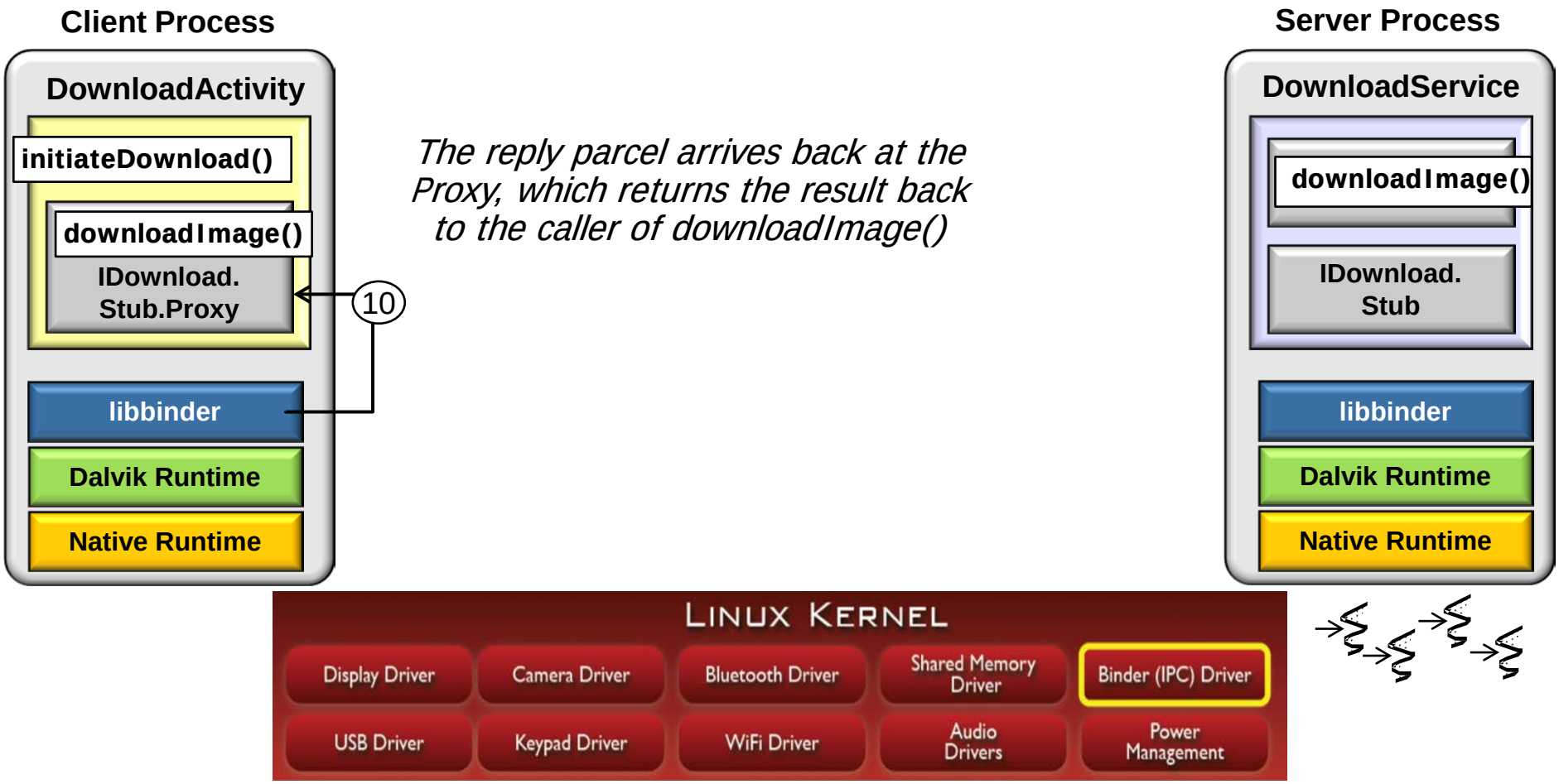
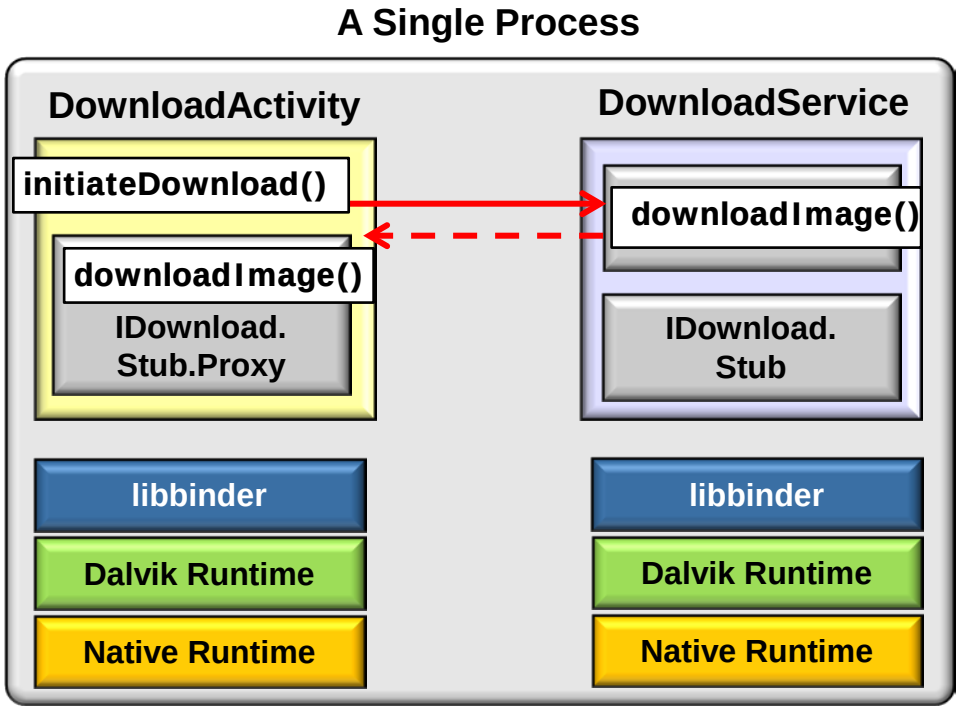


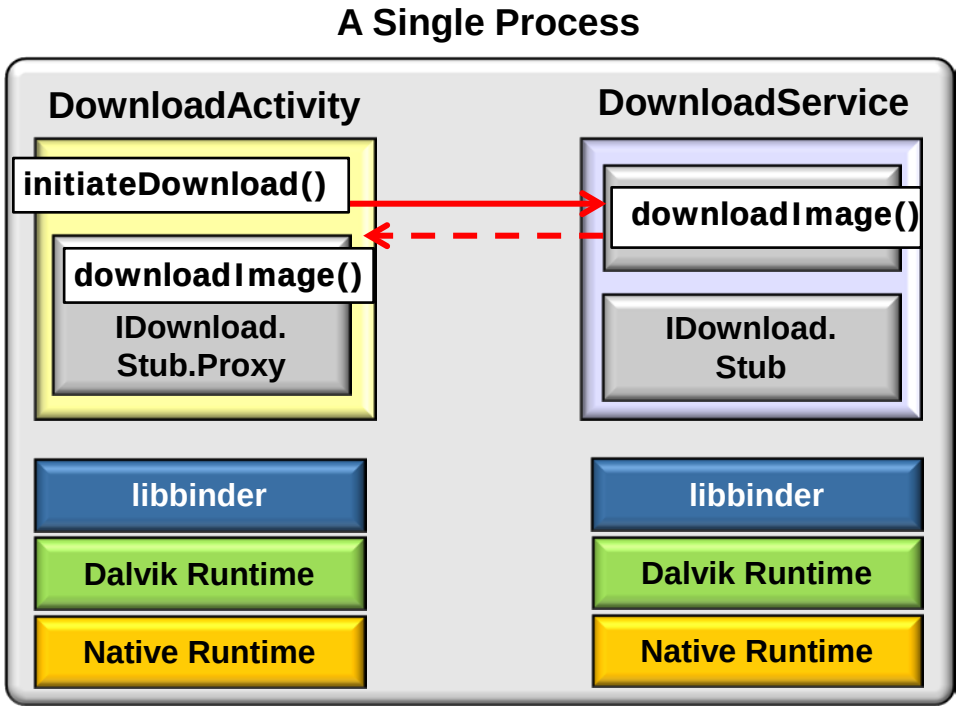
AIDL & Binder RPC Call Semantics

- Calls made from a local process are executed in the same thread that makes the call
  - If this is the main UI thread, that thread continues to execute in the AIDL interface



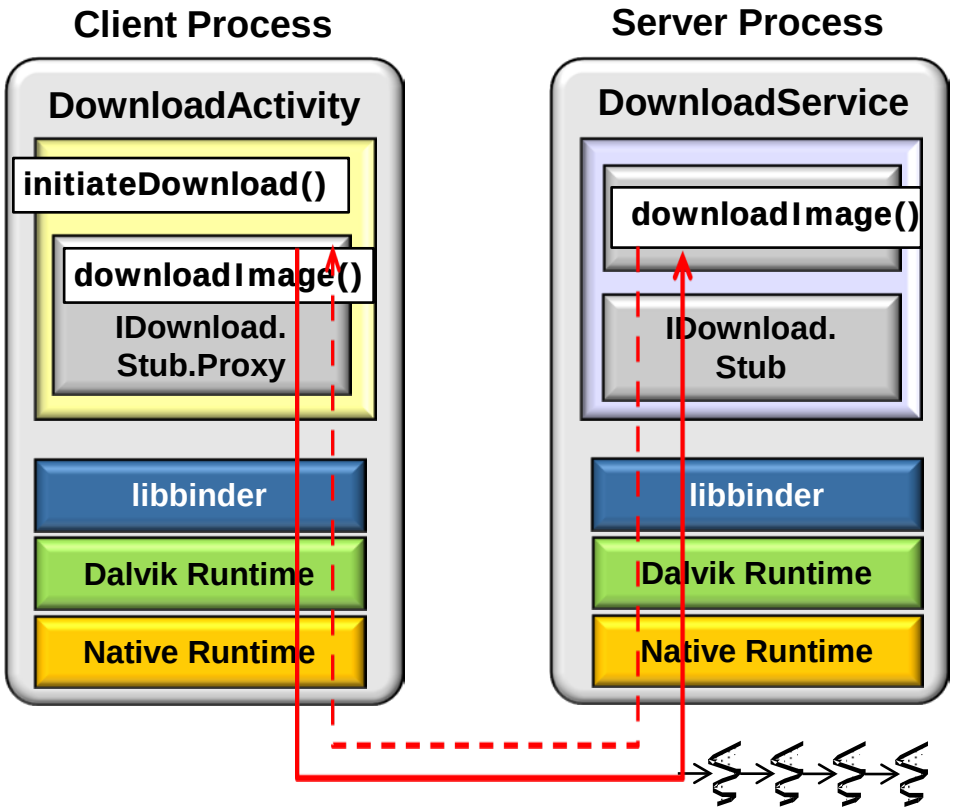
AIDL & Binder RPC Call Semantics

- Calls made from a local process are executed in the same thread that makes the call
  - If this is the main UI thread, that thread continues to execute in the AIDL interface
  - If it is another thread, that is the one that executes the code in the Service



AIDL & Binder RPC Call Semantics

- Calls made from a local process are executed in the same thread that makes the call
- Calls from a remote process are dispatched from a thread pool the platform maintains inside of a process
  - An implementation of an AIDL interface must therefore be completely thread-safe



AIDL & Binder RPC Call Semantics

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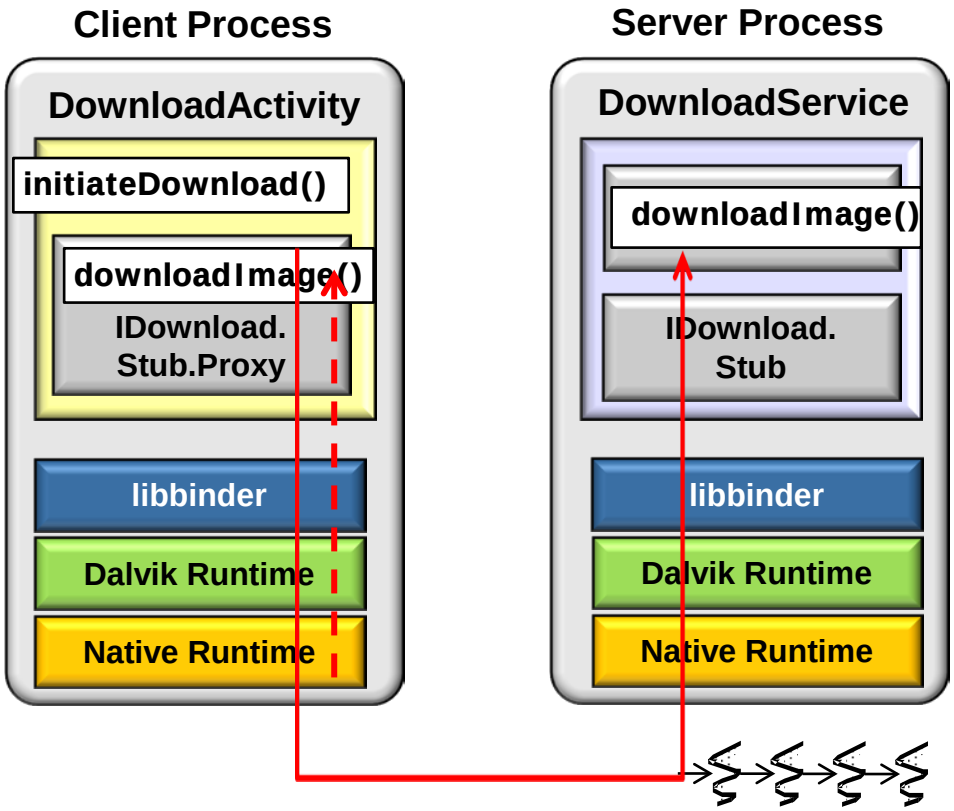
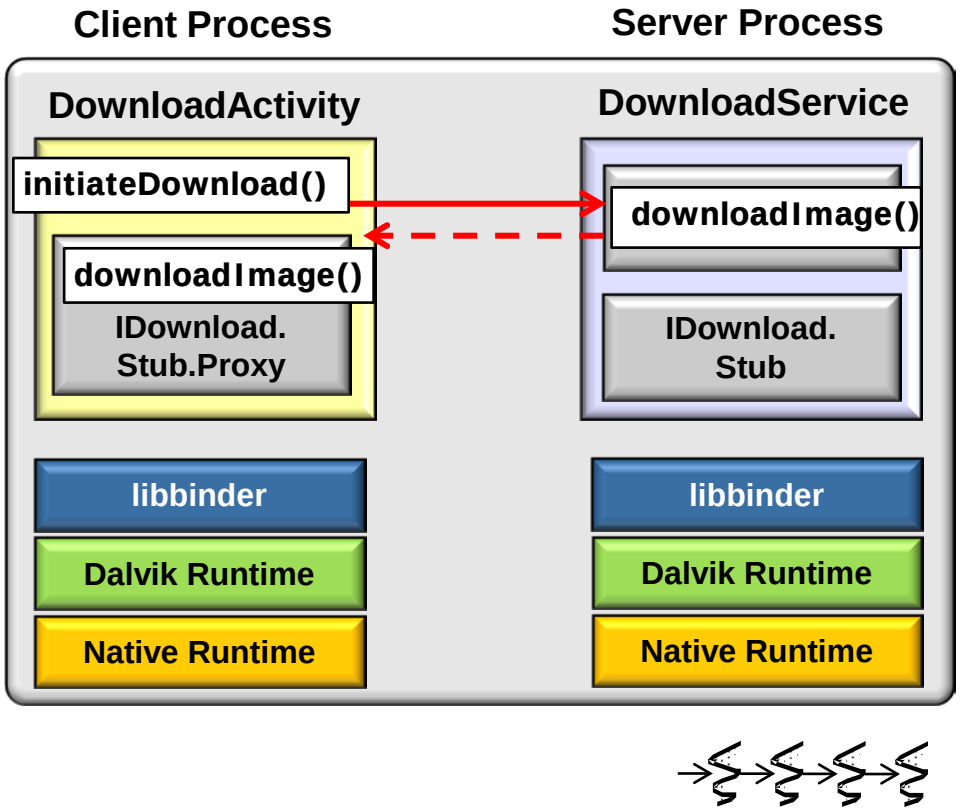
- Calls from a remote process are dispatched from a thread pool the platform maintains inside of a process
- The **oneway** keyword modifies the behavior of remote calls
  - When used, a remote call does not block—it simply sends the transaction data & returns immediately



AIDL & Binder RPC Call Semantics

- Calls made from a local process are executed in the same thread that makes the call
- Calls from a remote process are dispatched from a thread pool the platform maintains inside of a process
- The **oneway** keyword modifies the behavior of remote calls
  - When used, a remote call does not block—it simply sends the transaction data & returns immediately
  - If **oneway** is used with a local call, the call is still synchronous
    - But no results are returned



Summary

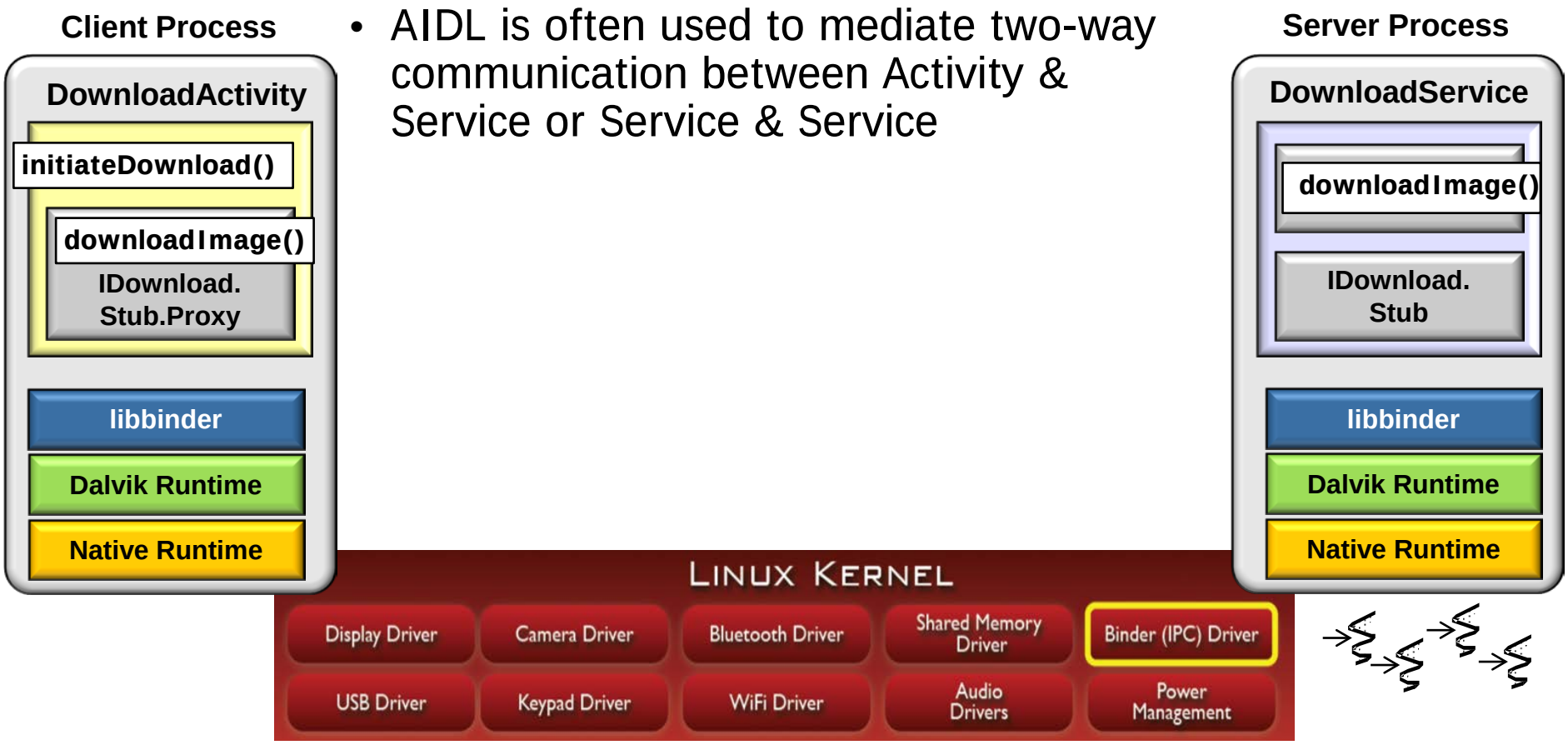
- AIDL is an interface definition language used to generate code that enables two processes on an Android device to interact using IPC
  - If code in a process calls methods on an object in another process, AIDL can generate code to (de)marshal parameters passed between processes

Summary

- AIDL is an interface definition language used to generate code that enables two processes on an Android device to interact using IPC
- AIDL is interface-based, similar to CORBA & Java, but lighter weight
  - It uses a proxy to pass values between a client & Bound Service

Summary

- AIDL is an interface definition language used to generate code that enables two processes on an Android device to interact using IPC
- AIDL is interface-based, similar to CORBA, but lighter weight
- There are hundreds of *.aidl files used in Android
- AIDL is often used to mediate two-way communication between Activity & Service or Service & Service



Android Services & Local IPC: Advanced Bound Service Communication – Programming Apps with AIDL

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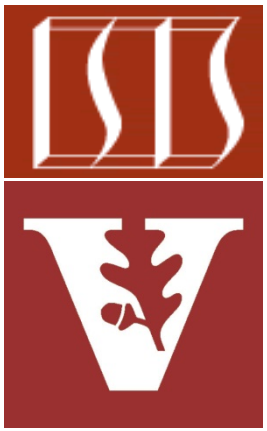

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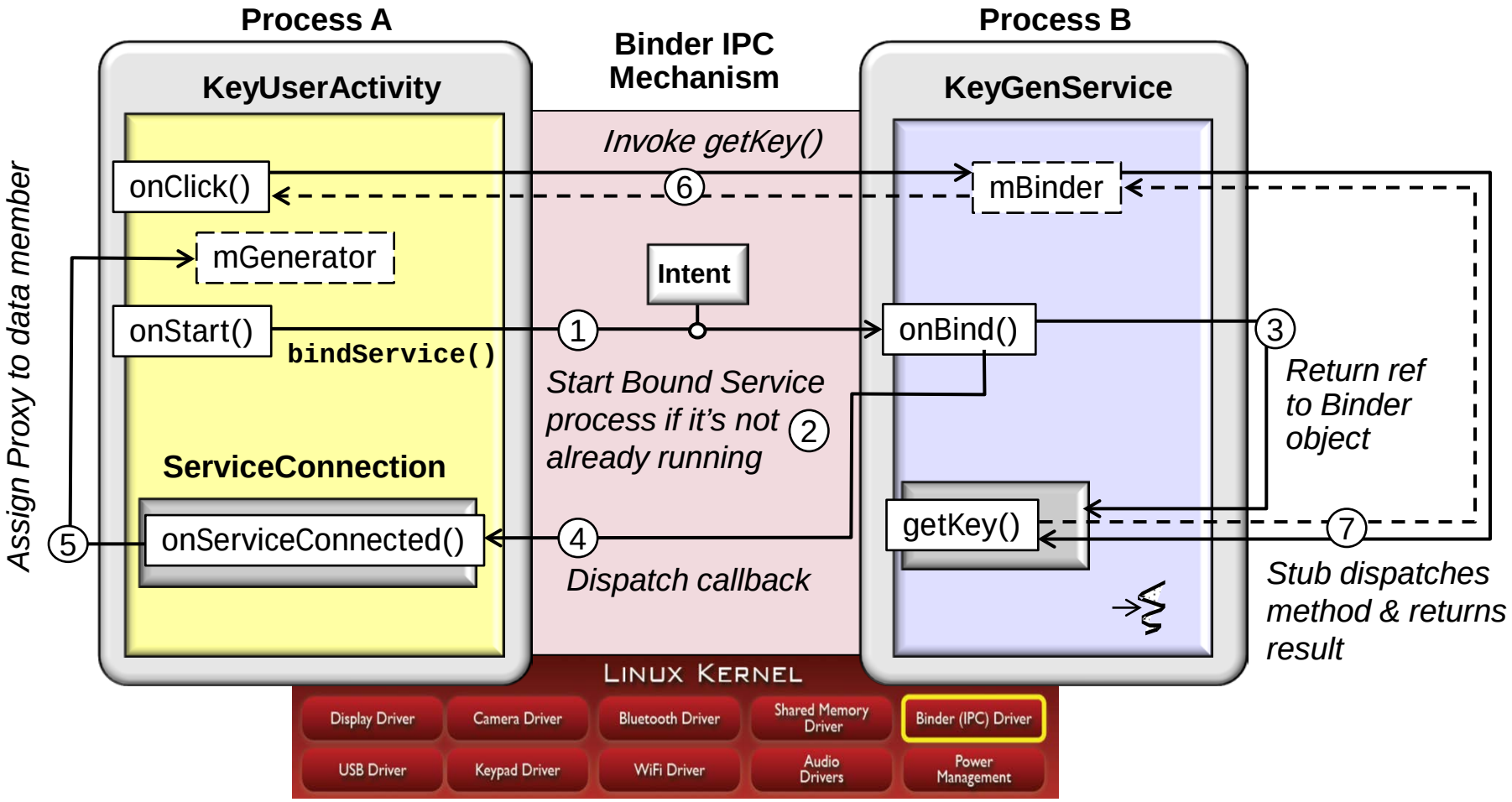
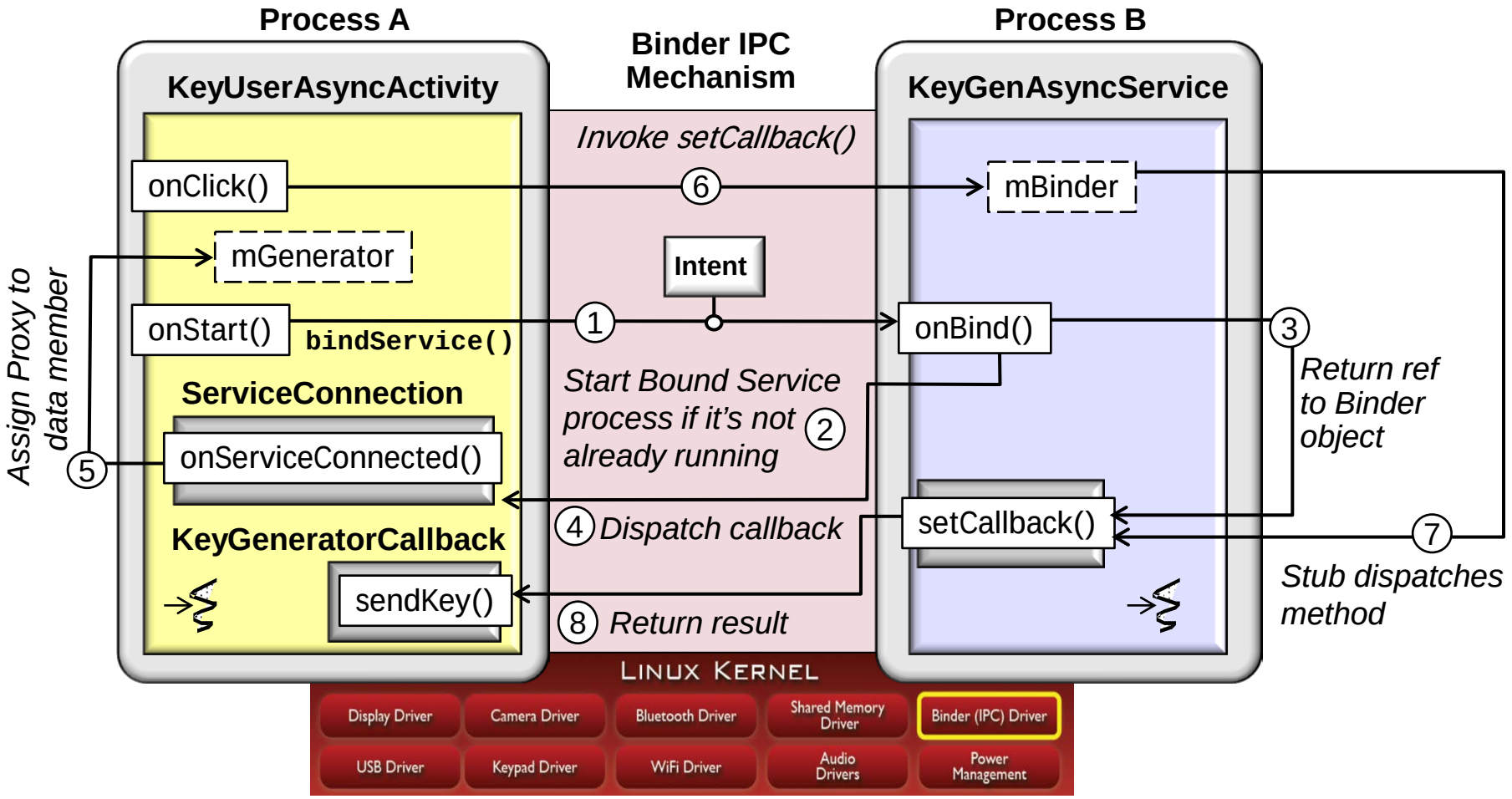
Learning Objectives in this Part of the Module

- Understand how to program an App using AIDL & Bound Services
  - Both synchronous



Learning Objectives in this Part of the Module

- Understand how to program an App using AIDL & Bound Services
  - Both synchronous & asynchronous



ID Service via Synchronous AIDL

- Client uses a “Bound Service” hosted in another App
  - Requires IPC via AIDL & the Android Binder RPC mechanism

ID Service via Synchronous AIDL

- Client uses a "Bound Service" hosted in another App
- Client needs an ID from service

ID Service via Synchronous AIDL

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- Overall structure of this solution is similar to the Messenger solution presented earlier
  - Main difference is that the AIDL calls are synchronous, statically typed, & thread-safe, whereas the Messenger calls are asynchronous, dynamically typed, & sequential

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- Overall structure of this solution is similar to the Messenger solution presented earlier
  - Main difference is that the AIDL calls are synchronous, statically typed, & thread-safe, whereas the Messenger calls are asynchronous, dynamically typed, & sequential
  - We'll also show an asynchronous AIDL example shortly

Define a Remote Interface

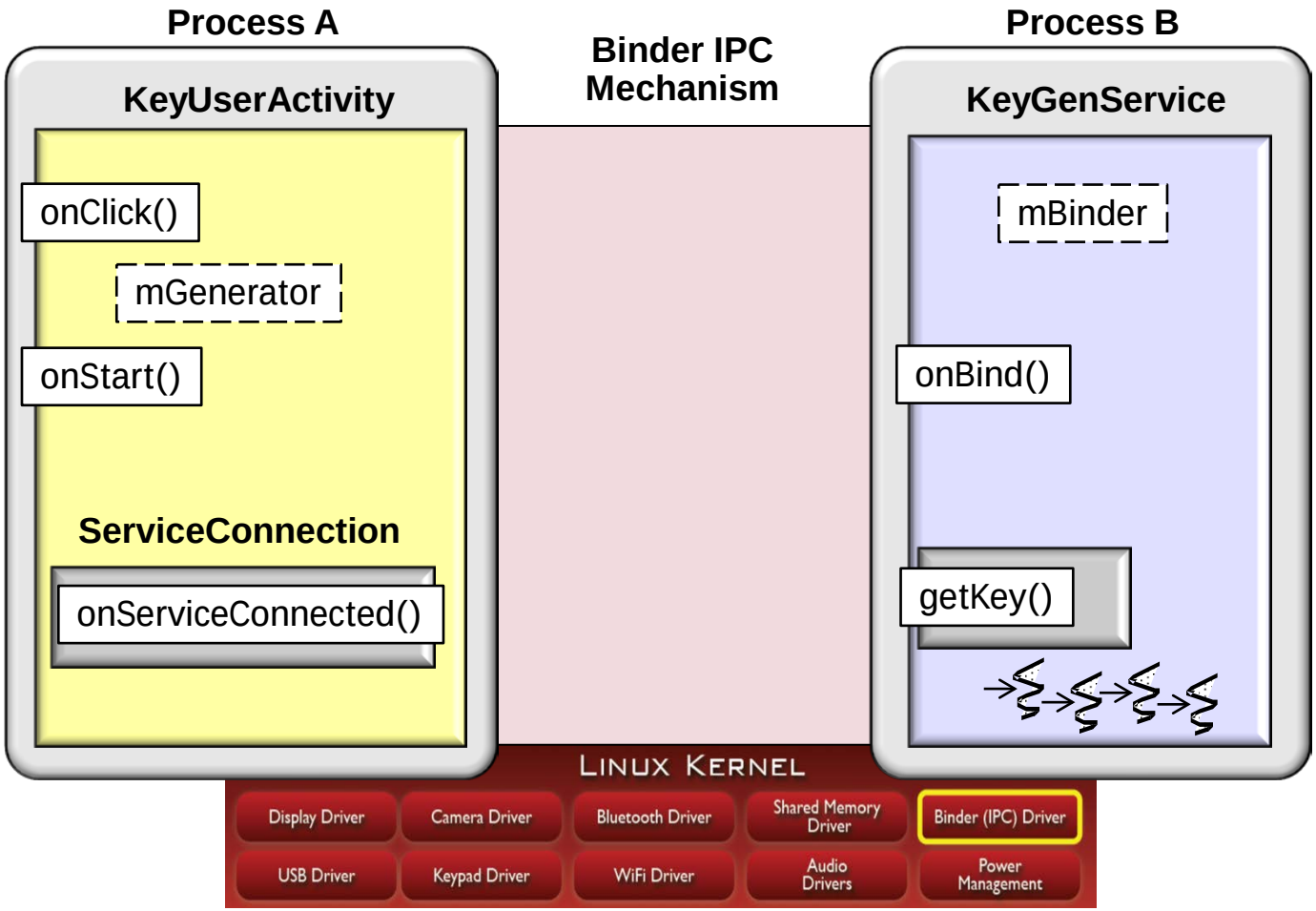
- Declare interface in an .aidl file

```
package course.examples.
        Services.KeyCommon;

interface KeyGenerator {
    String getKey();
}
```

Using a Synchronous AIDL in a Bound Service

- Enables synchronous interaction between an Activity & a Bound Service using AIDL & Binder RPC



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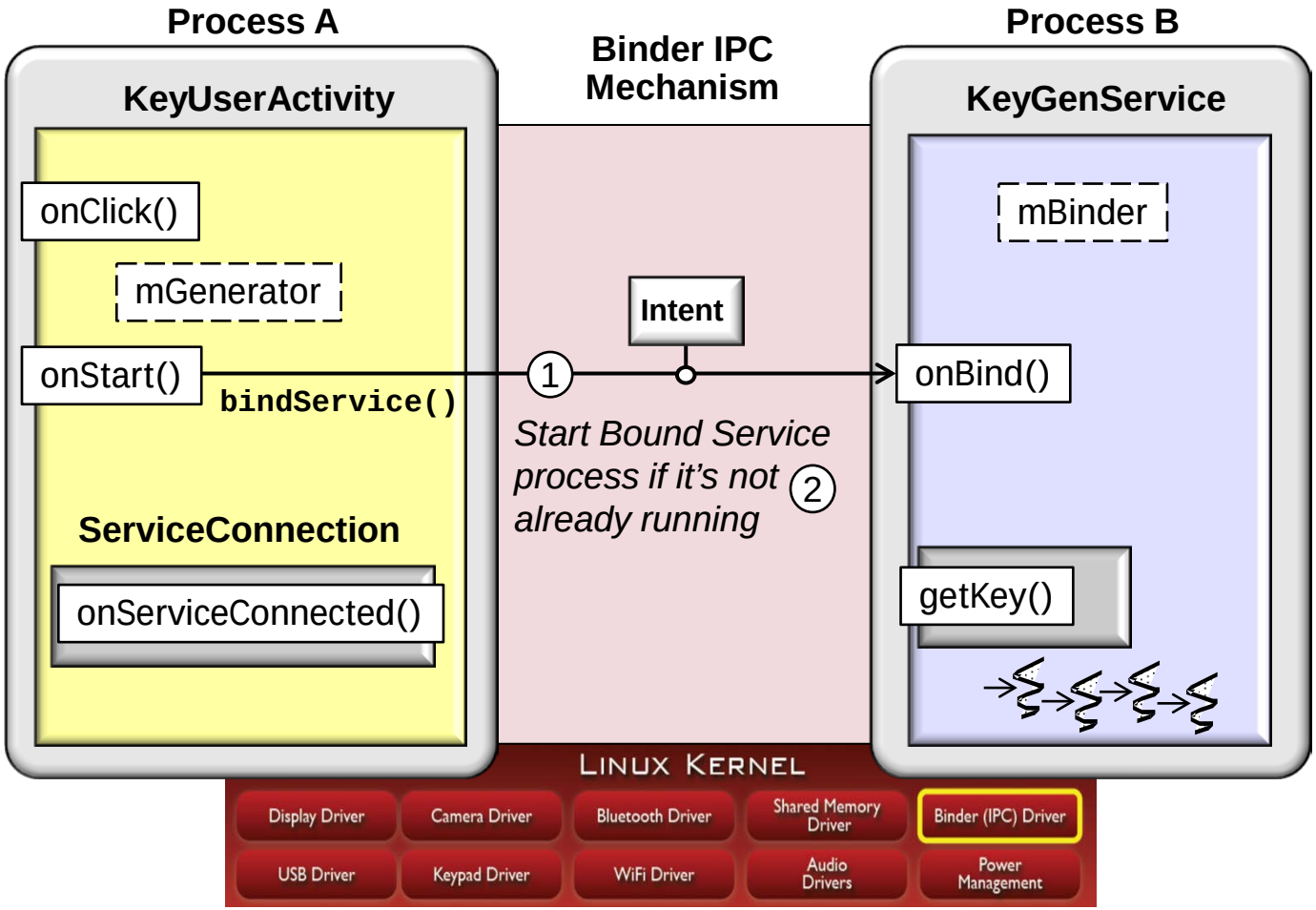

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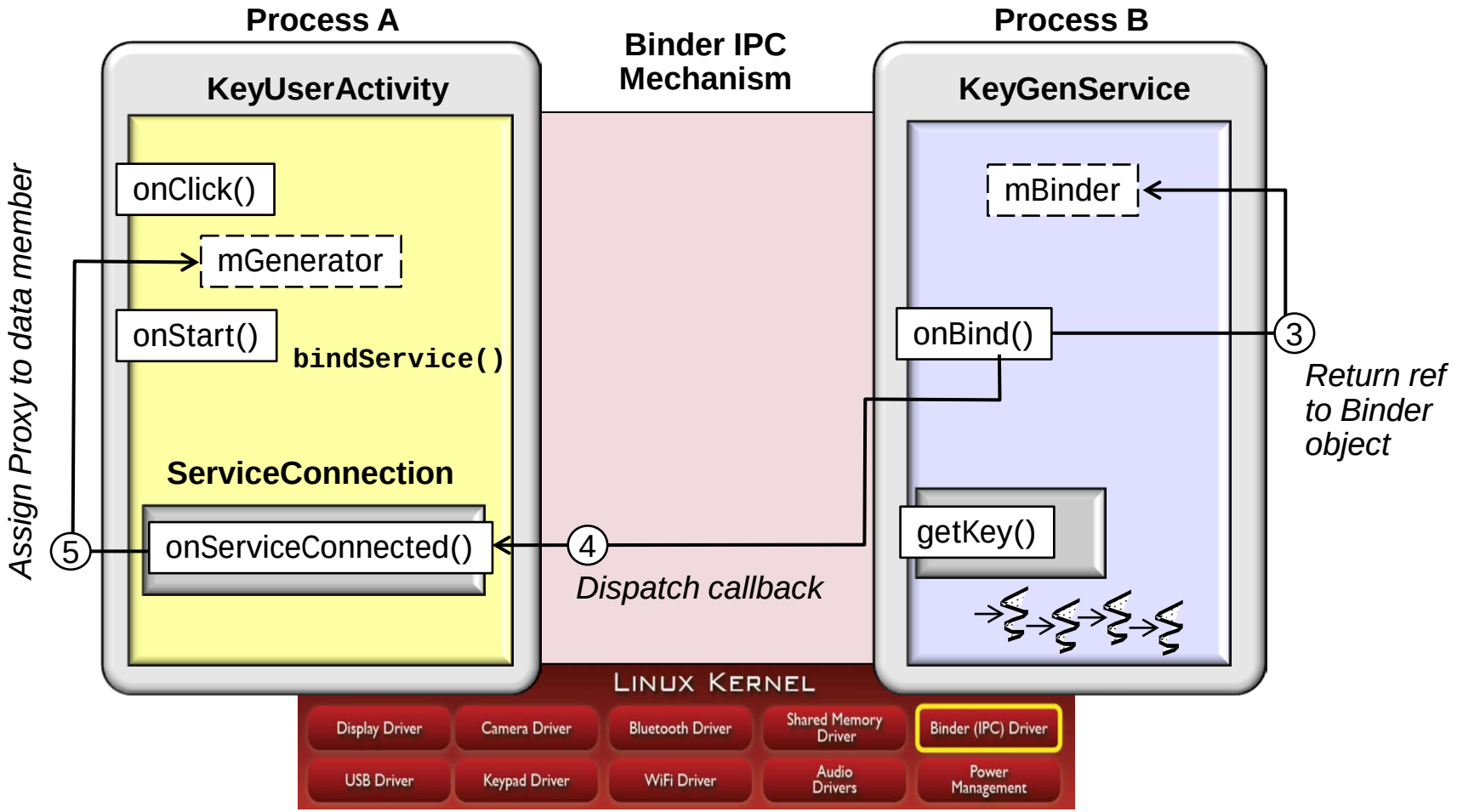

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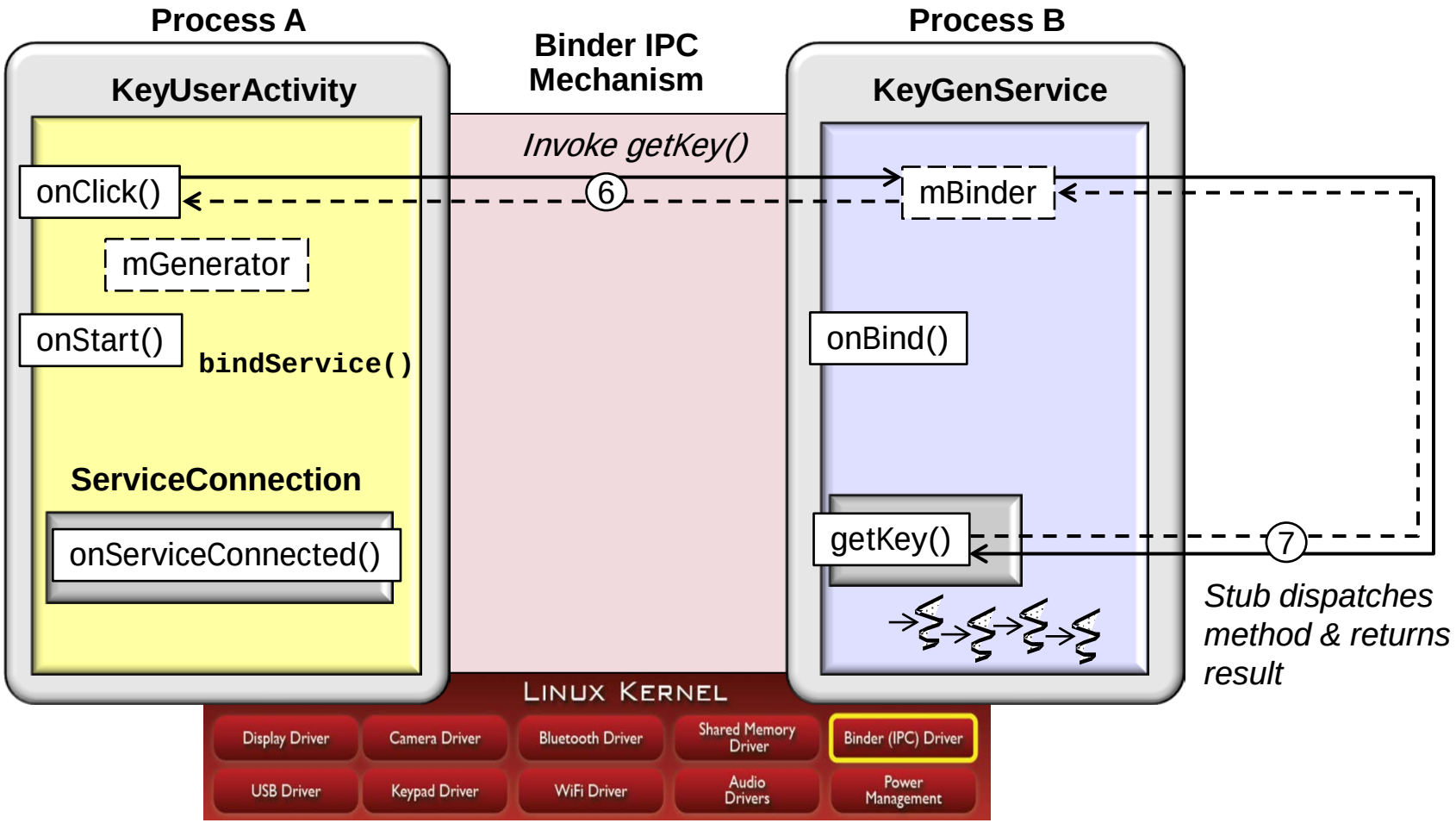
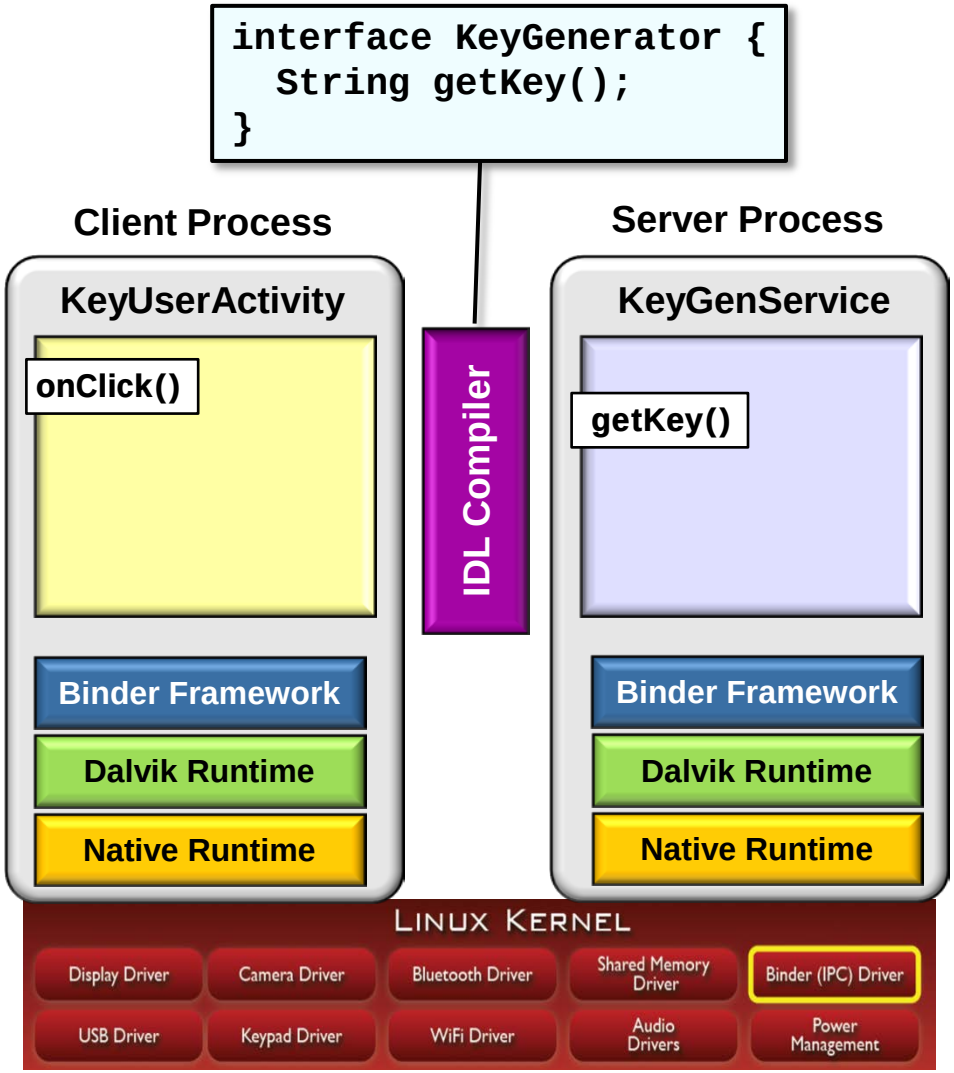


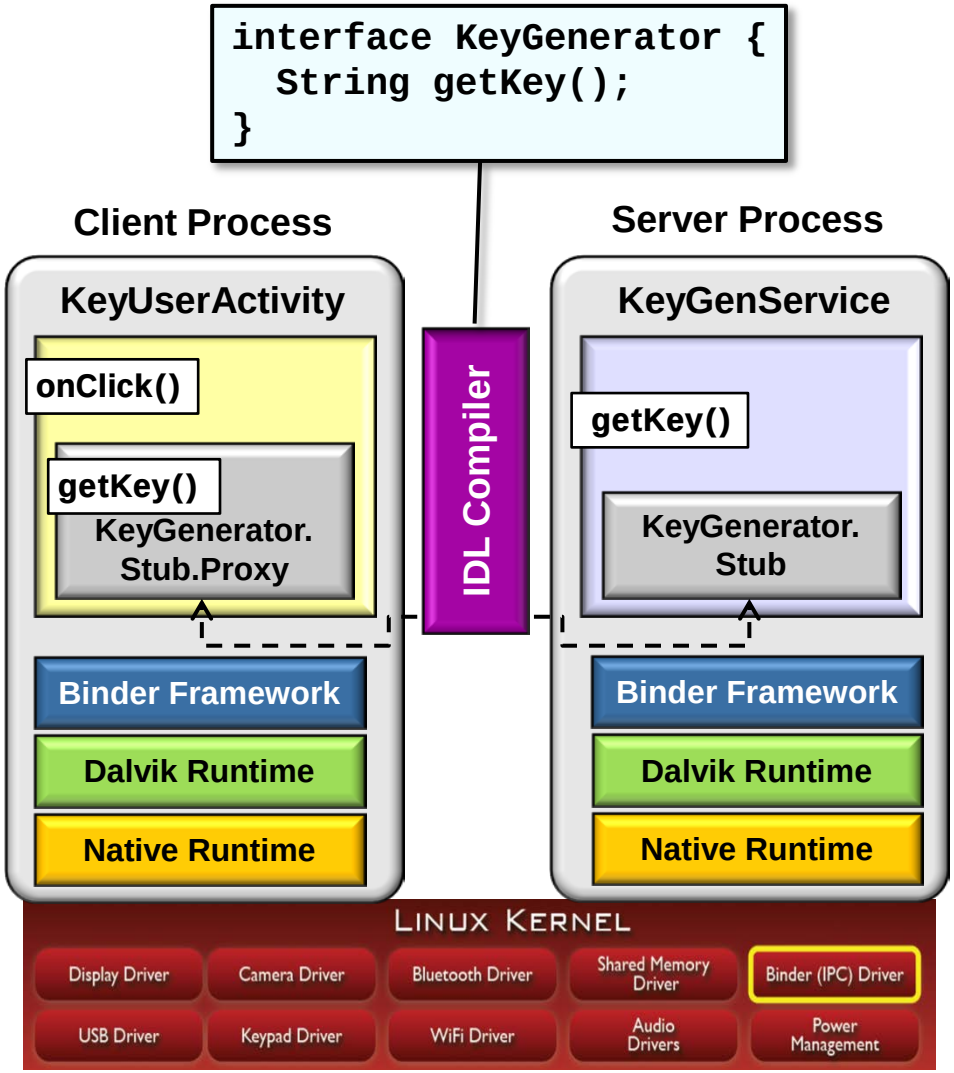
Compile .aidl File to Generate Stub & Proxy

- Generate a Java interface with same name as .aidl file
  - Eclipse does this automatically



Compile .aidl File to Generate Stub & Proxy

- Generate a Java interface with same name as .aidl file
- Generated interface contains:
  - Abstract inner class called Stub & a Proxy class
  - Interface & helper methods



Implement Remote Methods

```
public class KeyGenService extends Service {
  private Set<UUID> keys = new HashSet<UUID>();

  private final KeyGenerator.Stub mBinder =
                                        new KeyGenerator.Stub() {
    public String getKey() {
      UUID id;
      synchronized (keys) {

        do { id = UUID.randomUUID(); } while (keys.contains(id));
        keys.add(id);
      }
      return id.toString();
    }
  };

  public IBinder onBind(Intent intent) { return this.mBinder; }
}
```

Unique set of keys

Generate unique ID in a thread-safe manner & return it

Return reference to the Binder object

Implement the ID Client Activity

```
public class KeyUserActivity extends Activity {
  private KeyGenerator mGenerator;
  private boolean mBound;

  private ServiceConnection connection =
                                      new ServiceConnection() {
    public void onServiceConnected(ComponentName className,
                                   IBinder iBinder) {
      mGenerator = KeyGenerator.Stub.asInterface(iBinder);
      mBound = true;
    }
     ...

    public void onServiceDisconnected(ComponentName className){
      mGenerator = null; mBound = false;
    }
  };
```

Local state

Remote Service callback methods

Proxy to the remote Bound Service

Implement the ID Client Activity

```
public class KeyUserActivity extends Activity {
  ...
  protected void onStart() {
    super.onStart();

    Intent intent = new Intent(KeyGenService.class.getName());
    bindService(intent,this.connection,
                       Context.BIND_AUTO_CREATE);
  }


  protected void onStop() {
    if (mBound) unbindService(this.connection);
    super.onStop();
  }
}
```

Use name of KeyGenService as an ACTION

Bind to Service

Unbind from Service

Implement the ID Client Activity

```
public class KeyUserActivity extends Activity {
  TextView output; ...
  public void onCreate(Bundle icicle) {
    ...
    output = (TextView)findViewById(R.id.output);
    final Button goButton = (Button)findViewById(R.id.go_button);

    goButton.setOnClickListener(new OnClickListener() {
      public void onClick(View v) {
        try {

          if (bound)
            output.setText(mGenerator.getKey());

        } catch (RemoteException e) {}
      }
     });
}
```

Set the click handler

Invoke two-way (blocking) remote method

Service AndroidManifest.xml

- The Service AndroidManifest.xml file must be registered with Android before the client Activity tries to run

```
<manifest ... package="course.examples.Services.KeyGenService">
   <application "...">
      <service android:name=".KeyGenService"
               android:exported="true">
         <intent-filter>
            <action android:name=
             "course.examples.Services.KeyGenService"/>
         </intent-filter>
      </service>
    </application>
</manifest>
```

Use name of the Service as a filter!

Client AndroidManifest.xml

- The client Activity AndroidManifest.xml file has the typical format

```
<manifest ... package="course.examples.Services.KeyClient">
   <application "...">
      <activity android:name=".KeyUser" ...>
         <intent-filter>
            <action android:name=
                  "android.intent.action.MAIN" />
             <category android:name=
                  "android.intent.category.LAUNCHER" />
          </intent-filter>
      </activity>
   </application>
</manifest>
```

ID Service via Asynchronous AIDL

- Client uses a “Bound Service” hosted in another App
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ID Service via Asynchronous AIDL

- Client uses a “Bound Service” hosted in another App
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ID Service via Asynchronous AIDL

- Client uses a "Bound Service" hosted in another App
- Client needs an ID from service
- Overall structure of this solution is similar to the AIDL solution presented earlier
  - Main difference is that the AIDL calls in this example are one-way asynchronous
    - In contrast, the previous AIDL example calls are two-way synchronous

ID Service via Asynchronous AIDL

- Client uses a "Bound Service" hosted in another App
- Client needs an ID from service
- Overall structure of this solution is similar to the AIDL solution presented earlier
  - Main difference is that the AIDL calls in this example are one-way asynchronous
  - This solution is also similar to the asynchronous Messenger example
    - The main difference is that the calls are statically typed, more "stylized," & multi-threaded

Define Two Remote Interfaces

- Declare interface in two .aidl files since you can't define more than one interface in each *.aidl file

KeyGeneratorCallback.aidl

```
package course.examples.Services.KeyCommon;

interface KeyGeneratorCallback {
   oneway void sendKey(in String key);
}
```

KeyGenerator.aidl

```
package course.examples.Services.KeyCommon;

import course.examples.Services.KeyCommon.KeyGeneratorCallback;

interface KeyGenerator {
  oneway void setCallback(in KeyGeneratorCallback callback);
}
```

Define Two Remote Interfaces

- Declare interface in two .aidl files since you can't define more than one interface in each *.aidl file

KeyGeneratorCallback.aidl

```
package course.examples.Services.KeyCommon;

interface KeyGeneratorCallback {
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```

KeyGenerator.aidl

```
package course.examples.Services.KeyCommon;

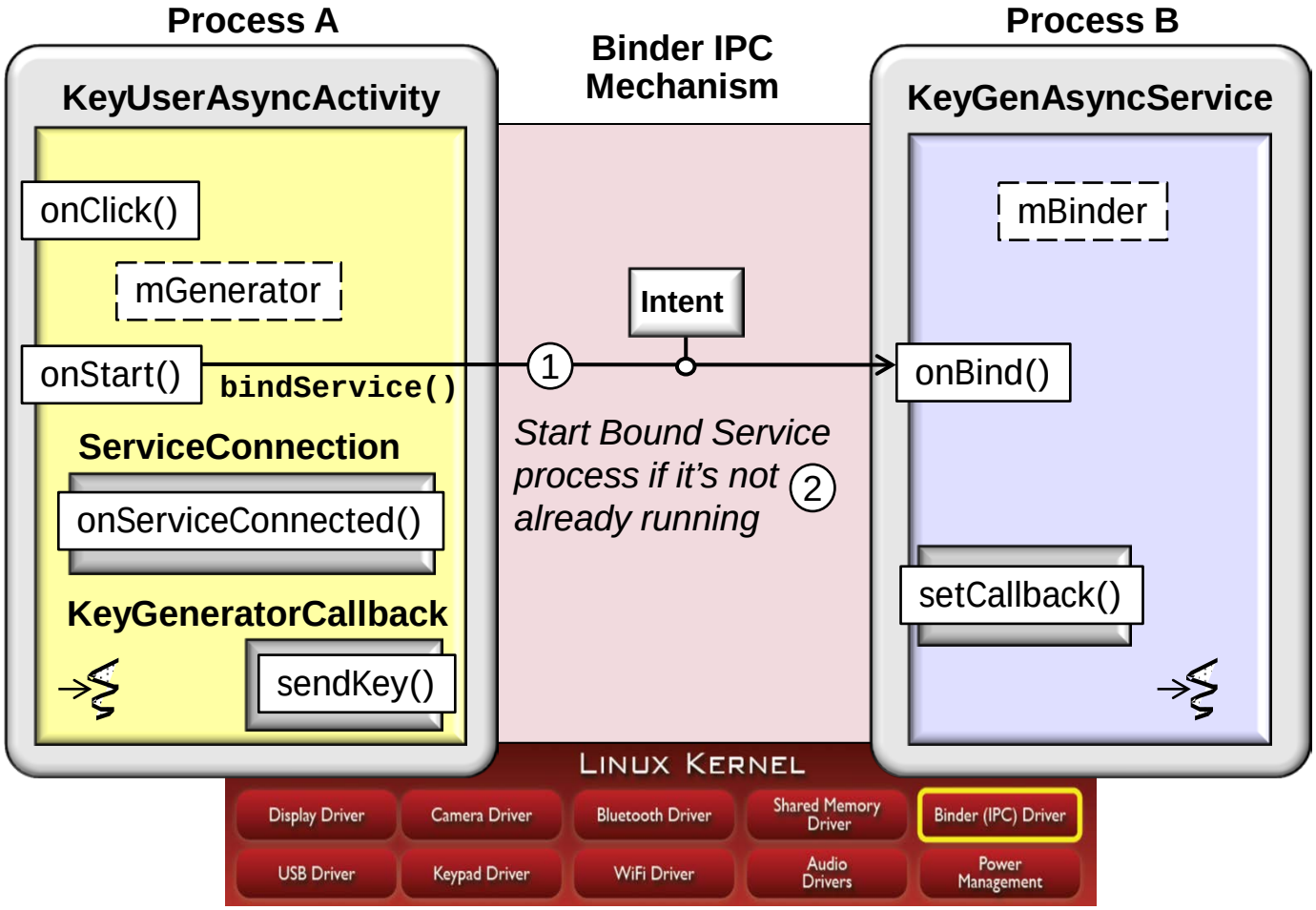
import course.examples.Services.KeyCommon.KeyGeneratorCallback;

interface KeyGenerator {
  oneway void setCallback(in KeyGeneratorCallback  callback);
}
```

- When **oneway** is used on a remote call it does not block
  - It simply sends the transaction data & immediately returns

Using an Asynchronous AIDL in a Bound Service

- Enables asynchronous interaction between an Activity & a Bound Service using AIDL & Binder RPC



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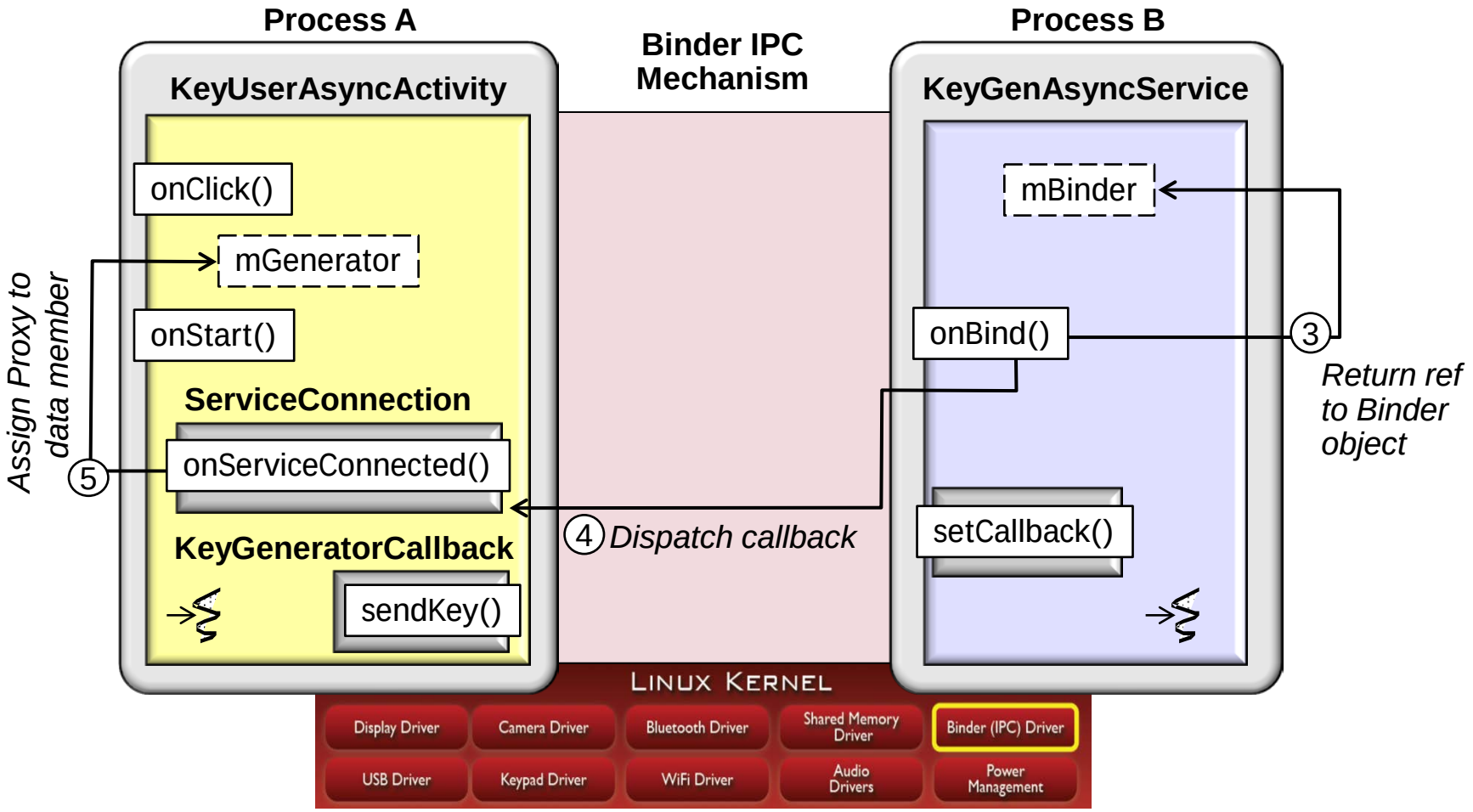

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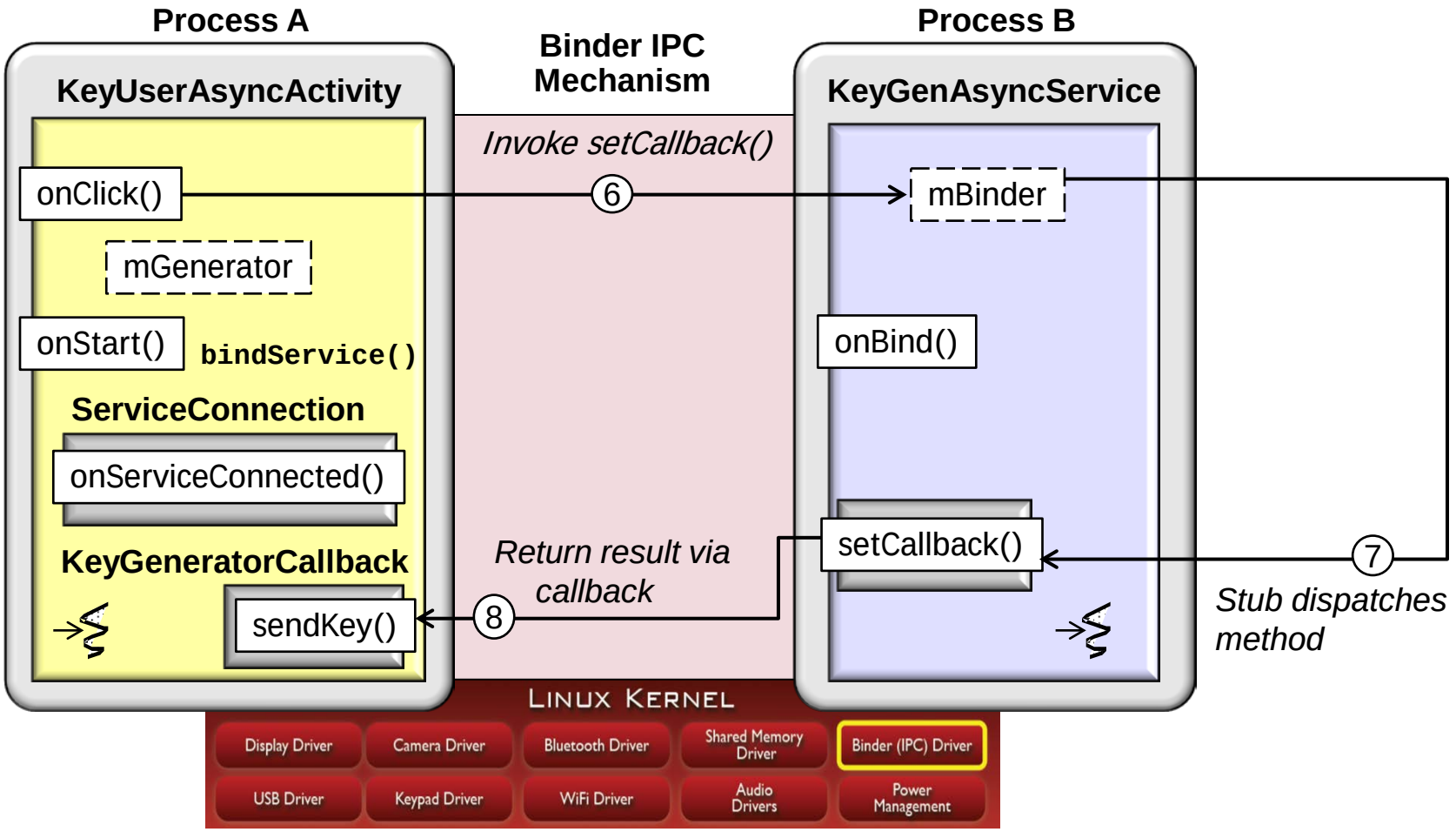


Implement Remote Methods

```
public class KeyGenAsyncService extends Service {
  private Set<UUID> keys = new HashSet<UUID>();

  public void setCallback(final keyGeneratorCallback callback) {
    UUID id;

    synchronized (keys) {
      do { id = UUID.randomUUID(); } while (keys.contains(id));
      keys.add(id);
    }
    final String key = id.toString();
    ...
    callback.sendKey(key);
    ...
  }

  public IBinder onBind(Intent intent) { return this.mBinder; }
}
```

Unique set of keys

Runs in a thread from Binder's thread pool

Generate unique ID

Make a one-way (non-blocking) call to return result

Return reference to the Binder object

Since setCallback() is a one-way it doesn't block the Activity caller

Implement the Asynchronous ID Client Activity

```
public class KeyUserAsyncActivity extends Activity {
  private KeyGenerator mGenerator;
  private boolean mBound;

  private ServiceConnection connection =
                                      new ServiceConnection() {
    public void onServiceConnected(ComponentName className,
                                   IBinder iBinder) {
      mGenerator = KeyGenerator.Stub.asInterface(iBinder);
      mBound = true;
    }
     ...

    public void onServiceDisconnected(ComponentName className){
      mGenerator = null; mBound = false;
    }
  };
```

Local state

Remote Service callback methods

Proxy to remote Service

Implement the Asynchronous ID Client Activity

```
public class KeyUserAsyncActivity extends Activity {
  ...
  protected void onStart() {
    super.onStart();

    Intent intent = new Intent(KeyGenService.class.getName());
    bindService(intent,this.connection,
                       Context.BIND_AUTO_CREATE);
  }


  protected void onStop() {
    if (mBound) unbindService(this.connection);
    super.onStop();
  }
}
```

Use name of KeyGenService as an ACTION

Bind to Service

Unbind from Service

Implement the Asynchronous ID Client Activity

```
public class KeyUserAsyncActivity extends Activity {
  TextView output; ...
  public void onCreate(Bundle icicle) {
    ...
    output = (TextView)findViewById(R.id.output);
    final Button goButton = (Button)findViewById(R.id.go_button);

    goButton.setOnClickListener(new OnClickListener() {
      public void onClick(View v) {
        try {

          if (bound)
            mGenerator.setCallback(mCallback);

        } catch (RemoteException e) {}
      }
     });
}
```

Set the click handler

Call remote method (non-blocking) to register callback

Implement the Asynchronous ID Client Activity

```
public class KeyUserAsyncActivity extends Activity {
  ...
  private final KeyGeneratorCallback.Stub mCallback =
    new KeyGeneratorCallback.Stub() {

      public void sendKey (final String key) {
        runOnUiThread (new Runnable() {
           public void run() {
               output.setText(key);
           }
        });
      }
}
```

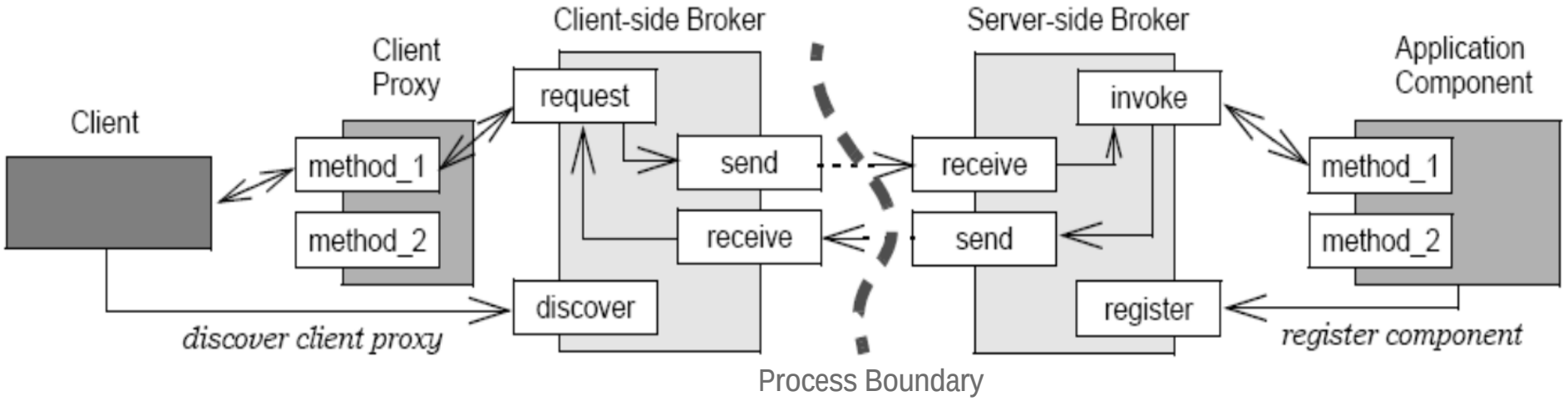
Runs in a thread from Binder's thread pool

Output the key to the display in the UI thread via a Runnable

Since sendKey() is a one-way it doesn't block the Service caller

Summary

- AIDL implements *Broker*, Messenger implements *Command Processor*



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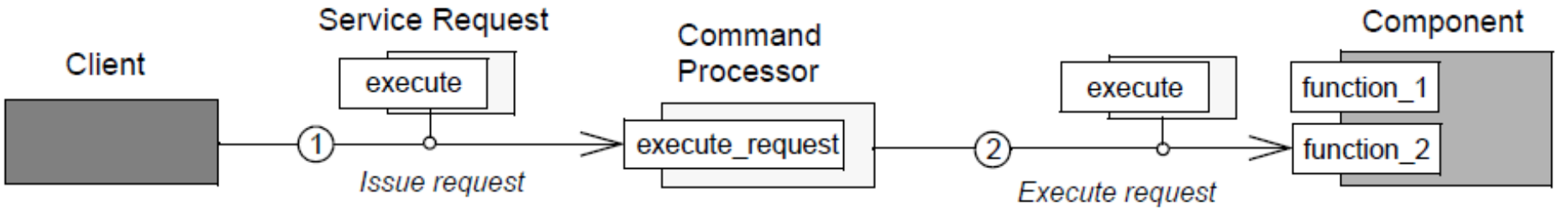
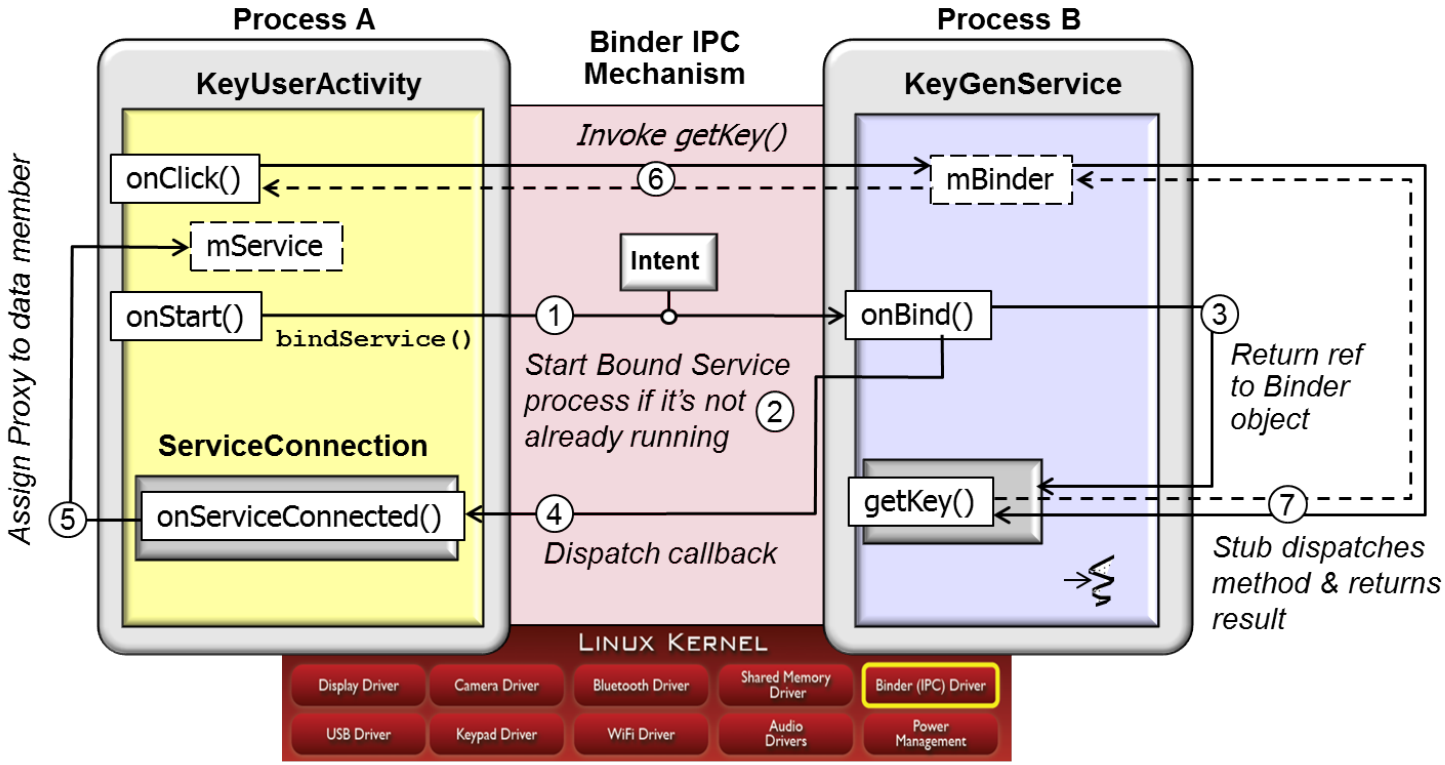


Summary

- AIDL implements *Broker*, Messenger implements *Command Processor*
- When you need to perform complex IPC interactions, using AIDL for your interface is often easier than implementing Messengers
  - AIDL calls are two-way synchronous, Services processes calls concurrently



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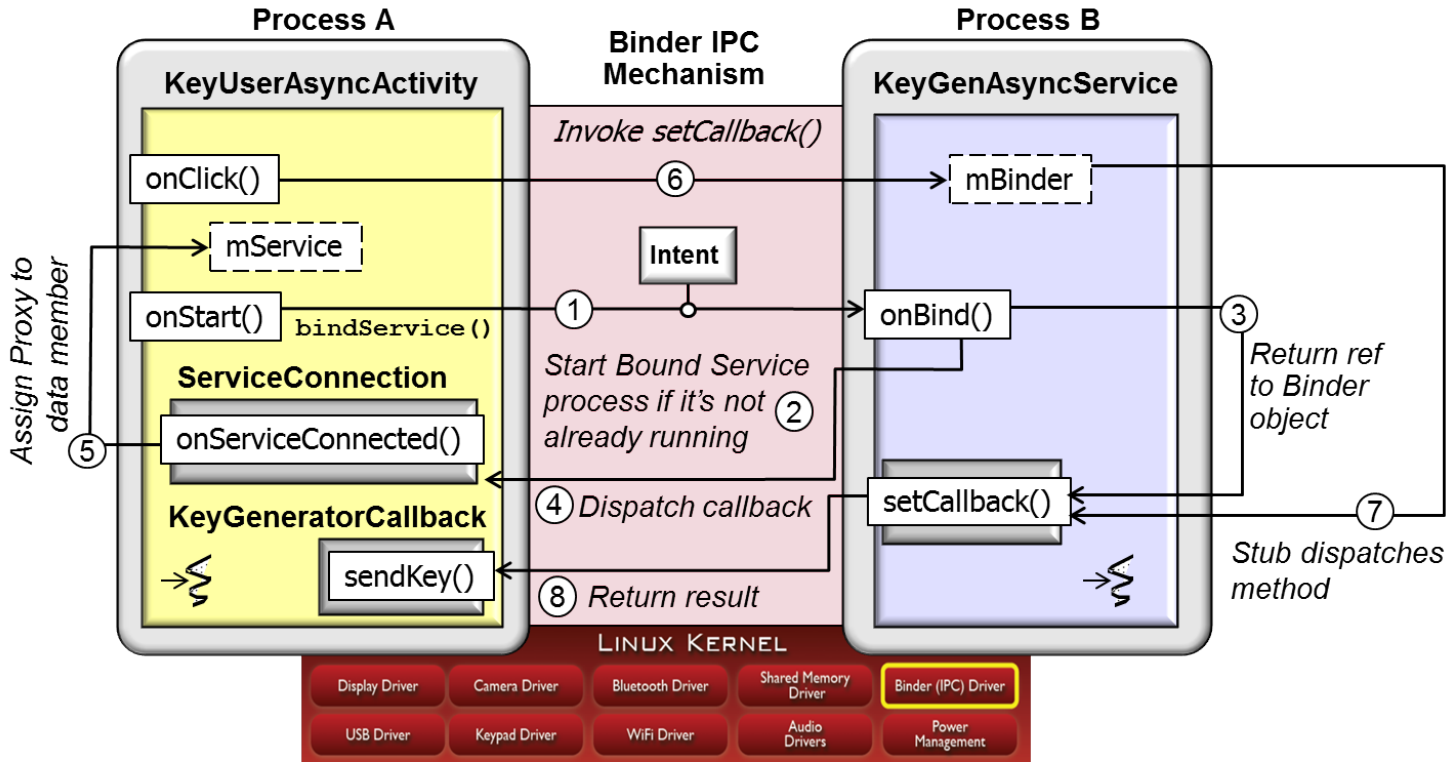
- When you need to perform complex IPC interactions, using AIDL for your interface is often easier than implementing Messengers
  - AIDL calls are two-way synchronous, Services processes calls concurrently
  - AIDL also supports asynchrony via callback objects



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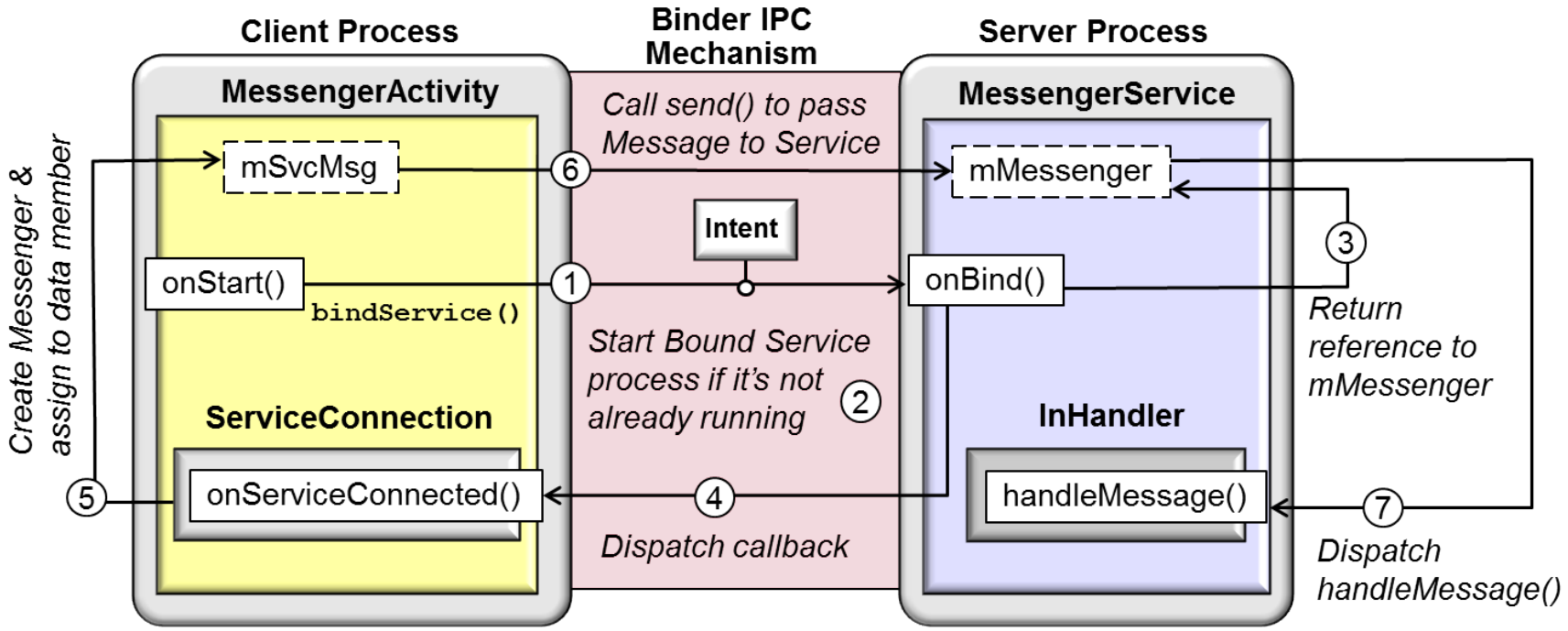
- When you need to perform complex IPC interactions, using AIDL for your interface is often easier than implementing Messengers
- When you need to perform simple IPC interactions, using a Messenger for your interface is often easier than implementing it with AIDL
  - A Messenger queues all calls, which Service then handles asynchronously



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- For many Apps a Service doesn't need to perform multi-threading
  - Using a Messenger allows the service to handle one call at a time without extra programming effort

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- When you need to perform complex IPC interactions, using AIDL for your interface is often easier than implementing Messengers
- When you need to perform simple IPC interactions, using a Messenger for your interface is often easier than implementing it with AIDL
- For many Apps a Service doesn't need to perform multi-threading
  - Using a Messenger allows the service to handle one call at a time without extra programming effort
  - If it's important that your service be multi-threaded, then you should use AIDL to define your interface