Android System Development
Day-4

Team Emertxe

Android System Service

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Introduction to service

Introduction to Service
(what?)

“A Service is an application component that can perform long-running operations in the background and does not provide a user interface”

- Another app component can start a service and it will continue to run in the background even if the user switches to another application
- Additionally, a component can bind to a service to interact with it and even perform inter-process communication (IPC)
- Example - play music, download a file, tracking distance traveled through sensor, all from the background

Introduction to Service
(what?)

- Service is not process
- Faceless task that runs in the background
- No visual user interface
- Can run indefinitely unless stopped
- Each service extends the Service base class

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Introduction to Service
(Types)

- Scheduled
- Started
- Bound

Introduction to Service
(Types - Scheduled)

- A service is scheduled through JobScheduler
- JobScheduler API was introduced in Android 5.0 (API level 21)
- API is used for scheduling various types of jobs against the framework that will be executed in app's own process
- Example :
  - Cricket score update

Introduction to Service
(Types - Started)

- A service is started when an application component (such as an activity) calls **startService()**
- After it's started, a service can run in background indefinitely, even if the component that started it is destroyed
- Usually, a started service performs a single operation and does not return a result to the caller
- Example : download or upload a file over the network
- When operation is complete, service should stop itself

Introduction to Service
(Types - Bound)

“A bound service is the server in a client-server interface. It allows components (such as activities) to bind to the service, send requests, receive responses, and perform interprocess communication (IPC)”

- A bound service typically lives only while it serves another app component and does not run in the background indefinitely
- Example : GPS service

Introduction to Service
(Types - Bound)

- A service is bound when an app component binds to it by calling **bindService()**
- A bound service runs only as long as another app component is bound to it
- Multiple components can bind to the service at once, but when all of them unbind, the service is destroyed

Introduction to Service
(Basics)

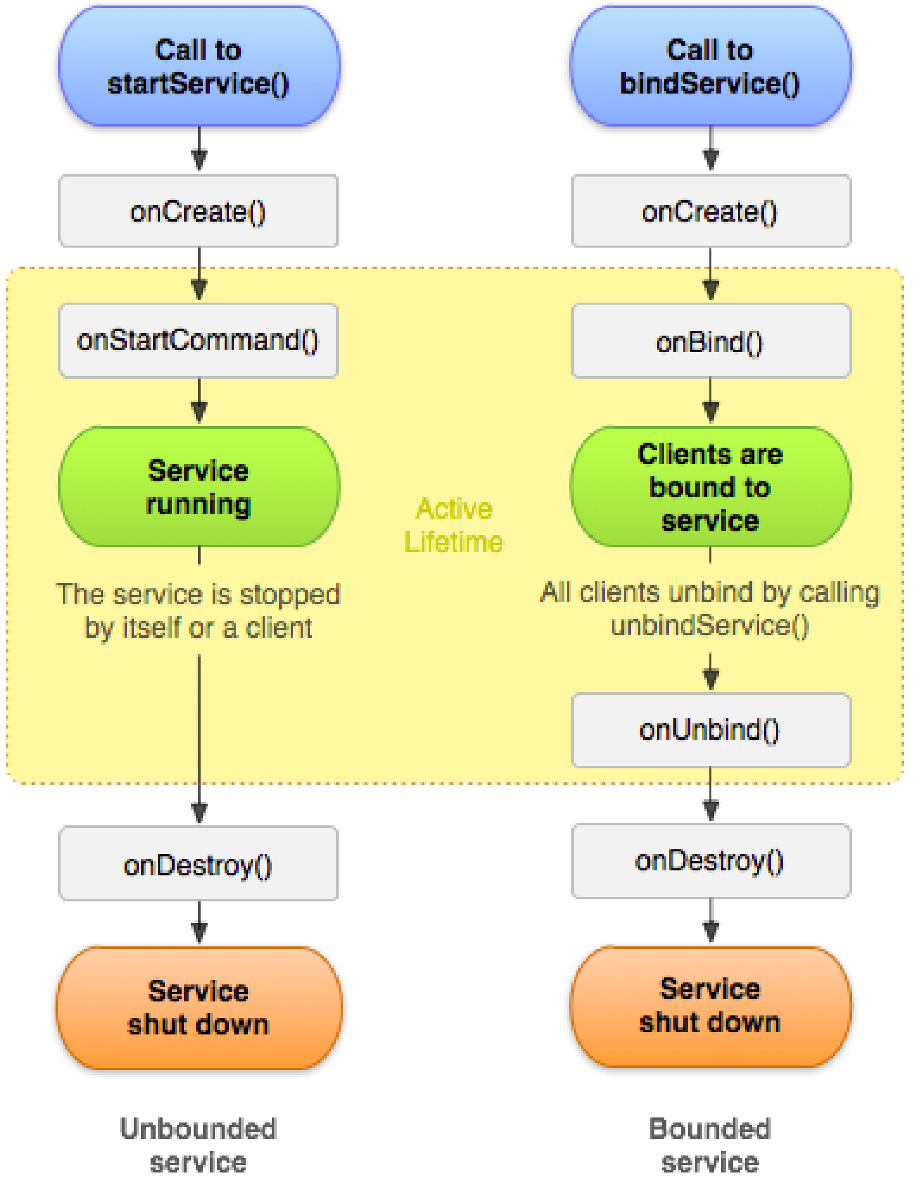
- A service can be started (to run indefinitely), bound or both
- Any app component can use the service (even from a separate application) in the same way that any component can use an activity—by starting it with an Intent
- If required, declare the service as private in manifest file and block access from other app

Introduction to Service
(Basics)

- A service runs in the main thread of its hosting process
- The service does not create its own thread and does not run in a separate process unless specified

⚠	Services expected to do CPU-intensive work or blocking operations, such as MP3 playback or networking, shall create a new thread within the service to complete that work Separate thread reduces the risk of "Application Not Responding" (ANR) errors, and apps main thread can remain dedicated to user interaction with activities

Introduction to Service
(Life-cycle)



Inter-Process Communication

IPC
(Different ways)

- AIDL
- Binder
- Message

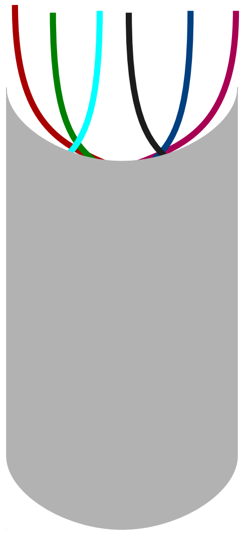
IPC
(AIDL)

“Android Interface Definition Language (AIDL) enables to define programming interface that both client and service agree upon in order to communicate with each other using inter-process communication (IPC)”

IPC
(AIDL)

AIDL usage is necessary only if you allow clients from different applications to access your service for IPC and want to handle multi-threading in your service

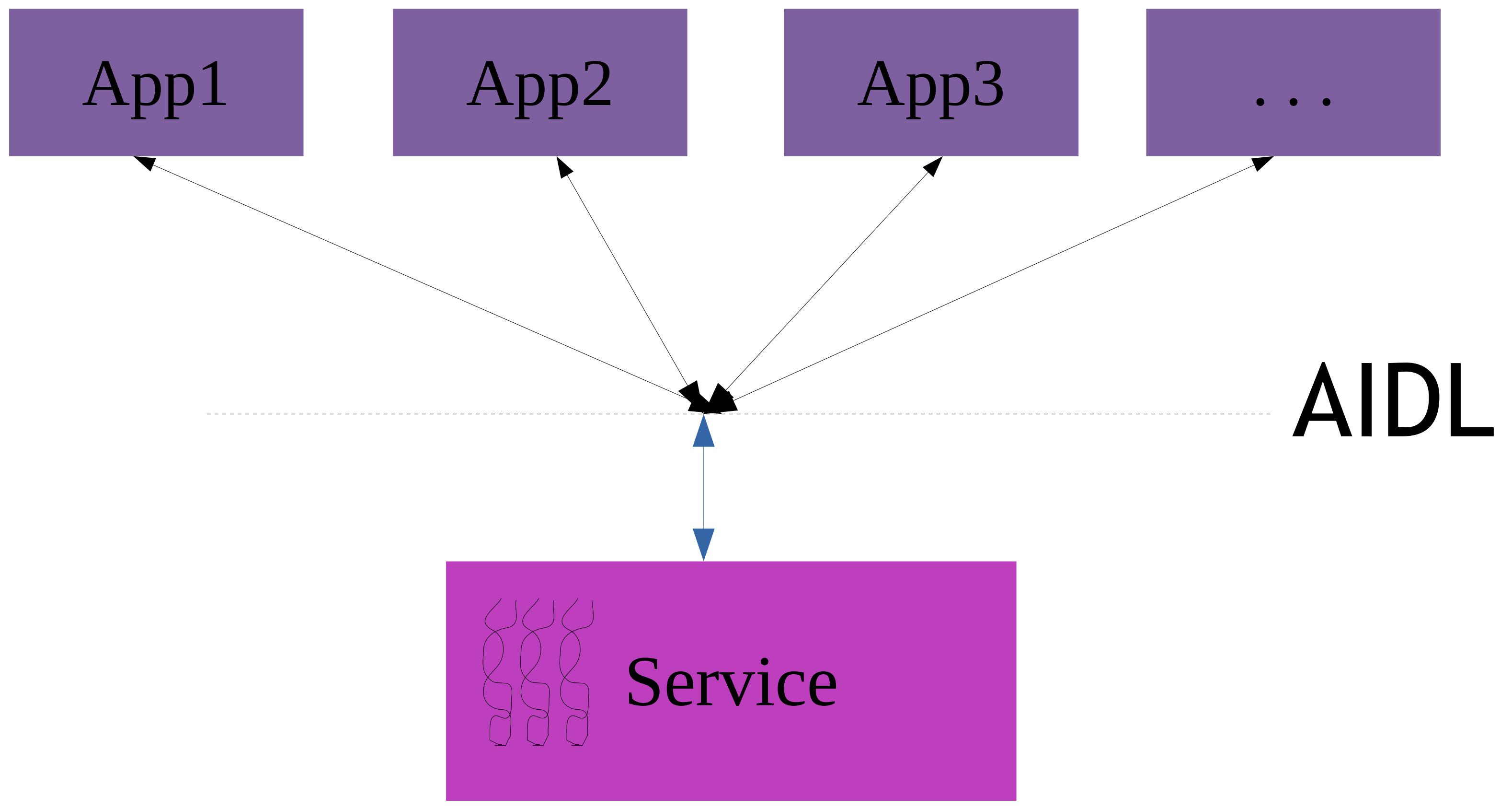
Example : A sensor hub service catering to different requests from multiple apps



IPC
(AIDL - why?)

- In Android, one process cannot normally access the memory of another process
- So processes need to decompose their objects into primitives that operating system can understand
- These primitives are marshalled by OS across process boundary
- The marshalling code is tedious to write, so Android handles it with AIDL

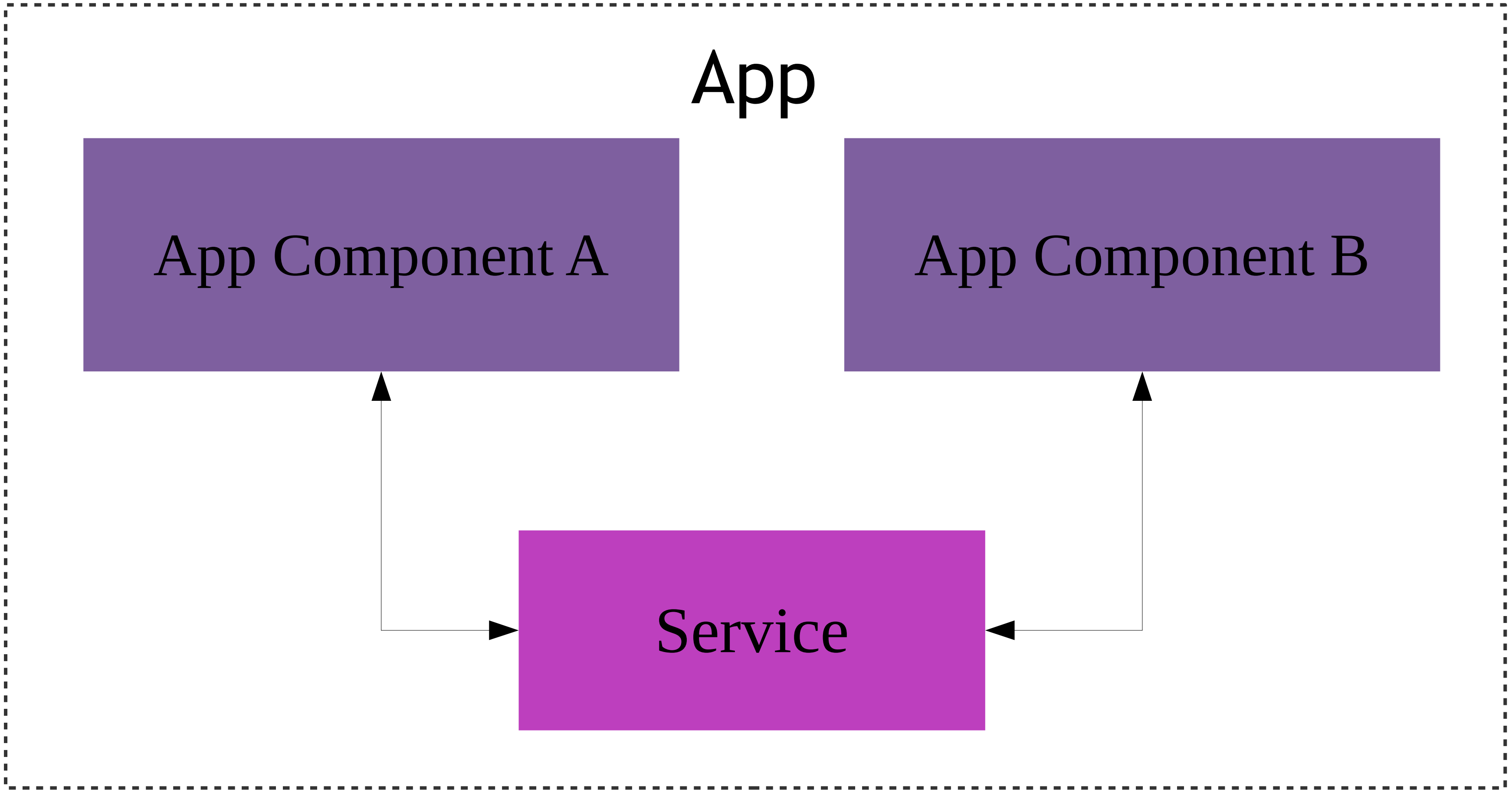
AIDL (usage)



IPC (Binder)

- Create your interface by extending Binder if -
  - There is no need to perform concurrent IPC across different apps
  - Your service is private to your own application and runs in the same process as the client (your service is merely a background worker for your own app)

IPC
(Binder - usage)



IPC
(Binder - class)

- Binder is base class for a remotable object
- Binder class implements IBinder interface
- IBinder provides standard local implementation of such an object

IPC
(IBinder - class)

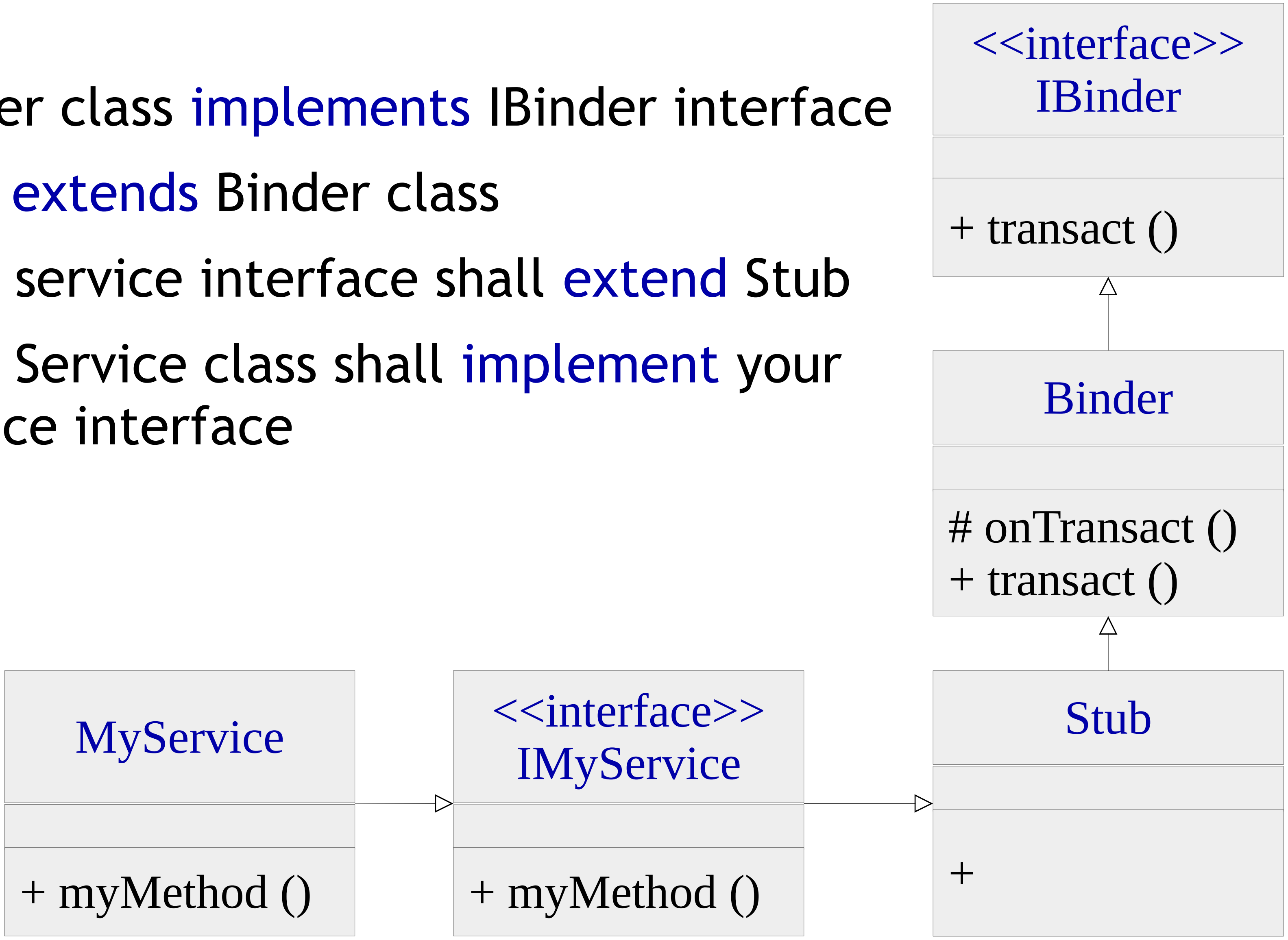
- Base interface for a remotable object
- This interface describes abstract protocol for interacting with a remotable object

IPC (Binder)

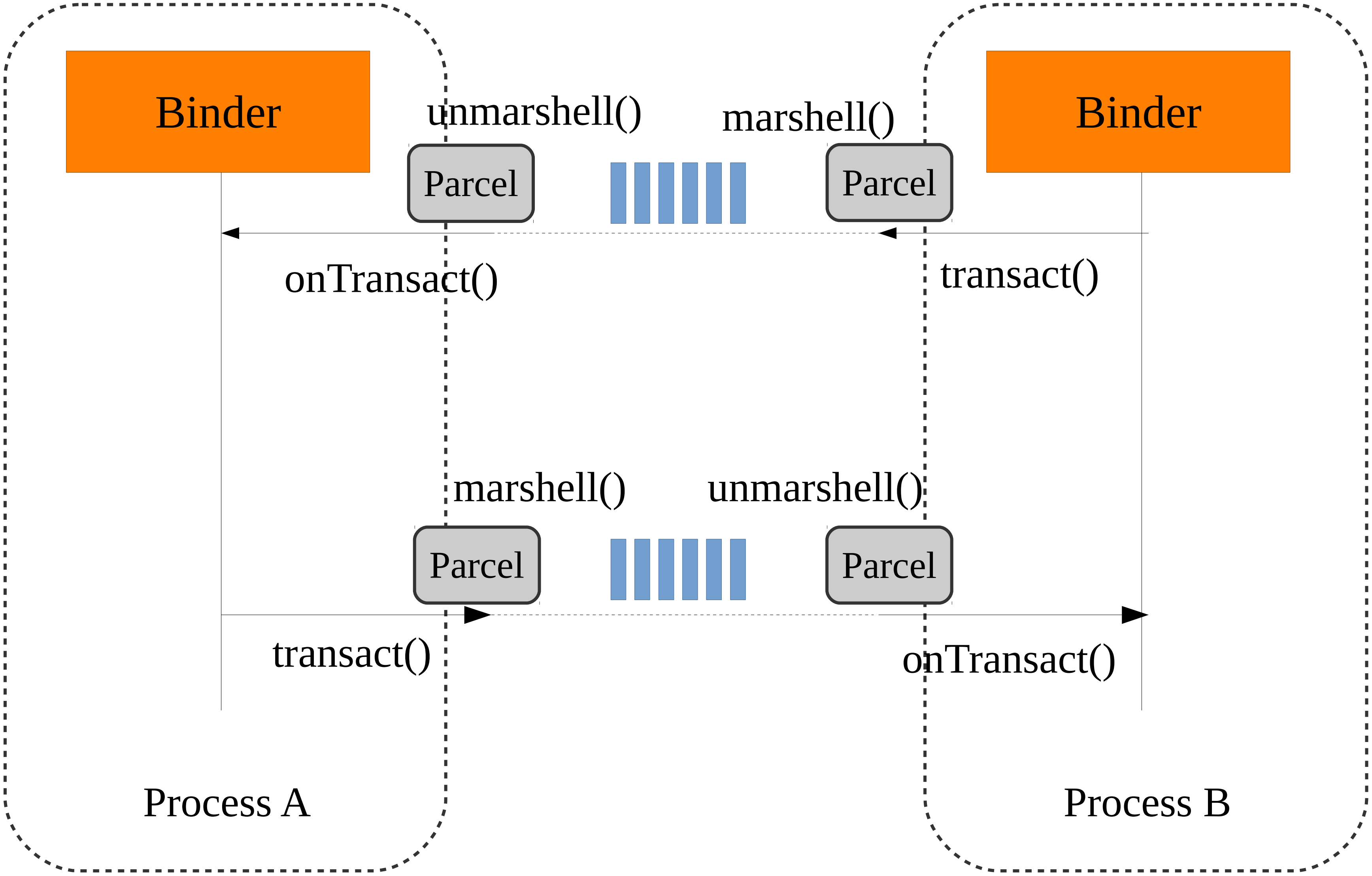
- The data sent through transact() is a Parcel
- Parcel is a generic buffer of data that also maintains some meta-data about its contents
- The meta data is used to manage IBinder object references in the buffer, so that those references can be maintained as the buffer moves across processes
- “transact()” is internally mapped to “onTransact()”

IPC
(Binder - Class Hierarchy)

- Binder class implements IBinder interface
- Stub extends Binder class
- Your service interface shall extend Stub
- Your Service class shall implement your service interface

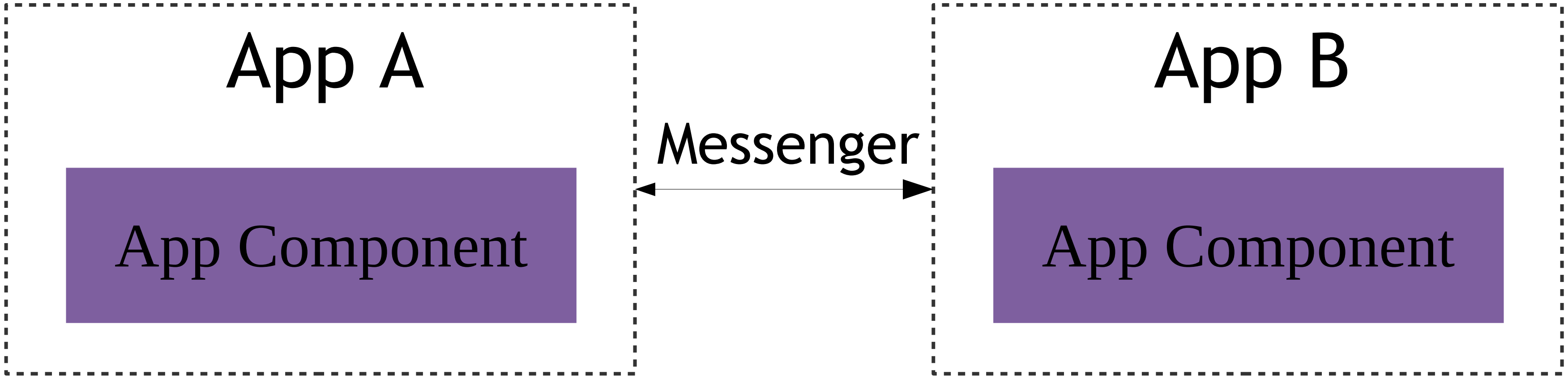


IPC
(Binder)

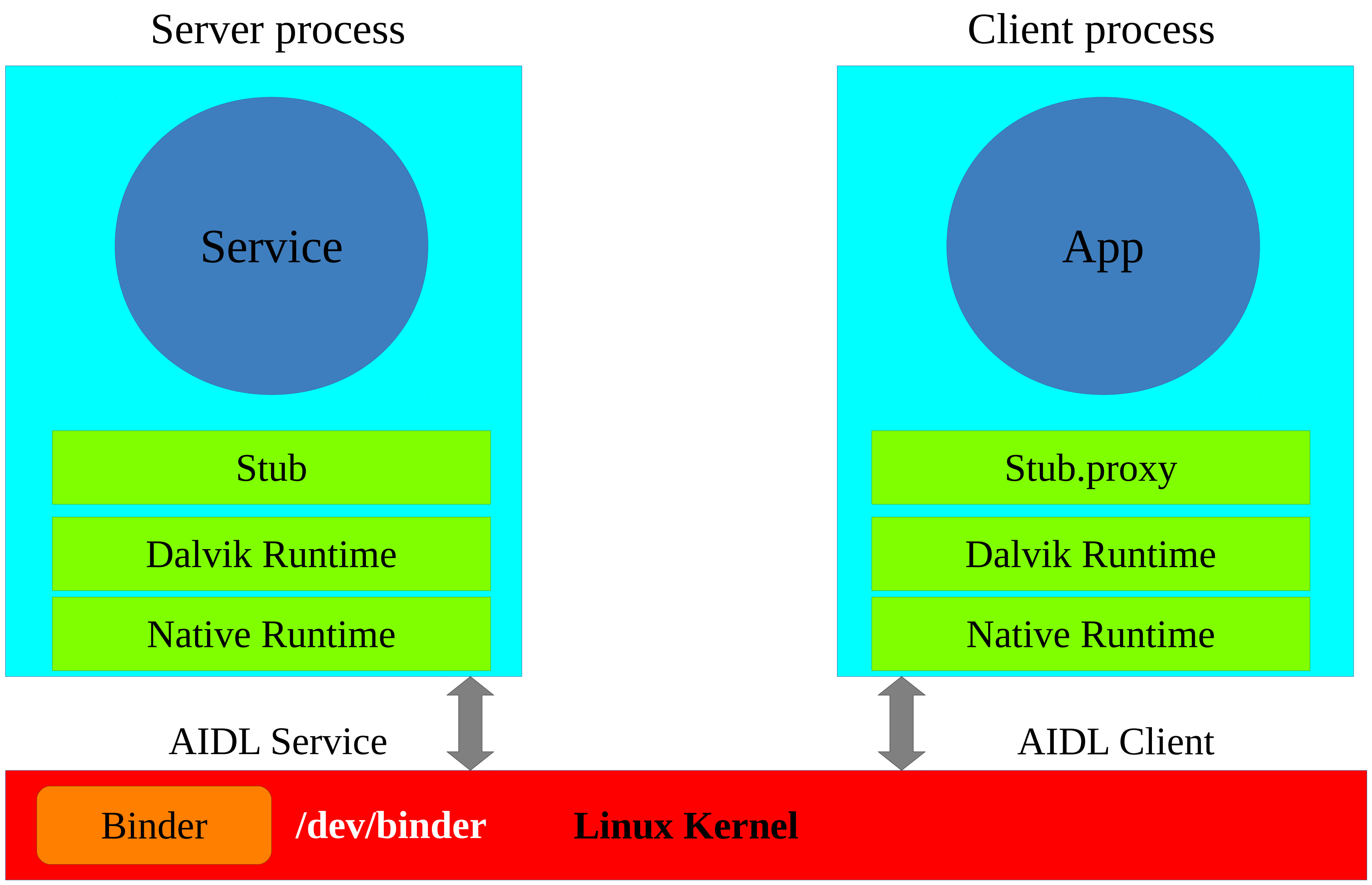

Binder
unmarshell()
marshell()
Binder
Parcel
Parcel
onTransact()
transact()
marshell()
unmarshell()
Parcel
Parcel
transact()
onTransact()
Process A
Process B

IPC
(Messenger)

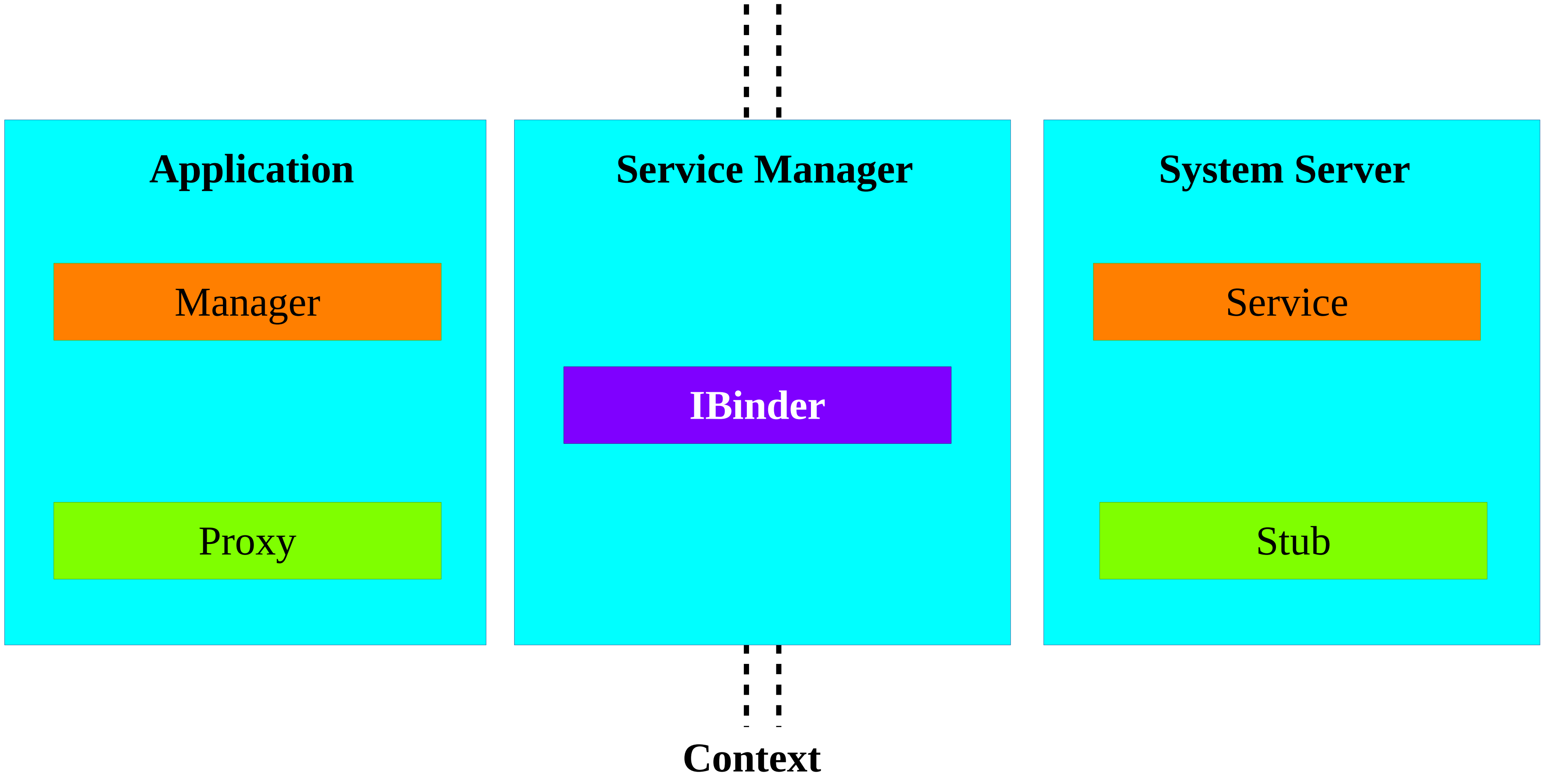
- Messenger - If you want to perform IPC, but do not need to handle multi-threading, implement your interface using a Messenger



IPC (Architecture)



IPC (Architecture)



IPC
(Synchronous)

- Synchronous RPC
  - The synchronous calls are blocking calls
  - Sender waits for the response from remote side
  - Synchronous methods may have “out” and “inout” parameters
  - The method must have return type

IPC
(Synchronous)

- Example -

```
public interface IMathInterface {
    int add(int x, int y);
}
```

IPC
(Asynchronous)

- Asynchronous AIDL interface is defined with oneway keyword
- Keyword is used either at interface level or on individual methods
- Asynchronous methods must not have out and inout arguments
- They must also return void

IPC
(Asynchronous)

- Example -

```
oneway interface IAsyncInterface {
    void methodX(IAsyncCallback callback);
    void methodY(IAsyncCallback callback);
}
```

IPC
(“in”, “out” and “inout”)

- “in” indicates :
  - Object is used for input only
  - Object is transferred from client to service
  - If object is modified in service then change would not be reflected in client
- “out” indicates :
  - The object will be populated and returned by service as response
- “inout” indicates :
  - If any modification is made to the object in service then that would also be reflected in the client’s object

Adding Custom service

Adding Custom Service

- Step 1 : Writing service
- Step 2 : Writing service manager
- Step 3 : Writing Interface (AIDL, JNI)
- Step 4 : Register Service (context, registry)
- Step 5 : Start Service
- Step 6 : Writing Sepolicy
- Step 7 : Update APIs

Step 1: Writing Service

- Path: /frameworks/base/services/core/java/com/android/server/
- File :MyAwesomeService.java

```
package com.android.server.myawesome;
...
import android.os.IMyAwesomeService;
import com.android.server.SystemService;
...
public class MyAwesomeService extends SystemService {

    private static final String TAG = "MyAwesomeService";
    private Context mContext;
   …
}
```

Step 2: Writing Service Manager

- Path : frameworks/base/core/java/android/os
- File : MyAwesomeManager.java

```
Import android.os.IMyAwesomeService;

Public class MyAwsomeManager {
        IMyAwesomeService mService;
        private static final String TAG = “MyAwesomeManager”;
        ….
        ….
}
```

Step 3: Write Interface

- AIDL interface for new service
  - Path : frameworks/base/core/java/android/os/
  - File : IMyAwesomeService.aidl

```
package android.os;
interface IMyAwesomeService {
    ...
    String read(int maxLength);
    ...
    int write(String mString);
}
```

Step 3: Write Interface

- Add AIDL file in android make file
  - Path : /framework/base
  - File : Android.mk

```
core/java/android/os/IMyAwesomeService.aidl  \
```

Step 3: Write Interface

- JNI interface for new service
  - Path : frameworks/base/core/java/android/os/
  - File : com_android_server_MyAwesomeService.cpp

```
#include <hardware/myawesome.h>
…
namespace android
{
    myawesome_device_t* myawesome_dev;
    …
    …
};
```

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Step 3: Write Interface

- Add JNI file in android make file
  - Path : /framework/base/services/core/jni
  - File : Android.mk

```
$(LOCAL_REL_DIR)/com_android_server_MyAwesomeService.cpp \
```

Step 3: Write Interface

- Add JNI file in android make file
  - Path : /framework/base/services/core/jni
  - File : onload.cpp

```
int register_android_server_MyAwesomeService(JNIEnv* env);
```

Step 3: Write Interface

- Add interface file for HAL
  - Path : /hardware/libhardware/include/
  - File : myawesome.h

```
struct myawesome_device_t {

    struct hw_device_t common;

    int (*read)(char* buffer, int length);
    int (*write)(char* buffer, int length);
    …
};
struct myawesome_module_t {
    struct hw_module_t common;
};
```

Step 4: Register Service

- Update Registry
  - Path: /frameworks/base/core/java/android/app
  - File : SystemServiceRegistry.java
- Update Context
  - Path : /frameworks/base/core/java/android/content
  - File : Context.java

Step 5: Start Service

- Path: /frameworks/base/services/java/com/android/server/
- File : SystemServer.java

```
import com.android.server.myawesome.MyAwesomeService;
…
public class SystemService {
…
        private void startOtherServices() {
        …
                mSystemServiceManager.startService(MyAwesomeService.class);
        …
        }
…
}
```

SELinux Policy

- Access control mechanisms
  - DAC (Discretionary Access Control)
    - Access is provided based on user permission
  - MAC (Mandatory Access Control)
    - Each program runs within a sandbox that limits its permissions

SELinux Policy
(MAC vs DAC)

- Generally, MACs are much more effective than DACs
- MAC are often applied to agents other than users, such as programs, whereas DACs are generally applied only to users
- MACs may be applied to objects not protected by DACs such as network sockets and processes

Step 6: Writing Sepolicy

- Path :
  - /device/<vendor>/<product>/sepolicy
  - Example : /device/brcm/rpi3/sepolicy
- File(s)
  - device.te
  - service.te
  - service_contexts
  - <custom-service>.te (Example : myawesome.te)

***policy configuration files end in .te**

Step 6: Writing Sepolicy

- Specify service type (service.te)

```
type myawesome_service, app_api_service,
system_server_service, service_manager_type;
```

Step 6: Writing Sepolicy

- Specify service type (device.te)

```
type myawesome_device, dev_type;
```

Step 6: Writing Sepolicy

- Writing myawesome.te

```
type myawesome, domain, domain_deprecated;
app_domain(myawesome)
binder_service(myawesome)
allow myawesome myawesome_device:chr_file
rw_file_perms;
allow myawesome app_api_service:service_manager
find;
allow myawesome system_api_service:service_manager
find;
allow myawesome shell_data_file:file read;
```

Step 6: Writing Sepolicy

- Writing service_contexts

```
myawesome    u:object_r:myawesome_service:s0
```

Step 7 : Update APIs

- Android APIs shall be updated for custom service
  - make -j4 update-api
- Now, compile AOSP to generate system.img and ramdisk.img
  - make -j4

Custom HAL

```
struct myawesome_module_t HAL_MODULE_INFO_SYM = {

        .common = {
                .tag = HARDWARE_MODULE_TAG,
                .module_api_version =
MYAWESOME_MODULE_API_VERSION_1_0,
                .hal_api_version = HARDWARE_HAL_API_VERSION,

                .id = MYAWESOME_HARDWARE_MODULE_ID,
                .name = "MyAwesome HAL Module",
                .author = "Emertxe",
                .methods = &myawesome_module_methods,
                .dso = 0,
                .reserved = {},
        },
};
```

Compile SDK

- $ source build/envsetup.sh
- $ lunch aosp_x86-eng
- $ make -j4 sdk
- Copy “android.jar” to Android Studio
  - Source : /target/common/obj/PACKAGING/android_jar_intermediates/
  - Destination : /android-studio/plugins/android/lib/

Testing custom service

- Write an app in android studio and test

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