Android Architecture and Binder

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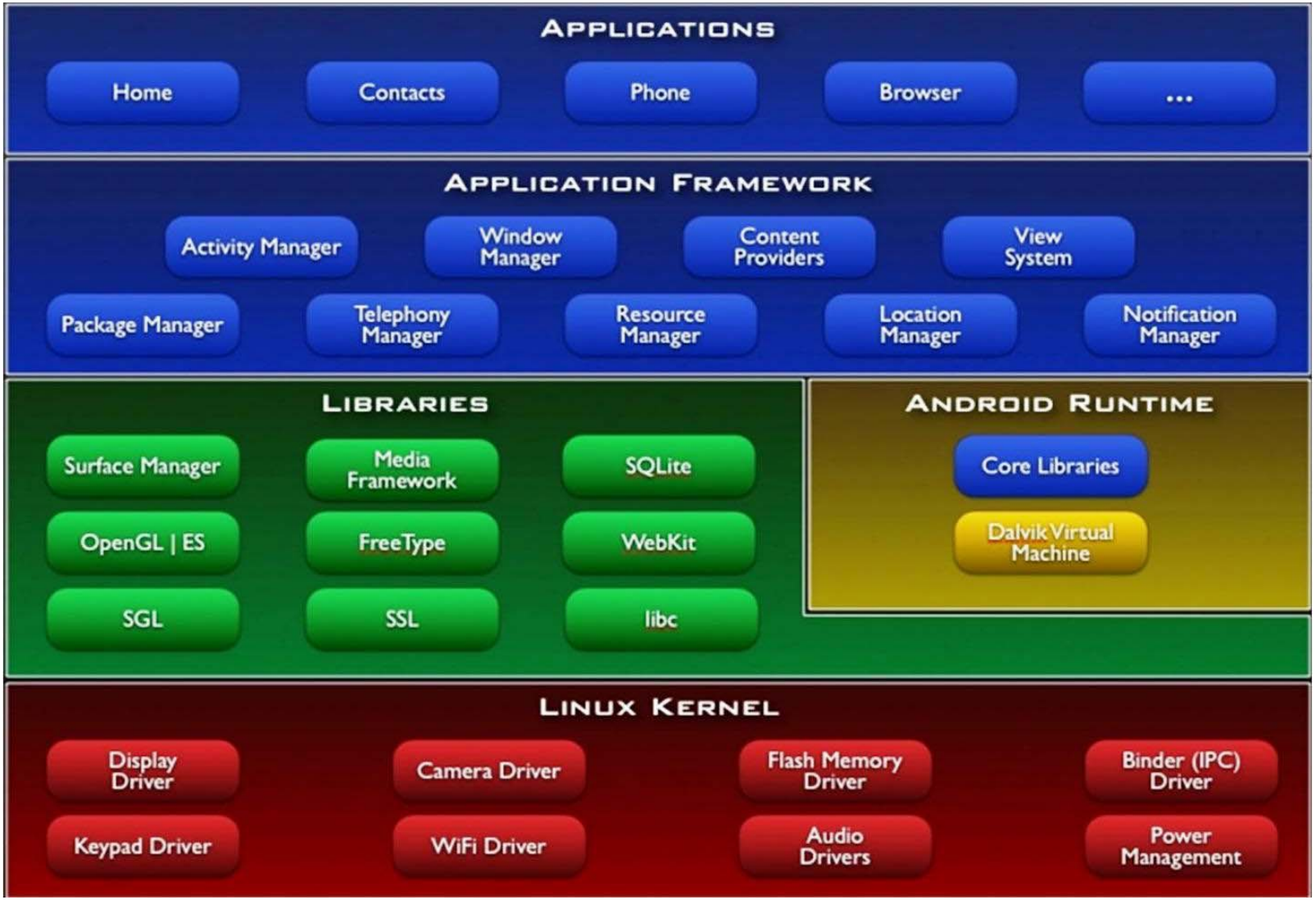
Android Software stack



Anatomy of an Android application

- Activity

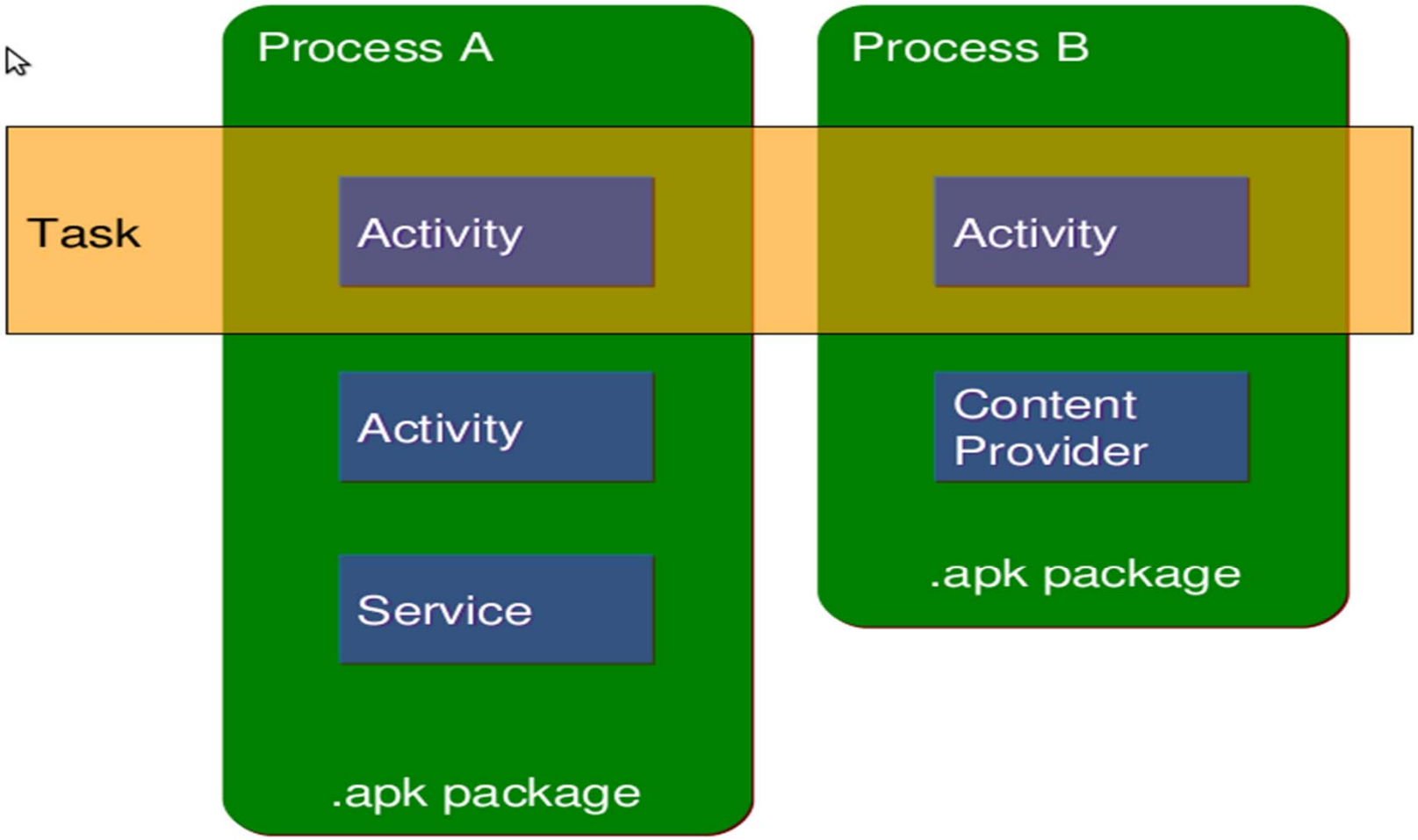
  UI component typically corresponding of one screen
- Service

  Background process without UI (E.g mp3 player).
- Content Manager

  Enables applications to share data (E.g Contacts shared b/w all applications)
- Broadcast Receiver

  Responds to external events, can wake up your process (E.g SMS, Phone ring, Low battery)

Anatomy of an Android Application



IPC is ubiquitous throughout the Android platform

- Example: An mp3 player application
- It executes as 2 separate process

  mp3 player UI [Activity]

  mp3 player backend [Service]

IPC mechanism in android

- In GNU/Linux
  - Pipes
  - Shared Memory
  - Message Queue
- In Android
  - Binder

Why Binder over conventional IPC

- Binder has additional features that sockets don't have E.g binder allows passing file descriptors across processes.
- Pipes cannot perform RPC.
- Object reference counting, Object mapping.
- Binder has elaborate data referencing policies, it is not a simplistic kernel driver.

Binder and Open Binder

- Developed under the name OpenBinder by Palm Inc.
- Android Binder is the customized re-implementation of OpenBinder.

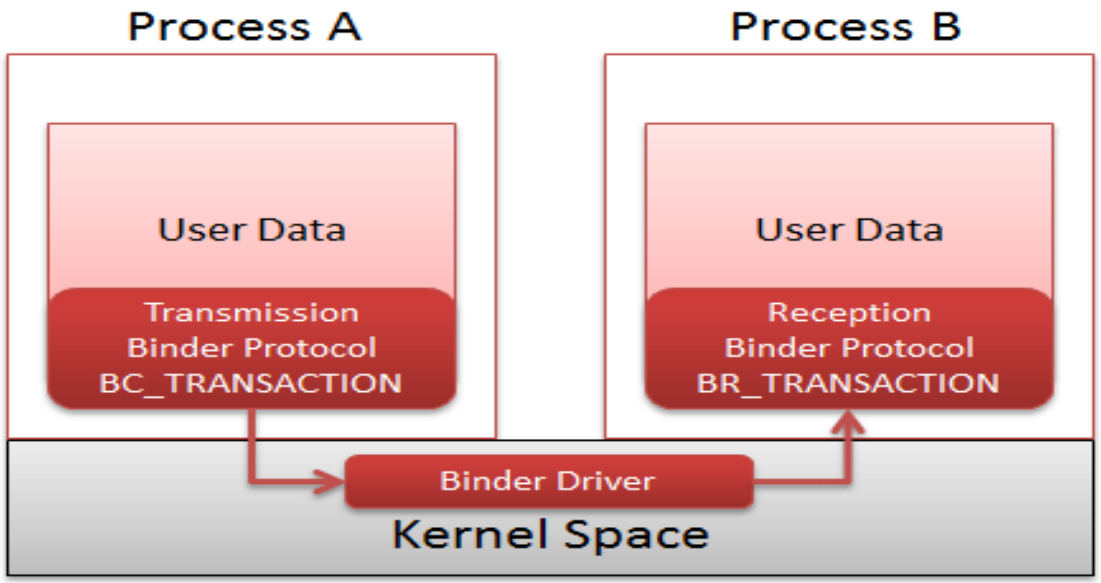
Binder

- A kernel driver to facilitate inter-process communication
- Lightweight RPC (Remote Procedure Communication) mechanism
- Per-process thread pool for processing requests
- Synchronous communication b/w processes

IPC internals from Bottom Up

- IPC over Binder kernel driver
- IPC over the middleware
- IPC over the Application layer

IPC over Binder kernel driver



- Binder Driver supports the file operations open, mmap, release, poll and the system call ioctl
- The first thing an application must do is open the Binder kernel module("/dev/Binder").
- This associates a file descriptor with that thread
- The kernel module uses the descriptor to identify the initiators and recipients of Binder IPCs.

- All interactions with the driver will happen through a small set of ioctl() commands.

  BINDER_WRITE_READ

  BINDER_SET_MAX_THREADS

  BINDER_SET_CONTEXT_MGR

  BINDER_THREAD_EXIT

  BINDER_VERSION

- The key command is BINDER_WRITE_READ, which is the basis for all IPC operations.

  ioctl(fd, BINDER_WRITE_READ, &bwt);

- To initiate an IPC transaction, ioctl call with BINDER_READ_WRITE command is invoked

The data to be passed to the ioctl() call is of the type struct binder_write_read

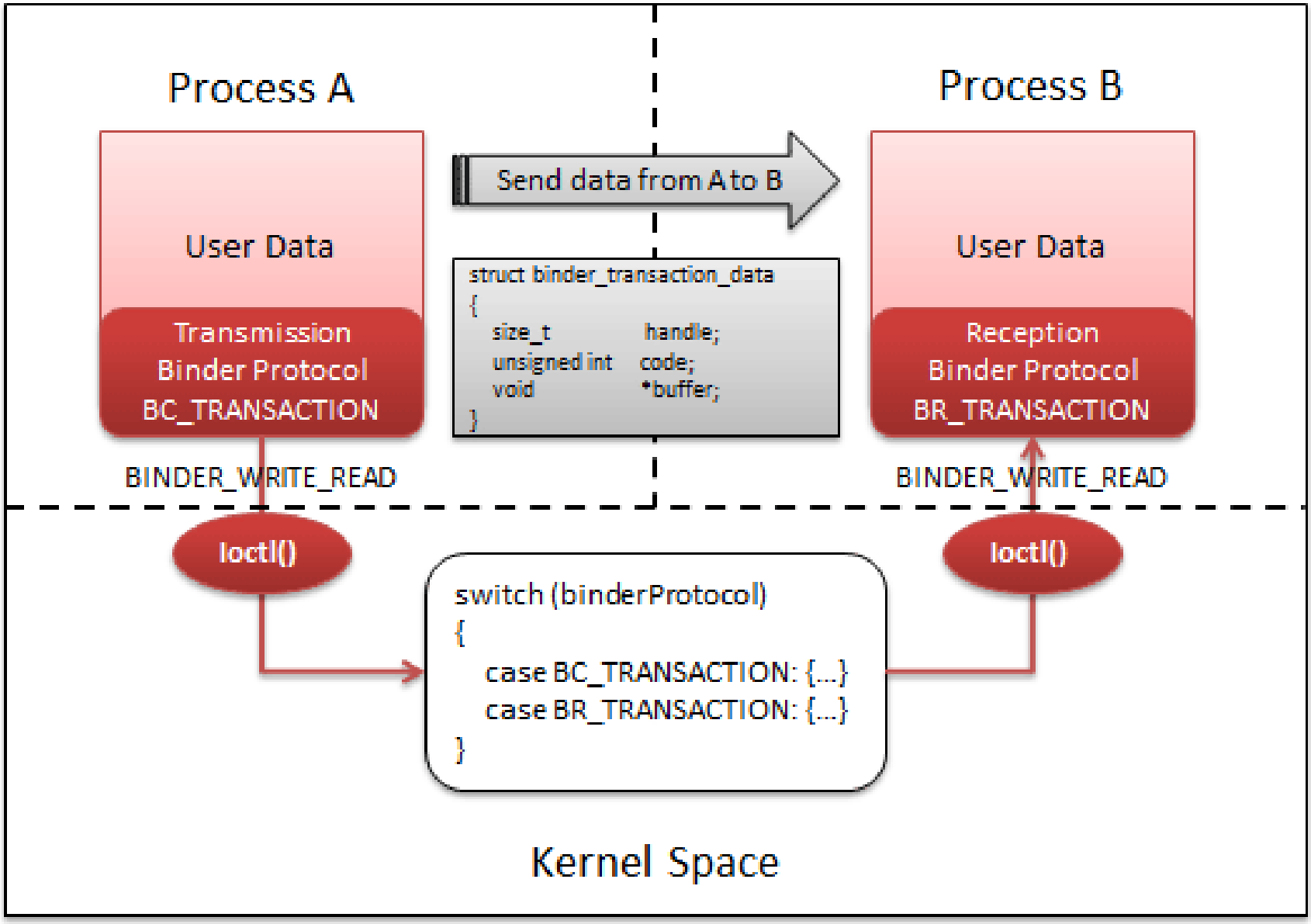
```
struct binder_write_read
{
        ssize_t write_size;             /*bytes to write*/
    ssize_t write_consumed;   /*bytes consumed*/
        const void* write_buffer;
    ssize_t read_size;          /*bytes to be read*/
        void* read_buffer;              /*bytes consumed*/
};
```

- The write buffer contains an enum bcTRANSACTION followed by a binder_transaction_data.

- In this structure target is the handle of the object that should receive the transaction

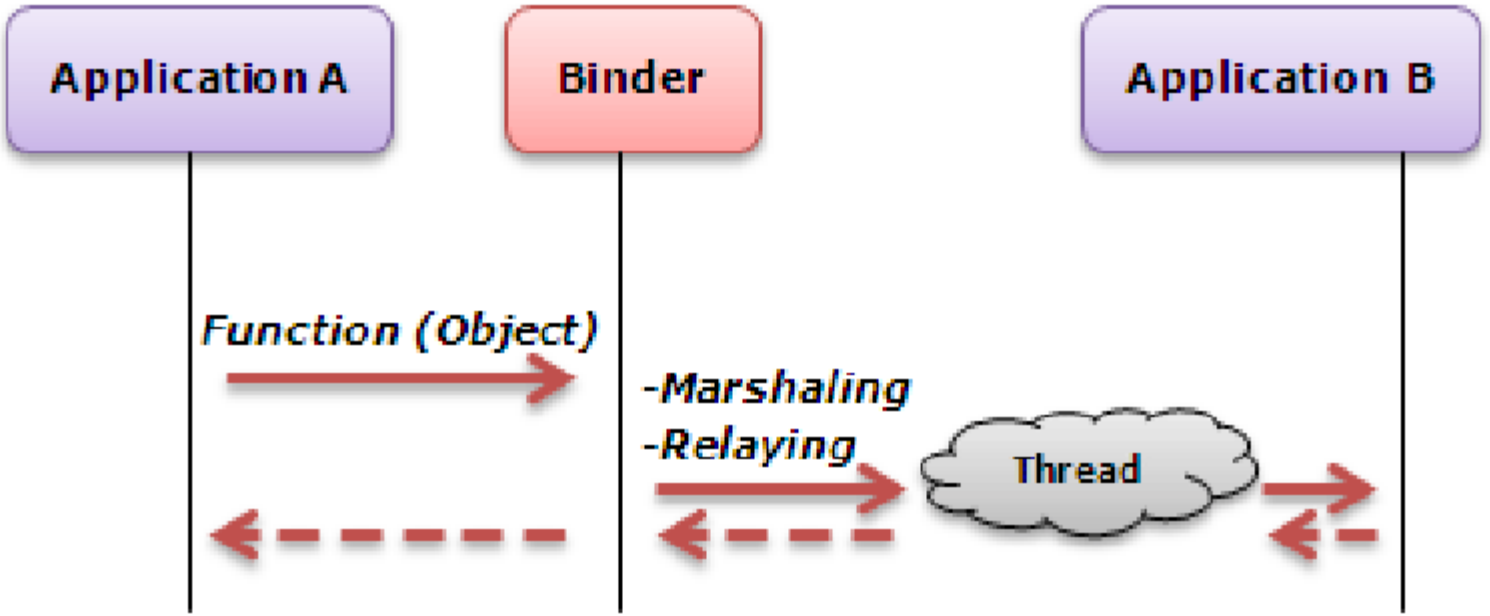
- The code refers to the Method ID.

```
struct binder_transaction_data {
    union {
        size_t  handle; /* target descriptor of command transaction */
        void    *ptr;   /* target descriptor of return transaction */
    }target;
    void *cookie;    /* target object cookie */
    unsigned int code;       /* transaction command */
    /* General information about the transaction. */
    unsigned int    flags;
    pid_t       sender_pid;
    uid_t       sender_euid;
    size_t      data_size;  /* number of bytes of data */
    size_t      offsets_size;   /* number of bytes of offsets */
    .........
};
```


Process A
Process B
User Data
Send data from A to B
User Data
struct binder_transaction_data
{
size_t handle;
unsigned int code;
void *buffer;
}
Transmission
Binder Protocol
BC_TRANSACTION
Reception
Binder Protocol
BR_TRANSACTION
BINDER_WRITE_READ
BINDER_WRITE_READ
Ioctl()
Ioctl()
switch (binderProtocol)
{
case BC_TRANSACTION: {...}
case BR_TRANSACTION: {...}
}
Kernel Space

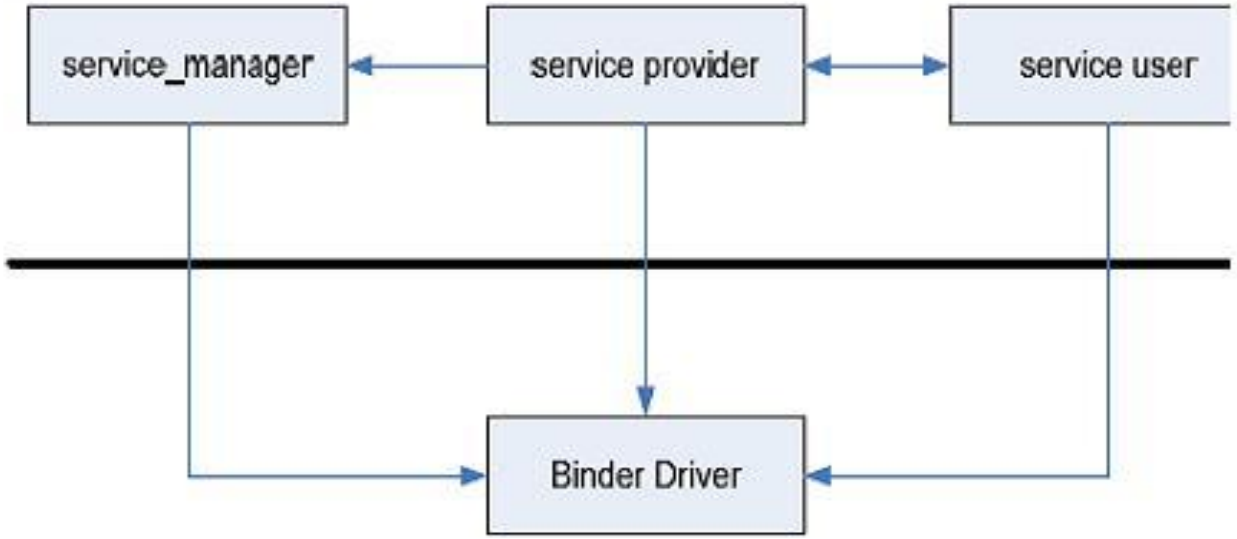
How does a user process receive the handle to a target process?

Binder Driver IPC

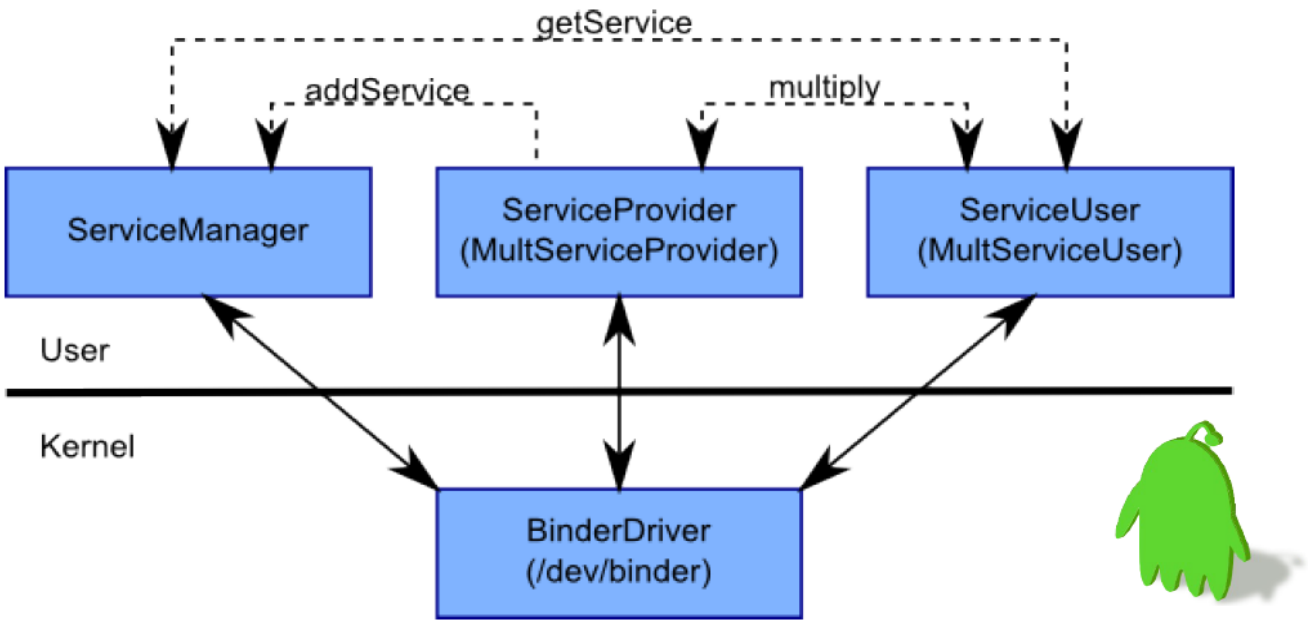


- Binder performs mapping of objects between two processes.
- A pool of threads is associated with each service to process incoming IPC

Service Manager

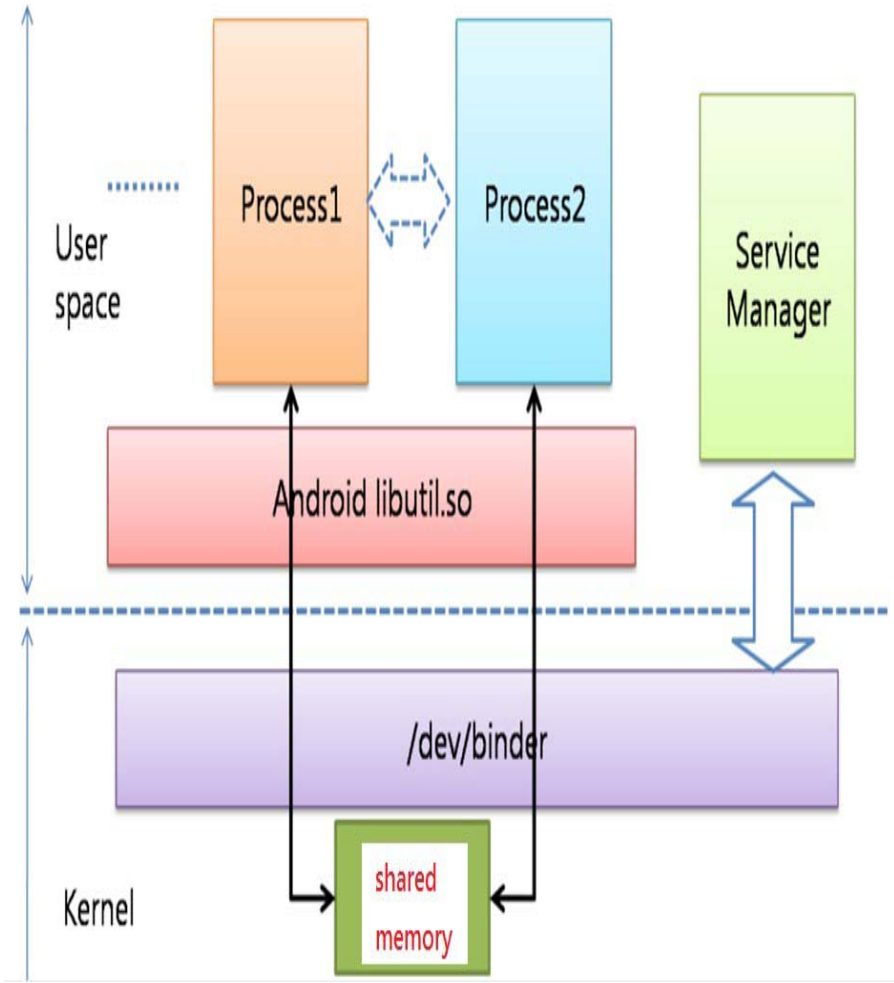


- Service_manager provides registry service to other processes
- It must be started before any other service gets running
- It first opens “/dev/binder” driver
- It then calls BINDER_SET_CONTEXT_MGR ioctl to let binder kernel driver know it acts as a manager
- *service_manager* runs first, it will register itself with a handle 0
- The other process must use this handle to talk with service_manager



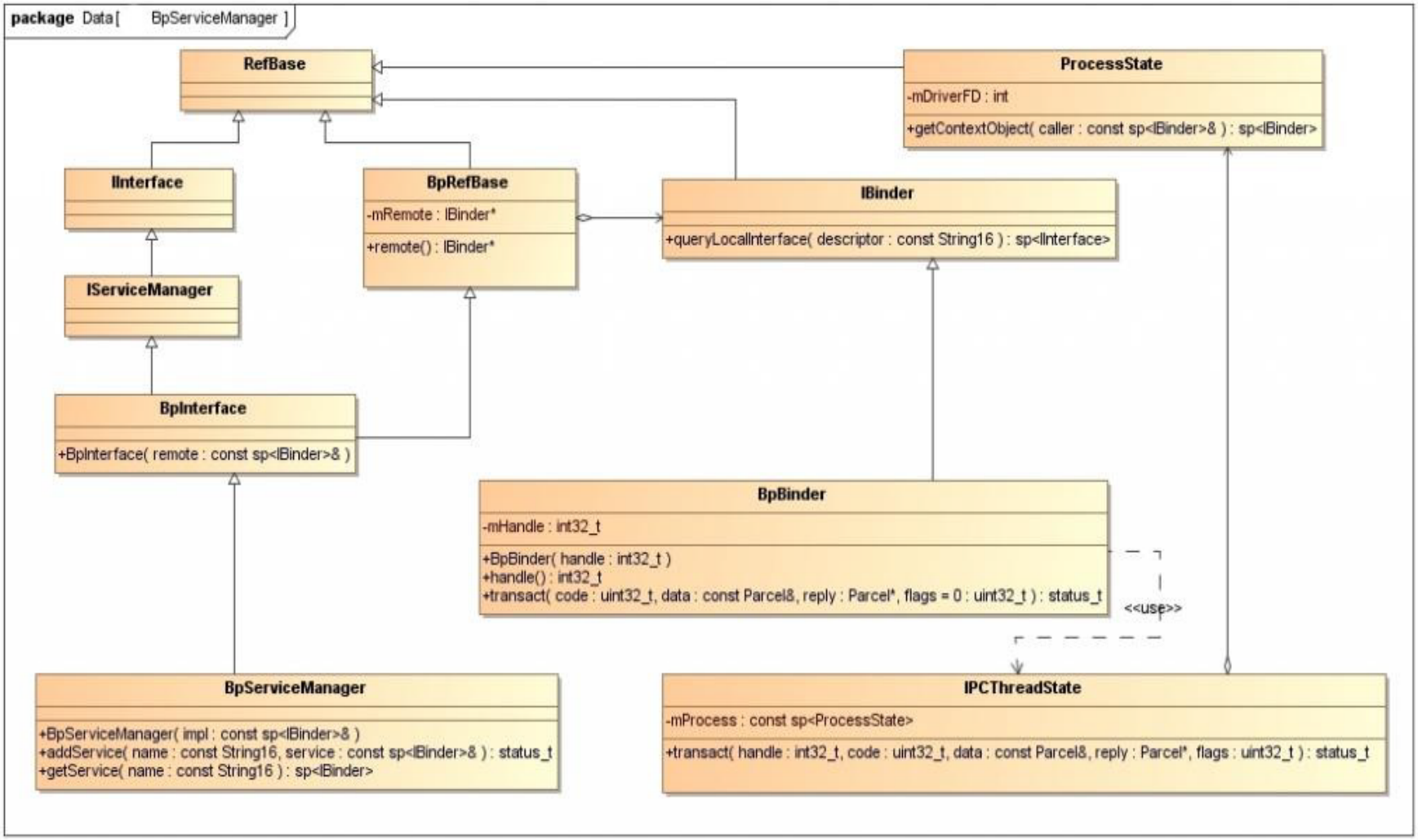
- Using 0 as the handle, service provider registers a service with the service manager
- The binder will generate a handle (assume 10) for the service
- Service manager will store the name and handle
- Using 0 as the handle, the client tries to get a particular service
- Service manager on finding that particular service will also return the handle '10' of the server, so that the client can communicate with the server directly

IPC over middleware



- C++ framework over the binder kernel driver
- A high level interface responsible for marshalling and unmarshalling
- Access the kernel driver for the application

Native Binder framework



IPC over Application Layer

public interface **IBinder**

boolean transact(int code, Parcel data, Parcel reply, int flags)

public class **Binder** implements **IBinder**

onTransact(int code, Parcel data, Parcel reply, int flags)

Bound Service

- Return an IBinder for the client to use
- Implement onBind() and other methods for RPC
- Create a *.aidl* file which generates interface

file in java

```
mBinder = new IRemoteService.Stub()
public IBinder onBind(Intent intent)
{
// Return the interface
return mBinder;
}
```

Client

- Calls bindService() to bind to the service
- Implements onServiceConnected() callback

```
public void onServiceConnected(ComponentName className, IBinder
service)
 {
mIRemoteService = RemoteService.Stub.asInterface(service);
 }
```

What to do with IPC?

- **Passing Objects over IPC**

send parcels

transact() and onTransact()

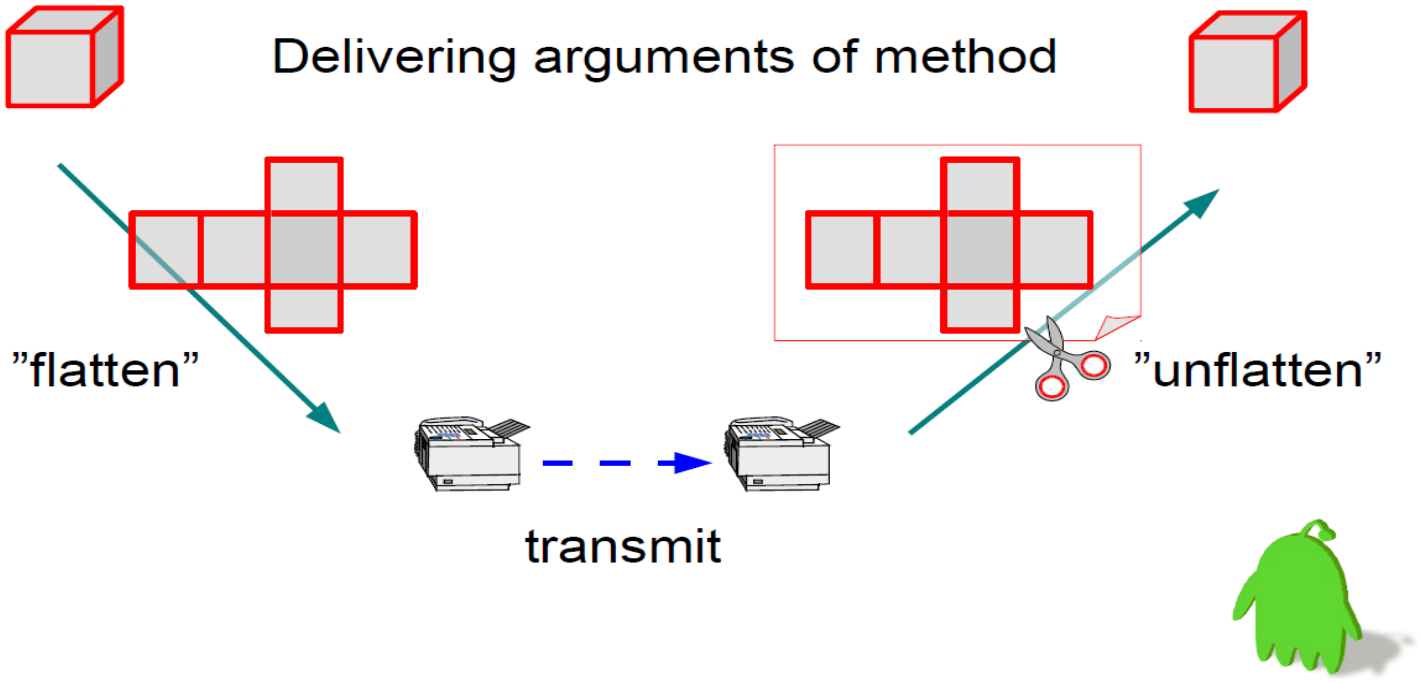
- **Calling an IPC Method**

Use IBinder object at the client to call methods implemented by the server

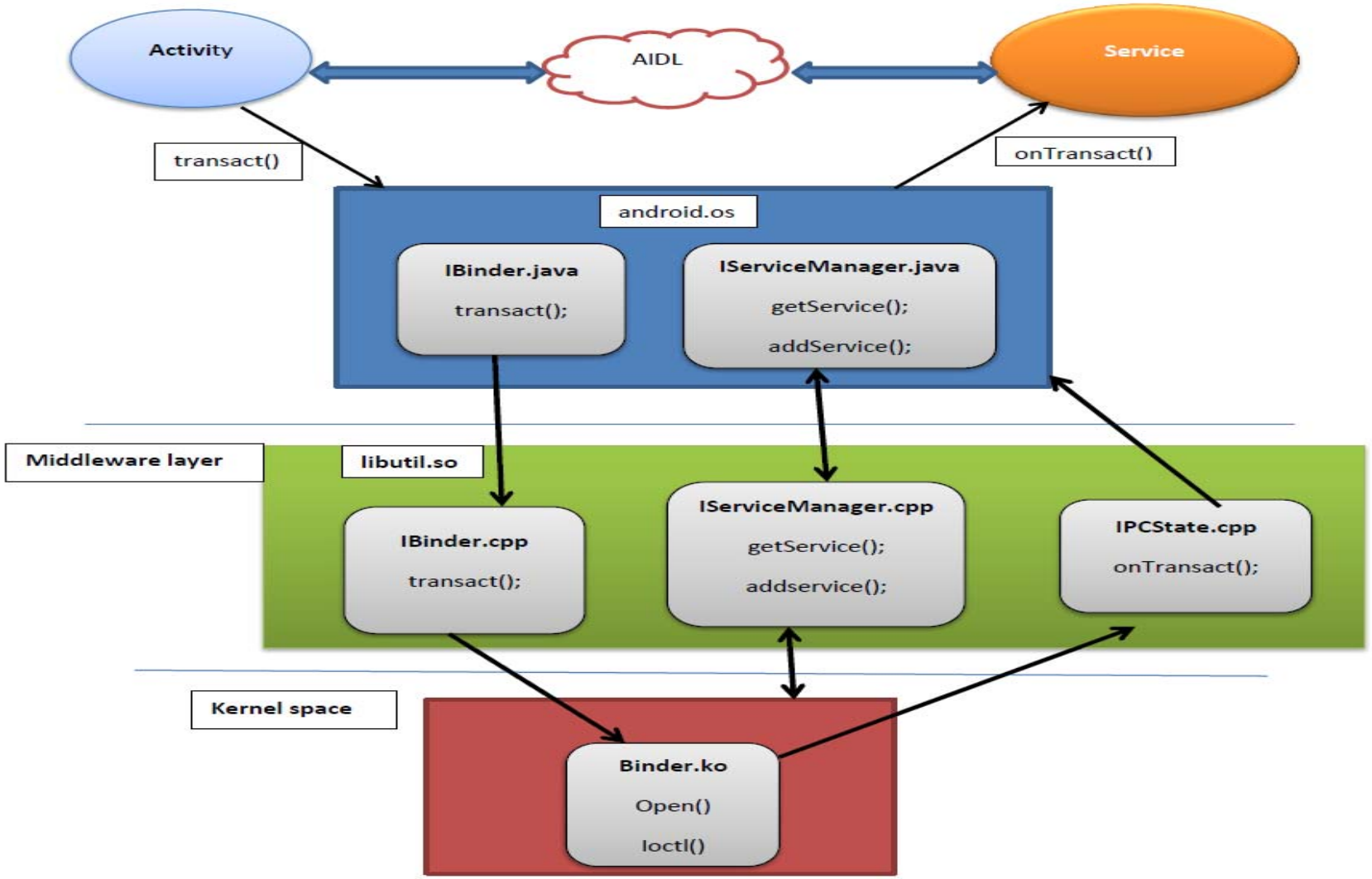
mIRemoteService.getService()

Parcel

android.os.Parcel



IPC overview across layers



Other Android specific features…

- DVM: A JVM for Android
  - Compact byte code
  - Register based implementation
  - Native Libraries bypass DVM
- Power Management
  - Battery Power – Android tries to put device to sleep
  - A mechanism to say that your app wants device to stay on i.e., don’t sleep
  - acquire(long timeout)
  - void release()

Project plan…

- Analyze binder performance
- Trace Binder IPC data/control flow

References:

http://www.cubrid.org/blog/dev-platform/binder-communication-mechanism-of-android-processes/

http://www.nds.rub.de/media/attachments/files/2012/03/binder.pdf

http://developer.android.com/guide/

http://app-solut.com/

http://mindtherobot.com

http://www.slideshare.net/jserv/android-ipc-mechanism **by** Jim Huang

Analysis of the Android Architecture -Stefan Br¨ahler

http://elinux.org/Android_Binder

http://www.angryredplanet.com/~hackbod/openbinder/docs/html/index.html

Service Manager Run [blogimg.chinaunix.net/blog/upfile2/081203105044.pdf]