Contents

1 IPC

Inter-process communication. Each process has its own address space. This provides data isolation and prevents direct interaction between different processes. How can we communicate with a Service, or send an Intent? Use **Binder**.

- Underpins most Android communication, i.e. when we use various system capabilities
- Kernel driver: provides lightweight RPC (remote procedure calls), data passing. C.f. Linux/Unix signals / pipes / sockets etc. Reading and writing Parcels between processes. Process, user ID authority / trust
- Per-process thread pool for handling requests
- Synchronous calls between processes

2 Binder

2.1 Facilities

- Calls: Simple inter-process messaging system. One-way, two-way
- Identifying: PID, UID
- Notification: Link to death, Leaked Service connections
- Managing: Reference counting, object mapping across processes, sleeping and waking worker threads
- Indirect functionality: As a token, sharing fd (file descriptor) to shared memory area

2.2 Implementation

API for apps

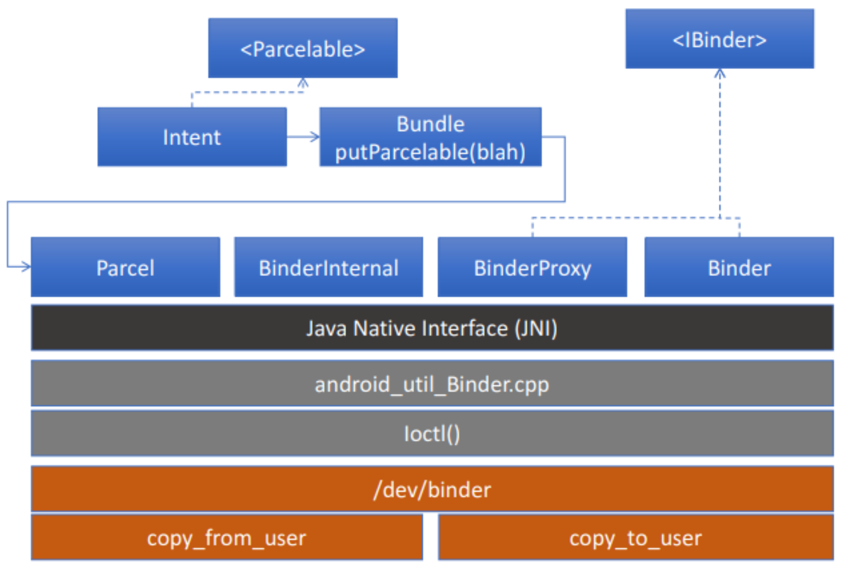
- AIDL
- Java API wrapper
  - Exposes the IBinder interface
  - Wraps the middleware layer
  - Parcelable object *marshalling* interface

Native Middleware

- Implements the user space (i.e. within a process) facilities of the Binder framework
- Marshalling and unmarshalling of specific data to primitives
- Provides interaction with the Binder kernel driver

Kernel driver

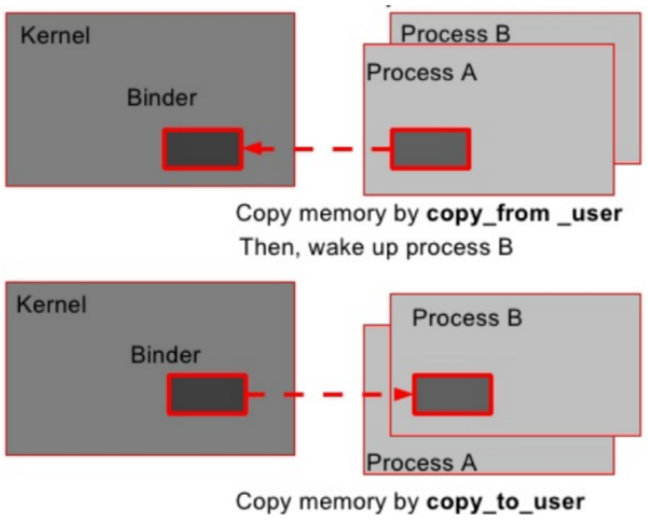
- Supports ioctl system calls from the middleware
- Supports cross-process file operations, memory mapping
- Thread pool for each service application for IPC
- Mapping of objects between processes via `copy_from_user`, `copy_to_user`

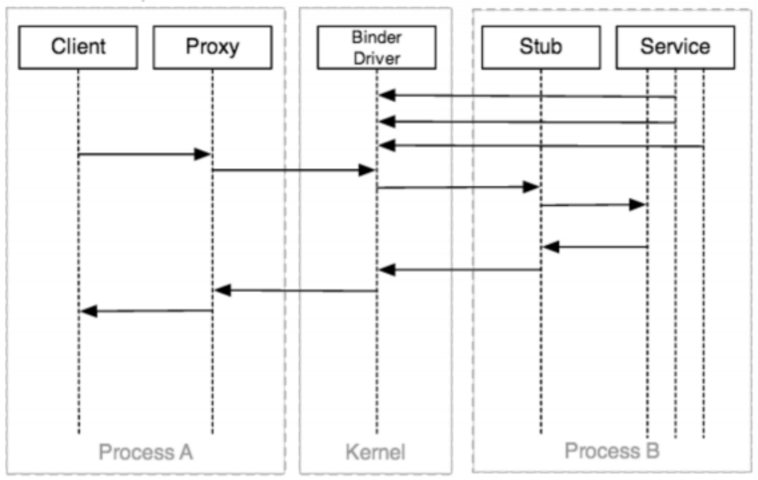

<Parcelable>
<IBinder>
Intent
Bundle putParcelable(blah)
Parcel
BinderInternal
BinderProxy
Binder
Java Native Interface (JNI)
android_util_Binder.cpp
Ioctl()
/dev/binder
copy_from_user
copy_to_user

2.3 Transactions

A transaction between processes: IBinder.transact -> Binder.onTransact(). Binder maintains a pool of transaction threads in each process

- To dispatch all IPCs coming from other processes
- If process A calls process B
  - Calling thread in A blocks in transact()
  - Sends the transaction to process B
  - Next available thread in B receives the incoming transaction, calls onTransact() on the target object, replies with the resultant Parcel
  - Thread in process A returns, resumes execution
- Reliant on Service (B) responding in a timely manner
  - Hence catching remote exceptions, transaction failures
  - Developer defined worker threads
  - Handling multiple calls from multiple transaction threads





3 Defining Remotely Bound Services

Using the Android Interface Definition Language (AIDL)

- Specify an interface for the service functionality
- Generates a proxy object
- To be used locally as if the remote service was not remote
- Generates a stub implementation
- The remote side of the transaction
- Generates a communication protocol
- Parcelling and unparcelling steps

Similar to Java interface definitions. Has label method parameters for efficiency

- in: transferred to the remote method
- out: returned to the caller
- inout: both in and out
- oneway: asynchronous

Permitted types

- Java primitive types, Lists, Maps
- Other AIDL-generated interfaces
- Classes implementing the Parcelable protocol

4 IPC Abstraction

Intent

- Highest level abstraction
- Asynchronous message passing

Inter-process method invocation by using AIDL (Android Interface Definition Language). **Binder**: kernel driver. **Ashmem**: Shared memory.

- Passed as file descriptor objects by Binder
- The USB service gives a specific USB device to an app without giving it unrestricted access

5 Binder Objects and Tokens

Binder Object

- An object that can be accessed through the Binder framework
- Implements the IBinder interface
- A unique identity maintained across processes
  - Allocated by the Binder driver. Cannot be duplicated. Binder objects maintain a unique ID even when parcelled
  - A 32 bit handle maintained by the kernel

Process A creates a binder object `<-` references memory directly

- Passes it to process B `<-` referenced by handle
- Passes it to process C `<-` referenced by handle

Capability-based security model

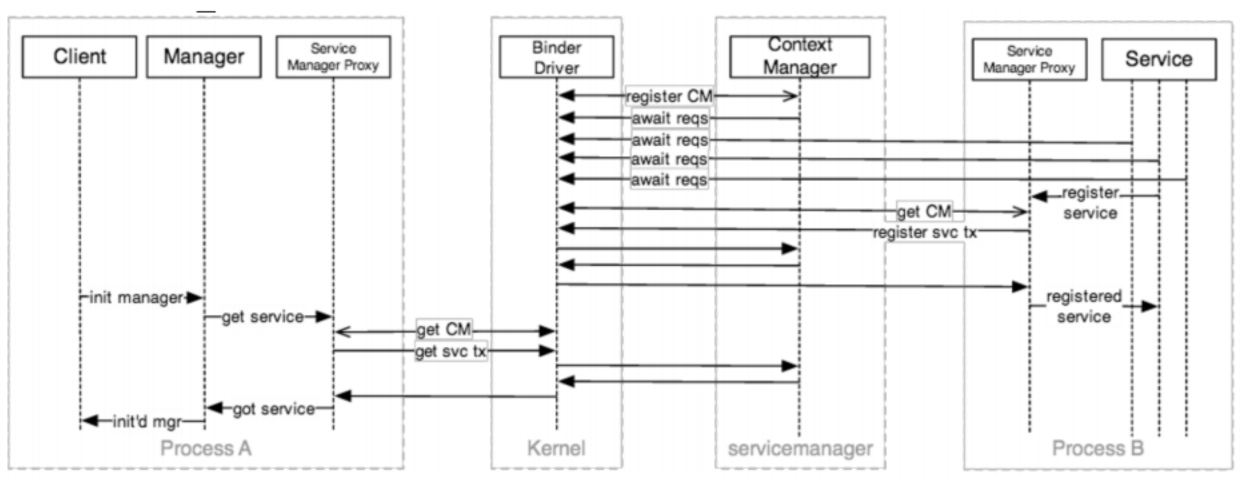
- Processes are granted access to a particular resource by giving them a capability in the form of the binder object. Binder object as token.
- The possession of a token grants the owning process full access to the Binder object enabling it to perform Binder transactions on the target object
- The only way to communicate with a Binder object is to be given a reference to it

6 ServiceManager

A single context manager that maintains references to Binder objects

- Implemented as ServiceManager
- Also hosts many system services within its process
- A Binder instance with a known Binder handle (0)
- Knows about other remote services
  - The first to be registered with Binder
  - Only trusted system services allowed to register. System, radio, media

Client does not know the token of remote Binder. Only the Binder interface **knows its own address**. Binder submits a service name and its Binder token to the ServiceManager via IPC. Client retrieves remote service Binder handle with service name and communicates with remote service



7 Binder

7.1 Security

Binder doesnt deal with security

- Enables a trusted execution environment
- Transactions via the kernel
- Client identity managed by the kernel
- Binder.getCallingUid(), Binder.getCallingPid()
- UID / PID included in each transcation

Access controlled in two ways

- Limit who can obtain a reference to a Binder object. Has interface reference security. Client cannot guess address of a service without going via the Service Manager.
- Check caller identity before performing an action on the Binder object
- Service asks package manager about UID permissions
- Check whether it holds a permission we want to enforce via PackageManager.getPackageInfo(...)

7.2 Performance

Explicit limitations

- Transactional buffer size 1Mb per process for all concurrent transactions in a process
- Many moderately sized transactions could also exhaust its limit. Arguments and return values are too large
- Keep transaction data small

Implicit limitations

- Data is copied: duplication of memory resources
- Native binary parcelling: better than reflection based serialization, still has overhead of parcel marshalling
- Not ideal for large data-streams, but good enough for window / activity / surface management $\rightarrow$ graphics
- Pass file descriptors to shared memory regions (ashmem - Android shared memory)

marshalling

The process of gathering data and transforming it into a standard format before it is transmitted over a network so that the data can transcend network boundaries