

Direct

A LIBRARY TO SIMPLIFY THE ANDROID WI-FI PEER-TO-PEER API

TYLER MCBRIDE | 100888344

<https://github.com/tylerjmcbride/Direct>

Contents

Preamble	3
What is Wi-Fi Direct?	4
Android's Wi-Fi P2P Framework	4
Motivation	5
Alternative Solutions	5
Basic Usage	6
Initial Setup	6
Setting Permission & Minimum SDK Version.....	6
Initialization	6
Host Initialization	6
Client Initialization	6
Service Management	7
Starting a Service	7
Stopping a Service.....	8
Discovering Services.....	8
Connecting to a Service.....	8
Disconnecting from a Service.....	9
Sending Objects	10
Sending an Object to a Client.....	10
Sending an Object to the Host	10
Internal API	11
DirectBroadcastReceiver	12
HostRegistrar	14
start	14
stop	14
ClientRegistrar	15
register	15
unregister	15
Direct	16
Host	17
Host	17
startService	17

stopService.....	17
send.....	18
Client.....	19
Client	19
startDiscovery	19
stopDiscovery.....	19
connect	20
disconnect.....	20
send.....	21
Future Prospects.....	22
Conclusion	23
Bibliography.....	24

Preamble

Direct is a library that I have created to provide a simplified interface to wrap around the Wi-Fi Peer-to-Peer API. In essence, this interface acts as a facade around the Wi-Fi Peer-to-Peer API by hiding its implementation details.

Wi-Fi Direct has peer-to-peer functionality, hence initially being called Wi-Fi Peer-to-Peer; however, this library will be designed to support a client server architecture instead. In order to establish connections and send data amongst these connections, Wi-Fi Direct provides an abundance of details that are of little actual use to the developer.

This library abstracts this abundance of details in order to enable the developer to implement Wi-Fi Direct without having to be aware of the underlying functionality; thus, reducing the both the technical load on the developer and the potential for bugs. Ultimately, this library frees the developer of the specific details of the Wi-Fi Direct API.

What is Wi-Fi Direct?

Wi-Fi Direct is a fairly recent technology which enables Wi-Fi compliant devices to make direct connections without the need for an intermediate access point. In other words, these devices may connect directly to one another without an internet connection. Wi-Fi Direct connections may be made anywhere at any time as these connections are not dependent on a Wi-Fi network. (Alliance, n.d.)

Android's Wi-Fi P2P Framework

Android provides a Wi-Fi P2P framework which complies with the Wi-Fi Alliance's Wi-Fi Alliance's Wi-Fi Direct™ certification program. Inclusively, Android 4.0 or later devices are all built with the appropriate hardware to support Wi-Fi Direct. (Android, n.d.)

Android supplies several APIs that enable Wi-Fi Direct discovery and connections to other devices whom all support Wi-Fi Direct. The [WifiP2pManager](#) class in the [android.net.wifi.p2p](#) package supplies methods for service discovery, peer discovery, and connection requests. These methods all accept listeners which notify of the success or failure of respective calls. Events detected by the Wi-Fi P2P framework produce intents that notify of changes, such as a dropped connection, or a discovered peer. (Android, n.d.)

There are three main reasons for using Android's Wi-Fi P2P framework. Wi-Fi Direct is useful for applications that share data among users, it uses direct connections via Wi-Fi without an intermediate access point, and last but not least it reaches distances much longer than any Bluetooth connection. (Android, n.d.)

Motivation

Despite support of Wi-Fi Direct being released on Android 4.0 in October 2011, the Wi-Fi Direct API continues to be very complex and difficult to understand. Many developers steer clear of Wi-Fi Direct due to its complex nature and confusing documentation. I wanted to reduce these deterrents from preventing the use of Wi-Fi Direct in future android development.

My solution was to create this library in order to create a library that is much easier to understand than that of the Android Wi-Fi Peer-to-Peer API. Unfortunately, as a consequence of this library abstracting details of the Android Wi-Fi Peer-to-Peer API there is a loss of functionality; therefore, developers making use of this library will not be able to customize their application to the full extent that the Android Wi-Fi Peer-to-Peer API provides.

Alternative Solutions

There do exist existing solutions that solve this issue; however, these solutions are less than ideal for my standards. An example solution is the [Salut](#) library. This library has nearly equivalent functionality to that of the functionality that my library provides. There are a number of subtle differences between the two libraries. For example, the [Salut](#) library uses JSON to transfer data while this library uses serialized Java objects.

The [Salut](#) library is also riddled with code smell. In addition, upon using said library myself for an Android application I made in an Object-Oriented Software Engineering course, I was forced to fork the library as I encountered a number of bugs. Forking this library proved to be difficult due to the lack of documentation. In summary, this library did not live up to the standard of code that I come to expect from an external library.

There exist other libraries for working with the Android Wi-Fi Peer-to-Peer API; however, these other libraries lacked documentation and proved to be much too difficult to start a project with; therefore, my library not only solves the overall problem but is compliant with general coding standards and is well documented.

Basic Usage

This section will explain how to use this library to quickly set up a Wi-Fi Direct enabled application to send and receive serializable Java objects.

Initial Setup

Setting Permission & Minimum SDK Version

Before getting starting, the following permissions must be explicitly stated within the Android manifest. These permissions are required to ensure that the application may use the Wi-Fi hardware. A minimum SDK version of 14 is required as only Android 4.0 or later devices are built with the appropriate hardware to support Wi-Fi Direct.

```
<uses-sdk android:minSdkVersion="14" />
<uses-permission android:name="android.permission.ACCESS_WIFI_STATE" />
<uses-permission android:name="android.permission.CHANGE_WIFI_STATE" />
<uses-permission android:name="android.permission.CHANGE_NETWORK_STATE" />
<uses-permission android:name="android.permission.INTERNET" />
<uses-permission android:name="android.permission.ACCESS_NETWORK_STATE" />
```

Initialization

It is recommended that the initialization is done in an [Application](#) class as it is necessary that the class persists between context switches.

Host Initialization

Below is the code to initialize a host, it is worth noting that this instance should persist through switching context as this instance registers itself within the application context. The service tag should be unique, as to prevent being confused with a different application using this library. The instance tag should attempt to be unique, but is not necessary.

```
Host host = new Host(getApplication(), "UNIQUE_SERVICE_TAG",
    "UNIQUE_INSTANCE_TAG");
```

Client Initialization

Below is the code to initialize a client, it is worth noting that this instance should persist through switching context as this instance registers itself within the application context. The service tag **must** equal the service tag that the host implements.

```
Client client = new Client(getApplication(), "UNIQUE_SER-
    VICE_TAG");
```

Service Management

Starting a Service

Below is the code for a host to create a service and advertise said service to client devices. More details after code snippet.

```
host.startService(new ObjectCallback() {
    @Override
    public void onReceived(Object object) {
        // Object received from client
    }
}, new ClientCallback() {
    @Override
    public void onConnected(WifiP2pDevice clientDevice) {
        // Client has connected
    }

    @Override
    public void onDisconnected(WifiP2pDevice clientDevice) {
        // Client has disconnected
    }
}, new ServiceCallback() {
    @Override
    public void onServiceStopped() {
        // The service has stopped, possibly unexpectedly
    }
}, new ResultCallback() {
    @Override
    public void onSuccess() {
        // Succeeded to request for the service to be started
    }

    @Override
    public void onFailure() {
        // Failed to request for the service to be started
    }
});
```

The [ObjectCallback](#) is called whenever the host receives an object from a client. The [ClientCallback](#) is called whenever a client connects or disconnects from the host. The [ServiceCallback](#) is called when the service has stopped, which is useful in the event where the service may have stopped unexpectedly. It is important that any callback does not contain any references to objects that will not persist between a switch in context.

Stopping a Service

Below is the code for a host to stop a service and discontinue advertisement to client devices, effectively closing all client connections. If this request is successful, it will trigger the `onServiceStopped()` method in the [ServiceCallback](#) provided when starting the service as the peer group will cease to exist.

```
host.stopService(new ResultCallback() {
    @Override
    public void onSuccess() {
        // Succeeded to request for the service to be stopped
    }

    @Override
    public void onFailure() {
        // Failed to request for the service to be stopped
    }
});
```

Discovering Services

Below is the code for a client to discover services. The [DiscoveryCallback](#) will be called whenever a new host has been discovered. If the client would rather see the entire list of available hosts, call `client.getNearbyHosts()`.

```
client.startDiscovery(new DiscoveryCallback() {
    @Override
    public void onDiscovered(WifiP2pDevice hostDevice) {
        // New service discovered
    }
}, new ResultCallback() {
    @Override
    public void onSuccess() {
        // Succeeded to start discovery
    }

    @Override
    public void onFailure() {
        // Failed to start discovery
    }
});
```

Connecting to a Service

After the client has discovered a service, that client may now connect to that service with the respective host [WifiP2pDevice](#).

The [ObjectCallback](#) is called whenever the client receives an object from the host. The [ConnectionCallback](#) is called when the client officially establishes connection—the request itself is not enough to guarantee success—with the host, or when the client loses said connection with the host. It is important that either callback does not contain any references to objects that will not persist between a switch in context.

```
client.connect(hostDevice, new ObjectCallback() {
    @Override
    public void onReceived(Object object) {
        // Object received from host
    }
}, new ConnectionCallback() {
    @Override
    public void onConnected() {
        // Connected to host
    }

    @Override
    public void onDisconnected() {
        // Disconnected with host, perhaps the host discontinued
the service?
    }
}, new ResultCallback() {
    @Override
    public void onSuccess() {
        // Connection request succeeded
    }

    @Override
    public void onFailure() {
        // Connection request failed
    }
});
```

Disconnecting from a Service

When the client would like to disconnect from the host, that client may easily disconnect by the following method. The [ResultCallback](#) does not guarantee a successful disconnect, this event will be captured in the [ConnectionCallback](#) provided in the connect method.

```

client.disconnect(new ResultCallback() {
    @Override
    public void onSuccess() {
        // Succeeded to request a disconnect from the service
    }

    @Override
    public void onFailure() {
        // Failed to request a disconnect from the service
    }
});

```

Sending Objects

Sending an Object to a Client

After a client has connected, the host may send a serializable object to said client.

```

host.send(clientDevice, serializableObject, new ResultCallback()
{
    @Override
    public void onSuccess() {
        // Succeeded to send object
    }

    @Override
    public void onFailure() {
        // Failed to send object
    }
});

```

Sending an Object to the Host

After a client has connected with the host, that client may send a serializable object to said host.

```

client.send(serializableObject, new ResultCallback() {
    @Override
    public void onSuccess() {
        // Succeeded to send object
    }

    @Override
    public void onFailure() {
        // Failed to send object
    }
});

```

Internal API

This section will explore in depth the underlying functionality that each class within the library provides. Before reading the following documentation, it is important to understand that all of the Wi-Fi P2P framework methods are one way communication; in other words, any method called with the Wi-Fi P2P framework is only a request, and it's success only reflects the success of the hardware receiving said request, not that the request has been fulfilled. The state of the hardware is only available through the [DirectBroadcastReceiver](#).

For example, calling [connect](#) from the [WifiP2pManager](#) will only send the hardware the request to connect to the respective [WifiP2pDevice](#). The only way to determine if the connection has been establish is through the [DirectBroadcastReceiver](#) receiving a [WIFI_P2P_CONNECTION_CHANGED_ACTION](#) intent.

DirectBroadcastReceiver

`abstract class DirectBroadcastReceiver extends BroadcastReceiver`

The [DirectBroadcastReceiver](#) class extends [BroadcastReceiver](#), which receives and handles broadcast intents. The [BroadcastReceiver](#) is essentially the means of reacting to changes in the Android system. In particular, there are five intents that the [DirectBroadcastReceiver](#) is interested in:

- [WIFI_P2P_STATE_CHANGED_ACTION](#)
 - This action indicates whether Wi-Fi P2P is enabled or disabled.
- [WIFI_P2P_DISCOVERY_CHANGED_ACTION](#)
 - This action indicates whether the peer discovery has either been started or stopped.
- [WIFI_P2P_PEERS_CHANGED_ACTION](#)
 - This action indicates that the available peer list has changed. The peer list will be changed when peers are lost, found, or updated. This will be exclusively used by the host to unregister clients who have been lost.
- [WIFI_P2P_CONNECTION_CHANGED_ACTION](#)
 - This action indicates that the Wi-Fi P2P connectivity has changed. This will be used to get a handle on the:
 - [WifiP2pInfo](#)
 - This class represents Wi-Fi P2P group connection information. This class contains the field [groupFormed](#) which indicates whether a Wi-Fi P2P group has been successfully formed. This class also contains the field [groupOwnerAddress](#) which may be used to retrieve the host IP address, which is necessary for the client to register with the host.
 - [NetworkInfo](#)
 - This class represents the current network connection. This class is used to call the method [isConnected\(\)](#) to determine whether the current device has established a connection and is able to perform data transactions.
 - [WifiP2pGroup](#)
 - This class represents the current Wi-Fi P2P group. This group consists of the group owner and one or more clients. In particular, this class will be used to call the method [getOwner\(\)](#) to retrieve the host [WifiP2pDevice](#).
- [WIFI_P2P_THIS_DEVICE_CHANGED_ACTION](#)
 - This action indicates that the Wi-Fi P2P device has changed. This will be used to get a handle on the current [WifiP2pDevice](#).

The [BroadcastReceiver](#) requires the extending class to implement the abstract method [onReceive\(\)](#), which is the method that handles received intents; however, this method generally promotes the If-Then-Else code smell, you may see this code smell in the official Android documentation for [creating a broadcast receiver](#). To combat this, the [DirectBroadcastReceiver](#) splits the abstract method [onReceive\(\)](#) into method into the following more intuitive methods:

- `stateChanged(boolean wifiEnabled)`
 - This method is called when the `WIFI_P2P_STATE_CHANGED_ACTION` intent has been broadcasted.
- `discoveryChanged(boolean discoveryEnabled)`
 - This method is called when the `WIFI_P2P_DISCOVERY_CHANGED_ACTION` intent has been broadcasted.
- `peersChanged()`
 - This method is called when the `WIFI_P2P_PEERS_CHANGED_ACTION` intent has been broadcasted.
- `connectionChanged(WifiP2pInfo p2pInfo, NetworkInfo info, WifiP2pGroup p2pGroup)`
 - This method is called when the `WIFI_P2P_CONNECTION_CHANGED_ACTION` intent has been broadcasted.
- `thisDeviceChanged(WifiP2pDevice thisDevice)`
 - This method is called when the `WIFI_P2P_THIS_DEVICE_CHANGED_ACTION` intent has been broadcasted.

HostRegistrar

```
class HostRegistrar
```

The [HostRegistrar](#) is in charge of handling the registration of clients, this class will be used by the [Host](#) in order to encapsulate the registration functionality.

start

```
void start(ServerSocketInitializationCompleteListener  
initializationCompleteListener)
```

This method will start the registration process. To begin, this method will initialize a new [ServerSocket](#) which will accept incoming client connections; however, the [ServerSocket](#) has a blocking method which requires the registration process to run on a separate [Thread](#). This blocking method is the [ServerSocket](#) accept method as it must wait for a request to come in over the network. To process these requests, the registrar will then spawn another new thread for each individual client request through an [ExecutorService](#). The communication between these sockets are done through the use of an [ObjectInputStream](#) and an [ObjectOutputStream](#).

These client requests aim to either register or unregister said clients from the host. Clients who wish to register will send a [Handshake](#) object and clients who wish to unregister will send over an [Adieu](#) object. In the case of a client registering, the host will then reply with its own [Handshake](#) object.

Both the [Handshake](#) and the [Adieu](#) class contain the MAC address of the device and the port number of the [ObjectReceiver](#) running on the device, while the IP address can easily be derived from the connecting [Socket](#). This enables both the client and host to establish a connection with one another's [ObjectReceiver](#) for the purpose of sending one another objects. Depending on which object is processed the registrar will update the library accordingly.

stop

```
void stop()
```

This method will stop the registration process, the [ExecutorService](#) will be shut down, the [ServerSocket](#) closed, and the [Thread](#) running the registrar will be interrupted; hence why a new [ServerSocket](#) will need to be initialized on registrar start. This is to ultimately clean up resources while there are no Wi-Fi P2P services running.

ClientRegistrar

```
class HostRegistrar
```

The [ClientRegistrar](#) is in charge of handling registration with the host, this class will be used by the [Client](#) in order to encapsulate the registration functionality.

register

```
void register(InetSocketAddress address, RegisteredWithServerListener  
registeredWithServerListener)
```

This method will register the client with the appropriate host. To begin, this method will initialize a new [Socket](#) which will accept to connect to the [HostRegistrar ServerSocket](#). This connection is made on a separate [Thread](#) to prevent a [NetworkOnMainThreadException](#) as a networking operation must be completed to establish a connection.

In order to register, the client will send a [Handshake](#) object and then the host will reply with its own [Handshake](#) object. This is done in order for the client to retrieve the port that the host [ObjectReceiver](#) running on, as well as for the host to retrieve the port that the client [ObjectReceiver](#) is running on as well as the client IP address.

Once the transfer of the [Handshake](#) objects are complete the [ClientRegistrar](#) will close the [Socket](#) effectively ending the connection. The communication between these sockets are done through the use of an [ObjectInputStream](#) and an [ObjectOutputStream](#).

unregister

```
void unregister(InetSocketAddress address,  
UnregisteredWithServerListener unregisteredWithServerListener)
```

This method will unregister the client from the appropriate host. To begin, this method will initialize a new [Socket](#) which will accept to connect to the [HostRegistrar ServerSocket](#). This connection is made on a separate [Thread](#) to prevent a [NetworkOnMainThreadException](#) as a networking operation must be completed to establish a connection.

In order to register, the client will send an [Adieu](#) object to the [HostRegistrar](#). This is done in order to notify the [HostRegistrar](#) that the client would like to unregister. The host will have no reply for this action as the client is disconnecting and need no further information.

Once the transfer of the [Adieu](#) object is complete the [ClientRegistrar](#) will close the [Socket](#) effectively ending the connection. The communication between these sockets are done through the use of an [ObjectInputStream](#) and an [ObjectOutputStream](#).

Direct

`abstract class Direct`

The [Direct](#) abstract class contains common behaviour and variables that are inherited by both the [Host](#) and [Client](#) classes. In particular this class creates an instance of [IntentFilter](#) which listens for the following intents:

- [WIFI_P2P_STATE_CHANGED_ACTION](#)
- [WIFI_P2P_DISCOVERY_CHANGED_ACTION](#)
- [WIFI_P2P_PEERS_CHANGED_ACTION](#)
- [WIFI_P2P_CONNECTION_CHANGED_ACTION](#)
- [WIFI_P2P_THIS_DEVICE_CHANGED_ACTION](#)

These actions are received by the abstract class [DirectBroadcastReceiver](#) which is extended by an [anonymous class](#) within both the [Host](#) and [Client](#) constructors and registered with the application context. While this class is used by both the [Host](#) and [Client](#) classes, they have different implementations of the five methods the [DirectBroadcastReceiver](#) provides. The reason why these classes are anonymously extended is that they require access to private members of both the [Host](#) and [Client](#) classes.

Apart from creating the [IntentFilter](#), the [Direct](#) class initializes the [Channel](#) which is the link that connects the given application to the Wi-Fi P2P framework. This class will also use the respective [Application](#) to retrieve the application context in order to create a [Handler](#) in order for asynchronous methods to post a [Runnable](#) to the main thread.

Host

`class Host extends Direct`

The [Host](#) class is responsible for hosting services.

Host Constructor

`Host(Application application, String service, String instance)`

This constructor will create an instance of an anonymous class inheriting from [DirectBroadcastReceiver](#) and register said instance with the application context. This constructor will create an instance of `Map<String, String> record` to store within an instance of [WifiP2pDnsSdServiceInfo](#).

The [WifiP2pDnsSdServiceInfo](#) will eventually be passed to clients who are discovering the respective service. In particular, an entry will be put into the `Map<String, String> record` with the `SERVICE_NAME_TAG` key with the value as the respective `service` that will be hosted. This constructor will also create an instance of [HostRegistrar](#) to handle the registration of clients and [ObjectReceiver](#) to receive data from said clients.

startService

`void startService(ObjectCallback dataCallback, ClientCallback clientCallback, ServiceCallback serviceCallback, ResultCallback callback)`

This method will begin by clearing all local services, or in other words, stopping any previously existing service that the host may be providing.

Afterwards, the method will start the [ObjectReceiver](#) and [HostRegistrar](#), initializing their respective [ServerSocket](#)s. The host now has a handle on the [HostRegistrar](#)'s [ServerSocket](#) port as it has been initialized. This port number will be put into the `Map<String, String> record` with the `REGISTRAR_PORT_TAG` as the key. Then the host instance of [WifiP2pDnsSdServiceInfo](#) will be updated to reflect the updated `record`.

Once the above has been successfully completed, this method will add the local service accompanied by the [WifiP2pDnsSdServiceInfo](#) for service discovery. This is important as the clients will use the [WifiP2pDnsSdServiceInfo](#) to look at the `Map<String, String> record` on discovery.

stopService

`void stopService(final ResultCallback callback)`

This method will practically work in the reverse order of the `startService` method. This method will remove the local service respective to the [WifiP2pDnsSdServiceInfo](#) instance.

After removing the local service, this method will remove the current P2P group, and through reflection, this method will attempt to delete the persistent P2P group as well.

This is because P2P groups are by default persisted in the Wi-Fi P2P framework. By reflection I mean that the method to within the Wi-Fi P2P framework to delete these persistent groups is not visible and must be accessed through reflection. Overall, this method will effectively end the P2P group for all devices that are connected.

send

```
void send(WifiP2pDevice clientDevice, Serializable object, final  
ResultCallback callback)
```

With the client IP address and the client [ObjectReceiver](#) port obtained from the respective `clientDevice`'s registration handshake, this method will effectively send the respective `object` through the host [ObjectTransmitter](#). The `object` is required to implement [Serializable](#) as communication between the [ObjectTransmitter](#) and the [ObjectReceiver](#) make use of [ObjectInputStream](#) and [ObjectOutputStream](#).

Client

```
class Client extends Direct
```

This class is responsible for discovering services, and connecting to said services.

Client Constructor

```
Client(Application application, String service)
```

This constructor will create an instance of an anonymous class inheriting from [DirectBroadcastReceiver](#) and register said instance with the application context. The constructor will finally set the [DnsSdServiceResponseListener](#) and [DnsSdTxtRecordListener](#) to be reused with each service request, more on this will be covered in the explanation of the [startDiscovery](#) method. This constructor will also create an instance of [ClientRegistrar](#) to handle the registration with the [HostRegistrar](#).

startDiscovery

```
void startDiscovery(DiscoveryCallback discoveryCallback,
ResultCallback callback)
```

This method will create a new service request instance and send it to the Wi-Fi P2P framework. If successful, this method will then initiate service discovery. Service discovery is a process that involves scanning for requested services for the purpose of establishing a connection to a peer that supports an available service.

The service discovery notifies the library through the use of both a [DnsSdServiceResponseListener](#) and [DnsSdTxtRecordListener](#). For the purpose of this library, only the [DnsSdTxtRecordListener](#) is used. This is because the [DnsSdTxtRecordListener](#) retrieves the `Map<String, String> record` which contains two entries that are useful to the client. These two entries are [SERVICE_NAME_TAG](#) and [REGISTRAR_PORT_TAG](#). The [SERVICE_NAME_TAG](#) entry used to filter the discovered services, this entry will contain the unique identifier of the application. The [REGISTRAR_PORT_TAG](#) will contain the host registrar port, which in combination with the IP address of the host will be used to both register and unregister.

The services discovered which contain the proper [SERVICE_NAME_TAG](#) will be stored in `Map<WifiP2pDevice, Integer> nearbyHostDevices`, which is a map which the key is the respective host [WifiP2pDevice](#) and value is the respective registrar port stored in the [REGISTRAR_PORT_TAG](#).

stopDiscovery

```
void stopDiscovery(final ResultCallback callback)
```

This method will remove the service request created in `public void startDiscovery(final ResultCallback callback)` if said service request is not null. `Map<WifiP2pDevice, Integer> nearbyHostDevices` will be cleared and all peer discovery will be ceased.

connect

```
void connect(WifiP2pDevice hostDevice, ObjectCallback dataCallback,
ConnectionCallback connectionCallback, ResultCallback callback)
```

This method will attempt to connect to the given `hostDevice` based on a `WifiP2pConfig` consisting of the MAC address from said host device. This method will only attempt to establish this connection if the given host device is contained within `Map<WifiP2pDevice, Integer> nearbyHostDevices`, this is to prevent the client from connecting to host devices that are not running with the proper unique identifier.

This method will not actually establish the connection but rather sends a connection request to the Wi-Fi P2P framework. In the event of a successful connection between the client and host device, a [WIFI P2P CONNECTION CHANGED ACTION](#) intent will be broadcasted and notify the client of a change in connectivity.

When a successful connection is broadcasted, the client will first create an instance of [ObjectReceiver](#), which is essentially a [ServerSocket](#) listening for objects to be received from the host. At this point, the client has access to the host device IP address through the [WifiP2pGroup](#). Given the host IP address and registrar port, the client then connects to the [HostRegistrar](#) through the [ClientRegistrar](#) and sends a [Handshake](#) object consisting of the client MAC address and port the client [ObjectReceiver](#) is listening on. This is to notify the host of the established connection and to provide the host with means of sending objects to the client [ObjectReceiver](#).

The host will then send a [Handshake](#) object in return consisting of the MAC address and port of the host [ObjectReceiver](#) is listening on. This is to provide the client of the established connection and to provide the host with means of sending objects to the client [ObjectReceiver](#).

disconnect

```
void disconnect(ResultCallback callback)
```

This method will begin by unregistering the client from the host, this is done by sending an [Adieu](#) object to the host through the [ClientRegistrar](#) to the [HostRegistrar](#). This will notify the host that the client is disconnecting to prevent the host from continuing to send objects to the client [ObjectReceiver](#). This is required as the Wi-Fi P2P framework has no reliable functionality to detect client disconnects. The registrar is required to unregister before disconnecting, for when the client leaves the P2P group the [ClientRegistrar](#) will no longer be permitted to connect to the [HostRegistrar](#)'s [ServerSocket](#).

After unregistering, this method will then remove the current P2P group, and through reflection, this method will attempt to delete the persistent P2P group, as P2P groups are by default persisted in the Wi-Fi P2P framework. By reflection I mean that the method to within the Wi-Fi P2P framework to delete these persistent groups is not visible and must be accessed through reflection. This will effectively disconnect the client from the host.

As usual, this method will not actually remove the P2P group but rather sends a request to the Wi-Fi P2P framework. In the event of a successful disconnect between the client and host device, a [WIFI_P2P_CONNECTION_CHANGED_ACTION](#) intent will be broadcasted and notify the client of a change in connectivity. When a successful disconnect is broadcasted, all host information will be cleared and the client [ObjectReceiver](#) will be stopped.

send

```
void send(Serializable object, ResultCallback callback)
```

With the host IP address and the host [ObjectReceiver](#) port obtained from the registration handshake, this method will effectively send the host the respective **object** through [ObjectTransmitter](#). The **object** is required to implement [Serializable](#) as communication between the [ObjectTransmitter](#) and the [ObjectReceiver](#) make use of [ObjectInputStream](#) and [ObjectOutputStream](#).

Future Prospects

This library was only tested with a Nexus 5, HTC One M7, and a Galaxy S6; therefore, it will need to be tested with many more devices. I plan to get my hands on at least a few more devices before publishing this library onto [JitPack](#) and advertising it in the community.

I plan to—in the future—implement the [Strategy](#) design pattern in order to allow developers whom use this library to implement their own functionality for process such as the [OutputStream](#) and [InputStream](#) for transmitting and receiving data. Forcing the developers to only have the option to use the [ObjectInputStream](#) and an [ObjectOutputStream](#) with serializable objects is clearly a design flaw; therefore, I will implement a way for developers using this library to provide their own logic if desired.

The goal eventually is, if a developer using my library implements their own functionality for, they may submit a pull request for me to add to my library for other developers to benefit.

In addition, I would like to make use of the [Builder](#) pattern by allowing a developer whom uses the library to define their own constant values. This builder would likely be packed full of options for the developer using the library to choose from. For example, the pool size for the [ExecutorService](#) in the [ObjectReceiver](#). Ideally the builder would look something like the following:

```
Host host = new HostBuilder(getApplication(),  
    "UNIQUE_SERVICE_TAG",  
    "UNIQUE_INSTANCE_TAG").setObjectReceiverThreadPoolSize(5).build()  
;
```

Conclusion

I intend this library to be used by many other developers who wish to implement the Wi-Fi Direct functionality and potentially become a community to further progress the strength and reliability of the library through collaborative efforts.

Bibliography

Alliance, W.-F. (n.d.). *Wi-Fi Direct*. Retrieved from Wi-Fi Alliance: <http://www.wi-fi.org/discover-wi-fi/wi-fi-direct>

Android. (n.d.). *android.net.wifi.p2p*. Retrieved from Android Developers: <https://developer.android.com/reference/android/net/wifi/p2p/package-summary.html>

Android. (n.d.). *Wi-Fi Peer-to-Peer*. Retrieved from Android Developers: <https://developer.android.com/guide/topics/connectivity/wifip2p.html>

Android. (n.d.). *WifiP2pManager*. Retrieved from Android Developers: <https://developer.android.com/reference/android/net/wifi/p2p/WifiP2pManager.html>