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Implementation of Adhoc Communication In D2D Technology using Android Mobiles

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***Abstract*—D2D(Device to Device) technology is the recent 5G(5th Generation) Technology. In the following transaction we have implemented the transfer of Image and Video using MANET Routing Protocol in D2D technology. To implement this we used the Wi-Fi Direct app(Wireless fidelity Direct application) provided by Google android apps. In fact the Wi-Fi-Direct and LTE-Direct(Long term evolution Direct) are the technologies which are categorized as D2D technology.**

***Index Terms*— P2P(Peer-to-Peer),D2D(Device-to-Device communication), AODV (Adhoc on Demand Distance Vector Routing),W-Fi (Wireless Fidelity),LTE(Long Term Evolution)**

I. INTRODUCTION

Apart from Data offloading the mean reason for which we implemented the Adhoc communication in D2D technology Android Mobiles is the Disaster management. The implemented Mobile Application will work without Network in the ISM Band. Hence we are able to transfer the Image of Video to long distances in terms of Kilometers also without the use of cellular Network.
In this paper Section-II discusses about the Implemented D2D technologies like Wi-Fi-Direct. Section-III speaks about another D2D technology called LTE-Direct and the reason why we didn't implement it along with its advantages and disadvantages. Section-IV discusses about the Android app for Wi-Fi-Direct and its specifications where we have modified it according to Adhoc Criterion. Section-IV discusses about the transaction setup scenario with equipments required. Section-V speaks about the results with screen shot of implementation in 4G Mobile sets. Section-VI speaks about the future enhancement that can be carried out on the existing implemented transaction of mobile Handsets with Conclusion.

II. WI-FI-DIRECT

Wi-Fi Stands for Wireless fidelity based on IEEE 802.11 Standards. Wi-Fi Devices consists of two components as following:

- Wireless Station
- Access Point

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The Characteristics of Wi-Fi are depicted in the below Table.1
There are different classes of Wi-Fi of which Wi-Fi-Direct is the one which is used for 5G D2D communication. Wi-Fi Direct is a new technology defined by the Wi-Fi Alliance aimed at enhancing direct device to device communications in Wi-Fi. Thus, given the wide base of devices with Wi-Fi capabilities, and the fact that it can be entirely implemented in software over traditional Wi-Fi radios, this technology is expected to have a significant impact [1-6].
The Fig.1- shows the Wi-Fi Architecture having Wireless stations, Access Points, Hub and Routers.
Given the wide adoption of Wi-Fi in many kinds of devices, a natural way for the technology to progress is to target device-to-device connectivity, i.e. without requiring the presence of an Access Point (AP), traditionally provided by other technologies [7].Access Point is a Hardware Device which connects the Wi-Fi Complaint wireless device to a Wired Network consisting of Router, Hub etc. It's a means of connectivity between wired and wireless Network. The Wireless Stations are the Mobile Handset, Laptops and other roaming devices. Unlike the previous Wi-Fi technologies, the Wi-Fi Direct technology takes a different approach to enhance device to device connectivity. Instead of leveraging the ad-hoc mode of operation, Wi-Fi-Direct builds upon the successful IEEE 802.11 infrastructure mode and lets devices negotiate who will take over the AP-like functionalities.

TABLE I-CHARACTERISTICS OF WI-FI

Characteristics	**Description**
Physical layer	Direct Sequence spread spectrum, Frequency Hopping spread spectrum, Orthogonal frequency division Multiplexing, Infrared
Frequency Band	2.4 GHz(ISM band) and 5 GHz
Data Rates	1 Mbps, 2Mbps, 5.5 Mbps, 11 Mbps, 54 Mbps
Data and Network security	RC-4 Based stream encryption algorithm for confidentiality, authentication and integrity. Limited Key Management.
Operating Range	Up to 150 feet indoors and 1500 feet outdoors
Positive aspects	Ethernet speeds without wires
Negative aspects	Poor Security in Native mode

Fig.1-Wi-Fi-Architecture

Thus, legacy Wi-Fi devices may seamlessly connect to Wi-Fi Direct devices (as explained in detail below). By taking this decision, Wi-Fi-Direct immediately inherits all the enhanced QoS, power saving, and security mechanisms developed for the Wi-Fi infrastructure mode in the past years [1-6].
WiFi-Direct allows devices to implement the role of either a client or an access point (AP), and hence to take advantage of all the enhanced Quality of Service (QoS), power saving and security mechanisms typical of the infrastructure mode [8].
The above Fig.2 shows how Wi-Fi and Cellular Network are using P2P discovery.
In a typical Wi-Fi network, clients discover and associate to WLANs, which are created and announced by Access Points (APs) [1-6]. In this way, a device unambiguously behaves either as an AP or as a client, each of these roles involving a different set of functionality. A major novelty of Wi-Fi Direct is that these roles are specified as dynamic, and hence a Wi-Fi Direct device has to implement both the role of a client and the role of an AP (sometimes referred to as Soft-AP).These roles are therefore logical roles that could even be executed simultaneously by the same device, for instance by using different frequencies (if the device has multiple physical radios) or time-sharing the channel through virtualization techniques. In order to establish a communication, then, P2P devices have to agree on the role that each device will assume [1-6].
Wi-Fi Direct devices, formally known as P2P Devices, communicate by establishing P2P Groups, which are functionally equivalent to traditional Wi-Fi infrastructure networks. The device implementing AP-like functionality in the P2P Group is referred to as the P2P Group Owner (P2P GO), and devices acting as clients are known as P2P Clients. Given that these roles are not static, when two P2P devices discover each other the negotiate1 their roles (P2P Client and P2P GO) to establish a P2P Group. Once the P2P Group is established, other P2P Clients can join the group as in a traditional Wi-Fi network except 802.11b [1-6].

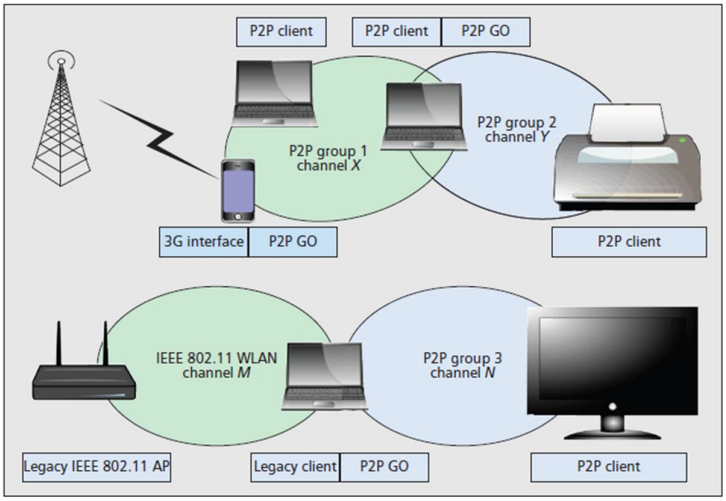

Fig.2- Wi-Fi direct supported topologies

In order to act both as P2P Client and as P2P GO the laptop will typically alternate between the two roles by time-sharing the Wi-Fi interface [1-6].

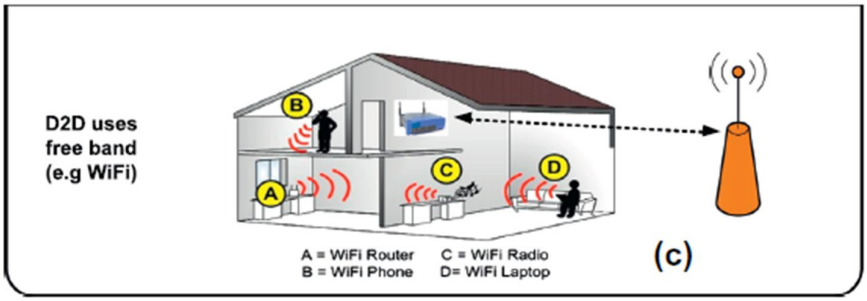

Fig.3-D2D Wi-Fi- Direct Scenario

A P2P GO announces itself through beacons, and has to support power saving services for its associated clients. The P2P GO is also required to run a Dynamic Host Configuration Protocol (DHCP) server to provide P2P Clients with IP addresses. In addition, only the P2P GO is allowed to cross-connect the devices in its P2P Group to an external network, and for this cross-connection bridging is not allowed. Therefore, the connection must be done at the network layer, typically implemented using Network Address Translation (NAT) [1-6].

There are several ways in which two devices can establish a P2P Group [1-6]. There are three types of this which are as follows:

Standard: In this case the P2P devices have first to discover each other, and then negotiate which device will act as P2P GO. WI-Fi Direct devices usually start by performing a traditional Wi-Fi scan (active or passive), by means of which they can discover existent P2P Groups and Wi-Fi networks [1-6].

Autonomous: A P2P Device may autonomously create a P2P Group, where it immediately becomes the P2P GO, by sitting on a channel and starting to beacon. Other devices can discover the established group using traditional scanning mechanisms, and then directly proceed with the WPS Provisioning and Address Configuration phases [1-6].

Persistence: During the formation process, P2P devices can declare a group as persistent, by using a flag in the P2P Capabilities attribute present in Beacon frames, Probe Responses and GO negotiation frames [1-6].

Once the two P2P Devices have found each other, they start the GO Negotiation phase. This is implemented using a three-way handshake, namely GO Negotiation Request/Response/Confirmation, whereby the two devices agree on which device will act as P2P GO and on the channel where the group will operate, which can be in the 2.4 GHz or 5 GHz bands [1-6].

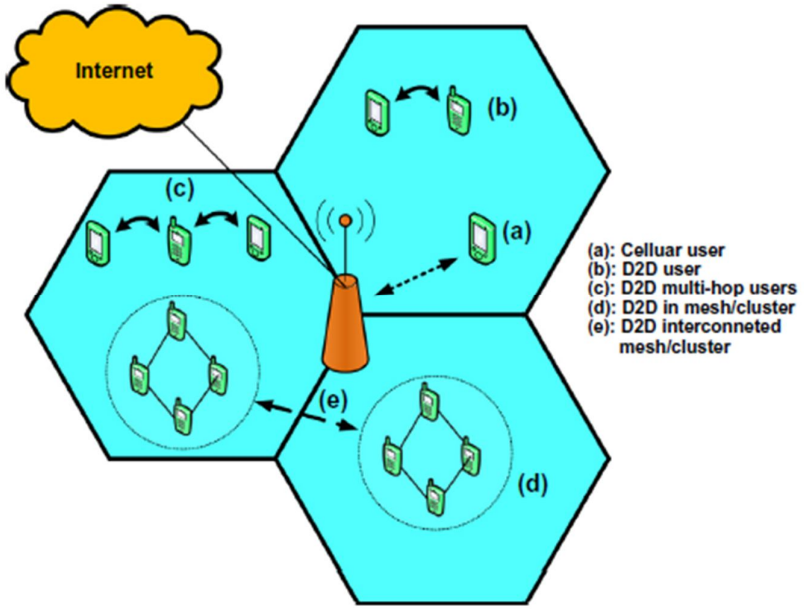

Fig.4-Actual D2D Scenario

The Fig.5 shows how the paths are being formed by AODV routing to communicate with D2D WI-Fi- Direct Technology in MANETs. This is how when a Source Node finds the destination Node far away from the source Cluster, AODV routing is performed and the intermediate Cluster communicate with one another to form a Source to Destination Path. The main advantage in our technology is that the Cellular Network is absent for this transaction to be implemented [1-5].

III. LTE-DIRECT

LTE-Direct is a technology which uses the Side link Bands that we already discussed in the simulation implementation as we implemented the simulation in Matlab using LTE-Direct. Fig.6 show the general

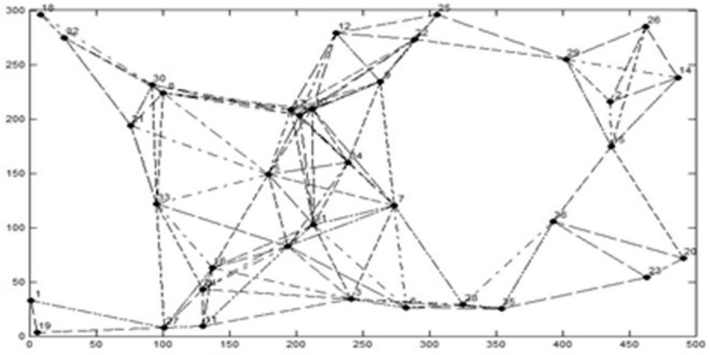

Fig.5-Modified D2D with Wi-Fi-Direct using AODV Routing

Scenario in LTE-Direct in D2D technology wherein eNodeB is also involved. Not only eNodeB are used but also MME are used to provide the Physical Resource Blocks (PRB) for control and Data communication.
The below Fig.9 shows the difference between the Wi-Fi-Direct and LTE-Direct using ISM Bands and Licensed Band respectively. The main difference is whenever the network fails the licensed Bands can't be used where ISM Bands are for Wi-Fi Direct can be used anywhere. There are options wherein we can use the ISM Bands for LTE-Direct but these will not be the SideLink Bearers as discussed in simulation implementation of experiment.

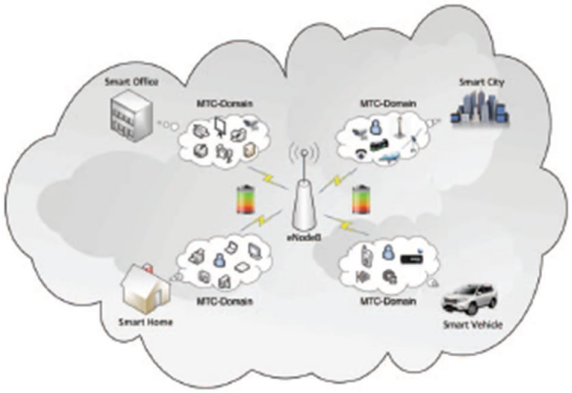

Fig.6- D2D scenario under LTE-A cellular coverage

SAE stands for system Architecture Evolution which include Policy Charging System Function (PCRF), Packet gateway (PGW), Serving Gateway (SGW) and Mobility Management Entity (MME). This SAE and eNodeB are directly involved in resource allocation for sidelink spectrum bands. D2D communication is carried out with the operation involving eNodeB, EPC and User Equipments i.e. Mobile Handsets as shown in the Fig.7 and Fig.8.

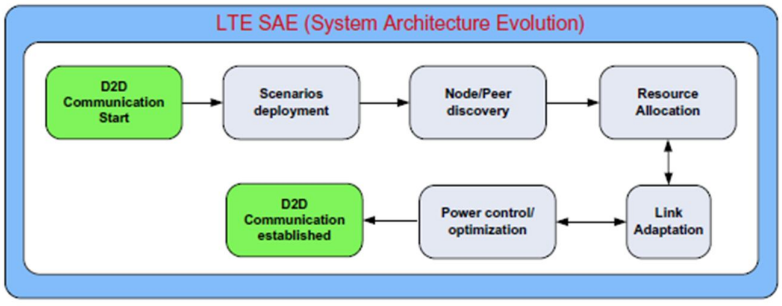

Fig.7-D2D Block structure in LTE-Direct

Fig.8 Show how the bearers are being used when the entities like User Handsets, eNodeBs and EPCs are involved for D2D communication using LTE-Direct. This is what we call as functional Block Diagram of LTE-SAE.

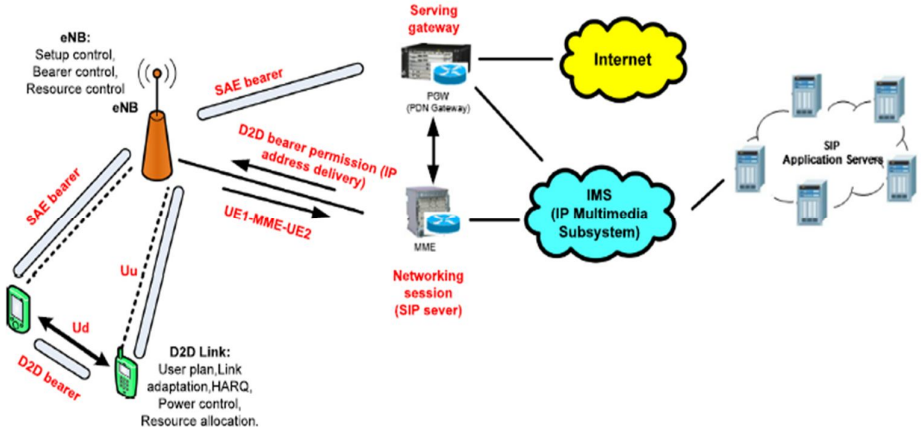

Fig.8-D2D Functional Block in LTE-SAE

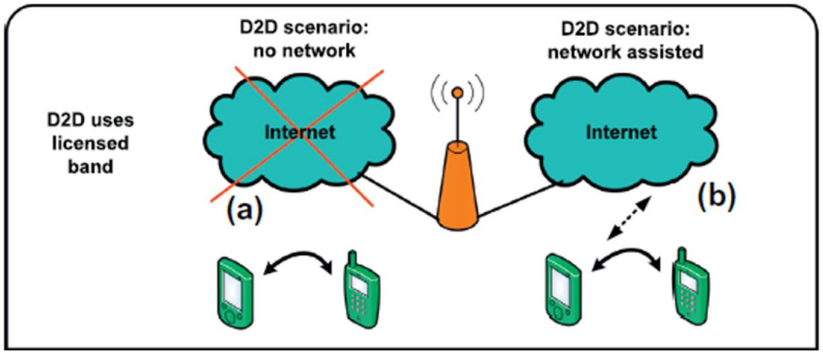

Fig.9-D2D LTE-Direct Scenario

D2D communication, which can reduce the burden on the cellular infrastructure and also increase the spectral efficiency, is one such paradigm considered to be a promising technique in the next generation cellular networks. Unlike the traditional communications, traffic has to go through the Base Station (BS) even if the users are within short range of each other. Via D2D technique, UEs transfer data directly to each other without traversing the BS or a core network. D2D communication in cellular network can be categorized into both In-Band and Out-Band based on the spectrum in which D2D communication occurs. The motivation for choosing In-Band communication is usually the high control over licensed spectrum. In-Band communication can be further divided into both underlay and overlay modes. In underlay D2D communication, cellular and D2D communications share the same licensed spectrum. In contrast, D2D links in overlay communication are given dedicated cellular resources. The motivation behind using Out-Band (such as ISM 2.4G) D2D communication is to eliminate the interference between D2D and cellular link. In academia, the majority of D2D communication literatures focus on the In-Band pattern, and the main research aspects are the interference issues between D2D and cellular communications and resource allocation. Nevertheless, some other researchers propose utilizing the Out-Band pattern so that the cellular spectrum is not affected by the D2D users [9].

P2P is Peer to Peer discovery is being carried out in two ways in LTE-Direct

Priori Scheme: MME will be involved in Peer to peer discovery along with eNodeB. Beacons for MME and eNodeB will scan and discover the Devices.

Posteriori Scheme: Here beacons from the eNodeB and Mobile handset will exchange and peer discovery is established then this message is being conveyed to the PGW or SGW.

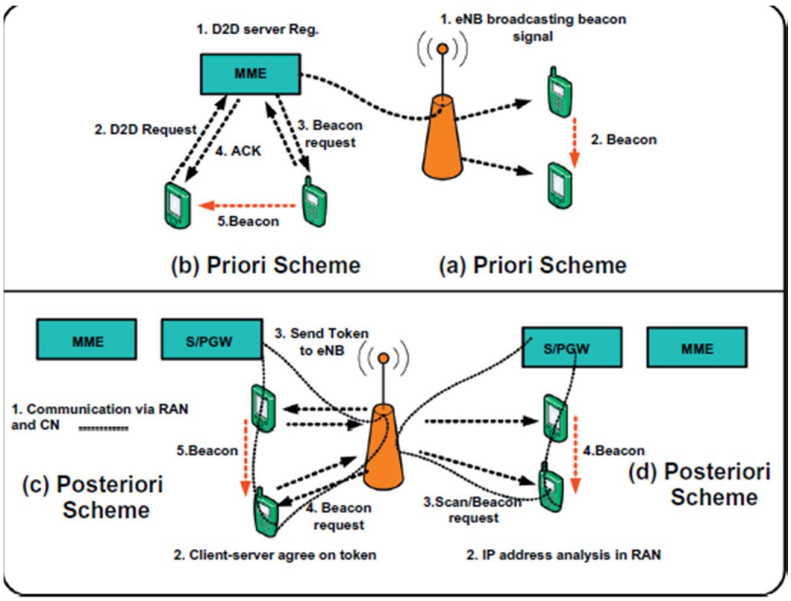

Fig.10-Peer Discovery Techniques

IV. Android App for Wi-Fi Direct

Android was developed by Google privately. Android Application are those which extend the functionality of handheld devices like Mobile sets. These Applications are developed using Android Software development Kit using Java or sometimes Java mixed with C/C++ also.API is the abbreviation for Application Programming Interface. An API is a set of protocols, routines, and tools for building web-enabled and mobile-based applications. The API specifies how you can authenticate (optional), receive and request for data from the API server.

Android is an Operating System which has its own framework. But it is definitely not a coding language. Android is a stack of software for mobile devices that includes an operating system, middleware and key applications. Android Framework has different Levels which are nothing but the versions of Framework on which applications can be built.

Android Runtime is byte code, and VM (Virtual Machine) used by the Android system for running Android applications.

Byte code is computer object code that is processed by a coded program, usually referred to as a virtual machine, instead of the "real" computer machine, the hardware processor.

Native Libraries are those which are copied in particular Subfolder when ever required to build Android Packages using apkbuilder in Android SDK.

HAL stands for Hardware abstraction Layer. Hardware abstractions are routines sets in software that emulate some platform-specific details, giving programs direct access to the hardware resources. They often allow programmers to write device-independent, high performance applications by providing standard Operating System (OS) calls to hardware. HAL is a Software Sub System.

Hence we got an application for Wi-Fi-Direct for Android by Google, from which we developed the application for our Implemented scenario. It is called Wi-Fi-Direct Peer to Peer API developed by Google.

V. Transaction Scenario

Wi-Fi Direct Peer-to-Peer (P2P) allows Android 4.0 or later devices with the appropriate hardware to connect to each other via Wi-Fi Direct without an access point. Android Wi-Fi Direct P2P framework complies with the Wi-Fi Direct standard. Wi-Fi Direct generally provides more speed and distance, but requires more power than Bluetooth connection. This project will highlight the basic steps to setup the socket connection between two Android devices.

Fig.11-Android SDK Architecture

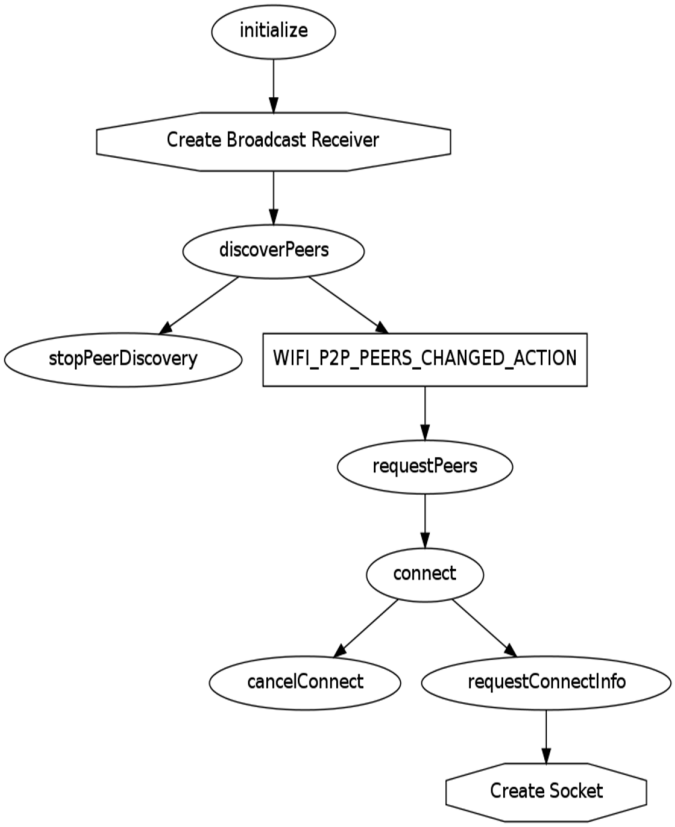

Fig.12-Flow Chart of functionality of Wi-Fi Direct P2P Android API

The working of the Wi-Fi Direct P2P API supported and provided by google is given as flow chart in the Fig.12. Its more akin to Socket Programming employing JAVA and also C/C++ in some cases.
To be able to use Wi-Fi Direct P2P, an application must correctly set a minimum SDK version to 14 and request the following permissions in AndroidManifest.xml file:

- ACCESS_WIFI_STATE
- CHANGE_WIFI_STATE
- ACCESS_NETWORK_STATE
- CHANGE_NETWORK_STATE
- INTERNET

Application should call initialize method of WifiP2pManager object to register the application with the Wi-Fi DirectP2P framework. This method must be called before any Wi-Fi DirectP2P operations. Application should create and register a broadcast receiver for the following Wi-Fi DirectP2P intents:

- WIFI_P2P_CONNECTION_CHANGED_ACTION
- WIFI_P2P_PEERS_CHANGED_ACTION
- WIFI_P2P_STATE_CHANGED_ACTION
- WIFI_P2P_THIS_DEVICE_CHANGED_ACTION

After these steps an application will be able to call Wi-Fi DirectP2P methods in WifiP2pManager object and receive Wi-Fi DirectP2P intents. Most of WifiP2PManager methods are asynchronous so the developer needs to provide the listener to each method call to obtain the status and the result.

a) To discover available Wi-Fi DirectP2P devices, call the discoverPeers() method of WifiP2pManager object. The discover process will continue until the device starts the Wi-Fi DirectP2P connection or the stopPeerDiscovery method will be called.
b) When the application receives the WIFI_P2P_PEERS_CHANGED_ACTION intent, a list of discovered peers can be obtained using the requestPeers()method of WifiP2pManager object.
c) To connect to the specific device from the fetched peers list, prepare the WifiP2pConfig object with the completed deviceAddress field and call the connect() method of WifiP2pManager object.
d) After the successful connect, obtain the device IP address by calling requestConnectInfo() method of WifiP2pManager object.
e) After that, create a Socket and ServerSocket objects using the IP address. Perform communications using a standard socket interface.

These steps are the minimum requirement to create a Wi-Fi DirectP2P connection between two Android devices. An application should implement handlers for all Wi-Fi DirectP2P intents and listeners to adequately react to different events such as connection loss or disabling Wi-Fi. Please refer to Android documentation for more detailed information.
The Fig.13 and Fig.14 shows the scenario of a pure D2D Communication using both Wi-Fi Direct as well as LTE-Direct. But In our Scenario of experimentation we have implemented without cellular Network using only Wi-Fi-Direct. In these figures there is applicability of eNodeB Cellular Network as being depicted.

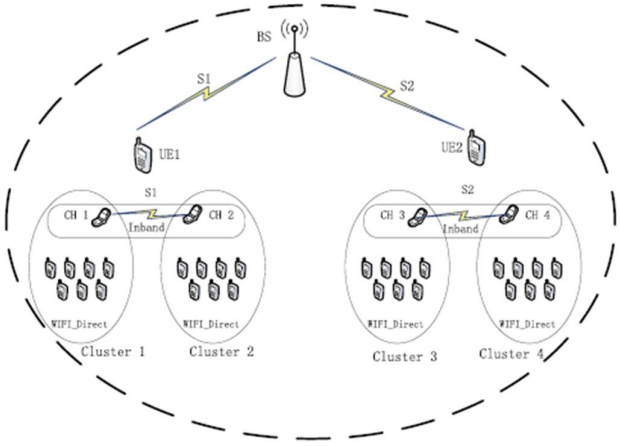

Fig.13-Scenario Tested so far in Industry

Fig.15 shows the even in the absence of the cellular Network our Implemented Project will work based on Wi-Fi Direct with AODV routing to reach far of destination Node from Source Node. Here the Cluster Group Owner will contact the neighboring Cluster Group Owner and forms a path in terms of Adhoc on demand Vector Routing (AODV) Algorithm. This is done as part of Disaster management tool development to work under the no Cellular network situation as the Base Station and Towers get collapsed.

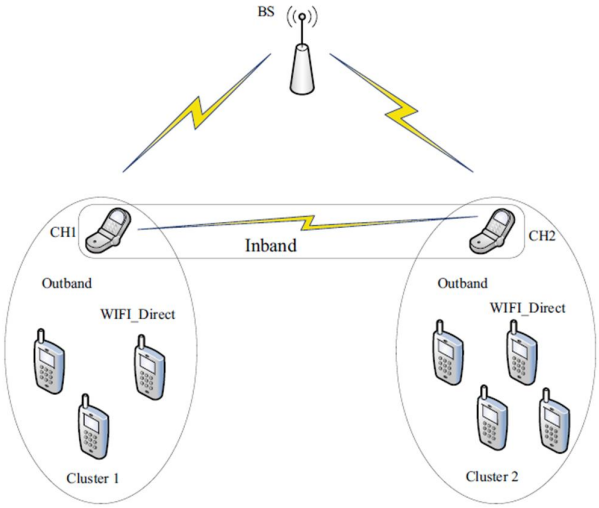

Fig.14- Actual D2D scenario using WiFi-Direct

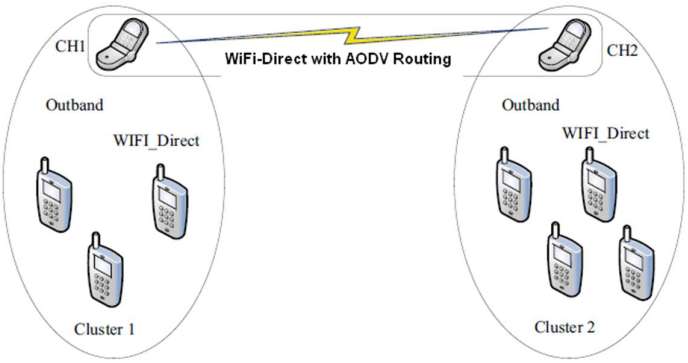

Fig.15- Implemented Scenario for Modified D2D

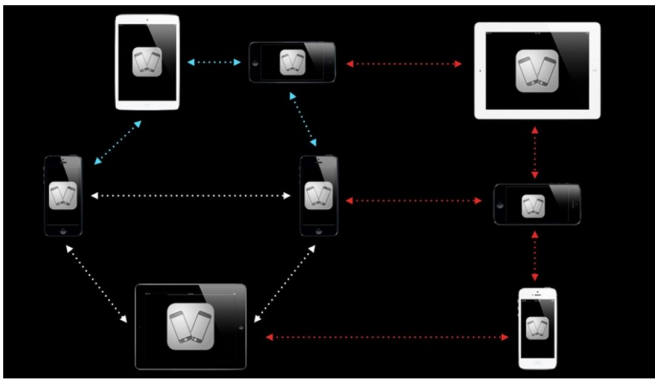

Fig.16- Working of Wi-Fi-Direct P2P discovery and communication using Android App

Fig.16 shows the working of android app which was developed to work on Modified D2D communication. Here we need to modify the Wi-Fi-Direct in a sense that we need to discard DHCP protocol for Network address assignment. For Disaster Situation the old Network address should be retained and no new address should be assigned. The advantage of this is that, when cellular network fails there is alternate network of Wi-Fi-Direct to maintain communication with the existing device working earlier on Cellular Network before being aborted.

VI. RESULTS

The results we got from the experimentation of the Transaction implementation are outstanding. We found that without the network we are able to transfer the images and videos to far off places. This should be extended to the voice and video online calls. To do so we required Android 4G mobiles having the app developed installed on them. Here we are presented few screen shots of the implemented scenario of Wi-If-Direct with AODV Routing in D2D technology for disaster Management.

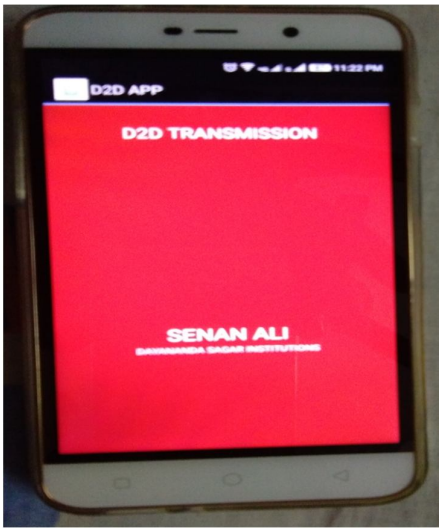

Fig.17-Login Screen of the Android App for Wi-Fi-Direct with AODV Routing

Fig.17 shows the screen of Login of the developed Android App for Wi-Fi-Direct under AODV Routing.

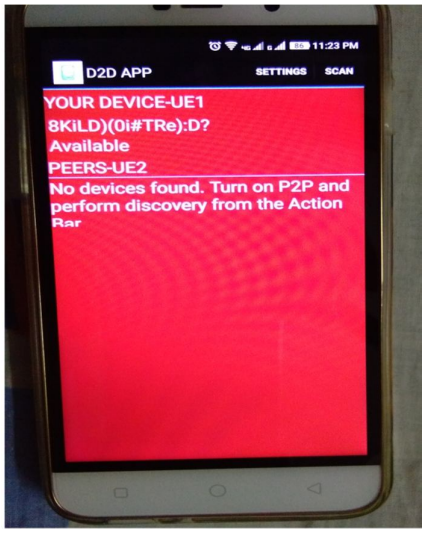

Fig.18-Screen for Scanning of peer discovery in Wi-Fi-Direct with AODV Routing

Fig.18 shows the screen display of android app developed while scanning for peer to peer discovery from one cluster to another.
Fig.19, Fig20, Fig.21, Fig22, Fig.23, Fig24, Fig.25, and Fig.26 shows different stages of the android app on display screen of 4G Mobile handsets.

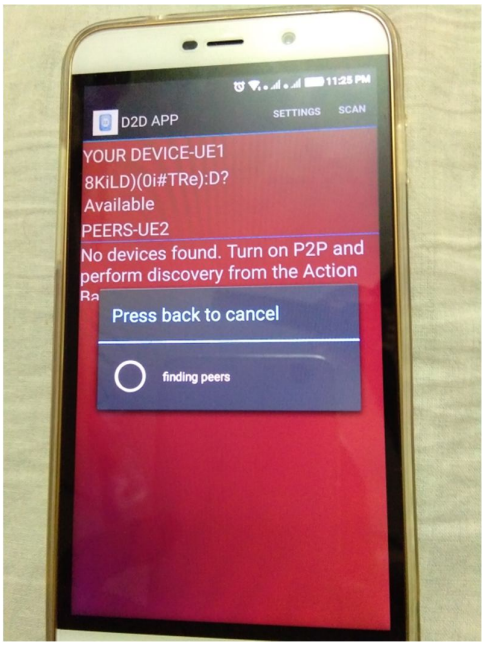

Fig.19-Android App showing the status of Peer discovery with AODV routing

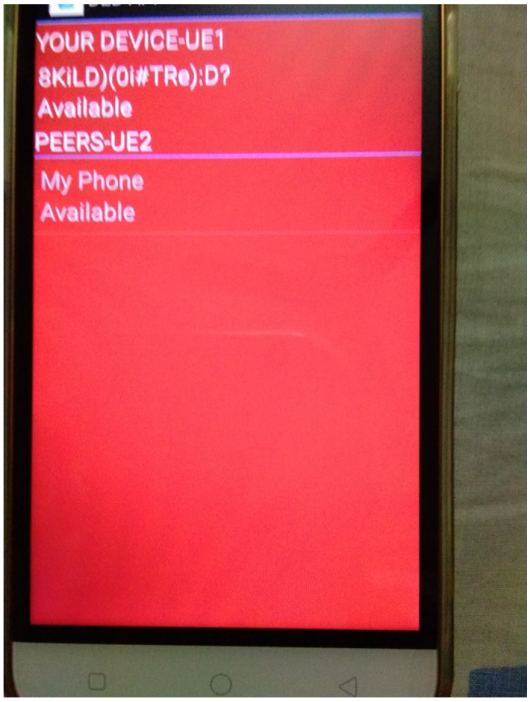

Fig.20- Android app showing status after discovering Peers

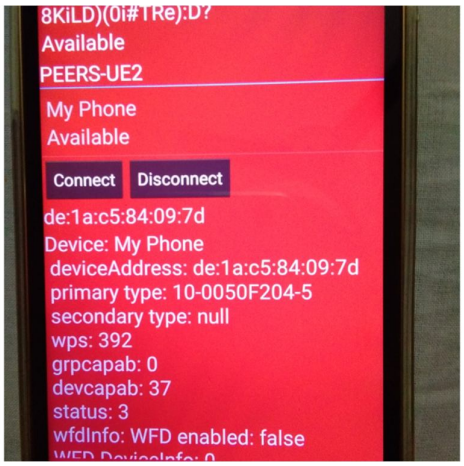

Fig.21-Android App displaying massage to ask the consent of user for connection

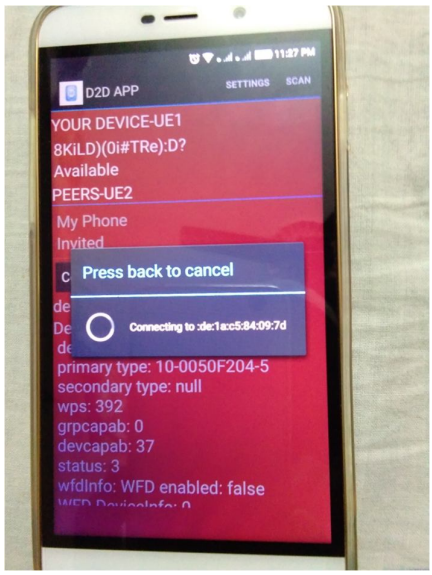

Fig.22-Android app displaying the status while connecting to peer device using AODV

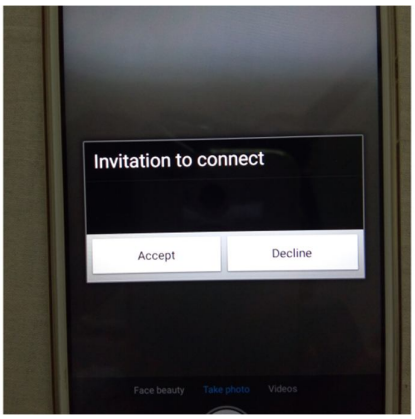

Fig.23-Android App displaying the massage to get the consent from destination Node

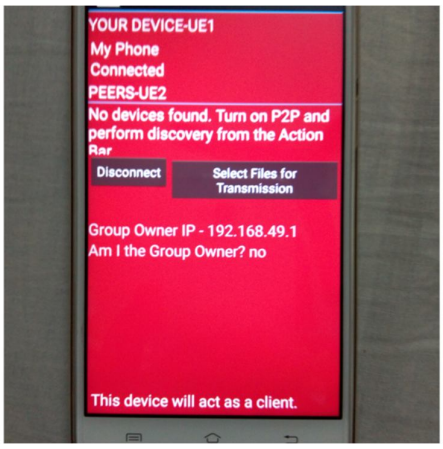

Fig.24-Android app with options browsing status to select the files to send to destination nodes

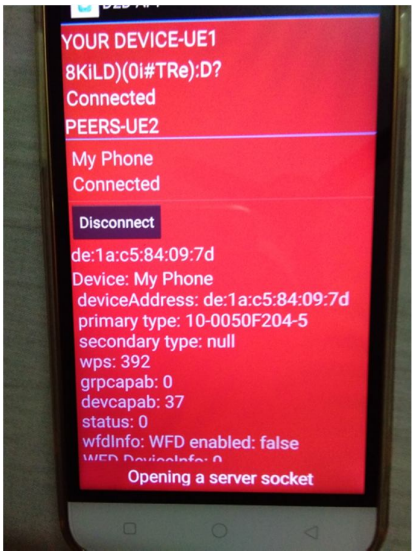

Fig.25-Android app displaying message to ask the User's Consent to continue connection

Fig.26-Image and Video Transfer by Wi-Fi-Direct in Modified D2D technology under no Network

VII. Conclusion

We got outstanding results from the implementation wherein we are able to transfer the image and video files to far off distances without cellular Network using ISM Bands of frequency. We have implemented directing taking the API from Google for Wi-Fi-Direct and modifying it to AODV Routing. The charge of conducting AODV Routing with the other Clusters depends on the Group Owners of the Cluster in Wi-Fi-Direct technology Implementation. A few changes we need to make in order to adapt this scenario for rescue squad in Disaster Management which are listed as:

1)We need to abort the assigning of network address by DHCP protocol and modify the persistence discovery of peers in which we need to retain the old Cellular Network address of Devices under communication.

2) We need to remove the procedure of asking the Intermediate Cluster group Owner the consent to accept or reject the connection. In fact in disaster Situation we need to remove all procedures which is seeking the permissions to every device which comes as a mediator from source to destination node.

Acknowledgment

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References

[1] Daniel Camps-mur , Andres Garcia-Saavedra and Pablo Serrano,"Device-to-device communications with wifi direct: overview and experimentation", IEEE Wireless Communications ,June 2013

[2] Wi-Fi Alliance, P2P Technical Group, Wi-Fi Peer-to-Peer (P2P) Technical Specification v1.0, Dec. 2009.

[3] IEEE 802.11z-2010—Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) specifications Amendment 7: Extensions to Direct-Link Setup (DLS).

[4] Wi-Fi Alliance, Quality of Service (QoS) Task Group, Wi-Fi Multimedia (including WMM PowerSave) Specification v1.1, 2005.

[5] Wi-Fi Alliance, Wi-Fi Protected Setup Specification v1.0h, Dec. 2006.

[6] Wi-Fi Direct in Linux, ttp://linuxwireless.org/en/developers/p2p/

[7] J.-S. Lee, Y.-W. Su, and C.-C. Shen, A Comparative Study of Wireless Protocols: Bluetooth, UWB, ZigBee, and Wi-Fi, Industrial Electronics Society, 2007, IECON 2007.

[8] Massimo Condoluci, Leonardo Militano, Antonino Orsino, Jesus Alonso-Zarate, and Giuseppe Araniti," LTE-Direct vs. WiFi-Direct for Machine-Type Communications over LTE-A Systems", 2015 IEEE 26th International Symposium on Personal, Indoor and Mobile Radio Communications - (PIMRC): Workshop on M2M Communications: Challenges, Solutions and Applications

[9] Zhijian Lin, Zhibin Gao ,Lianfen Huang ,Chi-Yuan Chen ,Han-Chieh Chao,"Hybrid Architecture Performance Analysis for Device-to-Device Communication in 5G Cellular Network", Springer Science Business Media New York 2015, DOI 10.1007/s11036-015-0566-7