A comprehensive algorithm to enable D2D communication between two UEs

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Abstract

In wireless mobile communication, base station overloading is becoming a huge problem due to increasing multimedia file transferring by the end devices. At first, the device sends a request to the base station and then sends the data bit by bit until the full file transfer is complete. As number of users increase over time, it overloads the base station managing their file transmission. In order to offload the base station, the next-generation LTE-A device to device communication will be used to transfer files among multiple devices bypassing the base station, it will limit the frequency usage and will restrict unauthorized access by utilizing the licensed frequency band. In this paper, we propose a novel algorithm for D2D communication for traffic offloading of the base station. Simulations performed here show the step-by-step implementation and analysis of time consumption of this study and reveal the potentiality of the proposed algorithm.

Keywords— LTE; D2D communication, eNB; UE;

BACKGROUND STUDY

A. *LTE:* Long Term Evolution (LTE) refers to a standard for smooth and efficient transition toward more advanced leading-edge technologies to increase the capacity and speed of wireless data network. LTE is often used to refer to wireless broadband or mobile network technologies. LTE features include an all-IP flat network architecture, end-to-end quality of service (Qos), higher download rates approaching 300 mbps and upload rates of 75 mbps, expanding cell capacity to accommodate 200 active users and supporting fast moving mobiles. LTE is referred to as the next generation network beyond 3G, with the capacity to support a high demand for connectivity from new consumer devices tailored to new mobile applications. In 2010, many well-known U.S. and global wireless service providers/manufacturers began using LTE (1)

B. *D2D Communication:* The term device-to-device (D2D) communications refers to direct short-range communications between terminals of a mobile network, without the intermediate transmission to a base station (eNB). Differing from conventional approaches, such as Bluetooth and WiFi-Direct, D2D communications utilize licensed spectrum with quality of service (QoS) guarantees, while no manual network detection-selection is required. Compared to the very appealing cognitive radio communications, where secondary transmissions are allowed in parallel with cellular (primary) transmissions, D2D communications are established by cellular (primary) users, reaping the benefits of being synchronized and controlled by the base station [2-3].

C. *D2D Reference Architecture:* Additional to the entities of the conventional LTE architecture, Application servers (ProSe App Server) is used to incorporate the ProSe [4-5] capability for building the application

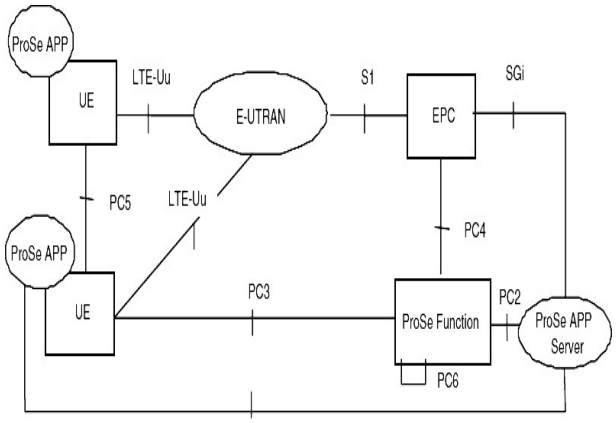

Fig. 1. 3GPP ProSe Service structure

D. *D2D scenarios*

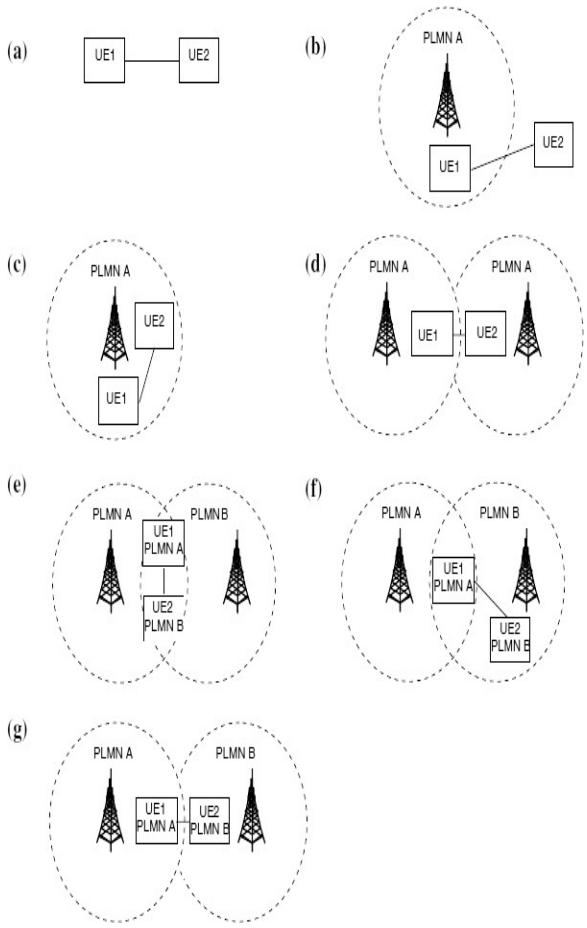

Fig. 2. Various PLMN/cell types

E. The D2D communication model

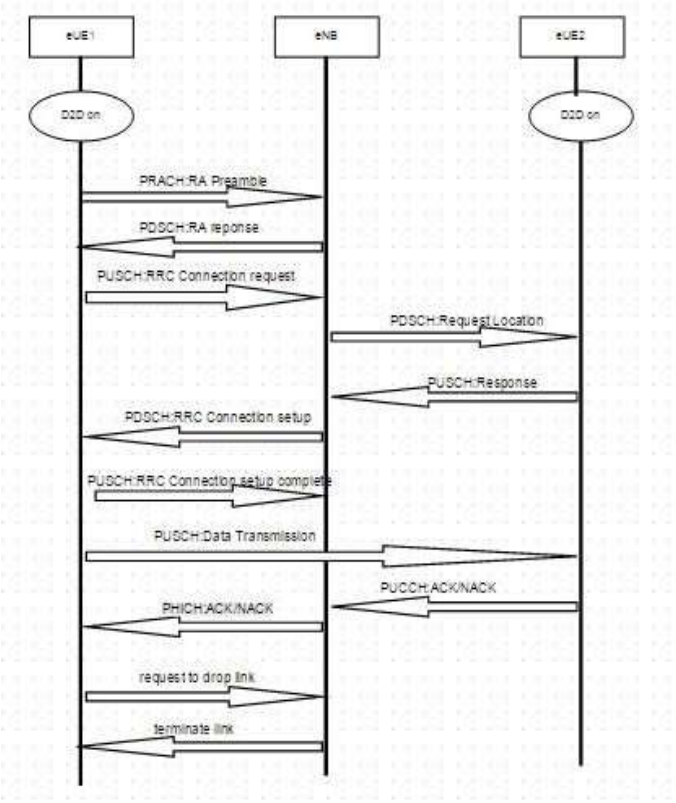

Fig. 3. Signals exchanged during D2D communication

Proposed model: In order to transfer data between users with traffic offloading,we objectives are:

- To enable Device to device communication under corewireless network.
- To utilize unused uplink frequency for datatransmission between two devices.
- To enable traffic offload on core network with directcommunication between the devices.

A. Assumptions

- The network coverage must support LTE A network.
- The resource that is used in D2D communication is theunused uplink frequency[3].
- Same PLMN/cell and both UEs are in their own servingcells' coverage.
- Initially the UE [mobile/end device] starts the D2Dcommunication with a request to eNB.
- Cellular communications are dropped during the D2Dcommunications [7].

- One dimensional data transmission occurs from UE1 toUE2[6].
- ProSe Server is enabled.

B. *Network modeling*

Step 1: UE1turns D2D on and sends request to eNB

- UE1 starts ProSe direct communication; a communication between two or more UEs in proximity that are ProSe-enabled, by means of user plane transmission using EUTRA technology via a path not traversing any network node.
- eNB provides an empty RB(resource block) to the UE1 and also generates its D2D ID using Hashing Algorithm. Hashing algorithm produces unique identities for the UE's which will become repeatable once that id is released by the UE1.

Step 2: UE1 requests eNB for target D2D receiver(UE2)

- The eNB launches a peer discovery procedure for the requested D2D pair.
- This enables devices to discover each other automatically and continuously, and to communicate, peer-to-peer, at broadband speeds without the need for intermediary infrastructure.
- The eNB allocates cellular resources to valid D2D pairs and informs both D2D peers, tuning them indirectly at the same spectrum portion.
- After the link setup UE1 sends transmits data to the UE2 and the UE2 acknowledges the reception (or not) of the data through the eNB.

Step 3: UE1 requests eNB for termination of D2Dcommunication

- UE1 requests the eNB to drop the D2D communication.
- The eNB terminates the link.
- If any cellular call is received then the D2Dcommunication is dropped.

C. *Logical Modeling*

Client side [mobile device]Void UE1 (void){

```
Start Prose_service;
If D2D_enable== true{
    Send (Request_for_D2D_ID) to eNB;Wait_for_response;
    If (D2D_ID==received){
        Send (Request_for_Receiver UE2) to eNB;Wait_for_response;
End_if;}
```

```
If(eNB_Response==true){ While (Data=available){
While(Data==ready){
Start (D2D_comm_UE2);Wait_for_ACK_UE2;}
If (incoming call==true){
Drop D2D_comm && Return;}Send (Request_suspend_D2D) to eNB;}
Drop D2D_comm && Return;}End_While; }}
Void eNB (void){
Start Prose_Server;
Send (D2D_ID to requesting UE1);
If (UE1_request==D2D_comm to UE2){While (Resource==Available){
If (UE2==same_cell && same_location){Setup (link_pair=true);
If (incoming call ==true){
Drop link_pair && Return;}}End_while;
End_if; }}
```

D. Flow chart

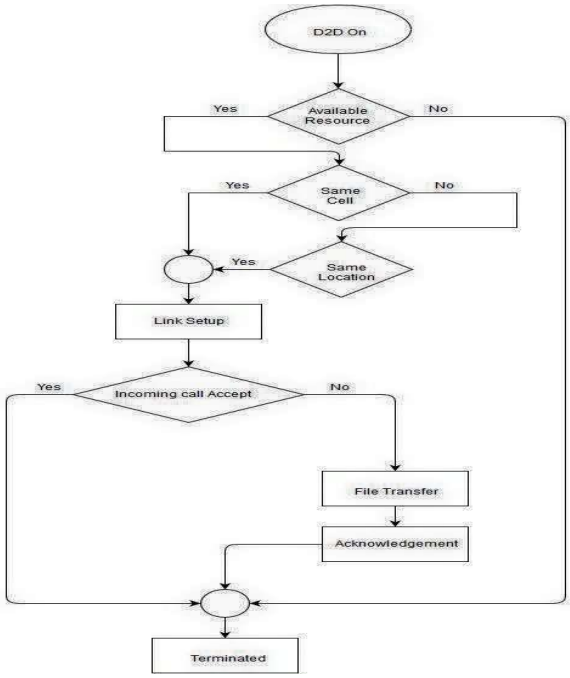

Fig. 4. Flow chart of the proposed algorithm for D2D communication

I. SIMULATIONS PERFORMED

We have used several software and frameworks to implement our proposed algorithm for D2D communication. Omnet++ and INET Framework is used for file transfer that will take place once the D2D communication is established; while Java programming is done in Netbeans to request the eNB and to discover targeted UE for link establishment, TCP socket programming is implemented (6).

A. Initial scenario: UEs under eNB for D2D communication

Several mobile phones [UEs] lie within the range of the base station [eNB] and are in the suitable range for D2Dcommunication to take place. One of the UEs can request for aD2D communication to the eNB.

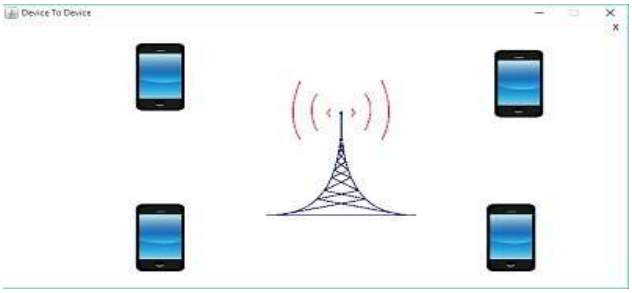

Fig. 5. Several UEs under an eNB for D2D communication

B. D2D communication simulation steps

Step 1: Device Initiates D2D communication: i. UE1 turnson D2D function and sends request to eNB for communication;

ii. eNB sends D2D_ID to UE1 required for transmission.

Step 2: Discover target device via eNB: The target UE isdiscovered for communication via the eNB.

Step 3: File transfer and termination: D2D communication takes place by sending the required files from UE1 to UE2 andterminated after completion.

Simulaion of Step 1: D2D function is on and request forcommunication

i. In this phase, UE1 runs Java code requesting eNBallow D2D communication.

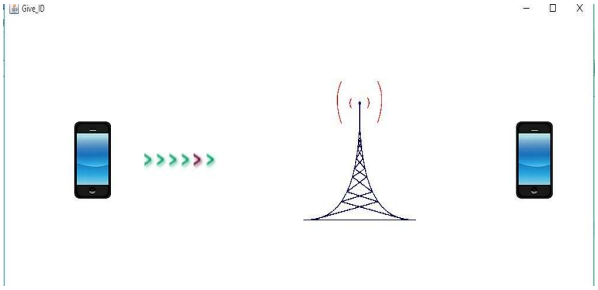

Fig. 6. Request from UE1 for D2D ID to eNB

ii. eNB runs code in Java to find out the D2Dcommunicating pairs. A hash table in the eNB

contains all UEs under it. The hash table is checked to find out whether the target UE2 is currently under it or not.

In the following simulation, the device, UE1 is requesting its base station eNB for granting it the required resources for initiating D2D communication.

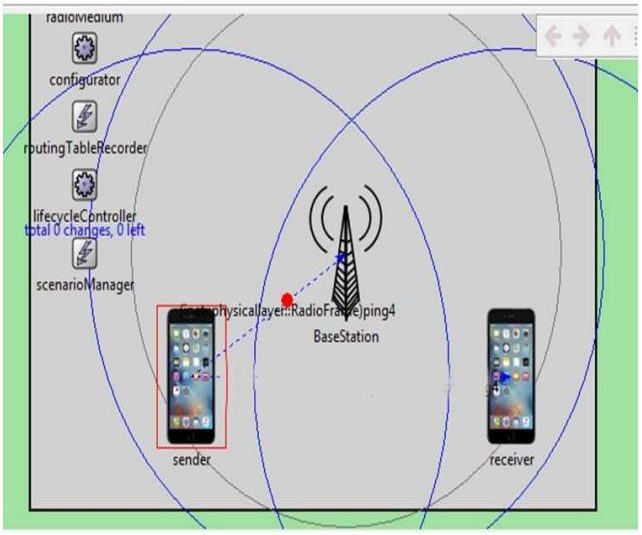

Fig. 7. UE1 sends request to eNB for D2D

Simulaion of Step 2: Discover target device UE2 via eNB

The base station discovers whether the target device is within range for the D2D communication; then the base station grants the resources for communication if available. The base station also generates the D2D IDs from the SIM numbers.

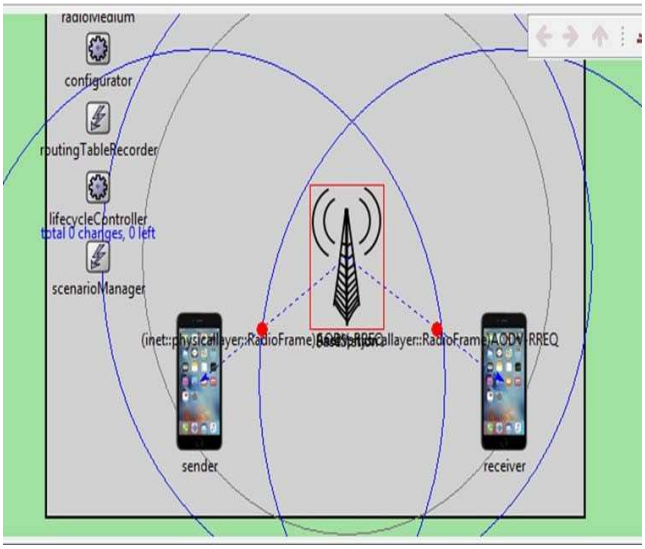

Fig. 8. eNB discovers target UE2 for D2D communication

This step has also been implemented in Java. In Java Hashing Function has been used to produce the D2D IDs.

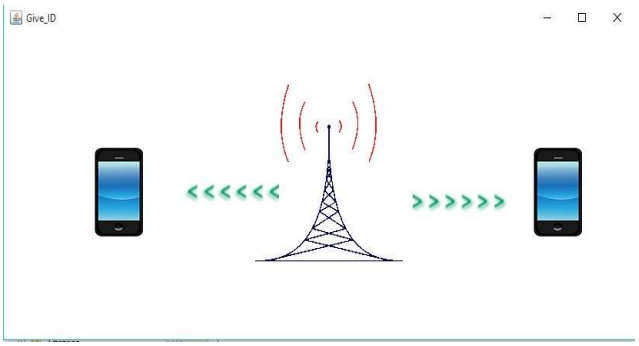

Fig. 9. eNB assigns resource to UEs for D2D communication

Simulaion of Step 3: File transfer between UE1 and UE2

In the final step of D2D communication transfer of files from the UE1 to UE2 takes place as the eNB grants the resources. The base station monitors the file transfer whole time.

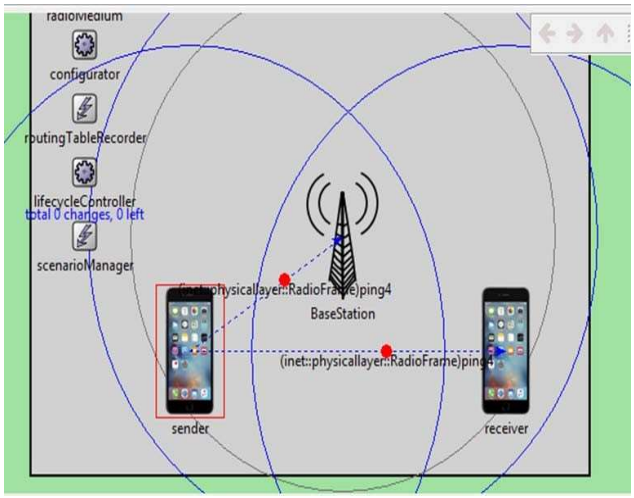

Fig. 10. UE1 starts file transfer to UE2 while eNB monitors

II. SIMULATION RESULTS

The results of our work are based on the simulations that are run on INET framework in Omnet++ and Java in Netbeans. Timescale of Event Graph is provided below from Omnet++ project result folder elog file.

Step 1: Time required for UE1 requesting D2D ID = 0.800s. Time required for eNB creating ID = 0.500s.

Step 2: Time required for D2D request with UE2 = 1.200 s. Step 3: Time required for file transfer with D2D= 1.000 s.

Total time required for D2D algorithm = 3.677 s.

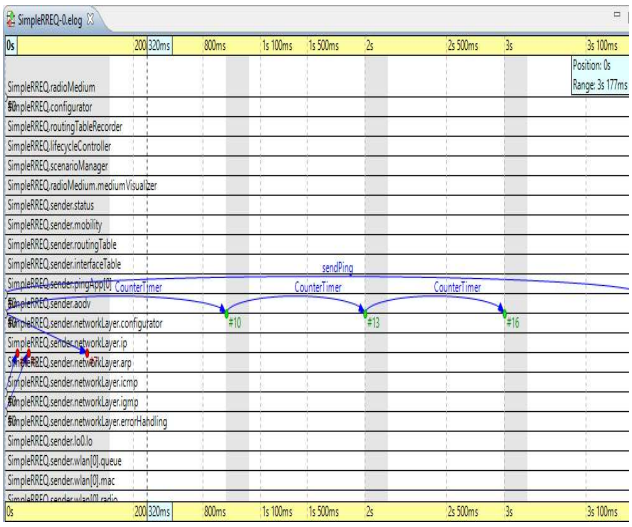

Fig. 11. Graph showing time required for D2D communication

The time complexity of this algorithm is O(n).Thus we cansay that we are successful to maintain efficient time for transforming file between two UE's and with a high data rate.

III. CONCLUSION

In this paper, we developed an algorithm to enable D2D communication between two UEs to transfer files under the LTE network. This will reduce the load on the base station thatoccurs when UEs connect to the eNB to communicate with each other. In D2D communication, eNB provides the required resource if there is free resource. In this case, eNB allocates resource block(RB) from the uplink frequency[4][5], as it provides more efficient reuse of unused uplink frequency. Since D2D communication offloads eNB, this reduces power consumption of both the eNB and UE drastically. Also, the direct transfer of files between UEs can occur faster. Transferring files between communicating UE pairs is more secured than unlicensed Bluetooth or other technologies.

As we run our algorithm to establish D2D, the D2D IDs aregenerated in eNB using hashing function from the SIM numbers. Socket transmission occurs for eNB to UE1, where the D2D communication is initiated. Simulations show that total time required for D2D communication to transfer file between UE1 to UE2 is 3.177 sec.

Though LTE network is slowly growing and the 3GPP [8] is still working towards future developments in LTE- Advanced, this device to device technology will open up whole new vistas for the modern future world we want to live in.

IV. LIMITATIONS

We have considered implementing the algorithm only for same PLMN/cell and both UEs are in their own serving cells' coverage. This proposal strictly is based on LTE enabled UEs capable of D2D communication.

V. FUTURE WORK

Improvements can be achieved if the algorithm can perform for UEs under different PLMN/cell and different operator. As a consequence the range of D2D communications will increase. In the present algorithm we need to drop the D2D communication when normal call arrives at UE1. In our future work we will provide an option for the users whether to accept or drop the call. It can be further improved to simultaneously receive the call and continue with the D2D communication process. The present work is restricted to transfer file from sender to receiver using simplex communication only. So, the algorithm can be extended to transfer file on duplex channel.

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