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Sidelink based D2D Communication in LTE-A

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ABSTRACT*:* Device-to-Device (D2D) communication is one of the emerging topic in the upcoming LTE-Advanced (LTE-A) mobile communication technology. D2D offers opportunities for access to services through direct neighbor device connection with or/and without ENodeB (eNB) assistance. It will facilitate the interoperability between critical public safety networks and ubiquitous commercial networks based on LTE-A. The design problems faced in this case are discovery of neighbor user equipment (UE) and services, as well as designing suitable and secure protocols for D2D communication. In this paper we propose a design for D2D communication in LTE-A through sidelink. The sidelink is considered to be allocated with a separate band apart from uplink and downlink. We discuss the sidelink access design for D2D communication and high level communication representation at both client and server side. The design is carried out for three cases: either both UE's are within eNB's coverage, one of the UE is within eNB coverage (partial coverage) or for both UE's being out-of-coverage.

KEYWORDS*:* Device to Device Communication, Prose, Sidelink Communication, Long Term Evolution, 3rd Generation Partnership Protocol, Proximity Services, and LTE Advanced.

I.INTRODUCTION

In recent years, higher data rate applications such a video calls, online gaming etc. have become very popular and needs much of attention. Third Generation Partnership Project (3GPP) Long Term Evolution (LTE) is aiming to provide technologies with high data rates and higher network capacity. Apart from this, LTE-A adds new components for LTE to meet higher communication demands. D2D communication is one such addition for LTE-A designed in view of providing higher data rates and public safety services. D2D is specified by 3GPP in LTE Release 12, focusing on Public Safety applications. D2D enabled LTE devices have the potential to become competitive for fallback public safety networks that must function when eNB is not functional. Direct communication between nearby UE's will improve spectrum utilization, energy efficiency and throughput, and enabling new peer-to-peer services and location-based applications. D2D can be integrated into cellular networks by having an in-band communication or out-band communication. In an in-band communication, licensed spectrum is used to have D2D communication. Thus for an in-band communication a user can use dedicated pool of resources termed as underlay approach or re use other UE resources termed as overlay approach. While for out-band communication an unlicensed band is used for D2D communication.The D2D is termed as proximity services by 3GPP and has two main components: direct discovery and direct communication. Where direct discovery allows a UE to discover UE's in proximity which are capable of D2D communications and direct communications lets the UE to communicate with other UE's through LTE network or unlicensed band interface. Since D2D is all together a new component being added, it introduces many design challenges such as a choice between uplink and downlink for D2D communications, Multiple access technology, resource allocation schemes, D2D functions when UE is in different coverage scenarios, etc..In this paper we propose a sidelink based D2D communication for multiple scenarios with a consideration that a separate unlicensed band allocated for sidelink based communication. In the remaining part of paper we discuss about D2D communication scenarios, its protocol stack, Sidelink access design and high level communication design at both client and server side.

II.D2D COMMUNICATION

D2D communication as described earlier has two main components: direct discovery and direct communication. Direct discovery is an important aspect among these, since once device discovery is completed UE's can use the underlay

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network or an ad-hoc network to communicate between them. In this paper we are mainly focused on direct discovery and will be using a sidelink based D2D Communication as depicted in Fig 1. Where in a UE within coverage will use uplink [5] and downlink [6] for its LTE based communication and a sidelink for D2D communications. Here we consider that a separate unlicensed to be allocated for sidelink and will not use from the available downlink or uplink resources available with eNB.

Fig. 1: Sidelink D2D Communication

A. Scenarios

Various scenarios considered for the design in this paper are as presented in Fig. 2. Where either both the UE's are considered to be either in-coverage, both of them out of coverage or in partial coverage (One UE is in coverage). In in-coverage coverage scenario, the synchronization and resources will be allocated by eNB and out of coverage scenario a default configuration in the UE will be used, while for partial coverage scenario the UE within coverage ill get the information from eNB and uses the information to become a sync reference UE.

Fig. 2: Coverage Scenarios

B. Protocol Stack

The protocol stack for D2D LTE-A communication is as described in Fig. 3. Physical layer provides data transport services to higher layers and to provide this services physical layer is expected to perform functions like error detection, forward error correction, mapping of transport channels to physical channels, Multiple input multiple output (MIMO) antenna processing, beamforming, transmit diversity, RF processing, etc. MAC layer provides data transfer and radio resource allocation services to the upper layers and supports various functions which include scheduling, mapping between logical channels and transport channels, radio resource section for sidelink, etc.. RRC layer offer multiple services to upper layers which include broadcast of control information, UE status and transfer of dedicated control information. It includes many functions such as broadcast of system information, paging, establishment/modification or release of RRC connection, measurement configuration and reporting, establishment/modification or release of radio bearers carrying user data, generic protocol error handling, etc.

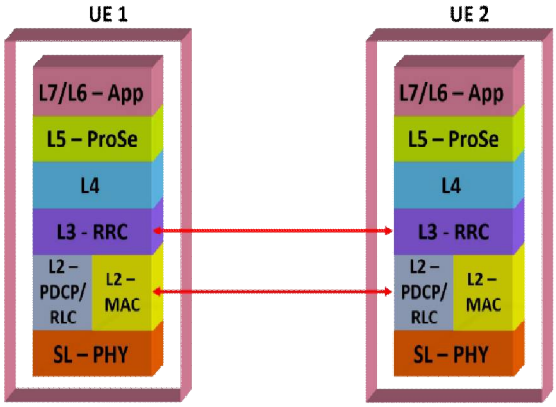

Fig. 3: Protocol Stack

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The other important layer for D2D communication is Proximity Services (Prose Layer) which includes functions such as direct provisioning for direct discovery and direct communication, direct discovery name management, storage of Prose related subscriber data, acting as location services client to enable EPC level Prose discovery.

III.PROPOSED DESIGN

A. Sidelink Access Design

The sidelink access design for D2D communication is designed as in Fig 4. Here Client side RRC will be waiting for UE sync reference to have a sidelink communication or will be transmitting MIB if it is acting as a sync reference UE. The Transmitting UE which will be acting as a server will broadcast SIB18 and SIB 19 information and will be able to receive sidelink UE information received from client UE as a response. Based on the respone UE will send RRC reconfiguration and receive reconfiguration complete acknowledgement for the client UE. For in-coverage and partial coverage eNB simulator is used which will be acting as a eNB for that particular cell and PC5 simulator is used which will be acting as sync reference UE.

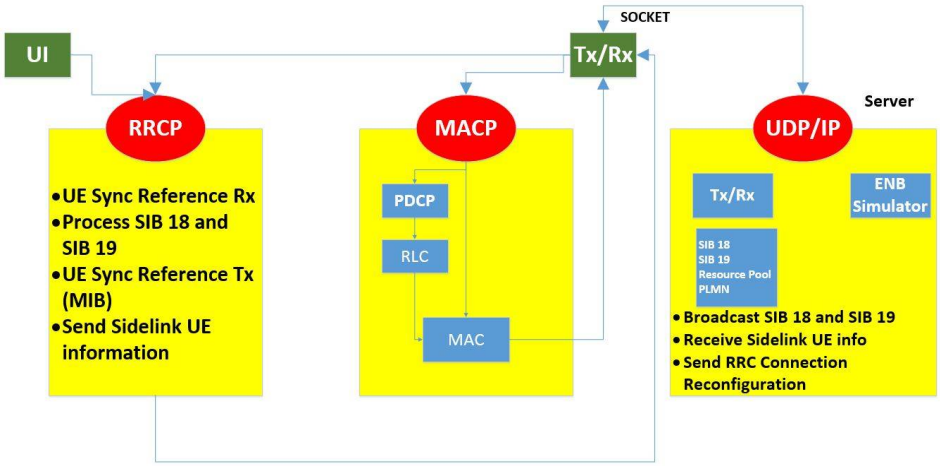

Fig. 4: Sidelink Access Design

B. High level D2D communication Design

The high level communication diagram for server side and client side communications is presented in Fig. 5. Here the server side eNB and other UE which will initialize communication will be considered as eNB simulator and PC5 simulator respectively.

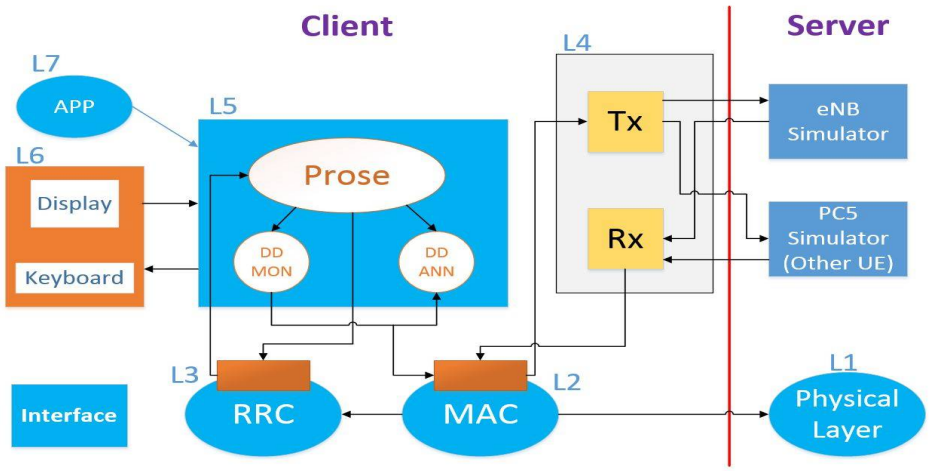

Fig. 5: Client and Server side High Level Communication

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For in-coverage and partial coverage scenario, eNB simulator which will be acting as a eNB will broadcast radio parameters and will be acquired by the receiver which will be part of layer 4 (represented as L4 in Fig. 5). The received radio parameters will be sent to MAC layer (L2 in Fig. 5) and in turn will be sent to RRC (L3). Prose of L5 will trigger RRC and request for acknowledgment to perform DD announcement or DD monitor. Based on the information obtained by RCC, Prose will trigger DD monitor or DD announce. The one triggered will then send a message to MAC and which will be transmitted later through L4 (Tx) and the eNB will then receive the information from the Tx of UE. For out of coverage scenario, eNB will not be functional and hence all the messages to be handled by UE which will be acting as reference UE (PCS in this work). For selection of reference UE highest preference will be given to those UE's which are with in coverage in the cell, the next rpioriti is given to those UE's which will have sidelink synchronization information and then lastly to other UE.

IV.CONCLUSION

D2D communication is one of the major influences on the present day public safety. To perform D2D communication only direct discovery of UE is sufficient while the communication part can be done using underlay network. In this paper we have proposed a design for sidelink based D2D communication without the need of taking uplink and downlink resources. A sidelink based access design and high level communication implementation have been described for SL-D2D communication and will be looking further to implement the design.

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