Deploying Energy Efficient D2d Communication in Mobile Networks

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***Abstract*— Device-to-Device (D2D) communication is a new technology that put forward many features for the LTE advanced network such us wireless peer-to-peer services and higher spectral efficiency. It has advantages like low energy consumption and enhanced system capacity. It has been proposed effectively for future 5G wireless communication system and used in diverse fields such as IoT vehicular communication, public safety, social services and cellular traffic offloading. In this paper we focus on,**

1) Formation of a effective community based on number of users

2) Allocation of resources based on requirement of user. Resource allocation for D2D communication is an important problem in terms of achieving the fore mentioned benefits. Hence we concentrate in optimal resource allocation schemes in order to make D2D community more energy efficient.

Keywords: Community, Peer to peer, Resource allocation

I. INTRODUCTION

With the growing number of mobile users, there is a thirst for bandwidth that needs to be allocated for all the users without having traffic among them. D2D communication represents a new class of wireless communication techniques in which network nodes assist each other in relaying information. This communication allows two nearby devices to communicate with each other in the licensed cellular bandwidth without a base station (BS) involvement or with limited base station involvement. This is obviously a vivid exodus from the conventional cellular architecture. As a new communication method, Device-to-Device (D2D) communications are proposed in Long-Term Evolution Advanced systems to increase network capacity [2], [3], whereby under the control of evolved Node Base stations (BS), i.e., base stations, user equipment (UE) devices exchange information over direct wireless links using cellular resources instead of through BS. For D2D communications, the peer head (PH) sends its request to the BS. The BS then calculates the available resources and sends the allocated resource indexes back to the peer head (PH). After receiving the resource indexes, the PH begins to transmit the data over the allocated channels. There are two channel allocation mechanisms. One is orthogonal sharing, where the D2D communication is allocated with channels orthogonal to those allocated to the cellular communication. In this case, there is no interference between cellular and D2D communications. The other is non orthogonal sharing, where D2D and cellular communications may utilize the same frequency channels, which will cause interference, influence achievable communication rates, and, therefore, needs careful interference management by the BS [4], [5]. In this paper, we focus on non orthogonal sharing since it supports reusing the network resources and achieves higher spectrum efficiency.

II. AN OVERVIEW OF D2D COMMUNICATION

Devices communicate with each other without intermediate nodes (Offloads traffic from the core network) and uses Cellular Spectrum. The proximity of equipments provides high bit rates (low delays) and Low energy consumption. Radio resources may be simultaneously used by cellular and D2D links so that the same spectral resource can be used more than once within the same cell (reuse gain).It uses the same pre-existing cellular infrastructure and supports more services. Proximity discovery is a natural trigger for direct communication. Proximity discovery can be used as a standalone service and not trigger communication (social networking). D2D provides 2 methods of discovery.

1. Network discovery (Radio)

   A device is able to discover and be discovered by other devices in radio proximity

2. User assisted discovery (Application Layer)

A user of a service or social networking application is able to discover and be discovered by other users of the same service or social networking application

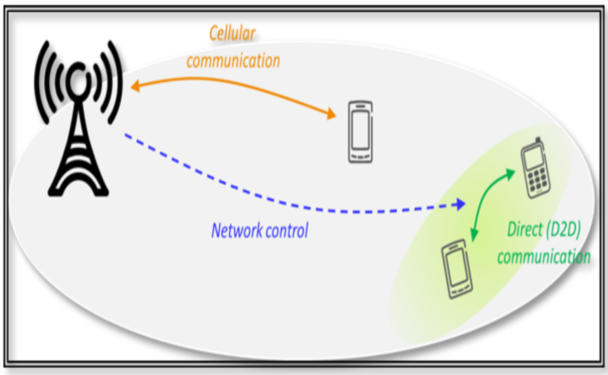

Fig.1 D2D communication

D2D communication in cellular network is characterized into both In-band D2D and Out-band D2D based on the spectrum in which D2D communication occurs. D2D communications is divided into two modes or categories called ' In band underlay mode ' when the D2D communications use the cellular resources and spectrum and ' In band overlay mode 'when cellular resources are allocated for the two D2D end devices that communicate directly. High control over licensed spectrum is the key motivating factor for choosing the In-band D2Dcommunication. In other hand, the main motivation of using Out-band D2D communications is the capacity to eliminate the interference between D2D links. In addition, Out-band D2D communications is faced with a lot of challenges in the coordination between different bands.

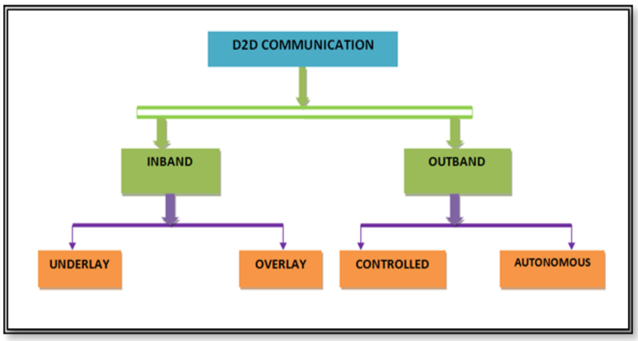

Fig.2 D2D Classification

In the current market, technologies such as Wi-Fi or Bluetooth provide some D2D communication functionality. However, these make use of unlicensed band, and it results in uncontrollable interference. In addition, they cannot provide security and quality of service (QoS) guarantee as cellular networks. D2D communication functionality has not been considered in the first four generations of cellular networks. This is largely because it has mainly envisioned as a tool to reduce the cost of local service provision. The operators' attitude towards D2D functionality has been altering recently because of several trends in the wireless market. For instance, the amount of context-aware services and applications are growing fast. These applications require location detection and communication with neighboring devices, and the accessibility of such functionality would reduce the cost of communication among devices. D2D functionality can also play a essential role in mobile cloud computing and assist effective sharing of resources (spectrum, computational power, etc.) for users who are spatially close to each other. Service providers can have added advantage of D2D functionality to take some load off of the network in a local area such as a stadium or a big mall by allowing direct transmission among cell phones and other devices.

III. RELATED WORKS

There are papers which illustrates about the problem of resource allocation and interference management for D2D communications in cellular networks The major step towards resource allocation in D2D communications is to optimize the spectrum efficiency (SE) defined as bits per second per Hertz (bits/s/Hz). One of the existing methods is the **Two-step coalition game formulation** which is based on merge and split approach. In a two-step coalition game, it is introduced to address the resource allocation problem for D2D pairs and the Coalition formation between the communities [1]. In a reverse iterative combinatorial auction based resource allocation algorithm was proposed to optimize the total system sum rate of the overall cellular network. The UEs' preferences were fixed, which only depends on the channel selection and power allocation strategies obtained in the first stage [6]. A game-theoretical approach based spectrum-efficient resource allocation algorithm was proposed in [7], in which each D2D UE chooses a best response strategy to a virtual price signal optimized and issued by the BS. Existing methods for resource allocation include enabling D2D pairs to join or leave a coalition based on the well-defined preferences [8], modelling the allocation mechanism as a reverse iterative combinatorial auction [9], and using the social centrality to assist peer discovery [10]. However, these studies assumed that the number of D2D pairs is not greater than the number of channel resources, which ignores that the D2D pairs number will go beyond the number of available resources in future. In a multiuser scenario, in order to make users as many as possible to get reliable service, it is predictable to divide up channel resources between different D2D pairs. Therefore, the interference situation in system will become more complicated. Except for the interferences between D2D communications and cellular networks, there are some other interference between different D2D pairs. In addition, the channel state information (CSI) required for interference management at BS will increase, which will increase BS's burden. Hence Graph theory which is an effective mathematical tool to analyze the interaction and relationship of different types of networks. There have been several schemes using graph theory to allocate resources for D2D communications [11, 12, and 13]. Additionally, there are usually multiple cellular users and multiple D2D pairs coexisting in the system. The channel rate that one D2D pair achieves may vary with different channels due to UE geo location. Moreover, the interference for a D2D pair is generated not only from the cellular user but also from other D2D pairs that occupy the same channel. Therefore, how to efficiently allocate cellular channels to each D2D pair is the second challenging problem. All the above said approaches deals with resource allocation and spectrum allocation between a single D2D pair and a D2D pairs that exists in the community. Hence we propose a novel algorithm that resolves the problem of resource allocation done by the base station to the community head which involves in resource distribution.

IV. PROPOSED PARADIGM

One of the primary problems for D2D communications is whether cellular users are agreeable to share their resources due to the existence of interference. In the previous methods, there exists coalition between different D2D communities and each node can share its channel resources with at most, one D2D pair, and that one D2D pair can occupy at most, one channel at any time slot respectively [1]. In our method of proposal the channel occupied by a single D2D pair can be shared to the number of devices in the community. We propose a novel method that can be used to share resources to all devices (users) of a community by having a peer head (PH) which serves as distributor of resources to the members of the community.

TABLE I
PARAMETERS OF THE ENERGY EFFICIENT D2D COMMUNICATION SYSTEM

PARAMETERS	DESCRIPTION
N	Number of nodes in the community
L_C	Total load allocated to the community by the base station
U_{MIN}	Minimum nodes present to form a community
U_{MAX}	Maximum nodes present in the community
$_{MAX}L_N$	Maximum Load allocated to each node in the community
T_{MAX}	Total time allocated to be present as the peer head
N_{ACK}	Negative acknowledgement
L_{SUM}	Sum of the load of the community
P_H	Peer head of the community
L_{REQ}	Load request from node
P_{ACK}	Positive Acknowledgement
T	Time taken by a node to act as a peer head
L_{REM}	Remaining unused load by a node
$_TL_{REM}$	Remaining unused load within the community
$_NL_{REQ}$	Load request by a new user

The proposed algorithm consists of three steps. First is the community formation in which a community is formed with different nodes (mobile user) that merges based on a pre-defined condition as shown in Fig 3.

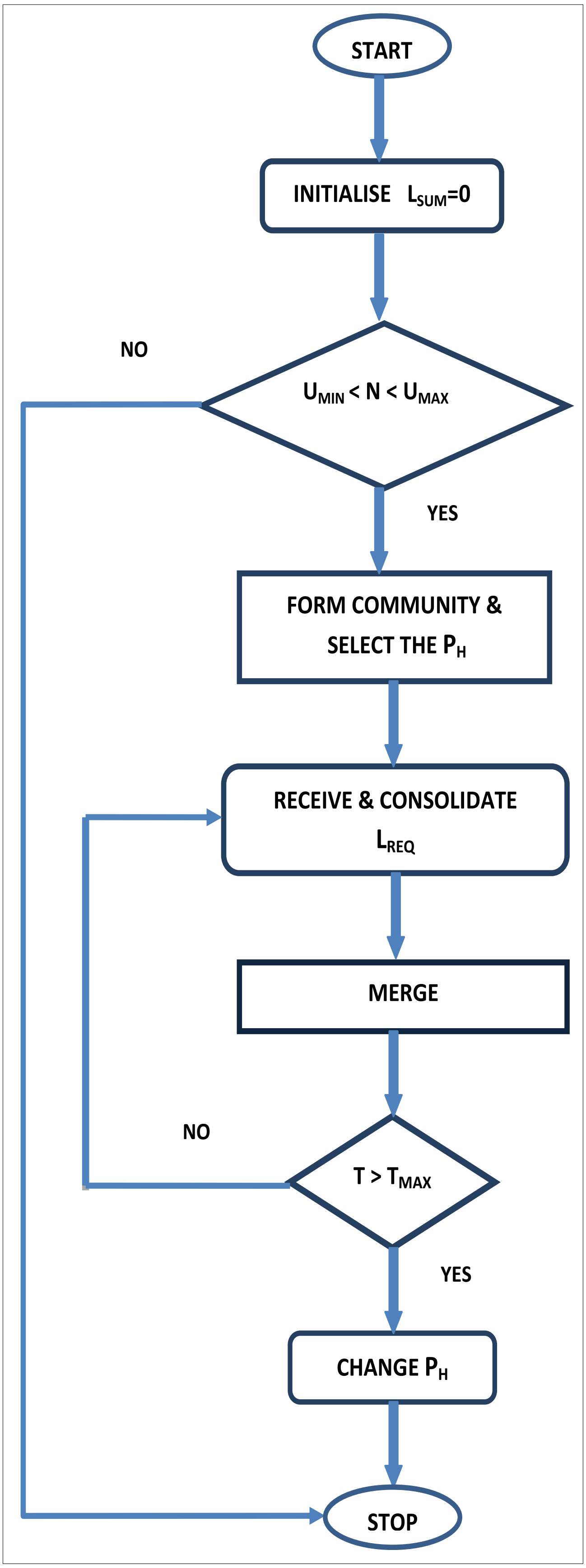

Fig. 3 Flow Chart for Community Formation

The second algorithm specifies how each member of the community request the peer head for resource and how it allocates optimally. The peer head allocates the requested load if it is less than the maximum load allocated to it by the peer head of the community and also checks if there is remaining load unused by other users in the community and allocates to it. The remaining load and the load requests each time by each node is updated periodically to the peer head and when the peer head is changed, it gives the table with updated information. The nodes which are outside the community can come under the BS control or it can join the community as a new user as shown in Fig 5.

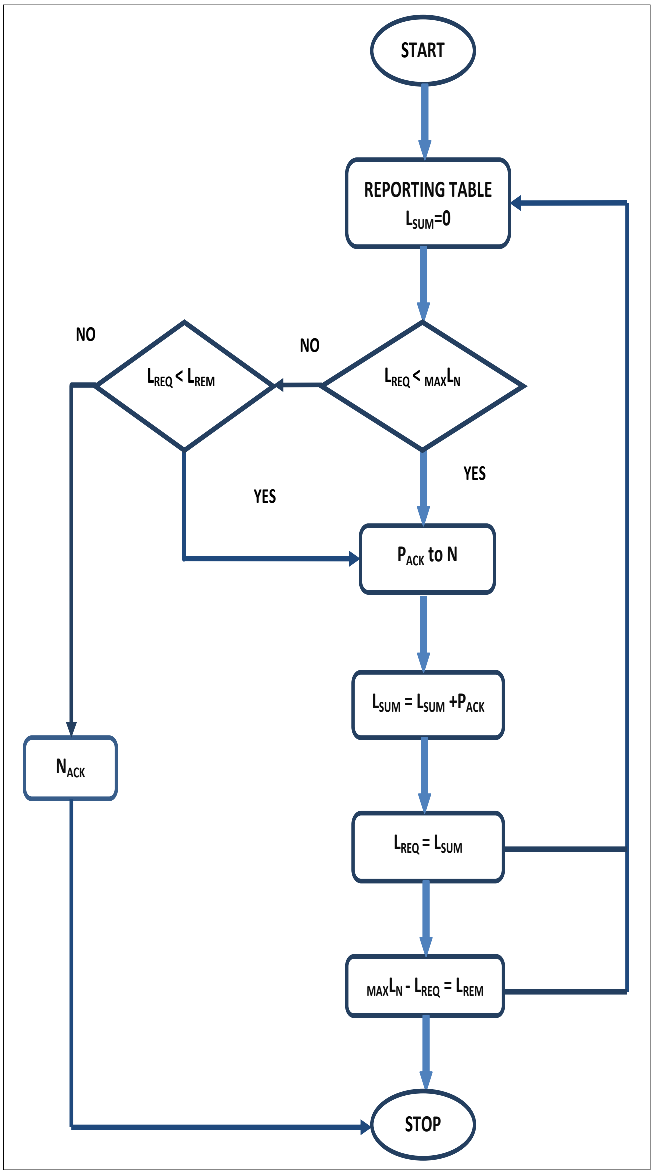

Fig.5 Flowchart for Single Node Operation

Third algorithm is the new user arrival in which a new node requests the peer head of the community to join them. The algorithm specifies whether it merges with the community or else it comes under another community or comes under the control of base station. Since the peer head is changed dynamically, the power required for operation is comparatively lower. And it also checks the node which is idle and transfers its allocated load and hence no data is wasted. And handshake time between base station (BS) and the peer head (PH) is comparatively low when compared with the handshake between a D2D pair and the base station (BS) as shown in Fig 6.

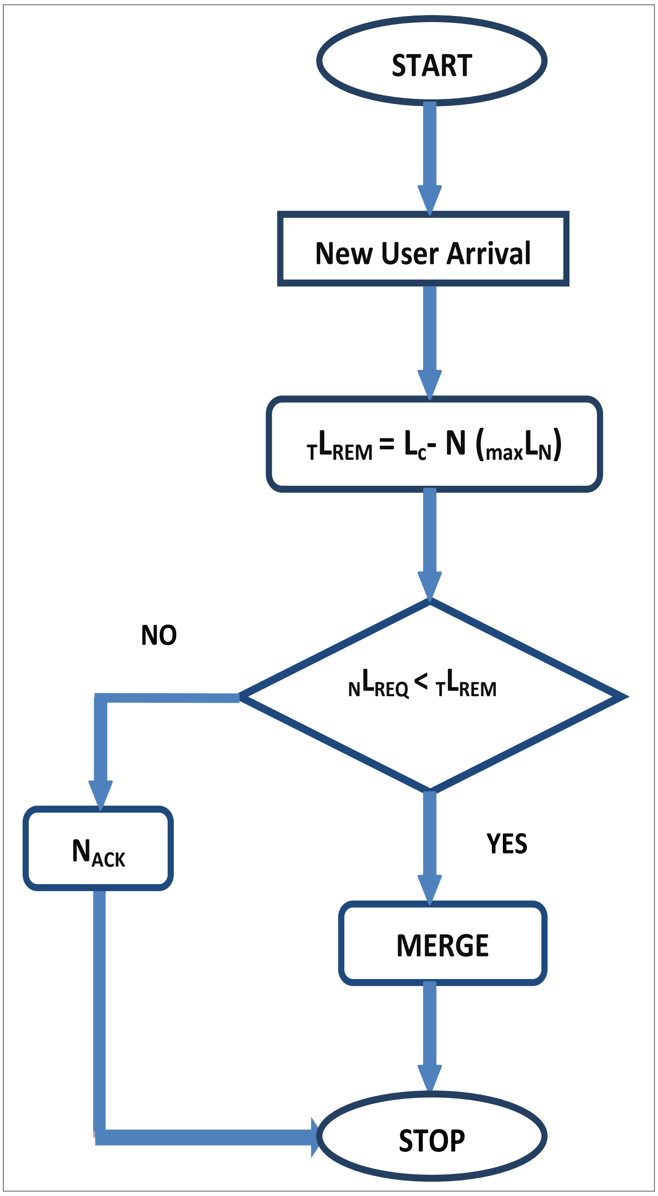

Fig.6 Flowchart for New User Arrival

V. RESULTS AND DISCUSSIONS

The above algorithms are executed in MATLAB GUI and the following results are obtained. Nodes are randomly generated and the community is denoted by forming an ellipse within the specified area. The peer head is selected and is randomly changed after servicing for a particular time. There exists base station which allocates the load to the peer head of the community and it takes care of the community. The connection between the base station and the community is represented by arrow drawn.

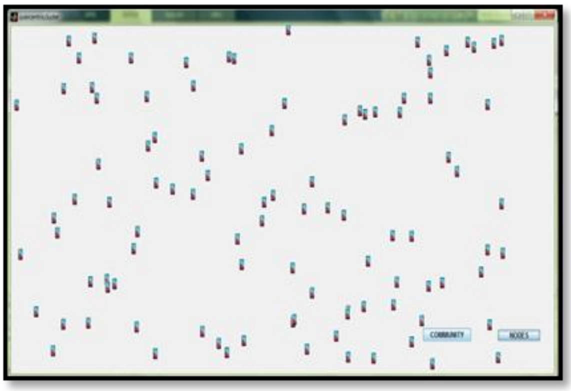

Fig.6 Random node generation

From figure 6,we can infer that mobile nodes are randomly distributed.This is done with the help of MATLAB Graphical User Interface where the region of the GUI is divided into 3*5 matrix . Initially a blank GUI window is created using “guide” command.Subsequently, two push button are created named as NODES and COMMUNITY respectively.On clicking the push button, these nodes are generated over the region which are programmed in the editor window.

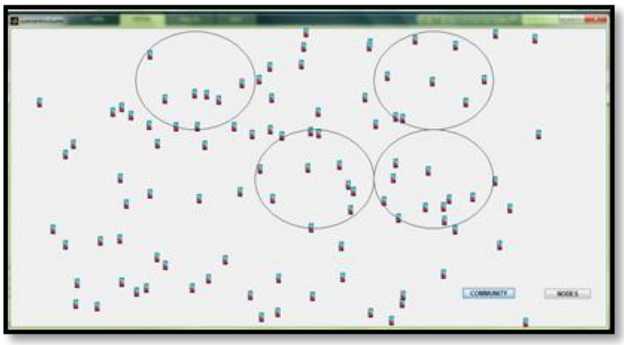

Fig.7 Formation of the community

After generation of nodes, community formation is necessary for D2D communication.Therefore,we have formed the community based on the number of available nodes which are of close proximity. The grouped nodes are represented as ellipse when the COMMUNITY button is hit it off as shown in figure7.

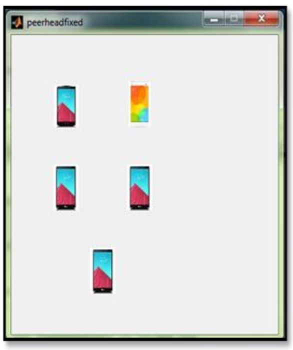

Fig.8 Random Selection of Peer Head

Fig.9 Selection of New Peer Head

Within the community there should be a peer head to assist other nodes in the community for proper distriution of bandwidth from the base station.Single node cannot bear the power loss when acting as a head for all the time therefore peer head selection will always be dynamic with respect to T_{MAX}.

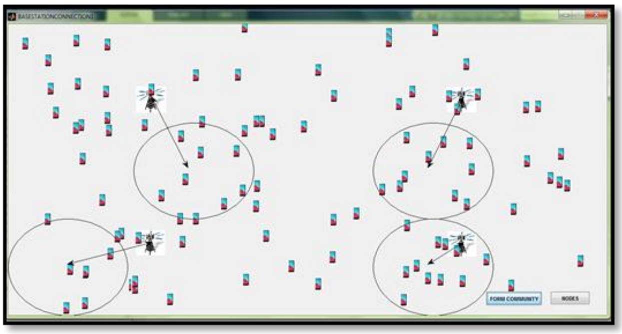

Fig.10 Connection of Peer Head with Base Station

The bandwidth allotment from the base station to the community is the next step shown in fig.10 and is represented using the arrow drawn. Community consisting of nodes is connected to the base station through the peer head which is based on the nearby coverage area.

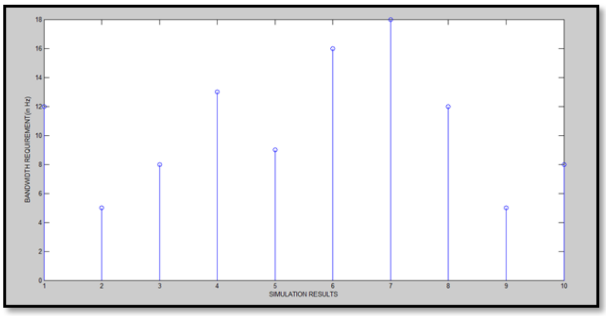

Fig.11 Threshold Fixation based on Consumption of Bandwidth

While analyzing the bandwidth requirements in different scenarios, the simulation results are obtained as shown above in figure 11. Based on this, we infer that the load consumption of the communities is taken into account and the threshold is fixed such that it is suitable for three-fourth of the total communities.

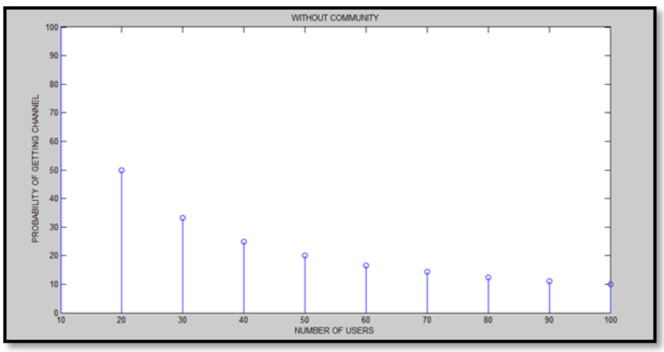

Fig.12 Number of users Vs Probability of getting the channel without community

The base station allocates channels for a limited number of users depending on the availability of the channel. The probability of getting the channel decreases if the number of users increases. They both are inversely proportional. This is the scenario that happens while getting channel directly from the base station and makes the users to wait when giving out the channel to the user for longer time.

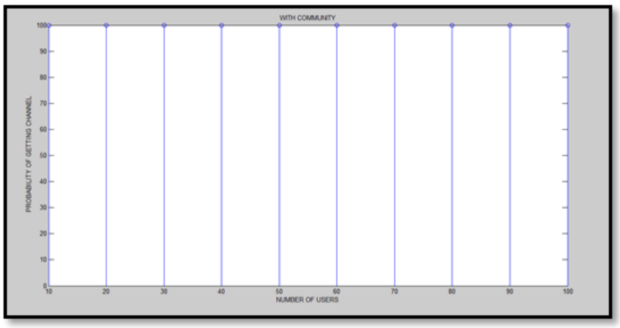

Fig.13 Number of users Vs Probability of getting channel within a community

Here, in the figure 13, it is shown that the probability of getting a channel to the user is higher when a community is formed (D2D communication) when compared to direct base station connectivity .The bandwidth allotment from the base station to the community is distributed to different users with the help of peer head. Every node has the chance to get the channel with or without the involvement of base station.

VI. CONCLUSION

In this paper, we have discussed the overview of D2D communication and how it can be effectively used in sharing resources among different communities reducing the requirement of base station. In section II, the methods that are related to resource allocation are discussed. Section IV specifies the efficient resource allocation i.e. sharing the load from the peer head to the different nodes in the community in an optimal manner. The simulation are carried out in MATLAB GUI and the results are shown in Section V consisting of generation of nodes and community formation among them and the connection between base station and the community are shown. The Plot between number of users and the probability of getting the channel with community and without community are shown. These graphs show that our proposed algorithm is efficient when compared with the existing methods.

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