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ENERGY EFFICIENT D2D COMMUNICATION IN 5G NETWORK

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ABSTRACT

There is a need to increase the capacity of thenetwork for meetinggrowing demands.To support a large number of connected devices the next generation heterogeneous network will need to support higher data rates and higher throughput. The available resources are limited and to support the demand of next generation networks, device-to-device (D2D) communication is the upcoming solution. D2D communication is expected to enhance the energy efficiency and spectrum efficiency of the next generation network. This paper presents a survey on the features and challenges of D2D communication with a focus on improved Energy Efficiency due to the use of D2D which will be a prime part of the next generation networks.

Keywords: D2D, Next generation network, Energy Efficiency

I.INTRODUCTION

With the introduction of a number of smart hand-held devices, the demands of users for mobile broadband are increasing. The drastic growth of bandwidth and energy hungry applications has risen greatly. This has called for next generation cellular systems supporting higher data rates and enhanced capacity. A very important technique in the next generation networks is Device-to-Device Communication. This will allow support for higher bandwidth applications, enhanced network capacity and efficient spectrum utilization along with an increase in energy efficiency. Also, it is desirable that the throughput should be maximised. With D2D employed in the network, enhanced throughput will be achieved along with reduced latency.

With all these advantages being provided by the D2D communication in the cellular networks, another important advantage of this technique is offloading traffic on the base station. Excessive number of users causes immense traffic. Thus, D2D communication is a solution for offloading traffic and is being studied by 3GPP [1]. For its implementation into the cellular networks, various aspects need to be studied like resource management, power control, security, interference management, etc. So, D2D communication is expected to play a key technology in 5G networks.

D2D communication can be in-band D2D communication or out-band D2D communication. In In-band D2D, the communication occurs in the licensed band. An important factor for choosing In-band D2D is the high control which it provides over the licensed spectrum. This D2D can be further divided into underlay(same

spectrum shared by cellular users and D2D users) and overlay(dedicated resources for cellular and D2D users). Out-band D2D communication exploits the unlicensed spectrum and can be further divided into autonomous and controlled D2D. In controlled out-band D2D communication, the cellular network has control of a second interface/technology, where as in autonomous out-band D2D the D2D communication is completely controlled by the users themselves.

D2D communication in cellular networks has numerous advantages [3] listed as follows-

- Single hop communication- Due to one hop connection between the devices, the network possesses lower complexity as the need for routing protocols is no more. Also, there is a considerable increase in the spectrum efficiency, and delays are also greatly reduced, in comparison to traditional cellular communication.
- Improved Spectral Efficiency- Due to shorter distance between source and destination, the data rate increases.
- Reusability of the Spectrum-D2D communication and cellular communication can simultaneously utilize the same spectrum if there is proper resource allocation and interference management. This correspondingly results in an increase in the spectrum reuse factor.
- Power optimization- A D2D link between two communicating devices at a short distance can use low transmission power. Also, there is a reduction in the consumption of energy by the communicating devices.
- Extended Coverage Area-A D2D link allows a device to act as a relay, and this can be extended to greater ranges, thus increasing the overall coverage area.

The various advantages offered by the D2D communication make it a great choice for the next generation cellular networks. The device-to-device communication technique is thus expected to play a crucial role in the 5G networks.

II.D2D RELAYING TECHNIQUES

The fifth generation cellular networks, with Device-to-Device Communication enabled within is considered as two-tier networks. The two tiers in these networks are referred to as the macrocell tier and the device tier. Conventional cellular communication is supported by the macrocell tier, while D2D communication is supported by the device tier. These cellular networks thus are similar to the existing networks. The difference lies in the fact that faithful services can be achieved by the devices at the cell edges and those in the congested areas within the cell. As devices in the device tier allow direct D2D communication, the base station may have a partial control or a full control over the communication between the devices. Thus, device to devicecommunication is categorized into four different types [2]:

- Device relaying with operator controlled link: Devices at the cell edges or in poor coverage areas are capable of communicating with the base station by relaying information through other devices. All tasks of establishing the communication between the devices are handled by the base station. The battery life of the devices is enhanced this way. The architecture is as shown in figure 1.

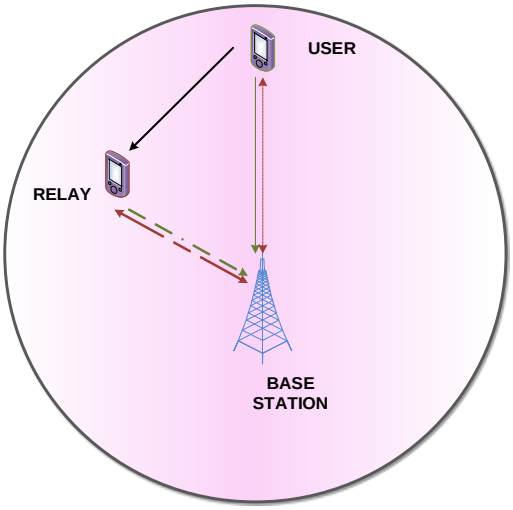

Fig.1. Relaying Devices with operator controlled link

- Direct communication between devices with operator controlled link: Two devices communicate directly with each other, with control links provided by the base station. Though direct, the communication is entirely managed by the base station. The architecture is as shown in figure 2.

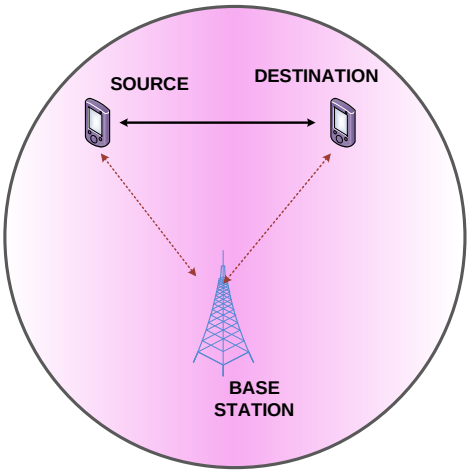

Fig.2. Direct communication between devices with operator controlled link

- Device relaying with device controlled link: Two devices communicate via relays, within the cellular networks. Resource allocation, setting up of call, interference management, all is managed by the devices themselves, in a distributive fashion. Control of the base station is missing. The architecture is as shown in figure 3.

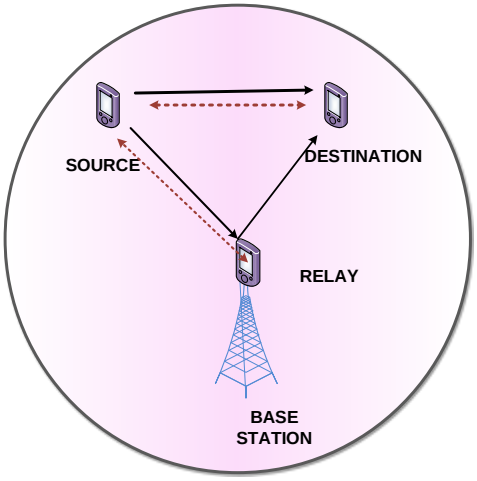

Fig. 3.Relaying device with device controlled link

- Direct communication between devices (Direct D2D):Devicescommunicate directly, without aid from the base station. Call setup and management are handled by the devices themselves. The architecture is as shown in figure 4.

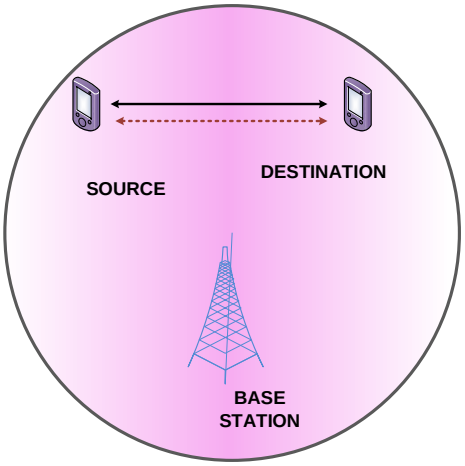

Fig.4. Direct communication between devices (Direct D2D)

Prior to direct transmission of information between the devices, these need to find each other. Device discovery can be possible by a periodic broadcasting of the device identity. Distance constraint is generally considered, for D2D pair formation. Peer discovery and mode selection is an open research issue in device-to-device communication. For any cellular network, a major concern is security. When exchanging information through relays network security must be assured. This can be made possible by ‘closed access’where a list of trusted devices is prepared by every device belonging to the device tier. If a device, under the relay scenario, does not find some devices in its own list, it communicates in the macro cell tier.

III.ENERGY EFFICIENT D2D

With the growing trend of proximity-based applications,such as peer-to-peer file sharing andlocal multicasting and advertising, D2D communicationshave been proposed to improve localservice flexibility and network throughput, andto support public safety service in case of lack ofnetwork coverage in 3GPP LTE-Advanced. Figure5 illustrates D2D communications in next generation networks.

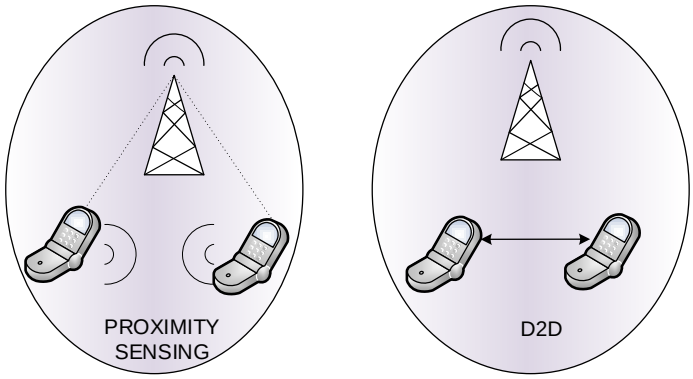

Fig.5.D2D Communication

In D2D communications, proximity usersin cellular networks can transmit data directly toeach other without going through the BS. Dueto physical proximity, D2D communications canpotentially provide proximity gain, reuse gain,and hop gain. Thus, D2D communications cansignificantly improve network SE and device EE.Furthermore, D2D communications can providemore freedom for D2D users, as they cantransmit data in three modes:

• Dedicated mode: D2D users directly transmitdata by using the orthogonal resource of regularcellular users.

• Reusing mode: D2D users directly transmitdata by reusing the resource of cellular users.

• Cellular mode: D2D users are treated as regularcellular users and communicate with eachother through the BS in the standard way.

Through proper mode selection, EE of bothdevices and the network can be significantly improved.

IV.CHALLENGES IN IMPLEMENTATION

Although Device to Device communication has numerous advantages in cellular networks, certain key challenges also persist, which need to be addressed. D2D communication in cellular networks, once enabled will allow the whole network to take advantage of its features. However, it will result in some challenges and design problems [4]. Some of these are listed below:-

- Peer discovery: The process of peer discovery should be efficient, so that D2D links are discovered and established quickly. This also ensures optimum throughput, efficiency and resource allocation within the system. For setup of direct links between the devices, the devices must first discover each other. Once they discover each other, D2D links are setup and transmission takes place. Different approaches are available for the device discovery. These are restricted discovery and open discovery [5]. In case of restricted discovery, the

UEs cannot be detected without their prior explicit permission. This, thus maintains user privacy. In case of open discovery, UEs can be detected during the duration for which they lie in proximity of other UEs. From the perspective of the network, device discovery can be controlled by the base-station either tightly or lightly. Device-to-Device discovery and the setting up sessions is a very challenging job.

- Resource allocation: The radio resources are allocated using centralized or distributed techniques in D2D communication [6]. Centralized techniques cause complexity in case of large networks while distributed techniques tend to decrease the device complexity. Hybrid solutions also can be provided, and an area of research. The complexity in this arises due to the large number of devices in the cellular networks.
- Power control: Setting the optimum transmission power for reusing the frequency is an area of interest for the researchers. It is particularly important in case of uplink because of the near-far effect and co-channel interference. Once a maximum power level is allocated to the D2D users, then Quality of Service of the cellular users is maintained in the network.
- Interference management:D2D links can cause interference between cellular users and D2D users, resulting in an increase in intra-cell interference. Inter-cell interference is also possible in case of D2D communication. Interference can be mitigated through mode selection, optimum resource allocation, power control.
- Security:The security schemes provided by the cellular operators can be used by the D2D users if they are under their coverage [7]. But, users outside the coverage of the operators can't be secured. In this case, security signals may be passed on through relays. But, relays are highly susceptible to malicious attacks. As a result, designing security schemes for D2D communication is an important challenge to be addressed.

Thus, apart of the numerous advantages and a key role of device-to-device communication in cellular networks, these challenges also need to be addressed in order to make it a success in the existing cellular network and offloading traffic. With optimal resource allocation, controlled power levels, interference mitigation and secure communication, device-to-device communication can greatly enhance the capacity of the cellular networks and provide very high spectrum efficiency.

V.CONCLUSION

In this paper an extensive survey on device-to-devicecommunication has been performed. This emerging technology is expected to solve the variousissues of the mobile network operator efficiently satisfying all the demands of the subscribers. An overview about the different types of D2D communication has been brought up. A number of features can be used in conjunction with D2D communication to enhance the functionality of cellular networks. Some challenges related to the implementation of device-to-device communication have been discussed.Thus, D2D communication is an integral technology of the next generation networks which will be put to efficient use in the near future.

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