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Social-Aware Energy Harvesting Device-To-Device Communications in 5G Networks

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Abstract

With the emerging wireless technologies, the need of the hour is speed and 5G is the current trend in the field of wireless communication, but the increase of speed brings with it, the need to have energy efficient devices. Nowadays many new cellular communication architectures are adopted which incorporate social networking characteristics and energy harvesting technologies. The paper discusses the various architectures adopted for device to device communication along with the advantages of their use. This architecture is realized under three modules: the physical domain, the energy domain, and the social domain. The manuscript is further inclined towards the discussion on evolution of D2D communication to its present position and social aware energy harvesting in 5G networks. Various challenges faced by the D2D networks are also highlighted along with the efficiency comparison of the D2D communication networks with traditional ones.

Keywords*: Device-to-Device (D2D) Communication, Energy Harvesting, 5G, Social Aware, Wireless Architecture*

1. Introduction

The wireless generation has taken a systemic leap from its first generation (1G) to the current emerging 5G. With the rapid growth in wireless sector the number of hand-held devices is increasing drastically leading to an increasing demand for applications with higher data rate. Thus, the existing techniques need a refinement which can be done with the implementation of the fifth generation (5G) networks. The latest trend now is Device-to-Device (D2D) Communication, which will definitely play a role in making the communication more efficient in terms of energy conservation and other factors too. Earlier, D2D communication was not of much importance in wireless communications but it's going to bring about a change when collaborated with 5G networks. The rising trends [1] pave way for this emerging technology. D2D communications makes direct transmission possible along with providing better reliability.

The term D2D communication refers to communication between two devices, without the involvement of the Base Station (BS). The small distance between two devices leads to power saving within the network, which otherwise is not possible in case of conventional cellular communication. It further leads to improvising the energy efficiency, throughput and delay. It also has its impact upon the offload traffic of the network. Hence, it is a flexible technique of communication, within the cellular networks. Qualcomm's FlashLinQ [3] Device-to-Device (D2D) communications is one of the key technologies in 5G cellular networks; it refers to the discovery of physically close devices, and enables direct, low-power communication between these proximate devices by reusing licensed spectrum resources. Due to the physical proximity and the potential

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reuse gain, D2D communications can improve spectrum efficiency, reduce power consumption and efficiently offload traffic from the Base stations/access points [6].

Besides a number of advantages of Device-to-Device (D2D) communication, its implementation also involves a few considerations. Sharing same resources leads to more interference between the cellular users.

This paper is further arranged under sub sections as, Section II includes the basics of D2D communication and social aware energy harvesting in D2D, Section III is about outline of D2D communication, Section IV the techniques involved in D2D communication, Section V covers the challenges of this form of communication followed by conclusions in Section VI.

2. D2D Communication and Social Aware Energy Harvesting

The continuous demand of increasing the network capacity to meet the growing needs of subscribers has advanced cellular communication from first generation to fifth generation. Soon 5G will replace 4G to fulfill the high data rate demand of the users. 5G is combination of various technologies like Visible Light Communication (VLC). Massive MIMO, microwave communication, cognitive radio networks *etc.* It also includes numerous technologies like non and quasi orthogonal or Filter Bank multi-carrier (FBMC), Multiple Access Beam Division Multiple Access (BDMA). First four generations were network centric being completely dependent on base station but fifth generation is based on device centric approach known as device to device communication. With D2D, we expect increased system capacity, enhanced spectral efficiency, reduced latency and greater throughput.

The cellular traffic is constantly increasing and it is overloading the Base Station (BS) thereby decreasing Quality of Service (QOS). Because of this overload, demand for the power increases. To satisfy power demand, some part of traffic is offloaded from base station with the help of device to device communication. In Device to device communication, devices can communicate with each other without involving base station by which load on base station is highly decreased

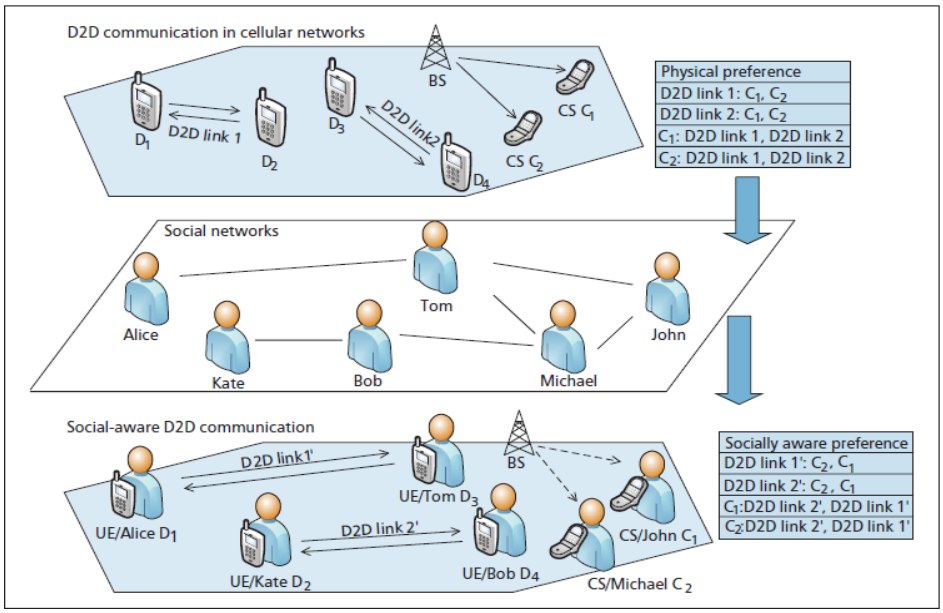

Figure 1. Illustration of Socially Aware Preference for D2D Communication with Social Awareness [6]

3. Device-to-Device (D2D) Communication Networks

From the architecture, device to device communication network appears to be same as Cognitive Radio Network (CRN) and Mobile Ad-hoc Networks (MANETs). There are numerous challenges in MANETs and CRN. In comparison to these two, device to device communications can either device controlled or base station controlled. Challenges of both can be controlled by device to device communication. Because of the advantages offered by D2D communication, it is considered as an effective solution to complete the increasing demands of users. This technique aids in development of new applications and data offloading. The fifth generation (5G) cellular networks using Device to Device Communication is a two tier network, macro cell tier and the device tier. Conventional cellular communication uses the macro cell tier, whereas Device to Device communication is supported by the device tier. The device tier provides faithful service at the cell edges and in the congested area with in cells. Device tier allows devices to have direct device to device communication resulting in the base station having a partial control or a full control over the communication between the devices. So, device to device communication using device tier can be categorized into four different types [13]:

1) Device relaying with controlled link establishment from the operator:

In this approach, the devices at the cell edges or in poor coverage areas can communicate with the base station (BS) by relaying information through other devices. The base station (BS) handles all tasks of establishing the communication between the devices. By this, the battery life of the devices is enhanced to some extent.

2) Direct communication between devices with controlled link establishment by the operator:

In this approach, two devices communicate directly to each other with the help of control links provided by the base station. Therefore, the communication is fully managed by the base station.

3) Device relaying with controlled link establishment from the device:

In this approach, two devices communicate via relays within the cellular networks. The device manages the resource allocation, setting up of call, interference management, in a distributive fashion by them. There is no control by base station.

4) Direct communication between devices (Direct D2D) with controlled link establishment by the device:

Here the devices communicate directly with each other without assistance from the base station (BS). Call setup and management are also handled by the devices. Energy harvesting is the process by which energy is derived from external sources, such as solar energy, thermal energy, wind energy, salinity gradients is captured, and stored for small, wireless autonomous devices. Now-a-days energy harvesting is being implemented in 5G network [10] [11] in which wireless devices are made to harvest energy from renewable resources such as wind, sound, solar to increase the battery life of the devices and also to increase system energy efficiency. In D2D communication, energy preservation improvements include optimal power control for energy efficiency, the design of energy-aware resource allocation schemes and energy efficient proximity device discovery.

In energy harvesting D2D communication system, the devices harvest energy from access points [11] and later use this energy for communication. Y. Li *et al.* [12] proposed a social aware enhanced D2D communication system that uses social network features for solving technical problems in D2D communication. The purpose of using social features is that the knowledge of human social relations and structures can be used to help in establishment of stable D2D connections to improve system performance.

4. Techniques Adopted

Energy harvesting is suggested and implemented as a solution to the energy constraint in wireless communications. Various techniques and ways have been proposed and developed for an energy efficient harvesting communication. They can be explained as: *Vshare* is a novel architecture which supports highly dynamic and time-sensitive social behaviors in vehiclular networks. VeShare separates vehicle networks into control and data plans, which allows efficient social group management and data transfer. Internet of vehicles is another promising area related to D2D communication [1]. Another phrase used is Internet of vehicles, with the assistance of an agent-based model intended to reveal hidden patterns behind superficial data. Supportive technology and methods are incorporated which include deep reinforcement learning, privacy preserving data mining, and sub-cloud computing in order to detect the most significant and interesting information for each individual effectively.[9]

D2D communication study earlier focused on the reduction of interference management and capacity maximization of both D2D links and cellular links. But the recent literature has observed that the QoE can also be greatly enhanced by designing caching strategies for contents of mobile devices. Hyper graph framework is designed that uses caching based D2D communication scheme by taking social ties among users and common interests into consideration. The key concepts of hyper graph and related techniques are hyper graph coloring and multidimensional matching. [2]

Another major concern of D2D communication is efficient radio resource allocation between cellular links and D2D links, which poses critical challenges. The network knowledge extracted from underlying mobile social networks (MSNs), a socially aware D2D communication scheme is formulated to improve the spectrum and energy efficiency in cellular networks [1]. Recently, the service demand for rich multimedia over mobile networks has continually been soaring at a tremendous pace. To solve the critical problem of mobile traffic explosion, substantial efforts have been made to offload mobile traffic from infra-structured cellular links to direct short-range communications locally among nearby users. A solution is to potentially combine users online and offline to exploit D2D opportunistic sharing for offloading mobile traffic. A tag-assisted social-aware D2D sharing framework, TASA, with corresponding optimization models, architecture design, and communication protocols is formed. TASA can offload up to 78.9 percent of mobile traffic effectively. [5]

Another joint task is - data offloading framework for mobile devices that have insufficient energy budgets or data usage budgets. Based on the proposed framework, a mobile device association problem is formulated and solved by exploiting matching-based and game-theory-based schemes. This leads to decrease in energy consumption and data usage. [6]

5. Challenges

Success of device to device communication depends upon distance restrictions and interference between the same tier users or between different tier users. The D2D communication is controlled by base station, the base station acts as central controlling entity which controls interference and spectrum allocation. In device to device communication there is no control by base station. For optimum performance, interference management schemes are incorporated. Before transmitting data, devices need to find each other which is possible by broadcasting device identity information. Another major issue is security while exchanging information among the devices. Information security is possible by keeping a list of trusted device by each device in device tier.

6. Conclusion

The increasing demand of mobile applications creates challenges for mobile devices on energy consumption and data usage. As a solution, device-to-device communication can serve as a powerful paradigm in futuristic cellular networks to enable local cooperation of mobile devices. By leveraging social awareness, users can share surplus communication and computation resources on their mobile devices to stimulate beneficial cooperation, which can cut down on energy consumption and data usage.

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