INTERNATIONAL JOURNAL OF TECHNO-ENGINEERING
IJTE

ISSN: 2057-5688

OPTIMAL INFORMATION CENTRIC CACHING IN 5G DEVICE-TO-DEVICE COMMUNICATIONS

G MOHAN

Research Scholar, Department of ECE, ***Brilliant Institute of Engineering and Technology***, Hyderabad, Telangana, India. Mail id: mohang10@gmail.com

ABSTRACT:

Device-to-Device (D2D) communications are a prominent feature of 5G systems, introduced to provide a native support to distributed services in mobile environments. D2D technologies enable straight interactions between mobile terminals without a compulsory involvement of base stations. In this manuscript, we study and propose an optimized caching strategy to content distribution on top of D2D technology, based on Information Centric Networking (ICN) principles. The rationale is that ICN architectures can provide seamless support to mobile services and decouple contents from node identifiers, thus providing a promising match with D2D requirements. To this end, a novel fluid-based model in proposed hereby that catches the interplay between ICN functionalities, D2D requirements and 5G specifications. Then, based on this model, an optimal content replication problem is formulated, encompassing caching overhead and system load. Additionally, this problem is thoroughly analyzed to prove that it has an optimal solution with time threshold form. A practical algorithm ς∗-OCP is further proposed in order to implement the optimal caching control in realistic environments. Finally, a massive simulation campaign is carried out to test the proposed algorithm in comparison to state of the art solutions.

Key words: D2D, ICN, OCP, 5G, High efficiency, fluid based model.

I. INTRODUCTION

ISSN: 2057-5688

The number of hand-held devices is drastically increasing, with a rising demand for higher data rate applications. In order to meet the needs of the next generation applications, the present data rates need a refinement. The fifth generation (5G) networks are expected and will have to fulfill these rising demands. A competent technology of the next generation networks (NGNs) is Deviceto-Device (D2D) Communication, which is expected to play an indispensable role in the approaching era of wireless communication. The use of D2D communication did not gain much importance in the previous generations of wireless communication, but in 5G networks, it is expected to be a vital part. The rising trends pave way for this emerging technology. With the introduction of device-to-device (D2D) communication, direct transmission between devices is possible. This is expected to improve the reliability of the link between the devices, enhance spectral efficiency and system capacity , with reduced latency within the networks. Such a technique is essential for fulfilling the chief goals of the mobile network operators (MNOs).

D2D communication allows communication between two devices, without the participation of the Base Station (BS), or the evolved NodeB (eNB). Proximate devices can directly communicate with each other by establishing direct links. Due to the small distance between the D2D users, it supports power saving within the network, which is not possible in case of conventional cellular communication. It promises improvement in energy efficiency, throughput and delay. It has the potential to effectively offload traffic from the network core. Hence, it is a very flexible technique of communication, within the cellular networks.

Qualcomm's Flash LinQ was the first endeavor towards the implementation of device to device (D2D) communication in cellular networks. It takes advantage of orthogonal frequency division multiple access (OFDMA) in conjunction with distributed scheduling for peer discovery, link management and synchronization of timings. Another organization involved in examining D2D communication in cellular networks is 3GPP (Third

ISSN: 2057-5688

Generation Partnership Project) . D2D communication is under investigation by the 3GPP as Proximity Services (ProSe). It is expected to function as a public safety network feature in Release 12 of 3GPP. The task of standardization of device-to device communication and the ongoing projects are briefly discussed in APPENDIX A and B. A next generation network scenario, supporting device-to-device (D2D) communication along with some general use cases is depicted in Fig.1. The most popular use cases of D2D include public safety services, cellular offloading, vehicle-to-vehicle (V2V) communication, content distribution.

In spite of the numerous benefits offered by device-to device (D2D) communication, a number of concerns are involved with its implementation. When sharing the same resources, interference between the cellular users and D2D users needs to be controlled. For this, numerous interference management algorithms have been proposed in literature. Other concerns include peer discovery and mode selection, power control for the devices, radio resource allocation and security of the communication.

2. LITERATURE SURVEY

According to Kitchenham et al., both research and practice in Software Engineering require evidence based approach which is the synthesis of scientific studies correlated to a question or topic of the research. In addition, it is also being agreed by that, combining empirical studies on a particular topic greatly ensures the chances of reliability. Therefore, a secondary study known as Systematic Literature Review (SLR) is recommended for aggregating evidences.

The aim of Systematic Literature Review (SLR) is to institute a formal process for conducting a literature review, making sure that no biasness and other eventualities such as thorough investigation and analysis are administered. SLRs allow the identification, evaluation and interpretation of all available and relevant information with respect to the topic of research

ISSN: 2057-5688

A tertiary study was conducted in order to evaluate the actual state of Mobile Data Synchronization. This study was planned and executed based on the methodology in and the protocol presented in which the impact of Systematic Reviews in SE is properly evaluated.

In this research, we used comprehensive and detailed electronic libraries such as IEEE Xplore, Science Direct, ACM, Springer, Web of Science, and Google Scholar to search for the relevant materials. Out of these libraries we managed to retrieve journals papers, conference proceedings, books chapters as well as symposiums

Existing system:

In Wireless communication, antennas playing an important role. Different antennas have been designed for different application i.e., for WLAN, PCS, 3G and for 4G. The use of smart phones and the speedy growth of data rate generating unexpected challenges for the wireless service providers that to overcome the total bandwidth scarcity, to deliver low latency with high-quality video and multimedia application for wireless devices. In 5G cellular system is shifted higher frequency where it is easy to obtain the wideband. The centimeter or millimeter wave can provide very wide bandwidth as compared to 3G or 4G frequency bands. There are different bands are selected for 5G one of them is 28 GHz. To move to theses millimeters waves band it will create new challenges in the design of antennas for the mobile device and base station. However many challenges lie ahead of using millimeter wave frequencies which include propagation loss shadowing, sensitivity to blockage, large scale attenuation of human bodies and materials and atmospheric absorption. To control these challenges, we need high gain high directional beam forming antennas for both mobile device and at base station should be deployed. The beam forming can be applied to overcome the path loss at millimeter wave frequencies. The antenna array plays has an important role in long distance communication due to its high transmit and receive gain, spatial diversity, interference suppression, and angle of arrival estimation. The microstrip antennas consist of four parts

ISSN: 2057-5688

i.e., the ground, patch, substrate, and feeding part. The patch antenna can be categorized as a single resonant element or more than single antenna elements. The patch is very thin i.e., the thickness of the patch is very small than free space wavelength, λo of the radiating metal strip or array of strips that is located on one side of the substrate. The thickness of substrate layer is in between 0.01 to 0.05 of the free space wavelength. The purpose of the substrate is to separate the ground plane and the radiating patch. The insertion loss of the substrate should be low and the loss tangent should be less than 0.005. The advantage of the microstrip patch antennas is that it has a small size, low profile and lightweight conformable to the non-planner and planner surfaces. In this paper, we have proposed unit element and two element patch antenna array for 28 GHz operating frequency. The directivity of the antenna array is increased as compared to the unit element. The remaining paper can arrange as, the Section 2, address the analysis and design of single patch antenna, Section 3 address the simulated results of the single patch antenna and two patch antenna array while the last Section 4 address the conclusion.

3. PROPOSED NOC CROSSBAR ARCHITECTURE

Similar to the cognitive radio, D2D communication is among the key technologies that can improve the spectrum utilization and capacity of next generation cellular networks . Due to advent of new multimedia applications, there is an increasing demand to improve the capacity of 4th generation (4G)/beyond 4G cellular networks (i.e. next generation 5G cellular networks). One of the possible solutions to achieve high capacity is small cell networks (eg. micro-BS, femto-BS). In small cell network, cell size is reduced to increase the spectrum reuse 19 factor. Cellular user and BS are in close proximity to achieve high data rate and lower delay. However, there are issues based on construction and maintenance cost (eg. the backhaul bottleneck).

Recently, the concept of D2D communication has been proposed for cellular networks to avail the high capacity benefits to cellular users with

ISSN: 2057-5688

minimal constraints on maintenance and construction. In a generic D2D framework, two cellular users living in proximity can form a direct link for data transmission without routing it through the base station (BS). However, control or signaling information between the users is still carried out by the BS. A simplified form of integration of D2D communication in a cellular network is shown in 1.6. Traditionally, D2D technologies were restricted to short-range communication networks such as WiFi-Direct and Bluetooth working on unlicensed 2.4 GHz band. The unlicensed bands are generally crowded with a large number of interferers; thus traditional D2D technologies do not provide the QoS and security as expected in the cellular networks. Several applications of D2D like proximity-based services, emergency communication, cellular traffic offloading, Internet-of-things (IoT) enhancement, etc.

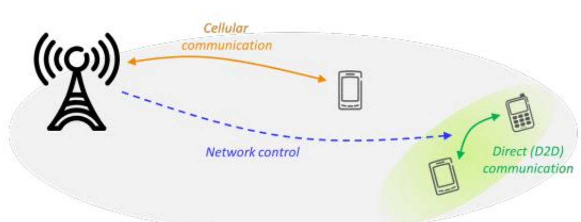

Fig.1. simplified D2D communication integrated in a cellular network.

UNDERLAY D2D COMMUNICATION

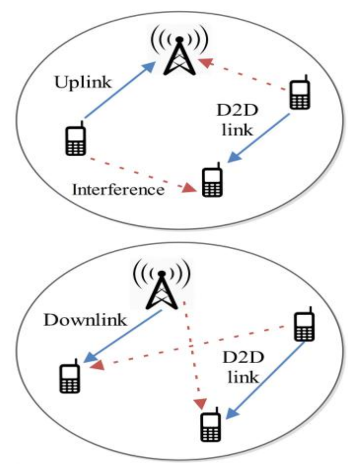

Fig .2. D2D using cellular uplink and downlink resources

Here, a D2D user shares the uplink resources of the cellular user, thus cellular and D2D transmission causes interference to each other. Specifically, at same time/frequency resource block, a cellular user and D2D Tx transmit their data to BS and D2D Rx respectively. Thus, BS receives interference from D2D Tx, whereas D2D Rx receives interference from the cellular user. Hence in underlay D2D framework, the biggest concern is to

ISSN: 2057-5688

manage the interference caused by the cellular to D2D user and vice-versa. In , authors studied the interference man

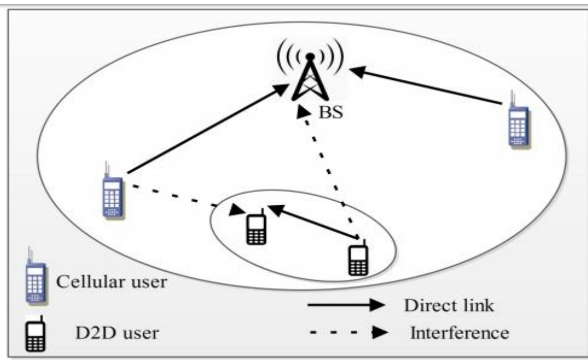

Fig.3. Underlay D2D communication.

Agreement for underlay D2D framework in LTE-A cellular networks. In , the resource sharing between the D2D user and the cellular user is optimized while satisfying the individual power constraints. Distance constrained resource sharing criteria for underlay D2D cellular network is considered in . Specifically, authors have formulated an analytical approach to find an optimum distance between the cellular user and D2D receiver to mitigate D2D interference.

Overlay D2D communication

Compared to underlay, in overlay D2D communication, BS allocates dedicated spectrum or time slots to D2D link as long as the QoS of the cellular user is not compromised . It eliminates the mutual interference between cellular and D2D users. However, it may not utilize the available spectrum resources efficiently. A schematic of overlay D2D communication framework is shown in Fig. 1.10. Here, a D2D user shares the cellular uplink resources in an uninterrupted way. Specifically, if target QoS of the cellular uplink transmission is satisfied by the fraction of available time/frequency resource block, then BS allocated D subcarriers (or T1 time) to the cellular user for BS transmission while remaining N − D subcarriers

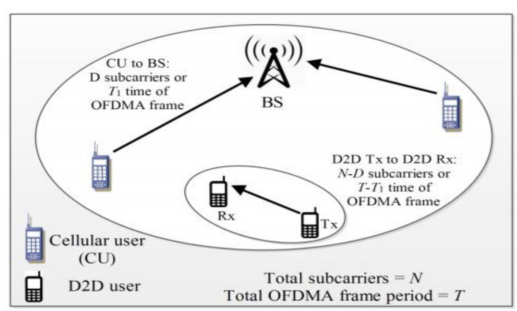

Fig.4. Overlay D2D communication.

(or T − T1 time) can be used for D2D communication. It is quite obvious that

ISSN: 2057-5688

there will be no interference between cellular and D2D links, as both use orthogonal sets of subcarriers. A spectrum sharing protocol for D2D communication overlaying cellular mode is proposed in . According to , the D2D users can assist bi-directional communication between the cellular users and BS, and at the same time communicate through a direct link with each other. Further, improved sum-rate derivation with power control mechanism for the cellular and D2D users are provided. A stochastic geometry approach to evaluating the performance of the D2D network over generalized fading channels is proposed. Closed form expressions for spectral efficiency and outage probability are derived for the overlaid D2D network. However, the analysis in is limited to the D2D communication overlaying cellular networks. Comparison with underlay and other frameworks has not been discussed.

EXPERIMENTAL RESULTS

MATLAB simulations of a 5G network with commonly used hexagonal cells are adopted to evaluate the performance of the aforementioned mechanisms in terms of the secure level and latency. A total of 9 small cells in Fig. 3 with an inter-site distance (i.e., distance between two APs) of 100 m are considered in the simulation. Users are randomly distributed around APs, while each UE takes a random walk and changes direction every 5's. The wrap-around technique (i.e., users moving out of the predefined service area are assumed to enter the area from the other side of the network) is used to avoid boundary effects.

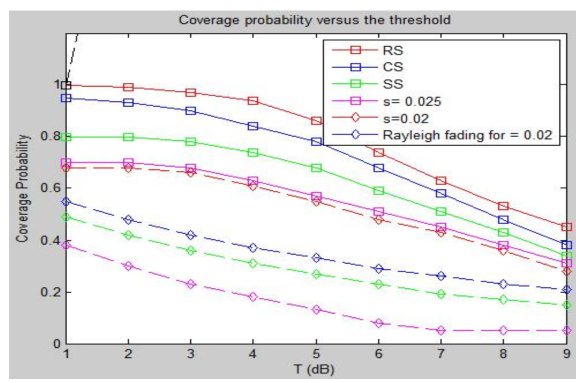

Fig: 5 coverage probability VS Threshold

In simulating the proposed Software density networks (SDN)-enabled validation handover, we consider the separation distance between UE and APs, and the moving direction

ISSN: 2057-5688

of the UE as the transferred SCI to verify the reliability of the proposed SCI-based validation handover scheme. From the simulation results, we find that during the monitored user handover process, the probability that any two users have the same distance to the closest AP is 44 percent.

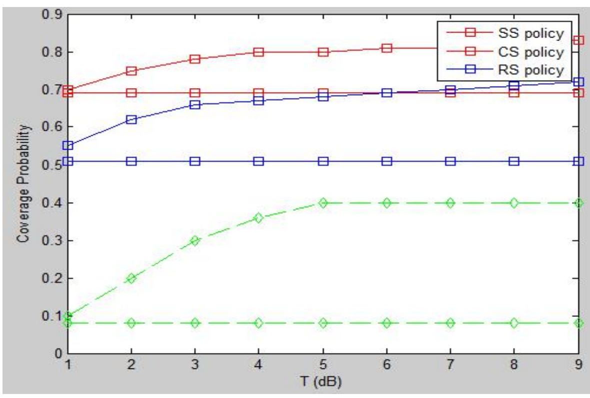

Fig:6 policy analysis for coverage probability

When it comes to the same AP, the probability of two users having the same distance to this AP decreases to 11 percent. Combined with moving direction, signal strength, channel state information, and other user-specific attributes, the probability of UEs with the same SCI could be reduced to virtually 0. Therefore, we believe that the SDN-enabled validation handover mechanism using SCI transfer is robust to guarantee security with enough SCI attributes. Moreover, it is flexible in setting a security level by different combinations of user specific attributes.

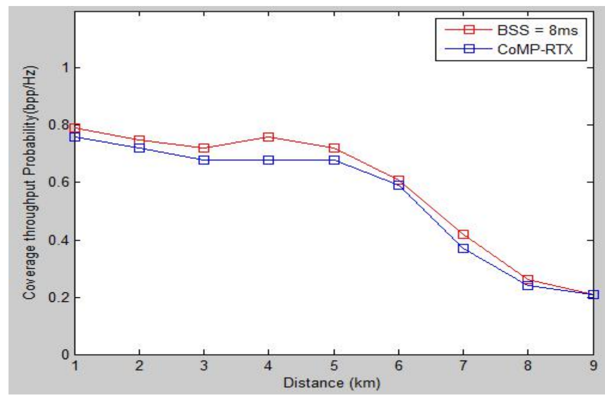

Fig:7 BSS and CoMP schemes for received packets

Figure 6 shows the comparisons of validation transmit power vs. 5G network utilization rates. Here network utilization is defined as the ratio of total data arrival rate and controller processing rate. Network utilization rate is used as it reflects the different load situations of the network. We can see from Fig. 6 that when the network load is fairly low, validation delay is not a problem for all different methods. With more arrivals and increased network load, SDN-enabled validation handover

INTERNATIONAL JOURNAL OF TECHNO-ENGINEERING
IJTE

ISSN: 2057-5688

still keeps the latency under 1 ms most of the time, which meets the 5G latency requirement. NOX-MT- and Beacon-enable solutions perform 30 and 14.29 percent better than traditional handover validation protocol in latency reduction with the commonly used deployment of an eight-core machine, 2 GHz CPUs, and 32 switches in [14]. It is obvious that the SDN-enabled validation handover and privacy protection scheme meet the critical latency requirement in 5G, while maintaining the SDN flexibility, programmability, and data offloading capability in further improving the energy efficiency and network management of 5G networks.

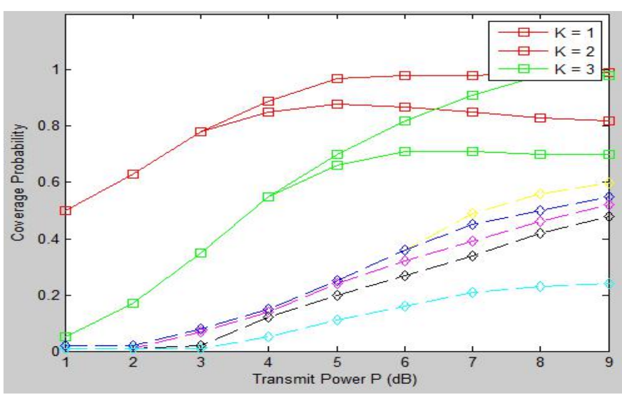

Fig: 8 Transmit power VS 5G network

A proposed extension of this work is the consideration of a distance-based power control to handle the effects of multiuser interference.

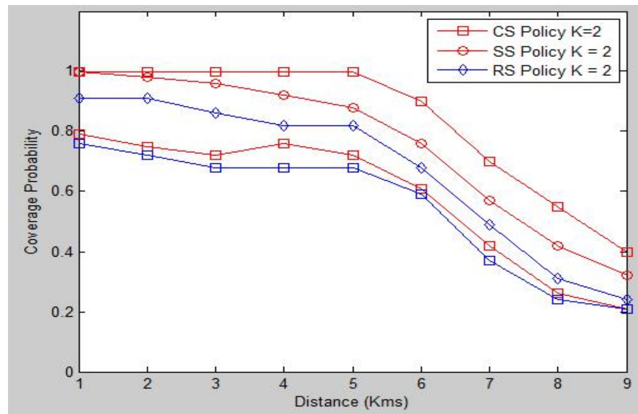

Fig: 9 Received Packets for different policies at distance k=2

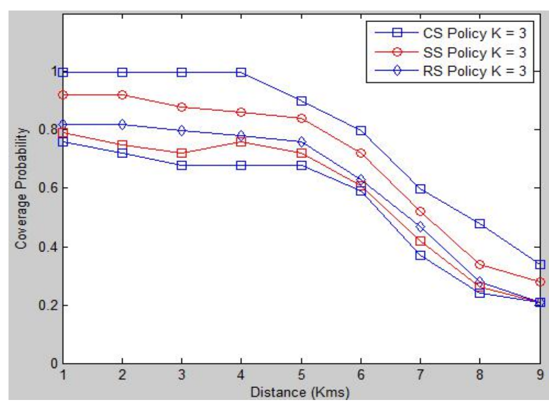

Fig: 10 Received Packets for different policies at distance k=3.

V. CONCLUSION

ISSN: 2057-5688

This project studied the problem of optimal caching in ICN 5G D2D environment. We modeled replica dissemination process in ICN 5G D2D as a fluid-based model, which captures the dynamic relationship between content replication and users behavior under controllable caching operations. Furthermore, our formulation has led to an optimal control problem to jointly minimize the caching cost and system load. We then proved the superiority of this time threshold caching control with respect to probabilistic-based methods and existence of a time threshold solution for above optimization problem. Additionally, we also designed a practical caching algorithm named ς ∗ -OCP which integrate with our time threshold-based optimal caching control. Simulation results showed our ς ∗ -OCP achieves higher caching hit ratio, lower caching redundancy and delivery latency when comparing with the state-of-art solutions. Our work also opens some avenues for future work in this field. First, although RWP is an general mobility model, yet is not well suit for vehicular environment where vehicles are moving along the pre-given routes (such as streets). Hence, new models could be introduced in order to provide more comprehensive analysis. Second, in our fluid based model, we consider two widely used ICN forwarding schemes: random unicast and broadcast, other forwarding strategies such as geographical-based forwarding can be also adopted with some modification on fluid-based model. In this case, except for investigating the caching dynamic, the proposed fluid-based model can be also used to analyze the performance of request forwarding strategies. Third, as our model can be also used to describe the data dissemination under different forwarding strategies, our future work may also include designing efficient forwarding strategies that reduce the delivery latency and forwarding energy costs.

REFERENCES

[1] E. Bastug, M. Bennis, and M. Debbah, “Living on the Edge: The Role of Proactive Caching in 5G Wireless Networks,” IEEE Communications Magazine, vol. 52, no. 8, pp. 82–89, 2014.

[2] S. Woo, E. Jeong, S. Park, J. Lee, S. Ihm, and K. Park, "Comparison of Caching Strategies in Modern Cellular Backhaul Networks," in Proceeding of the 11th annual international conference on Mobile systems, applications, and services. ACM, 2013, pp. 319–332.

[3] X. Lin, J. Andrews, A. Ghosh, and R. Ratasuk, "An Overview of 3GPP Device-to-Device Proximity Services," IEEE Communications Magazine, vol. 52, no. 4, pp. 40–48, 2014.

[4] F. Malandrino, C. Casetti, and C.-F. Chiasserini, "Toward D2D-Enhanced Heterogeneous Networks," IEEE Communications Magazine, vol. 52, no. 11, pp. 94–100, 2014.

[5] G. Fodor, E. Dahlman, G. Mildh, S. Parkvall, N. Reider, G. Miklós, and Z. Turányi, "Design Aspects of Network Assisted Device-to-Device Communications," IEEE Communications Magazine, vol. 50, no. 3, pp. 170–177, 2012.

[6] A. Asadi, Q. Wang, and V. Mancuso, "A Survey on Device-to-Device Communication In Cellular Networks," IEEE Communications Surveys & Tutorials, vol. 16, no. 4, pp. 1801–1819, 2014.

[7] M. Haenggi, Stochastic Geometry for Wireless Networks. Cambridge University Press, 2012.

[8] M. Ji, G. Caire, and A. Molisch, "Fundamental limits of caching in wireless d2d networks," IEEE Transactions on Information Theory, vol. 62, no. 2, pp. 849 – 869, 2014.

[9] M. Ji, G. Caire, and A. F. Molisch, "Wireless device-to-device caching networks: Basic principles and system performance," IEEE Journal on Selected Areas in Communications, vol. 34, no. 1, pp. 176–189, 2016.

[10] N. Golrezaei, P. Mansourifard, A. F. Molisch, and A. G. Dimakis, "Base-station assisted device-to-device communications for high-throughput wireless video networks," IEEE Transactions on Wireless Communications, vol. 13, no. 7, pp. 3665– 3676, 2014.

AUTHOR:

INTERNATIONAL JOURNAL OF TECHNO-ENGINEERING
IJTE

ISSN: 2057-5688