Design of an Optimized Social Arithmetic Mean Based Relay Selection Scheme for D2D Cooperative Communication

Deepika Rani Sona, Kalapraveen Bagadi

Abstract*: Over the years, wireless mobile connectivity has encompassed billions of people all over the world giving more connectivity and freedom to interact. Dramatically increasing data traffic has been a significant product of this exponential rise in the subscriber base, leading to a drastic demand-supply shortage. Current generation cellular networks such 5G mobile networks and D2D cooperative communication have been poised as solutions for the global bandwidth and supply shortage, anticipating more power efficiency, transmission capacity, reduced latency and a host of other improved efficiency parameters. However, as the mobile devices in a particular area grow, short-range data and multimedia transfer using fewer resources need to be exploited to give better transferability.The paper deals with improving the delivery performance parameters by designing a multi-hop relay based device-to-device communication paradigm where both proximity and social link parameters have been utilized to increase throughput.

Index Terms*: Device to Device (D2D) communications, Long Term Evolution (LTE), User Equipment, Signal to Noise Ratio (SNR), social-aware relay selection.

I. INTRODUCTION

Next-generation cellular networks are agreed to increase global coverage, more user connectivity, and coverage. There has been an unprecedented growth in India over the years with the year 2017 recording over 730.7 million devices [1] and a 4.77 billion forecast. This fact has modeled an impending challenge for the telecom industry, which has faced severe spectrum scarcity [2], [3], higher data rate demand and coverage crisis. While the subscriber base and subscriber density have been increasing astonishingly fast in populous countries such as India, Brazil, etc., efficient technologies are still in an incubation mode to cater to all growing demands. One of these has been the area of device-to-device communication, a form of short-range [4] transmission between two devices nearby is working without the perpetual intervention of a backbone Base Station (BS) network. 4G LTE D2D networks may operate in both in-band(licensed) spectrum, and the out-band (unlicensed) spectrum is making it best suitable for D2D communication. The significant benefit of D2D is its flexibility to offload data from the base station to relay user [5].

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It promises ultra-low latency [6], [7] and improved throughput for communication among users. It is an excellent addition to the traditional cellular communication paradigm and increasingly needed in subscriber-dense areas for proximity transmission. Direct Device to device communication has a deprived direct link, therefore using a relay improves Excellence of Service and range of communication. In the circumstance of D2D communication, to choose an efficient relay, the ensemble of both distance and social-link parameters deem necessary. In this paper, we suggested a Social Aware Mean-based Relay Selection Structure (SAMRSS) to discover relays in the proximity of the Arithmetic Mean (AM) between the source and distance user node coordinates and simultaneously calculate the social link between them. The performance of such relays against traditional Direct Transmission Scheme (DTS) and other proximity-based and Hybrid Relay Selection Scheme (HRSS) [8], will be compared and results will be distinguished. We aim to increase the throughput by about 50% against conventional established relay-designing techniques.

In [9], Zulhasnine, Huang, and Srinivasan examine the different modes of D2D communication succinctly with a bid to increase the spectral and energy efficiency parameters in each of the nodes. In [10] location-based resource allocation is emphasized for combating interference related issues and improving spectral efficiency further. In [11], Doppler and Rinne first developed the idea of including social-relation parameters while selecting a relay and compare with existing simple distance-based selection schemes. The comparison is made using a Hybrid Selection Scheme (HSS) developed by them, and the parameters outperform previously used methods in nearly all cases. The development of stage-by-stage finite-horizon ideal preventing theory for relay assortment in cooperative networks is approached [12]. In [13], Chen and others have proposed facts on social links considering two factors resolute using decent means-social trust and social reciprocity and established a network-support relay assortment method for executing the coalitional game theoretic problem. Zhang and others in [14] have proposed power allocation, and transmission parameters for an ideal multicast D2D communication scenario are measured concerning the D2D relay scenario.

II. PROBLEM STATEMENT

Let us consider a densely-packed hexagonal

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cell, where user nodes at proximity are placed, with a base station positioned in charge over them. For all of the internet access features and high-speed data/multimedia transfer, uplink and downlink resources have exploited in the traditional cellular framework under the hierarchical jurisdiction of the Base Station (BS). However, for sending high-speed data to nearby members and friends, device-to-device (D2D) communication bypasses the BS and adopts an intermediate relay as a tertiary node for transmitting with greater efficiency [15],[16] and lower latency. A simple relay-determination approach would be for the source to consecutively test all nearby relays to figure and look at a data rate, utilizing individual SNR values. The source selects a relay that propounds the most significant performance[17],[18]. This methodology diminishes the entire throughput because of persistent analysis. An alternative method is arbitrary relay assortment: A source randomly chooses an allocation and transfers certain information without any delay “to be published” [19]. Few cases determine relay selection using nearest neighbor scheme [20]. This incorrect assortment degrades the throughput. Arbitrary relay assortment is reasonable for applications which don't have rigorous throughput requirements but are delay biased. However, this poses the ubiquitous question- to exploit the human social life [21]towards the augmented D2D communication for cooperative communication. Our objective is to enhance the social links between source and neighboring nodes to discover friends who can transmit the data at higher efficiency and less resource utilization, thus easing seamless connectivity and communication[22].

III. METHODOLOGY

Initially, two-dimensional D2D network simulated in MATLAB. The parameters were initialized by randomly placing the nodes (N=50) in the given space and then connecting every two nodes if the calculated distance between them is <= to the targeted range (R). Now, one-way data gathering was initiated by establishing transmitter-receiver links and choosing the links. Selecting the best relay for hopping is faced with many challenges. Traditionally, the node nearest in proximity to the source has been taken, which often has the disadvantage of high SNR and low throughput. Relay nodes are positioned at the midpoint of origin and destination rather than discovering it in the vicinity of the situated reference [4]. So in this way a high SNR is maintained in between the source and the target and also from hand-off to goal. In such manner, we have examined the discovering competitor hand-off hubs close to the midpoint which pull down the number of hubs. A framework can be poised to increase the throughput such that a source would then be able to choose whether to impart through a synchronize connection or D2D interface in the wake of looking at obtainable information level by mutual network connection plus gathering the relationship proposing most extreme information ratio to amplify network instinct.

A. Social Trust

A flow diagram of cellular communication paradigm is shown in fig.1.To formulate an intangible entity like social link [5] of the selected optimal relay node and nearby users to families into a mathematical relationship [3], the call log history, and call duration deposited in the impending Base Station (BS) can be utilized. Social trust between friends is framed as follows:

$$B_{i,j} = \frac{T_{i,j}}{\sum_{k\in\varphi I} T_{i,k}} \qquad (1)$$

Here, $T_{i,j}$ is the noted time of interaction history among user equipment $i(UE_i)$ and user equipment $j(UE_j)$, the divisor represents the total contact time between UE_i and other IUEs (idle user equipments). $B_{i,j}$ is calculated by speculating base station path of contact among users and keep a note of contact history and contact time among them. The number 0 and 1 is assigned for $B_{i,j}$, as greater value stands for a better social connection while a lesser value represents a weaker social connection.

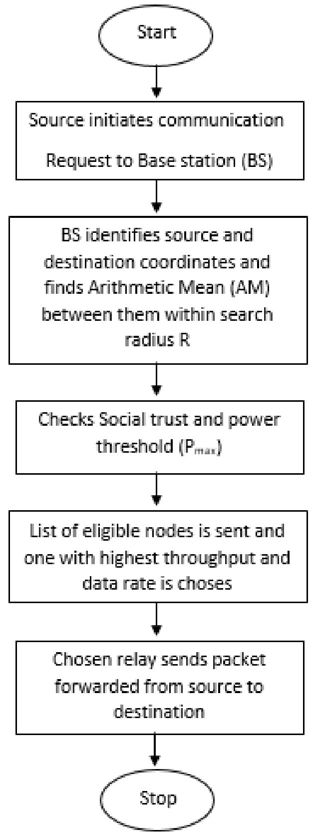

Fig.1 Flow Diagram of cellular communication paradigm

B. Arithmetic Mean Distance

We employed available source and destination node coordinates for calculating the mean value distance or mid-point between them. The Arithmetic Mean distance x_{AM}, y_{AM} between two points x_1, y_1 and x_2, y_2 is given by:

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$$x_{AM}, y_{AM} = \left(\frac{x_1 + x_2}{2}, \frac{y_1 + y_2}{2} \right) \quad (2)$$

Time division multiple access (TDMA) technique is used for the channel design with a slot duration of 0.2 ms. Rayleigh fading channel is assumed with a moderate bandwidth of 1MHz and average SNR of nearly 30 db.

The Signal to Noise Ratio(SNR) of the least path is shown as:

$$\gamma_{s,t} = \frac{P_{s,t} D_{s,t}^{-\alpha}}{N} \quad (3)$$

Where $P_{s,t}$ is the broadcast power of a signal from the source to target, $D_{s,t}$ is the depth of source and target, N is noise power and a path loss exponent is α .

The data rate of a direct link as per Shannon's channel capacity is designated as:

$$C_{s,d} = W \log_2 (1 + \gamma_{s,t}) \quad (4)$$

Where W is the channel width.

The data rate of a full duplex decode and forward relaying D2D link is specified by[6] as:

$$C_{s,r,t} = W \min\{\log_2(1+\gamma_{s,r}), \log_2(1+\gamma_{s,t}+\gamma_{r,t})\} \quad (5)$$

Where $\gamma_{s,r}$ is SNR of a signal from a source to relay, $\gamma_{s,t}$ is SNR of a signal from a source to the target and $\gamma_{r,t}$ is SNR of a signal from the relay to the target.

The throughput of multi-hop D2D link using equation (5) is calculated as:

$$T_{s,t} = C_{s,r,t} \{TSD - (PD * NP)\} \quad (6)$$

Where timeslot duration is termed TSD, probe duration is PD, and NP is the number of probes.

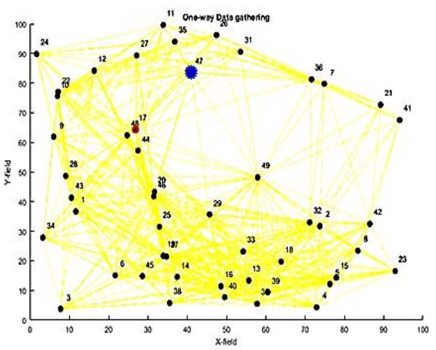

Fig. 2 A D2D network topology with N=50 nodes.

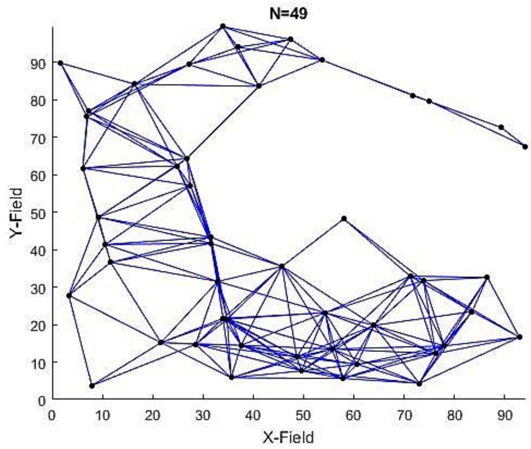

Fig. 3 Relay paths selected for data transfer

IV. SYSTEM DESIGN

Our proposed network system design comprises of 50 nodes in fig.2 such that the node located at the arithmetic mean distance of the source and targeted destination can be cast-off as a relay. In fig.3 relay path is framed for data transfer.

The flow diagram of relay selection scheme is shown in fig.4 and the steps are recited as :

1) Communication initiated by source by sending an appeal to the base station(BS) which holds source and target information.

2) The location of origin and target point is identified by the base station to calculate harmonic mean point m and escorts to record empty nodes present inside exploration band of range R, and maximum permissible transmission power P_{max} to the origin.

3) The appearance of applicant relay nodes is within the circular radius having common conviction with source node. The source acknowledges the relay nodes and destination points. This concept results in to overcome the count of casting probe and also raises the outcome of nodes are communicating at excellent power control.

4) The endpoint relay nodes play an important role to send the SNR of the collected probing packet by the applicant relay node to the base node and pushing the packet to the endpoint with a power delivered related to the common conviction.

5) SNR is computed for every searching nodes by the destination node and transmits to the base node.

6) The base node determines the probable data rate for every applicant relay nodes and initiates the communication.

7) Path selection is made by source node which proposed a higher data rate. As per the greater data rate available in between D2D link and direct link, the source node picks the desired link for data transmission.

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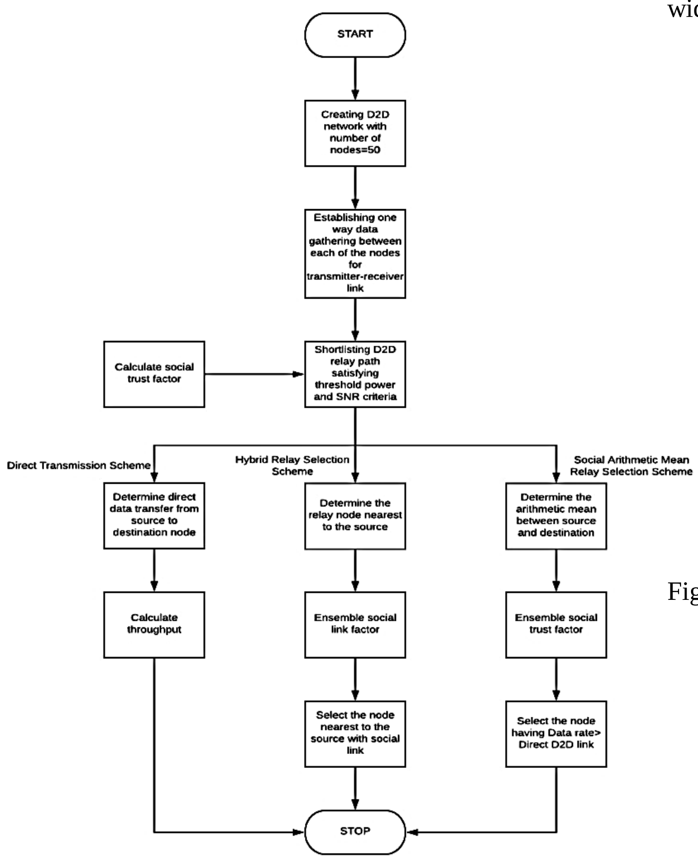

Fig. 4 Flow Diagram of relay selection schemes

V. RESULTS AND DISCUSSION

For the designed scheme SAMRSS, network width is varied in steps starting from d=100m,500m and 1000m shown in fig.5, fig.6, fig.7.The average throughput of the arrangement is compared and depicted in fig.8 along with the variation in the range of the search ring(0-150m). We observed that the highest performance achieved was in the range of 0-50m. Also, the network width of 200m in fig.5 shows the most top average performance, and this confirmed that the network width should not be a very high value. When the maximum average performance was compared among the three established schemes-DTS, HRSS; SAMRSS is shown in fig.9 an increase in performance of about 43.64% in comparison to HRSS and 172.41% against DTS, it is also observed that for most of the cases, the average maximum throughput was attained at mid-radius and then fell despondent.

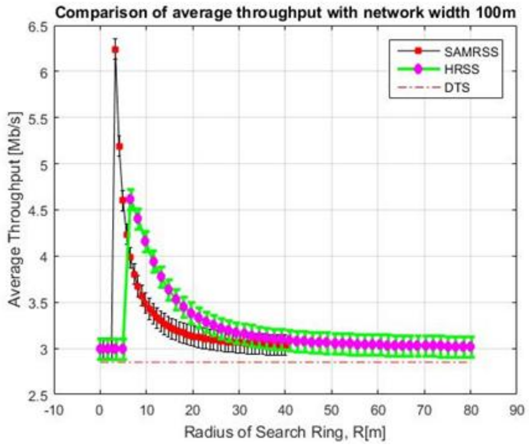

Fig. 5 Comparison of average throughput with network width= 100m

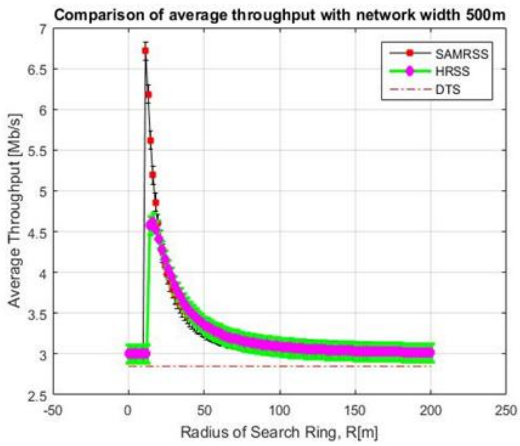

Fig. 6 Throughput comparison for network width=500m

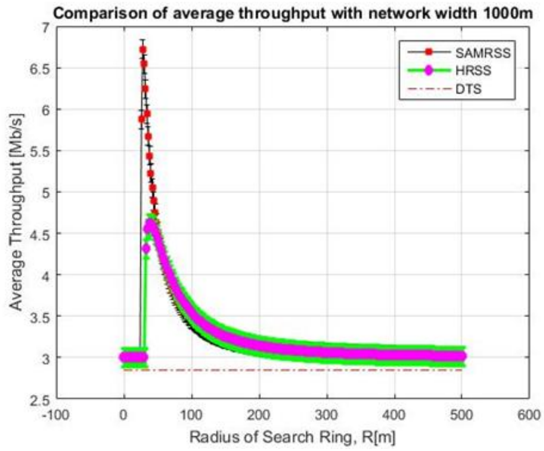

Fig. 7 Throughput comparison for network width=1000m

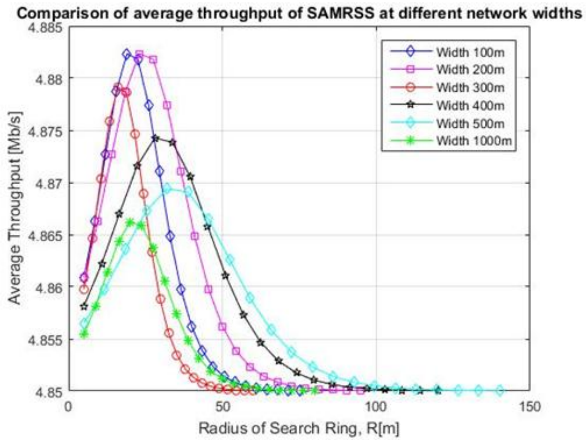

Fig. 8 Average Throughput of SAMRSS at different network widths

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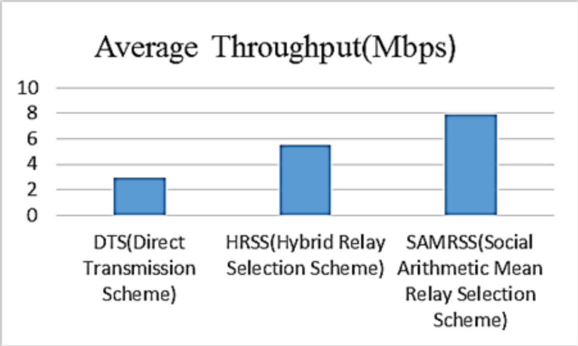

Fig. 9 Average Throughput comparison of relay selection algorithms

VI. CONCLUSION

We have proposed a relay selection scheme that takes into account both distance factor by making the arithmetic mean among the source and target nodes and also integrating social trust factor between nearby "friend" nodes by interpreting call history. We find that the designed algorithm SAMRSS outperforms concerning throughput by 43.64% against HRSS and 172.415% against DTS. Also, varying the network width confirmed that optimum relay was discovered in the mid-radius section, and the network width should be either too low or too high for relay selection. Thus, short-range D2D data transfer could be accomplished with greater ease and efficiency among nearby friend nodes with a pertinent mix of social and proximity parameters.

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