GLOWWORM SWARM BASED COOPERATIVE MOBILE DEVICE DISCOVERY FOR D2D COMMUNICATION IN CELLULAR NETWORKS

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ABSTRACT*—Device to Device (D2D) communication is attaining reputation, recognizing efficient means for discovering proximate end users (EUs) has turned out to be important. The procedure of proximal discovery ought to be effective, so D2D EUs are found and established links quickly. Device discovery of an emergency user and a regular user is a primary task when a catastrophic event occurs. Accomplishing this objective, the rescuer applies discovery techniques that investigate the received signal to discover a potential victim. In any case, the exactness of the discovery might be influenced by a few factors, for example, signal strength, shadowing fading and interference. These parameters can damage the performance of victim's device discovery. Cooperative device discovery is the best solution to discover devices to avoid the interference and minimize the energy consumption between D2D and cellular users. To cope up these issues, using cooperative knowledge of cellular and D2D users, Glowworm swarm optimization technique based discovery model is proposed which minimize the interference, energy consumption and increase the discovery accuracy. This technique performs well in the device tier cellular network and results are validated by the simulation in term of discovery ratio and energy consumption.*

Keywords—D2D Communication, Device Discovery, In-Band underlay, Glowworm Swarm Optimization

I. INTRODUCTION

A consistent need to expand the network capacity with respect to taking care of the developing demands of the end users (EUs) has prompted the advancement of wireless communication systems from 1G to 5G. Billions of associated devices will be connected in the nearing future. Such an extensive number of devices associations are relied upon heterogeneity, requesting, minimum delays, upgraded network capacity, maximum data rates and unrivaled throughput. Device to Device (D2D) communication is one of the emerging technology to implement 5G [1]. Regardless of the various advantages offered by D2D communication, various concerns are included with its implementation. To initiate D2D communication device discovery is the primary task and when sharing similar radio resources, device discovery and interference of the D2D and cellular users should be coordinated. For this, various device discovery algorithm has been proposed in the literature. Different concerns incorporate in D2D communication are device discovery and mode selection, device power management, resource allocation and the security.

5G cellular systems, with enabled D2D communication, contemplated as two tier networks and these two tier networks are further subdivided into macro cell tier and device tier [2]. D2D communication is reinforced by device tier and conventional cellular communication reinforced by macro cell tier. These cellular systems, therefore, are like the current cellular systems. The distinction lies in a way that steadfast provisions can be accomplished through the devices on the cell edges and the congested areas inside the cell. As the devices in the device, tier permits D2D communication, and the base transceiver system (BTS) may have an incomplete control or a complete control over the communication among the devices [3]. In this manner, D2D communication is characterized into four distinct mode types into device tier network as silent mode, dedicated mode, reuse mode and cellular mode.

D2D communication in cellular mode can adequately enhance the spectral proficiency and furthermore alleviate the bottleneck of constrained radio resources. Specifically, proximal discovery is the key procedure influencing the D2D functioning. However, the vast majority of the conventional researches about on proximal discovery of D2D communication are mostly service requirement oriented. In fact, communication between end users (EUs) is often influenced by trust degree and other social properties. Therefore, it cannot ensure a successful establishment of D2D communication links to perform proximal discovery just as indicated by the service quality. In this research using social information cooperatively, device discovery is performed. Glowworm swarm optimization technique is applied for efficient device discovery, it uses the cooperative information and calculates the position of devices. If any two devices lie in optimum values then they are qualified for D2D communication.

Rest of the paper is organized as follows; proximal device discovery related work is explained in section II and section III consists of proposed framework for cooperative device discovery and position updating rule. It also explains the proposed model and simulation results. At the end, the paper is concluded in section IV.

II. RELATED WORK

Because D2D communication is attaining reputation, recognizing effective means for discovering neighbor EUs has turned out to be important. The procedure of proximal discovery ought to be effective, so D2D EUs are found and established links quickly. It is additionally critical for guaranteeing ideal throughput, proficiency and resource allocation with in the network. Establishing direct associations expects devices find each other and once devices are discovered, then direct associations are setup, and afterward, transmission occurs over those associations. Researchers are toiling at various methodologies for device discovery. Spatial correlation of channel based, discovery is proposed in [4]. It is contemplated low power proximal discovery and simulation results also shows that proximal devices can be discovered by less power ingesting. It also gives an exceptionally accurate technique for proximal discovery. Proximal discovery can be classified into two main groups which are open discovery and restricted discovery [5]. In open discovery, EUs can be discovered through for which they exist in the vicinity of different EU.

In restricted discovery, the EU can't be discovered without their earlier consent. This, therefore, keeps up EUs security and privacy. From a network perspective, device discovery is controlled either lightly or tightly by BTS [6, 7].

The authors suggest a proximal discovery [8] method which depends on power vectors and contemplating a time varying channel. It is quite a complex algorithm, and the probability of false discovery is near zero but the power consumption to the provision of D2D communication is elevated. For a power efficient system, device discovery strategy is suggested in [7]. A social aware device discovery method has been suggested in [9]. The scheme upgrades the system performance by enhancing the data distribution ratio, developing the social awareness. A powerful network assisted strategy for device discovery has been suggested in [10] for the help of D2D communication in LTE (long term evolution) systems. The results demonstrate device discovery probability high in this method, for a specific discovery interim. Using sounding reference signal proximal device discovery is proposed in [11]. The uplink transmissions of the cellular EUs assume a basic part in discovering the neighbors. Proximal discovery under obscure channel measurements is also contemplated. An assessment of different methods for device discovery is discussed [12,13]. These incorporate Wi-Fi (Ad-Hoc) discovery, Bluetooth discovery, IrDA device discovery, Direct discovery, request based discovery, Network assisted discovery, Packets, and Signature based discovery. An abstract of different proximal discovery techniques is given in Table 1.

On fulfillment of proximal discovery, session setup happens and for the establishing of sessions, two strategies have been established; IP based discovery and devoted D2D signaling. The current literature fundamentally concentrates on single cell situations, for session setup and device discovery. Deals with the multi-cell situation are more advantageous as it supports productive resources utilization. D2D discovery and session setup is an exceptionally difficult trade since it needs participation from the adjoining base stations. Inter-node estimations give just incomplete position information. For instance, connectivity includes no information on the network scale, orientation, and worldwide discovery, range measurements indicate the network scale yet still can't point out global discovery and network orientation, and bearing estimations decide the orientation of the system. To get complete discovery, worldwide reference data gave by the known positions of BTSs ought to be included. BTS position, SINR and angle estimation using this information, in Glowworm swarm optimization technique device position to be discovered in the multi-cell scenario. Along with discovery, energy efficient and minimum interference is the key parameters of efficient discovery.

Table 1. Methods of proximal device discovery

Reference	Methodology
[4]	Low power Discovery
[5]	Restricted Discovery and Open Discovery
[7]	Energy effective device discovery
[8]	Power vectors based discovery
[9, 14]	Social aware based peer discovery
[10]	Network-assisted device discovery
[11]	Reference signal for proximal discovery
[15]	Bluetooth Discovery, Wi-Fi Direct Device Discovery, IrDA Device Discovery, Network Assisted Discovery, Packet and Signature-based Discovery, Request Based Discovery, Direct Discovery

III. PROPOSED FRAMEWORK

A. *Cooperative Device Discovery*

D2D communication permits performing cooperative device discovery in 5G systems. As found in Figure 1, the inter D2D links give relative position area information between the devices, which serve as an enhancement to the BTSs to devices links. Assume a 5G network made of N nodes, which comprise of devices, BTSs, access points (APs), or any entity fit for transmitting and receiving radio signals. From the radio signals, the receiver can abstract the relation between the position of the receiver and the transmitter by measuring or assessing at least one signal metrics, e.g., network, territory estimations, and angle estimations. Utilizing these estimations, one can estimate the locations of the nodes, may be requiring some reference data, for example, hubs with known areas.

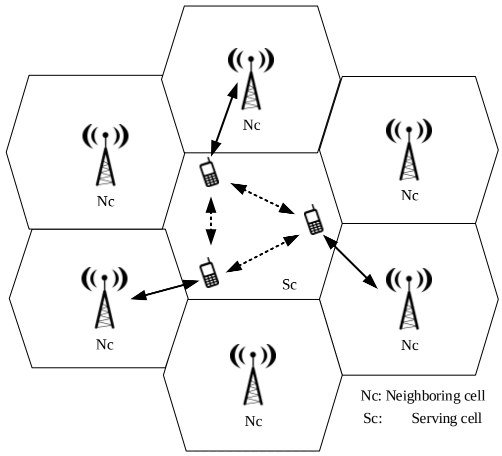

Figure 1. Cooperative discovery: Communication links between the BTSs and devices, as well as links between devices, would all be able to be gathered to exploit the position of the devices, where BTS location are thought to be known.

In the device discovery process, estimations are aggregated to give contributions to a discovery algorithm. Then, the discovery information can be inferred in the following conduct: Centralized Versus Distributed: In centralized device discovery, all measurements are exchanged to BTSs, and a central processor decides the position of the devices. Due to the cellular architecture of the 5G network, the centralized discovery is doable to discover economically with limited memory resources and computations and can give high accuracy by intertwining GPS discovery or local signal fingerprints. In distributed device discovery, devices gather their own position based on locally collected data. The data incorporates the internode estimations among the adjacent nodes, together with the close-by node positions. Distributed algorithms are versatile and consequently alluring for large networks with a predetermined number of BTSs. Besides, distributed device discovery dodges the time delay in uploading estimations and downloading positions, which is vital for a few applications, for example, self-driving. Absolute Versus Relative: absolute device discovery alludes to giving position information in a pre-defined coordinate scheme. The coordinate scheme is typically given by a geographic coordinate scheme, such as longitude, latitude, and elevation in GPS position or inferred in anchor positions. Relative device discovery gives position information with regards to one's neighbors or nearby condition. Without a given coordinate scheme, the relative position is otherwise called relative map or relative arrangement.

Noncooperative Versus Cooperative: Noncooperative device discovery decides the position of EU in light of just the estimations amongst EUS and BTSs, without the inter node estimations between EUs. To get the positions, different BTSs are required. Thus, particular settings, for example, IPDL (idle period downlink) and UMTS (Universal Mobile Telecommunications Service) in the 3G standard, ought to be required to increment contiguous BTS hearability. In cooperative device discovery, D2D communication expels the requirement for all EUs to be associated with numerous BTSs, hence long range BTS transmissions are replaced with multi-hop communication among dense located EUs. Since D2D connection has higher SNR and lower probability of non-line of sight (NLOS) path, cooperative device discovery can offer expanded precision and coverage contrasted with noncooperative device discovery [16]. To established D2D communication device discovery of an emergency user rather than a regular user when a catastrophic event occurs. Accomplishing this objective, the rescuer applies discovery techniques that investigate the received signal to discover a potential victim. In any case, the exactness of the discovery might be influenced by a few factors, for example, signal strength, shadowing fading and interference. These parameters can damage performance of victims device discovery. [17] At the time t, the position update of the devices using glow worm, is $x_i(t)$, and its corresponding consequences of the objective function at glow worm $i's$ position at the time t is $J(x_i(t))$. The luciferin level [18] related to glow worm and location of i^{th} user is given in (1)

$$l_i = (1-\rho)l_i(t-1) + \gamma J(x_i(t)) \quad (1)$$

where ρ is Luciferin constant and γ is signal strength coefficient.

B. *Proposed Network model*

A single cell situation, with the BTS at the center, D2D users (DUs) and cellular users (CUs) is considered, as depicted in Figure 2, with underlay D2D communication and cellular communication. The EUs that are fit for completing direct D2D communication is distinguished by the BTS. The position information of all EU and the channel state information are given to the BTS through the GPS receiver accessible on all EU. There are high odds of potential interference among the EU's, as delineated by the interference signals, in Figure 2. A D2D interface exists between the D2D devices, as per the separation requirement like the distance between D2D devices always less than the maximum distance of direct communication.

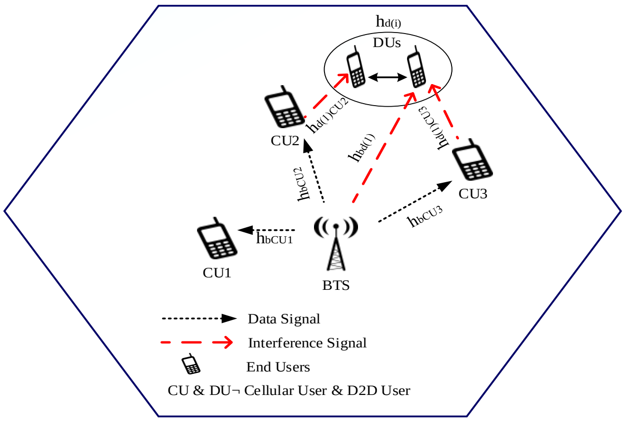

Figure 2. The system model for device discovery using absolute cooperative, in a centralized network.

The objective function $f(h)$ where $h = (h_1, h_2, ... h_k)^T$ and I_i (intensity) is the signal strength, γ is signal strength coefficient. The discovery criteria are $I_i > I_j$, where i devices are moving towards j devices. The device appealing factors are

$$I(r) = I_0 e^{-\gamma r^2} \quad (2)$$

r is the distance and

$$I(r) = \frac{I_0}{1+\gamma r^2} \quad (3)$$

$$e^{-\gamma r^2} \approx 1 - \gamma r^2 + \frac{1}{2}\gamma^2 r^4 ... \quad (4)$$

$$\frac{1}{1+e^{-\gamma r^2}} \approx 1 - \gamma r^2 + \frac{1}{2}\gamma^2 r^4 ... \quad (5)$$

$e^{-\gamma r^2}$ is the presence (glow-ness) of devices to present their identity in coverage area or out of coverage area. To calculate the distance based on fitness function and signal power is using (6) and (7)

$$r_{cus-dus} = \| h_c - h_d \| = \sqrt{\sum_1^x (h_{ck} - h_{dk})^2} \quad (6)$$

$$SINR = \frac{P_{BTS}\, h_{bCU(j)}}{\eta + P_{D2D} h_{D2D\ CU(j)}} \quad (7)$$

C. *Simulation results*

Proximal device discovery probability for the k number of D2D request for device discovery with a maximum distance between D2D EUs is $D = 100$. The cooperative distance between cooperative EUs is $d_i = 10$ and the number of EUs outside the coverage area is $N_i = 15$. Number of EUs with proximity services among N users are $n_t = 10$ and the maximum distance between BTS and EUs is $r = 980$. The distance between the edge of network coverage and EUs is $h = 20$ and radius of the cell $R = 1000$. From these parameters $z = h * (2R - h)$, and length of arpeggio inside cell coverage is $a = 2\sqrt{z}$. $A_1 = R^2 a\ cos((R-h)/R)$ is an area of sector inside cell and $A_2 = \frac{\pi D^2}{2}$ area of the semi circle covered by EU. $A = A_2 - A_1$ area outside cell covered by EU and EUs density outside the cell is $\lambda = N/A$. $P = 1 - \exp^{-\lambda p_i d^2}$ proximity probability in given area[19].

To discover the proximal j devices for each update of glow-worm devices i and each glow-worm device moves toward the proximal devices with the probability given by (8)

$$p_{ij}(t) = \frac{I_j(t) - I_i(t)}{\sum_{k \in N_i(t)} I_k(t) - I_i(t)} \quad (8)$$

The position updating using glow-worm devices is

$$x_i(t+1) = x_i(t) + st * \left(\frac{x_j(t) - x_i(t)}{\|x_j(t) - x_i(t)\|} \right) \quad (9)$$

Where st is step size. Local decision for proximal range updating using (10)

$$rd_i(t) = \min\{rs, \max[0, rd_i(t-1) + \beta(n_t - |N_i(t-1)|)]\} \quad (10)$$

Different types of cooperative devices have been discovered in a specific area as presented in Figure 3. There exist heterogeneous devices like cellular, D2D, and cognitive devices. These devices provide the cooperative information to each other and also to BTS or their centralized control system. As the distance between devices and number of devices increase the probability of D2D pair increase as presented in Figure 4 because more devices give more cooperative information more probability to D2D pair discovery. When devices show their presence (Glow) cooperatively, their energy consumption reduces efficiently as presented in Figure 5. When 5 devices glow cooperatively then the energy consumption is 0.14, when 25 devices glow energy consumption reduce to 011 and when 50 devices glow cooperatively energy consumes less than 0.08.

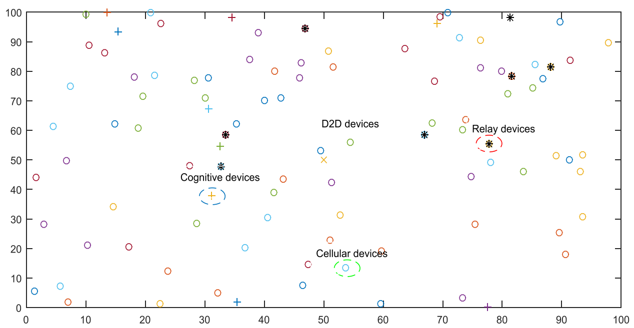

Figure 3. Discovered devices in the specific cellular area where every cellular device is discovered which is operated in in-band. This may be D2D, cellular, relay and cognitive devices.

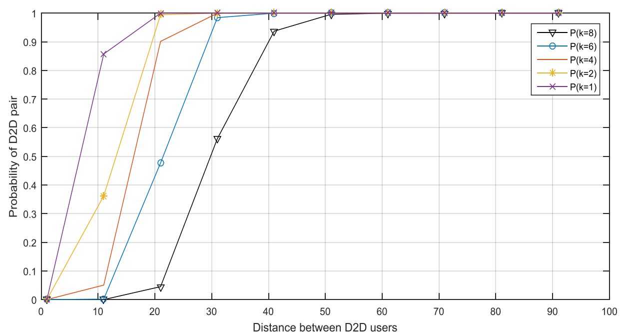

Figure 4. The probability of cooperative D2D pair with respect to D2D user's distances.

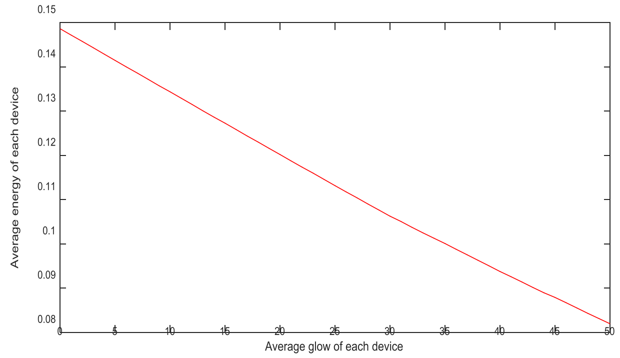

Figure 5. Energy consumption of cooperative glow devices

IV. CONCLUSION

In cooperative device discovery, D2D communication dismisses the requirement for all EUs to be associated with numerous BTSs, hence long range BTS transmissions are replaced with multi-hop communication among dense located EUs. Since D2D connection has higher SNR and lower probability of non-line of sight (NLOS) path, cooperative device discovery can offer expanded precision and coverage contrasted with noncooperative device discovery. When a large number of device glow cooperatively then discovery ratio increases and energy consumption reduced. Glowworm swarm optimization techniques perform well over cooperative information like signal strength, the angle of arrival and fading. Maximum devices are discovered in the dense area with the help of cooperative information. This work can be extended for the integration of internet of things (IoT) cooperatively which minimize the energy consumption.

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