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Energy Efficient Data Transmission for Narrow Band-IOT Devices using Double Auction

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***Abstract*—Energy efficiency plays a vital role in NB-IOT cellular communications. In this paper we discussed about the optimization of energy efficiency to increase cell-edge users (CEUs) using double auction method. The users are selfish that they don't want to share the information wasting their resources. Hence they are paid off to provide the information for cell-edge users. There exists a problem of optimization of energy efficiency in wireless mobile network. This can be solved by using energy efficient Low power short range (EE-LPSR) Algorithm .Energy Efficiency of a cellular network depends on communication between numbers of UEs. Using this EE-LPSR method Energy Efficiency of cooperative cellular networks is increased and more cellular and D2D UEs are connected to the NB-IOT devices.**

***Index Terms*— cooperative cellular networks, Double Auction method, NB-IOT, Energy Efficiency.**

I. INTRODUCTION

Cooperative communication is the technology which is going to be used in future generation cellular networks to increase the coverage area and quality-of-service (QoS). Fixed relay cooperation (FRC), mobile relay cooperation (MSC) are the two types of cooperative communications, this classification is done based on relays. Mobile devices are used as relays for MSC [1] where dedicated devices are used as relays for FRC to relay the information. The mobile devices which relay the information shown in fig:1 termed as relay users and which generate and receive the information are termed as source users. Since the service providers can't plan and manage the mobile device, MSC is difficult than FSC. One more problem to use mobile device as a relay is the selfishness of mobile users that they don't want to supply the relay information for others in the cost of their own resources.The above problem is solved by paying the idle users, such that source user gives rewards to the relay users for buying the service. An agreement is made between source and relay users to form a legal buyer/seller market based on buyers and sellers intention to pay the amount and receive the amount for the services respectively. To solve that problem various auction-based mechanisms are used [2], single-side auction and double side auction are the two types. Single-side auction is used for a one-seller and multiple-buyer or multiple-seller and one-buyer where as double-side auction is used for multiple-buyers and multiple-sellers. Double auction is more appropriate than single-side auction as most of the users act as buyers and sellers at same time. A fuzzy logic based on bidding approach is presented by Minghua in [3], which has rules and a mechanism to

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determine a best ask/offer for agent. R.B.Myerson claims that the strategy proof and system efficiency of double auction mechanisms are impossible. The SNR auction mechanism, the power auction mechanism is the two mechanisms proposed by authors in [4], choosing the relay and allotment of power to relay are decided by them. A pricing game is proposed by authors in [5] to activate cooperation by repaying for the selfish relay.

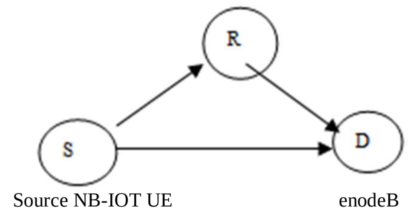

Fig:1 Cooperative communication model for NB-IOT

Internet of things (IoT's) are heterogeneous and resource-utilization in nature, the most challenging thing is ensuring connectivity throughout the network. The solution to this is LTE cellular technology which is used for guaranteeing the connectivity of Iot's , but the problem is with the diffusion of information with the help of cellular technology which not only occupies the bandwidth and also overall cost increases . A new technology introduced by 3GPP known as Narrow-Band-Iot(NB-Iot) which was mainly introduced to support large number of low power devices and to reutilize the wireless spectrum efficiently, thereby increasing the network coverage. This Social-Aware Group Formation Framework (SAGA) scheme [6] is used with effective cooperation among the User Equipment (UE's) which provides high link connectivity and capacity. A D2D topology was established which by the use of multi hop technique information was forward between eNodeB within a LTE. For the spectrum reuse of NB-IoT's a scheduling optimization which overcomes the problem of RB allocation by using relay method was formulated for the D2D group formation. This formulated scheme is very complex and requires high computation, we design a solution considering the power and relay selection. The method presented can significantly increase the energy efficiency comparing with the existing solutions. Massive number of devices with communication capabilities and environment monitoring are in the internet of things. At the peak period at the urban areas the growing traffic rate creates a challenge for the current communication infrastructure. The main problem is to ensure the information exchange as the network is having an heterogeneous architecture. A promising and alternative solution is to provide the complete network connectivity with the help of LTE cellular technology. The problem for implementation of LTE for communication is the increasing scarce resource spectrum and additional cost fees. To enable machine-to-machine communication Narrow Band IoT radio interface,D2D communication were introduced by 3GPP.Nb-IoT is a technology which uses Orthogonal Frequency Division Multiple Access(OFDMA)[7]was introduced by 3GPP LTE standard Release13 was demonstrated effectively in reducing time taken for specific application in LTE. Initially NB-IoT was developed to compatible with only 3GPP devices which were redistributed by the LTE operator by using the allocated physical Resource Block (RB) which has a frequency of 180Khz.The aim of introducing a technology like IoT is that any object with readable and locatable address can be connected and worked to achieve a common goal. Due to the evolutionary change in the course of IOT that is smart objects are now a social object, therefore an effective management for interaction among Device-to-human (D2H), Device-to-Device (D2D) and Device-to-Infrastructure(D2I) is needed [8]. D2D communication between User Equipment's (UE's) within mutual proximity ensure the over usage of the congested bandwidth of cellular networks and increase the spectrum utilization.

II. Related Work

The existing technologies support D2D communication by using of unlicensed frequency bands. To provide wide coverage multi-hop D2D communication can be used but the problem occur due to additional backhaul line which adds communication delay and have low network reliability.NB-IoT which is a sub branch of IoT can support large number of devices which are having low bandwidth, power consumption and delay sensitivity [9]. NB-IoT has information diffusion problem in D2D. Since cellular technology was designed for H2H communication, additional functionalities should be developed to support D2D communication. D2D communication uses LTE technology to enable communication, but the existing work mainly focuses on to reduce the multi-hop delay and guarantee network connectivity. It is significantly important to achieve a situation where both the social features and network constraint of NB-IoT and cellular technology is satisfied.

The challenging thing is how to integrate the relay feature of NB-IoT's and the features of D2D that are communication and cellular network to have a optimal solution. High speed data transmission will increase the link capacity, but the sensitivity of network for interference and the ability to reuse the spectrum is limited. Therefore the choice is to be made between transmission rate and spectrum utilization.D2D communication links are scheduled depending upon the rate of transmission and the state of channel of which are schedule at the base station(BS's) and uploading the information in the in-band of NB-IoT. A relay selection scheme for low power devices gaining benefit from the operator for short range communication is used for uploading the information. Now the above method was used for communication of short range of devices but for long range communication of devices we use multi-hop method to increase the effective use of spectrum . A group formation scheme is utilized to integrate the RB allocation and D2D communication in cellular network by satisfying the constraints that are low transmission cost ,network overload and so on. Because the computational complexity of the formulated method is high this method provides a approximately low computation which relax the link scheduling.LTE are having a bandwidth of 180KHz comprising of a physical resource block this can be utilized by the NB-IoTs which increase the use of spectrum. Since the devices are low power NB-IoTs is the technology which can be used for communication. The following section focuses on information diffusion in NB-IoTs spectrum reuse ,and network optimization .Due to the maximum deployment of the IoT devices, these are the key role in enabling information exchange in smart cities. Militant et al. [10] proposed a coalition game to obtain cooperation among UE's by taking their channel diversity into consideration. For alerting message delivery in 5G a context-aware information diffusion scheme was studied in[10], both the social based and networking metrics are considered for time estimation of information diffusion. Before sending out the information from the BS both the context-aware information by D2D communication and collected data are elaborated and integrated . In , Cao et al. a system was developed by taking the social trust and reciprocity into consideration. Since selfishness of users largely effects the information diffusion performance in NB-IoTs, Gao et al. studied the impact of selfishness in D2D communication. At first, two kinds of opportunistic and connected selfishness transmission patterns are modelled. The impact of selfishness on D2D communication is studied by a time-varying graph model.

III. PROPOSED WORK

When the distance between two UE’s is in specific limits then only the direct D2D communication takes place and it also satisfies signal-interference-plus-noise-ratio(SINR). This system can be implemented in small scale areas like colleges, city malls, airport but it requires LTE cell for connectivity. The terminal UE’s and rescuers should be able to receive the updated information about any accidents to take decisions. For this model to function we require high connection and sufficient capacity from D2D communications such that the data is sent within a very short time in NB-IOT’s. In this model we have taken a time division multiple access-based scheduler which is located near eNodeB . It makes sure that the RB’s are assigned to scheduled devices. When D2D communication is used one can choose UE’s which stimulates simultaneously & are brought jointly and interference can be avoid by using various RB’s. In the further sections we describe system backgrounds of D2D communications and LTE.

In a system based on LTE, before assigning RB’s to the scheduled UE’s RB allocation is under the control of BS (enodeB). Considering the collections of nodes and links as V and E, networks are modelled to directed graph G= (V, E). For cellular and D2D UE’s, to use the same part of radio spectrum again and for correlative interference to exist we assume that all subcarriers income RB to contain the similar channel condition given in [9]. The major differences between D2D enabled transmission and cellular based transmission is on the interference coordination of transmission links and transmission power control. Considering CUD=V we define C with sets of cellular and D with sets of D2D UE’s. Binary variables Xc,s and Xd,s denote the D2D-enabled transmission link is activated or not. If direct interaction between users d&s is done with each other, a D2D connection is established. If not, an intermediate node, r is used in helping d-r-s as one of the session. When an uplink transmission starting at BS to the cellular user or the other way is considered as interference produced by the concurrent transmissions so as to use similar RB is formulated by

$$\mathrm{Ic} = \sum_{\mathrm{d} \in \mathrm{R}-\{\mathrm{S}\}} \mathrm{Xc,s.Ps,d.Gs,d}$$

The SINR of cellular user c is

$$\mathrm{SINRc,s} = \frac{\mathrm{Pc,s.Gc,s}}{\eta + \mathrm{Ic}}$$

And Cc,s =Wlog2(1+SINRc,s). The bandwidth of present RB is denoted by W and we consider the bandwidth is similar to make it simple. Unlicensed and licensed spectrum resources are 2 kinds of D2D communications strategy which are grouped for using spectrum resources. Again it can be classified into 3 different modes[10] that is the cooperative, underlay and overlay modes for using wireless spectrum of cellular users again. One can define overlay& underlay modes of D2D communication and then further elaboration of cooperative mode [11] is done.

1)Overlay and underlay modes: For underlay mode, same spectrum band is shared simultaneously by the UE's of cellular and D2D communication. Managing of interference among D2D and cellular transmission links is a bit challenging. In overlay mode before assigning the network resources to D2D communication links we have to see that the rate of transmission of the cellular links is verified or not. The interference between them can be reduced by using overlay mode but in here the efficiency of network of spectrum reuse is less than the underlay mode. Reducing the network interference is taken as prime objective of the underlay mode. The interference caused at the node s due to activation of D2D link d-s for information diffusion is calculated by

$$\mathrm{Is} = \sum_{c \in C} \mathrm{Xc, s. Pc, s. Gc, s} + \sum_{d \in R-\{s\}} \mathrm{Xd, s. Pd, s. Gd, s}$$

SINR for underlay mode from UE's d to s is calculated by

$$\mathrm{SINRd, s} = \frac{\mathrm{Pd, s. Gd, s}}{\eta + \mathrm{Is}}$$

And Cd,s=Wlog2(1+SINRd,s) is the attainable information rate obtained by underlay D2D communications. A part of OFDMA frame is kept for D2D communications in overlay mode. For information diffusion the cellular UE's use portion of whole length of frame (ξ). Cd,s=(1-ξ)Wlog2(1+SINRd,s) and Cc,s=ξWlog2(1+SINRc,s) are respective rates of transmission of cellular based and D2D link in underlay mode. To improve the transmission rate of Cd,s s is defined as area between the maximum attainable data rate of cellular link and required data rate. The overlay mode is not as effective in reusing the wireless spectrum when compared to underlay mode.

2)Cooperative Mode: The cooperation between the ends play a major part in D2D NB-IOT's because of the easy deployment& efficient resource economy. It encourages devices which have a selfish character to send data to others and it also takes best relay process to support spectrum resources. A relay is required if maximum rate of transmission of cellular users can't reach threshold and also if there exists a direct path for devices to communicate it handles in a multi hop pattern because much greater power is needed for direct transmissions and for longer range which introduces interference to other transmissions. To decrease interference among cellular & D2D UE's, cooperative transmission based on relay is recommended for NB-IOT's.

$$T = (1/Cs, r) + (1/Cr, d)$$

$$Cd, r, s = \frac{1}{T}$$

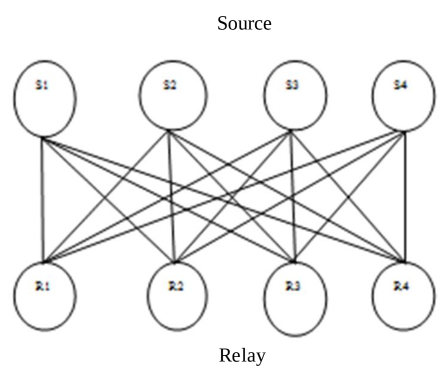

Fig2:Possible source relay uE pairs

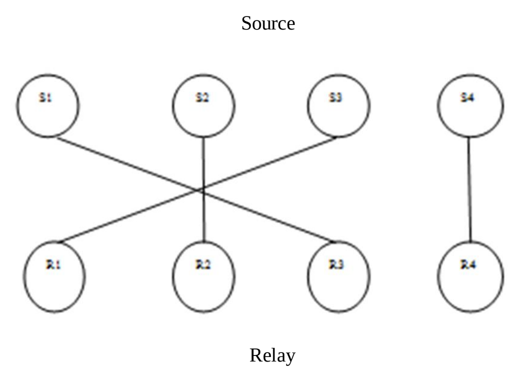

Fig 3: Energy Efficient UE pairs by EE-LPSR Algorithm

In the proposed EE-LPSR algorithm, The true valuations of the NB-IOT device and Relay users can be calculated, the NB-IOT UE will give a bid less than its actual value, the relay user will expect greater than its actual value, the NB-IOT device bid value is defined as $Bs_m\, r_n$

$$Bs_m\, r_n = Vs_m r_n (1 - \beta_m)$$

The expected value of the relay user is defined as Ern

$$Ern = Qr_n (1 + \alpha_n)$$

Number of source users and relay users are m,n respectively and Q is the actual costs of the all relay users. α_n, β_m are the mark-up values of the bid. When NB-IOT device is connected to the relay user, the price of the data transmission transaction (PT) is

$$PT_{sm\,rn} = \frac{Bs_m r_n + Ern}{2}$$

Non-negative profits to the NB-IOT UE and relay UE is obtained with the condition

$$Bs_m r_n > Ern$$

Each source will be connected to more number of Relays as shown in fig.2 whenever in the double auction the bid value is greater than the ask value and final relay will be connected by the wait of the each source relay pair as shown in fig.3 . Energy Efficiency of the cooperative communication network will be increased by increasing the number of connections between NB-IOT UEs and Relay UEs, Energy Efficiency can be increased in the proposed EE-LPSR algorithm

$$EE = \sum_{m=1}^{M} \sum_{n=1}^{N} \left(\frac{Cd,r,s}{Ps,r + Pr,d} \times tm,n \right)$$

$$tm,n = \begin{cases} 1, if\ Relay\ Assigned\ to\ NB-IOT\ UE \\ 0, if\ Relay\ User\ not\ Assigned\ to\ NB-IOT\ UE \end{cases}$$

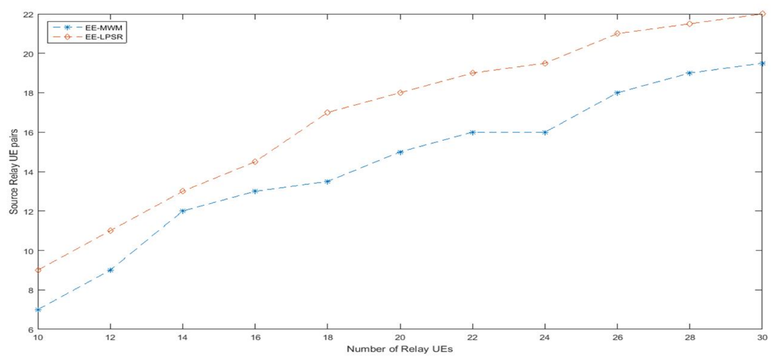

Fig 4 Number of Relay UE pairs vs Source Relay UE pairs

A. Number of Relay UE pairs vs Source Relay UE pairs

Figure 4 shows that by using EE-LPSR method the source relay pairs are increasing when compared to the EE-MWM method because the transmission power of Narrowband IOT UE is low in comparison with the transmission power of the cellular UE. For 10 Relay UE's the number of Source relay UE pairs in EE-MWM are 7 whereas in the proposed EE-LPSR method the number of Source relay UE pairs are 9 which shows that number of Source Relay UE pair are increased. Similarly for the reaming number of relay UEs also source relay user pairs are increased in this proposed EE-LPSR Algorithm.

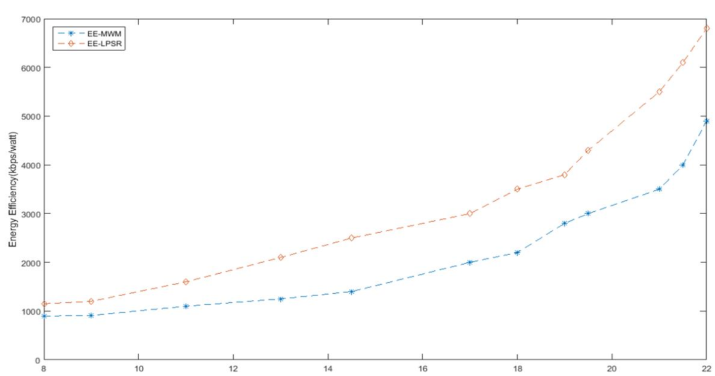

Fig 5 Source Relay UE pairs vs Energy Efficiency

B. Source Relay UE pairs vs Energy Efficiency

Figure 5 shows the energy efficiency usage between EE-MWM and EE-LPSR. For 10 number of Source Relay UE pairs the Energy efficiency is 900(kbps/watt) in EE-MWM method where as in the proposed method the Energy Efficiency is 1200(kbps/watt) thereby increasing the Energy Efficiency, for other source relay UE pairs also Energy Efficiency is continuously increased in proposed EE-LPSR Algorithm.

IV. CONCLUSION

In NB-IOT cellular communication the devices are low power and energy efficiency is the important factor. The low power devices can communicate to short-range but this paper has discussed the method with the help of relay which can communicate to long range. The energy efficiency in EE-NBIOT when compared to the EE-MWM method is improved.

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