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Cross-Tier Interference Avoidance Prioritized Dynamic Resource Allocation Algorithm in Coexistence of MTC and LTE-A Networks

M. Mano Raja Paul[1], M. Leeban Moses[2], T. Perarasi[3], A. Bhuvanesh[4]

[1]Department of Electrical and Electronics Engineering, Nehru Institute of Engineering and Technology, Coimbatore, Tamil Nadu

[2,3]Department of Electronics and Communication Engineering, Bannari Amman Institute of Technology, Sathyamangalam, Tamil Nadu

[4]Department of Electrical and Electronics Engineering, PSN College of Engineering and Technology, Tirunelveli, Tamil Nadu

Abstract

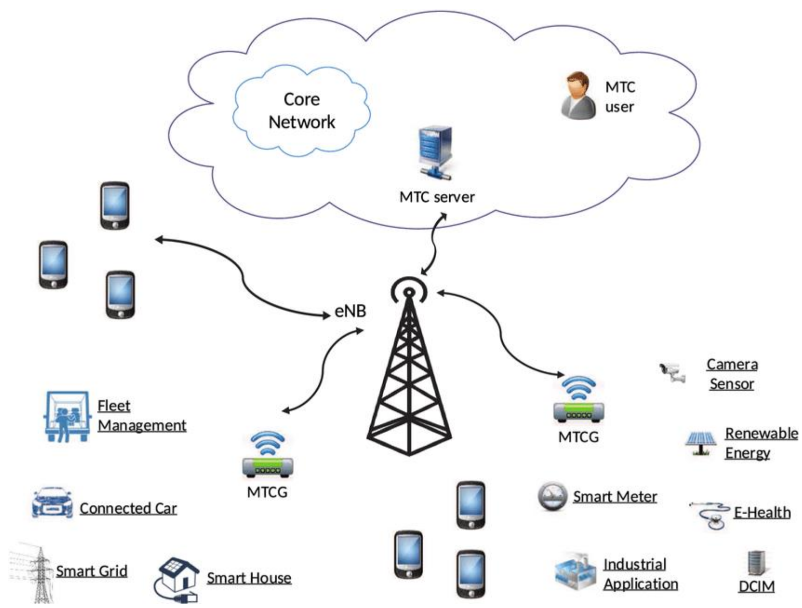
Internet of Things (IoT) is a developing perspective which provides accessibility as well as connectivity of smart objects which enclose people at daily activities, like various methods of sensors, vehicle-to-vehicle communication, health care devices, RFID and NFC tags, etc. There are high expectations for IoT devices and networks concerning reliability, performance, quality, and long-term availability. Indeed, wireless connectivity is the most critical success factor for the IoT era. The demand for machine type communication (MTC) is increasing, so that the challenge for allocating resource blocks for users has also increased. The patented nature of existing hardware devices cost of contribution space as well as energy for a variation of intermediate boxes, as well as lack of trained executive to combine as well as continue this service is difficult. To maintain the Quality of Service (QoS) requirements for H2H communication and to provide data traffic for MTC networks, LTE faces a serious challenge for allocating the resources blocks to the users. A Cross-Tier Interference Avoidance Prioritized Dynamic Resource Allocation algorithm is presented in this work for optimizing the problems faced by critical MTC and H2H communication networks by maintaining the QoS requirements from a cross-layer design perspective. The resource allocation problem for different combinations of Channel Quality Indicator (CQI) modes is performed and the computational complexity is measured in terms of cell throughput and probability of delay bound violation (PBDV). Finally, the performance of the proposed scheduling algorithm is evaluated via numerical analysis.

Keywords: Dynamic Resource Allocation, Prioritized Channel Quality Indicator, Probability of delay bound violation (PBDV), Machine type communication, Quality of Service (QoS)

1. Introduction

LTE network is 4G wireless communication technologies, which provide IP-based voice, data and multimedia streaming at high speed of 1 GB per second. It is the current generation of cellular network and it partitioned with two parts. First part handles to technology of radio access and next part evolved packet core (EPC) handles to technology of core network. The user device (UE) connects with eNodeB through the interface of radio. The eNodeB handles the inter-cell interference and process the task for controlling the radio resource like allocating the radio resource and this eNodeB links network as mobile backhaul to serving gateway (SGW). The function of regional anchor point mobility is handover as inter-eNodeB and this SGW supports the significant number of eNodeB [1]. The packet data network (PDN) and packet data gateway (PGW) is linked with SGW and it allocates the user IP addresses, filter packets, charges and enforces regulations. For interface of packet data, internal network is destination point. Mobility management entity (MME) represents major control body of the LTE network and it is responsible for setting up client traffic bearers and upholds the mobility management conditions for UEs. Home subscriber server (HSS) is the storage area to store the user profiles and act as the central database.

Figure 1. System Model for MTC and H2H users



Data packet user is transmitted among PGW and eNodeB through GPRS tunneling protocol (GTP). The overall structure of LTE mobile network is shown in Fig.1. There are some issues in LTE such as difficulty to manage in radio access, installation of many base stations, mobile backhaul network and the control plane delivery which may leads to be inconsistent. The inefficient distribution of an operating cost and high implementation are the challenges when hardware by network organization is used. In general, the MTC device has data or information at randomly to variation of data packet size [2]. It is used to assign resource with user and assign resource for MTC device, every device need to assign by amount known as QoS class identifier (QCI). The QCI allocated based on the throughput, delay and priority requirements. The QCI is categorized into two parts namely guaranteed bit rate (GBR) as well as non-guaranteed bit rate (N-GBR). Resource allocation issue work consist concurrency H2H users to MTC devices and physical resource blocks (PRB) are defined for the resources to bandwidth of 180 KHz[22]. Generally MTC devices contain data in a random manner with variations in the packet size of data. Hence it will be more difficult for the MTC network to allocate the resource blocks to the users [3]. To allocate the resource block to the network for critical MTC devices, each of the devices in the network will be allocated with a number which is called as QoS Class Identifier (QCI). Each QCI will be numbered on the basis of the priority requirements, delay and throughput [4]. The QCI will be classified into two types depending upon the bearer class as Guaranteed Bit Rate (GBR) and non- Guaranteed Bit Rate (N-GBR).

The important feature of MTC devices is that their transmission of packets will be very small such that low data rates can be provided to allocate resources which will not affect the QoS requirements. But the latency of each packet should be considered according to the different priority level of the users which is depicted in Figure 1 and their latency does not affect the performance of QoS[5]. The important feature of H2H devices is that it needs high data rate to improve the QoS requirements. The major difference compared to MTC devices is that, when the data rate increases its QoS requirements also gets increased. Latency of every packet is examined depend on various user priority level and performance of the QoS is not affected by this latency[6].

2. Related Work

A group-based M2M communications has been proposed, in which MTC devices are clustered based on their wireless transmission protocols, their QoS characteristics, and their requirements [7]. The resource allocation problem is solved by first transforming it into a binary integer programming problem and then formulates a dual problem using the Lagrange duality theory [8]. A memetic based differential algorithm for MTC devices has been proposed, in which Two different vectors such as a job-machine assignment vector and a speed vector are considered to accelerate the convergence of the algorithm the algorithm considers the efficient speed adjusting and job-machine swap heuristics and they are integrated into a local search approach by an adaptive meta-Lamarckian learning strategy.

A memetic based resource allocation algorithm for MTC devices has been proposed, in which the application of healthcare and home appliances with time window and synchronization constraints [9]. A mixed integer programming model is developed by using memetic algorithm by considering the two original crossover operators [10]. A fair QoS-aware dynamic LTE scheduler for MTC devices has been proposed, to ensure the diversity of service requirements and to control the performance reduction in the classical mobile services of H2H communication. This algorithm dynamically adjusts to the level of congestion of the network based on the current traffic information of each device to support the M2M traffic by satisfying the QoS requirements, to ensure the fair allocation of resources and to control the impact of H2H traffic performance.

A balanced alternating technique for MTC uplink scheduling over LTE has been proposed [11], in which the algorithm dictates a Resource allocation for MTC devices that offers a balance between throughput and delay requirements which is adaptive to traffic characteristics since it considers both channel state and system deadlines in an adjustable manner according to network needs. The 4G technology is more useful as a major driver of the extension of IOT applications [12]. M2M communication technology has been implemented to supports the large amounts of smart devices and enables the vision of connected world. Wireless Network Function Virtualization is used to distribute of 4G-IOT, in which NFV will disconnect flexible and scalable hardware and underlying network functions to enable 4G-IOT focus on generic cloud servers.

A two-step adaptive algorithm has been proposed [6], to maximize network sum rate where a set of reused channels by each D2D pairs the algorithm for D2D resource channel allocation that used for minimizes interference among D2D, cellular and small cells while maximizing overall network capacity. D2D communication supports user equipment (UE) located within close proximity, enabling communication without utilizing cellular base stations. Brute-force search is applied to determine the optimal allocation solution based on optimal candidates RBs found in SMS. Brute-force solution is used as a benchmark for the SMS algorithm [13]. Mixed integer nonlinear problems can be solved and optimal solutions determined by applying Brute-force searching methods.

An Energy-efficient Resource Allocation for Energy Harvesting-based Cognitive Machine-to-machine Communications has been proposed [14], to overcome the problem of spectrum scarcity and limited battery capacity by enabling M2M transmitters (M2M-TXs) to harvest energy from ambient radio frequency signals, as well as to reuse the resource blocks (RBs) allocated to cellular users (CUs) in an opportunistic manner [15] has proposed Congestion control with adaptive access class barring for LTE M2M overload using Kalman filters. An MTC device randomly chooses a preamble from a pool of preambles and transmits it during the RACH. The evolved node B (eNodeB) acknowledges the successful reception of a preamble if that preamble is transmitted by only one device.

3. System Model and Problem Formulation

To perform the requirements of QoS, it requires high data rate. The main variation among the MTC devices is, if the data rate is increased then the QoS requirement also increased. The optimization problem of the cross-layer [17] for MTC devices and H2H users are formulated below as

$$\max(a)\sum_{j\epsilon A}\sum_{i=1}^{I} X_{i,j}\,Y_{i,j} \qquad (1)$$

Where $X_{i,j}$indicates the reasonable rate of useriover j the PRB and $Y_{i,j}$indicates the binary indicator matrix over the PRB. The above equation is obtained by achieving the condition to find the PRB which are allocated to only a single user and it is mathematically formulated[23] as

$$\sum_{j=1}^{J} C_{i,j} \le 1 \qquad (1a)$$

The above equation is contented with entire values of I ϵ J. The information assured is forced by restriction of H2H users are given by

$$\sum_{i=1}^{I} R_{i,j}\,S_{i,j} \ge R_V(max),\;\; j \in A \qquad (1b)$$

Based on users H2H as well as devices MTC, the conditions are defined by a cross layer constraint which is depend on the needs of users H2H as well as devices MTC[24], as entire value J ϵ B, PRB must be allowed for MTC devices and it is possible for the binary number which is evaluated at following equation.

$$\sum_{i=1}^{I} S_{i,j} \le M_1(ax)\ ;\ j \in B \qquad (1C)$$

$$S_{i,j} \in \{0,1\}\ ;\ i \in I, j \in J \qquad (1d)$$

It is important to compute signal value with noise rate to approximate the rate of data.

$$Y_{l,i} = \frac{A_{i,j}\ P_{i,j}^2}{M} \qquad (1e)$$

Where $P_{i,j}$ represent power channel profit, denotes power transmission by user j above ith PRB, A=180KHz is the bandwidth of PRB and $N=N_0B$ indicates power of noise. Based on value QCI, a priority value is assigned for obtaining the value of SNR, the number of index assigned with QoS class identifier (QCI). These sections, requirement of delay sensitive MTCD cross-layer as well as subsequent issues are deal with this technique for several instance of CQI detailing [16]. The process of mimetic depend on cross layer resource programming algorithm is given in Figure 3. The optimization problem is reframed for the Memetic based cross layer algorithm that is given at equation (1a) through (1e). The characteristics of MTC is described briefly for that first let as consider the channel quality indicator for the devices of MTC as well as users H2H are periodic.

Based on scheduling period implement stable conditions of channel for each MTC devices as well as H2H users, channel is regarded as the bandwidth with the path loss parameters and shadowing [18]. The allocation channel for every user is deterministic constant service and it is measured by the Poisson process for the machine type communication devices. The buffer dynamic of M/D/I queuing algorithm is used to solve the problem of traffic which is generated by MTC devices .This queuing algorithm produced PDBV in LTE network that guarantees quality of service to the users for restrictions of cross layer H2H users and MTC devices may be expressed as

$$X_a(A_j > P_j) \le U_j^{max}\ ;\ j \in B \qquad (2)$$

Here X_a represents probability of delay violation, P_i represents delay, $A_i = V_j + \tau$; V_j indicates time waiting, $\tau = \frac{1}{s_j}$is the service time[25]. By using restrictions of cross layer which is established to PDBV for networkLTE as well as reframe optimization impact calculated based on restriction of cross layer as user H2H as well as MTC devices are discussed in previous equation are reframed as, $\max\ A^T M,\ XP < C,\ f(x) \le U^{MAX},\ P \in \{0,1\}$[19]. Here x indicates the indicator represents the matrix decision variable, D represent vector cost and expressed as,

$$D = \begin{cases} K_J^T & ;\ J \in M \\ R_K^T & ;\ otherwise \end{cases} \qquad (3)$$

X is the inequality matrix. By utilizing Memetic algorithm, optimization issue is generated and it is formulated as binary non-linear programs (BNLPs) which is a step by step process.

4. Cross-Tier Interference Avoidance Prioritized Dynamic Resource Allocation Algorithm

Since the scheduling optimization variables are binary, the proposed scheduling optimization problems are of a combinatorial nature. Accordingly, obtaining an exact solution using an exhaustive search has an exponential complexity in the number of users, number of service providers, and the number of the resource blocks. There are various steps in this memetic-based cross layer scheduler that are as follows.

Step 1: Initialization

The first step is initialization, to measure amount of users available at network existing LTE in coexistence of devices MTC as well as users H2H. Let N_{xv} represent amount of RBs available at TTI, N_x represent amount of active devices such as H2H UE, if $N_x<N_{xv}$, then it consists of few process of selection for allocation of resources between the users and this resource is individually classified with users at bandwidth 180 MHz.

Step 2: Calculation of minimum PRB requirements of users

Resource allocation starts when $N_x>N_{xv}$ the minimum PRB for H2H users is calculated as total number of user's j which includes the device machine type communication.

Algorithm: for all $\mathrm{X} \in \mathrm{A}$ do

$$\mathrm{PRB_j(min)} = \frac{\mathrm{A_j(min)}}{\mathrm{a_j}}$$

End for

Where $A_j(min) = \rho_j$ denotes the H2H users arrival rate.

$$K_j = \begin{cases} A_j & ; \; A_j \leq \rho_j \\ \rho_j & ; \; A_j > \rho_j \end{cases} \qquad (4)$$

The above condition is directly proportionate with average performance and denoted as user rate j depends on rate of arrival as user H2H.

Step 3: Calculation of minimum PRB requirements of users

It is necessary to analyze minimum PRB requirements of devices MTC, after the completion of requirements as minimum PRB for H2H users.

Algorithm: for all $\mathrm{J} \in \mathrm{B}$ do

for $X = \frac{\rho_j}{X_j} : K_v(max)$ do

if $Ms\lfloor C_j > A_j | D_j = fr_j \rfloor \leq U_j(max)(or)\ f = M_j(max)$

then $B_j(max) = f$; Break this for loop

end if

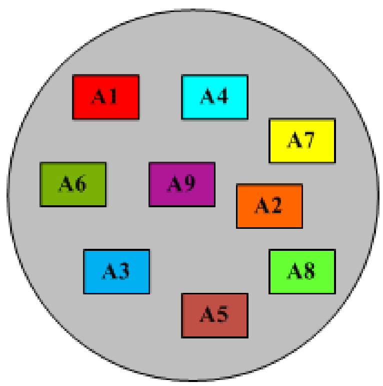
end for

Maximum threshold value is compared with the probability of delay bound and blocks resource classified devices as machine-type communication. This MTC device exceeds the threshold value that is compared to the PBDV value.

Step 4: Memetic optimization scheme

Users are selected individually according to state of vitality as well as nature of LTE-M dynamic tool channel in the main interval of time. The first step is to differentiate the dynamic hub in the cell before the choice step and the eNB verifies the LTE-M gadget is dynamic depend on buffer status report. LTE-M gadget is dynamic then check it consists of data in its framework is ready as transmission otherwise it denotes as non-dynamic gadget. In this Mimetic optimization scheme it consists of several sub steps are as follows.

Figure 2. Population Initialization and Solution Representation



The amount of users at LTE-M network to concurrence of H2H users as well as MTC devices is represented as A1 to A9 as in Fig. 2. Several colors in the boxes of A1 represent the device which is arranged in the priority levels. Here the term of population is utilized by represent matrix of F solution to size J.

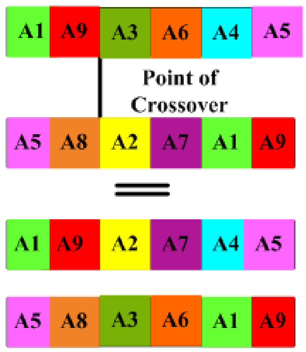
Step 4.2: Crossover

Let R1 and R2 are the two solutions among the crossover and U1 is distinguished as a factor at range 0 and 1 that contrasts two arrangements are occur among the crossover and the point of crossover is projected in Fig. 3.

$$\begin{cases} u_1 \leq \rho_c \,; Cross\ over\ will\ happen \\ u_1 > \rho_c \,;\ No\ Cross\ over \end{cases}$$

Where ρ_c indicates the stable value represents probability of crossing. If u_1 is higher than probability of hybrid, then β_k is the arbitrary position which implemented at last mentioned provision as RBs. Let a variable among 0 and 1 are denoted as u_1 and the probability of crossover is denoted ρ_m. Transformation is implemented at RBs arrangements; J denotes erratic location indicated $\rho_m$in the event of u_2 is higher than the characterized likelihood.

Figure 3. Crossover Operation

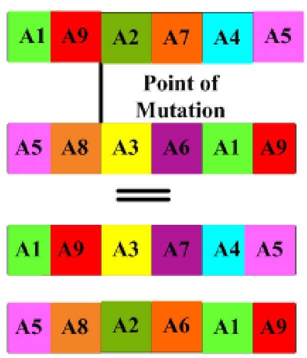


Step 4.3: Mutation

In the event of u_2 is higher than the characterized likelihood, in location of arbitrary position it means the ρ_m transformation is carried out in disposition of RBs. The mutation operation is in **Fig. 4**. Let the variable among 0 and 1 are denoted as u_1 and the probability of crossover is denoted as ρ_m.

$$\begin{cases} u_2 \leq \rho_m \text{ ; } Mutation\ over\ will\ happen \\ u_2 > \rho_m \text{ ; } No\ Mutation\ happens \end{cases}$$

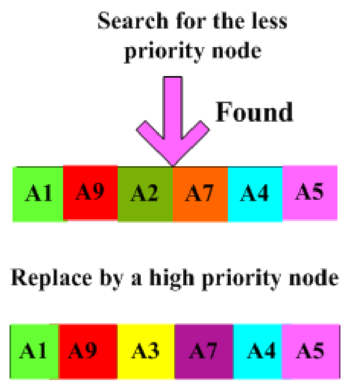
Figure 4. Mutation Operation



Step 4.4: Improvement of local search

The improvement of local search measurement, it verifies as well as absorbs the devices LTE-M based on large level of priority to arrangement at last is running. According to minimum vitality conditions of channel, the high priority channel is considered for the scheduling even though they are qualified is not as in **Fig. 5**. Along with these lines for a higher priority, the fairness is improved in light and these devices are cell edge hubs.

Figure 5. Improvement of Local Search

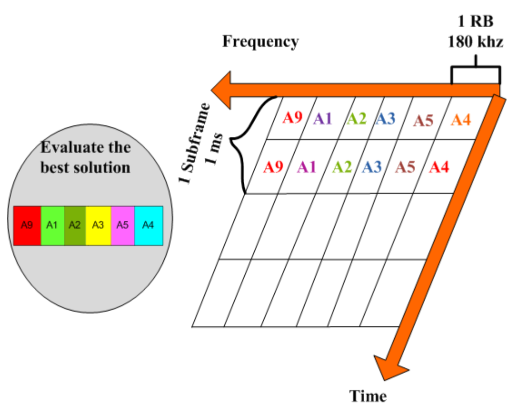


Step 4.5: Population Evaluation

The process of prior evaluation of the allocation of resources is the evaluation of population in the algorithm of memetic as forecasted in **Fig. 6**. Every parent arrangement is replaced with kid's arrangement which gives the best well-being. End is indicated as F_i is process in generated arrangements as well as it is differ from the beginning arrangement F_i as per users.

$$\{if\ \overline{s_c} > S'_{ci}\ ;will\ replace\ F\ in\ all\ populations\}$$

Fig. 6. Population Evaluation



Step 5: Max-space Algorithm

It is important to represent the frequency of domain after assigning the nodes number with user on LTE-M at step 4 to improve the quality of service among the users. The LTE-M restricts the assets measurements, which is dispensed with RBs of every gadget. If quantity of dynamic hub is more to quantity of accessible RB is also high. The max-space algorithm arranged the extra RBs for the critical LTE-M gadgets without the delay and throughput. Each hub is accomplishes the diverse channel quality in light on every RB. The eNB searches the LTE-M depend on data implemented to signal SRS for allocating resource on priority and it is estimated as,

$$V_i = \frac{f_i}{PDB_i^n}$$

Where the urgency factor is denoted as V_i amount of devices MTC is denoted as f_i. Based on the urgency factor, the classification of several resources with users by the schedule till the performance arrived. Else blocks of resource with user and cannot split the methods of MS.

Results and Discussions

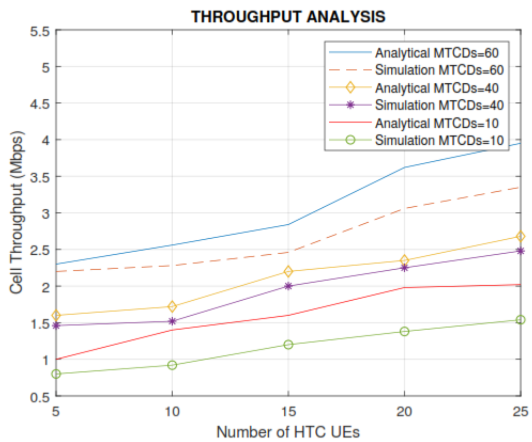
In the conclusion, you can reiterate the main points of the paper, but do not duplicate the abstract as a conclusion. You can elaborate on the importance of the task or suggest applications and extensions. The performance of the optimal algorithm for allocating cross-layer resource depends on memetic differentiated to Proportionate Fair (PF) programmer as well as part of the asset based on calculation allowed to algorithm Maia. Parameters are denoted to resolve the problem as classification of resources shown in **Table 1**. The imitation results are evaluated for critical machine type communication (MTC) devices and H2H UE at unique environment of cell to single eNB placed in center of cell to radius 500m given at table[20]. Uplink classification of resource method is mentioned using 3 various imitation experiments as single cell at environment of mixed traffic.H2H is a source of traffic which contains the voice data services based on services as multimedia like live video streaming applications and Voice-over-IP (VoIP) [21]. The resources of machine type communication devices consists of various critical devices utilized at applications of industrial and medical, as well as data arrival at MTC critical is evaluated with rate arrival of data as well as Poisson arrival process are considered to be as same.

Table 1. Parameters for Simulation and their Ranges

Simulation Parameters	**Range**
Number of eNBs	1
Number of runs	29
Radius of the cell, R	500m
Simulation time	1000 TTI
Distribution of UEs/MTCDs	Uniform and fixed
Transmitter power	14 dBm
H2H arrival rate	64,128,256 kbps
Noise	17dB
Number of PRBs	100
Delay bound	0.2 ms
M2M arrival rate	10,20,30 kbps

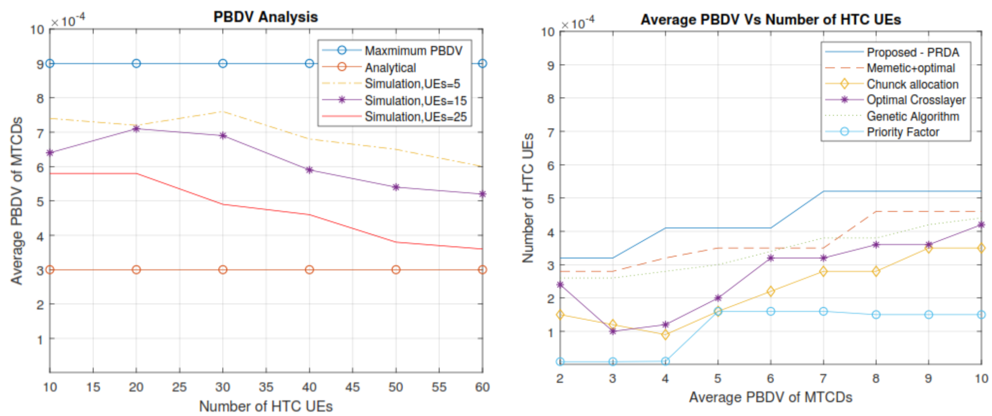
The performance evaluation of co-operate devices of critical MTC as well as users H2H are shown in Figure 7 as a simulation result. Initially the performance calculated analytical as variant amount of UE H2H as 5 to 25, as well as amount of devices MTC is kept as 10 and then it is compared with parameter results. Amount of equipment user maximize the performance also maximizes based on fixed amount of devices MTC and it is shown in the performance analysis.

Figure 7. Comparison of simulation results with analytical results for throughput analysis to varying number of users H2H and MTC users



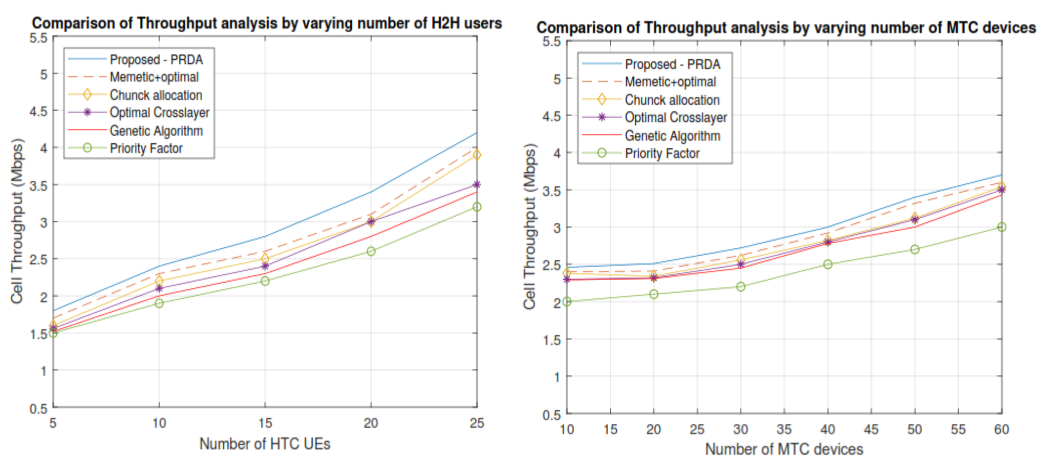
Simulation result appeared in **Fig. 7** represents Comparison of simulation results with analytical results for throughput analysis to varying number of users H2H and MTC users. The cell throughput is measured by fixing the number of MTCD devices and varying the number of HTC UEs. At first the comparison is made between the analytical results and simulation results by fixing the number of MTCD devices as 60. The plot observed in the figure dictates that through simulation the throughput increases from 2.2 Mbps to 3.4Mbps using Cross-Tier Interference Avoidance Prioritized Dynamic Resource Allocation algorithm and the throughput increases from 2.4 Mbps to 3.9Mbps Analytically when the number of HTC UEs vary from 5 to 25. Second the comparison is made between the analytical results and simulation results by fixing the number of MTCD devices as 40. The plot observed in the figure dictates that through simulation the throughput increases from 1.4 Mbps to 2.5Mbps using simulation and the throughput increases from 1.5 Mbps to 2.6Mbps Analytically when the number of HTC UEs vary from 5 to 25. At last the comparison is made between the analytical results and simulation results by fixing the number of MTCD devices as 40. The plot observed in the figure dictates that through simulation the throughput increases from 1.0 Mbps to 2.1Mbps using simulation and the throughput increases from 0.8 Mbps to 1.5 Mbps Analytically when the number of HTC UEs vary from 5 to 25.

Figure 8. PBDV Analysis by Varying Number of MTC Devices with Fixed Number of H2H Users



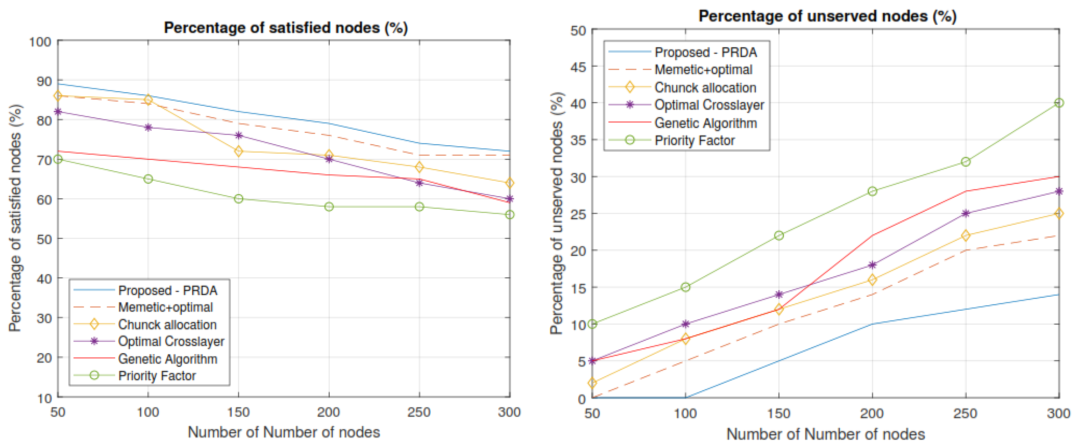
Simulation result appeared in **Fig. 8** depicts the representation of PBDV analysis by varying number of MTC devices with fixed number of H2H users and by varying number of H2H users with fixed number of MTC devices. The first plot determines the average PBDV analysis analytically and simulated with fixed number of MTCD as 5, 15 and 25. The second plot determines the average PBDV analysis for the proposed PRDA scheme and compares it with the Memetic algorithm, Chunk Allocation algorithm, Optimal cross layer scheduling algorithm, Genetic and PF. These QoS requirements of the MTCDs fulfillment of the constraints could be with equality or as an inequality based on what maximizes the objective function. As expected, Cross-Tier Interference Avoidance Prioritized Dynamic Resource Allocation algorithm satisfies the required level of QoS in all cases and this is due to the fact that any feasible solution to an optimization problem must satisfy its constraints and the constraints of the problem.

Figure 9. Through put analysis comparisons by varying number of HTC UEs and varying number of MTC devices



Simulation result appeared in **Fig. 9** depicts the representation of Throughput analysis comparisons by varying number of HTC UEs and varying number of MTC devices. RB would be advised to throughput than memetic algorithms in light of fact, consider the last delay as well as performance due to procedure of programming.

Figure 10. Representation of Percentage of Satisfied Nodes Unserved Nodes in Delay



Due to instance, devices LTE-M that run time applications of consuming remain deprived of most pressing programming conduct as well as significant distribution possibilities, however it delay-sensitive devices don't require ensured rate of bit. As other performance examinations, it took as algorithm of Memetic optimal model 100 hubs performance turns out to be around stable as quantified performance devices which needs to ensure bit rate. Regarding last necessary performance to mean values as 19.97 kb/s as QCI (1-2), 28.24 kb/s as QCI (3-4) while different devices contain minimum value of performance which fluctuates among 5–10 kb/s. Additionally assessed the device of percentage which fulfilled needed performance ensured.

Simulation result appeared in **Fig. 10** demonstrate the effectiveness of cross-Tier Interference Avoidance Prioritized Dynamic Resource Allocation algorithm contrasted with another algorithms that considers better QoS as far as delay as well as performance though sparing a significant measure of computation time. The first result portrays evaluation of PBDV to variable users H2H to fixed MTC UEs. User's rudiments of QOS get fulfilled as minimum PBDV values. It displays, which PBDV estimation is least contrasted and the various optimal algorithms. The second result portrays percentage of unserved nodes by increasing the number of MTCD UEs. The unserved nodes in the proposed PRDA algorithm gets decreased when compared with the Memetic algorithm, Chunk Allocation algorithm, Optimal cross layer scheduling algorithm, Genetic and PF. The efficiency of the proposed PRDA optimization is clearly shows in the above figure by evaluating the percentage of un- served nodes in delay and throughput. The memetic algorithm is the best performing algorithm in serving LTE-M devices based on the urgency status in the scheduling process.

Conclusion

This paper proposes a Cross-Tier Interference Avoidance Prioritized Dynamic Resource Allocation algorithm in coexistence of MTC and LTE-A Networks. In a cross layer environment, the QoS requirements, the Throughput and the probability of delay bound violation (PBDV) becomes a challenging task and this is considered to be the optimization problem which is discussed in this paper. To provide solution for the optimization problem, a step by step Prioritized Dynamic Resource Allocation algorithm is proposed and is simulated by comparing with different types of the existing algorithm. The results showed that, the throughput analysis and the PBDV analysis produce better results compared with the existing algorithms. The analysis of this algorithm is outperformed when compared to the existing algorithms because of the evaluation based on the number of users in H2H environment and critical MTC devices. The reproductions results approve the scientific examination and uncover that the proposed techniques beat the other resource allocation algorithm from past examinations in the literature.

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