Ph.D. Research Proposal

Doctoral Program in "Department Name"

Dynamic Load Balancing For LTE Network Management Using Deep Learning Approaches

by

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I. INTRODUCTION / BACKGROUND

LTE is a high speed wireless communication for mobile phones and data terminals. LTE brings up several beneficial supports to users; they are reliable and instant communications, utilization of licensed spectrum and reduction of interference. It increases the speed and capacity of different radio interface that can be supported with core networks, which also improves the process. Data rates of LTE is 100 mbps, it is the next level of UMTS 3G technology works with IP. LTE was first global standard for the mobile broadband which was introduce for reducing the occurred data traffic.

LTE was required to deliver a peak data rate of 100 Mbps in the downlink and 50 Mbps in the uplink. This requirement was exceeded in the eventual system, which delivers peak data rates of 300 Mbps and 75 Mbps respectively. For comparison, the peak data rate of WCDMA,in Release 6 of the 3GPP specifications, is 14 Mbps in the downlink and 5.7 Mbps in the uplink. (We will discuss the different specification releases at the end of the chapter.)It cannot be stressed too strongly, however, that these peak data rates can only be reached in idealized conditions, and are wholly unachievable in any realistic scenario. A better spectral efficiency, which expresses the typical capacity of one cell per unit Bandwidth. LTE was required to support a spectral efficiency three to four times greater than that of Release 6 WCDMA in the downlink and two to three times greater in the uplink. Latency is another important issue, particularly for time-critical applications such as voice and interactive games.

Advantages of LTE

- Higher speed
- Higher capacity
- Reduced latency
- Flexible Bandwidth usage
- Cell Breathing

There are two aspects to this. Firstly, the requirements state that the time taken for data to travel between the mobile phone and the fixed network should be less than five milliseconds, provided that the air interface is uncongested. Secondly, we will see in Chapter 2 that mobile phones can operate in two states: an active state in which they are communicating with the network and a low-power standby state. The requirements state that a phone should switch from standby to the active state, after an intervention from the user, in less than 100 milliseconds. There are also requirements on coverage and mobility. LTE is optimized for cell sizes up to 5 km, works with degraded performance up to 30 km and supports cell sizes of up to 100 km. It is also optimized for mobile speeds up to 15 km hr1, works with high-performance up to 120 km hr and supports speeds of up to 350 km hr Finally, LTE is designed to work with a variety of different bandwidths, which range from 1.4 MHz up to a maximum of 20 MHz. The requirements specification ultimately led to a detailed design for the LTE air interface, which we will cover in Chapters 3 to 10. For the benefit of those familiar with other systems.

1.1 Research Outline & Scope

Our main aim is to design LTE network with effective load management under interference. The scope of this work is to provide better QoS results to the users in order to provide better data transmission in the LTE-A network.

1.2 Research Objectives

The research objective of this work is formulated as follows:

- To provide better scheduling in uplink transmission in order to ensure better QoS experience to the end users.
- To allocate optimal load to cell by considering their QoS requirements, power constraints in heterogeneous network.
- To mitigate inter cell interference in heterogeneous network via performing proper handover decision.
- To select optimal relay node for edge users in the network to provide better uplink transmission.

II. RESEARCH GAPS

2.1 Common Problem Statement

There have many issues encountered in LTE heterogeneous network. They are discussed as follows: In LTE network, handling load from massive resources is big issue. Since, user request belongs to different traffic (video, voip, web) during uplink transmission requests. On the other hand, managing user mobility in the heterogeneous network is challenging task. Since, it induces interference and concurrent handovers in the network. The edge user in the LTE-A based heterogeneous network faces numerous issues like packet droppings, less QoS and so on. It is due to the difficulties introduced in relay selection such as interference, user mobility and so on.

2.2 Problem Definition

The authors in this paper have performed [1] the uplink scheduling process in LTE advanced and 5G networks. Here, the new courteous algorithm is utilized to detect the uplink scheduling process which allocates priority to the data traffic. In this paper, three different data traffic are utilized that are handoff, real time and non-real time. Here, the handoff traffic is scheduled using the non-preemptive priority queuing algorithm and real and non-real time traffic are scheduled using the weighted fair scheduling algorithm. In this, packets are dynamically scheduled by considering their average waiting time.

Problems

- In this, traffic is dynamic scheduled by considering the average waiting time of each queues. However, average waiting time of the queue doesn't provide exact state of the buffer. Since, there exists data traffic with both high and low waiting times. Hence, scheduling data traffic in this way result in poor QoS results.
- Here, the scheduling for RT and NRT traffic are performed using the WFQ algorithm. However, WFQ algorithm works better under the slow links, hence it cannot guarantee suitable bandwidth to transmit the RT and NRT traffic. Thus results in the data losses during the transmission.

- In this paper, handoff traffic is considered during the scheduling. However, they don't decide optimal decision on handover by considering the network oriented factors such as traffic load, SINR and so on. Thus increases the interference, traffic load in the network that result in poor QoS.

Proposed Solutions

- In our work, we schedule the user data using the priority of the requested traffic and arrival time. Thus increases the QoS in the network
- In our work, we schedule the user request through SRR algorithm which provides better bandwidth for the data transmission.
- In our work, we make handover decision utilizing the WASPAS algorithm that evades the cell traffic load in the network.

In this paper, the fair scheduling is proposed [2] in the uplink based LTE advanced network. Here, the two different mechanisms are utilized for the scheduling process that are delay aware real time traffic scheduling (DARTS) and delay aware fair scheduling (DAFS). These scheduling processes are undergone using integer linear programming model. Here, DARTS is used to schedule the real time traffic and DAFS is used to schedule the multiple traffic classes of each user such as Video, VoIP and web data packets. In these methods, packet dropping probability is considered to schedule the packet in the network. In this, resources are allocated by utilizing the bipartite matching algorithm.

Problem

- The entire scheduling process is relied on the single parameter i.e. packet dropping probability of the user device. Thus tends to degrade the performance of the data transmission in the LTE-A network. Since, packet dropping probability doesn't result in high quality data transmission for real time traffic packets such as video and so on.
- In this, scheduling processes are performed using the integer linear programming model. However, it doesn't have ability to consider non-linear data in the network. However, this

paper considers non-linear data for processing such as RT and NRT traffic. Hence, this model introduces difficulties when processing different traffic in the network.

Proposed

- In our work, we have considered the user traffic, arrival time parameters to schedule the data in the network. Thus provides high quality data transmission in the network.

This paper introduces the urgency based fair scheduling for uplink based LTE network [3]. Here, three types of traffic are considered for data transmissions that are VoIP, Video and Web. Here, the packets are scheduled by considering its degree of urgency and degree of allocated resources. Here, the degree of urgency is estimated by considering the tolerable delay and head of line delay of the packet. Based on the priority of the data traffic, this paper allocates the respective channel resource to the users in the network.

Problem

- The end to end delay of proposed urgency based mechanism is higher. Since, they focus on high packet drop ratio during the data transmission. However, without considering packet drop ratio and end to end delay jointly during uplink transmission result in poor QoS in network.
- In this paper, channel resource is allocated by considering the delay oriented metrics However, due to the absence of power constraints consideration, resources are not optimally allocated for each user. Hence, there exists poor quality during uplink transmission that results in less QoS.

Proposed Solutions

- Our work reduces the end to end delay by prioritizing the user request based on the QoS requirements. Thus improves the network performance in terms of the QoS provisioning.
- In our work, we have optimized power resource dynamically to the user based on their QoS constraint. Hence, our work doesn't have any quality degradation during the RT and NRT traffic transmission.

In this paper, the game theory based uplink power control [4] is introduced in the 5g heterogeneous network. The heterogeneous network comprises of femtocells and macrocell in it. In this, non-cooperative game theory model is utilized to optimize the power control. The interference in the network is mitigated through reducing the transmit power of the FUE. It is based on the priority and high interference indicator broadcasted from the eNB. Here, the high priority is allocated to VoIP traffic and low priority to the web traffic.

Problems

- In this non cooperative game theory based power optimization, each player doesn't dependent on the other players during the utility estimation. Hence, two different user could use same channel thus tends to cause interference in the network. Since, heterogeneous network has more number of users in macro and micro cells.
- In this, edge cell user communicates with eNB directly that tends to reduce the QoS in the network due to high power requirements. Since, it doesn't select the optimal relay between the edge users and eNB during uplink transmission.
- The absence of handover in the heterogeneous network degrades the network performance drastically. Since, user equipment moves frequently that tends to high rate of handover probability and link failures. Therefore, this paper achieves poor results in QoS achievement.

Proposed Solutions

- In our work, we have allocated resources using the EK based deep q-learning based algorithm in the base station. It doesn't introduce any interference during the data transmission in the network.
- We have selected optimal relay node during the edge macro cell user uplink data transmission. Hence, our work doesn't have any quality degradation during the data transmission.
- In our work, we make handover decision using the WASPAS decision making algorithm that improves the network performance.

In this paper, inter cell interference is mitigated in 5G heterogeneous network [5] through resource aware relay selection procedures. Here, the relay is selected between interference faced device and eNB in the network. The relay is selected based on the SINR and transmission power related metrics. After communicating eNB through relay node, resource is allocated to each user in the network. In this, channel resource is allocated to each user based on the arrival rate and their position in the network.

Problem

- In this, one hop relay is selected between the user and eNB that tends to induce high transmission delay in the network. Besides, it results in the high packet loss in the heterogeneous network.
- Here, relay is selected based on the SINR and transmission power. However, without considering buffer status information during relay selection leads to more packet droppings in the network. As a result, this paper has poor heterogeneous network performance.

Proposed Solutions

- Our work utilized multi-hop relay based communication in the heterogeneous network. Therefore, our work doesn't introduce any delay during the transmission.
- In our work, we have selected relay based on the RSSI, distance and buffer status. Hence, our work doesn't have any packet droppings during data transmissions.

III. RESEARCH CONTRIBUTIONS

Network construction

At first, based on the users (UEs) we have to construct small cells it randomly distributed through the network. For this network UEs equipped with LTE network our aim is to be load balancing and find resource block utilization ratio. MLB is responsible for load balancing in the network.

Information gathering

The network gathering all information's about UEs (User Equipment's), they are location and edge area of each cell that is used for neighboring cell handover process. UEs measurement report handled by cell based on information, compute average and threshold values. Then we also update the information which is presented in the cell.

Load Balancing

In this module, the network performs load balancing when the UEs moving loaded cell to highly loaded cell. At first we collect the cell information and then find average and edge value and then calculate threshold value to found when the cell is highly loaded or under loaded. If the cell greater than the threshold, it is assume as overloaded or below the threshold (Tsalis Entropy) it is assumed to be under loaded. Finally SARSA algorithm updates the cell load information and also balancing the load.

Buffer based Relay Selection

In our work, edge users in the network select the best relay to communicate the respective eNB in the network. In this work, we have considered relay as UE in the network. It is achieved through executing buffer based relay selection mechanism. Here, we have employed **SALP Optimization** Algorithm in which preference ranking is estimated for each UE Here, the preference ranking is estimated using the RSSI, distance, and mobility and buffer status. The relay selection using these credentials result in better uplink transmission performance in the network. Based on the estimated preference ranking for each player, it selects the strategy such as relay and non-relay.

Interference Aware Handover Decision Making

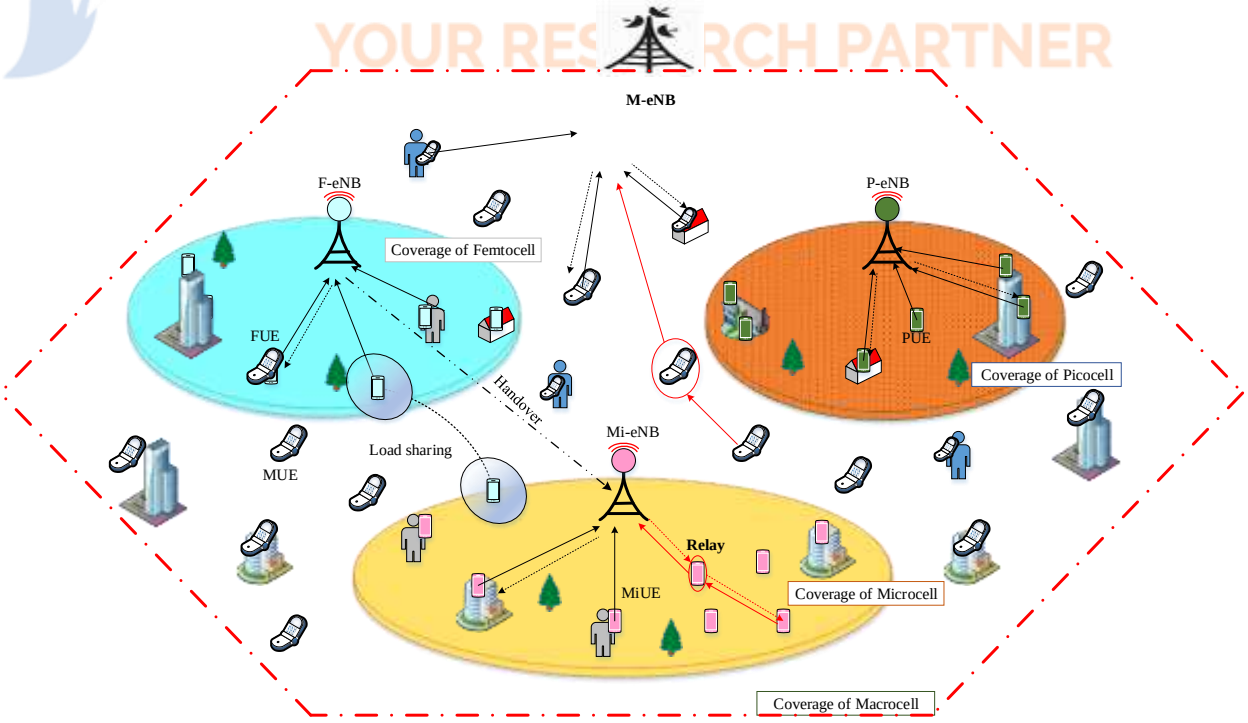
We mitigate inter cell interference in the network using the proper handover decision making process. For this purpose, we have performed interference aware handover decision making method in network. It this, we utilized **Weighted Sum Model** algorithm. It makes the handover decision by considering the parameters such as SINR, cell traffic load, user speed and Received Signal Reference Power (RSRP). Based on these credentials computation, WSM provides decision on when to handover one user to other eNB in the network. By selecting better decision on handover, our work avoids the inter cell interference in the network.

Performance Evaluation

For this module performance evaluation, evaluates UEs load balanced also performs smoothened communication. In order to increase the performance, the following performance metrics are considered.

- Delay (ms)
  - With respect to number of users
- Packet Loss Rate (%)
  - With respect to number of users
- Throughput (Mbps)
  - With respect to number of users
- Call Drop Rate (%)
  - With respect to number of users
- Load (%)
  - With respect to number of users

SYSTEM ARCHITECTURE



V. PREVIOUS WORKS & LIMITATIONS

Paper 1

Title - A threshold-based multi-traffic load balance mechanism in lte-a networks

Concept

This article investigates mobility load balancing (MLB) algorithm implementation through network simulator (ns-3) in long term evolution (LTE) systems employing orthogonal frequency division multiple access (OFDMA) for downlink (DL) data transmission. MLB is introduced by the third generation partnership project (3GPP) as a key target of LTE self-organizing networks (SONs). The contribution is twofold. First, implemented elementary procedures (EPs) related to load management (LM) function of the X2-application protocol (X2AP) as specified in TS 136.423. Then, particularly focused on EPs Resource Status Reporting Initiation Procedure' and 'Resource Status Reporting Procedure. Second, implemented a MLB based adaptive handover (HO) algorithm enabling to configure adaptively HO hysteresis threshold for each neighboring cell, of an overloaded cell, according to its current load information.

Limitations

- Consumes more time
- Computational efficiency will be low

Paper 2

Title - A hybrid unicast-multicast utility-based network selection algorithm

Concept

This paper goes a step further and proposes a Hybrid Unicast-Multicast utility-based Network Selection algorithm (HUMANS), which offers the additional option of selecting multicast transmissions in the network selection process. Testing of users in both low- and high-

density scenarios has demonstrated that HUMANS outperforms other solutions in terms of outage percentage, resource utilization and average quality of transmission as well as achieves more efficient resource utilization. This is done by serving users with good channel conditions via unicast transmissions and the ones with poor channel quality conditions via multicast

Limitations

- Poor quality
- High Time in data transmission

Paper 3

Title – Enhanced power-friendly access network selection strategy for multimedia delivery over heterogeneous wireless networks

Concept

In this context, this paper proposes an enhanced power-friendly access network selection solution (E-PoFANS) for multimedia delivery over heterogeneous wireless networks. E-PoFANS enables the battery of the mobile device to last longer, while performing multimedia content delivery, and maintains an acceptable user perceived quality by selecting the network that offers the best energy-quality tradeoff. Based on real test-bed measurements, the proposed solution is modeled and validated through simulations. The results show how by using E-PoFANS, the users achieve up to 30% more energy savings with insignificant degradation in quality, in comparison with another state-of-the-art energy efficient network selection solution.

Limitations

- Low quality of service

Paper 4

Title – A Survey of LTE Wi-Fi Coexistence in Unlicensed Bands

Concept –

In this paper the authors have discussed about a detailed view on coexistence of LT and Wi-Fi over the unlicensed band. A comparison table is provided by differentiating the characteristics of LTE and Wi-Fi. On the whole this paper gives a detailed discussion about carrier aggregation, deployment scenarios and LTE-U coexistence scenarios.

Paper 5

Title – CU-LTE: Spectrally-Efficient Fair Coexistence Between LTE and Wi-Fi in Unlicensed Bands

Concept –

This paper proposed a cognitive coexistence scheme which is capable to enable spectrum sharing between U-LTE and Wi-Fi networks. The proposed scheme includes dynamic channel selection, carrier aggregation and fractional spectrum access. It is defined that approximately 50% of LTE frames are left idle which can be sensed and utilized by Wi-Fi networks. A fairness criterion is defined to perform fair spectrum sharing between Wi-Fi and U-LTE. The criterion is determined based on equivalent spectrum access time reservation.

Limitations –

- Degradation of throughput occur due to co-channel interference

Paper 6

Title – Duet: An Adaptive Algorithm for the Coexistence of LTE-U and WiFi in Unlicensed Spectrum

Concept –

A Medium Access Control (MAC) is presented in this paper to enable LTE-U and WiFi, efficient communication. In this work Duet-SCU (Slotted Channel Utilization) is proposed, using this the ON/OFF periods of LTE-U is varied either linearly or proportionally. The information

like average airtime and airtime of packet are aggregated from small cell. Fairness is defined from quality of link level.

Limitations –

- Clustering of four UEs will make the system complex, since as per increase in number of UEs the number of clusters will also be increased.

Paper 7

Title – Maximising LTE Capacity in Unlicensed Bands (LTE-U/LAA) while Fairly Coexisting with 802.11 WLANs

Concept –

In this work, a coexistence mechanism is performed to achieve higher throughput by fairly coexisting LTE with WLAN. In this proposed mechanism the total airtime is split into two orthogonal airtime. Only a single Listen-Before-Talk (LBT) station is involved in the network. LBT airtime is formulated with fraction of idle slots have possibilities to change into busy slots and transmission duration.

Limitations –

- Collision occur in LBT-stations (LTE)

Paper 8

Title – A Spectrum Etiquette Protocol and Interference Coordination for LTE in Unlicensed Bands (LTE-U)

Concept –

The authors of this paper have proposed spectrum etiquette protocol for balancing the unfair competition between LTE-U and WLAN. This work also includes Successive Interference Cancellation (SIC) for the requirement of coordination during interference. WLAN users are

considered as primary user and given high priority. According to this protocol, if an idle band is detected then a normal power model is used else low power model is used. In lower power model the channel capacity is formulated without SIC.

Limitations –

- Spectrum etiquette restriction minimizes throughput over LTE-U
- Low power at eNB degrades channel capacity at WLAN

Paper 9

Title – Efficient Coexistence of LTE with WiFi in the Licensed and Unlicensed Spectrum Aggregation

Concept –

In this paper four significant functionalities are performed such as carrier selection, listen-before-talk, discontinuous transmission and transmit power control. During sensing period energy detection is performed for carrier selection. Then it is followed by LBT mechanism and the discontinuous transmission. In this work, Q-learning is also applied for enhancing spectrum exploitation and utilization. This work supports with all the key functionalities that are required for co-existence of LTE-U and Wi-Fi.

Paper 10

Title – Comprehensive Spectrum Management For Heterogeneous Networks in LTE-U

Concept –

In this paper a new protocol (i.e.) Carrier Sense LTE Unlicensed Access (CASLUA) is proposed for carrier sensing and avoiding interference. A carrier sense LTE-U is developed by considering multiple criteria as interference, cell load and capacity. In this work dual-sub frame allocation is performed in which one sub frame is transmitted via licensed band and the other via unlicensed band. The Wi-Fi transceivers perform sensing using CSMA for avoiding interference

with LTE-U. In this work LTE-U acts and processes in normal mode whereas WiFi uses CASLUA for spectrum sensing and channel accessing.

Limitations –

- Exchange of RTS/ CTS messages may lead to interference

Paper 11

Title- Spectrum Allocation for Enhanced Cross-Tier Interference Mitigation with Throughput Improvement for Femtocells in a Heterogeneous LTE Cellular Network

Concept

The authors in this paper have mitigated in the interference in the heterogeneous network in LTE based network. In this, inter cell interference between the two cells of heterogeneous network is mitigated. The inter cell interference in the heterogeneous network is mitigated using the frequency spectrum reuse mechanism. Besides, it also reduces the power of the eNB in order to mitigate the interference caused in the heterogeneous network.

Paper 12

Title- Deadline-Constrained Connection Request Scheduling in Mobile Relay-Assisted LTE Networks

Concept

This paper proposed the scheduling in the mobile relay based LTE networks. In this paper, a stochastic queueing model is utilized to measure the behavioral dynamics of the mobile relay node in the network. The earliest deadline first algorithm is utilized to schedule the packets in the relay based LTE networks. In this, user requests are scheduled by considering the mobile relay queue dead line constraints, service matching, probability of block and average system response time parameters.

Limitations

- In this, dead line fist based scheduling is performed. However, deadline based scheduling is not sufficient to provide better QoS during the resource allocation in the network

Paper 13

Title- Auto Tuning Self-Optimization Algorithm for Mobility Management in LTE-A and 5G HetNets

Concept

In this paper, authors have proposed the self-organization algorithm to manage the handover in the heterogeneous network. This paper proposes the auto tuning optimization algorithm to adaptively change the handover margin and time to trigger. It is achieved through considering the user speed and received signal interference power metrics. The handover margin and time to trigger parameters are adjusted adaptively by considering the user mobility. Based on these conditions, handover control probability for user equipment is optimized.

Limitations

- The self-organization based handover process utilized in this paper degrades the network performance due to the frequent call drop rate. It is because of absence of considering the parameters such as SINR, cell traffic load and so on during the handover process.
- Handover decision making consumes more time since utilized self-organization based optimization algorithm utilized tedious computational process.

Paper 14

Title- Robust resource allocation scheme under channel uncertainties for LTE-A systems

Concept

This paper proposed the robust resource allocation scheme for LTE-A network. Here, the resources are allocated for uplink data transmission in LTE-A network. In this, the QoS requirements of the user are considered during the channel allocation in network. The real time and non real traffic are considered during the scheduling of uplink transmission. Here, the

scheduling is performed using the kalman filter based interval fuzzy 2 algorithm. Using this algorithm, scheduling is performed in the network. After completing scheduling, resource is allocated based on the QoS requirement of user.

Paper 15

Title- A Weight-Based Resource Scheduling Algorithm for Uplink LTE-A Femtocell Network

Concept

This paper proposed the weight based resource scheduling algorithm in uplink LTE-A based heterogeneous network. Here, the sub channel and power resources are allocated to each user in the network. In this, weight based scheduling algorithm is utilized to allocate proper resource to the each femto user in the network. The user experience based parameters are considered to provide proper channel resource to the user. They are user mobility, path loss and shadowing effects parameters utilized during uplink resource scheduling.

Limitations

- In this, QoS related parameters are not concentrated during the resource allocation. Hence, this paper has more packet losses during the uplink data transmission in heterogeneous network.

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