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Research paper

A cluster based load balancing in long term evaluation self optimization network

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Abstract

Load Balancing (lb) is an important use case in long-term evaluation (lte) self-optimizing networks (sons). To overcome the potential ping-pong load transfer and low-convergence issues, we propose a clustering algorithm in lte son to solve the asymmetry traffic distribution among multiple cells .The proposed algorithm, which is referred to as clustering algorithm which optimally redistributes the load of cells to the multiple cells on clustering. Thus the clustered nodes formed selects the cluster head based upon the efficiency of the node. The cluster head is responsible for gathering the information about all the nodes within and outside the cluster, thus the speed gets increased and convergence time gets reduced by this method the hidden node problem gets avoided by implementing the enhanced protocol .

Keywords: *Clustering Algorithm, Long-Term Evaluation (LTE), Enhanced Protocol Software, Self-Optimizing Networks (Sons).*

1. Introduction

A self-optimizing network is one of the best way to facilitate future network management and maintenance in Long-term evaluation (lte) systems, which supports the co channel-deployed heterogeneous networks and significantly increases the quality of service. More importantly, it sharply reduces the cost of network operation . An important use case of the son, load balancing (lb) can release the traffic unbalance of multiple enbs (e-utran nodebs) to improve network-wide capacity .
An lte son, loadbalancing is usually referred to as mobility load balancing (mlb)which is automatically performed to optimally use overall network resources by setting the cell individual offset (cio) value and is applied between the overloaded cell and a possible target cell if an omni directional antenna is used to achieve optimal system performance.

The sensor nodes have the capability to collect (sense) data from the environment, and cooperate with other sensor nodes to relay the data to a central processing center, known as the sink, using multi-hop wireless communication. A wide range of agricultural, environmental, industrial, manufacturing, military, and security monitoring applications. Generally it is assumed that the nodes in wireless sensor networks are homogeneous, but in reality, homogeneous sensor networks hardly exist. Even homogeneous sensors have different capabilities like different levels of initial energy, depletion rate, etc. In heterogeneous sensor networks, typically, a large number of inexpensive nodes perform sensing, while a few nodes having comparatively more energy perform data filtering, fusion and transport.

In 3GPP TS 36.331, handovers (HOs) can be triggered by a number of events . In this paper, we are concerned with one particular event known as event A3, which defines the entering and leaving conditions of HOs. Note that the event is reached and reported only when the entering criterion is kept fulfilled and the leaving condition is not reached within the interval time-to-trigger. CLB is based on the entering condition. When the inequality of the entering condition is held for a particular user equipment (UE), the UE will be handed over from its currently serving cell to a specific neighbor target cell, which is mathematically represented as (1).

A method for load estimation based on signal-to-interference-plus-noise ratio (SINR) prediction and UE measurements after HO occurs is presented in [6] by optimizing the offset value to make the users be handed over to the target cell. An autonomic flowing water balancing method is proposed in [7], and new modules are added in eNBs to detect the overload conditions and trigger HO actions. A Load Balanced Clustering Algorithm, it proposed the load balanced group clustering to balance the battery power in wireless sensor network by implementing dynamic route calculation according to the condition of energy distribution in the network.

All of the aforementioned approaches balance the traffic load between a pair of cells, i.e., a highly loaded cell offloads some traffic to one of its lightly loaded neighboring cells. Due to the insufficient load information of other cells (hidden cells, the details of which can be found), irrational LB might be triggered, causing a "ping-pong" LB problem.

This means that the offloading will be returned to the source cell again in a short period of time. Meanwhile, the huge diversity of load distribution easily triggers a series of MLBs among multiple cells, causing another slow-convergence problem.

Differing from these cell-to-cell ways, a multicell-to-multicell LB method is proposed in this paper, the rationale of which is motivated by the theoretical conclusion in [15]: "Assume that the total traffic in an *n*-cell system is *T* Erlangs, then the (system wide) call blocking probability is minimized when the traffic in each cell is *T/n* Erlangs.” This is to say always, a low blocking probability will be achieved when each cell carries the similar load. Referred to as zone-based mobility load balancing (ZLB), our scheme can distribute load more rationally among multiple cell pairs in a given zone, so that unnecessary MLB actions are avoided. More specifically, the problem of slow convergence is solved, and the system average blocking probability decreases, which are pointed out as serious issues in [15]. The main contributions of this paper are fivefold.

- To deal with potential risks of ping-pong and slow-convergence problems in the conventional MLB schemes, we propose a cluster based load balancing algotithm, which implements multicell-to-multicell LB to achieve an optimal load redis-tributions and low blocking probability.
- A Load Balanced Clustering Algorithm, it proposed the load balanced group clustering to balance the battery power in wireless sensor network by implementing dynamic route calculation according to the condition of energy distribution in the network. It also solves hidden node problem.
- It relies on a grouping strategy that splits each cluster of a WSN into disjoint groups of non-hidden nodes and then scales to multiple clusters via a cluster grouping strategy that guarantees no transmission interference between overlapping clusters

This paper is organized as follows. In Section II, the network model and some preliminaries are given. In Section III, the clustering algorithm is described. The load-balancing in clustering algorithm is given in Section VI. Finally, the simulation results and a comparative analysis are presented in Section VII.

2. Network model and preliminaries

To combat the potential ping-pong load transfer and low-convergence issues, we propose an algorithm that optimally redistributes the load of all cells within a cluster from a sys-tematic viewpoint..

Clustering of nodes [20] in a cluster is an energy efficient approach by avoiding the long distance communication of nodes. In static clustering scheme, clusters are fixed and one node acts as a cluster head for each cluster. Cluster head is responsible for gathering data of nodes in the respective cluster and for sending data from sender to receiver.

2.1. Network model

As shown in Fig. 1, we consider an LTE network with 21 cells named 1, 2, . . ., 21. Every three cells is controlled by concerned cluster head. Each highly loaded cell, such as cell 1 in Fig. 1, cluster head acts as the activator of LB.

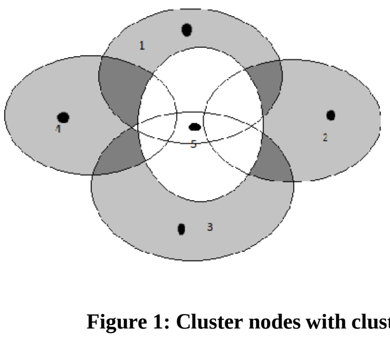


Figure 1: Cluster nodes with cluster head

The two main steps taken place in cluster based load balancing algorithm are:

1. **Clusters formation**: A subset of nodes ’clusterheads’ is elected to coordinate their respectiveclusters.

2. **Load balancing within each cluster:** Ourload balancing algorithm is a centralized algorithm since the global members load information of each cluster is collected by theclusterhead which ensures some balance between its members.

2.2. Hidden Cell

In traditional MLB, source eNBs exchange load information with their adjacent eNBs using an X2 interface. A specific cell just knows the load state about its neighbor eNBs [16]. Therefore, the hidden-cell problem arises. Given a specific cell *i*, the cells that are two hops away are its potential hidden cells.

The detailed effects and description of the hidden-cell phenomenon are shown in Fig. 1, where we concentrate on the hidden-cell phenomenon within the two overloaded cells termed cells 6 and 11. Cell 7 will be first involved in the game circle of cell 6. At the same time, it may also be one component for cell 11’s circle, so that if certain UE devices of cell 6 are offloaded to cell 7 while certain UE devices from cell 11 are also offloaded to cell 7, then cell 7 will become the new overloaded cell. This phenomenon happens due to the hidden-cell phenomenon, where cells 6 and 11 are the mutual hidden cells with respect to cell 7 since there is no direct interaction between eNB2 and eNB4. If cell 6 knows the load information about cell 11 in advance, then cell 6 may reduce the expectation of its own MLB by offloading less traffic to its target cell (e.g., cell 4). In our load-balancing scheme, the hidden-cell problem is solved, which will be discussed as follows.

2.3. Adjustment of mobility parameter

In MLB, each cell will adjust the HO regions by biasing the HO measurements. More specifically, for A3 event, the HO condition can be expressed as [4]

$$M_j - M_i > O_i^{(cs)} - O_{i,j}^{(cn)} + Hys + off \qquad (1)$$

where M_i and M_j correspond to the UE measurement result of cells *i* and *j*, respectively, which can be in the form of reference signal received power (dBm) or reference signal received quality (dB) [4]. $O_i^{(cs)}$ is the cell-specific offset of the serving cell *i*, and $O_{i,j}^{(cn)}$ is the cell-specific offset of the neighbor cell *j* with respect to cell *i*. *Hys* is a hysteresis term,and *off* is a fixed offset. By increasing the offset $O_{i,j}^{(cn)}$, it is possible to cause a mobile user served by cell *i* to be handed over to the neighbor cell *j*, thereby reducing the load in cell *i*. In our paper, each cell will automatically adjust the value ofmobility parameter $O_{i,j}^{(cn)}$ based on cell load measurements to perform LB.

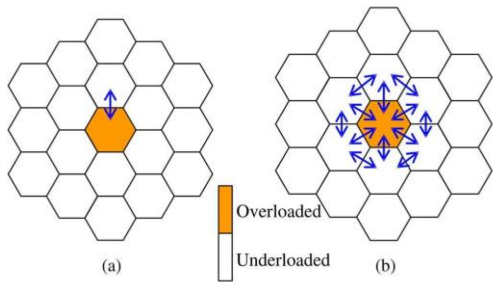
3. Proposed approach of zone based mobility load balancing game model

It is well known that a multioligopoly Cournot model can well depict the commodity exchange process among a limited number of monopoly companies involving several parameters of price and production of a specific commodity [9]–[12]. If we regard the traffic load bearing of a cell in the investigated cell set as the commodity, then we can observe the similarity between ZLB implementations and the multioligopoly Cournot game model. Hence, we formulate the multicell-to-multicell ZLB problem as a Cournot game model G_{ZLB} to capture the dynamic behaviors and strategic interactions between different cells. Using this game model, we can get the optimal load distribution of each cell.

Definition 1: The ZLB game model is defined as$G_{ZLB}=\{N, L, U\}$, where

- N is the cell set of ZLB associated cells in a specific zone,where each cell is one of the players in the ZLB game;
- L is the LB strategy space, which contains all the loaddistribution strategies L_i of each cell $i \in N$. In addition, each choice of load of cell $i \in N$ is $l_i \in L_i$, so that set

To compare the proposed CLB scheme with the conven-tional MLB, we depict their basic implementation principles, as shown in Fig. 2. Here, to simply illustrate the rationale behind them, we only depict "Overloaded" and "Underloaded" cells in Fig. 2. In Fig. 2(a), the overloaded cell will offload the traffic just to one of the underloaded neighbor cells. However, in Fig. 2(b), the ZLB scheme utilizes a totally different algorithm, where the offloading requirement of the overloaded cell will further trigger the load redistribution of a series of neighbor cells.The design of our ZLB strategy consists of two parts as follows.



where ↔ indicates the partici-pants of LB players.

- We design the utility function of each game player as a function of load distribution (l_i, l_{-i}), where l_i and l_{-i} represent the load of cell i and other cells except cell i, respectively. We solve this game to find out the optimum load distribution (l_i^* , $l_{-}^* {}_i$) in the zone.
- After deriving the optimum load distribution (l_i^*, $l_{-}{}^*{}_i$), each cell can calculate the difference between its current load and the optimal load value. Then, a detailed load-balancing algorithm based on a utility-metric function has been presented to redistribute the load to multiple cells.

4. Cluster based load balancing algorithm

4.1. Clusters formation procedure

1. Find the neighbors of each node i (nodes within its transmission range). They are defined as follows: $V(i) = \{i\_ \_= i/dist(i, i\_) \leq txrange\}$ where *txrange* is the transmission range of node i.
2. Compute the speed average for every node. This gives a measure of its mobility.
3. Choose the node which has the smallest value of mobility and the highest value of battery power as clusterhead. All its neighbors are designated as its members and they can no longer participate in the election procedure.
4. Repeat steps 2-4 for the remaining nodes not yet assigned to any cluster.

4.2. Cluster head procedure

The nodes mobility causes changes in the network topology. If at a given time a node is detached from its current cluster and is attached to another, the corresponding cluster heads will update their members' tables. If a node leaves its cluster and doesn't find any other cluster to attach itself, the clusterheads election procedure is invoked.

- A clusterhead keeps the information concerningits members (identifier ID, status,load, energy). It can detect if another clusterhead is entered in its cluster. In these cases, one of them is constrained to give up its cluster head's role.
- Because of the additional functionalities for which the cluster head is intended, its energy is likely to be exhausted. A minimum threshold of energy is defined for each cluster head. If it is reached, the cluster heads election procedure is invoked.

4.3. Load Balancing in clustering Algorithm

A subset of nodes 'clusterheads'
is elected to coordinate their respective clusters. clusterheads' is elected to coordinate their respective clusters.

Our load balancing algorithm is a centralized algorithm since the global members load information of each cluster is collected by the cluster head which ensures some balance between its members. A principal role of a clusterhead is the maintenance of load balancing in each cluster. It is the principal coordinator of its cluster; it collects periodically information about each member node of its cluster, such as energy and load values. These data are collected in the members table.

When a node reaches an overloaded or low energy state, a discharge message will be transmitted to its cluster head. The latter consults its members table and chooses the one which has the smallest load and the highest energy capacity. Then it sends a response to the concerned node.

Hidden Problem Identification

- **S**ource eNBs exchange load information with their adjacent eNBs using an X2 interface.
- A specific cell just knows the load state about its neighbor eNBs Therefore, the hidden-cell problem arises.
- This can be avoided by implementing protocol enhance software.
- In CLB there will be one access point called master which maintains the transfer of packets. Clients are not allowed to send data without the master's invitation.
- This eliminates the hidden node problem at the cost of increased latency and less maximum throughput

5. Simulation results

System Throughput*:* Fig. 2 is the statistical results of sys-tem throughput with the user arrival rate. The average through-put of the system is gradually increased as the user arrival rate increases. We can see that the system throughput of the three compared schemes is in the sequence of CLB > ZLB > Without LB.

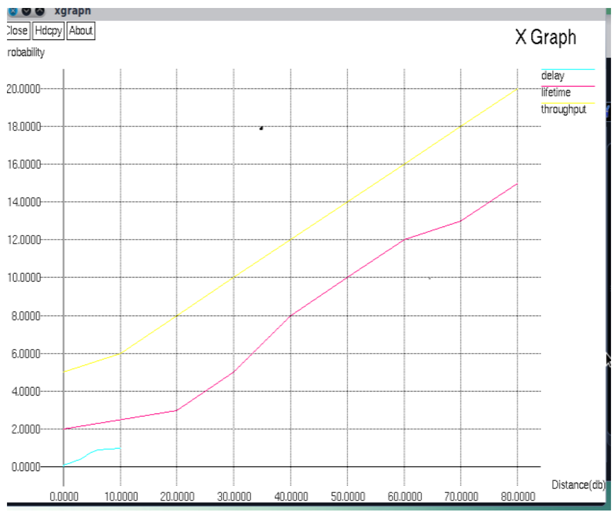


Fig. 2: is the statistical results of system throughput with the user arrival rate

When the user is uniformly generated within the system, the proposed ZLB algorithm achieves a slightly higher throughput than the other two cases. When the user is not uniformly distributed, the gain of the ZLB algorithm is relatively close to the MLB algorithm, which is due to the fact that the average blocking rate of both algorithms is closer to each other.

6. Conclusion and future work

To handle the Ping-Pong and slow-convergence problems of the conventional MLB, in this paper, we have presented a cluster based algorithm to the LTE SON LB problem. The proposed CLB carries out the LB action from the perspective of the multi cell region, which means that the participant of the LB process are increased from a pair of cells to a whole region of cells. Simulation results show that CLB dramatically reduces the average blocking probability and the number of unsatisfied users of the system while the cell throughput is guaranteed

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