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A Novel Approach for Load Balancing In Heterogeneous Cellular Network

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ABSTRACT: Heterogeneous network is an important component of cellular networks to meet the increasing mobile data demands. Due to uneven traffic distribution, some nodes suffer from heavy load, and their adjacent nodes may carry only light load. This load imbalance among nodes restricts the network from fully utilizing its capacity and providing better services to users. So there is a need of load balancing mechanism to be present in the network. In this paper a load balancing scheme is proposed that moves the load of heavy nodes to lightly loaded or idle nodes by finding next shortest path. This may lead to efficient utilization of nodes and nodes can allocate resource efficiently.

KEYWORDS: Heterogeneous network, Load Balancing, Overload

I. INTRODUCTION

A cellular network or mobile network is a wireless network [2]. This network is distributed over areas called cells. Each cell in the network is served by at least one base station. In a cellular network, a different set of frequencies are used by each cell from neighbouring cells, to avoid interference. A node will use channel to connect to its closest node. Each node can get connected to another node through the mobile switching centre (MSC) of the cellular network.

Due to increase in traffic, its uneven distribution and limited bandwidth availability, it will not be possible to meet the mobile data demands only with macro cell base stations (MBSs). To meet this, low power nodes such as microcell, pico cell, femto cell are used in combination with the existing macro cell network. Since the network is now a combination of macro cell, microcell, pico cell, femto cell, it is termed as heterogeneous cellular network [3].

During communication, all nodes mostly choose shortest path. So there is a great chance for nodes on the shortest path to become overloaded. Heavily loaded nodes can cause packet loss and buffer overflow, which may lead to longer end-to-end delay, degradation in throughput, etc. Hence, it is important that some form of load balancing to be present in the network.

Load balancing aims to move the load from the overloaded area to less loaded areas to achieve better performance of the network. It allow nodes to better serve its users i.e., resource allocation can be done efficiently. In the existing mechanism, when a node want to communicate it find shortest path and use that for communication. When this path becomes heavily loaded, it must wait until the load on the shortest path decreases. In the proposed mechanism, when a node is over loaded, identify the lightly loaded one, activate it and use it for transmission. Since idle nodes are identified and utilized to balance the load, maximum utilization of nodes is possible. The rest of this paper is organized as follows: Section II contains some related work, section III explains the proposed load balancing mechanism, section IV deals with results and discussion and the conclusion and future direction of work is given in section V.

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II. RELATED WORK

In Best SNR heuristic method [8], a node is associated with the node from which it receives the highest power. When load on a node increases, power received from it decreases. So when a node want to communicate it choose lightly loaded node since the power received from lightly loaded node is higher than overloaded node. Hence load on node is balanced. It is robust against interference. The drawback of this is that: the macro nodes transmit with a higher power than the pico nodes, so only a small number of nodes is associated to pico nodes. This may cause a strong load imbalance between macro and pico nodes. Hence this approach is good for macro only cellular network and is not efficient for heterogeneous network.

To overcome the above drawback, fixed range heuristic [1] method has been proposed. In this the power received from pico nodes is increased by adding a fixed bias to it. This allows more users to connect to pico nodes, providing a better balanced load between the macro and pico nodes. But, some users are connected to the pico node even if they receive a stronger signal from the macro node due to biasing. So, this is also not efficient in load balancing.

Channel assignment schemes [4] are used to balance the load on the network. There are three channel assignment schemes: Fixed Channel Assignment (FCA), Dynamic Channel Assignment (DCA) and Hybrid Channel Assignment Scheme (HCA). In FCA [4], a number of channels is assigned to each cell depending on the desired signal quality. So, channels can only be used in designated cells. In this case there is a definite relationship between cells and channels that can be used there at any time. In this case, when a new call arrives in a particular cell, if all the channels assigned for that cell are busy then that call must wait until some channel become free. To overcome these deficiencies DCA scheme has been introduced. In the DCA [4] approach, all channels are placed in a pool and they are assigned to new calls as needed. There is no definite relationship between the cells of the system and the channels that are used in them. Channels are temporarily assigned for use in cells for the duration of the call. After the call is over, the channels are returned and kept in a central pool. DCA scheme is less efficient than FCA under heavy load condition. Hybrid Channel Assignment Scheme (HCA) [5], is a mixture of two schemes (FCA and DCA) and hence the name Hybrid. In this there are a total of T duplex channels available for service. They are divided into two sets A and B that is not necessarily equal. The set A (called nominal channels) contains channels that are used like FCA and the set B (called borrowable set) contains those channels that can be used in any cell in the system, like the Dynamic Channel Assignment scheme. When a new call arrives in a particular cell, if all nominal channels for that cell are busy then channels are borrowed from the borrowable set. This way load is balanced in HCA. In HCA also, when heavy load arises, all channels are in use then load cannot be efficiently balanced.

III. PROPOSED APPROACH

In the existing methods, when a source node want to communicate with another node, then source find that a node in the shortest path to destination is overloaded, then it must wait until load is reduced. A novel approach for load balancing in heterogeneous cellular network is proposed to overcome these deficiencies.

In the proposed mechanism, when a source node wants to send data to an unknown destination node, it identifies the shortest path using path discovery process. Once the shortest path is identified, then the source node start sending data to the desired destination through this path. When a node in this path becomes overloaded, the link of that node with others is broken and source node find next shortest path by re-initiating path discovery process. Since the overloaded node's link is broken, that node is excluded during next path discovery process. So, re-initiating path discovery process find shortest path that contains only lightly loaded nodes. Hence load on nodes can be balanced efficiently by moving load from congested nodes to lightly loaded nodes.

A. Path Discovery

The path discovery process is initiated whenever a source node needs to communicate with another node whose location or

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routing information is unknown. The source node initiates path discovery by broadcasting a request (REQ) packet to all its neighbours. The REQ contains the following fields:

- source address
- sequence number
- destination address
- hop count

The sequence number is incremented whenever the source node issues a new REQ. Each node keeps a cache where it stores the source address and sequence number of the received REQs. If a node receives another REQ with the same source address and sequence number, then it is discarded and does not rebroadcast it. Hence, duplicated REQs are prevented.

At each intermediate node, when a REQ is received a route to the source is created and stored in its routing table. Each node that receives the REQ, check whether the destination addresses match with its own address. If so, it send a reply, REP back to the source. Otherwise rebroadcasts the REQ to its own neighbours after incrementing the hop count. A REP contains the following fields:

- source address
- destination address
- hop count
- sequence number

The reply is propagated through the path from which the request is received. As the REP propagates, each intermediate node creates a route to the destination. When a node receives REP it propagates REP towards source. If a node receives another reply with same source and destination address then it propagates REP towards source only if it has greater sequence number than the previous REP or the same sequence number with a smaller hop count. When the source receives the REP, it records the route to the destination in its routing table and start sending data. Hence shortest path with smaller hop count is obtained.

B. Routing Table Management

Each node keeps a routing table within that it maintains an entry to each destination. Each routing table contains the following fields:

- destination
- next hop
- number of hops
- sequence number

When a node say n2 receives a REQ packet from node n1, n2 checks in its routing table a route to n1 present or not. If not then it add a route entry to n1 in its routing table. Similarly, when n2 receives REP packet from n3, n2 checks in its routing table a route to n3 present or not. If not then it add a route entry to n3 in its routing table. If a route in its routing table is not used by the node for a long time then node thought that, that node is not active or it is invalid and so remove it from the routing table. When a node receives a data packet, it first checks the destination address match with its own. If not then it check in its routing table the next hop to reach that destination and route data to that hop.

C. Connectivity Management

When a node is active in the network, then it periodically broadcast a HELLO message to its neighbours. So a node can

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identify that its neighbour is invalid or failed or a link break occurs, if it does not receives HELLO message from it.
When a node is overloaded, its entire link is broken. When a link break or invalid node is detected by its upstream node, it removes all routes that use that node from its routing table and broadcast an error message to its neighbours. The error message contains address of those nodes that become unreachable due to broken link. When an error message is received, the node searches in its table if there is any route listed in error message. If so, it update its routing table and a new error message is broadcast to its neighbours. When the error message is received by the source it reinitiates location discovery process to find new routes excluding the invalid nodes.

IV. ANALYSIS AND DISCUSSIONS

A. Average end-to-end delay

Average Delay is the time taken by the data packets from the generation of the packet by the source to their reception at the destination and is expressed in seconds. In existing systems, when a node is overloaded or channel is busy, then the source node want to wait until load is reduced. So average end-to-end delay is high. In the proposed system, when a node becomes heavily loaded, it needs to find next shortest path using path discovery. This cause some delay in the network and is very low compared to existing systems.

B. Normalised Load

When a node is heavily loaded, load balancing mechanism proposed in this paper identify next shortest path contain lightly loaded node and utilize it to transmit. So the load on the nodes is balanced. Hence normalized routing load using this balancing mechanism is low. In the existing systems, load is very high.In Best SNR heuristic method, since macro nodes transmit with a higher power than the pico nodes, only a small number of nodes is associated to pico nodes. This may cause a strong load imbalance between macro and pico nodes. Hence load on network using this is high. In fixed range heuristic method, the power received from pico nodes is increased by adding a fixed bias to it. This allows more users to connect to pico nodes. So the load on pico nodes increases and become high. In channel assignment schemes, when channel is overloaded, source must wait until load reduces. Due to this large delay, there is an increase of load in the network.

C. Throughput

Throughput is defined as the total number of packets received by the destination. It is a measure of the effectiveness of a routing protocol. When load on a node increases, throughput decreases. In Best SNR heuristic method, there is a strong load imbalance between nodes and hence load on network increases. This may lead to decrease in throughput. In fixed range heuristic method, since more users are connected to pico nodes, load is high and hence degradation in throughput may arise. In the proposed system, before the node is heavily loaded, throughput increases. When the node becomes overloaded, throughput decreases and when the node identify next path and start transmission, throughput again increases. So degradation in throughput is low in proposed method compared to existing methods.

D. Packet Loss

In the existing methods, delay and load is high, so packet loss is also high. In the proposed mechanism, when a node is overloaded, it immediately identify next path and start sending through that path. Inorder to identify next path, a small delay may occur. So there is less number of packet drop may arise.

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V. CONCLUSION

In this paper, a load balancing mechanism in heterogeneous network is proposed. When a node is overloaded, utilize nodes that are lightly loaded to balance it. This is done using a uni-path routing mechanism i.e., when a node is heavily loaded, identify next shortest path using another path discovery process to balance the load. In this, some delay may occur since the node needs to initiate path discovery process again. To overcome it, a multipath routing mechanism can be introduced as future work.In multipath routing, multiple routes between source and destination as alternate routes are found at the time of route discovery. So, if there is any node in primary path is heavily loaded or failed, then the alternate path can be used for recovery. Since alternate paths are found during initial path discovery itself, delay and traffic can be reduced effectively.

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