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IMPROVED VERTICAL HANDOFF ALGORITHM IN A 4G NETWORK

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Abstract:-The major issue in the heterogeneous networks is the vertical handoff from one wireless network to the other wireless network. Vertical handoff is a process of transferring a connection from one base station to other base station when moving across different access technologies. Vertical handoff can be triggered by various parameters like RSS, bandwidth, data rate, cost etc. Call drop rate is a big problem in the 4th generation networks. A vertical handoff based on congestion parameters in the cell is used in a converged ad hoc and cellular network system. This results in less call drop rate.

Key words: - Vertical handoff, Call drop rate and TDS.

1. INTRODUCTION

There are various ways to combine the wireless access technologies in order to get benefits of these technologies in a single network. The way in which various technologies are combined at one place depends on the objective of user. For example if we want to balance the traffic between two adjacent cells of a cellular network. This aim can be accomplished by integrating ad hoc networks with cellular network so that ad hoc routes are used to balance the traffic between adjacent cells. This is called integrated cellular and ad hoc overlaying system (iCAR) [1]. Similarly if the aim is to provide high data rate services to the users which are in low data rate areas then ad hoc routes are used as high data rate channels. Such a system is called unified cellular and ad hoc network (UCAN) [2].

There is another way of using characteristics of cellular and ad hoc network in order to enhance the performance of the cellular system known as converged ad hoc and cellular network system [3].Vertical handoff across these networks need to be seamless in order to provide good quality of service. A vertical handoff algorithm based on congestion parameters like call blocking probability is used to reduce the call block rate in the cellular system. This paper is organized in six sections. The system model is explained in section2.In section 3, vertical handoff algorithm is given. The numerical results on the basis of algorithms are obtained in section 4. In section 5, the numerical results are simulated and results are shown. Finally in section 6, the work is concluded.

2. SYSTEM MODEL

A converged ad hoc and cellular network (CACN) system [3] is a 4th generation network which has various cell like in any cellular network and these can be connected through ad hoc relaying routes. The basic objective of this system is to balance the traffic between neighbouring cells. A CACN system consists of Base Station (BS), Mobile Handsets (MH), Traffic Diversion Stations (TDS) and Cellular Central Control System as shown in figure 3.1.

Base station (BS):-It is the same base station used in the present cellular networks. The communication between base stations is in wired mode.

Central Control System:-The base stations of different cells are connected to each other through wires and communication between them is controlled by a central control (CC) system. This cellular central control system is then connected to the internet. This system takes important decisions regarding possible next access points for handover.

Traffic diversion station (TDS):-TDS is a system which diverts the traffic between two base stations by forming ad hoc routes. It is equipped with both A-interfaces and C-interfaces. TDSs are deployed with managed mobility [4]. In a TDS, C-interfaces that operate on in-band bandwidth are used for communication with a BS or an MH with C-interface. A-interfaces are used for communication between TDSs or with MHs with an A-interface. So the access of MHs is only done from A-interface as well as from C-interface.

Mobile Handsets (MH):-Mobile hosts or mobile handsets (MHs) in a CACN system are diverse mobile devices such as mobile phone, laptop and PDA.These are equipped with both A-interface and C-interface, or either of them.

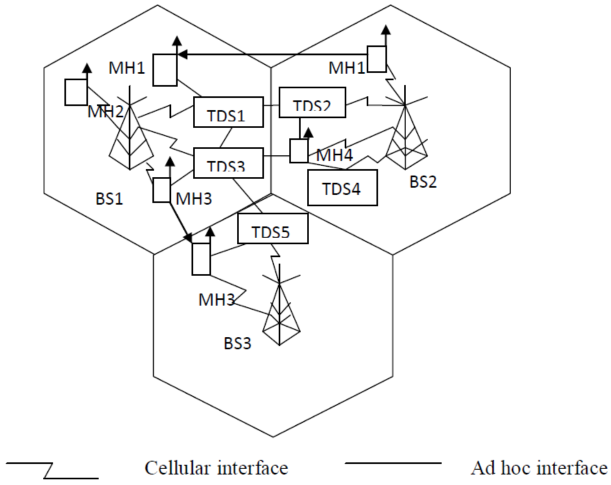

Figure.3.1 A CACN system model

Ad hoc relaying routes in CACN are formed by TDSs and MHs with an A-interface.

Figure.3.1 describes a simple three-cell model to illustrate the general operation of a CACN system. If MH1 is making a call through BS1, which is congested, this call will be dropped in conventional cellular networks. In a CACN system, this blocked call will be diverted to a non-congested cell through an ad hoc relaying route such as MH1-TDS1-TDS2-BS2. There are different methods of ad hoc relaying route discovery and selection to find shortest and efficient relaying route [5]. On the other hand, if MH2 that is not in the coverage of any TDS is also trying to make a call through BS1 which is congested, this call cannot be directly diverted to a non-congested cell. For making this call successfully, a pseudo-source like MH3 is chosen to divert its on-going call to another cell which is non-congested by using a relaying route. It releases its occupied bandwidth for the use of the source node MH2.The pseudo source selection is an important factor in providing a free channel to the demanding user, various algorithms are used to select a pseudo source [6].

Challenges for a vertical handoff:-

The main issue in vertical handoff is the semlessness.In a CACN system, there are two vertical handoffs,

- Handoff from cellular mode to ad hoc mode.
- Handoff from ad hoc mode to cellular mode.

The cellular mode is the communication between an MH and a BS through C-interface. The ad hoc mode is that an MH is using its A-interface to make a call through a relaying route.

Above vertical handoffs makes two things clear

- A vertical handoff brings more delay to the system
- It also causes some calls dropped during the handoff process.

These issues can make interruption to the data services in the CACN system, so efficient vertical handoff is required.

Call block probability in a cell:-A fixed spectrum is allotted to a particular cell in a cellular network. So there are limited numbers of channels available for the users. If all channels are occupied at a particular time then new user is blocked to make a call. There is probability that call is blocked in such a situation. This probability is called call blocking probability [3].

Call blocking probability B in a single cell is given by formula

$$B = \frac{(T)^M / M!}{\sum_{i=0}^{M} (T)^i / i!} = f(T,M)$$

where T is the traffic density of the cell and M is the number of cellular band channels. The call blocking probability of a home BS with which an MH is currently connected with, is B_H. If an MH is taking a handoff to BS_i, the call blocking probability of BS_i can be calculated as

$$B_i = \frac{(T)^M / M!}{\sum_{i=0}^{M} (T)^i / i!} = f(T,M)$$

In order to avoid congesting BS_i, an MH takes a handoff to BS_i only when $B_i \le B_{\max}$ .B_{max} is the threshold of call blocking probability, and shows the saturated situation of a BS. When BS_i is congested or nearly congested, extra handoff traffic which is diverted to BS_i will be diverted to other non-congested cells. Thus, the main objective of traffic balancing in CACN will be realized successively.

Transmission drop rate: - Traffic diversion stations employed in the cells of a CACN system have limited badwidth.So a limited traffic can be diverted by these TDSs.Due to this limitation, some of the traffic can be dropped during diversion process. The rate at which the traffic is dropped during diversion process is known as transmission drop rate of a TDS.It is given by formula

$$D = \frac{(T_T)^{M_T} / M_T!}{\sum_{i=0}^{M_T} (T_T)^i / i!} = f(T_T, M_T)$$

T_T defines the traffic density in a TDS and M_T shows the number of TDS band channels. In CACN, one MH can only use one IEEE 802.11b physical channel for diversion service from an MH to a BS through an ad hoc relaying route. This diversion service remains stable. If an MH is taking a handoff to TDS_i , the transmission drop rate of TDS_i can be calculated as D_i

$$D_i = \frac{(T_T)^{M_T} / M_T!}{\sum_{i=0}^{M_T} (T_T)^i / i!} = f(T_T, M_T)$$

To decrease the overall number of calls dropped in TDS_i , an MH takes a handoff to TDS_i only if $D_i \le D_{\max}$. D_{max} is the threshold value of transmission drop rate, and presents the saturated situation in TDS.

3. VERTICAL HANDOFF ALGORITHM

Vertical handoff from cellular mode to ad hoc mode:-

The vertical handoff from cellular mode to ad hoc mode follows the steps as follows:-

- An MH first find out whether it has been chosen as a pseudo-source to transfer its calls to the ad hoc mode.
- If it is chosen as pseudo source then it will search for ad hoc relaying route to neighboring non congested cell.
  - When a relaying route is available, the MH will verify if $B_i \le B_{\max}$ and $D_i \le D_{\max}$ .This is because the traffic which is diverted from the MH to a neighbour cell (BS_i) should avoid further congesting BS_i if BS_i has already been congested.
  - If above condition holds then a vertical handoff to ad hoc mode occurs. Otherwise call is dropped.

- On the hand, if MH is not chosen as pseudo source
  - An MH tries to take a horizontal handoff from one cellular cell to another, It will be successful if $B_i \leq B_{max}$ holds for the cell in which handoff is occurring.
  - If above condition does not hold then ad hoc relaying route discovery and selection process is started .If relaying route is available and cell is non congested then vertical handoff to ad hoc mode occurs.
- It is considered that both relaying routes and pseudo-sources are available in the handoff process. So A call request from an MH moving to BS_i is only dropped, when free channels, relaying routes and pseudo-sources are all not available.

Vertical handoff from ad hoc mode to cellular mode:-
A vertical handoff from ad hoc mode to cellular mode follows the step as follows:-

- If an MH is going out of the range of transmission of its connected TDS then MH will try to take a vertical handoff to cellular mode, and to find a free channel in the present cell.

- If the present cell is congested $B_P > B_{\max}$, the MH will start to find a new relaying route. B_P is the call block rate of the present cell where the MH is located.
  - If relaying route discovery is failed, the MH will seek for a channel through the C-interface until obtaining a new free cellular channel. After the ad hoc connection is terminated, the call will be dropped if there is still no free channel available in the present cell.
  - On the other hand if there a relay route available then it is checked for the next cell if $B_i \leq B_{\max}$ and $D_i \leq D_{\max}$ holds or not.
    - If above condition holds then a horizontal handoff to another TDS occurs.
    - Otherwise it waits for a free channel in the cell. Call will be dropped if free channel is not obtained.
- If the present cell is not congested then a vertical handoff to the cellular interface occurs.

4. NUMERICAL RESULTS

Here, it is considered that the traffic density of the BS in Cell A is T_A at time point t_i. The average traffic density of each TDS in Cell A is T_T at t_i.The overall band channels of Cell A are M_A. The overall band channels of each TDS are M_T. The overall number of TDSs deployed in Cell A is N. And, Cell A is already congested at t_i. Then, at time point t_{i+1}, Cell A has T_E extra traffic from neighbour cells, which is introduced by handoffs.

If the handoff algorithms do not consider the saturated situation in Cell A, the overall traffic in Cell A at t_{i+1} will be (T_A +T_E +T_TN). Then, the call blocking probability of Cell A and the transmission drop rate of each TDS at t_{i+1} are

$$B_{i+1} = f(T_A + T_E, M_A)$$

$$D_{i+1} = D_i$$

Thus, the overall call drop rate $B_{i+1}[overall]$ of cell A at t_{i+1} is

$$B_{i+1}[overall] = \frac{(T_A + T_E)B_{i+1} + T_T D_{i+1} N}{T_A + T_E + T_T N}$$

If saturated condition is considered in cell A in the vertical handoff algorithm, threshold call drop rate can be set as $B_{\max} \leq B_i$. Thus, the call blocking probability of Cell A and the transmission drop rate of each TDS at t_{i+1} are

$$B'_{i+1} = B_i$$

$$D'_{i+1} = f(T_T + \frac{T_E}{N}, M_T)$$

So the overall call drop rate $B_{i+1}[overall]$ of cell A at t_{i+1} is

$$B'_{i+1}[overall] = \frac{T_A B'_{i+1} + (T_T + (T_E / N))D'_{i+1} N}{T_A + T_E + T_T N}$$

$B_{i+1}[overall]$ can be decreased when we increase the number of TDSs appointed in Cell A. In saturated situation in BS, the extra traffic which is due to handoffs can be diverted back to neighbour cells through relaying routes, without further congesting BSs .

5. SIMULATION RESULTS

The simulation tool used for the simulation is MATLAB 7.0. Some parameters are fixed as default as shown in table 3.1.

Parameter	Default value
Number of band channels of BS in cell A,M_A	50
Number of the band channels per TDS in cell A,M_T	5
Number of TDSs deployed in cell A,N	6
Traffic density of BS in cell A at t_i , T_A	50 Erlangs
Extra traffic introduced by handoffs at t_{i+1} ,T_E	10 Erlangs
Average traffic density per TDS at t_i ,T_T	3 Erlangs

Table 3.1.Default parameters used

The value of N is set at 6 and 10, respectively, and traffic density (T_A) of Cell A is increased at time t_i from 50 to 90 Erlangs. With the increase in T_A, both $B_{i+1}[overall]$ and $B'_{i+1}[overall]$ increases heavily as shown in figure 3.4. At the saturated situation, more traffic added in Cell A results in more traffic dropped.

At a very higher traffic level, the vertical handoff considering saturation still shows a better performance than the vertical handoff without considering saturation. This is because the vertical handoff considering saturation does not bring more traffic burden which is introduced by handoffs to BS. It diverts the extra traffic to neighbour cells. This leads to relatively less call dropped in BSs.

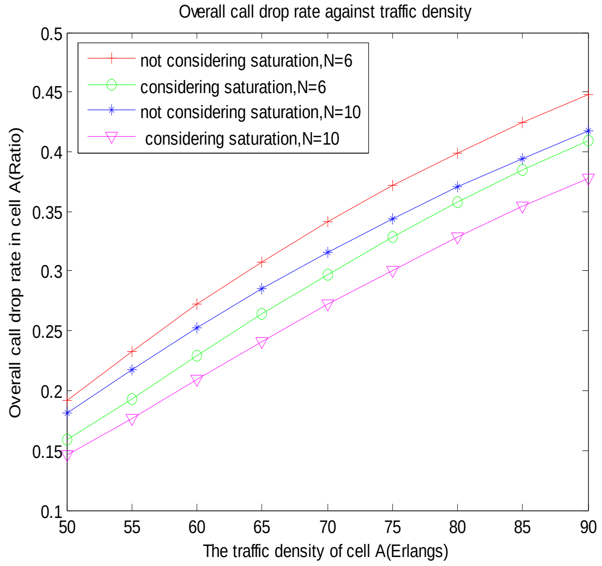

Figure.3.4 Overall call drop rate vs traffic density of cell A

If more extra traffic is introduced by handoffs, the performance of both vertical handoff algorithms, is affected and shows fall in performance i.e overall call drop rate increases. The vertical handoff considering saturation can divert more extra traffic introduced by handoffs to neighbour cells so that it shows better performance.

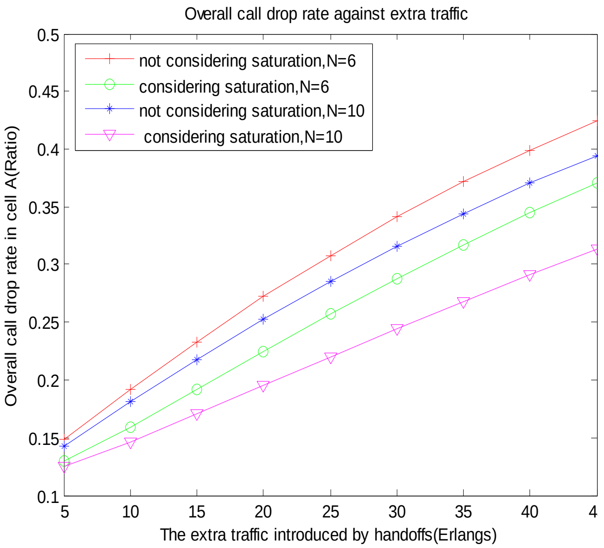

Figure.3.5 Overall call drop rate vs extra traffic introduced by handoffs

If Traffic density of cell A, T_A is set 60 and 70 Erlangs respectively. Number of TDS deployed in cell A, N is varied from1 to 10. The vertical handoff considering saturation shows a much better performance than the vertical handoff without considering saturation as shown in figure 3.6. Obviously, more TDSs added in Cell lead to more traffic diverted from Cell A to neighbour cells, and finally reduce the number of dropped calls.

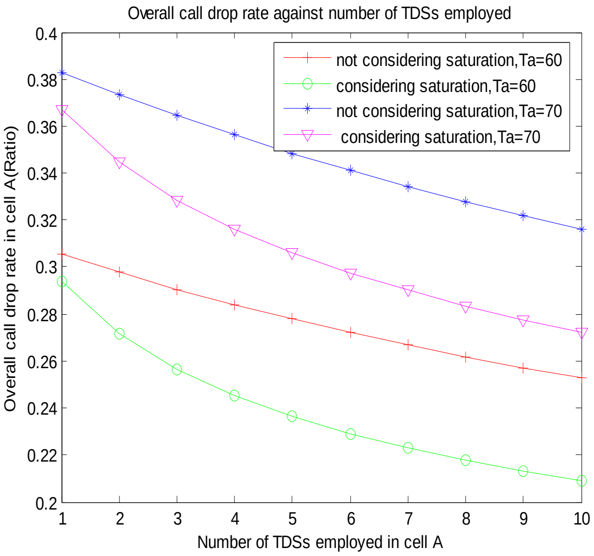

Figure.3.6 Overall call drop rate vs number of TDSs employed in cell A

6. CONCLUSION AND FUTURE SCOPE

The results obtained show that the vertical handover algorithm considering congestion aware parameters such as maximum call blocking probability and maximum transmission drop rate, provides less call drop rate as compared to the vertical handover algorithm without considering saturation in a CACN system. The call drop rate and the delay introduced by the vertical handoff should be minimum so research should be oriented towards this topic.

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