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Handover Call Management between Two Congested Neighboring Cells using Fuzzy Logic

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Abstract - *A major shift in the deployment and optimization of Cellular networks, such as small cells are being massively deployed, thus making cellular systems and networks heterogeneous. In order to operate successfully in a dense deployment, the small cells should have efficient self-organizing capabilities of the available resources to intelligently adapt themselves to the neighborhood. A novel handover algorithm targeting common sharing of resources usually excessive unused channels between densely populated cells to reduce handover failure rate is explored. The unused excessive channels of the neighborhood cells are lend to the congested cell so that User Equipment (UE) is provided Quality of Service (QoS). The candidate cell for sharing excessive channels is determined by some threshold values so that the cell may not suffer itself for want of channels in case of certain traffic inflation. The increased area of operation of the densely populated cell proportionate to the increase in traffic and correspondingly increased channels for traffic management is also described. The fuzzy logic-based simulation results show that the proposed algorithm efficiently is in line with improved successful handoffs and at the same time, handover failure ratio is also appreciably reduced.*

Key Words: Excessive Channels, Fuzzy Logic, Handover, Mobile networks, Small cells.

1.INTRODUCTION

The recent demands of accessing information anytime and anywhere has created new challenges in user profiles with new advanced applications. The explosion of the use of mobile devices and QoS in handoffs in multitier Networks affecting both the performance of the network and the user experience is given in [1]. The dense deployment of small cells is seen to enable the high capacity and as an energy efficient way of the service provisioning [2]. The future networks to deal with many small cells are deployed dynamically in a heterogeneous way. Modeling the Traffic Load of Selected Key Parameters for GSM Networks has been described in [3]. The impact of various parameters, such as offsets and timers, on the performance of the user's mobility support in heterogeneous networks is described in [4]. The exploration of device-to-device Communication in 5G: Towards Efficient Scheduling for enhanced traffic management is given in [5]. The algorithm adaptively adjusting the handover parameters based on changes in the users' mobility is presented in [6]. The main drawback of this approach is the handover decision confined to macrocell scenario only. By the deployment of small cells into network, several new issues related to handover needs arise and are to be tackled [7]. The most critical problem in handovers performed between two cells is the increased frequency (ping-pong handovers) thereby increasing the overhead processing). An improved bidirectional call overflow scheme for traffic management has been presented in [8], the performance of this scheme is encouraging except for excessive handoffs between two tiers. Mobile velocity based efficient handoffs between two layers has been presented in [9], this enables the ability of cell to retain control of call of mobile station if its velocity is within its threshold limit and avoids excessive handoffs, thus reducing overhead processing. In [10], two handover hysteresis margins are employed for energy efficient handover decision making. The first hysteresis margin is considered to avoid cells that can compromise service continuity and the second hysteresis margin identifies the cell with the minimum requirements in terms of Reference Signal Received Power (RSRP). Many researchers focus on exploitation of fuzzy logic to automate network management control for handovers. Fuzzy logic benefits from its ability to translate linguistic variables into a set of basic rules mapping the input to the output. Such rules are derived from the knowledge and experience of human expert, designing the fuzzy system. In [11], fuzzy system-based handover decision making is proposed to modify the decision-related parameters and to improve the network performance. Another fuzzy logic handover decision algorithm is presented in [12]. Bidirectional call overflow scheme between two layers of microcells and macrocells is presented in [13] where handoffs and the originating calls are decided on the basis of traffic density and availability of channels in the target cell to receive the call.

In this paper, we propose common sharing of resources between neighboring densely populated cells for improved handovers. The resources shared for efficient management of handovers are returned back after the traffic pattern changes and each cell suffices the requirement . The two thresholds in RSRP are also employed for optimizing handovers. The objective of the proposed algorithm is to reduce ratio of failed handovers so that overhead processing is reduced and more new originating calls are also accommodated.

Traffic managemnt algorithm

The handover failure is highly undesirable and at the same time not accommodating of new originating calls is also not acceptable. Both the problems need to be addressed for enhanced QoS. During peak hours the traffic load to microcells and pico cells increases particularly in downtown areas. Even the high load traffic management in congested cells becomes a challenge. The proposed solution uses to share some resources between two neighboring congested cells to combat the problem in hand. The sharing of resources (excessive channels of neighboring candidate cell) helps the congested cells for better traffic management. The increasing of channels in the congested cell acts as if its area of operation is increased proportionately and is depicted in Fig 1.

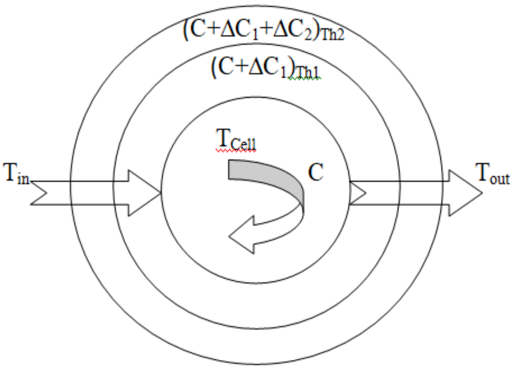

Fig.1. Traffic structure and channel assignment

Let T_{in} be the traffic entering the cell

T_{out} be the traffic leaving the cell

T_{Cell} be the traffic contained in the cell

C be the channels allocated to cell

ΔC_1 and ΔC_2 be the incremental increase in channels related to thresholds Th_1 and Th_2 respectively then

If $T_{in} > (T_{cell} + T_{out})_{Th1}$ (Yellow zone)

Channels in cell are increased from C to $C+\Delta C_1$

If $T_{in} > (T_{cell} + T_{out})_{Th2}$ (Red zone)

Channels in cell are increased from C to

Correspondingly

If $T_{in} < (T_{cell} + T_{out})_{Th2}$

Channels in cell are reduced from $C+\Delta C_1+\Delta C_2$ to $C+\Delta C_1$ and

If $T_{in} < (T_{cell} + T_{out})_{Th1}$

Channels in cell are reduced from $C+\Delta C_1$ to C

$$\Delta C_1 = \sum_{i=0}^{6} \mathrm{C_i}$$

Where C_i is the summation of first batch of pooled channels of neighboring cells (6 in hexagonal cellular system)

$$\Delta C_2 = \sum_{j=0}^{6} \mathrm{C_j}$$

Where C_j is the summation of second batch of pooled channels of neighboring cells (6 in hexagonal cellular system)

$T_{in} = T_{cell} + T_{out}$

$T_{cell} = T_{in} - T_{out}$

The handoff failure rate should be low for enhanced Quality of Service (QoS). The handover failure rate is the ratio of number of handover failures (Nfail) and number of handover attempts. The handover attempts are given by the sum of number of the failed handover and number of successful handovers (Nsucc).

$$HF = \frac{N_{fail}}{N_{fail} + N_{succ}}$$

The handoff failure rate can be low only when the successful handoffs are high, the novel approach adopted in this paper implements the common sharing of resources which implies as if we are dealing with a single cell with larger area to combat the high traffic movement. Of course the Ping-Pong effect is also optimized by signal strength threshold so that a mobile UE stays longer than the minimum critical time, If a connection is handed over to a new cell and handed back to the original cell in less than a critical time, denoted as minimum time-of-stay, the handover is considered as Ping-Pong handovers.

Load balancing by changing area of cell

The two neighboring cells may have high traffic during peak hours; but there may always be difference in traffic density. The cell with higher traffic density will increase in area and the area of its neighboring cell will proportionately decrease to combat high traffic load.

Let r_1 be radius of high traffic congested cell A and

r_2 be radius of moderately low traffic congested neighboring cell B

let n be channels allocated to cell A and

m be channels allocated to cell B then

for load balancing

the radius of cell A becomes r_1+r and

the radius of cell B becomes r_2-r and

new channels of cell A becomes n+p and

new channels of cell B becomes m-p

where p is the common shared channels between two cells and r is the change in radii in two cells proportionate to traffic loads.

$$\begin{cases} \pi r^2_{(OA)} \\ \pi {r_1}^2_{(RA1)} \\ \pi {r_2}^2_{(RA2)} \end{cases} \Leftrightarrow \begin{cases} HF \\ HF_1 \\ HF_2 \end{cases} \Leftrightarrow \begin{cases} \pi r^2_{(OA)} \\ \pi {r_1}^2_{(IA1)} \\ \pi {r_2}^2_{(IA2)} \end{cases}$$

$$\pi r_2^2 < \pi r_1^2 < \pi r^2 \qquad HF_2 < HF_1 < HF \qquad \pi r_2^2 > \pi r_1^2 > \pi r^2$$

OA = Original Area of cell

RA_1 = Reduced area '1' in non-congested cell

RA_2 =Reduced area '2' in non-congested cell

IA_1 =Increased area '1' in congested cell

IA_2 = Increased area '2' in congested cell

HF =Handover failures

2. HANDOVER DECISION USING FUZZY LOGIC

The fuzzy logic systems have been developed to manage vagueness and uncertainty in a reasoning process of an intelligent system, such as knowledge based system, an expert system or a logic control system [14]. The Fuzzy logic benefits to translate a human knowledge into a set of rules mapping the input to the output in linguistic terms. Such rules are derived from the knowledge and experience of human expert who design the fuzzy system. In [15] fuzzy system based handover decision is proposed to modify the decision related parameters and to improve the network performance. By adjusting the parameters the serving area of the cell is modified. Thus the coverage of a congested cell is reduced while the coverage of the adjacent less loaded cell is increased.

In this paper we propose common sharing resources between neighboring congested cells as if there is a virtual cell common to both the cells for optimizing handover decision parameters between the two. The architecture of the proposed fuzzy logic system is shown in Fig. 2.

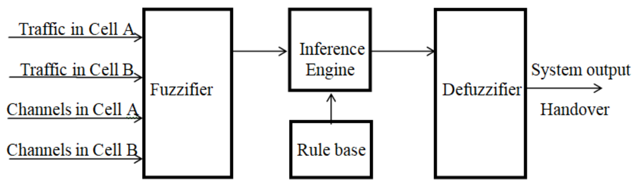

Fig. 2. Block diagram for Fuzzy logic traffic management

The first block, Fuzzifier, converts input data into suitable linguistic values, which may be viewed as labels of fuzzy sets. This stage involves transformation of the values of the input variables and a scale mapping. The scale mapping translates the range of the inputs values into corresponding universes of discourse. Then, the fuzzy representation of the non-fuzzy input values is found. The second block, Rule Data Base, defines fuzzy membership functions that allow assigning the grades of membership to the fuzzy sets.

3. RESULT AND DISCUSSIONS

Since handover mostly depends upon the available resources, either in individual cells or commonly available channels pooled so as to target for peak traffic management during busy hours. The sharing of resources will enable to continue with the ongoing call thus reducing the overhead processing or in other words hysteresis for avoiding ping pong in handoffs is maintained automatically. This will additionally help to increase the range of operation for moving a mobile station in either direction. The relationship between various effective membership functions is shown in table 1 and Fig. 3 depicts the graphical relationship between various membership variables. The three dimensional relationship between different variables is depicted in Fig. 4.

Table -1: Channel assignments with traffic density in cells

Traffic in Cell A	Traffic in Cell B	Channels in Cell A	Channels in Cell B	Handover
0.31	0.32	0.81	0.82	0.31
0.29	0.52	0.81	0.82	0.31
0.31	0.81	0.82	0.82	0.31
0.52	0.32	0.81	0.82	0.32
0.52	0.53	0.81	0.82	0.32
0.52	0.81	0.81	0.82	0.32
0.83	0.33	0.83	0.53	0.31
0.83	0.52	0.83	0.33	0.32
0.84	0.84	0.33	0.53	0.84
0.33	0.54	0.54	0.54	0.54
0.32	0.84	0.32	0.84	0.84
0.51	0.51	0.52	0.52	0.53
0.52	0.85	0.28	0.51	0.86
0.84	0.84	0.28	0.51	0.86

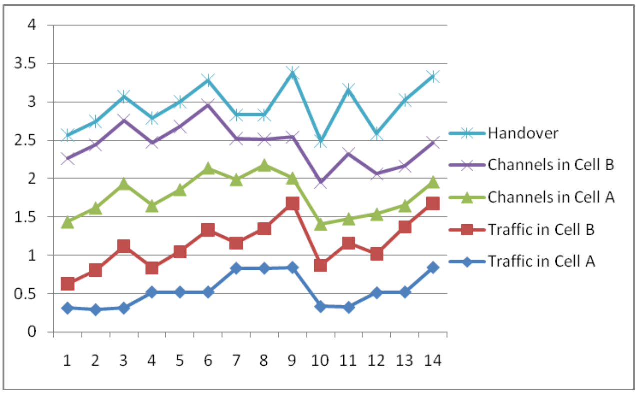

Fig. 3. Relationship between different variables

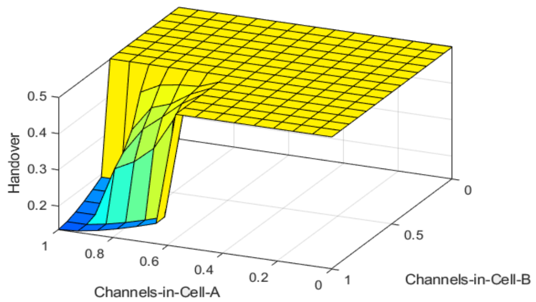

Fig. 4. 3D view of different variables

4. CONCLUSION

The sharing of common resources as per demand of increasing or decreasing traffic density in either single or both neighboring cells gives some sort of dynamic feature to the system for better traffic management. The virtual cell enables optimum handoffs with reduced overhead processing thereby allowing service to new originating calls into the system. Moreover the increased serving area of the congested cell proportionate to its due share from common resources enables the longevity of the on-going call. Inclusion of the bidirectional call overflow with the macrocell will further increase the quality of service provided by the system.

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