Fuzzy Logic Design for Handover and QoS Control in LTE HETNET

Zeinab A. aboelezz, Hala B. Nafea, and Fayez W. Zaki
Department of Electronics and Communications Engineering, Faculty of Engineering, Mansoura University, Egypt

Abstract— In heterogeneous (HetNet) networks the handover is an important process that affects the Quality of service performance. The decision of handover is the objective rule in the handover process. Due to the fact that the handover is of primary importance in QoS for LTE networks, it is considered in the present work using fuzzy logic design procedure. To determine the handover decision for macro cell or small cell a fuzzy logic design with the following input parameters: Signal-to-Interference-Noise Ratio (SINR), Data Rate, Load, Distance between user and base station and Velocity of user equipment (UE) is introduced. The proposed design is a combination of multi stages of fuzzy logic to reduce the number of rules. This will simplify the design for large input parameters, i.e., reduce the design complexity.

Moreover, a proposed three stage-fuzzy logic design for QoS in the LTE networks will also be introduced for VOIP application. The comparison carried out between the proposed design and the conventional one showed a performance improvement of the fuzzy system over the conventional one. Matlab simulation and results will be presented and discussed.

Key Words: Handover, Fuzzy logic controller, QoS.

1 INTRODUCTION

Heterogeneous networks (HetNet) are consists of mobile cellular networks such as UMTS, GSM, WLAN, WI-MAX etc. In these multicellular networks a mixture of multi-cellular has been used (e.g. macro, pico, or femto cells). Small cell is realized as the one to cover limited area and little amount power base station, while macro cell is realized as to cover big area and large amount of power base station. When, the small cell numbers have been increased, the system capacity is increased; however the amount of power consumption will be high. Hence, the users which located in the edge of small cells would achieve low amount of throughput due to the increased interference [1].

In cellular networks the basic effect of handover on the quality of service (QoS) is considered call drop. Call drop would happen because of handover failure, interference, rise bit error rate, reduced system capacity, and failure of radio link etc. [2]. To reduce the call drop the handover procedure would be improved. This in turn could maintain the desirable QoS.

The handover would occur when the user equipment (UE) moves away from one base station to another. Handover process may be classified into vertical handover and horizontal handover. Horizontal handover occurs when the mobile moves between different cells that are using the same networks technology such as, (WLAN to WLAN). On the other hand vertical handover occurs when the UE moves between different cells that are used different network technology such as, (LTE to WLAN) [3]. In LTE networks there are three types of handover [4]. The first is Hand-in handover in which the user moves from a macro cell to a small cell. The second is Hand-out in which the user moves from a small cell to a macro cell. The third is the Hand-off in which the user moves from a small to a small cell.

In [5] handoff control for microcellular mobile networks using fuzzy logic was presented. The effect of received signal strength, the load, and the distance between base station and user was considered upon the handover decision. The authors in [6] take speed, direction, distance, load, and signal strength into consideration in their fuzzy logic design. Authors in [7] designed intelligent handover decision process using fuzzy logic system and in addition to various QoS parameters has been introduced. A simulation of fuzzy logic model for vertical handover in heterogeneous networks using eight input parameters was presented in [8]. The results illustrated the improved performance and reduced complexity. Service aware fuzzy logic based handover decision for heterogeneous wireless network was introduced in [9]. Authors take into account type of service to determine the handover decision between macro and femto cells was presented. A context aware fuzzy logic based vertical handoff decision strategies for heterogeneous wireless network were introduced in [10]. The authors take into consideration the available bandwidth, bit error rate, jitter, and end to end delay as parameters for QoS.

Fuzzy logic is an intelligent decision-making technique which has the ability to treat inaccurate, and/or un-modeled data to support in solving control troubles. In the present work the fuzzy logic is introduced to determine the handover decision of macro base station and small base station with different mechanism parameters. In the decision design, to pick out the appropriate cell the velocity of user was taking into consideration. Therefore, at high velocity the macro cell was chosen, whereas at low velocity a small cell was chosen [9]. Moreover, the QoS of LTE for various applications are evaluated using fuzzy logic [11].

The paper is organized as follows: part 2 introduces system model, part3 introduced steps of design for fuzzy inference system, and part 4 presents comparison between proposed system and the conventional one, part5 presents the design of fuzzy logic to evaluate the Quality of service for LTE networks and LTE VOIP application.

2 System Model

The system consists of two-tier HetNet which contain a set of macro cells overlaid with small cells within the coverage area of macro cells. The HetNet base station consists of a group of macro base stations (M) and small base stations (S), where $M=(m_1,m_2,\ldots\ldots\ldots,m_M)$, $S=(s_1,s_2,\ldots\ldots\ldots\ldots,s_S)$ respectively. Therefore, all HetNet base station is ($B=M\cup S$). The user equipments (UEs) given by $K=(k_1,\ldots\ldots.,k_{NUE})$ are uniformly distributed over the entire area. All of the user equipments have the same frequency band and all of them move randomly as shown in Fig. 1.

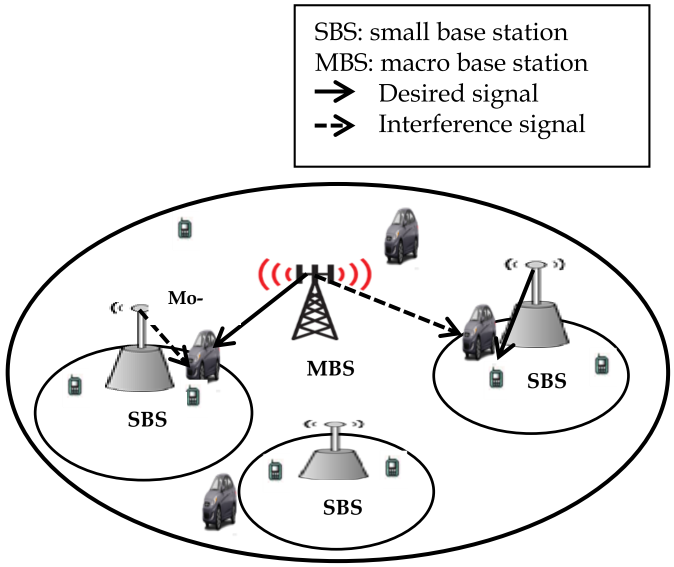

Fig. 1, Two Tier HetNet with Small Cells and Mobile Users

If user k is served by base station $b \in B$, the signal to interference and noise ratio of the user γ_b^k can be expressed by [12]:

$$\gamma_b^k(x,t) = \frac{p_b(t) g_b^k(x,t)}{\sum_{b' \neq b} p_{b'}(t)\, g_{b'}^k(x,t) + N_0} \quad (1)$$

Where, $p_b(t)$ is the down link transmission power at time t, $g_b^k(x,t)$ denotes the total channel gain including path loss and lognormal shadow fading from the user location x to the base station and N0 is the thermal noise power spectral density. The maximum data rate of user k with bandwidth B is given by the Shannon theorem as [12]:

$$C_K(x,t) = B \log_2\left(1 + \gamma_b^k(x,t)\right). \quad (2)$$

When UES achieve constant bit rate R_K, the base station load is expressed as [12]:

$$\tau_b(t) = \sum_{k \in k_b} \frac{R_K}{C_k(x,t)}. \quad (3)$$

3 Steps of Design for Fuzzy Inference System

Step One: Determine the input parameters: distance between the base station and mobile, velocity, Signal to Interference-Noise Ratio (SINR), Data Rate, and Load. The last three parameters are calculated from equations (1, 2 and 3). Matlab simulation will be used for an LTE network having a single macro cell at the origin and small cells with UE's uniformly distribution on the entire geographical area as shown in Fig. 2.

The simulation parameters used are shown in Table 1. The simulation results for each macro and small cells are tabulated in Table 2.

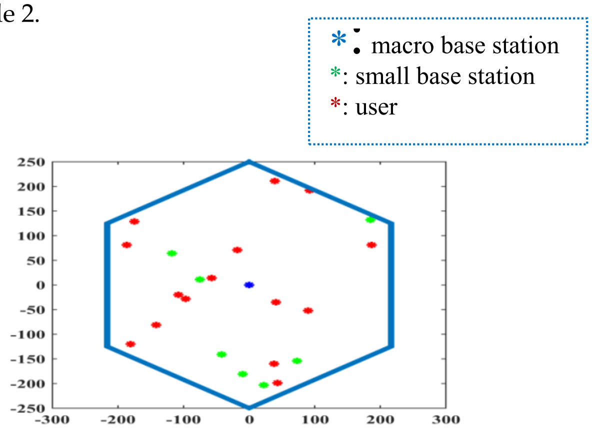

Fig. 2, Two Tier HETNET Macro Base Station at The Origin and Group of Small Cells Cover The Entire Area.

TABLE1
SIMULATION PARAMETER

Parameter	MBS Macro base station	PBS (Pico Base Station)
Cell radius	250m	20m
Number of cell	1NMBS	7NSBS
Minimum distance	75m for MBS-SBS 35m for MBS-UE	40 m for SBS-SBS 10 m for PBS-UE
Minimum load	0.1	0.1
Max TX power	46dBm	30dBm
System parameter		
Packet arrival rate	1 kpbs	
Mean packet size	1800 bits	
Channel bandwidth (B)	10 MHZ	
Number of users(NUE)	15	
Velocity of users	0-120 KM/H	

TABLE 2,
SIMULATION RESULTS

Macro cell	SINR	14-46 dB
	Data rate	5-154 Mbps
	load	0.1-0.9
Small cell	SINR	0-22 dB
	Data rate	10-73 Mbps
	load	0.1-0.7

Step Two: The crisp input must be converted into linguistic variables. Therefore, this step is known as fuzzification step. The input is fuzzified using membership functions. The membership functions used in the present work are triangular and trapezoidal functions. Note that the triangular shape and trapezoidal shape functions are expressed respectively as:

$$\mu(x) = \begin{cases} \dfrac{x-a}{b-a}, & a \le x \le b \\ \dfrac{c-x}{c-b}, & b \le x \le c \end{cases} \quad (4)$$

for triangular shape and

$$\mu(x) = \begin{cases} \dfrac{x-l}{m-l}, & l \le x \le m \\ 1, & m \le x \le n \\ \dfrac{u-x}{u-n}, & n \le x \le u \end{cases} \quad (5)$$

for trapezoidal shape.

The membership functions for macro base station inputs and small base station (distance, load, SINR, DATA-RATE, and velocity) are shown in Fig. 3 and Fig. 4 respectively:

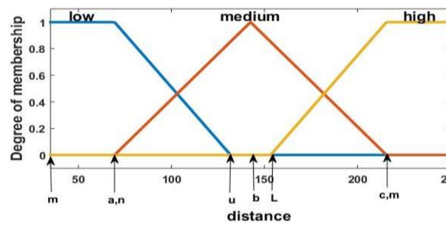

Fig. 3 (a), Membership Function of Distance

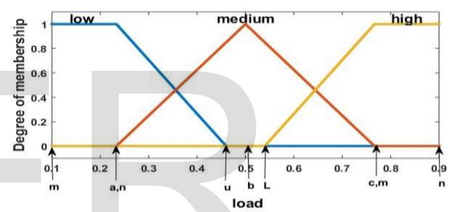

Fig. 3 (b), Membership Function of Load

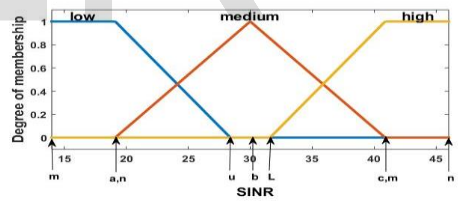

Fig. 3(c), Membership Function of SINR

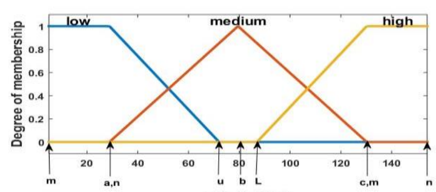

Fig. 3 (d), Membership Function of DATA-RATE

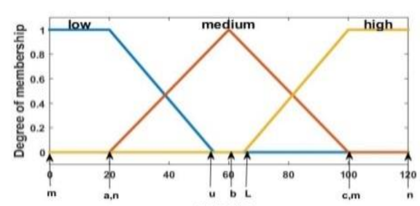

Fig. 3 (e), Membership Function of Velocity

Fig. 3, Membership Functions for Input Parameters of Macro Base Station

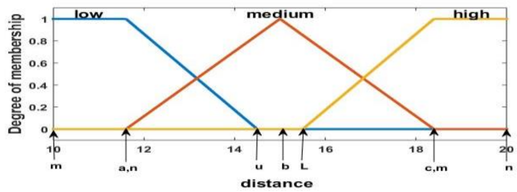

Fig. 4(a), Membership Function of Distance

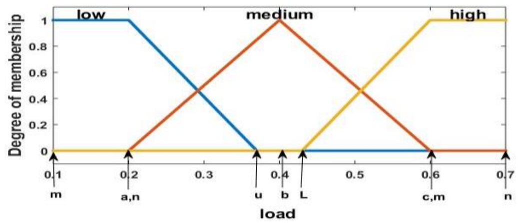

Fig. 4(b), Membership Function of Load

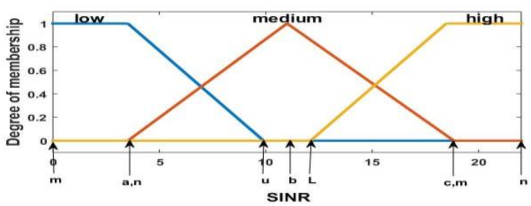

Fig. 4(c), Membership Function of SINR

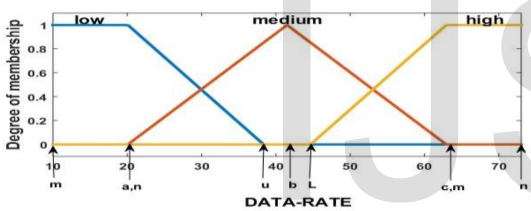

Fig. 4 (d), Membership Function of DATA-RATE

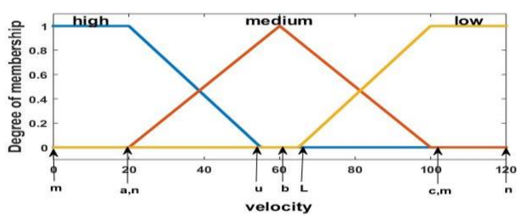

Fig. 4(e), Membership Function of Velocity

Fig. 4, Membership Function of Input Parameters for Small Cell

Step Three: Perform a rule base between input and output. The rule base take the form of IF….AND….OR, THEN with the operations AND, OR, etc. The number of the rules =MN. Where, M is the number of sets (low, medium, high) and N is the number of inputs so the number of rules=35 =243 rules. Note that the number of rules is very large. Therefore, a new design is introduced to reduce the number of rules using three fuzzy logic with five inputs instead of just one fuzzy logic. This proposed design is shown in Fig. 5. The first fuzzy logic with input parameters (distance and load) and the outputs (distance-loadfactor), the second fuzzy logic with inputs(SINR and DATA-RATE) and outputs (SINR-RATEFACTOR), the third fuzzy logic with inputs (SINR-RATEFACTOR, distance-loadfactor and velocity) and the output is handover decision factor (HOF). The AND logic operation is used to determine the firing strength αi as expressed by

$$\alpha_i = \mu(\text{first input})\times\mu(\text{second input})\times\mu(\text{third input}) \quad (6)$$

Where, μ (first input), μ (second input), and μ (third input) is the membership function of first input, second input and third input respectively. The output rule (zi) is determined by multiplication of the firing strength αi with membership function of the output.

Step Four: Defuzzification which determines the weighted average of all the output rules specified by

$$W=\frac{\sum_{i=1}^{N}\alpha_i z_i}{\sum_{i=1}^{N}\alpha_i} \quad (7)$$

Where z_i is the output membership function value of the rule i, and W specifies the Handover of MBS and SBS.

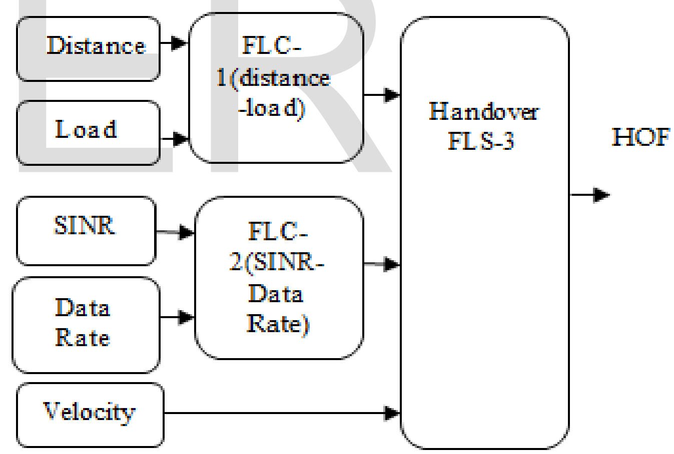

Fig. 5, Fuzzy Logic Controller for the Handover Decisoion

5.1 Fuzzy Logic Design for Macro Cell and Small Cell

First Fuzzy Logic: It has two input parameters (distance and load) and one output (distance-loadfactor). The membership function of output for first fuzzy logic is shown in Fig.6, and the output surface for macro and small cell between distance, network load and distance-loadfactor are shown in Fig.7 and Fig. 8respectively.

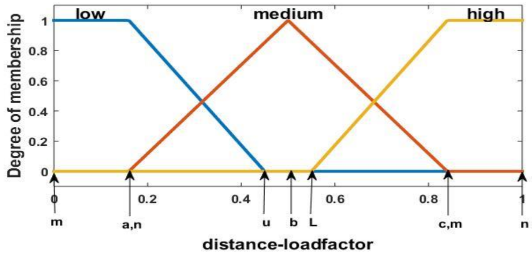

Fig. 6, MembershipFunction of Distance-Load Factor

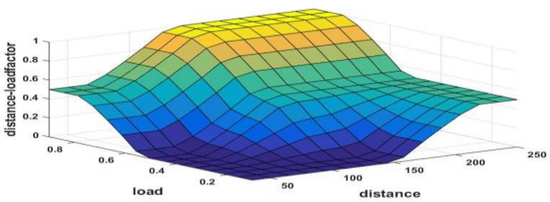

Fig. 7, Output Surface between Network Load, Distance, and Distance-Load Factor for Macro Cell

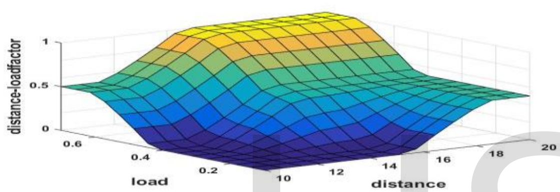

Fig. 8, Output Surface between Network Load, Distance, and Distance-Load Factor for Small Cell

It is seen from Fig. 7 and Fig. 8, that the distance-loadfactor is increased as both the distance and load increase. For macro cell the distance greater than 142 meter and the load greater than 0.5, the distance-loadfactor is greater than 0.5. However, the distance would equal to 250 meter at a load equal to 0.9 and the distance-loadfactor is equal to 1. For small cell the distance greater than 15 meter and the load greater than 0.4, the distance-loadfactor is greater than 0.5. However, the distance would equal to 20 meter at a load equal to 0.7 and the distance-loadfactor is equal to 1.

Second Fuzzy Logic: It has two input parameters (SINR and DATA-RATE) and one output (SINR-RATEFACTOR). The membership function for output of second fuzzy logic is shown in Fig. 9 and the surface curve for macro and small cell between SINR, DATA-RATE, and SINR-RATEFACTOR are shown in Figs. 10 and 11 respectiviely.

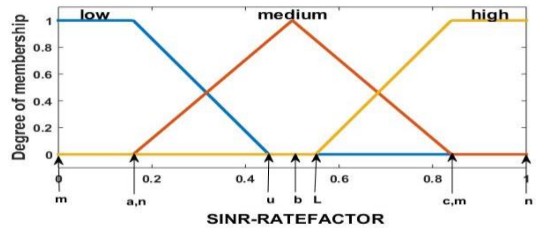

Fig. 9, Membership Function of SINR-RATEFACTOR

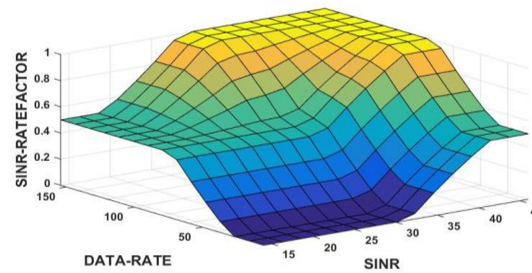

Fig. 10, Output Surface between SINR, DATA-RATE, and SINR- RATE-FACTOR

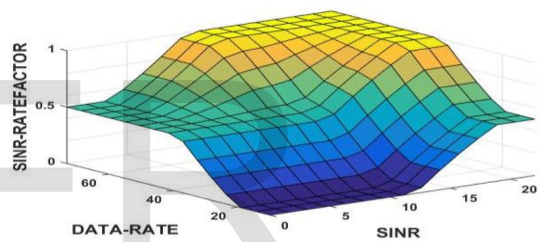

Fig. 11, Output Surface Between SINR, DATA-RATE and SINR-RATEFACTOR

It is seen from Fig. 10 and Fig. 11, that the SINR-RATEFACTOR is increased as the SINR and DATA-RATE increase. For macro cell the SINR greater than 30 dB and the DATA-RATE greater than 80Mbps, the SINR-RATEFACTOR is greater than 0.5. However, the SINR would equal to 46 dB at a DATA-RATE equal to 154 Mbps and the SINR-RATEFACTOR is equal to 1. For small cell the SINR greater than 11 dB and the DATA-RATE greater than 41.5Mbps, the SINR-RATEFACTOR is greater than 0.5. However, the SINR would equal to 22 dB at a DATA-RATE equal to 73 Mbps and the SINR-RATEFACTOR is equal to 1.

Third Fuzzy Logic: The membership functions of outputs for the first and second fuzzy logic (distance-loadfactor and SINR-RATEFACTOR) shown in Fig. 6 and Fig. 9, were used as inputs for the third fuzzy logic. Therefore, the third fuzzy have three input parameters (distance-loadfactor, SINR-

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RATEFACTOR, and velocity) and one output (macro base station Handover factor and small base station handover factor). The membership function of the maco base station handover factor (MBS-HOF & SBS-HOF) is shown in Fig.12, and its output surface between distance-loadfactor, SINR-RATEFACTOR, and MBS handover factor and SBS-HOF are shown in Fig.13 and Fig. 14 respectively.

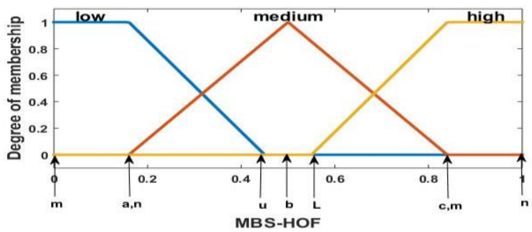

Fig. 12, Membership Function of Macro Base Station Handover Factor (MBS-HOF&SBS-HOF)

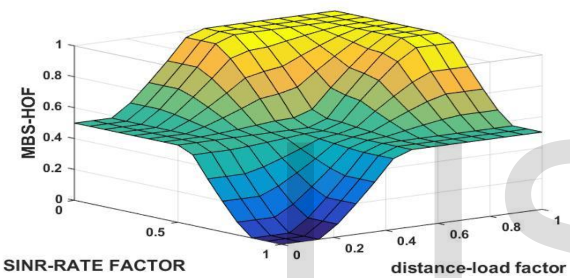

Fig.13, Output Surface between SINR-RATEFACTOR, Distance-Load Factor and Handover Decision

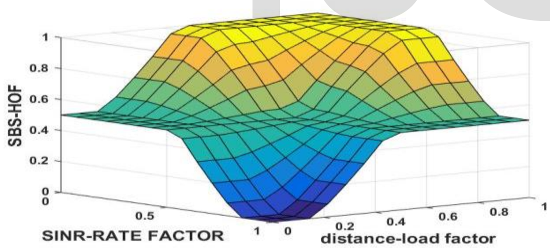

Fig.14, Output Surface between SINR-RATEFACTOR, Distance-Load Factor and SBS-HoF

It is seen from Fig. 13, that the macro base station handover factor (MBS-HOF) is increased as the distance-loadfactor increase and decrease of the SINR-RATEFACTOR. For SINR-RATEFACTOR less than 0.5 and the distance-loadfactor greater than 0.5, the MBS-HOF is greater than0. 5. However, the SINR-RATEFACTOR would equal to 0.1 at a distance-loadfactor equal to 1 and MBS-HOF equal to 1, where velocity equal 20 km/h.

It is seen from Fig. 14, that the SBS-HoF is increased as the distance-loadfactor increase and decrease of the SINR-RATEFACTOR. For SINR-RATEFACTOR less than 50% and the distance-loadfactor greater than 0.5, the SBS-HoF is greater than0. 5. However, the SINR-RATEFACTOR would equal to 0.1 at a distance-loadfactor equal to 1 and SBS-HoF equal to 1, where the velocity equal to 100 km/h.

When the user moves in the macro cell, there will be two cases may occur either user handover to small cell or remains in macro cell. Therefore, handover for macro cell must be estimated. Simulation results for the handover factor as a function of velocity for macro cell at different values of distance-loadfactor are shown in Fig. 15(a). Similar results for handover factor as a function of velocity at different values of SINR-RATEFACTOR are shown in Fig. 15(b). It is noticed that, in Fig. 15(a), as the distance-loadfactor increases the handover increases whereas, in Fig. 15(b), as the SINR-RATEFACTOR increases the handover factor decreases.

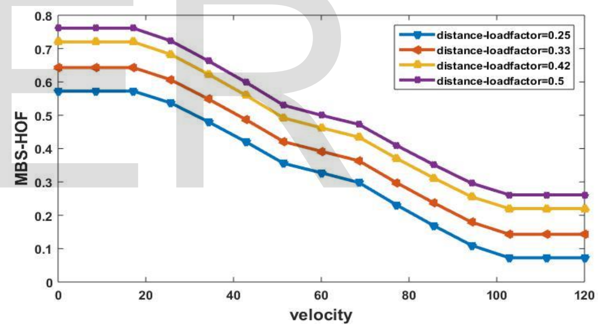

Fig. 15(a), Handover Factors as a Function of Velocity for Different Values of Distance-Load Factors

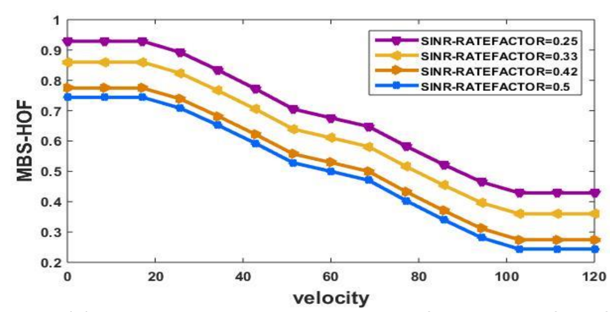

Fig. 15(b), Handover Factors as a Function of the Velocity for Different Values of SINR-RATEFACTORS

Fig. 15, Design of Handover FLC for Macro Base Station (MBS)

When the user moves in the small cell, there will be two cases may occur either user handover to macro cell or remains in small cell. Therefore, handover for small cell must be estimated. Simulation results for the handover factor as a function of velocity for small cell at different values of distance-loadfactor are shown in Fig. 16(a). Similar results for handover factor as a function of velocity at different values of SINR-RATEFACTOR are shown in Fig. 16(b). It is noticed that, in Fig. 16(a), as the distance-loadfactor increases the handover increases whereas, in Fig. 16(b), as the SINR-RATEFACTOR increases the handover factor decreases.

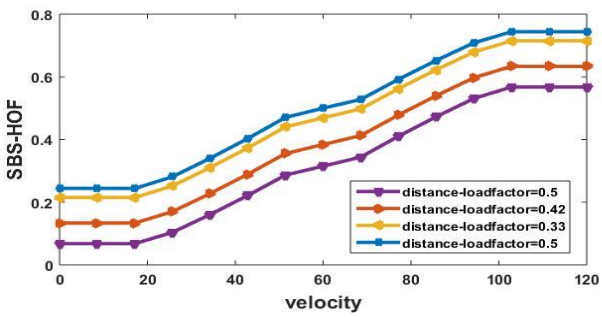

Fig. 16 (a), Handover Factors as a Function of the Velocity at Different values of Distance-Load Factor.

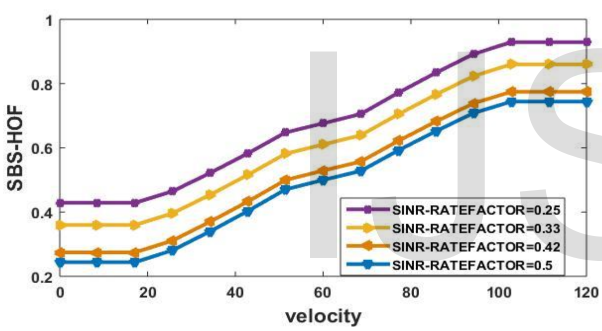

Fig. 16(b), Handover Factors as a Function of the Velocity at Different values of SINR-RATEFACTOR.

Fig. 16, Design of Handover FLC for Small Base Station (SBS)

4 Comparison between proposed system and the conventional one

In this part of study a performance comparison has been conducted between our proposed system and the conventional one for two cases macro cell system and small cell system and the results are shown in Figs. 17, 18, and 19. From these figures it is noticed that our system provides improvement of handover factor than the conventional system by about 87% for handover factor from macro to small cells (Fig. 17). However, for handover factor from small to macro cells our system provides an improvement of about 46.8% over the conventional one (Fig. 18). In Fig. 19 the proposed system provides an improvement in the throughput of about 21.9% over the conventional one. Note that, the handover factor of conventional system is estimated using equ (20) in [15] and cell throughput using equ (12) in [16], then the total system throughput which is the sum of the system cells throughput.

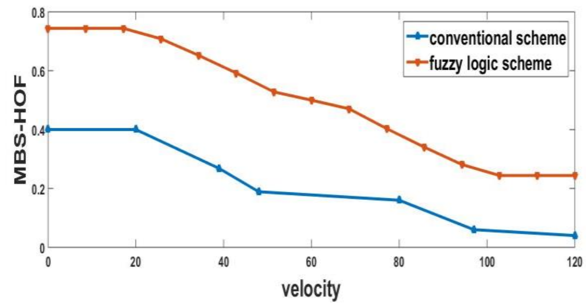

Fig. 17, Handover Versus UE Velocity for Macro Cell

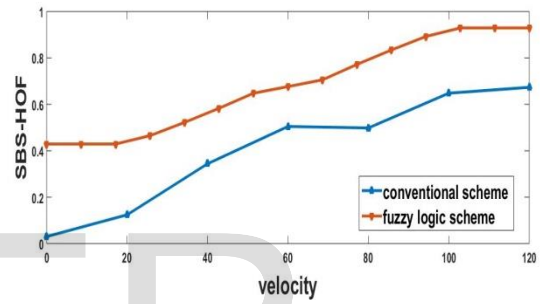

Fig. 18, Handover Versus UE Velocity for Small Cell

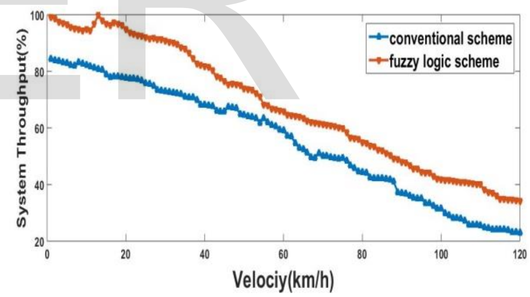

Fig. 19, System Throughput Versus UE Velocity (km/h)

5 Quality of service of LTE network

The second objective of the work reported here is to design a fuzzy logic implementation for the QoS in LTE networks. There are many parameters that affect the Quality of service (QoS) of the LTE network such as delay, loss rate, throughput and jitter. Three stages are design to calculate the quality of service. The first stage determines the handover decision of macro and small cell for the network as shown in Fig. 5, the second determines the effect of handover decision on the data loss rate as shown Fig. 20, and the third determines the Quality of services (QoS) of the networkas shown in Fig. 28.

The loss rate of the network is determined by two parameters, the handover factor and coverage area as shown in Fig. 20. Where the coverage area of LTE macro and small cells is given byπR^2, and R is the radius of LTE macro and small cells.

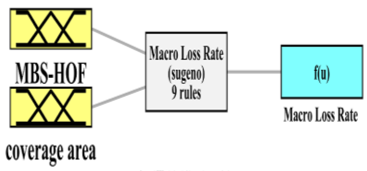

Fig. 20(a), Macro LTE Loss RATE

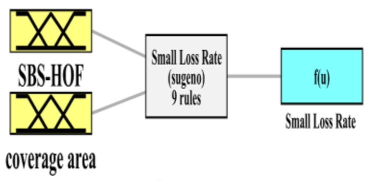

Fig. 20(b), Small LTE Loss RATE

Fig. 20, LTE System Loss Rate (2 Inputs, 1Output and 9 Rules)

The values of MBS-HoF and SBS-HoF has ranged from 0 to 1 as shown in Fig. 12. The coverage area of macro cell value has ranged from 4 to 196 km and small cell has ranged from 0.3 to 1.3 km according to the boundary parameters a, b, c, l, m, n, and u as shown in Figs. 21 and 22 respectively.

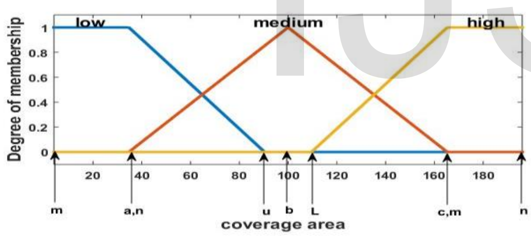

Fig. 21, Membership Function of Coverage Area of Macro Cell LTE

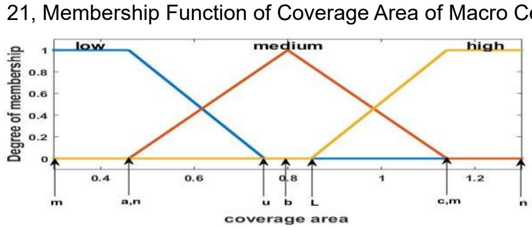

Fig. 22, Membership Function of Coverage Area of Small Cell LTE

The number of rules $=3^2=9$ as shown in Table 3. Membership function of loss rate can be calculated from equations (4 and 5). The value of loss rate has ranged from 1 to 3 as shown in Fig. 23. The output surface between the handover factor, coverage area of macro and small cells and LTE loss rate are shown in Figs. 24 and 25 respectively.

TABLE 3

RULE THAT DETERMINED THE LOSS RATE OF NETWORK

Rule No	Handover factor	Coverage area	Loss rate
1	low	low	high
2	low	medium	high
3	low	high	medium
4	medium	low	high
5	medium	medium	medium
6	medium	high	low
7	high	low	medium
8	high	medium	low
9	high	high	low

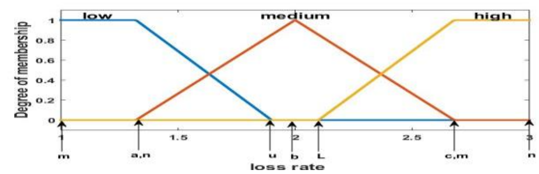

Fig. 23, Membership function of LTE Loss Rate

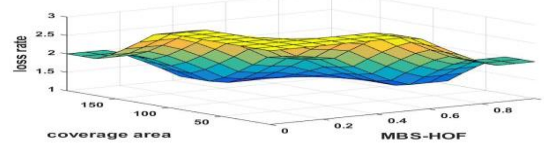

Fig. 24, Output Surface between MBS-HoF, Coverage Area of Macro Cell, and Loss Rate

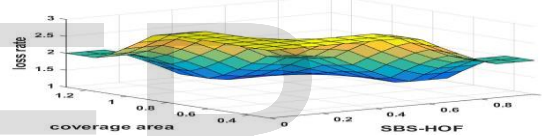

Fig. 25, Output Surface between SBS-HoF, Coverage Area of Small Cell, and Loss Rate

It is seen from Figs. 24 and 25, that the loss rate of LTE is increased as the handover factor and coverage area decrease. For macro base station handover factor (MBS-HoF) greater than 0.5 and the coverage area of macro cell greater than100km, the loss rate is less than 2%. For small base station handover factor (SBS-HoF) greater than 0.5 and the coverage area of small cell greater than 0.8km, the loss rate is less than 2%.

The Quality of service of LTE network can be determined by designed the fuzzy logic with four inputs delay, loss rate, throughput, and jitter and one output Quality of service (QoS) of LTE network as shown in Fig. 28.

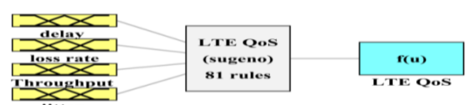

Fig. 28, System LTE QoS (4 Inputs, 1Output and 81Rules)

Membership function of input parameters delay, loss rate, throughput, and jitter can be calculated from equations

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(4 and 5). Where the value of delay has ranged from 40 to 60, loss rate from 1 to 3, throughput from 40 to 100, and jitter from 20 to 60 according to the boundary parameters a, b, c, l, m, n, and u as shown in Fig. 29. The number of the rule $=3^4=81$ rules as shown in Table 4. The output surface of the Quality of service of LTE network is shown in Fig. 30.

It is seen from Fig. 30, that the LTE QoS is increased as delay and loss rate decrease. For delay less than 50ms and the loss rate less than 2%, the LTE QoS is greater than 25%. However, the delay would equal to 40ms at loss rate equal to 1% and LTE QoS equal to 100%, where throughput equal to 100Mbps and jitter equal to 20 ms.

TABLE 4
FUZZY RULE TO DETERMINE THE QUALITY OF SERVICE (QOS) OF LTE NETWORK

No rule	Delay	Loss rate	Throughput	jitter	QoS
1	Low	low	low	low	medium
2	Low	low	low	medium	l-medium
3	Low	low	low	high	low
4	Low	low	medium	low	m-high
5	Low	low	medium	medium	medium
25	Low	high	high	low	l-medium
26	Low	high	high	medium	low
27	Low	high	high	high	low
28	Medium	low	low	low	l-low
29	Medium	low	low	medium	low
30	Medium	low	low	high	low
75	High	high	low	high	low
76	High	high	medium	low	low
77	High	high	medium	medium	low
78	High	high	medium	high	low
79	High	high	high	low	low
80	High	high	high	medium	low
81	High	high	high	high	low

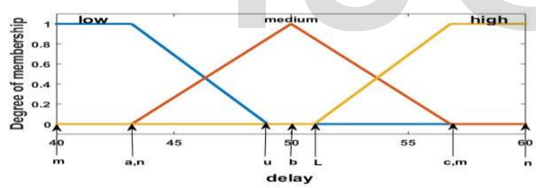

Fig. 29 (a), Membership Function of LTE Delay

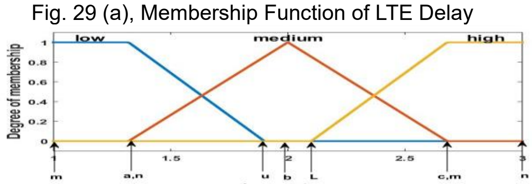

Fig. 29(b), Membership Function of LTE Loss Rate

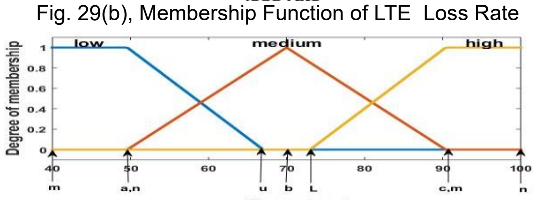

Fig. 29(c), Membership Function of LTE Throughput

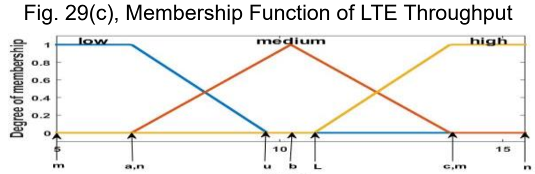

Fig. 29(d), Membership Function of LTE Jitter
Fig.29, Membership Function of LTE QoS Parameters

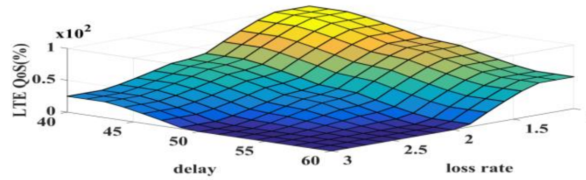

Fig. 30, Output Surface between Delay, Loss Rate, and LTE QoS

In Fig. 31, the LTE Quality of service (QoS) is decreased as the delay, loss rate, and jitter increase, so these parameters are inversaly proportinal with the LTE QoS. As the throughput increased the LTE QoS increased so the throughput is directly proportional with LTE QoS.

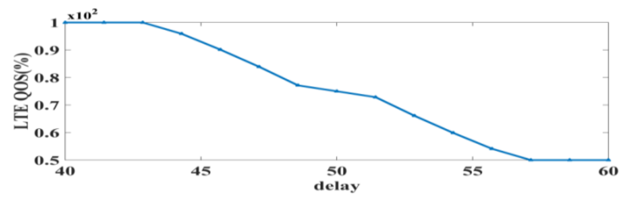

Fig. 31(a), LTE QoS as a Function of Delay

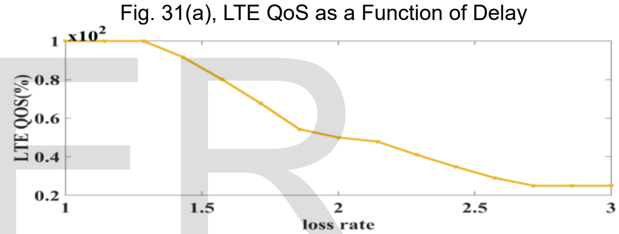

Fig. 31(b), LTE QoS as a Function of Loss Rate

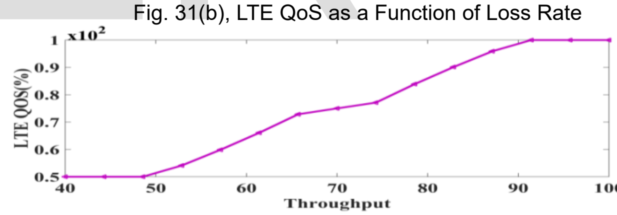

Fig. 31(c), LTE QoS as a Function of Throughput

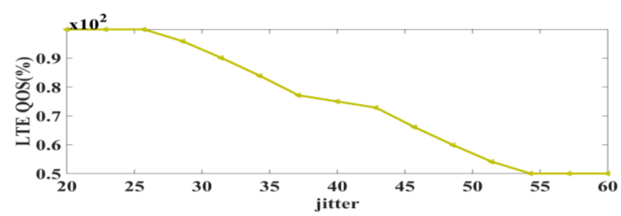

Fig. 31(d), LTE QoS as a Function of Jitter

Fig. 31, LTE QoS as a Function of Delay, Loss Rate, Throughput, and Jitter

5.1LTE Quality of Service (QoS) for VOIP Application

Fuzzy logic is designed to determine the quality of service of VOIP application. Fuzzy has four inputs delay, loss rate, throughput, and jitter. The number of the rule$=3^4=81$

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rules as shown in Table 4.

In Fig.32, the LTE QoS of VOIP as a function of delay, loss rate, throughput, and jitter. As the delay, loss rate, and jitter increased the QoS decreased but the throughput increased the QoS increased for each application.

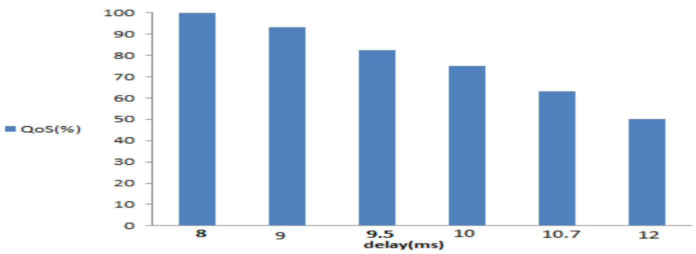

Fig. 32(a), LTE QoS as Function of Delay for VOIPApplication

Fig. 32(b), LTE QoS as Function of Loss Rate for VOIP Application

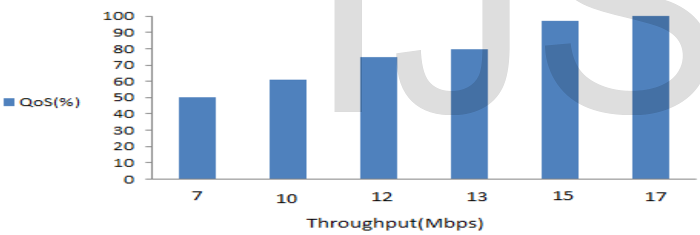

Fig. 32(c), LTE QoS as Function of Throughput for VOIP Application

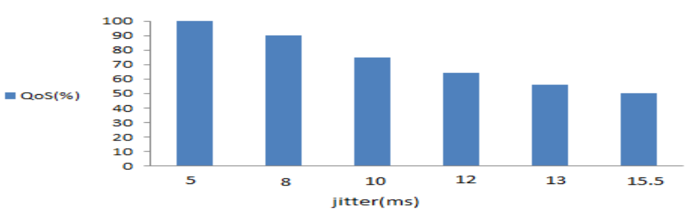

Fig. 32(d), LTE QoS as Function of Jitter for VOIP Application

Fig. 3.32, LTE VOIP QoS

6 Conclusion

This paper a study for the handover of LTE network with large number of inputs based on fuzzy logic. The proposed design reduced the number of rules for large number of inputs by design more than one fuzzy logic. The effect of handover decision on the loss rate as an input parameter that affects the QoS of LTE network is designed by the fuzzy logic with other parameters such as: delay, loss rate, throughput, and jitter which are used to calculate QoS performance of LTE network. A study was conducted for handover and throughput to compare between our proposed system and the conventional one [14] and the results showed a performance improvement of fuzzy system over the conventional system. Finally this paper shows QoS for VOIP. The simulation results were obtained using Matlab simulation programs.

References

[1] K. Son, S. Lee, Y. Yi, S. Chong, “ REFIM: A Practical Interference Management in Heterogeneous Wireless Access Networks”, IEEE, Journal On Selected Areas In Communications(JSAC), Vol. 29,No. 6, pp. 1260–1272, June2011.

[2] P. Sankar, Dhanya, “Call Drop Improvement in the Cellular Network, by Reducing the Bit Error Rate” International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering (IJAREEIE), Vol. 5, No. 2, pp. 1117–1122, February 2016.

[3] T. Velmurugan, S. Khara, S. Nandakumar, D. Sumathi, “seamless Vertical Handoff Using Modified Weed Optimization Algorithm for Heterogeneous Wireless Networks”, Izvestiya Vysshikh Uchebnykh Zavedenii, Radio electronica (IVUZ), RE, Vol. 60,No. 10, pp. 559–580, 2017.

[4] D. K. Bhargavi, A. M. Vijaya, “A Novel Handover Algorithm For LTE based Macro-Femto Heterogeneous networks” International Journal of VLSI design and Communication Systems(IJVLSICS), Vol. 6, No4, pp. 25-33, August 2015.

[5] D. C. Sati, P. Kumar, Y. Misra, “Fuzzy Logic Based Handoff Controller for Microcellular Mobile Networks” International Journal of Computational Engineering and Management (IJCEM), Vol. 13, pp. 28–32, July 2011.

[6] M. A. Monil, R. Qasim, R. M. Rahman, “Speed and Direction Based Fuzzy Handover System”, IEEE International Conference on Fuzzy Systems (ICFS), pp. 1-8, July 2013.

[7] P. Tillapart, T. Thumthawatworn, P. Viriyaphol, P. Santiprabhob, “Intelligent Handover Decision Based on Fuzzy Logic for Heterogeneous Wireless Networks”, IEEE (ECTI-CON), pp. 1-6, August 2015.

[8] H. Gill, S. Baghla, “A New Fuzzy Simulation Model for Vertical Handoff in Heterogeneous Networks” SSRG International Journal of Electronics and Communication Engineering (SSRG-IJECE), Vol. 1, pp. 24-29, August 2014.

[9] M. M. Rahman, M. Z. Chowdhury, “Service Aware Fuzzy Logic Based Handover Decision in Heterogeneous Wireless Networks”, IEEE Electrical, Computer and communication engineering (ECCE), pp. 686-691, February2017.

[10] M. S. Kausar, D. Cheelu, “Context Aware Fuzzy Rule Based Vertical Handoff Decision Strategies for Heterogeneous Wireless Networks”, International Journal of Engineering and Science (IJES), Vol.3, Issue 7, pp. 06-12, August 2013.

[11] S. Radouche, C. Leghris, A. ADIB, “MADM Methods Based on Utility function and Reputation for Access Network Selection in a Multi-access Mobile Network Environment”, IEEE International Conference on Wireless Networks and Mobile Communications (ICWNMC), pp. 1-6, 2017.

[12] A. H. Arani, M. J. Omidi, A. Mehbodniya , F. Adachi, "A Handoff Algorithm Based on Estimated Load for Dense Green 5G Networks", IEEE Conferences, 2015 IEEE Global Communication Conference(GLOBECOM),San Diego, CA, USA, pp. 1-7, 2015.

[13] . S. S. Sawant, N. K. Vernekar, "Adaptive Distance Handover scheme in mobile wimax ", International Journal on Advanced Computer Theory and Engineering (IJACTE) , Vol. 2, Issue 3, pp. 87-91, 2013.

[14] . A. Bijwe, C. G. Dethe, "RSS based Vertical Handoff algorithms for Heterogeneous wireless networks - A Review", International Journal of Advanced Computer Science and Applications (IJACSA), pp. 62-67.

[15] P. Lal, V. Yamini, N. Mohammed, "Handoff mechanisms in LTE networks", IOP Conference, Materials Science and Engineering, 2017.

[16] M. Saeed, M. El-Ghoneimy, and H. A. Kamal, "Solving LTE Handover Problem Using a New Fuzzy Logic Optimization Technique", International Journal of Development Research(IGDR), Vol. 06, Issue, 12, pp.10587-10593, December, 2016.

Biographies

Zeinab A. Aboelezz has received B.Sc degree from Department of Communications and Electronics Engineering, Misr Higher Institute for Engineering and Technology, Mansoura, Egypt. She is now an M.Sc student at Dept. of Electronics and Communications Eng., Faculty of Engineering, Mansoura University, Egypt. Her research interest is in the area of Communications networks.

Hala B. Nafea has received B.Sc, M.Sc, and Ph.D. degrees from Department of Electronics and Communications Engineering, Faculty of Engineering, Mansoura University, Egypt. She is now an assistant professor in the Dept. of Electronics and Communications Eng., Faculty of Engineering, Mansoura University. Her main research interests are in Digital Communications, Mobile Communications and Communications Networks.

Fayez Wanis Zaki is a professor at the Department of Electronics and Communications Engineering, Faculty of Engineering, Mansoura University, Egypt. His main research interests are in Digital Communications, Mobile Communications, Communications Networks, Speech and Image Processing. He is with Dept. of Electronics and Communications Eng., Faculty of Engineering, Mansoura University since 1969. He has received his Ph.D from Liverpool University in 1982. He supervised several M.Sc and Ph.D. thesis. He is now a member of the professorship promotion committee in Egypt.