Research Paper: Comparative Evaluation of Soft Computing Techniques in Intersystem Handoff Algorithms

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Abstract— This research work is carried out in the field of inter-system handovers. The next generation communication depends upon many types of co-existing mobile communication Systems/Networks normally GSM/ WCDMA Networks, Satellite communication based networks, high altitude stratospheric platform systems (HAPS). An individual have to move from one area covered by one type system to another area covered by different kind of Technology/Network. This inter-system handoff assumes significance for seamless communication without call being dropped. So in this seamless communication, when strength of signal of one system goes down in the mean time the signal of another system reaches high. So call will be handed over to another system without any interruption. But if the mobile station moves in overlapped region of intersystem again and again, then the rate of handoff become very high and this causes an affect called as ping pong. In this work, there is implementation of Fuzzy System based and Neural Network based ping pong avoidance algorithm for intersystem handoff. In this a comparison between two systems is also presented. This work is to find out the optimality of intelligent systems such as fuzzy and neural networks in saving the cost of handover between two networks and finding the critical factors and their sensitivity in determining the requirement of handoff.

Key words: Handoff, Intersystem Handoff, Fuzzy system, Neural System, Soft Computing Techniques

I. Introduction

A. Cellular Networks

M.G. Marconi did the pioneer work establishing the first successful radio link between a land based station and a tugboat, wireless communication systems have been developing and evolving with a fast pace. The cellular systems connect with each other via mobile switching and directly access the public switched telephone networks with an advantage of providing facilities to the mobile users to make a phone call *anywhere* and *anytime.* The structural design of a GSM system contains a Base Station (BS), many Mobile Stations (MSs), and several Network Subsystems (NSs). The MS is carried by the subscriber, the BS Subsystem controls the radio link with the MS and the Network Station performs the switching of calls between the mobile and other fixed or mobile network users as well as mobility management. The MS and the Base Station Subsystem communicate across the radio link. Three major interconnected subsystems that interact between themselves and with the users through certain network interfaces are: Base Station Subsystem (BSS) , Network and Switching Subsystem (NSS), Operation Support Subsystem (OSS).

WCDMA Network Architecture consists of two types of nodes: Radio Base Station (RBS) and Radio Network Controller (RNC). RBS handles one or more cells and controls radio transmission and reception to/from the handset over radio interface. RNC is the node that controls all WCDMA Radio Access Network (RAN) function which connects the WCDMA RAN to the core network via interfaces. WCDMA RAN is mainly used to provide a connection between handset and core network. This is also helpful in isolating radio issues from core network. With fast growth of Communication, Code Division Multiple Access (CDMA) has become popular to use in the field of wireless communication. This is also called as Wideband Code Division Multiple Access (WCDMA) or CDMA-2000.

B. Handoff in Wireless Mobile Network

Handover or Handoff is the process of transferring an ongoing call from one cell to another as MS moves through the coverage area of a cellular system. When a call is in progress, the network is required to maintain the call across the cell boundaries. Handoff process consists of the following three phases: Handoff initiation:. Either the mobile station or network identifies the need for a handoff or the handoff is initiated. Allocation of resources: After the Handoff is initiated, necessary resources either network or radio are reserved to support the handoff. Handoff Execution: In this phase, the actual handoff of the call without violating the Quality of Service (QoS) requirements of the user takes place.

C. Ping Pong Effect

1) Introduction

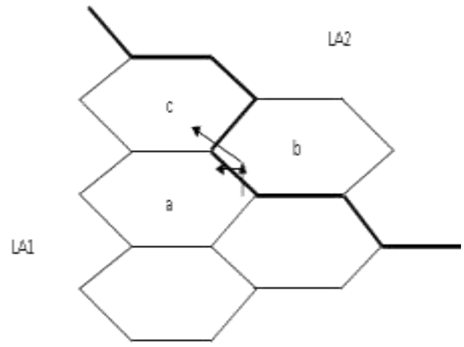

Fig. 1: Ping Pong Effect

In the location areas scheme, a mobile terminal updates its location whenever it moves into a cell that belongs to a new location area. When a mobile terminal is moving back and forth between the two neighboring location areas, it causes excessive location updates. This phenomenon is referred to as the traditional ping-pong location update effect. For example, given the location areas shown in Fig. 1, if a mobile user moves from cell a to b, it will perform a location update to register with location area LA2. However, if the mobile user immediately comes back to the cell a or another cell c in location area LA1, it will again perform a location update to register with LA1. This is referred to as the traditional ping-pong location update effect or simply the traditional ping-pong effect [6].

II. LITERATURE REVIEW

A. *Handoff Algorithms*

- Conventional Handoff Algorithms
- Signal Strength Based Algorithms

B.J.Singh *et al.* [7],have written that that are several variations of signal strength based algorithms, including relative signal strength algorithms, absolute signal strength algorithms, and combined absolute and relative signal strength algorithms. These algorithms are briefly discussed next.

B. *Relative Signal Strength Algorithms*

The averaged signal strength of base station 1 decreases as the mobile moves away from it. Similarly, the averaged signal strength of base station 2 increases as the mobile approaches it.

Gregory P. Pollini [8], discussed the various approaches like Relative signal strength, Relative signal strength with threshold, Relative signal strength with hysteresis, Relative signal strength with hysteresis and threshold. Sanjay Dhar ROY [4] has done the evaluation of various handover algorithms. In this, handover delay, shadow fading and effects of averaging are evaluated. The received signal strength coming from any one of BTS can be given with the following equation.

$$P_{rx1}(d) = K_1 - K_2 \log_{10}(d) + x_1(d) \quad d \in (0,D) \text{ meter} \quad \ldots\ldots\ldots\ldots(1)$$

$$P_{rx2}(d) = K_1 - K_2 \log_{10}(D - d) + x_2(d) \quad \ldots\ldots(2)$$

P_{rx1} (d) and P_{rx2} (d) are received signal from BTS1 and BTS2 respectively at a distance d meters from BTS1. Rayleigh fading is neglected since it has shorter correlation distance compared to shadow fading. K_1 and K_2 are due to path losses. K2 is actually 10n, where n is path loss component. x_1(d)and x_2(d)are two independent zero mean stationary Gaussian processes.

C. *Emerging Handoff Algorithms*

1) *Neural Handoff Algorithms*

G. Edwards [9],presents a signal strength based handoff initiation algorithm using a binary hypothesis test implemented as a neural network. However, simulation results are not presented. Most of the proposed neural techniques have shown only preliminary simulation results or have proposed methodologies without the simulation results. These techniques have used simplified simulation models. Learning capabilities of several paradigms of neural networks have not been utilized effectively in conjunction with handoff algorithms to date.

2) *Fuzzy Handoff Algorithms*

ChiewFoongKwonget al. [2], proposed a newer approach using Adaptive Network Fuzzy Inference System (ANFIS) where the training element is incorporated into the existing fuzzy handoff algorithm. The fuzzy handoff algorithm proposed by earlier work is not optimized and required constant attention from the human experts. The aim of this approach is to minimize the ping pong effect and to enhance the quality of service during the handoff process. Sheng Jieet al. [10], proposed a triangle module operator and fuzzy logic based handoff algorithm for heterogeneous wireless networks. It adapts fuzzy logic algorithm to fulfill the fuzzy decision values of RSS based algorithm and Qos parameters based algorithm respectively. In this, the triangle module operator is used to calculate handoff decision value. Presila Israt et al.[3], have developed a new fuzzy logic-based adaptive handoff (FLAH) management protocol for next generation wireless system for seamless communication. This is then integrated with an existing cross layer handoff protocol. Mobility management consists of two parts: the first is location management and second is handoff management. In location management, the location of mobile node is to track with respect to movement of user. In handoff management, the call connectivity should be there when the user moves from the coverage area of one cell to another cell. Manoj Sharma et al.[1], have proposed intelligent approach for handover decision in heterogeneous wireless environment using sugeno type fuzzy system. In this, RSS, network availability and bandwidth are taken as fuzzy input variables. On the basis of input variable the handoff decision changes. Leonard Barolliet al. [11], proposed a Fuzzy-based handover system for avoiding Ping-Pong effect in cellular networks. In this, signal strength from present serving BS, signal strength of neighboring BS and distance between MS and BS are taken as handoff decision parameters for Fuzzy system. In this, Monte Carlo technique is used. MeriemKassaret al. [5],proposed an intelligent approach for handover in intersystem environment for future generation wireless networks. In this, the author used the concept of always best connected (ABC) for seamless connectivity through the different available networks. B.J. Singh et al. [12], proposed a fuzzy based multicriteria handoff algorithm. The fuzzy handoff algorithm has been shown to possess enhanced stability (i.e., less frequent handoffs). The algorithm so developed is based on the received signal strength threshold, received signal strength with the hysteresis margin and the time interval for reduced signal level condition. The effect of threshold value and hysteresis margin on the performance of HO algorithm has been studied in a descriptive manner. The only hysteresis value used in conventional handoff algorithm may not be enough for heavy fading's, while fuzzy logic has inherent fuzziness that can model the overlap region between the adjacent cells.

III. PROPOSED WORK & SIMULATION MEHODILOGY

The proposed research work is being carried out in the field of inter-system handovers. In this work, it is proposed the fuzzy and artificial neural network based handoff system based on signal strengths of competing networks, trigger threshold and, degree of stability trigger threshold has achieved, which have a far reaching potential as building blocks in tomorrow's computational world. In this, a comparative analysis of both the algorithms with a view of alleviating the effect of ping pong effect and also optimizing handoff cost without degrading the quality of service. Handoff is to be initiated and executed at an appropriate time so as to ensure the quality of service (QoS).

IV. THE SYSTEM MODEL

For the sake of simplicity, a basic system consisting of two BSs separated by a distance of *D* is considered in this paper

[17] [20] [18] [19]. Both of the BS(s) are assumed to be located in the center of the respective cell and operating at the equal transmitting power as depicted in Fig. 3. Hexagonal geometry of the cell has been considered. The UE moves from one cell to another along a straight line trajectory with constant speed.

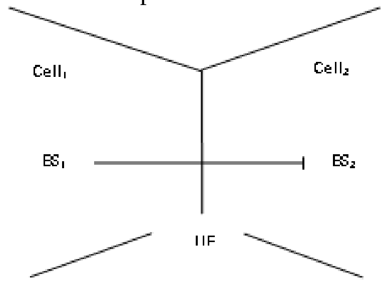

Fig. 3: Cellular Configuration

The table 1 shows the various system parameters chosen for measurement of handoff. Apart from these parameters, other parameters consider in this measurement is threshold value and counter value is also taken.

D = 1500 m	Distance between the two BSs.
γg = 3.2; γw = 3.6	Path loss exponents for GSM and WCDMA cells respectively.
σ = 6 dB	Standard deviation of shadow fading.
Nw_gsm=30; Nw_wcdma = 30	Number of samples used in the averaging window for GSM and WCDMA networks respectively.
ds = 1m	Sampling distance.

Table 1: System Parameters

Received Signal Strength (RSS) at UE is affected by three components as follows: (i) Path loss attenuation with respect to distance (ii) Shadow fading (iii) Fast fading. Path loss is the deterministic component of RSS, which can be evaluated by outdoor propagation path loss models [14-15]. Shadowing is caused due to the obstruction of the line of sight path between transmitter and receiver by buildings, hills, trees and foliage. Multipath fading is due to multipath reflection of a transmitted wave by objects such as houses, buildings, other man made structures, or natural objects such as forests surrounding the UE. For UE at a distance'd' from BSi, attenuation is proportional to

$$\alpha\,(d,\zeta) = d^n\ 10^{\zeta}_{10} \qquad (1)$$

where ζ is the dB attenuation due to shadowing, with zero mean and standard deviation σ. Alternatively, the losses in dB are

$$\alpha\,(d,\zeta)[db] = 10\eta\log d + \zeta \qquad (2)$$

Where η(eta) is path loss exponent. where d represents BS to UE separation in kilometers. The autocorrelation function between two adjacent shadow fading samples is described by a negative exponential function as given in [17]. Let di denote the distance between the UE and BS***i***, *i*=1, 2. Therefore, if the transmitted power of BS is Pt, the signal strength from BS***i***, denoted Si,(d) *i*=1, 2, can be written as

$$S_i(d) = P_t - \alpha(d_i,\zeta) \qquad (3)$$

The measurements are averaged using a rectangular averaging window to alleviate the effect of shadow fading according to the following formula.

$$\hat{S}_i\,(k) = \frac{1}{N_w}\sum_{n=0}^{N-1} S_i\,(k-n)W_n, \quad i=1,2 \qquad (4)$$

where; *i S*ˆ is the averaged signal strength and *i S* is the signal strength before averaging process. Wn is the weight assigned to the sample taken at the end of (k - n) th interval. N is the number of samples in the averaging window

$$N_w = \sum_{n=0}^{N-1} w_n$$

In the case of rectangular window W_n = 1 for all n. Shadow fading in the present work is modeled as follows:

$$\zeta(k) = \rho\zeta(k-1) + \sigma_i\sqrt{(1-\rho^2)}\mathrm{W}(0,1) \qquad (5)$$

where ρ(rho) is correlation coefficient, σ is standard deviation of shadow fading and (0,1) *W* represents truncated normal random variable.

A. Soft Computing based Model

Soft computing techniques are helpful in evaluating the imprecision calculations.

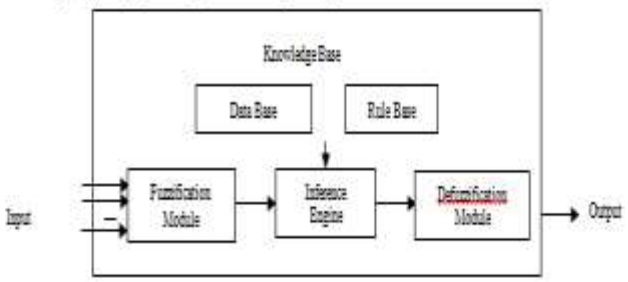

Fig. 4: Structure of Fuzzy Rule-Based System

1) Fuzzy Systems:

It is a proven fact now that fuzzy logic is a powerful problem-solving methodology with wide range of applications in industrial control, consume electronics, management, medicine, expert systems and information technology. A fuzzy system can be represented with the help of a block diagram as shown in Fig. 4. Any fuzzy system consists of four major modules of the system fuzzification, inference engine, knowledge base and defuzzification module. The fuzzification module transforms the crisp input(s) into fuzzy values. These values are then processed in fuzzy domain by inference engine based on the knowledge base (rule base and procedural knowledge) supplied by the domain expert(s). Finally the processed output is transformed from fuzzy domain to crisp domain by defuzzification module.

2) Neural Network:

An Artificial Neural Network (ANN) is an information processing paradigm that is inspired by the way biological nervous systems, such as the brain, process information. The key element of this paradigm is the novel structure of the information processing system. It is composed of a large number of highly interconnected processing elements (neurones) working in unison to solve specific problems. A neural network can be trained to perform a particular function by adjusting the values of the connections (weights) between elements. Typically, neural networks are adjusted, or trained, so that a particular input leads to a specific target output. Neural networks have been trained to perform complex functions in various fields, including pattern recognition, identification, classification, speech, vision, and control systems. Neural networks can also be trained to solve problems that are difficult for conventional computers or human beings. The toolbox emphasizes the use of neural network paradigms that build up to or are themselves used in engineering, financial, and other practical applications.

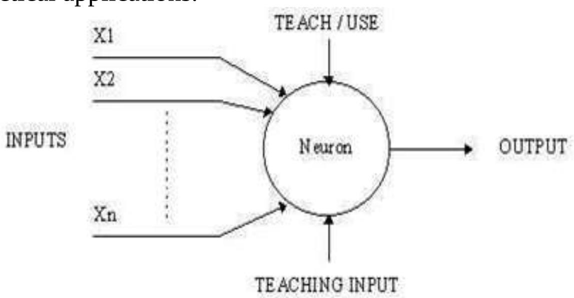

Fig. 5: Neural Network Structure

V. Results, Discussion & Conclusion

A. Handover Initiation Criterion

The handover initiation criterion used in the present work is based on absolute thresholds of received signal strength measurements.

A handover is performed if the following conditions are simultaneously fulfilled:

- The averaged signal strength from the serving base station falls below a threshold value.

And

- The averaged signal strength from the target base station becomes greater than a preset threshold.

B. A Fuzzy Model for Intersystem Handover

It is a proven fact now that fuzzy logic is a powerful problem-solving methodology with wide range of applications in industrial control, consume electronics, management, medicine, expert systems and information technology. It provides a simple way to draw definite conclusions from ambiguous or imprecise and incomplete information. For our handoff system we take two input variables i.e. GSM and WCDMA to the fuzzy system. Let us assume that the signal strength of GSM system ranging from -20 to 250 dB has been partitioned into 5 fuzzy sets namely negative, V_Low, LOW, MED and HIGH. The signal strength of WCDMA system ranging from -20 to 250 dB is also partitioned into five fuzzy sets (membership functions) namely negative, V_Low, LOW, MED and HIGH. After output specification, the next step is rulebase generation. We have created nine rules as shown in Fig. 6.

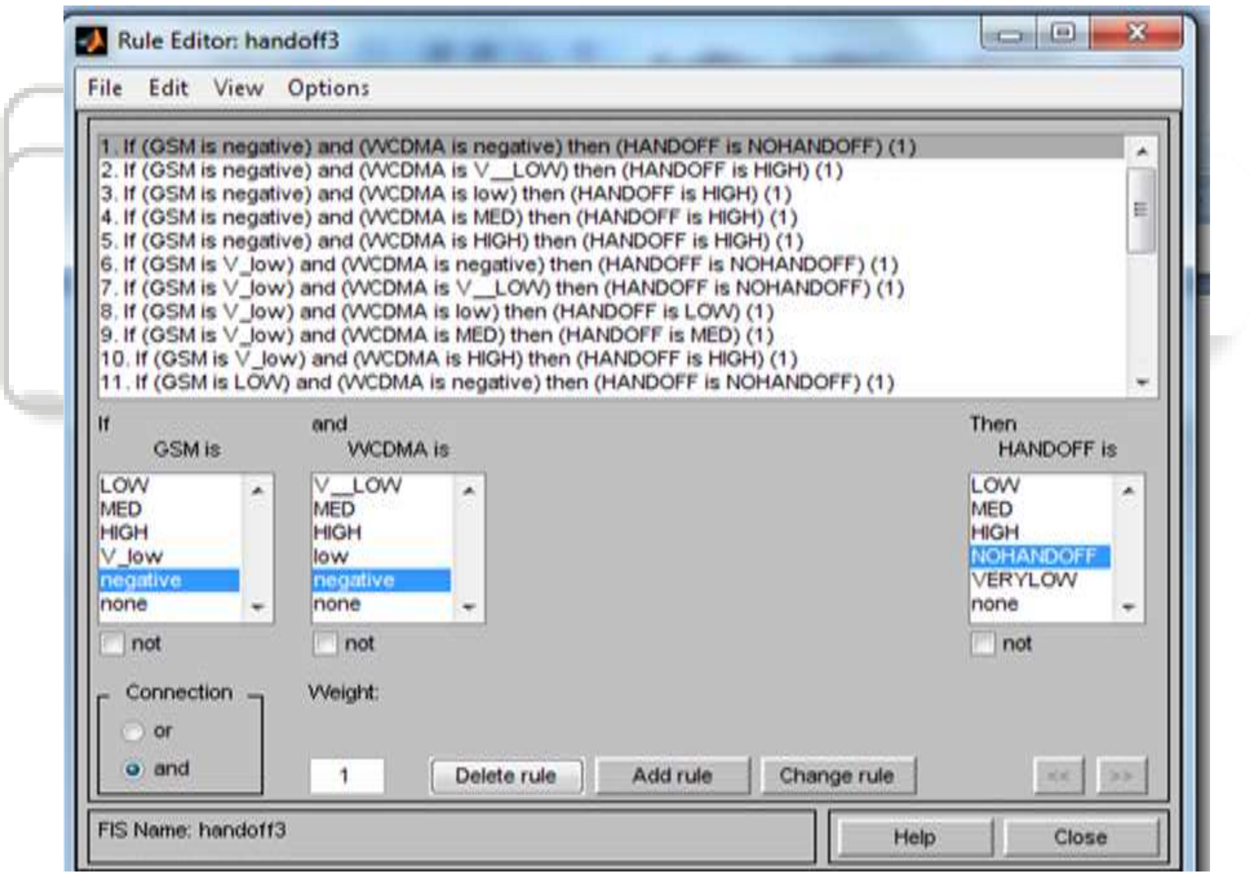

Fig. 6: Rules Generation

The rulebase generation is the last step of the creation of a fuzzy system. The system can be checked with the help of rule viewer, which is available in fuzzy toolbox of Matlab. The rule viewer for the above system is shown in the Fig. 7.

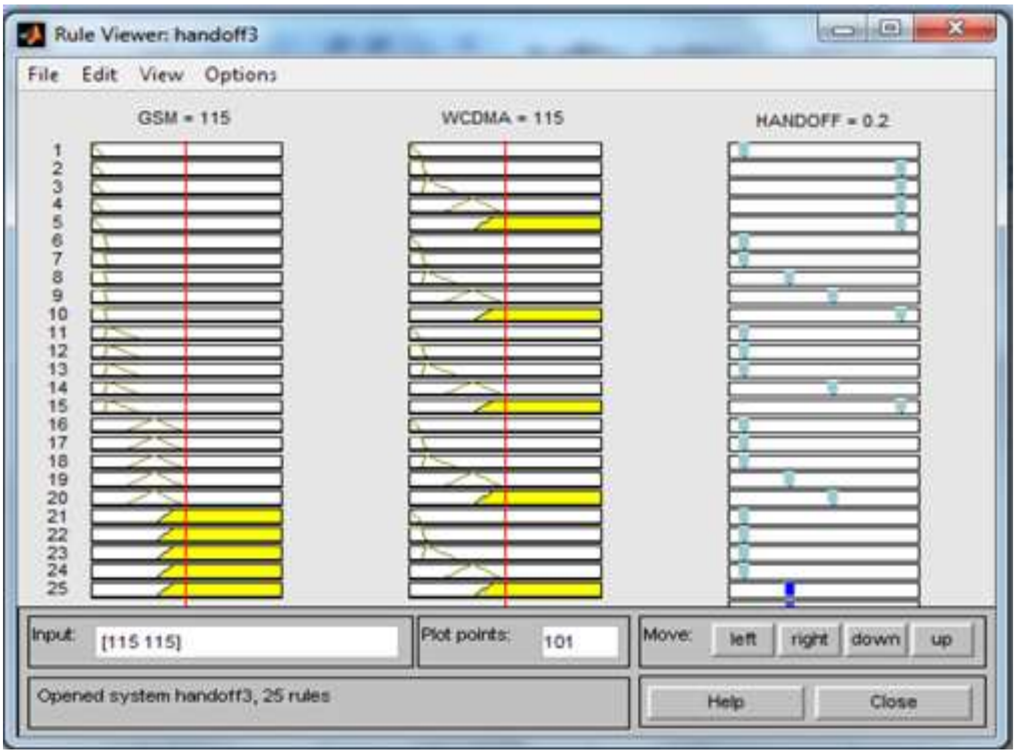

Fig. 7: Rule Viewer

In the Fig. 7, the signal strength for GSM is 115 and the signal strength for WCDMA is 115. According to these inputs the handoff probability will be 0.2. Hence we can check the output of the fuzzy system by applying any input in the fuzzy rule viewer. This complete procedure will produce a .fis file. This file contains the complete information of the designed system.

Table 2 presents the result obtained by the experimentation.

Method Type	**Parameters**		**No of Handoff**	**No of Connection Release**
	MAX Threshold	**MAX Counter**		
Counter Based Traditional handoff method	20	5	1	17
	10	5	1	10
	5	5	7	9
	20	3	1	7
	10	3	5	6
	5	3	7	5
Threshold based Handoff (Plane method)	0	0	109	0
	5	0	55	0
	10	0	37	0
	20	0	17	4
Fuzzy Based Method	Handoff probability >0.4		5	0
Neural Network based method	Handoff probability >0.4		Results are not encouraging and need reconfiguration to identify relationship between inputs and output.	

Table 2: Fuzzy Vs Traditional Handoff

In the results, it can be clearly seen that number of handoff is minimum for counter based system with threshold values between 10 to 20 but in these cases number of connection releases are high clearly making it a bad choice for handover. In the case of fuzzy based handoff system there is no connection releases while number of handoff switches are quite low so making it the favorite handoff system. Fig. 8 is the graphical representation of the tabular values. For Neural networks results are not very encouraging. Even after several experimentation and a large number of iteration for training neural network failed to identify the relationship between different inputs and output parameter. One reason for this may be that in training dataset of 2000 points there are hardly 5 ideal handover and neural network may not be able to establish relationship for handover mechanism and may need reconfiguration of inputs or redefining of problem to identify relationship between inputs and output.

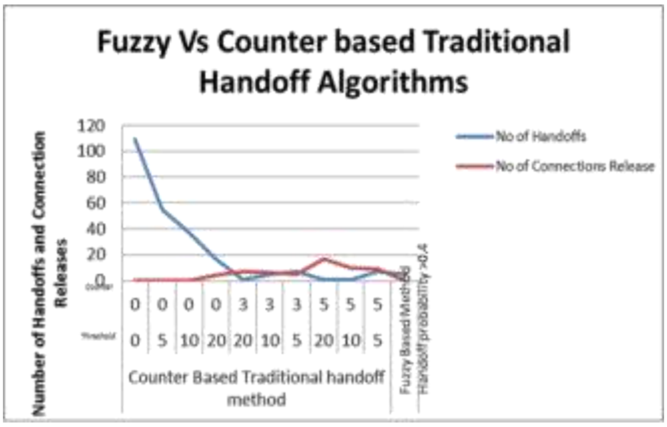

Fig. 8: Fuzzy Vs Neural Vs Traditional Handoff

WCDMA systems are interference-limited meaning that their capacities are closely related to the amount of interference the system can tolerate. Handover may be initiated when the Carrier to Interference Ratio (CIR) falls below a certain threshold. But for the problem under consideration the two systems i.e., GSM and WCDMA are supposedly operating in different spectrums. CIR, therefore, may not be the suitable criterion. Bit Error Rate (BER) may be another parameter for handover initiation. However, BER measurement is not always feasible as sufficient number of bits should be collected and this may introduce a significant and intolerable delay in handover initiation. Signal to Noise Ratio (SNR) can also make an Instantaneous estimate of BER. But direct comparison of SNR of two systems, which exploit different modulation and coding, may not be a reliable criterion for handover initiation. As a result of the above argument, the signal strength received by a dual mode mobile terminal can be a suitable criterion. However, measured signal levels cannot be directly compared since the signal variations (path loss exponents) in the two systems may be totally different. Hysteresis margin approach, therefore, cannot be utilized for intercell handovers. As a result, absolute value of received signal strength may the possible criterion for the problem of intersystem handovers between GSM and WCDMA networks. The handover initiation criterion used in the present work is based on absolute thresholds of received signal strength measurements.

In this paper, Soft computing methods used are fuzzy and neural network based. Neural network system in the present configuration doesn't show good results but fuzzy system has output satisfactory result. The handoff is a complex process and in which two conflicting requirements of reduction of handoff rate with maintaining quality of service have to be fulfilled. The fuzzy based handoff system is simulated for an environment containing shadowing effects and is compared with traditional counter based switching systems for their efficiencies of avoidance of ping-pong effect in terms of number of handoffs with number of call drops. The results obtained are very encouraging and clearly validate the supremacy of the approach of fuzzy based handoff system over traditional system. For this reason, proposed a FL-based approach, which can operate with imprecision data and can model nonlinear functions. The proposed system avoids the ping-pong effect and has a good handover decision.

REFERENCES

[1] Manoj Sharma & Dr. R. K. Khola, "An Intelligent Approach for Handover Decision in Heterogeneous Wireless Environment", International Journal of Engineering, Vol. 4, Dec. 2010, pp. 452-462.
[2] Chiew Foong Kwong, Teong Chee Chuah and Sze Wei Lee, "Adaptive Network Fuzzy Inference System (ANFIS) Handoff Algorithm", International Journal of Network and Mobile Technologies, Electronic Version Vol. 1, Nov. 2010, pp. 54-59.
[3] Presila Israt, Namvi Chakma, and M. M. A. Hashem, "A Fuzzy Logic-Based Adaptive Handoff Management Protocol for Next-Generation Wireless Systems", Journal of Networks, Vol. 4, Dec. 2009, pp. 931-940.
[4] Sanjay Dhar ROY, "Performance Evaluation of Signal Strength Based Handover Algorithms", International Journal Communications, Network and System Sciences, Vol. 2, Oct. 2009, pp. 657-663.
[5] Meriem Kassar, Brigitte Kervella, and Guy Pujolle, "An Intelligent Handover Management System for Future Generation Wireless Networks", EURASIP Journal on Wireless Communications and Networking, Vol. 2008, Aug. 2008, pp. 1-12.
[6] Guangbin Fan, Ivan Stojmenovic and Jingyuan Zhang, "Elimination of Generalized Ping-Pong Effects Using Triple-Layers of Location Areas in Cellular Networks", ComSIS consortium, Vol. 5, June 2008, pp. 1-16.
[7] B. J. Singh, S. Kumar, K. K. Aggarwal, "Handover Initiation Control Techniques in Mobile Cellular Systems" IETE Technical Review, Vol. 20, Jan-Feb 2003, pp. 13-21.
[8] G. P. Pollini, "Trends in handover design", IEEE Communications Magazine, Vol. 34, Mar. 1996, pp. 82-90.
[9] G. Edwards and R. Sankar, "Microcellular handoff using neuro-fuzzy Techniques", Wireless Networks, Vol. 4 , Sep. 1998, pp. 401–409.
[10] Sheng Jie and Tang Liangrui, "A Triangle Module Operator and Fuzzy Logic Based Handoff Algorithm for Heterogeneous Wireless Networks", IEEE International Conference on Communication Technology, 11-14 Nov. 2010, North China Electric Power University, China, pp. 488 – 491
[11] Leonard Barolli, Fatos Xhafa, Arjan Durresi and Akio Koyama, "A Fuzzy-based Handover System for Avoiding Ping-Pong Effect in Wireless Cellular Networks", International Conference on Parallel Processing – Workshops, 8-12 Sept. 2008, Portland State University, USA, pp. 135-142.
[12] B. J. Singh, S. Kumar and K. K. Aggarwal, "A Fuzzy Based Multicriteria Handover Algorithm for Cellular Systems", in Proceeding of National Conference on Computer devices for Communication, 21-23 Feb. 2001, REC, Jalandhar, pp. 8-15.
[13] E. Dahlman, B. Gudmundson, M. Nilsson, J. Skold, "UMTS /IMT-2000 Based on Wideband CDMA", IEEE Communications Magazine, Vol. 36, Sep. 1998, pp. 70 – 80.
[14] M. Gudmundson, "Correlation models for Shadow fading in Mobile Radio Systems," Electronics Letters Vol. 27, No. 23. November 1991.

[15] G.E. Corazza, D. Giancristofaro, and F. Santucci, "Characterization of Handover Initialization in Cellular Mobile Radio Networks," Vehicular Technology Conference, pp. 1869 – 1872, June 1994.
[16] France Telecom, "Handover from a UMTS FDD Cell to a GSM Cell," tdoc SMG2 UMTS-L1 69/98, April 1998.
[17] France Telecom, "Introduction of FDD to GSM Handover Scenarios," tdoc UMTS-L1, 177/98, June 1998.
[18] NEC Techn, "Handover Procedures for Dual-Mode WCDMA/GSM Terminals," tdoc. SMG2 A38/97. November 1997.
[19] Gianluca Durastaute and Alberto Zanella, "An Efficient Monitoring Strategy for Intersystem Handover from TD – SCDMA to GSM Networks", Proceedings of PIMRC, 15-18 Sept. 2002, LISBOA, PORTUGAL, pp. 1555 – 1560.
[20] Marco Leo and Michele Luglio, "Intersegment Handover between Terrestrial and Satellite Segments: Analysis and Performance Evaluation Through Simulation", IEEE Transactions on Vehicular Technology, Vol.50, May 2001, pp. 750 – 760.

