OPTIMIZED HANDOFF SCHEME USING FUZZY LOGIC

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ABSTRACT- *In this report described an optimized solution for handover across heterogeneous networks using Fuzzy-Logic. Handoff algorithm metrics such as Received Signal Strength (RSS), Signal to Interference Ratio (SIR), Transmit powers (Eb) are compared with Fuzzy-Logic based handoff algorithm for making handoff decision. Traditional handoff algorithm is based on stochastic and heuristic models. Because of statistical fluctuations in signal strength due to fading, a call gets repeatedly handoff back and forth between neighbouring base stations (ping-pong effect) before it is associated with single base station, or is forced to terminate as the signal strength falls below acceptable levels. This affects the quality of communication. In addition, delaying a necessary handoff also affects the connection quality of communication. Here RSS, SIR, Eb are taken as the metrics to make handoff decision. The results are simulated using MATLAB 7.0 software. From the results we can see that the proposed algorithm performs better than the traditional handoff algorithm like repeated handoffs and delay in handoffs are very well minimized in our proposed optimized handoff scheme using Fuzzy-Logic*.

Key words- Received Signal Strength (RSS), Signal to Interference Ratio (SIR), Transmit powers (Eb)

I. INTRODUCTION

The concept of mobility has been the subject of a lot of interest with in the internet community during the past decade, the telecommunications industry has revealed the benefits of able to communicate anywhere and anytime. With true IP level mobility, nomadic internet users would be able to access network resources and exchange data with each in a similar manner. This need becomes every day more evident. The number of mobile hosts is increasing with the emergence of lightweight digital personal assistants and laptop computers capable of wireless communication.

Mobile IP is the most prominent way to introduce mobility to the internet Protocol based communications. The idea is to make communicating hosts unaware of the underlying movement between the subnets. This allows applications to operate as if the hosts were stationary. A mobile node is a host that can change its point of attachment to the internet from one subnet to another. To maintain ongoing communications with other hosts, the IP address of the mobile node must remain immutable. Otherwise, the higher layer protocols lose the end-to-end connection needed for exchanging packets.

A permanent IP address called a home address is allocated from the home network of the mobile node. Packets destined for the mobile nodes are routed with the home address to the home network. The packets are intercepted by a home agent, a network entity residing at the home network. The home agent tunnels packets to the current location of the mobile node. Whenever the mobile node moves to a new subnet, it registers its new location to the home e agent. Moving from one subnet to another causers a handoff. During the handoff, a mobile nodes [point of attachment to the fixed network is transferred to another. This causes a disruption in the ongoing data flow. The overall delay can be separated into four components. First, the mobile node moves to a subnet, it registers its new location to the home agent. Moving from one subnet to another causes a handoff. During the handoff, a mobile node‟s point of attachment to the fixed network is transferred to another. This causes a disruption in the ongoing data flow. The overall delay can be separated in to four components. First, the mobile node has to be detected in the network layer. This can be done by employing network layer mechanisms or by sharing information between the link and the network layer. After that, a temporary IP address called a care-of address must be registered to the home agent in order for packets to be redirected to the mobile node. The connection is broken until a new tunnel is formed from the home agent to the care-of address.

If handoff is not handled properly, it causes user perceivable degradation of quality of service. Especially real-time and delay-sensitive applications suffer from the interrupted data flow. The handoff algorithm seeks to execute handoff as efficiently as possible to minimize packet drop and latency. When a mobile node possesses multiple network interfaces, the handoff algorithm must also choose the best interface to be used at a time. The right timing of the handoff is essential in wireless networks. Delayed handoff causes increased packet drop as signal quality decreases when the distance between the transmitters grows.

In the transport layer, TCP protocol interprets the break caused by the handoff as network congestion.

The congestion control mechanism delays packet transmission even more. Increased use of multi-media services calls for efficient handoff management. Recent years have seen the introduction of several new technologies for wireless data transfer.

Currently the assortment includes for instance GSM data, GPRS, UMTS, Wireless LAN and Bluetooth. Telecommunications networks have wide coverage areas, but modest bandwidth compared to the technologies of smaller cell sizes like IEEE-802.11.Inter- media or heterogeneous hand off are the way to make the best use of the currently available network resources. Wired connection can be used at the once, whereas wireless LAN is the best option for a mobile user. Cellular technologies fill the gaps in the wireless LAN coverage .A fast moving mobile node benefits from the large radio cell sizes of the cellular technologies. Using wireless LAN, a high velocity mobile node may not occupy one cell long enough for the hand off to complete at all. This results in frequent care-of address registration attempts that only increase network traffic. At the same time, zero user data is transferred .A large cell diminishes the hand-off frequency of a moving mobile node. Heterogeneous handoff algorithm collects data from each available transfer medium to make optimal inter and intra-media handoffs.

A.WHAT IS HANDOFF?

In telecommunication, the term handoff refers to the process of transferring an ongoing call or data session from one channel connected to the core network to another. In satellite communications, it is the process of transferring satellite control responsibility from one earth station to another without loss or interruption of service. The actual process of transferring the call is referred to as a handover.

In the telecommunication there are two reasons why a handover might be conducted. If the user has moved out of range from one base station and can get a better connection from a stronger transmitter or if one base station is full the connection can be transferred to another near by base station.

The most basic form of hand over is that used in most 1G and 2G systems where a phone call in progress is redirected from one cell transmitter and receiver and frequency pair to another cell transmitter and receiver using a different frequency pair without interrupting the call. If the terminal can only be connected to one base station and therefore needs to drop the connection for a brief period of time before being connected to other, stronger transmitter, this is referred to as a hard handover.

In CDMA systems the user can be connected to several base stations simultaneously, combining the data from all transmitters in range into one signal using a RAKE receiver. The set of base stations the terminal is currently connected to it‟s referred to as the active set. A soft handover happens when there are several base stations in the active set and the terminal drops one of these to add a new one. In W-CDMA there is a special case called softer handover where several connections in the active set point to the same station. The softer handover happens when one of these connections is dropped for another from the same base station.

Figure 1.1 shows how handoff takes place between different base stations.

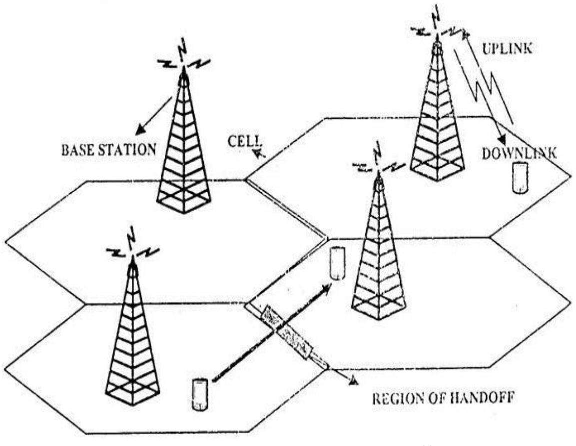


Figure 1.1 Scenario showing how handoff takes place

B.HANDOFFS IN MOBILE IP

Mobile IP was designed to provide macro mobility for mobile nodes. A macro handoff occurs whenever there is a need to register a new care-of address (CoA) to the home agent (HA). Similarly, the term micro mobility is referred when the mobile node (MN) moves within a subnet or an administrate domain. Registration Request is either unnecessary or terminated inside the administrative domain to up date the location of the MN locally. Mobile IP is ill suited for frequent handoffs. The main source of the problem is the latency and packet loss that is induced by lengthily registration processes: Registration messages must traverse all the way to the home agent and back. Besides, the Mobile IP network layer movement detection mechanism is slow. This delays the initiation of the registration process even more. Nowadays, real-time requirements are rapidly initiating the IP world and the mobile IP network layer handoff procedure is seen insufficient. Network layer (L3) handoff is a procedure, during which the MN moves to a new subnet and establishes the corresponding mobility binding with the home agent. Efficient execution of the handoff requires two things. The time that the MN is unable to exchange packets with the correspondent nodes should be minimal. The number of packets dropped because of the handoff should as well be minimal. The handoff process requires several tasks from the MN.

1. At the link layer an association top the new subnet is formed. This is simple with wired media, but with wireless medium like IEEE-802.11 a link layer handoff algorithm is needed. The link layer association may be possible with multiple access points at a given time, and most suitable access point should be chosen. The link layer handoff algorithm is responsible for selecting the target access point.

2. The network layer may or may not be aware of the link layer handoff. If not, the network layer handoff algorithm has to detect the movement by other means. Mobile IP suggests that is done by examining Agent Advertisements sent by foreign agents (FA) in the visited network. Alternatively, the link layer may provide triggers to inform the network layer about the movement.

3. Once the MN has found out that the movement has occurred, it has to start acquiring a new CoA.

4. The MN sends a Registration Request to the HA to update the mobility binding with the newly acquired CoA. The Registration Request is sent via a FA or directly to the HA in case of co-located CoA.

5. When the HA receives the Registration Request , it answers with a Registration Reply and starts to tunnel arriving packets to the new care-of address of the MN.

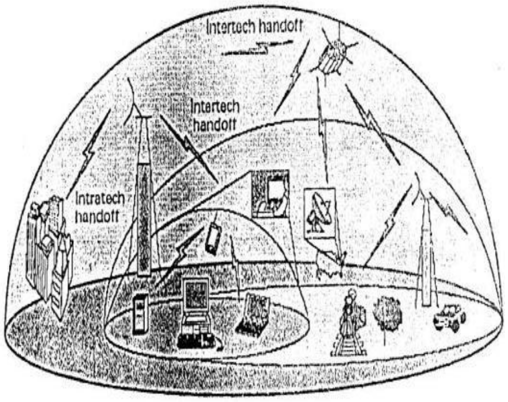


Figure 1.2 Hybrid or non-homogeneous networks

C. *COMPLEXITIES OF HANDOFF MANAGEMENT*

Handoff management achieves to maintain the communications of the mobile node at acceptable quality of service (QoS) level despite of the mobility. This involves efficient handoff execution to minimize the handoff latency and packet drop, and intelligent handoff target selection to avoid unnecessary handoffs and to ensure that the possible connection is used at a time.

Possible handoff targets can be prioritized for example by bandwidth, latency, packet error rate, cost of bandwidth, and the expected time of availability of a certain connection. The handoff algorithm makes trade-offs between these measures when selecting the handoff target. To make optimal trade-offs, the QoS needs of the currently used applications had to be known. For example, voice-over-IP needs low latency above all, whereas file download benefits mainly from high bandwidth. Unfortunately, current platforms do not commonly provide this information for the use of the handoff algorithm. Even the application itself is often unaware of its future QoS needs. Handoffs themselves affect the user perceived QoS. Advantage of a handoff to a point of attachment of a better connection has to be balanced against the interrupt caused by the handoff itself. The gain increases concurrently with the duration that the new point of attachment can be used. The expected time at the current location may be estimated for instance examining the past movements and the current velocity of the mobile node. Of course, this assumes that some kind of regularity can be found in the movement pattern of the particular mobile node.

Many difficulties in handoff management arise from the unpredictability of the networking environment. The network topology changes during the time as new network elements are deployed and old ones are removed. The cell coverage is dependent on surrounding terrain. Buildings and other barriers introduced sudden shadowing effects, which cause rapid decaying of the signal even within few meters of distance. Components of the signal may be received out of phase, as they take different paths and reflect from surface before arriving to the receiver. This multi-path propagation chausses part of the signal to encounter delay because travelling longer paths to the receiver. Represented information symbols overlap which impedes the demodulation of the signal.

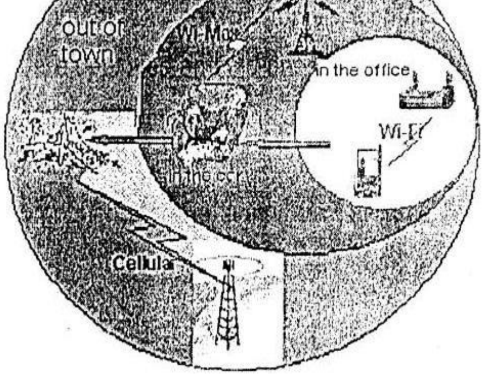


Figure 1.3 Networks everyday use scenario

Physical barriers are often temporary, like bypassing vehicles, and therefore difficult to be prepared for Radio links suffer also from the interference inflicted by other transmitters in the same frequency channel.

Link Layer Handoff Decisions

Link layer handoff decisions of an IEEE-802.11 interface are commonly based on the signal qualities of the available access points as other information can be hard to acquire. The received signal strength (RSS), Signal-to-Interference ratio (SIR), bit error rate (BER), or some combination of these can be used. A strong signal level implies a low packet drop, but also the likelihood of the proximity of the access point. The goal is too associated with the access point that provides the best link layer connection at time and that can be used for an extended period of time. Again, there is a trade-off between the signal quality level and the number of reassociations needed over time. Every reassociation decreases the overall quality of service. The lack of the predictability of the movement of the mobile node and the unknown coverage areas and placing of accesses points makes optimal decisions impossible. The nature of the radio network causes signal strengths to alternate frequently and unexpectedly. At the physical layer, only a few centimetres movement of the receiving antenna can affect drastically to the signal quality. For the use of the link layer, the changes are averaged over time, but the problem remains at larger scale. Rapid, but temporary variations in the signal quality disturb handoff decisions. One approach is to delay the handoff until it is more evident that the weakening of the signal is definitive, and the handoff is truly needed. This remedies a “ping-pong” situation, in which the mobile node rapidly oscillates between multiple access points. Naturally, this handoff policy has its weakness. When the signal is degradation indeed turns out to be definitive, the handoff to the new access point is unnecessarily delayed.L2 handoffs between the access points of one subnet are tolerable in comparison to those between separate subnets. Between subnets, a L3 handoff is needed and the overall handoff latency is increased usually by an order of magnitude. The L2 handoff algorithm running in the network interface card does not have the access to the information about the subnet boundaries. Due to the dynamic propagation environment, any link layer handoff algorithm that uses constant parameters to determinate the necessity of the handoff from the signal quality is suboptimal in certain situations.

NETWORK LAYER DIFFICULTIES

A network layer heterogeneous handoff algorithm forms mobility bindings for care of addresses. The decisions of which network interface to chose at a time is a complex problem. The criteria includes for examples the quality of the network layer connection to the corresponding nodes and to the home agent, the type of user application, the current handoff policy, the velocity of the mobile node, the cost of bandwidth, the duration that the care=of address can be used., and the services available at the interfaced network. The characteristics of the route to the home agent are often unknown at the decision making time. Without this information, the interface of the fastest available transfer media is usually chosen. Likewise, it is unknown how long a specific link layer connection is up. A fast moving mobile node may associate to an access point at L2 layer, but does not have enough time to complete the registration of the CoA (L3 handoff) until the link is lost again. The knowledge of the exact moments of the link layer handoffs would be beneficial. The L3 handoffs could schedule accordingly. In this case, the next network interface could be prepared in advance. This means for example, accruing a CoA and sending the registration request in advance to schedule L3 handoff to the same moment that the link layer connection to the old point of attachment is lost.

For a voice user, HO result in an audible click interrupting the conversation for each HO; And because of HO, data users may loss packets and unnecessary congestion control measures may comer in to play. Degradation of the signal level, however, is a random process and simple decisions mechanism such as those based on signal strength measurements result in t he ping-pong effect. The ping-pong effect refers to several HOs that occur back and front between two BSs. This takes a severe toll an both users quality perception and the network load. One way of eliminating the ping-pong effect is to persist with BSs for long as possible. However, if HO is delayed, weak signal reception persists unnecessarly, resulting in lower voice quality, increasing the probability of call drops and or degradation of quality of service, (QoS) consequently more complex algorithms are needed to decide on the optimal time for HO. Handoff also involves a sequence of events in a backbone network including rerouting the connection and reregistering with the new AP, which are additional loads on network traffic. Hand off has on impact on traffic matching and traffic density for individual BSs (since the load on the air interface is transferred from one BS to another). In the case of random access techniques employed to access the air interface or in code division multiple access (CDMA) , moving one cell to another impact QoS in both cells since throughput and interference depend on the no of terminals competing for the available bandwidth. In hybrid data networks, a decision on HO has on impact on the throughput of the system.

II PROBLEM STATEMENT

A. RELATED WORK

In the previous papers of the proposed algorithm many researchers are done the Fuzzy-Logic based algorithm for homogeneous networks. In the related work papers they proposed the algorithm considering only the received signal strength and trained considering the threshold, hysteresis value of the received signal strength as given in the reference papers of this report. The traditional handoff algorithm and its drawbacks are discussed in the next section.

TRADITIONAL HANDOFF ALGORITHMS

Various signal strength based handoff algorithms have been proposed. The primary criteria used for making handoff decisions in these algorithms are the received signal strength from the base station at the mobile station. Some of the RSS based algorithms are,

- Relative Signal Strength Algorithm ($RSS_{relative}$)
- $RSS_{relative}$ with absolute Threshold ($RSS_{relative}$-T)
- $RSS_{relative}$ with relative Threshold (hysteresis) ($RSS_{relative}$-H)
- $RSS_{relative}$ with hysteresis and absolute Threshold ($RSS_{relative}$-HT)

In relative signal strength ($RSS_{relative}$) algorithm, handoff decision is taken when the received signal strength from the candidate base station is greater than the serving base station where as in $RSS_{relative}$ with absolute threshold ($RSS_{relative}$-T) algorithm initiates handoff when the averaged signal strength of the current base station falls below a threshold value and the candidate base station signal strength is greater than the serving base station. The disadvantage is excessive HOs due to shadow fading effects. In many existing systems measurement for candidate BSs are not performed if RSS of existing BS exceeds a prescribed threshold. In the RSS with relative threshold (hysteresis) (RSS-H) approach handoff is initiated only if the target base station signal strength is sufficiently stronger by a hysteresis margin than the serving base station. Hysteresis reduces the number of unnecessary HOs but can increase dropouts since it can also prevent necessary HOs by introducing a delay in HO. But this algorithm may results in handoffs even when the serving base station signal strength is sufficiently strong. Such unnecessary handoffs can be prevented in RSS with hysteresis and absolute threshold of serving BS (RSS-HTser) algorithm, where absolute signal strength of the serving BS is used as an additional criteria.

Figure 2.1 Shows the RSS based Traditional HO Algorithm

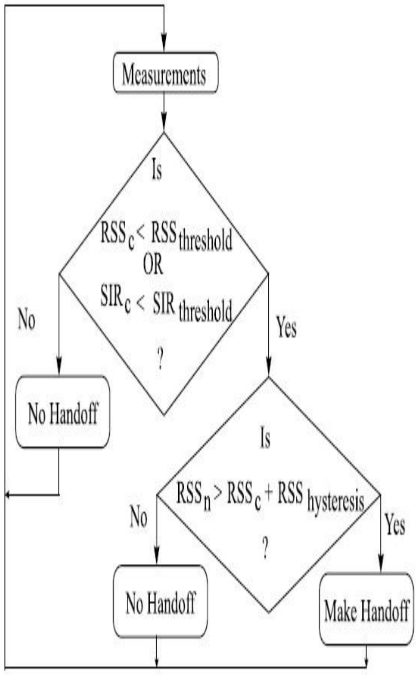


Figure 2.1 RSS based Traditional Handoff Algorithm

Here RSSc is the received signal strength of the current base station, RSSn is the received signal strength of the neighbouring BS, RSSth is the threshold level for making HO decision, and RSShy is the hysteresis margin used in the traditional algorithm.

B.1 Drawbacks

Traditional algorithms are based on stochastic and heuristic models as the received signal at the mobile is modelled as a random process. Consequently these algorithms do not have a universally good performance since they do not account for the rapidly changing radio environment or the site specifically. Because of statistical fluctuations in signal strength due to fading, a cell may be repeatedly handed off back and forth between neighbouring base stations before it is associated with a single base station, referred to as „ping-pong‟ effect, or is forced to terminate as the signal strength falls below the acceptable levels. Each such handoff involves a signalling cost that can increase because of an improperly designed handoff decision algorithm or it can result in a high probability of forced termination. Frequent handoffs affect connection quality and increase the load on the cellular network. Also, delaying a necessary handoff affects the quality of communication as the signal from the current base station starts to deteriorate. Limited system capacity and user satisfaction require reducing u necessary hand offs and making ones correctly.

Therefore the main objective is to reduce the number of necessary ho and minimizing the delay involved in making ho decision .a necessary balance between the number of ho and delay in ho need to be achieved by appropriate choice of threshold ,hysteresis and RSS averaging window. this is achieved in the scheme which is proposed in this report .the ho criteria used fro making ho decision are RSS ,sir mobile transmit power(Eb).here we are implementing this optimized handoff scheme based on the neural network for heterogeneous network.

III FUZZY LOGIC THEORY

A. ASSUMPTIONS IN FUZZY CONTROL SYSTEM DESIGN

A number of assumptions are implicit in a fuzzy control system design. Six basic assumptions are commonly made whenever a fuzzy rule-based control policy is selected.

1. The system is observable and controllable: state, input and output variables are usually available for observation and measurement or computation.
2. There exists a body of knowledge comprised of a set of linguistic rules, engineering common sense, intuition, or a set of input-output measurements data from which rules can be extracted.
3. A solution exists.
4. The control engineer is looking for a “good enough” solution, not necessarily the optimum one.
5. The controller will be designed within an acceptable range of precision.
6. The problems of stability and optimality are not addressed explicitly, such issues are still open problems in frizzy controller design.

B. SIMPLE FUZZY LOGIC CONTROLLER

A block diagram such as that shown in Figure 3.1 can generally depict the simple fuzzy controllers.

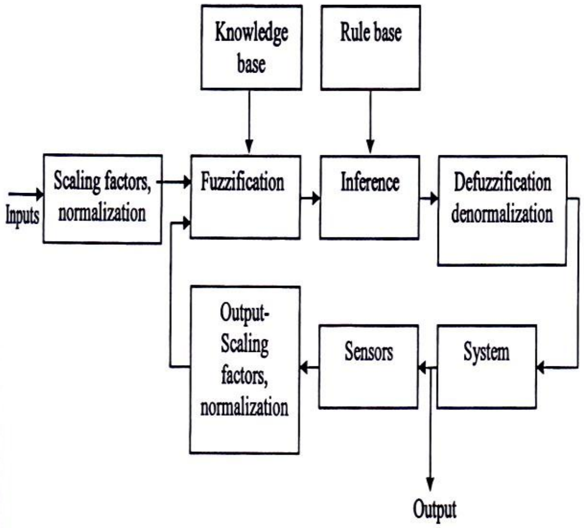


Figure. 3.1 A simple fuzzy logic control system block diagram.

NORMALISATION:

It is the process of scale transformation that is it maps the physical values of the current process state variable into a normalized universe of discourse (Physical input to crisp input).

FUZZIFICATION:

It is a process of converting point wise crisp value of a process state variable into a fuzzy set, in order to make compatible with the fuzzy set representation of the process state variable in the rule antecedent (crisp to fuzzy).

KNOWLEDGE BASE:

The knowledge based module in Figure. 3.1 contains knowledge about all input and output fuzzy partitions. It will include the term set and the corresponding membership functions defining the input variables to the fuzzy rule-base system and the output variables, or control actions, to the system under control.

RULE BASE:

The basic function of rule base is to represent in a structured way of control policy if an experienced process operator and/or control engineer in the form of a set production rules such as If (process state variable) then (control output variable)

INFERENCE ENGINE:

To calculate the fuzzy output that is to evaluate the activation strength of every rule base and combine their action sides.

DEFUZZIFICATION:

To calculate the actual output crisp value that is to convert the fuzzy output into precise numerical value. The design parameters of defiazziflcation depending upon the choice of deftuzzification operator are,

1. Center of area/gravity defbzzification
2. Center of sum
3. Center of largest area
4. First of maxima
5. Middle of maxima
6. Last of maxima
7. Height defluzzification.

DESIGN STEPS IN FUZZY LOGIC CONTROL

The steps in designing a simple fuzzy control system are as follows:

1. Identify the variables (inputs, states, and outputs) of the plant.
2. Partition the universe of discourse or the interval spanned by each variable into a number of fuzzy subsets, assigning each a linguistic label (subsets include all the elements in the universe).
3. Assign or determine a membership function for each fuzzy subset
4. Assign the fuzzy relationships between the inputs"s or state"s fuzzy subsets on the one hand and the output"s fuzzy subsets on the other hand, thus forming the rule-base.
5. Choose appropriate scaling factors for the input and output variables in order to normalize the variables to the [0, 1] or the [-1, 1] interval.
6. Fuzzily the inputs to the controller.
7. Use fuzzy approximate reasoning to infer the output contributed from each rule.
8. Aggregate the fuzzy outputs recommended by each rule.
9. Apply deflizzification to form a crisp output

3A. FEATURES OF FUZZY LOGIC

Fuzzy Logic was conceived as a better method for sorting and handling data. It uses an imprecise but very descriptive language to deal with input data.

FL offers several unique features that make it a particularly good choice for many applications.

1) It is inherently robust since ft does not require precise data information. The output is a smooth control function despite a wide range of input variations.

2) Since the Fuzzy Logic controller processes user-defined rules, it can be modified and tweaked easily to improve or drastically alter system performance.

3) FL is not limited to a few inputs and one or two outputs, it is necessary to measure or compute rate-of-change parameters in order for it to be implemented.

4) Because of the rule-based operation, any reasonable number of inputs can be processed (1-8 or more) and numerous outputs (14 or more) generated, although defining the rule base quickly becomes complex if too many inputs and outputs are chosen for a single implementation since rules defining their interrelations must also be defined.

5) FL can control nonlinear systems that would be difficult or impossible to model mathematically.

IV OPTIMIZED FUZZY LOGIC BASED HANDOFF ALGORITHM

A. INTRODUCTION

In order to achieve our objective of minimizing number of handoffs and reduction in handoff delay we use this new class of handoff algorithm called the “Optimized Fuzzy Logic Based Handoff algorithm”.

B. COMMONLY USED METRICS

Received Signal Strength (RSS)

This criterion is simple, direct, and widely used. Many systems are interference limited, meaning that signal strength adequately indicates the signal quality, and this is the motivation behind signal strength based decision. Moreover, there is a close relation between the RSS and the distance between the BS and the M. The lack of consideration of Co-channel interference (CCI) is a disadvantage of this criterion. Several factors (e.g., topographical changes, shadowing due ton buildings, and multipath fading) can cause the actual coverage area to be quite different from the indented coverage area. The RSS criterion can also to excessive number of handoffs.

Signal to Interference Ratio (SIR)

An advantage of using SIR o9r C/I as a criterion is that SIR is a parameter common to voice quality, system capacity and dropped call rate. BER is often used to estimate SIR. When actual (C/I) is lower than the designed (C/I) is lower than the designed (C/I) voice quality becomes poor, and the rate of dropped calls increases. SIR also determines the reuse distance. Unfortunately, CIR may oscillate due to propagation conditions and may cause the ping-pong effect (in which the MS repeatedly switches between the adjacent BSs). Another disadvantage is that even though BER is a good indicator of link quality, bad link quality may be experienced near the serving BS and handoff may not be desirable in such situations.

Transmit Power

Transmit power can be used as a handoff criterion to reduce the power requirement, reduce interference, and increase battery life

.

Distance

The criterion can be used to preserve cell boundary. The distance can be estimated based on the signal strength measurements, delays between the signals received from different base stations etc.

Traffic

Traffic level as handoff criterion balance traffic in adjacent cells.

Velocity

Velocity is an important handoff criterion especially fir overlay systems and velocity adaptive algorithms. Several algorithms use an estimate of velocity to modify handoff parameters. This estimate is useful to adaptively change the averaging interval in a handoff algorithm for both small and large cells. The estimation of mobile velocity is through maximum Doppler frequency f_o.

Dwell Time

Statistics such as total time spent in the cell by a call and arrival time of a call can also be used as handoff criteria. Elapsed time spent since last handoff is also useful criterion since it can reduce number of handoffs.

C. FUZZY-LOGIC BASED HANDOFF ALGORITHM

In this section a new class of handoff algorithm is proposed. The main idea is to combine attractive features of existing algorithms to obtain an efficient algorithm and to adapt the parameters of this efficient algorithm to the dynamic cellular environment using Fuzzy-Logic.

Issues involved in the Handoff Mechanism

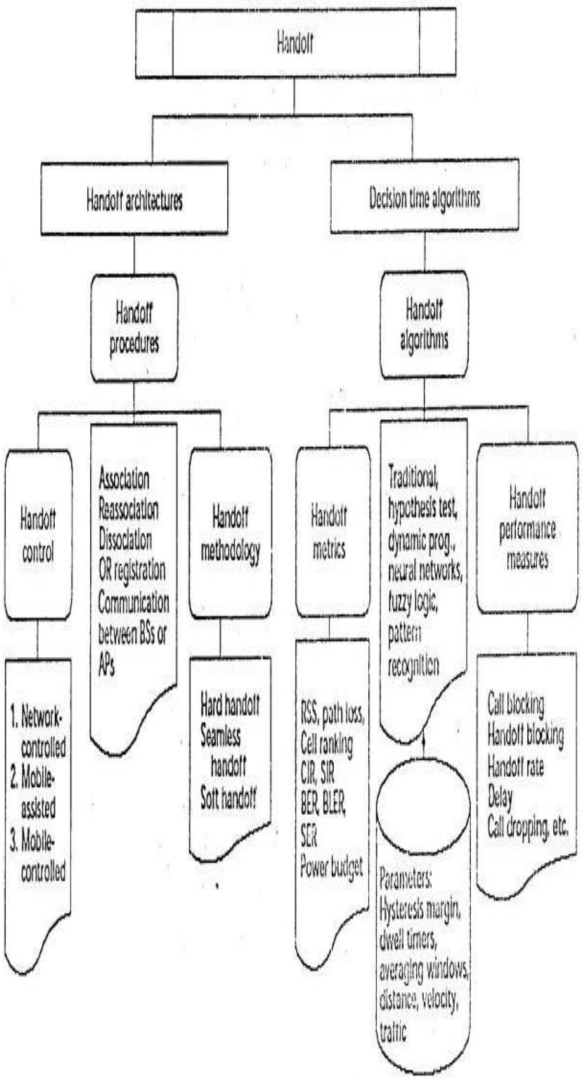


Figure 4.1 Important Issues involved in the Handoff Mechanism

ALGORITHM OVERVIEW

This section proposes a new class of handoff algorithms based on fuzzy logic, and figure 4.2 shows a generic block diagram of this proposed class. The main idea is to combine attractive features of existing algorithms to obtain an efficient algorithm to the dynamic cellular environment using a fuzzy logic system.

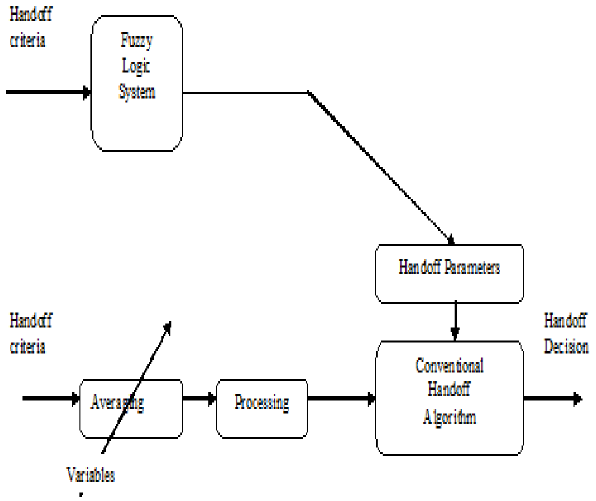


Figure 4.2 Block diagram of Fuzzy Logic Based Handoff Algorithm

Major phases involved in the design of the proposed class of algorithms are:

- Identification of desirable features and associated handoff algorithm attributes
- Selection and processing of handoff criteria
- Determination of the basic conventional handoff algorithm
- Design of a fuzzy logic system

Some of the desirable features and attributes of the algorithm are; a handoff algorithm should be simple, efficient channel allocation, traffic balancing, traffic adaptation, preservation of planned cell boundaries, identification of a correct cell for making HO, velocity adaptive averaging and low transmit power. Next task is to decide what are the metrics to be used for the new algorithm. Then we have to determine the conventional handoff algorithm which uses RSS as the primary criteria to make handoff decision. To implement this new class of algorithm a fuzzy logic system which involves the design of a fuzzy interference engine and the formation of fuzzy logic rule base. Based on these a configuration of a fuzzy based handoff algorithm is shown in figure 4.3 this is described in the next section.

D. DESCRIPTION OF THE ALGORITHM

Figure 4.4.1 shows a fuzzy logic based handoff algorithm. This configuration uses the combination of an absolute and relative RSS based algorithm along with SIR, mobile velocity and transmit power from the mobile. This algorithm has threshold (RSSthreshold) and hysteresis (RSShysteresis) as output parameters, fed to the conventional HO algorithm. It is assumed that the MS makes necessary measurements. However, the proposed algorithm can be easily extended to include BS measurements. Handoff criteria averaged according to the velocity adaptive averaging mechanism includes RSS of the current BS (RSSc), RSS of the neighbouring BS (RSSn) and SIR of the current channel (SIRc). The basic parameters to be adapted are RSSthreshold and RSShysteresis. An FLS is used as an adaptive mechanism. The inputs to the FLS are RSSc, RSSn, SIRc, Eb and MSvelocity, and the outputs of the FLS are RSSthreshold and RSShysteresis. Certain handoff criteria (e.g., RSS) need to be averaged to mitigate the effects of the propagation environment. To prevent an excessive number of dropped calls, handoff requests should be processed quickly for vehicles that are moving away the serving BS at high velocities.

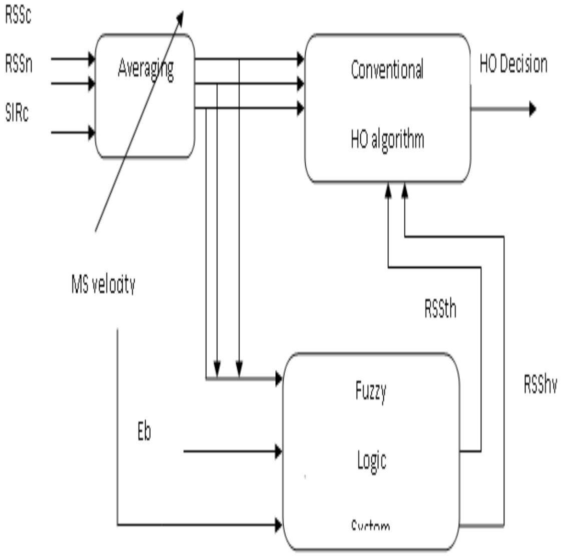


Figure 4.3 Fuzzy Logic Based Handoff Algorithm

A fixed time averaging interval gives best performance at only one velocity. For example, for a fixed parameter handoff algorithm with a fixed time averaging window, two situations exist: (I) for high velocities, handoff delay is long, and the number of handoffs is fewer and (ii) for low velocities, the handoff delay is short, and the number of handoffs is more. Also, there is a velocity (between the high and low extremes) that gives optimum performance for both the handoff delay and the number of handoffs. To provide similar performance (i.e., the desired trade-off between the handoff delay and the number of handoffs) to users with different velocities, the temporal window must be adapted based on the MS velocity. The RSSthreshold and RSShysteresis values which are fed into the conventional algorithm block will decide whether to make a handoff or not.

V. ESTIMATION OF METRICS

A. ESTIMATION OF MOBILE VELOCITY

There has been considerable interested in application of location and velocity of mobile vehicle in cellular and personal communications. For example, handoff requests from rapidly moving mobiles in micro-cellular networks must be processed quickly. Otherwise, excessive dropped calls will occur. The mobile velocity ν is proportional to the maximum Doppler spread through $f_x = vf_c / C$ where fc is the carrier frequency and c is the speed of propagation. If there is non line of sight path between the base station (BS) and MS, the signal envelope is then Rayleigh distributed. The received discrete-time band signal is given by

$$r(k) = \sum_{l=1}^{L} \alpha i \cos(\omega_C k + \omega_d k + \varphi_l \qquad (5.1)$$

Where ω_c and ω_d are discrete-time carrier and Doppler angular frequency, respectively. L is the number of incoming wave and K is the discrete time. α_i and φ_i are the amplitude and the phase angle of the Ith incoming wave. The low-pass equivalent received signal is given by

$$x(k) = x_I(k) + jx_Q(k) \qquad (5.2)$$

$$x_I(k) = \sum_{l=1}^{L} \alpha_l \cos(\omega_d k + \varphi_l \qquad (5.3)$$

$$x_Q(k) = \sum_{l=1}^{L} \alpha_l \sin(\omega_d k + \varphi_l \qquad (5.4)$$

are the in phase and quadrate components of the received signal respectively. In fact the received fading signal is always corrupted by noise in practical mobile communications systems. The low-pass component of the received signal can be written as

$$xx(k) = x(k) + n(k) \qquad (5.5)$$

Where n(k) is the noise component. In this paper, we use take (XX (k) ≈ X (k)), even in the presence of noise.

$$z(k) = \sqrt{x_I(k)^2 + x_Q(k)^2} \qquad (5.6)$$

is the received envelope, z(k) has a Rayleigh distribution at any time. the density distribution function of the received envelope is given by

$$f(z) = \frac{z}{\sigma^2} \exp(-\frac{z^2}{2\sigma^2}) \qquad (5.7)$$

Where

$$\sigma^2 = E[z^2]/2 \qquad (5.8)$$

The auto-correlation function of r is given by:

$$\phi_\pi(m) = E\{r(k)r(k+m)\} = \varphi_\pi(m)\cos(\omega_c k) - \varphi_m(m)\sin(\omega_c \qquad (5.9)$$

$$\phi_\pi(m) = E\{x_r(k)x_r(k+m)\} = \frac{1}{2}\sum_{N=1}^{N} E\{\alpha_n^2\} E\{\cos(\omega_d m)\} \qquad (5.10)$$

Likewise

$$\phi_m(m) = E\{x_I(k)x_Q(k+m) = 0 \qquad (5.11)$$

From eqn(5.10) and eqn(5.11) , we have

$$\phi_\pi(m) = \sigma^2 E\{\cos(\omega_d m)\} \qquad (5.12)$$

Where --- is the variance of the in phase component of the received fading signal. Here K represents the Kth sample and m is the number of samples the signal is shifted. The MS motion introduces a frequency variation called a Doppler shift (f_d).

$$f_d = f_m \cos(\theta) \qquad (5.13)$$

Where f_m is the maximal Doppler frequency and ---is the incident angle of the wave. Eqn (5.10) can be written as

$$\varphi_\pi(m) = \sigma^2 E_\theta\{\cos(2\pi f_m m \cos(\theta))\} = \sigma^2 \frac{1}{2\pi}\int_0^{2\pi} \cos(2\pi f_m m \cos(\theta))\, d\theta = \sigma^2 J_0(2\pi f_m m) \qquad (5.14)$$

Where J_0 is the zero order Bessel function of the first kind Letting the time index m in the equation (5.14) equal 0 and 1 respectively, we obtain:

$$J_0(2\pi f_m) = \frac{\varphi_\pi(1)}{\varphi_\pi(0)} \qquad (5.15)$$

This equation can be used to solve for the maximum Doppler frequency

$$f_m = \frac{1}{2\pi} J_0^{-1} \frac{\varphi_\pi(1)}{\varphi_\pi(0)} \qquad (5.16)$$

Where Jo^{-1} ( ) is then inverse of the zero order Bessel function of the first kind. It is assumed that each arriving wave at the receiver has arbitrary phase, angle of arrival and equal average amplitude. There is no direct line of sight path and no excess delay for each wave. The Doppler shift is bounded by the maximum Doppler frequency f_m.

$$f_x = v f_c \;/\; C \tag{5.17}$$

Where ν is the vehicle speed, fc is the carrier frequency and c is the speed of light. The ranges of Mobile Station Velocities assigned for each of linguistic variables is show in appendix 1.

B. ESTIMATION OF SIR

In cellular systems, the signal to Interference Ratio (SIR) is one of the parameters that give a qualitative measure of link performance. The estimation algorithms for digital TDMA cellular systems typically assume that the desired signal is of constant envelope of that a training sequence is used as part of the transmitted sequence of the desirable user. A subspace based algorithms have been developed to provide accurate measurements in a highly mobile and fading environment. Now we will see how SIR is estimated. Let the mobile be j and the base station be i. the power gain from the transmitter j to the receiver I in the reverse link, caused by multipath fading is given by

$$G_{ji}(t) = \frac{\Pr_{ji}(t)}{Pt_j(t)} \tag{5.18}$$

Where Pt_j (t) is the transmission power of mobile j and Pr_{ji} (t) is the received power of mobile j at the receiver i. if the transmission powers of the mobiles are assumed to remain unchanged over each power measurement period (PMP) Tm, i.e., Pt_j (t) =Pt_j for j = 1,2,……N, the SIR for mobile over a PMP can thus be obtained from

$$SIR_i = \frac{Pt_i \frac{1}{Tm} \int_0^{Tm} G_{ji}(t)dt}{\sum_{\substack{j=1 \\ j\neq 1}}^{N} Pt_j \frac{1}{Tm} \int_0^{Tm} G_{ji}(t)dt} \tag{5.19}$$

$$= \frac{Pt_i \overline{Gii}}{\sum_{\substack{j=1 \\ j\neq 1}}^{N} Pt_j \overline{Gji}}$$

$$= \frac{Pt_i}{\sum_{\substack{j=1 \\ j\neq 1}}^{N} Pt_j \frac{\overline{Gji}}{\overline{Gii}}}$$

$$= \frac{Pt_i}{(\sum_{j=1} Pt_j Bji) - Pt_i} \tag{5.20}$$

Where

$$\overline{Gji} = \frac{1}{Tm} \int_0^{Tm} Gji(t)dt$$

is the link gain from mobile j to receiver i over a PMP and

$$B_{ji} = \overline{Gji} / \overline{Gii} \tag{5.21}$$

is the link gain from mobile j to receiver i normalized to the link gain in the desired path of mobile i. the ranges of SIR assigned for each of linguistic variables is shown in appendix 1.

C. ESTIMATION OF MOBILE TRANSMIT POWER

In the uplink, mobile station channel, signals originating from different users will arrive at the base station with unequal power levels because of different locations (different distances to the base station) within the cell. If the user‟s transmit powers are not controlled, a distant user whose received signal at the base station is low will suffer due to the nearby user whose received signal level is high. This is known as the near-far problem. In addition to the near-far problem, the average received power at the base station may also vary slowly due to, what is called the shadowing problem. The shadowing occurs when a mobile station is moving through different terrains. Only the uplink is affected by near –far and shadowing problems. On the base station-to-mobile station or downlink channel (forward link), all user‟s signals originate from the same source (i.e. base station), then propagate through the same channel and therefore fade simultaneously. There is no near-far problem on the forward link. Power control on the forward link, however, is necessary to compensate for users at the cell boundaries who may suffer interference from other cells. The power control systems have to compensate not only for signal quality variations due to a varying distance between base station and mobile terminal, but must also attempt to compensate for signal quality variations typical of a wireless channel. These variations are due to the changing propagation environment between the base station and the mobile terminal as the mobile terminal moves across the cell or as some elements in the cell move. There are basically two types of channel variations, slow fading and fast fading. The necessity for power control in FDMA/TDMA- based cellular networks stems from the requirement for co-channel interference management. This type of interference is caused by frequency reuse due to limited available frequency spectrum. By a proper power adjustment, the harmful effects of co-channel interference can be reduced. This allows a more “dense” reuse of resources and thus higher capacity. Cellular networks stems from the requirement for co-channel interference management. This type of interference is caused by frequency reuse due to limited effects of co-channel interference can be reduced. This allows a more “dense” reuse of resources and thus higher capacity.

The reverse link power control mechanism consists of two parts, open loop power control and closed loop power control. The open loop power control is used to adjust the mobile terminal‟s transmitting power based on the received power from the base station.

Assuming that the radio environment is reciprocal in both forward and reverse link, the mobile terminal adjusts its reverse link transmission power according to the received power on the forward link. In the closed loop power control mechanism, the base station demodulates the reverse link and determines the signal to noise ratio (SNR)/bit error ratio (BER), of the user. If the SNR/BER is lower than a desirable threshold the base station orders the mobile terminal to raise the transmit power. If the SNR/BNR is higher than a desired threshold the base station orders the mobile terminal to lower the transmit power.

In figure 5.1 the effects of power control mechanism is shown. The power received by the subscriber gets faded as the mobile user moves away from the base station. The power transmitted by the mobile is going on increasing as it moves away from the BS. After the power control techniques are applied the received power at the base station is maintained at a constant level. In real time situation the information about the transmit power is obtained from the V_TP frame of RR connection frame structure. The information about the transmit power from the mobile is shown in appendix 2.

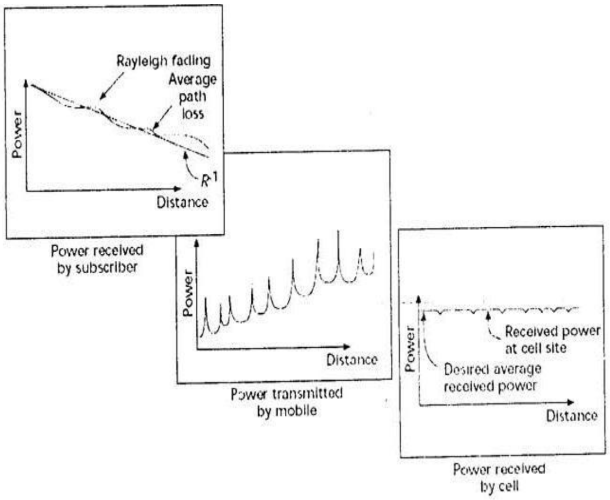


Figure 5.1 Effects of power control

5.4. ESTIMATION OF RECEIVED SIGNAL STRENGTH

In mobile communications, the received signal strength fluctuates as the vehicle travels through the interference patterns caused by multipath, shadowing owing to obstructions, and the change in the mobile station (MS)-base stations (BS) distance. Handoff initiation decisions are largely based on the mean signal strength that is estimated from the received signal. The handoff algorithm parameters such as hysteresis and averaging window size should be chosen to balance the conflicting requirements of minimizing handoff delay and mean number of handoffs which depend on the parameters of the received signal.

A widely accepted model for the received power at the mobile station is in the following product form:

$$p(t) = \left|h(t)\right|^2 s(t) \quad (5.22)$$

Where s (t) is the power fluctuations due to shadowing, and h(t) is the narrowband channel response due to multipath in complex base band form. In this paper we will only focus on narrowband channels. The multipath component is commonly assumed to be statistically independent of the shadow process. When the power is measured through a logarithmic amplifier, its decibel (dB) value has the following additive form:

$$p(t) = H(t) + S(t) \quad (5.23)$$

Where P(t) = 10 log(p(t)), S(t) = 10 log(s(t)), and H(t)=10log(|h(t)^2|). The multipath component h (t) a result of constructive and destructive superposition of many plane waves and a possible line of sight (LOS) component. Hence, for a mobile travelling through the interference pattern we adopt the following model for the multipath component in base band:

$$h(t) = \frac{1}{\sqrt{K+1}} \lim_{M\to\infty} \frac{1}{\sqrt{M}} \sum_{m=1}^{M} a_m e^{j(\omega d \cos(\theta m)t+\phi m)} \sqrt{\frac{K}{K+1}} e^{j(\omega d \cos(\theta o)t+\phi o)}$$

(5.24)

t=x(t) t=y (t)

Where the maximum Doppler frequency $\omega d = 2\pi v$ (and M is the number of independent scatters; the angles between the incoming waves and the mobile antenna (m, m=1,…,M-1,M are independent and identically distributed(i.i.d) with an angle of arrival (AOA) distribution p(); phases (m are i.i.d.,uniformly distributed on (-(,( ]; (0 and (0 are the angle that the LOS component makes with the mobile direction and the phase of the LOS component respectively; k = E|Y(t)|^2/E|X(t)|^2 is the ratio of the LOS component‟s power to that of the diffuse component and is referred to as the Rican factor. The correlation function of h(t) is given by direct substitution and using the assumptions on (m,(m and am.

The dB value of the shadow fading, S (t) is commonly modelled as a Gaussian process with mean (S and variance (S2. The mean is given by the path loss which decreases monotonically with the MS-BS distance. However, for the purposes of local mean and velocity estimation, (S can be assumed to be constant during the time that the received signal is processed. A first order autoregressive model for the shadowing process is based on the measured auto covariance function of S (t) in urban and suburban environments.

$$Cs(\tau) = \sigma_s^{\;2} \exp(-v|t|/Xc)$$

Where Xc is the so-called effective correlation distance. The pair ((S, Xc) can vary from (4.3 dB, 10m) in urban environments to7.5 dB,500m) in suburban areas. The shadow variance plays an important role in the selection of the hysteresis in handoff algorithms and the correlation distance Xc affects the optimum window size selection for local power estimation. The range of values for each of linguistic variables is shown in appendix1. The information about the quality of received signal is shown in appendix 3. Information about the serving cell and neighbouring cell is shown in appendix 4.

VI SIMULATION RESULTS

The proposed Algorithm is simulated using neural networks tool present in the Matlab 7.0 software. Various handoff metrics such as Received signal strength ((RSS), Signal to interference ratio (SIR), Transmit powers (Eb) are considered for simulation. These handoff metrics are then trained with the neural network tool TRAINGD and the results obtained are compared as shown in the following figures. The result shows when to make handoff from WLAN to GPRS by considering the above mentioned metrics. The proposed neural network algorithm shows less number of handoffs which implies the “ping-pong” is reduced there by reducing the packet losses and delays.

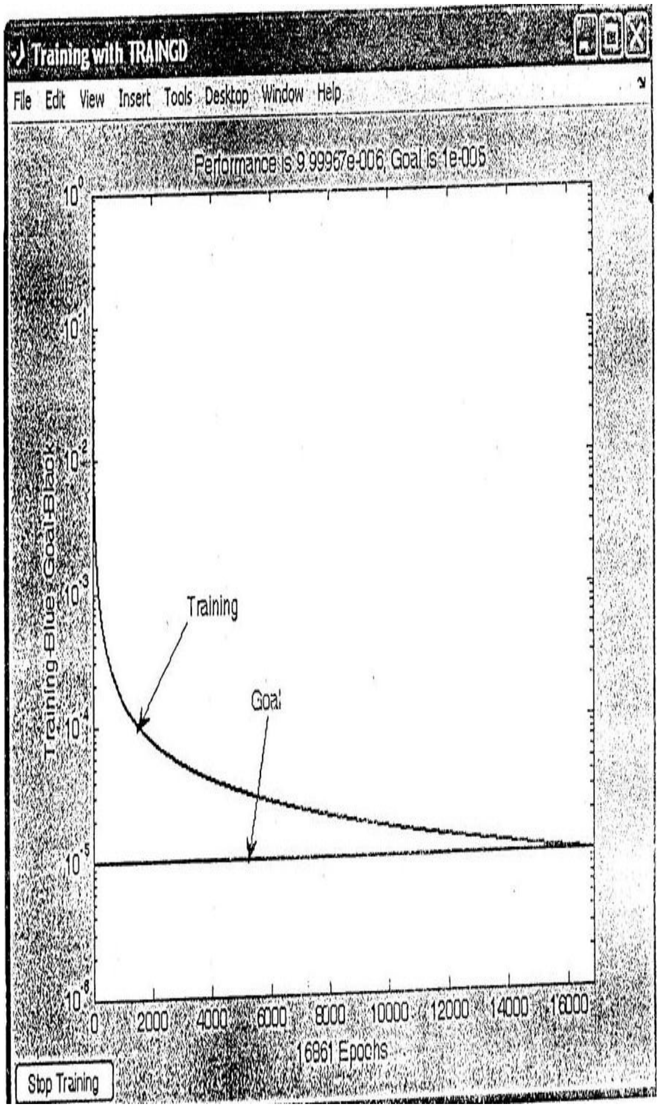
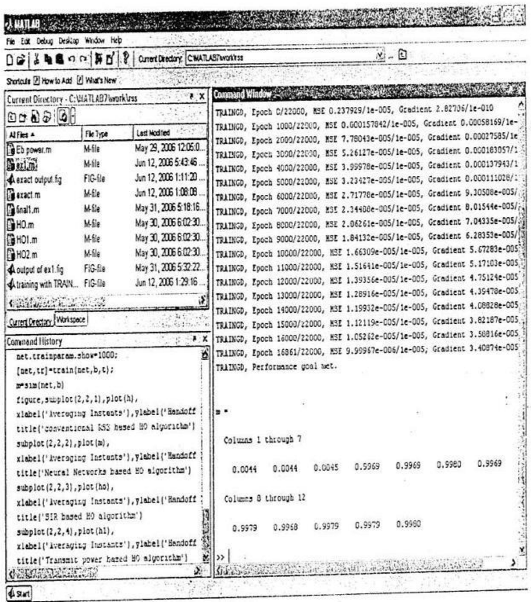


Figure 6.1 Training with TRAINGD

The above figure 5.1 shows the training with TRAINGD command for the goal 1e-005 using neural network tool present in the matlab 7.0 software.



All Files	File Type	Last Modified
Eb power.m	M-file	May 29, 2006 12:05:0...
ex1.m	M-file	Jun 12, 2006 5:43:46 ...
exact output.fig	FIG-file	Jun 12, 2006 1:11:20 ...
exact.m	M-file	Jun 12, 2006 1:08:08 ...
final1.m	M-file	May 31, 2006 5:18:16...
HO.m	M-file	May 30, 2006 6:02:30...
HO1.m	M-file	May 30, 2006 6:02:30...
HO2.m	M-file	May 30, 2006 6:02:30...
output of ex1.fig	FIG-file	May 31, 2006 5:32:22...
training with TRAIN...	FIG-file	Jun 12, 2006 1:29:16 ...

```
net.trainparam.show=1000;
[net,tr]=train(net,b,t);
m=sim(net,b)
figure,subplot(2,2,1),plot(h),
xlabel('Averaging Instants'),ylabel('Handoff
title('conventional RSS based HO algorithm')
subplot(2,2,2),plot(m),
xlabel('Averaging Instants'),ylabel('Handoff
title('Neural Networks based HO algorithm')
subplot(2,2,3),plot(ho),
xlabel('Averaging Instants'),ylabel('Handoff
title('SIR based HO algorithm')
subplot(2,2,4),plot(h1),
xlabel('Averaging Instants'),ylabel('Handoff
title('Transmit power based HO algorithm')
```

```
TRAINGD, Epoch 0/22000, MSE 0.237929/1e-005, Gradient 2.82706/1e-010
TRAINGD, Epoch 1000/22000, MSE 0.000157842/1e-005, Gradient 0.00058169/1e-
TRAINGD, Epoch 2000/22000, MSE 7.78043e-005/1e-005, Gradient 0.00027585/1e
TRAINGD, Epoch 3000/22000, MSE 5.26127e-005/1e-005, Gradient 0.000183057/1
TRAINGD, Epoch 4000/22000, MSE 3.99978e-005/1e-005, Gradient 0.000137943/1
TRAINGD, Epoch 5000/22000, MSE 3.23427e-005/1e-005, Gradient 0.000111028/1
TRAINGD, Epoch 6000/22000, MSE 2.71778e-005/1e-005, Gradient 9.30508e-005/
TRAINGD, Epoch 7000/22000, MSE 2.34408e-005/1e-005, Gradient 8.01544e-005/
TRAINGD, Epoch 8000/22000, MSE 2.06261e-005/1e-005, Gradient 7.04335e-005/
TRAINGD, Epoch 9000/22000, MSE 1.84132e-005/1e-005, Gradient 6.28353e-005/
TRAINGD, Epoch 10000/22000, MSE 1.66309e-005/1e-005, Gradient 5.67283e-005
TRAINGD, Epoch 11000/22000, MSE 1.51641e-005/1e-005, Gradient 5.17103e-005
TRAINGD, Epoch 12000/22000, MSE 1.39356e-005/1e-005, Gradient 4.75124e-005
TRAINGD, Epoch 13000/22000, MSE 1.28916e-005/1e-005, Gradient 4.39478e-005
TRAINGD, Epoch 14000/22000, MSE 1.19932e-005/1e-005, Gradient 4.08828e-005
TRAINGD, Epoch 15000/22000, MSE 1.12119e-005/1e-005, Gradient 3.82187e-005
TRAINGD, Epoch 16000/22000, MSE 1.05262e-005/1e-005, Gradient 3.50816e-005
TRAINGD, Epoch 16861/22000, MSE 9.99967e-006/1e-005, Gradient 3.40874e-005
TRAINGD, Performance goal met.


m =

  Columns 1 through 7

    0.0044    0.0044    0.0045    0.9969    0.9969    0.9980    0.9969

  Columns 8 through 12

    0.9979    0.9968    0.9979    0.9979    0.9980

>>
```

Figure 6.2 Trained Result for Goal 1e-005

Figure 6.2 shows the trained result for the proposed handoff scheme using neural networks in the matlab tool.

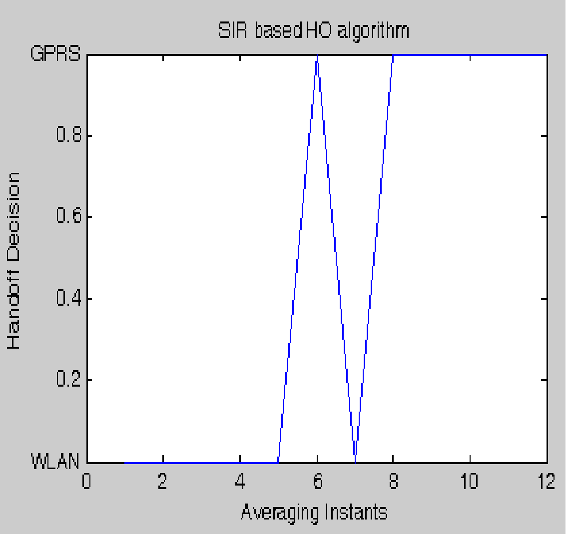


Figure 6.3: RSS based handoff algorithm

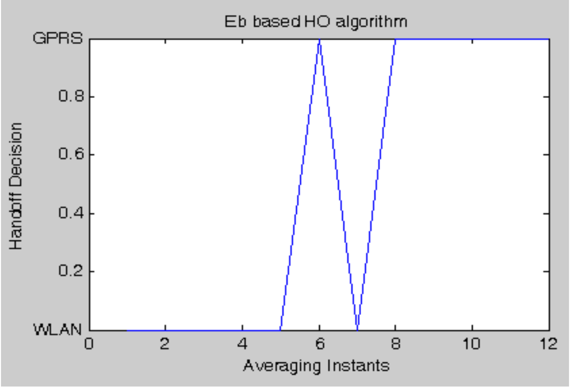


Figure 6.4: SIR based handoff Algorithm

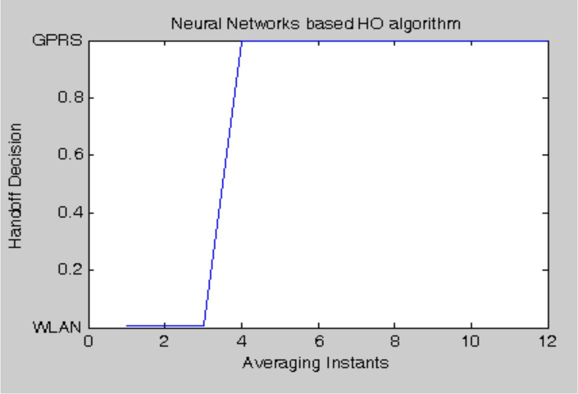


Figure 6.5: Transmit power based handoff algorithm

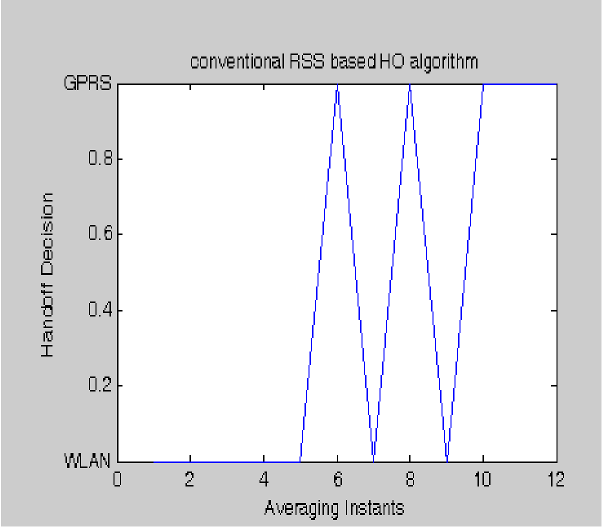


Figure 6.6 Fuzzy based Handoff algorithm

VII CONCLUSION AND FUTURE WORK

Thus this project gives an optimized solution for handoff across heterogeneous networks using Fuzzy-Logic. The trained result of the proposed handoff scheme shows that number of handoffs between WLAN and GPRS is much more reduced compared to the traditional handoff algorithm. This shows that ping-pong effect between the two networks is reduced, thereby reducing packet losses, delays during handoff. Here we considered only two different networks namely WLAN and GPRS. The different handoff metrics such as RSS, SIR, and Eb are trained using Fuzzy-Logic tool present in the Matlab software as shown in the above chapters.

The simulated result shows that compared to the traditional handoff metrics namely RSS, SIR, transmit power, in the proposed neural network based algorithm the handoff takes very less number of time. Therefore the ping-pong effect is reduced thereby the losses are reduced.

As a feature work further extend this algorithm for more than two different networks and considering other handoff metrics such as cost in the proposed algorithm.

APPENDIX

SPECIFICATION OF RANGES OF PARAMETERS

Table A.1.1 Specification of ranges of parameters used in the simulation

Parameters	Specification of ranges		
	High	Normal	Low
Received Signal Strength (dBm)	-76 to -40	-100 to -75	-120 to 101
Signal to Interference Ratio (dBm)	20 to 22	17 to 19	14 to 16
Transmit Power From the Mobile (dBm)	26 to 33	18 to 25	13 to 17
Velocity of the Mobile (Kmph)	>60	40 to 60	<40

White Paper: Signal Strength Measurements
GSM 05.08 Specification
Ericsson Erisoft AB

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