Wireless Networks using Fuzzy Logic

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***Abstract*—In wireless network the concept of Quality of Service(QoS) and handover strategies has been studied extensively in the literature. Another subject on which many researches have focused their attention is that of using Fuzzy-Based multi-Interface system(FDMIS).In fuzzy based multi interface system each node is equipped with two interfaces they are Mobile Ad hoc Network(MANET) and traditional cellular network interface. To the best of our knowledge, this is the first work in the relevant literature where such an approach has been proposed. Here the FDMIS switches cellular to ad hoc network or vice versa. The main four input parameters are User Request Security(URS),Node Mobility(NM),Angle between Node and Base station(ANB), and Distance Between Nodes(DBN).By computer simulations using MATLAB, we evaluate the performance of the proposed system.**

Keywords—QoS,Fuzzy-Logic,Intelligent-Systems,Ad-Hoc Networks,Cellular Networks.

I. INTRODUCTION

In wireless cellular networks, there are usually two classes of calls they are new calls and handoff calls. The new calls in a cell are the ones which are initiated in this cell and the handoff calls are the ones which are the ongoing calls handed off to this cell (see [2], [3], [10], [11] and the references therein). In the existing literature [8] [10] to simplify the analysis, the handoff call holding time is always assumed to be the same as that of the new call holding time, and the handoff call cell residence time is always assumed to be the same as that of the new call cell residence time. However, recent studies in [2], [3] ,[4] and the references therein showed that the new call channel holding time and the handoff call channel holding time may have different distributions. Worse yet, they may have different average values. Simulation study and field data also confirmed that they are different random variables [4].Since from last few years, the demand for multimedia services over the air has been steadily increasing. Cellular network is widely used and it uses provisioning strategies such as Call Admission Control (CAC) and handover. Thus the number of connections are limited into the network in order to reduce the network congestion and call dropping. In 4G wireless networks micro/pico cellular architecture is used [1].

Imagine a situation where you are hardly able to hear what your friend is talking over the phone or the phone gets cut when you are talking something important. These things are highly undesirable and you do not want to get low quality service for paying high monthly bills. Communication plays a major role in today's world and to support it QoS has to be given maximum priority. It is important to differentiate the traffic based on priority level. Quality of Service (QoS) in cellular networks is defined as the capability of the cellular service providers to provide a satisfactory service which includes voice quality, signal strength, low call blocking and dropping probability, high data rates for multimedia and data applications. In the Call Admission Control(CAC) algorithm new call arrival rates are estimated continuously and if they are higher than a predetermined level some calls are blocked irrespective of whether a channel is available or not. The objective of this scheme is to maintain the new call arrival rate lesser than a predetermined level.

Mobile Ad hoc Network(MANET) is a easy to deploy and low cost of wireless communication. By using MANET, nodes use each-other resources, while avoiding the overload in BSs. The well-known problem with MANET is the decrease in performance for large networks, which is often seen in recent developments of our society. Thus, MANET can be used when the nodes that want to communicate are near each other.

Here in this paper we propose a Fuzzy-Based Multi-Interface System(FBMIS),where each node is able to switch from cellular to MANET and vice versa. The main four input parameters are Distance Between Nodes(DBN),Node Mobility(NM),User Request Security(URS) and Node and Base station(ANB).They are fuzzified by Fuzzy Logic Controller(FLC) and give Decision Value(DV) as output, which is used to select which interface to use.

The remainder of this paper is organized as follows. In section II we give a basic description of Cellular Networks, section III gives a basic description of MANETs. Section IV Conclusions.

II. WIRELESS NETWORKS

A. Cellular Network

The basic requirement of wireless cellular network is of high capacity. High capacity is achieved by limiting the coverage of each base station to a small geographic region called a cell. This is different from the traditional radio transmitters which would cover the entire city and the whole city was one cell. This is a paradigm shift. In order to achieve higher capacity that is to support a larger number of users the city first must be divided into smaller cells and each cell must have a transmitting tower called the base station. The same frequencies or timeslots or codes are reused by spatially separating the base stations. So this factor of being able to reuse the frequencies actually allows you this high capacity. That means, a larger number of customers, more revenue and sustainability of the system.

However the movement we put more number of cells and at the same time promise the customers that they can move around because it is a mobile situation, we should have a mechanism to handoff the calls from one cell to another. So this is the price we have to pay in order to give enough mobility. This approach resolves the problem of limited radio spectrum. If we had the luxury of using infinite bandwidth, we don't need to reuse. Otherwise we will have to resolve to the techniques of frequency reuse.

As the demand increases, the number of base stations may be increased thereby providing additional capacity. So there are ways and means today to expand your services. If your number of customers increases you can scale up your system. So this reuse factor and certain other advanced techniques will allow you to continue providing service to more and more number of stations even though you are not asking for extra bandwidth. This is the basic concept all. A very intuitive understanding is as follows. Just like the whole city has been divided into cells, each cell can be divided into sub cells and further and further. So use smaller and smaller sub cells within the cell but keep in mind that the cell size can be reduced only if you reduce the power. But clearly the transmitted power is a factor which will decide how big your cell is. So I can reuse and include more number of users provided I keep my emitted power under control.

Mobile network providers install several thousands of base stations each with a smaller cell instead of using power full transmitters with large cells because, when the cell size is small we can have the following advantages:

1. Higher capacity: Smaller the size of the cell more the number of concurrent users i.e. huge cells do not allow for more concurrent users.

2. Less transmission power: Huge cells require a greater transmission power than small cells.

3. Local interference only: For huge cells there are a number of interfering signals, while for small cells there is limited interference only.

4. Robustness: As cellular systems are decentralized, they are more robust against the failure of single components.

Disadvantages of cellular systems are:

1. Infrastructure needed: Small cells require a complex infrastructure to connect all base station. The infrastructure required includes switches for call forwarding, location registers etc.

2. Handover needed: The mobile station has to perform a handover when changing from one cell to another very frequently.

3. Frequency planning: To avoid interference, frequency spectrum should be distributed properly with a very less range of frequency spectrum.

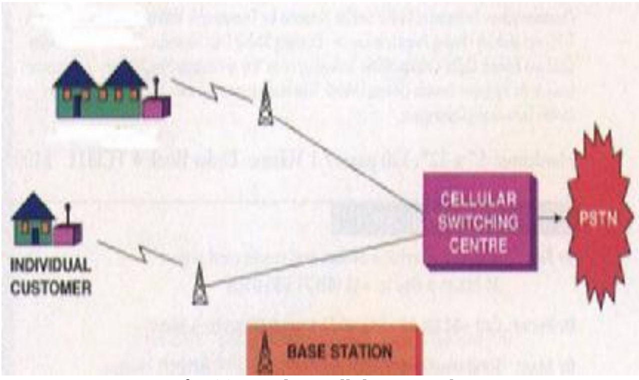

fig (a): wireless cellular network

Fig(a) shows how an individual customer gets connected to cellular switching centre through base station.

Cellular network has a number of desirable features they are as follows:

- Mobile devices use less power than with a single transmitter since the cell towers are closer.
- Larger the coverage area than a single terrestrial transmitter, since additional cell towers can be added indefinitely and are not limited by the horizon.
- More capacity than a single large transmitter, since the same frequency can be used for multiple links as long as they are in different cells.

B. Mobile Ad-Hoc Network

A **mobile ad hoc network** (**MANET**) is a continuously self-configuring, infrastructure-less network of mobile devices connected without wires. Ad hoc is Latin and means 'for this'. Each device in a MANET is free to move independently in any direction, and will therefore change its links to other devices frequently. Each must forward traffic unrelated to its own use, and therefore be a router. The primary challenge in building a MANET is equipping each device to continuously maintain the information required to properly route traffic. Such networks may operate by themselves or may be connected to the larger Internet. They may contain one or multiple and different transceivers between nodes. This results in a highly dynamic, autonomous topology[5].

MANETs are a kind of Wireless ad hoc network that usually has a routable networking environment on top of a Link Layer ad hoc network. MANETs consist of a peer-to-peer, self-forming, self-healing network. MANETs circa 2000-2015 typically communicate at radio frequencies (30 MHz - 5 GHz).The growth of laptops and 802.11/Wi-Fi wireless networking have made MANETs a popular research topic since the mid-1990s. Many academic papers evaluate protocols and their abilities, assuming varying degrees of mobility within a bounded space, usually with all nodes within a few hops of each other. Different protocols are then evaluated based on measures such as the packet drop rate, the overhead introduced by the routing protocol, end-to-end packet delays, network throughput, ability to scale. Mobility and the absence of any fixed infrastructure make MANET very attractive also foe rescue operations and time critical applications.

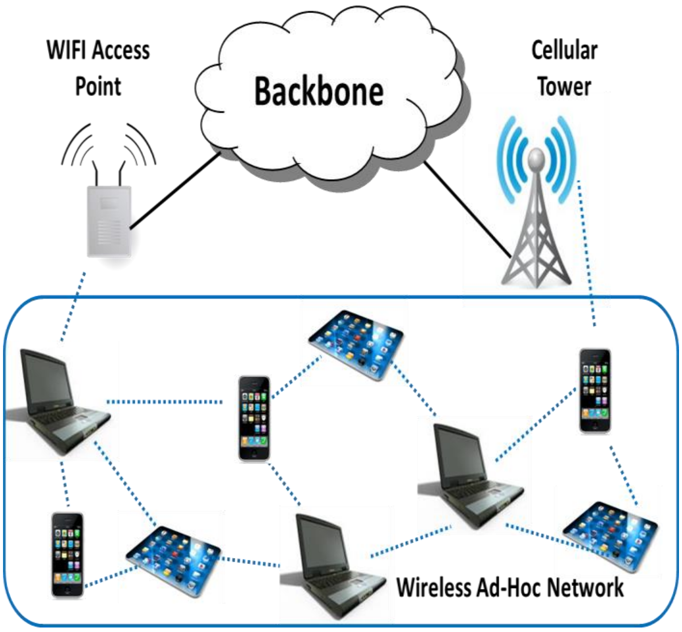

Figure 2. Wireless ad-hoc networks need incentives mechanisms to enforce cooperation among the selfish nodes.

With the rapid development of wireless communication technology and the extensive usage of mobile communication equipment, wireless ad hoc networks are getting more and more attention. Nowadays, wireless ad hoc networks are not only used in military, but also been applied to civilian application, including home area networks, mobile communication networks, and so on. Wireless ad hoc networks are envisioned to be one of the most important parts of future Internet. However, in civilian wireless ad hoc networks, nodes often belong to different parties who have their own interests and always want to maximize their own benefits. Such selfish behavior can hurt the robustness and availability of wireless ad hoc networks. In our work, we adopt solution concepts from microeconomics and game theory to study important incentive problems in wireless ad hoc networks, including spectrum allocation and routing. Our objective is to achieve a series of cooperation-incentive mechanisms with high availability, low cost, and high adaptability, through the following four closely related studies: game-theoretic problem modeling, impossibility analyzing, strong incentive mechanism designing, and systematic evaluation methodology developing. MANETs need to have implemented some mechanisms as follows:

- Security mechanisms, Node must be able to relay traffic since communicating nodes might be out range.
- Multi hop operation requires a routing mechanism designed for mobile nodes, and it provides inter-networking, an Internet access mechanisms is needed.
- Self configuring networks requires an address allocation mechanism, and Mechanism to detect and act on merging of existing networks.

Advantages of Ad-Hoc Networks are as follows:

- **Lower getting-started costs** :*no need to install base stations ,easier temporary setup.*
- **Well suited to free unlicensed spectrum:***significant savings given typical auction prices*
- **Inherent scalability:***with power control & cooperative relaying, each user contributes to network capacity.*

III. PROPOSED SYSTEM MODEL

In this section, we present how FBMIS selects cellular networks and MANET. The fig.3 shows the structure of FBMIS. The input parameters from the environment are taken by nodes and after the Fuzzy Control System(FCS) gives a Decision Value(DV), which is used for control.

A. Fuzzy Control System

As shown in fig. 4, the FCS consists of fuzzifier, interference engine, defuzzifier and Fuzzy Rule Base(FRB). The input and output parameters for the FCS are as shown in fig.5.we explain these parameters as follows:

- **Distance Between Nodes(DBN):**It is one of the important parameter in FCB. When two nodes are far, they will consider using cellular network to communicate, and if they are closer, they will consider using MANET. In this work, the distance varies from 0 to 3000 units. To select which network to use, it is very necessary to know the distance between to the two nodes. Depending on the distance between two nodes the FLC decision is taken.
- **Node Mobility(NM):** It is the moving speed of the node. FLC takes a decision depending on the speed of the node. If the node is moving slowly or stops then the NM is very low. When the node moves faster the NM becomes higher.
- **Angle Between the Nodes(ANB):** The value of the angle varies from -180 to +180. It is the vectorial difference of the angles formed between the vectorial relative speed of two communicating nodes, and the line connecting them. Fig.6, shows the meaning of angle values. When the nodes are moving towards BS then we consider the angle to be as 0. Otherwise we consider angle to be 180,node moves away from BS. This parameter is mainly considered to

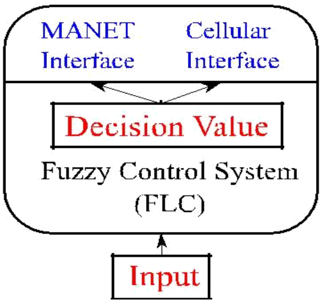

Figure 3: FBMIS structure.

predict the future distance between two communicating nodes.

- **User Request Security(URS):** It is nothing but the degree which user request from a client. The value of URS varies from 0.0 to 1.0unit. When a user requires more security, the user should connect to cellular network. It provides a security by opening new window in the computer. For example when we do banking we need security so we go for cellular network. If a user do not need a security, then the user will consider using MANET. The MANET network will not provide security. The user can browse anything in this network. We mainly use MANET just because it has more speed than cellular Network.
- **Decision Value(DV):**It decides which interface will be used to communicate between nodes. Depending on input values, the "decision" can be weak recommendation or strong recommendation and a strong Ad hoc or strong cellular response forces the node to change the connection to Ad hoc or cellular, respectively. A weak Ad hoc or weak cellular response will recommend the node to use ad-hoc or cellular modes, respectively. If they are not connected yet or stay connected with the actual interface. The not cellular not Ad hoc response does not change the interfaces if the node is already connected. It can be used to set up a default interface for each node.

B. FLC Design

The input parameters for FLC are: DBN, NM, ANB and URS, while the output linguistic parameter is the DV. The term sets of DBN,NM,ANB and URS are defined respectively as:

μ(DBN)={Near, Middle, Far}
={Ne, Mi, Fa};
μ(NM)={Low, Middle, High}
={L, M, H};
μ(ANB)={Left Back, Left, Center, Right, Right Back}
={LB, Le, Ce, Ri, RB};
μ(URS)={Low, Middle, High}
={Lo, Mid, Hi}.

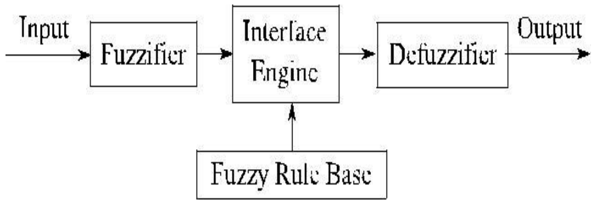

Figure 4: Fuzzy Control System

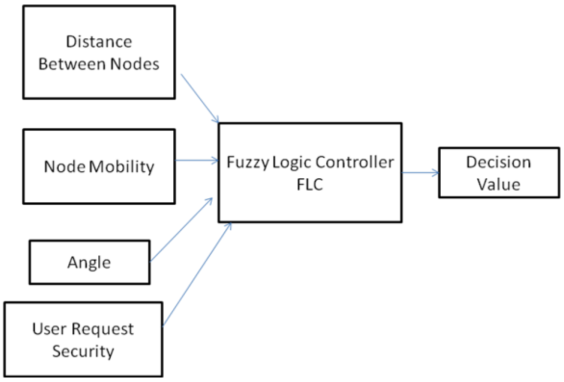

Figure 5: Structure of proposed FBMIS.

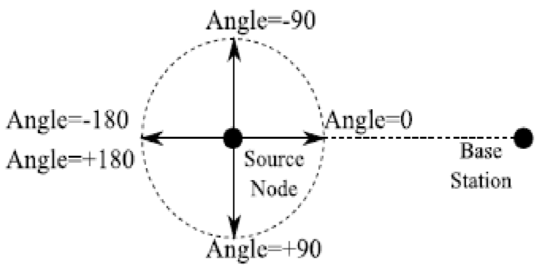

Figure 6: Meaning of angle values.

$$\mu(DV) = \begin{bmatrix} \text{Strong Adhoc} \\ \text{Weak Adhoc} \\ \text{Not Cellular Not Adhoc} \\ \text{Weak Cellular} \\ \text{Strong Cellular} \end{bmatrix} = \begin{bmatrix} SA \\ WA \\ NCNA \\ WC \\ SC \end{bmatrix}$$

III. SIMULATION RESULTS

In this section, we evaluate by computer simulations the performance of FBMIS. The simulations were carried out in MATLAB using the Fuzzy Toolbox. The results are as shown in fig. 8, for values of ANB of 0, 90 and 180 and URS of 0.1, 0.5 and 0.9, respectively. We consider that DBN is from 0 to 3000 units. However, results are the same after the DV is 1000 units. In each figure is shown the DV, the distance between the communicating nodes, for NM values. The five NM values

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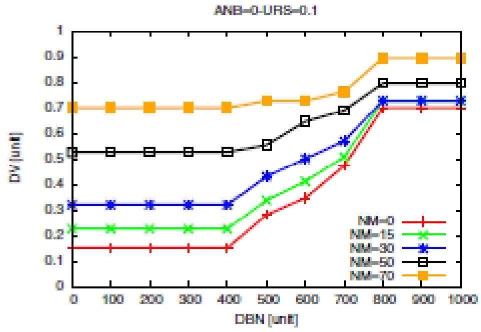
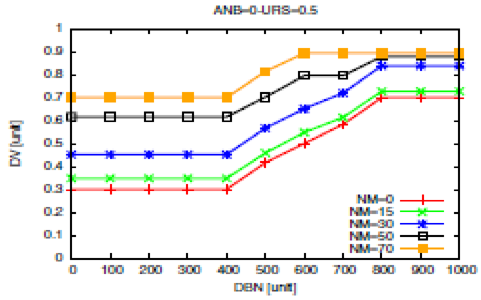
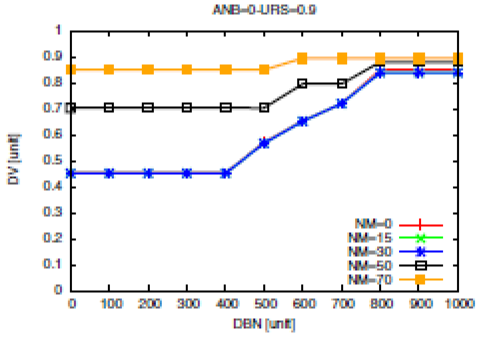
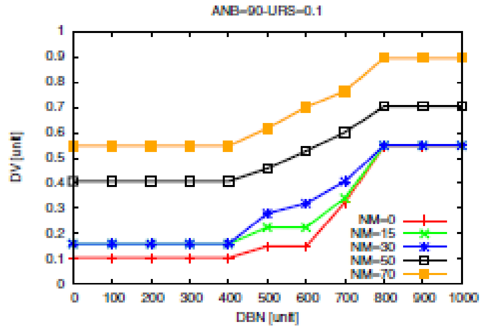




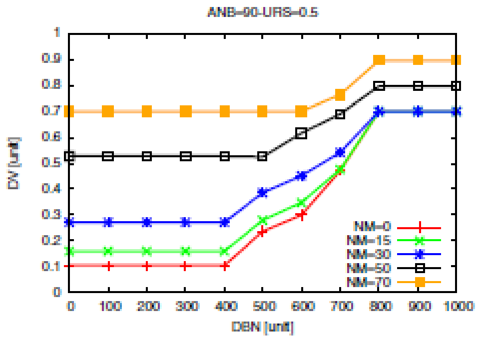
(b) ANB=0, URS=0.5



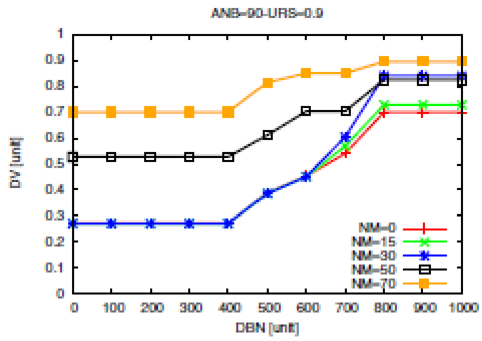
(c) ANB=0, URS=0.9



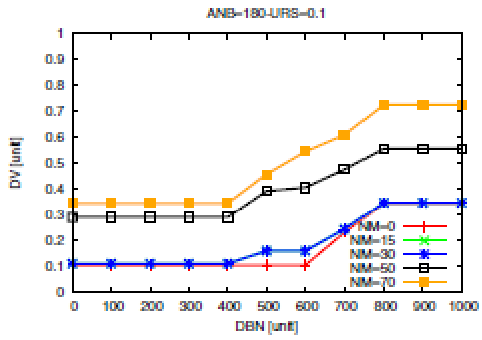
(d) ANB=90, URS=0.1



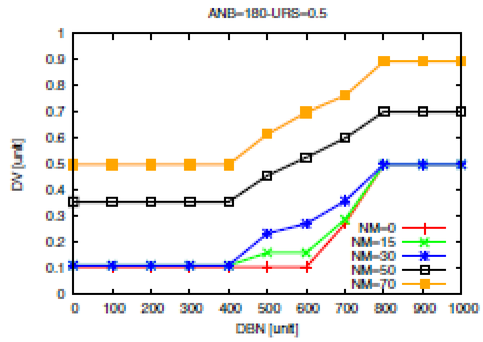
(e) ANB=90, URS=0.5



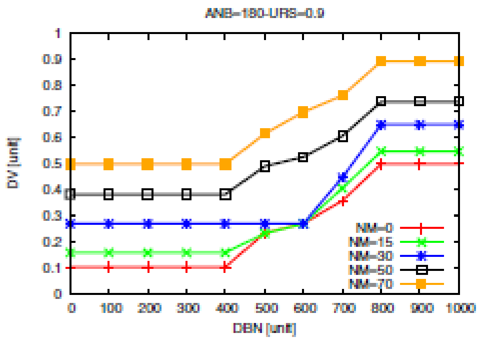
(f) ANB=90, URS=0.9



(g) ANB=180, URS=0.1



(h) ANB=180, URS=0.5



(i) ANB=180, URS=0.9

we consider here are 0, 10, 30, 50 and 70. By increasing the distance, the DV also increases. Hence the nodes should select cellular interface, as shown in previous work[29]. The performance of MANET decreases when the number of hops to reach the destination is more than 3. So for longer distances cellular network is better.

In fig. 8(a), we consider URS 0.1 and ANB 0 units. Then in fig. 8(b) and 8(c), we increase the values of URS to 0.5 and 0.9 units. As URS value increases DV also increases. In fig. 8(d), we set the values of ANB to 90 and URS to 0.1. Then in fig. 6(e) and 6(f), we increased the value of URS to 0.5 and 0.9. We can see that when the URS and NM values are increased, the DV is increased.

In fig. 8(g), we consider ANB values to 0.9 but URS is 0.1. Then in fig. 8(h) and 8(i), we increase the values of URS to 0.5 and 0.9 units. As URS, NM and DBN value increases the DV is increased. Therefore when the ANB increases, the DV is increased. In fig. 8 we see three zones. In first zone the DNB values are from 0m to 400, here the node tents to connect with MANET. In middle zone the DV values are from 400 to 800 units, where the DV increases with the increase of DBN value. The third zone, when DBN is larger than 800 units, here the node connects to cellular network.

IV. CONCLUSION

In this paper, we will propose and implement a FBMIS in order to improve the communication performance in wireless communications. Here we are going to use FL to decide if a node will use the cellular interface or MANET interface when connecting to other nodes. For simulation results, we will conclude that when distance increases FBMIS use cellular interface. When the NM value is low, FBMIS uses MANET interface. When the node moves towards BS, FBMIS uses cellular interface. When the node moves away from BS, FBMIS tends to connect with MANET. Here in this paper we considered four parameters. The future work may be by considering more parameters such as ns-3.

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