Chapter 9

Concluding Remarks & Future Scope

This chapter describes the conclusions about the results and remarks about it. Also some future scope suggested here to extend the project for further real time implementations.

Simulation study of wired network configuration having six nodes was carried out using NS2. The effect of packet processing from one node to other with parametric changes such as size of the packets/ channel, protocols for various layers layer. 1Mb 10ms Drop-Tail type duplex link was setup between the each node of the network.CBR (Constant bit rate) from the source nodes with the packet size of 500mb. Dropping of packets was detected in case of queue overflow. Similar study with five wireless nodes was carried out to find the throughput produced following results:

- Average Throughput [kbps] = 13156.03
- StartTime=36.83
- StopTime=585.72

The effect of parametric variations such as: change in the pause time, mobility of each nodes and network size was carried out. Results various routing protocols in the WANET has been reported.

- It is found that proactive flat routed global routing protocols do not scale very well. OLSR scales the best. This increase in scalability is achieved by reducing the number of rebroadcasting nodes through the use of multipoint relaying, which elects only a number of neighboring nodes to rebroadcast the message and has the advantage of reducing, channel contention and the number of control packet travelling through the network when compared to strategies which use blind or pure flooding where all nodes rebroadcast the messages.
- The proactive routing protocols performs better when the density of the network is less, as the density and mobility of nodes increases the performance of the reactive protocols are better than the proactive protocols.
- AODV suits applications where End-to-End delays are very critical. Considering the Overall performance of AODV, it performs well in low and medium node density where as for high node density DSR performs well. DSR is selected for the traffic which is highly dominated with file transfers where delivery ratio and throughput are the critical factors with less importance to end-to-end delay.

In WANETs, scalability is one of the major problems. If bandwidth is limited, scalability can be achieved by limiting control updates to locations close to changes. DSR proves to be better as network size increases and as the mobility of network increases.

Proactive protocols perform well in low/ medium node density where as Reactive performs well for high density environment. The proactive routing protocols performs better when the density of the network is less, as the density and mobility of nodes increases the performance of the reactive protocols are better than the proactive protocols.

In our simulation results, on-demand routing protocols DSR perform well in high maximum speed and high density then the table-driven(Proactive) routing protocol, OLSR shows the worst performance because its periodic route update and hello messages become the severe overhead in highly mobile and dense network.

Considering the Overall performance of Proactive protocols, it performs well in low and medium node density where as for high node density Reactive performs well. DSR is selected for the traffic which is highly dominated with file transfers where delivery ratio and throughput are the critical factors with less importance to end-to-end delay. The general observation from the simulation is that for application oriented metrics such as delay and delivery rate. The poor delay and throughput performances of DSR are mainly attributed to aggressive use of caching, and lack of any mechanism expires stale routes or to determine the freshness of routes when multiple choices are available.

The results show the hybrid routing protocols can achieve the better performance than the proactive and reactive protocol because of its scalable feature. Hybrid routing protocols have the potential to provide higher scalability than pure reactive or proactive protocols, because they attempt to minimize the number of rebroadcasting nodes by defining a structure (or some sort of a backbone), which allows the nodes to work together in order organize how routing is to be performed.

Soft computing techniques are applied here to adaptively determine the value of the protocols. For example: instead of keeping the hello messages interval fixed of the valued of 1 sec or 1.5 sec, it is made adaptive according to the situation of the network to find the effect on the WANET performance Fuzzy inference system; ANFIS, ANN and GA techniques are used based on network situation the network parameters such as transmission power and mobility of the each node.

The simulation study was carried out using software simulation tools such as: MATLAB/SIMULINK, True Time. NS2, Qualnet5. The performance metrics are evaluated to check the performance of various parameters for AODV protocol. The packet delivery ratio which is ratio of packets sent to the total packets received increases with increase in power. With increase in amount of power with which the packet is sent, the packet delivery ratio increase with decrease in number of hops. Also the end to end delay which is the delay between the packets sent and received decreases with increase in power. Thus the packet delivery ratio increases and end to end delay decreases with increase in power. The number of hops decreases with increase in power. The transmission range increases with increase in transmission power.

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The fuzzy logic system is implemented for optimizing signal reach which in turn optimizes the hop count with which the signal reaches destination from node. The power and threshold are two inputs to the fuzzy logic system. The output of the system is signal reach. The output is classified in three membership function. As signal reach increases the range for communication of each node increases which turn results in decrease in number of hop count. Fuzzy Inference System is proposed to adaptively decide the frequency of sending Hello Messages. The adaptive Hello intervals determined from the FIS is applied to the AODV protocol and the performance was evaluated. Fuzzy Inference system designed here which determines the value of hello interval based on the inputs of transmission power and mobility of the nodes. The input and output pairs generated by FIS is used for the training of ANN module. Once the ANN block is trained then we can use it to determine the hello interval based on the inputs transmission power and mobility of the nodes.

ANN based AODV is proposed which adaptively decide the frequency of hello interval (HI) Fuzzy AODV/ANFIS was used to generate the training pairs for I/O pairs (P, T) for training ANN. The performance of ANN based AODV is compared with traditional AODV whose hello interval (HI) are fixed as per IETF DRAFT. Simulation results shows that ANN based AODV has improvement than in traditional AODV. Effect of variation of nodes was also studied. The results indicate that throughput decreases with increase in node density. It is proposed that effect of combined Neuro-fuzzy based AODV may be explored which may lead to performance improvement

The adaptive Hello intervals determined from the ANFIS is applied to the AODV protocol and the performance was evaluated using Qualnet. Simulation results indicate that the throughput of the routing protocol is better in the higher node density. It is worth mentioning that the ANFIS is trained off line and value suggested by ANFIS is passed through MATLAB workspace manually.

Project includes hardware implementation of proposed ANN using FPGAs. The proposed network architecture with the 2 input nodes as the transmission power and mobility of the nodes of WANET and the output as Hello interval based on the inputs was decided by ANN. ANN has different layer modules, and it is possible to easily increase or decrease the number of neurons as well as layers. FPGAs can be used for portable, modular, and reconfigurable hardware solutions for neural networks. Simulation results (using ModelSim/ISIM) of the FPGA implementation of the neural controller have compared with MATLAB results of ANN. From the following **Figure 9.1(a)** we can conclude that the

Simulation results (using ModelSim/ISIM) of the FPGA implementation of the neural controller have compared with Matlab results of ANN. From the following **Figure 9.1(a)** we can conclude that the Relative difference of FPGA implementation of Purelin type ANN and MATLAB implementation is negligible.

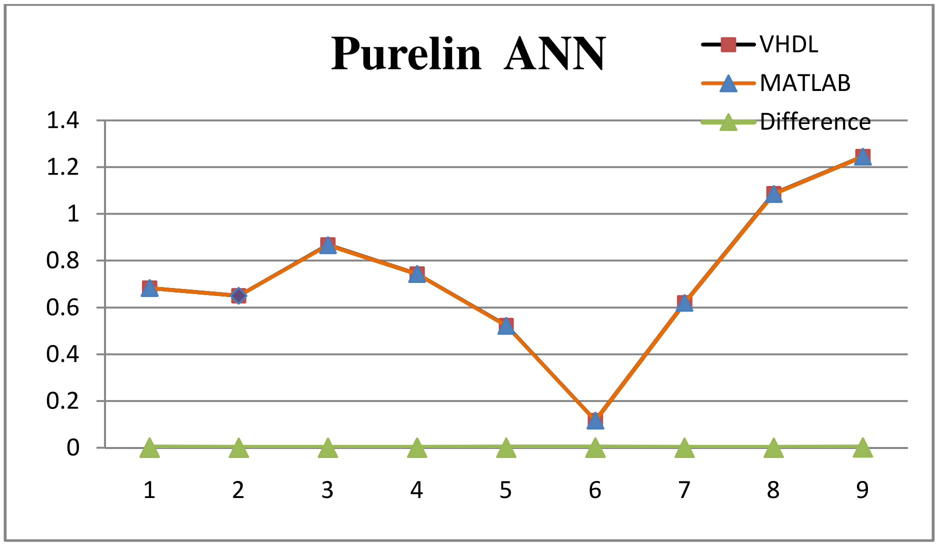

Figure 9.1 (a): Relative difference of Purelin type ANN

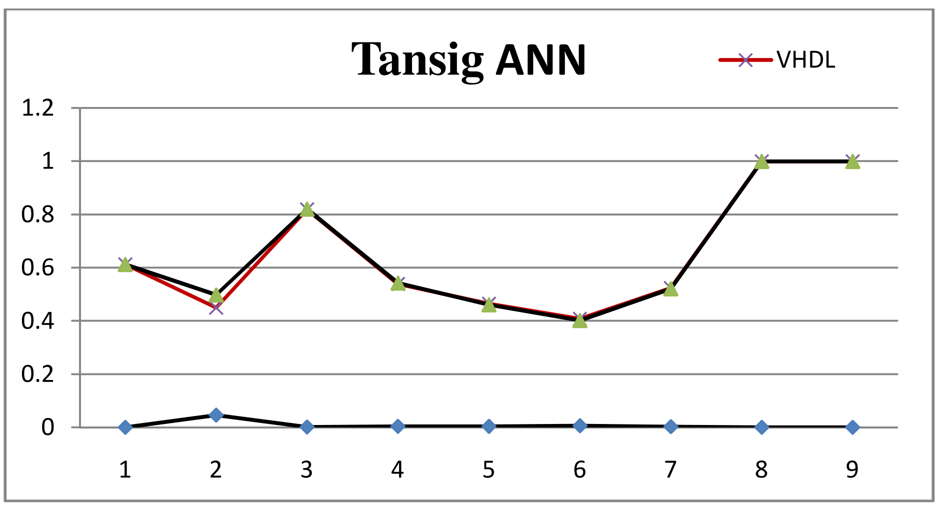

Figure 9.1(b): Relative difference of Tansig type ANN

While from **Figure 9.1(b)** we can observe that there is some relative difference present between the MATLAB implementation of TANSIG type ANN and the FPGA implementation due to the truncation of the number of bits in the lookup table implementation of the tansig activation function. Still the output is satisfactory to decide the value of hello interval.

In the hardware implementation the inputs are provided to the ANN from the GPIO input output pins and output is displayed on LCD, with the input and output values in hex.

ANN with the two activation functions viz. Purelin and Tansig type is analyzed to determine the Hello interval Parameter for the AODV reactive routing protocol in WANET. Both the type of ANN fed to the FPGA and executed by it and displays the value of hello interval on the output device LCD, then this Hello interval value now can be use in any real time WANET to optimize the performance of and to reduce the power consumption in Updation of the network situation. ANN in routing protocol for WANET is offline; this can be made online using links between software.

ANN is trained by fuzzy inference system to improve performance of ANN, while GA is used to optimized weights of each layer of ANN. Genetic Algorithm is used to tuned the biases and weights of each layer so that the minimization between the actual value of hello interval and target value of hello interval. The relative difference between the Genetic algorithm based ANN and Traditional trained ANN is shown in **Figure 9.1 (a) for Purelin Type and Figure 9.1(b) for Tansig type ANN.**

It can be safely concluded that the relative difference between the results obtained by GA and traditional training is more while the transmission power is sufficient the relative difference is less irrespective of the mobility of the models. So the genetic algorithm can trained the ANN better in the higher mobility situation of the network. The relative comparisons between all the soft computing techniques are shown in figure below for the node density of 40 and 30.

Average packet delivery ratio for the ANFIS based hello interval has the highest compared to all the other proposed techniques while it is less for node density of 30 type of network. While average end to end delay is less for ANFIS based AODV Hello interval. Average jitter is also less compared to other proposed techniques. Also the average number of received for ANFIS based AODV has moderate compared to the others.

FOR Nodes=40

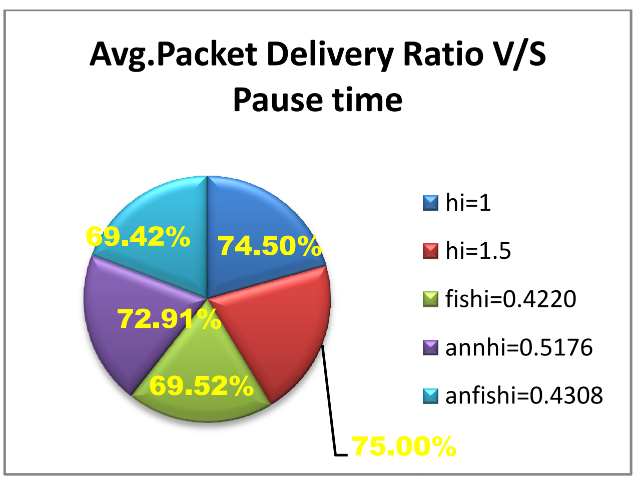

Figure 9.2:Average Packet Delivery Ratio V/S

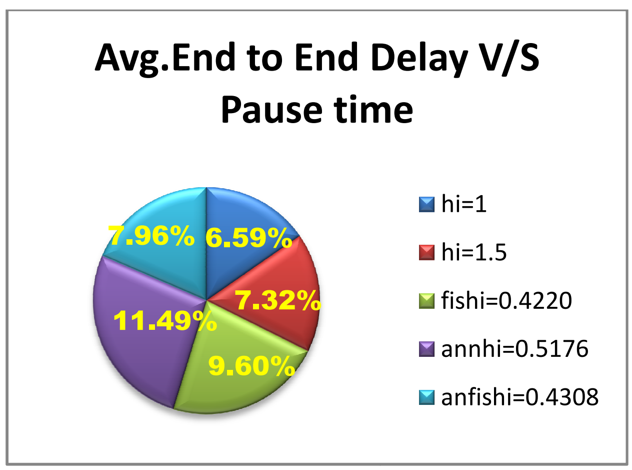

Figure 9.3: Average End To End Delay V/S

Pause Time Of Nodes

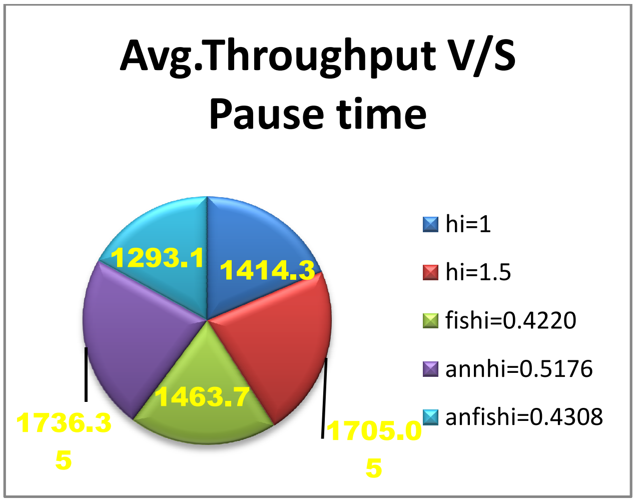

Figure 9.4: Average Throughput V/S Pause Time Of Nodes

Pause Time Of Nodes

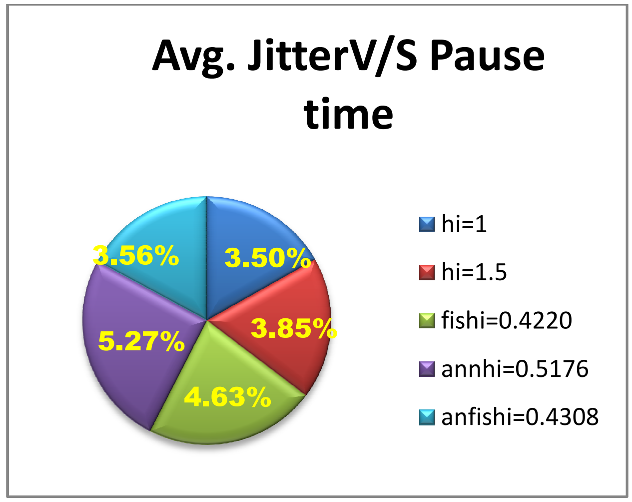

Figure 9.5: Average Jitter V/S Pause Time Of Nodes

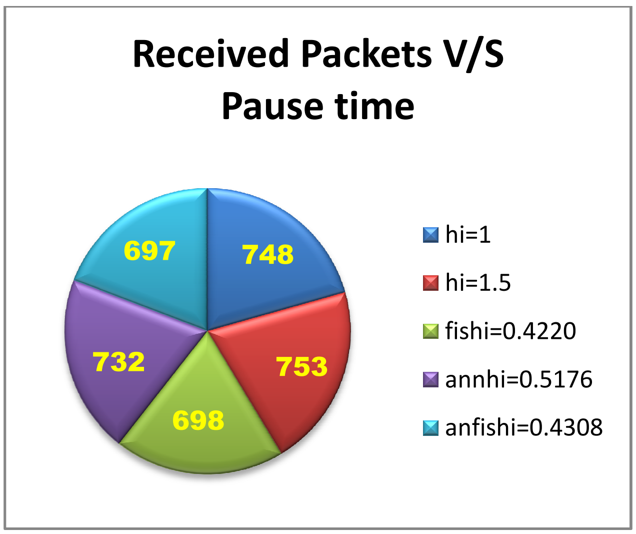

Figure 9.6: Average Number Of Received Packets V/S Pause Time Of Nodes

The average throughput of AODV protocol is improved if we use ANN based technique. The comparison of applied different optimization soft computing techniques with the standard value of hello interval of 1 sec and 1.5 sec is shown in figure 9.2 to 9.6 for the density of nodes as 40.

For the nodes 30 average packet delivery ratio and average throughput for FIS is better and therefore number of received packets performance is also better whenever the node mobility is increase or decrease. While the average end to end delay and average jitter is less in ANN based aodv when the mobility is higher. The comparison of applied different optimization soft computing techniques with the standard value of hello interval of 1 sec and 1.5 sec is shown in figure 9.7 to 9.11 for the density of nodes as 30.

For Nodes= 30

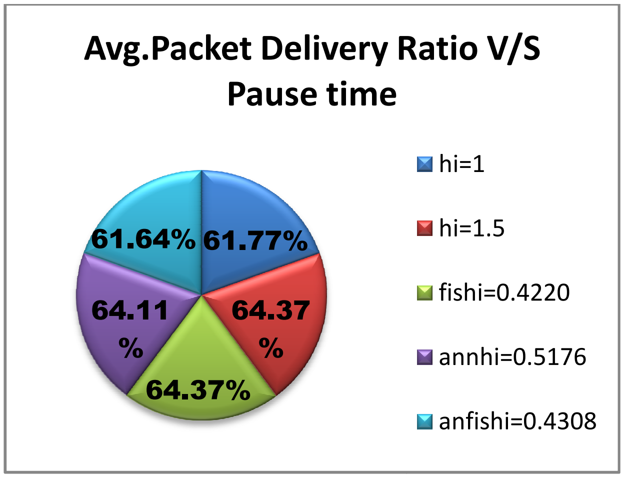

Figure 9.7: Average Packet Delivery Ratio V/S Pause Time Of Nodes

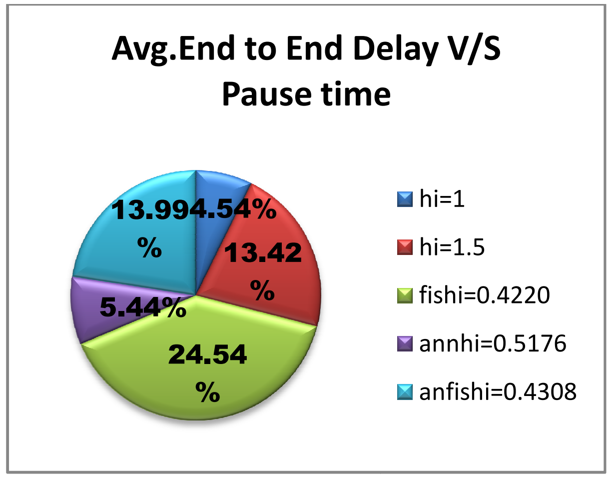

Figure 9.8: Average End To End Delay V/S Pause Time Of Nodes

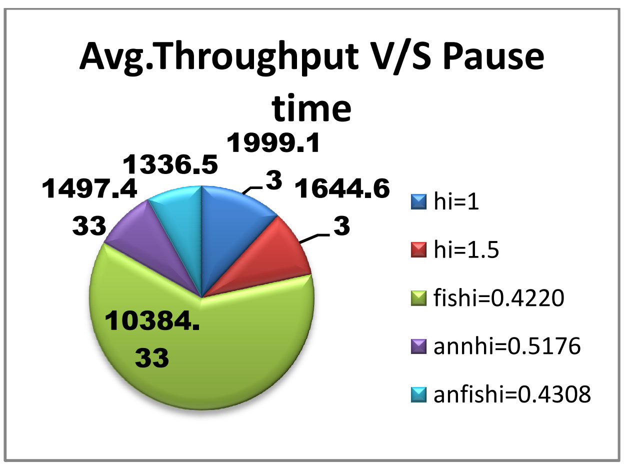

Figure 9.9: Average Throughput V/S Pause Time Of Nodes

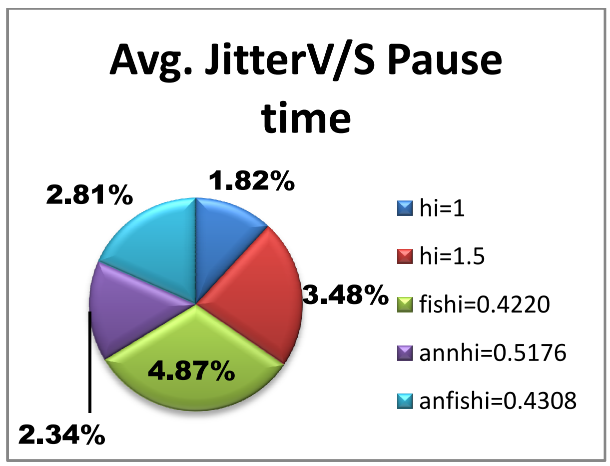

Figure 9.10: Average Jitter V/S Pause Time Of Nodes

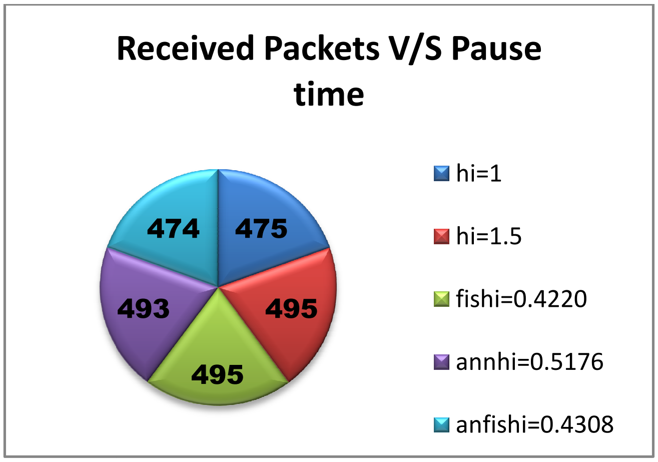

Figure 9.11: Average Number Of Received Packets V/S Pause Time Of Nodes

Finally It can be concluded that for the real time data, which depends on the mobility and the transmission power of the nodes, adaptive value of the hello messages for adaptive hello interval improve the performance.

For the network nodes with less mobility and low transmission power more number of hello messages to update the network situation is not necessary. But for nodes with high mobility and low power more hello messages are necessary to update the network situation. Hence by adaptively controlling the number of hello messages according to the situation of network, power consumption in the network used by the routing protocols to update the information in the network may be optimized.

Future Scope

The proposed guidelines for further work in the area of power control for WANET are listed below….

- The optimization of Signal reach can be done using neural network and genetic algorithm.
- Various other parameters of the protocol like number of hop, power, hello interval, active route time out etc. can also be optimized using fuzzy logic system, Neuro-fuzzy system neural network and genetic algorithm.
- The node topology can be changed by changing positions of nodes and results of communication can be tested.
- ANN with the two activation functions viz. Purelin and Tansig type is analyzed to determine the Hello interval Parameter for the AODV reactive routing protocol in WANET. Both the type of ANN fed to the FPGA and executed by it and displays the value of hello interval on the output device LCD, then this Hello interval value now can be use in any real time WANET to optimize the performance of and to reduce the power consumption in Updation

of the network situation. ANN in routing protocol for WANET is offline; this can be made online using links between software.

- An ANFIS model may be developed for on line training and work with automatic parameter passing.
- Others parameters like number of hops, channel width allocation, bandwidth allocation, and power consumption can be adaptively controlled using soft computing techniques according to the situation of the network.