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IMPLEMENTATION OF SECURED ROUTING USING NEURAL NETWORKS IN WIRELESS SENSOR NETWORKS

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ABSTRACT

Wireless communication between mobile users is becoming more popular than ever before. This is due to recent technological advances in laptop computers and wireless data communication devices, such as wireless modems and wireless LANs. This has lead to lower prices and higher data rates, which are the two main reasons why mobile computing continues to enjoy rapid growth. There are two distinct approaches for enabling wireless communication between two hosts. The first approach is to let the existing cellular network infrastructure carry data as well as voice. The major problems include the problem of handoff, which tries to handle the situation when a connection should be smoothly handed over from one base station to another base station without noticeable delay or packet loss. Another problem is that networks based on the cellular infrastructure are limited to places where there exists such a cellular network infrastructure. The second approach is to form an ad-hoc network among all users wanting to communicate with each other. This means that all users participating in the ad-hoc network must be willing to forward data packets to make sure that the packets are delivered from source to destination. This form of networking is limited in range by the individual nodes transmission ranges and is typically smaller compared to the range of cellular systems. This does not mean that the cellular approach is better than the ad-hoc approach. Ad-hoc networks have several advantages compared to traditional cellular systems. Because the nodes are forwarding packets for each other, some sort of routing protocol is necessary to make the routing decisions. Currently there does not exist any standard for a routing protocol for ad-hoc networks, instead this is work in progress. Many problems remain to be solved before any standard can be

determined. This paper underlines the routing approaches in the wireless sensor networks and the implementation of neural networks is done for effective and enhanced results.
Keywords – Wireless Sensor Networks, Secured Routing, Routing in WSN, Neural Network based Routing

INTRODUCTION

A wireless ad-hoc network is a collection of mobile/semi-mobile nodes with no pre-established infrastructure, forming a temporary network. Each of the nodes has a wireless interface and communicates with each other over either radio or infrared. Laptop computers and personal digital assistants that communicate directly with each other are some examples of nodes in an ad-hoc network. Nodes in the ad-hoc network are often mobile, but can also consist of stationary nodes, such as access points to the Internet. Semi mobile nodes can be used to deploy relay points in areas where relay points might be needed temporarily.

Because of the fact that it may be necessary to hop several hops (multi-hop) before a packet reaches the destination, a routing protocol is needed. The routing protocol has two main functions, selection of routes for various source-destination pairs and the delivery of messages to their correct destination. The second function is conceptually straightforward using a variety of protocols and data structures (routing tables). This report is focused on selecting and finding routes.

PROACTIVE ROUTING PROTOCOLS

Proactive routing protocols require each node to maintain up-to-date routing information to every other node (or nodes located within a specific region) in the network. The various routing protocols in this group differ in how topology changes are detected, how routing information is updated and what sort of routing information is maintained at each node.

Destination-Sequenced Distance-Vector (DSDV) Routing

DSDV (Perkins and Bhagwat, 1994) is a distance vector routing protocol that ensures loop-free routing by tagging each route table entry with a sequence number. DSDV requires each node to maintain a routing table. This routing table lists all available destinations from that node. Each entry, corresponding to a particular destination, contains the number of hops to reach the destination and the address of the neighbour that acts as a next-hop towards the destination. Each entry is also tagged with a sequence number that is assigned by the respective destination.

Wireless Routing Protocol (WRP)

WRP (Murthy and Garcia-Luna-Aceves, 1995) is a distance vector routing protocol that aims to reduce the possibility of forming temporary routing loops in mobile ad-hoc networks. It belongs to a subclass of the distance vector protocol known as the path-finding algorithm that eliminates the counting-to-infinity problem of DBF (Distributed Bellman-Ford). Each node, in a path-finding algorithm, obtains the shortest-path spanning tree to all destinations of the network from each one-hop neighbour. A node uses this information along with the cost of adjacent links to construct its own shortest-path spanning tree for all destinations.

Global State Routing (GSR)

GSR (Chen and Gerla, 1998) improves the link-state algorithm by adopting the routing information dissemination method used in DBF. Instead of flooding GSR transmits link-state updates to neighbouring nodes only.

Distance Routing Effect Algorithm for Mobility (DREAM)

DREAM (Basagni et al., 1998) uses location information using GPS (Global Positioning System) to provide loop-free multi-path routing for mobile ad-hoc networks. Each node in

DREAM maintains a location table that records location information of all nodes. DREAM minimises routing overhead, i.e. location update overhead, by employing two principles referred to as the 'distance effect' and the 'mobility rate'.

Source Tree Adaptive Routing (STAR)

STAR (Garcia-Luna-Aceves and Spohn, 1999) is based on a link-state algorithm that minimises the number of routing update packets disseminated into the network to save bandwidth (i.e. reduce network traffic) at the expense of not maintaining optimum routes to destinations.

Topology Broadcast based on Reverse Path Forwarding (TBRPF)

TBRPF (Bellur and Ogier, 1999) is a link-state based routing protocol that uses the concept of reverse-path forwarding to broadcast link-state updates in the reverse direction along the spanning tree formed by minimum-hop paths from all nodes to the source of the update. Unlike a pure link-state routing algorithm, which requires all nodes to forward update packets, TBRPF requires only the non-leaf nodes in the broadcast tree to forward update packets. Thus TBRPF generates less update traffic than pure link-state routing algorithms. The use of minimum-hop tree instead of shortest-path tree makes the broadcast tree more stable and thus results in less communication cost to maintain the tree.

Fisheye State Routing (FSR)

FSR (Pei et al., 2000) is an improvement of GSR (see Section 3.3). GSR requires the entire topology table to be exchanged among neighbours. This can consume a considerable amount of bandwidth when the network size becomes large. FSR is an implicit hierarchical routing protocol that uses the 'fisheye' technique (Kleinrock and Stevens, 1971) to reduce size of large update messages generated in GSR for large networks. The scope of the fisheye of a node is defined as the set of nodes that can be reached within a given number of hops.

Optimised Link State Routing (OLSR)

OLSR (Jacquet et al., 2001) optimises the link-state algorithm by compacting the size of the control packets that contain link-state information and reducing the number of transmissions needed to flood these control packets to the whole network.

Fuzzy Sighted Link Sate (FSLS) Routing

FSLS (Santivez et. al., 2001) is a link-state routing protocol that restricts the dissemination scope of routing updates in space and time similar to FSR (Pei et al., 2000) in order to scale well with network size.

Clusterhead Gateway Switch Routing (CGSR)

CGSR (Chiang et al, 1997) is a hierarchical routing protocol that uses DSDV (Perkins and Bhagwat, 1994) as its underlying routing algorithm but reduces the size of routing update packets in large networks by partitioning the whole network into multiple clusters. The addressing scheme used here is simpler than that of MMWM (Kasera and Ramanathan, 1997) since CGSR uses only one level of clustering hierarchy.

Hierarchical Star Routing (HSR)

Pei et al. (1999) have proposed a hierarchical link-state routing protocol, referred to as HSR, designed to scale well with network size. They argue that the location management (i.e. the location updating and location finding) in MMWM (Kasera and Ramanathan, 1997) is quite complicated since it couples location management with physical clustering. HSR aims to make the location management task simpler by separating it from physical clustering.

Landmark Ad-Hoc Routing (LANMAR)

LANMAR (Gerla et al., 2000) (Guangyu et al., 2000) is a combined link-state (i.e. FSR) and distance vector routing (e.g. DSDV) protocol that aims to be scalable. It borrows the notion of landmark (Tsuchiya, 1988) to keep track of logical subnets. Such subnets can be formed in an ad-hoc network with the nodes that are likely to move as a group such as brigades in the battlefield or colleagues in the same organization.

Hierarchical Optimised Link-state Routing (HOLSR)

HOLSR (Gonzalez and Lamont, 2005) is a routing mechanism derived from the OLSR protocol. The main improvement realised by HOLSR over OLSR is a reduction in routing control overhead, e.g. topology control information, in large heterogeneous mobile ad-hoc networks. A heterogeneous mobile ad-hoc network is defined as a network of mobile nodes where different mobile nodes have different communication capabilities, e.g. multiple radio interfaces with varying transmission powers.

	WCC	**WTC**	**RS**	**Frequency of updates**	**Critical Nodes**	**HM**	**Advantages**	**Disadvantages**
DSDV	O(N)	O(D)	F	Periodic and on-demand	No	Yes	Loop free, simple; Computationally efficient	Excessive communication overhead; Slow convergence; Tendency to create routing loops in large

								networks
WRP	O(N)	O(h)	F	Periodic and on-demand	No	Yes	Loop free; Lower WTC than DSDV	Does not allow nodes to enter sleep mode

MMWN	O(m+s)	O(2D)	H	On-demand	Location Manager	No	Low WCC and WTC	Complicated mobility management and cluster maintenance
CGSR	O(N)	O(D)	H	Periodic	Clusterhead	No	Lower routing overhead than DSDV & WRP; Simpler addressing scheme compared to MMWN	Higher time complexity than DSDV and WRP for a link failure involving clusterheads

GSR	O(N)	O(D)	F	Periodic	No	No	Requires less number of update messages than a normal link-state algorithm	Update messages get larger if node density and network size increase
DREAM	O(N)	O(D)	F	On-demand	No	No	Low routing overhead	Requires GPS
STAR	O(N)	O(D)	F	On-demand	No	No	Minimises the number of routing update packets disseminated in the network	May not provide optimum routes to destinations; Significant memory and processing overheads for large and highly mobile MANETs

HSR	O(n*l)	O(D)	H	Periodic	Clusterhead	No	Requires less memory and communication overhead than any flat proactive routing protocol	Introduces additional overhead for forming and maintaining clusters like any cluster based protocol
TBRPF	O(N)	O(D)	F	Periodic and on-demand	Parent node	Yes	Lower WCC compared to pure link-state routing	Overheads increase with node mobility and network size
FSR	O(N)	O(D)	F	Periodic	No	No	Reduces the size of update messages generated in GSR in large networks	Nodes may not have the best route to a distant destination
LANMAR	O(N)	O(D)	H	Periodic	Landmark	No	Improves routing scalability for	Assumption of group mobility,

							large MANETs	Nodes may not have the best route to a distant destination
OLSR	O(N)	O(D)	F	Periodic	No	Yes	Reduces size of update messages and number of transmissions than a pure link-state routing protocol	Information of both 1-hop and 2-hop neighbours is required
FSLS	O(N)	O(D)	F	Periodic	No	No	Reduces control overhead required in FSR or GSR.	Nodes may not have the best route to a distant destination
HOLSR	O(N)	O(D)	H	Periodic	Clusterhead	Yes	Suitable for large heterogeneous MANETs	Information of both 1 hop and 2 hop neighbours

								is required; Introduces additional overhead for forming and maintaining clusters
WCC: Worst Case Communication Complexity, i.e. number of messages needed to perform an update operation in worst case; WTC: Worst Case Time complexity, i.e. number of steps involved to perform an update operation in worst case; RS: Routing Structure; F: Flat; H: Hierarchical; HM: Hello Messages; N: Number of nodes in the network; D: Diameter of the network; h: Height of the routing tree; n: Average number of nodes in a cluster; l: number of hierarchical levels; m: Number of location managers in MMWN; s: Number of switches in MMWN.								

TABLE 1: Comparison of various proactive routing protocols

REACTIVE ROUTING PROTOCOLS

Unlike proactive routing protocols, reactive routing protocols find and maintain routes when needed so that routing overheads can be reduced where rate of topology change is very high. Route discovery usually involves flooding route request packets through the network.

Light-weight Mobile Routing (LMR)

LMR (Corson and Ephremides, 1995) maintains multiple routes to reach each destination. This feature increases the reliability of LMR since whenever a route to a particular destination fails the next available route to the destination can be used without initiating a new route construction procedure. It uses sequence numbers and internodal coordination to avoid long-term loops.

Dynamic Source Routing (DSR)

DSR (Johnson and Maltz, 1996) is based on the concept of source routing. Each node in DSR is required to maintain a route cache that contains the source routes to the destinations the node has learned recently. An entry in the route cache is deleted after it reaches its timeout period.

Associativity-based Routing (ABR)

ABR (Toh, 1996, 1997) uses the concept of source routing similar to DSR, but selects routes based on association stability, i.e. connection stability, of nodes. Routes selected in this manner are likely to be long lived, resulting in requiring fewer route reconstructions and less route control traffic. However, routes selected in this way may not be the shortest in terms of the number of intermediate nodes.

Signal Stability-based Adaptive (SSA) Routing

SSA (Dube et al., 1997) selects routes based on signal stability, i.e. the combination of signal strength and location stability, rather than using association stability as used in ABR. Like ABR, routes selected in SSA may not be shortest in terms of the number of intermediate nodes.

Temporally Ordered Routing Algorithm (TORA)

TORA (Park and Corson, 1997) is an improved variant of LMR. Like LMR it uses a directed acyclic graph, rooted at a destination, to represent multiple routes for a source and destination pair. However, unlike LMR, it restricts the propagation of control messages to a very small set of nodes near the occurrence of a topological change by using the concept of link reversal proposed by Gafni and Bertsekas (1981). When a link in a directed acyclic graph breaks, the link reversal method can transform the distorted graph in finite time so that the destination becomes the only node with no outgoing links. TORA uses time stamps and internodal coordination to avoid long-term loops.

Location-Aided Routing (LAR)

LAR (Ko and Vaidya, 1998) is a flood based routing algorithm, like DSR, that uses location information in order to reduce confine route search space and thereby minimises route control traffic. It assumes that each node obtains its location information using a GPS (Global Positioning System).

Ad-hoc On-demand Distance Vector (AODV) Routing

AODV (Perkins and Royer, 1999) routing protocol minimises the number of required broadcasts of DSDV by creating routes on a demand basis. It uses sequence numbers to avoid long-term loops.

Relative Distance Micro-Discovery Ad-Hoc Routing (RDMAR)

RDMAR (Aggelou and Tafazolli 1999) minimises routing overheads by localizing query flooding into a limited area. It uses the concept of sequence numbering, similar to AODV, to prevent forming long-term loops.

Multi-path Source Routing (MSR)

MSR (Wang et al., 2001) is an extension of DSR. It tries to improve end-to-end delay, average queue size, network congestion and path fault tolerance by employing the multi-path finding capability of DSR.

Ad-Hoc On-demand Multipath Distance Vector (AOMDV) Routing

AOMDV (Marina and Das, 2001, 2003) extends AODV to support multipath routing in mobile ad-hoc networks. It adds some extra fields in routing tables and control packets, and requires few new rules to be followed during a route discovery phase in order to compute loop-free and link-disjoint multiple routes. Link-disjoint routes do not contain any common link among the multiple routes between a source and destination pair.

Ant-colony based Routing Algorithm (ARA)

ARA (Gunes et al., 2002) adopts the food searching behavior of ants to find routes. When ants search for foods, they start from their nest and walk towards the food. While walking they leave behind a transient trail by depositing pheromone that is a substance that ants can smell. The concentration of pheromone on a certain route indicates its usage and allows other ants to follow the most commonly used route. In course of time the concentration of pheromone is reduced due to diffusion. Like AODV, ARA uses sequence numbers to avoid forming loops. However, unlike AODV, ARA can find multiple routes between a source and destination pair.

Cluster based Routing Protocol (CBRP)

CBRP (Jiang et al., 1999) is a hierarchical on-demand routing algorithm that uses source routing, similar to DSR, to avoid forming loops and route packets. Like other hierarchical routing algorithms, CBRP aims to scale well with network size. It can best perform in MANETs where nodes in each cluster move together (Abolhasan et al., 2004).

HYBRID ROUTING PROTOCOLS

These protocols combine the feature of both proactive and reactive routing strategies to scale well with the increase in network size and node density. This is usually achieved by maintaining routes to nearby nodes using a proactive routing strategy and determining route to far-away nodes using a reactive routing strategy. Description and comparison of a number of such protocols are provided in the rest of this section.

Zone Routing Protocol (ZRP)

ZRP (Haas, 1997) (Haas and Pearlman, 1998) utilises both proactive and reactive routing strategies in order to gain benefits from the advantages of both types.

Sharp Hybrid Adaptive Routing Protocol (SHARP)

SHARP (Ramasubramanian et al., 2003), unlike other hybrid routing protocols, adapts between proactive and reactive routing strategies by adjusting the radii of proactive zones dynamically.

Zone-based Hierarchical Link State (ZHLS) Routing

Unlike ZRP, ZHLS (Joa-Ng and Lu, 1999) divides the network into non-overlapping zones and employs a hierarchical structure to maintain routes. Unlike other hierarchical protocols, ZHLS does not require any clusterheads so avoids traffic bottlenecks, single points of failure, and complicated mobility management. It is proactive if the destination resides within the same zone of the source. Otherwise it is reactive, since location search is employed to find the zone ID of the destination. Thus it reduces communication overheads compared to any pure reactive routing protocol such as DSR and AODV.

Scalable Location Update Routing Protocol (SLURP)

Like ZLHS, SLURP (Woo and Singh, 2001) organises nodes into a number of non-overlapping regions. However it does not employ a global route discovery mechanism and thereby reduces the cost of maintaining routing information.

Distributed Spanning Tree (DST) based Routing Protocol

DST (Radhakrishnan et al., 1999, 2003) uses spanning trees in regions where the topology is stable and a flooding-like scheme in highly dynamic regions of the network.

Hybrid Ad Hoc Routing Protocol (HARP)

HARP (Nikaein et al., 2001) is a tree-based hybrid routing protocol. The trees are connected via gateway nodes, i.e. the neighbouring nodes belonging to different trees, to form a forest. Unlike DST, HARP does not require the trees to have root nodes. The trees are also referred to as zones. Similar to ZHLS, the zones in HARP do not overlap. However, unlike ZHLS, HARP does not rely on a static zone map. Moreover, it does not require a clusterhead to coordinate data and control packet transmissions.

	Proactive	**Reactive**	**Hybrid**
Routing Structure	Both flat and hierarchical	Usually flat	Usually Hierarchical
Availability of Routes	Always available.	Determined when needed. Sometimes overheard routes are stored for a limited time (e.g. in DSR).	Always available within if source and destination reside within the same zone/cluster/tree.
Volume of control traffic	Usually high. Exceptions such as FSLS and HOLSR.	Usually lower than proactive routing.	In most cases lower than proactive and reactive routing protocol.

Storage requirement	Usually high	Usually lower than proactive routing protocols	Usually lower than pure proactive and reactive routing protocols if the size of zones/clusters/trees can be properly determined in large networks.

Delay for route discovery	Predetermined	Higher than proactive routing protocols	Similar to proactive routing protocols if source and destination are located within the same zone/cluster/tree. Otherwise usually higher than proactive but lower than reactive.
Mobility support	Low to moderate mobility is supported. Group mobility is usually required for	Can support higher mobility than proactive routing protocols.	Usually supports lower level of mobility than reactive routing protocols since

	hierarchical structured routing.		routing structure is mostly hierarchical in this approach.
Scalability	Usually up to 100 nodes. FSLS and HOLSR may scale higher.	Source routing protocol does not scale well, usually up to few hundred nodes. Hop by hop routing scales better than source routing.	1000 or more.

Table 2 - Comparison of the proactive, reactive and hybrid routing strategies

RESULS AND DISCUSSION

The proposed implementation is done on the dynamic routing protocol in association with the artificial neural networks. Artificial neural networks (ANNs) are a family of statistical learning models inspired by biological neural networks(the central nervous systems of animals, in particular the brain) and are used to estimate or approximate functions that can depend on a large number ofinputs and are generally unknown. Artificial neural networks are generally presented as systems of interconnected "neurons" which send messages to each other. The connections have numeric weights that can be tuned based on experience, making neural nets adaptive to inputs and capable of learning.

An ANN is typically defined by three types of parameters:

1. The interconnection pattern between the different layers of neurons

2. The learning process for updating the weights of the interconnections
3. The activation function that converts a neuron's weighted input to its output activation.

Mathematically, a neuron's network function $f(x)$ is defined as a composition of other functions $g_i(x)$, which can further be defined as a composition of other functions. This can be conveniently represented as a network structure, with arrows depicting the dependencies between variables. A widely used type of composition is the *nonlinear weighted sum*, where $f(x) = K\left(\sum_i w_i g_i(x)\right)$, where K (commonly referred to as the activation function[29]) is some predefined function, such as the hyperbolic tangent. It will be convenient for the following to refer to a collection of functions g_i as simply a vector $g = (g_1, g_2, \ldots, g_n)$. There is decomposition of f, with dependencies between variables indicated by arrows. These can be interpreted in two ways.

The first view is the functional view: the input x is transformed into a 3-dimensional vector h, which is then transformed into a 2-dimensional vector g, which is finally transformed into f. This view is most commonly encountered in the context of optimization.

The second view is the probabilistic view: the random variable $F = f(G)$ depends upon the random variable $G = g(H)$, which depends upon $H = h(X)$, which depends upon the random variable X. This view is most commonly encountered in the context of graphical models.

The two views are largely equivalent. In either case, for this particular network architecture, the components of individual layers are independent of each other (e.g., the components of g are independent of each other given their input h). This naturally enables a degree of parallelism in the implementation.

Networks such as the previous one are commonly called feedforward, because their graph is a directed acyclic graph. Networks with cycles are commonly called recurrent.

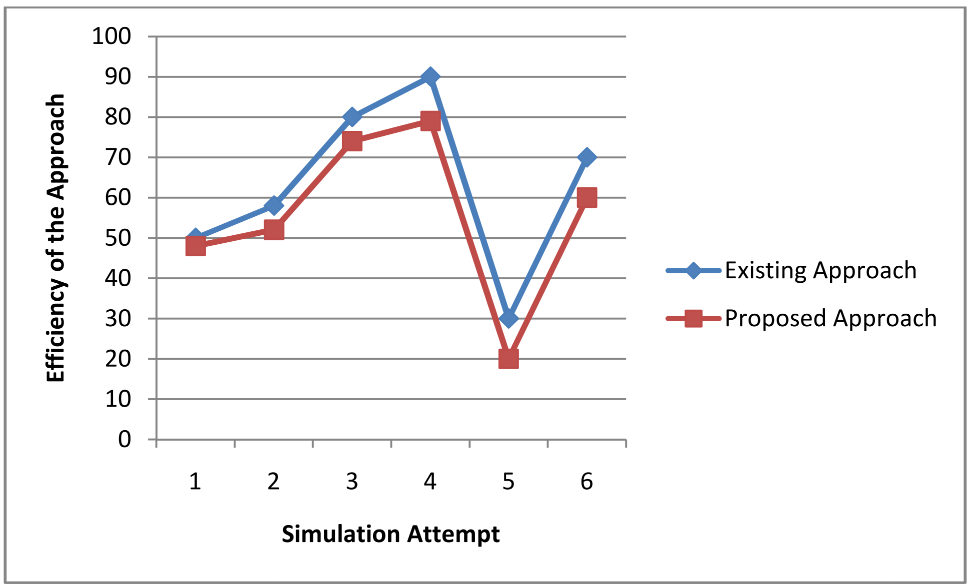

Figure 1 – Efficiency Analysis of the Approaches

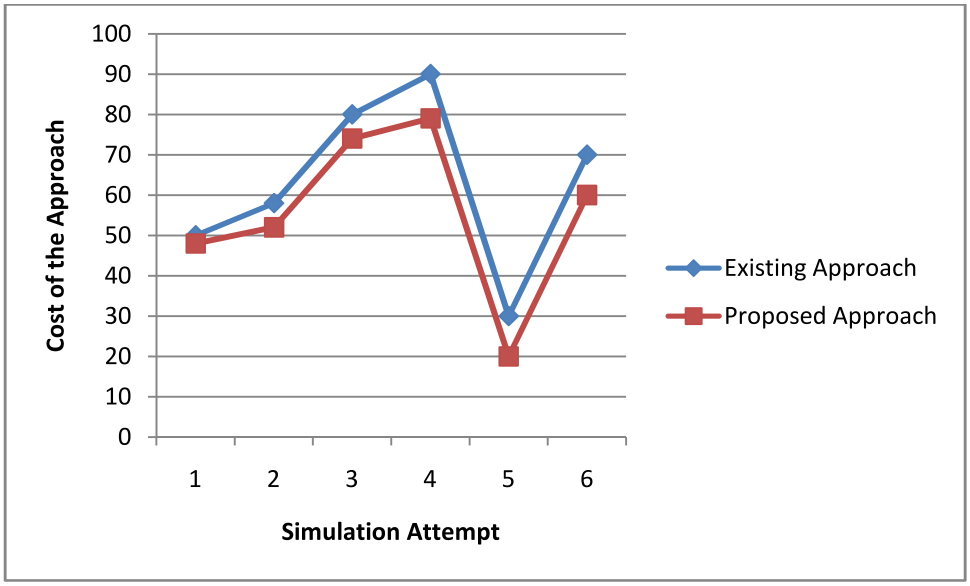

Figure 2 - Efficiency Analysis of the Approaches

CONCLUSION

The objective for this work is to evaluate the proposed neural based routing protocol for wireless ad-hoc networks based on performance and cost. This evaluation is done in the pragmatic aspects and through simulation. The proposed simulation and the work can further enhanced using simulated annealing, genetic algorithms or the hybrid approach of ant colony optimization.

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