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ABSTRACT

Wireless mesh network does not rely on any fixed infrastructure as most of the wireless networks do. Before deploying any wireless mesh network there are number of issues that are needed to be aware of. The most important issue in any wireless technology is security. As wireless mesh networks consist of unlimited energy and multi hop radio nodes it is more vulnerable to security attacks. For securing the network the access to the network has to be secured and it is only possible by good authentication and key management mechanism. Security of wireless mesh networks is built upon a reliable key management system to generate and distribute symmetric encryption/decryption keys for communicating parties. The central servers generate and distribute the keys in traditional wired networks, where central approaches will fail in such dynamic, high mobility networks. When the central servers fail the entire network cannot communicate. Where as in mesh network when the central server fails the communication will not terminate since wireless mesh networks are self healing. Threshold cryptography has been proposed to provide a reliable, distributive key management for networks. In a threshold system, there are n servers to provide key generation and distribution when needed for the whole network. From these n servers, any x servers can co-operate and generate a key for any node. Until now, threshold cryptography has remained only a theory. No practical key management system has been proposed to use threshold cryptography. A practical threshold key management system using maximum distance separable codes (MDS) is constructed. This will make a trusted connection and secure communication between the connected nodes. This is effective in corporate companies in developing a secured communication.

Keywords*— *Multi hop Radio Nodes, Key Management, Threshold Cryptography, Maximum Distance Separable Codes.

1. INTRODUCTION

A Wireless Mesh Network formulation has been done by employing gateways, mesh routers and clients. Gateways and mesh routers may be considered as the ones that form the basic foundation of the network, wherein there is a reduced. Mesh clients may be in the form of cell phones, laptops or various wireless devices. There is communication that takes place between Routers and the external network like in the case of internet; which is done by forwarding each one's traffic, this includes client traffic as well; in the direction of gateway nodes, that are directly connected and integrated with the wired infrastructure. A WMN in one wherein all the routers forward packets for other nodes (these include those that necessarily may not be within direct wireless transmission range of their destinations). Another promising approach that has been relatively popular in such scenarios is Multipath routing which helps achieve such results. Determining several paths between any given source and respective destination, enables load balancing between several routes and additionally also increases available bandwidth for applications. Primary aim in wireless mesh network is use of multipath routing while determining various reliable paths in order to reach specific destinations and simply not confining to determine one best path without having to impose additional control overhead whilst still maintaining such reliable paths.

The aforementioned issues have been resolved by employing the multipath route routing algorithm. Previous studies and researches conducted have used several multi-path routing algorithms that were suggested to resolve issues created on account of multipath route selection. A few of the multipath routing algorithms that had been developed before include split multi-path routing, multi-path dynamic source and ad hoc on -demand multi-path distance vector (AOMDV)which are referred to as the shortest path algorithms. Resolving multipath route selection issues and other related concerns regarding WMN QoS or quality of service still pose certain challenges.

2. LITERATURE REVIEW

[Ref. no:5] in his study for WMNs has proposed a multi-path routing design where in the main idea was to deploy the QoS-aware algorithm for computing multi-

path which were responsible for taking in to consideration channel load as well as interference on wireless links. In the protocol, hop-count metric can determine the location as well as the congestion its immediate neighbors. A study had proposed using a node-disjoint multi-path routing protocol. This was based AOMDV and additionally contributed by adding routing sequence number, which is quite similar to DSR source routing sequence. This particular innovative multi-path routing algorithm possesses less computational intricacy and routing overhead in comparison with AOMDV. [Ref. no:4] in his study of multi -path routing has researched about cooperation problem prevalent mesh routers and hence proposed reputation-based system wherein multi-path routing can actually provide stimulation for each node which will impact the different paths and thus packet forwarding will be possible from others. Hu along with a couple of associates [Ref. no:4]who were studying routing and sustenance of forwarding paths suggested using a multi-path routing protocol MGMP which has multiple gateways supported. Results from simulation clearly outlined performance of MGMP being far better than HWMP, AODV and OLSR.With respect WMNs [Ref. no:8], supporting video communications efficiently of prime importance. Hence in order to address this problem the following study evaluates and proposes various techniques and several descriptions for multipath routing for MD video delivery over IEEE 802.11 based WMN.

WMNs or wireless mesh networks [Ref. no:9] have static and traffic is transferred using backup paths can likely be adverse as it impacts other flows as well as the multicast group, as back up paths raise transmissions and subsequently network interference and congestion. Evaluation of this impact though has not been done with respect to multicast routing. Author here presents simulation results actually quantifying impact when comparing data overhead between multicast multipath and single-path routing.

Uncomplicated and efficient management WMN structure has been proposed by the author that may be referred to as configurable access network or CAN. As per the architecture the control and switching functions have been separated, such that control functions are executed by network operation center or NOC positioned in the wired infrastructure. NOC examines requirements of both network topology as well as user performance on the basis of which it determines the path between all wireless routers and gateways and further distributes fair bandwidth transferring associated traffic in the predefined route. Execution of functions like NOC helps in offloading network management overhead from wireless routers, further it helps in deploying simple/low -cost wireless routers. The main aim here has been to maximize network use through the process of balancing traffic load, at the same time generating fair service and quality of service or QoS thus guaranteeing users.

3. PROPOSED METHODOLOGY

Neighbor table here collects as well as stores neighboring node information through the early period of a network.

Neighbor table: This table is one which consists of a list of nodes wherein each node is capable to communicate with the other directly. Once the network's initial phase if over neighbor table of all the nodes are populated.

Graph table: Network graphs are deployed to route messages usually from source to destination nodes. However every node is not really aware of the entire route and knows only about the next hop destination legal for circulating the packet. Route with graph ID is on the basis of data transmission, along with graph ID as shown in the graph table. Routes fitness levels in any graph table are usually used to index for route selection (Fig. 1).

MINIMUM SPANNING TREE FORMATION USING PRIM ALGORITHM:

An industrial wireless mesh network can be represented as a simple connected graph, $G= (V_{G,G})$, where V_G and E_G denote the set vertices and the set of edges, respectively. In the previous work, the weight is considered as distance between the nodes. The distance between the nodes can be measured using the signal strength and it is mainly relies on Time-of-Arrival (TOA) measurement. The most basic localization system to use TOA techniques is GPS[1]. If the speed of the signal and time between signals sent and received are known then distance can be calculated by formula:

*distance=speed*time* (1)

The signal strength can be viewed as a good indicator for measuring link quality since a packet can be transferred successfully. Therefore the weight of the edge is referred as strength of the signal used between the nodes.

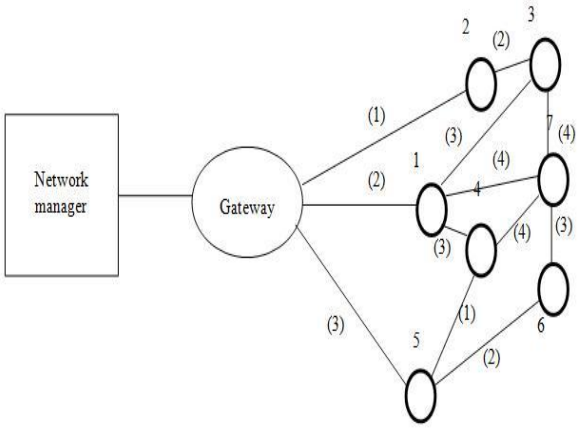

Fig. 1: Sample wireless mesh network

Though path selection is done on the basis of arrival time and signal strength, its efficiency is still a cause of concern. At time delay generally arises in the path on account of bandwidth as well as the intermediate node capacity. In order to address these inherent issues in previous work, the following research executes path selection on the basis of estimation of end to end bandwidth and then further it reflects as weight in the graph.

Bandwidth estimation: The gateway sends series of the packet with size S and length L to travel into each and every node present in the network. Once the neighboring node receives the series packets the time spacing between the arrival of first and last packet is calculated. The bandwidth between the two nodes is estimated as :

$$b(L) = (L-1) \times s \div \Delta(L) \quad (2)$$

where, b(L) is the bandwidth estimate, L is the length of the packet train, S is the size of each packet and Δ(L) is the difference in time between the first packet and the final packet of the train. The bandwidth is estimated for links between the nodes present in the network. In this research, the prim's algorithm is proposed to find the path between the nodes and gateway.The pseudo-code of the algorithm 1 is presented below:

Algorithm 1: Standard Prim's algorithm

Input: A non-empty related weighted graph G is a collection of vertexes VG and edges EG, possibly with null weights
Result: the minimal spanning tree in the *finalpath* array
Initialization: V_T ={r},where r is a random starting
node from V
while $VT \neq VG$ do
minimum ←∞
For Visited nodes s ∈ V_T do
For all edges (*s*,) and $v \notin VT$ do
If Weigh$(E) \leq$ *minimum* then
minimum ← Weig*ht*(E)
Edge ←E
newVisited ←v
End if
End for
End for
finalpath ← *finalpath* ∪ {edge}
V_T ← V_T ∪ {*newVisited*

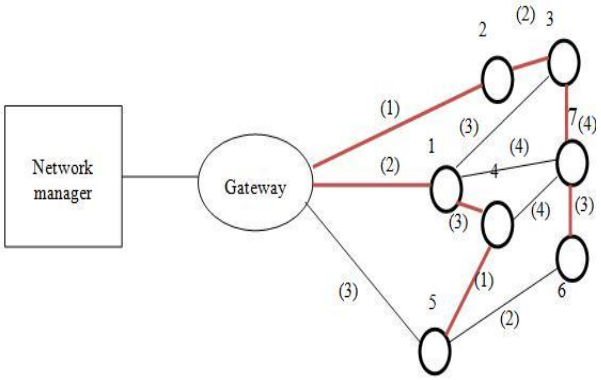

Fig. 2: Shortest path using Prim's algorithm in wireless mesh network

Let G be a connected, weighted graph. In each iteration of Prim's algorithm, an edge is identified that links a vertex in a sub graph to a vertex outside the sub graph. Since G is connected, there will always be a path to every vertex. The series of packet is send to the neighboring nodes. First the distances between the nodes are calculated by Eq. (1) then the bandwidth is calculated using the Eq. (2). If both bandwidth and distance are satisfied means then the node is included in the path. The output G of Prim's algorithm is a tree, since the edge and vertex added to G are connected (Fig. 2). Let Y be a minimum spanning tree of G. V be the set of vertices associated by the edges added before e.

Route exploration using hybrid firefly algorithm: Proposed algorithm:

In this research hybrid firefly algorithm using harmony search is proposed for selecting the best path for data transmission[Ref. no:10], initial populations are considered as a route discovered by prim's algorithm and named as a KEEP. The distance between the nodes is considered as r in the algorithm. The paths found in the first phase are considered as a firefly algorithm. The parameters such as energy, bandwidths are considered as parameters of the algorithm. The fitness value of the algorithm is considered as a residual energy. The light intensity is considered as a total energy cost for particular path or route from source to destination. The light intensity of the proposed system is(directly)∝(proportional) to the fitness of the algorithm .based on the light intensity the path's are selected and given as input to the attractiveness.

Fitness value: The residual energy of a node by calculating the total energy consumed by a node whenever it is in one of the following states [Ref. no:[10]

- **IDLE:** During this state the node is idle
- **CCA_BUSY:** During this state the node is busy
- **TX:** During this state the node only transmits packets
- **RX:** During this state the node only receives packets

- **SWITCHES:** During this the state the node switches from one channel to other.

The performances comparison results of the end to end delay between the methods such as PAWMNet, FKAWMNet and DAWMnet is illustrated in Fig. 3a, it shows that the proposed PAWMNet has less end-to-end delay than the other approaches FKAWMNet and DAWMnet.

The packet delivery ratio of the proposed PAWMNet and existing FKAWMNet and DAWMnet results are illustrated in Fig. 3b. It shows that the proposed PAWMNet has high packet delivery ratio when compare to existing approaches FKAWMNet and DAWMnet.

The Overhead in number of packets of the proposed PAWMNet and existing FKAWMNet and DAWMnet results are illustrated in Fig. 3c. It shows that the proposed PAWMNet has less Overhead in number of packets when compare to existing approaches FKAWMNet and DAWMnet.The graphical representation throughput comparison of PAWMNet and existing FKAWMNet and DAWMnet results are illustrated in Fig. 3d

Route maintenance for topological changes: There may be inherent changes in topology of the industrial fields which may be on account of either faulty nodes or imminent external environmental factors. Topological changes like those occurring in network topology like the node movement, joining of new nodes, or failure in nodes, can activate route maintenance. Hence in order to adjust to these networks the manager can generate matching processes on the basis of these varying topological changes.

Joining of new nodes: In case there is a node that intends to join the network, it needs to apply in order to do so as per the information from "Advertise" messages that other nodes to the network. Once that is a successful new nodes that have joined establish connections with others nodes provide distance between the nodes lies within range of communication. Several routes selection is done by the network manager for data transmission for node as per sampled routes attractiveness.

Nodes moving: With the existing nodes movement, notifications as "keep-alive" messages are relayed across to the neighbors of the node that is in movement. In the paper here network manger takes a decision regarding starting route exploration on the basis of certain definite conditions. Considering the node movement covers a short distance no change takes place in the hops between various nodes. Hence, route exploration commencement becomes redundant; as an alternative, routes fitness values are updated by the network manager depending on the moving node. This is because there is a change in the distance between node and its respective neighbors.

Node failure: When a neighboring node sends an "unconnected message" to the node, on receipt of the same or when there is no exchange from the neighbor node does regarding exceeding the "Time keep-alive interval," in that situation the node needs to inform the network manager by sending the command "Alarm graph route failed". Once received, the network manager passes on this information to other nodes regarding failure node route. This is done to facilitate other nodes to track this particular topological change. Link failure's route maintenance is relatively similar to the other two maintenance mechanisms that facilitate node movement.

4. EXPERIMENTAL RESULTS AND DISCUSSION

Proposed algorithm's performance is ascertained by carrying out model experimentation by employing the Ns2 simulator. Simulation is carried out selecting experimentation nodes in a random manner and those that are within the range 100, 200, 300 and 400 nodes in a square area with area distance end to end of 10 units. Data transmission communication is performed among two nodes based on their distance values which may be less than or equal to $\sqrt{2}$ units. Parameters below have been generally utilized for analyzing algorithm results in WMN:

- Here the End-to-end delay function is to measure delay time that is the time taken to send packets from source to destination in data transmission communication path.

- Packet delivery ratio refers to the packets that are received resultantly at the point of destination with no packet or failure loss, considering system packet delivered ratio is high then both security as well as efficiency are high.
- Overhead in number of packets refers to the association between number of packets which is monitored and checked throughout the process of data transmission communication as well total number of delivered packets at receiver side.

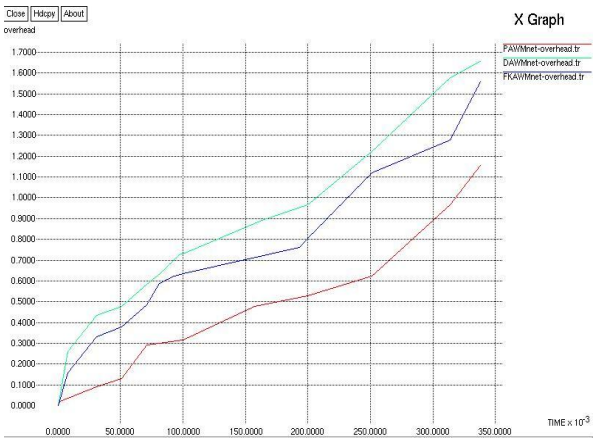

Fig. 3c: Overhead in number of packets

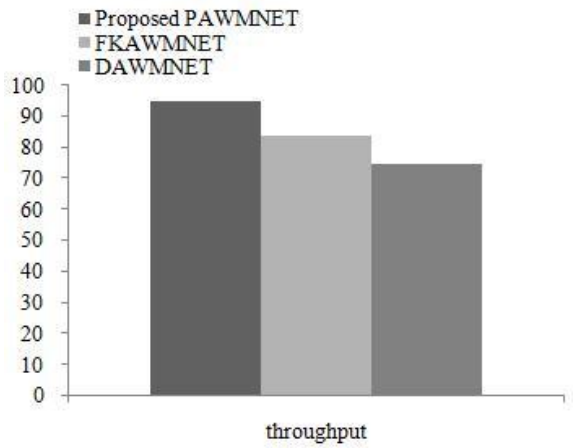

Fig. 3d: Comparison of throughput

5. CONCLUSION

Network coding is promising technology that can improve the performance of wireless mesh networks. Coding collision is a severe problem affecting network performance. The coding collision problem of flows is solved by introducing the information confirmation process, which effectively decreases the failure rate of decoding. Using the distributed key management technique the information can be kept secured. This technique is more advanced than information confirmation process by using both public and private keys. Both the symmetric and asymmetric encryption is used. The RC4 encryption algorithm is a symmetric encryptor where same key is used at both encryption and decryption. RSA Encryption Mechanism is asymmetric encryptor which is used to transmit the securely.

The distributed key generation techniques are based on cryptographic techniques. WMN's security is the challenging issue in providing authentication. Single shared key for many applications may raise problems in ensuring authentication. The approach of employing distributed key scheme for WMN ensures the network security. This distributed key generation technique can be applied in corporate companies to exchange the files with high security. The future work utilizes the cryptographic techniques for generation of distribution key that improves the network security in MANETs and in other wireless sensor networks. Compared to wireless mesh network providing security in sensor and mobile Adhoc network is more risky. This distributed key management technique can be applied in MANET and wireless sensor networks which will be more effective and useful. The proposed key management scheme can be implemented in cloud computing for data storage in public auditing system.

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