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RURAL COMMUNICATION ENHANCEMENT USING MOBILE AD-HOC NETWORK

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Abstract: *Research on Wireless Ad Hoc Networks has been ongoing for decades. The history of wireless ad hoc networks can be traced back to the Defense Advanced Research Project Agency (DAPRPA) packet radio networks (PRNet), which evolved into the survivable adaptive radio networks (SURAD) program. Mobile Ad-hoc Networks are a collection of two or more devices equipped with wireless communications and networking capability. These devices can communication with other nodes that immediately within their radio range or one that is outside their radio range. For the later, the nodes should deploy an intermediate node to be the router to route the packet from the source toward the destination. The Wireless Ad-hoc Networks do not have gateway, every node can act as the gateway.*

1. Introduction

Improvement in communication technologies has made life easier. Rural sector is also benefitted with this advancement. The evolution of communication technologies has changed the way Rural fight the wars, the way they work and the way they exchange information. Despite of this advancement, Rural is also susceptible to same problems faced by other structured organizations; which is organizational communication. Communication is central to organizing and therefore is essential component to bring order out of chaos in organizational context. Traditional FM/AM based radio network with antenna or satellite transmission can no longer satisfy the need of information exchange in Rural when the network needs are instant. The major problem in achieving the efficient network technology is the dynamicity in network, bandwidth of deployed network, infrastructure requirement and security. The Rural requires the network which can be set up quickly in a temporary shelter or in areas affected by war, crisis or disasters. Cellular base stations and mesh networking, combined together, can give Rural the required speed, but these types of network requires setting up the base stations, configuring the devices, defining the protocols, which requires lots of time and is not suitable for instant network requirements.

Thus, Rural requires a ubiquitous nature of network with very efficient routing mechanism and high degree of security to protect the Rural critical data and information. This nature of anytime-anywhere network also must address the dynamicity of the topology inside rural network and must be robust with least frequency of failure.

1.1 Recommended Prototype

Researchers have proposed a network model for Rural which ensures the ubiquitous communication mode, efficient data routing, high security and robustness. The proposed network model is named RMUC which stands for Rural Mobile Ad-hoc Network (MANET) for Ubiquitous Communication (Note: the proposed network will be referred as SRMUC now onwards in the document). Listed are the core features of the SRMUC:

1. Based on Ad-hoc networking: SRMUC is a decentralized wireless network. Devices in Ad-hoc networks have equal status on the network. A device makes temporary link with other device inside the network and is free to move. The use of ad-hoc networking makes SRMUC an anytime-anywhere available network with easy setup process.
2. Distributed Routing: Each device in SRMUC has in-built router inside it. Therefore, all the devices inside the network are able to perform the routing functions and actively participate in data communication process.
3. Uses features of PSO and Ant Colony Optimization techniques for routing: SRMUC uses the best of the Ant colony optimization approach and parallel search algorithm (PSO). Flooding concept of PSO is used for the route setup process and the route maintenance is done using Ant Colony Optimization algorithm.
4. Uses RSA for encryption.

SRMUC also provides the mechanism for encrypting the data. It uses RSA algorithm which is based on public key cryptography. It uses prime numbers to generate the primary key and encrypts the message to be transmitted so that no intruder can decode the meaning of the data even if the data is intercepted. Therefore, SRMUC is also highly secured nature of network with effective encryption technique for protecting data.

1.1.1 ASSUMED SCENARIO

Researchers have considered a simple network design to explain the features and functionalities for the clear understanding of the prototype. A very simple network is designed which has 6 nodes in total which are mobile in nature. Following diagram represents the assumed network scenario:

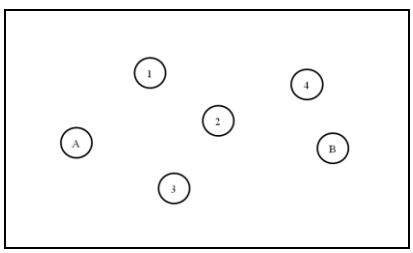

Figure 1.1: Assumed network scenario

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In the above scenario there are 6 nodes; all of which are labeled, for reading convenience. A, 1, 2, 3, 4 and B are the mobile nodes which are initially in the position as shown in above diagram. All the nodes are equipped with the routing device which can process and forward the data packets in the network. Every node has limited range for frequency broadcasting and uses RF antenna for broadcasting signals. All the in-built routers inside nodes have the agents and services as mentioned in the section "Agents and Services". Now onwards, the same scenario will be used in the document to explain the features of the SRMUC. Above presented scenario will be referred by "assumed scenario". Therefore, whenever there is the use of the phrase "assumed scenario" it should be clear to readers that the above mentioned scenario is referred.

2. Features of System Model

Following are the features of the proposed MANET system, SRMUC:

1. Autonomous Terminal:

Each of the mobile nods functions as the mobile host as well as routing device. Each of the nodes performs the job of routing and all the nodes work autonomously in the network without human assistance.

2. Automatic route establishment and management

In SRMUC the routes inside the networks are managed automatically as the packets travel in network. Data packets provide the information for managing and maintaining the routes in the network. As the time passes by, shortest routes are chosen by data packets to travel from source to destination nodes.

3. Supports Node Mobility

Dynamic nature of nodes in MANET is difficult to handle. SRMUC uses the algorithm which supports the dynamic topology and helps in maintaining the routes when a node moves out of network, is added to network of changes position within the network.

4. Link failure handling

Link failure handling is addressed by SRMUC in very effective manner reducing the time overhead. Whenever a link between two devices fails, it uses alternate path, local transmission facility to retransmit data or forms another route to destination.

3. Literature Survey

- The Ant System: Optimization by a colony of cooperating agents way ant colonies function. [Marco Dorigo] [1996]. An analogy with the way ant colonies function has suggested the definition of a new computational paradigm, which we call ant system (AS). We propose it as a viable new approach to stochastic combinatorial optimization. The main characteristics of this model are positive feedback, distributed computation, and the use of a constructive greedy heuristic. Positive feedback accounts for rapid discovery of good solutions, distributed computation avoids premature convergence, and the greedy heuristic helps find acceptable solutions in the early stages of the search process. We apply the proposed methodology to the classical traveling salesman problem (TSP), and report simulation results. We also discuss parameter selection and the early setups of the model, and compare it with tabu search and simulated annealing using TSP. To demonstrate the robustness of the approach, we show how the ant system (AS) can be applied to other optimization problems like the asymmetric traveling salesman, the quadratic assignment and the job-shop scheduling. Finally we discuss the salient characteristics-global data structure revision, distributed communication and probabilistic transitions of the AS.
- A survey on sensor networks [I. Akyildiz, W. Su][2002] This paper describes the concept of sensor networks which has been made viable by the convergence of micro-electro-mechanical systems technology, wireless communications and digital electronics. First, the sensing tasks and the potential sensor networks applications are explored, and a review of factors influencing the design of sensor networks is provided. Then, the communication architecture for sensor networks is outlined, and the algorithms and protocols developed for each layer in the literature are explored.
- Sensor networks: Evolution, opportunities, and challenges [C. Y. Chong and S. Kumar][2003] Wireless micro sensor networks have been identified as one of the most important technologies for the 21st century. This paper traces the history of research in sensor networks over the past three decades, including two important programs of the Defense Advanced Research Projects Agency (DARPA) spanning this period: the Distributed Sensor Networks (DSN) and the Sensor Information Technology (Sens IT) programs. Technology trends that impact the development of sensor networks are reviewed and new applications such as infrastructure security, habitat monitoring, and traffic control are presented. Technical challenges in sensor network development include network discovery, control and routing, collaborative signal and information processing, tasking and querying, and security. The paper concludes by presenting some recent research results in sensor network algorithms, including localized algorithms and directed diffusion, distributed tracking in wireless ad hoc networks, and distributed classification using local agents.
- Wireless Ad-hoc Networks [Lu Han] [2004] Mobile Ad-hoc Networks are a collection of two or more devices equipped with wireless communications and networking capability. These devices can communication with other nodes that immediately within their radio range or one that is outside their radio range. For the later, the nodes should deploy an intermediate node to be the router to route the packet from the source toward the destination. The Wireless Ad-hoc Networks do not have gateway, every node can act as the gateway. Mobile Ad-hoc Networks is a fundamental flawed architecture. The main reason for the argument is that Mobile Ad-hoc Networks are almost never used in practice, almost every wireless network nodes communicate to base-station and access points instead of co-operating to forward packets hop-by-hop. We take the position that Mobile Ad-

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hoc Networks (MANET) are a fundamentally flawed architecture. As argument, we try to clarify the definition, architecture and the characters of MANET, as well as the main challenges of constructing the MANET.

- Swarm intelligence for routing in mobile ad hoc networks [Gianni Di Caro][2005]Mobile Ad Hoc Networks are communication networks built up of a collection of mobile devices which can communicate through wireless connections. Routing is the task of directing data packets from a source node to a given destination. This task is particularly hard in Mobile Ad Hoc Networks: due to the mobility of the network elements and the lack of central control, routing algorithms should be robust and adaptive and work in a decentralized and self organizing way. In this paper, we describe an algorithm which draws inspiration from Swarm Intelligence to obtain these characteristics. More specifically, we borrow ideas from ant colonies and from the Ant Colony Optimization framework. In an extensive set of simulation tests, we compare our routing algorithm with a state-of-the-art algorithm, and show that it gets better performance over a wide range of different scenarios and for a number of different evaluation measures. In particular, we show that it scales better with the number of nodes in the network.

4. Problem Definition

The existing infrastructure based Rural network works on antenna and satellites. Communication devices are linked to central routing device and the communication takes place in the form, source device-central router-destination device. Each and every piece of information inside the network is processed and routed by the central routing device. This approach of communication has some drawbacks, which are:

Requires infrastructure: It requires setting up the antennas or launching the satellite which will act as central server for all the communications taking place inside network.

Time consuming set-up process: Setting up the devices, configuring the nodes etc. is time consuming job. Therefore, the set-up of the network requires huge investment of time in first installment.

Susceptible to interference: Since, the devices need to communicate with central router; every time they want to communicate the data on the link may be susceptible to interference by intruder. The communication links become more obvious to intruders in this kind of network, jeopardizing the whole network.

4.1 XML REPRESENTATION

All the values in italics are taken as sample data for the network which resemble to real data)

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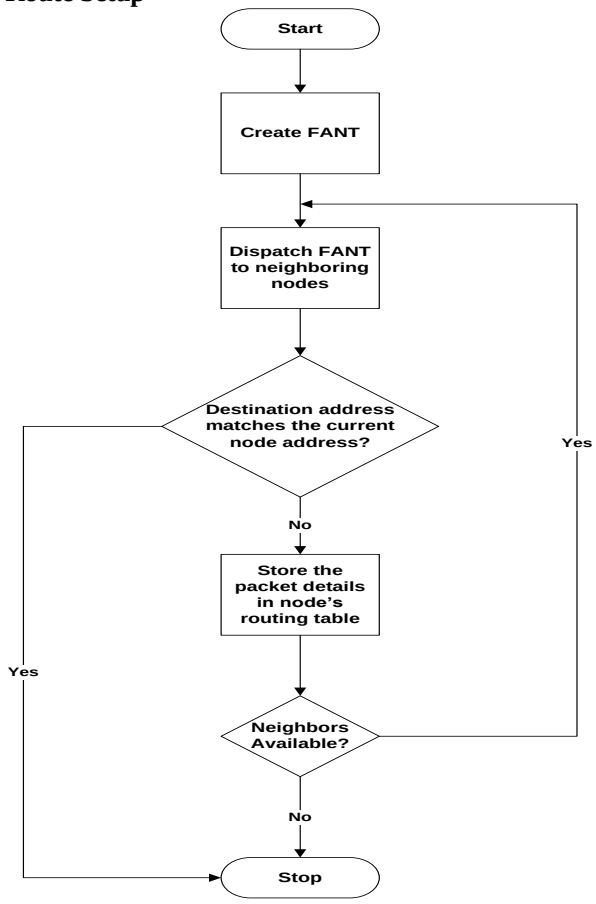
<network>
<node>
<network_interface_address>192.168.1.0</network_interface
_address>
<routing_table>
<table_entry>
<destination_address>192.168.1.44</destination_address>
<next_hop>192.168.1.15</next_hop>
<pheromone_value>0.67</pheromone_value>
</table_entry>
</routing_table>
</node>
<packet>
<destination_address>192.168.1.19</destination_address>
<data_packet>
<data>"Message From Node A"</data>
</data_packet>
<control_packet>
<FANT>
<sequence_number>13445</sequence_number>
<source_address>192.168.1.1</source_address>
<nodes_travelled>6</nodes_travelled>
<previous_hop>192.168.1.15</previous_hop>
</FANT>
<BANT>
<sequence_number>18235</sequence_number>
<source_address>192.168.1.19</source_address>
<nodes_travelled>6</nodes_travelled>
<previous_hop>192.168.1.17</previous_hop>
</BANT>
</control_packet>
</packet>
</network>
```

4.2 Route Setup



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5. Original Lagorithm

This is the original algorithm.

1. Generate two primes, P and Q, of approximately equal size such that their product N=P*Q is of the required bit length
2. Compute N=P*Q and (phi) φ = (P-1)(Q-1).
3. Choose an integer E, 1 < E < phi, such that gcd(E, phi) = 1.
4. Compute the secret exponent D, 1 < d < phi, such that ED ≡ 1 (mod phi).
5. The public key is (N, E) and the private key (D, P, Q). Keep all the values D,P,Q and phi secret.
   - N is known as the modulus.
   - E is known as the public exponent or encryption exponent or just the exponent.
   - D is known as the secret exponent or decryption exponent.

Encryption:

- Calculate the cipher text CT from the plain text PT as follows: CT = PTE mod N
- Then send CT as the cipher text to the receiver.

Decryption:

- For decryption, calculate the plain text PT from the cipher text CT as follows:
  PT = CTD mod N

Summary of RSA:

- N=P*Q, where P and Q are distinct primes.
- phi, φ = (P-1)(Q-1)
- E< N such that gcd(E, phi)=1
- D = E-1 mod phi.
- C = ME mod N, 1<M<N
- M = CD mod N.

5.1 Issues Faced

a. Network Saturation:

The introduction of automatic route setup and management brings in the huge risk of network saturation at some point of time when all the packets in network chose only the shortest path and alternate paths are no longer checked for. MANET is a network of dynamic nodes with no uniformity in mobility. Therefore, new nodes may be available for nodes which can lead to shorter route to the destination. No such mechanism to prevent the network saturation is introduced in prototype (although it has been introduced in research paper). In research paper, update ants (UANT) are used to prevent the network saturation by dispatching the UANTs time and again in order to check for availability of new nodes within range of a device. This mechanism has some major issues to be considered during implementation. Dispatching UANTs time and again in network means more work for nodes and requires additional processing. Also, the mobility pattern for different network is different which makes it difficult on setting up the intervals to dispatch the update ants.

b. Collision in network:

Wireless networks are susceptible to collisions due to interference, frequent path breaks due to node mobility and inherent fading property of the wireless signals. The collision detection and handling are not described in the research paper as well as prototype. Assumption is made that the network has zero bit error rate and no collision takes place. For a network to be effective, this issue must be addressed.

c. Packet Loss:

Due to rapid node mobility in networks, packets may not be delivered to the destination after it is dispatched from the source node. It is assumed in both the research paper and the prototype that the packet, once dispatched by the source node, reaches the destination. But, this is not at all acceptable in the real world network scenario. Real world networks have the problem of packet loss due to sudden change in link or any other problem, before the packet reaches the destination (on the route). This issue is not addressed in the research work of the researcher.

6. Conclusion

Researcher has worked on the routing algorithm based on swarm intelligence called Ant Colony Metaheuristics and derived a customized algorithm for routing in dynamic nature of wireless network. The algorithm addressed the popular issues in Mobile Ad-Hoc Networks like, node mobility, automatic route management and load balancing. The algorithm is also used to design the prototype for military mobile network named RMUC. Despite of all the research and findings in the researcher's work there are still some issues which are not addressed by the work of the researcher and require some new learning to overcome. Following section describes the assumptions made, issues faced and new learning required to address those issues in future.

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