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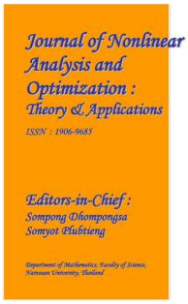

OPTIMIZING SERVICE DISCOVERY IN MANETS THROUGH SWARM INTELLIGENCE AND CONTEXT-AWARE TRUST MANAGEMENT

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Abstract
Mobile Ad Hoc Networks, often known as MANETs, facilitate communication between mobile devices independently of fixed infrastructure. However, service discovery in MANETs remains challenging due to the changeable topology and limited resources of nodes. Because they can't successfully manage trust or employ resources, conventional service discovery strategies often result in less than desirable outcomes. A novel approach that integrates Swarm Intelligence (SI) for service discovery with a Context-Aware Trust Management (CATM) system is proposed to overcome these problems. The SI-based discovery approach uses Particle Swarm Optimization (PSO) to move around the network efficiently and adapt to the constantly changing environment. By mimicking the swarm's natural behaviors, these algorithms optimize the search for services by reducing overhead and expediting response times. Simultaneously, the CATM system evaluates trust based on context-specific factors such as the kind of service being sought, the node's historical performance, and the network's condition. Our method integrates reputation-based and context-aware models to deliver a more flexible and accurate trust evaluation in the dynamic MANET environment. Several experiments and simulations demonstrate significant improvements in service discovery efficiency and reliability using the proposed SI-CATM technique. The results demonstrate that our strategy outperforms existing methods even in highly dynamic network circumstances, achieving superior precision, recall, and F-measure rates in the shortest amount of time. CATM in conjunction with SI offers a powerful solution to the issues surrounding service discovery in MANETs.
Keywords:MANET, service discovery, PSO,swarm intelligence, trust management, efficiency.

1. INTRODUCTION

Because of their intrinsic mobility, independent mobile nodes can constantly reorganize themselves to form a mobile ad-hoc network (MANET). The nodes are therefore unable to share services with other nodes in the vicinity [1]. Because it enables nodes to find and utilize services provided by other nodes inside the network, service discovery is essential in MANETs. The dynamic and unpredictable nature of MANETs, whose network topology frequently changes as nodes migrate, makes this process difficult. The general performance and usefulness of the network depend on nodes being able to locate the services they require promptly and reliably, which is ensured via efficient service discovery [2].

Hierarchical clustering, reputation-based systems, and flooding-based strategies are some of the technologies now in use for service discovery in MANETs. These methods' drawbacks, however, include frequently their high overhead, scalability problems, and susceptibility to sudden changes in the network. These obstacles demonstrate the need for more effective and flexible service discovery techniques that can get beyond the drawbacks of working in a MANET environment. In order to overcome these obstacles, a Swarm Intelligence-based Approach with Context-Aware Trust Management (SI-CATM) that combines PSO with an advanced trust management system is to be suggested for service discovery in MANETs.

The highlights of the suggested work are enumerated below:

- In MANETs, Swarm Intelligence via Particle Swarm Optimization (PSO) is used to dynamically find services, enhancing resource efficiency and search process optimization.
- Context-Aware Trust Management (CATM)is implemented to evaluate and ensure the reliability of discovered services by considering both reputation-based and context-specific trust factors.
- The integration of PSO and CATMenhances service discovery accuracy and reliability, even in the face of network topology changes and dynamic environments.
- Performance evaluation shows significant improvements in terms of precision, recall, F-measure and time consumption.

The rest of the article is organized as follows: Section 2 reviews related work, while Section 3 provides a detailed explanation of the proposed methodology. In Section 4, the effectiveness of the proposed approach is evaluated, and the results are discussed. Finally, Section 5 presents the conclusions of the work.

2. RELATED WORKS

The AODV protocol was modified by [3] to include service discovery and route determination to service providers. A ranking system was proposed to select the best server from multiple options based on server metrics and routing. An algorithm was introduced to handle Expanding Ring Search for finding servers. However, the ranking system may struggle with dynamic server availability and network changes.

[4] has suggested a novel secure MANET routing protocol to guard against internal assaults within the MANET system. Regarding intrusion detection, research has been done on a novel intrusion detection framework created especially for MANET. Two approaches have been used to solve security issues in MANET: prevention and detection. In MANET systems, balancing prevention and detection techniques may result in more overhead and complexity.

The Secured Multi Agent Rapid Trusty Adhoc On-Demand Distance Vector (SMART-AODV) Routing Protocol is proposed in [5] for the purpose of the Service Discovery Process in MANET. A complete solution is offered by the proposed Secured Multi Agent Rapid Trusty Adhoc On-Demand Distance Vector (SMART-AODV) Routing Protocol in terms of improving power growth, bandwidth conservation, and secure path selection. The SMART-AODV protocol and QoS-aware approach may add processing overhead and complexity to MANETs.

The service discovery protocol for MANETs (MSLD) introduced by [6] is a new and efficient protocol that supports heterogeneity among nodes and dynamically adapts to network changes without flooding the network with pointless protocol messages. It is scalable, flexible, lightweight, robust, and scalable. In today's network contexts, such as the Internet of Things (IoT), this is a major difficulty. One of MSLD's drawbacks is its stringent filtering standards, which could lead it to ignore important services.

[7] proposed the development of a semantic clustering algorithm as a means of classifying nodes based on semantic similarity. A hybrid trust management system is also implemented to assess the reliability of detected services. The system blends reputation-based and recommendation-based trust models to increase the accuracy of trust judgments.

This work, which draws inspiration from previous research, presents the Swarm Intelligence-based Approach with Trust Management system to improve accuracy and adjust to dynamic network changes, hence increasing service discovery efficiency in MANETs.

3. PROPOSED METHODOLOGY

PSO and an advanced trust management system are integrated in the suggested Swarm Intelligence-based Approach with Context-Aware Trust Management (SI-CATM) for service discovery in MANETs. The goal of this methodology is to improve the dependability and efficiency of service discovery in MANETs, which have a dynamic topology and constrained resources.

3.1. Network Initialization

When the network first starts up, every mobile node is modeled by a particle in the PSO algorithm. The significance of this representation lies in its ability to portray the network as a swarm, in which every particle, or node, is always moving in pursuit of the best solutions—in this example, available services. Every node keeps a $S = \{s_1, s_2, \ldots, s_n\}$ service availability vector, in which each member $s_i$represents a particular service that the node is capable of providing. Given that it describes the capabilities of every node in the network, this vector is essential for service discovery. Every node also has a trust vector $T = \{t_1, t_2, \ldots, t_n\}$, which indicates how trustworthy other nodes are based on previous interactions. Trust values are used to initialize this vector, and they will be dynamically changed based on node behavior and context during the service discovery process. The initialization phase makes sure that trust evaluations are in place right away and that the network is prepared for PSO-based exploration.

3.2. Particle Swarm Optimization (PSO) for Service Discovery

The use of PSO [8] for service discovery forms the basis of the SI-CATM methodology. PSO is a potent optimization method in which particles, or nodes, navigate the search space in search of the best possible solutions. It was inspired by the social behavior of fish schools and flocks of birds.

PSO facilitates the effective location of services throughout the network in the context of MANETs. Iteratively updating its position and velocity, each particle searches the network for services.

The velocity update is governed by Eq. (1):

$$v_i^{(t+1)} = w \cdot v_i^{(t)} + c_1 \cdot r_1 \cdot (p_i^{best} - x_i^{(t)}) + c_2 \cdot r_2 \cdot (g^{best} - x_i^{(t)}) \quad (1)$$

The inertia weight, or *w*, in this equation regulates the amount of the prior velocity that is kept, striking a balance between exploration-which involves looking for new places-and exploitation, which focuses on well-known areas. The influence of the particle's individual best position (p_i^{best}) and the global best position (g^{best}) discovered by the swarm is determined by the coefficients c_1 and c_2, in conjunction with the random components $r_1$and r_2. Particles can go through the network intelligently and converge at the best service places because to this combination.

The position update is straightforward stated in Eq. (2):

$$x_i^{(t+1)} = x_i^{(t)} + v_i^{(t+1)} \quad (2)$$

Particles effectively reflect the discovery of new service locations or upgrades to current ones as they update their positions. Because the PSO algorithm can swiftly adjust to the changing network topology, it is highly efficient in making sure that the service discovery process is reliable and effective even when nodes enter or exit the network.

3.3. Context-Aware Trust Management (CATM)

The CATM [9] system is in charge of managing the services' dependability, whereas PSO is in charge of their exploration and discovery. Because of the dynamic structure of the network and the wide range of node behavior, trust management in MANETs is difficult. Reliability in service selection may result from traditional trust models' inability to fully reflect the subtleties of context.

This is addressed by the CATM system, which uses a context-specific approach to trust evaluation. The trust score $T(x_i)$ for each node is calculated using Eq. (3):

$$T(x_i) = \gamma \cdot T_{rep}(x_i) + \delta \cdot T_{ctx}(x_i) \quad (3)$$

Reputation-based trust in this case is represented by $T_{rep}(x_i)$, which is obtained from input given by other nodes in the network. The node's reputation score indicates its previous dependability. In contrast, $T_{ctx}(x_i)$ is a context-aware trust that takes into account the node's recent performance, the kind of service sought, and the state of the network at the moment. Only dependable nodes are chosen for service provisioning thanks to the CATM system's more thorough and flexible trust evaluation, which is made possible by merging these two trust components.

The mechanism for updating trust is dynamic; trust scores are continuously modified in response to node interactions and changes in the network environment. For instance, a node's trust score will drop and it will be less likely to be chosen for subsequent service requests if it continuously fails to provide the services that it has promised. In a highly dynamic MANET environment, this adaptive

trust management solution is essential to preserving the integrity and dependability of the service discovery process.

3.4. Service Discovery Process

A node that makes a service request starts the real service discovery process. The swarm of particles drives the PSO algorithm, which searches the network for nodes that can offer the desired service. Particles (nodes) efficiently look for the best service providers as they travel and update their positions.

Following the identification of a possible service provider, the CATM system's trust score is assessed. Nodes are more likely to be chosen to fulfill the service request if they have higher trust scores and better fitness values (which take into account both trust and service quality). This guarantees the found services' dependability and availability.

The dynamic conditions of the network are continuously adjusted to using the SI-CATM technique. The PSO algorithm adjusts particle placements in response to node movements or changes in network topology, and the CATM system recalculates trust ratings to maintain the effectiveness and dependability of the service discovery process. Maintaining excellent performance on MANETs, where conditions might change quickly, requires this dynamic adjustment.

4. RESULT AND DISCUSSION

The 2021A replicates the suggested work on an independent computer with 8 GB of RAM. Popular performance measures including precision, recall, F-measure, and time consumption are used to assess the given work's performance. The performance of the suggested SI-CATM methodology in comparison to the most advanced techniques, MSLD [6] and Hybrid Trust Model [7].

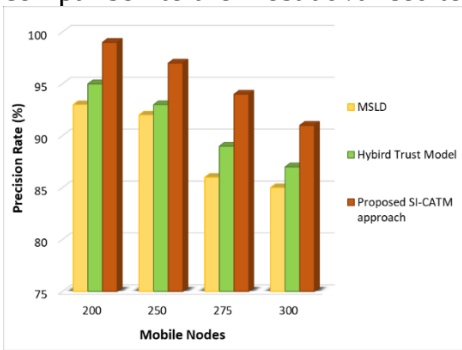

Figure 1. Comparison of Precision rate

The precision rate comparison between the suggested SI-CATM technique, the hybrid trust model, and the current MSLD is displayed in Figure 1.The suggested SI-CATM method demonstrates improved accuracy in service discovery in MANETs by consistently outperforming both the MSLD and Hybrid Trust Model in all node configurations. In particular, the SI-CATM method outperforms the Hybrid Trust Model by 4-6% and the MSLD method by 5-8%. These improvements demonstrate how well Swarm Intelligence and Context-Aware Trust Management work together to provide more precise service discovery. This steady increase at varying density of nodes highlights the resilience of the suggested method in dynamic network settings.

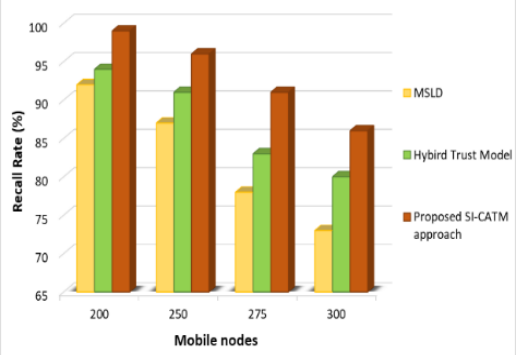

Figure 2. Comparison of Recall rate

The recall rate comparison between the suggested SI-CATM technique, the hybrid trust model, and the current MSLD is displayed in Figure 2. In various node topologies, the suggested SI-CATM

method consistently outperforms the MSLD and Hybrid Trust Model in terms of recall rates. In particular, the SI-CATM method performs 7–13% better than the MSLD method and 5-7% better than the Hybrid Trust Model. This illustrates the greater capacity of the SI-CATM technique to effectively retrieve pertinent services in MANETs, even with an increase in the node count.

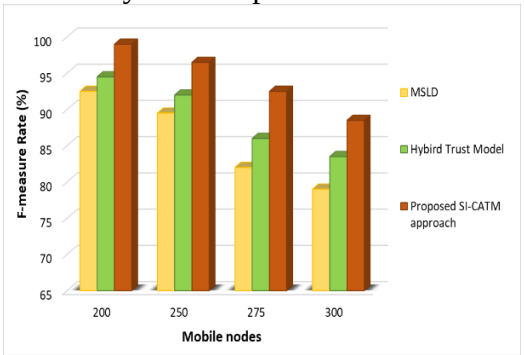

Figure 3. Comparison of F-measure rate

The F-measure rate comparison between the suggested SI-CATM technique, the hybrid trust model, and MSLD is displayed in Figure 3. In every node configuration, the suggested SI-CATM method consistently outperforms the MSLD and Hybrid Trust Model in terms of F-measure rates. In particular, it outperforms the MSLD approach by 6–10% and the Hybrid Trust Model by 4.5–5.5%. These findings demonstrate how well the SI-CATM technique balances recall and precision, resulting in more precise and dependable service discovery in MANETs.

Time consumption: It essentially keeps track of how long it takes the algorithm to find and display information about services that are accessible across a network. The time consumption comparison of the suggested SI-CATM technique, the hybrid trust model, and the current MSLD is displayed in Figure 4. The time consumption of the suggested SI-CATM technique is 1450 ms, which is much less than that of the Hybrid Trust Model (2300 ms) and MSLD (1700 ms). In particular, the SI-CATM technique shows improved efficiency in service discovery for MANETs by reducing time consumption by 37% compared to the MSLD method and 14.7% compared to the Hybrid Trust Model.

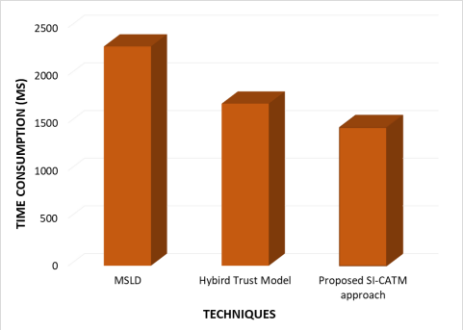

Figure 4. Comparison of Time consumption

5. CONCLUSION

The suggested method offers a reliable answer to the problems associated with service discovery in MANETs by integrating SI via PSO with a CATM system. The accuracy and speed of service discovery are greatly improved by the SI-based discovery mechanism, which effectively explores the network and dynamically adjusts to changing conditions. By assessing trust based on context-specific parameters in addition to reputation, the CATM method further improves the dependability of services found, improving the accuracy and adaptability of trust assessment to the dynamic nature of MANETs.The SI-CATM strategy regularly outperforms existing methods in terms of precision, recall, and F-measure rates while minimizing time consumption, as demonstrated by extensive simulations and experiments that prove its effectiveness. By addressing the crucial problems of resource usage and trust management in MANETs, this combination of swarm intelligence and context-aware trust management offers a highly efficient and scalable solution for service discovery in dynamic network environments. In the future, the SI-CATM strategy could be improved by using

machine learning techniques to adapt in real-time to increasingly complex and unpredictable MANET situations.

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