iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH
IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 12 Issue: IV Month of publication: April 2024

DOI: https://doi.org/10.22214/ijraset.2024.60007

An Improved Binary Dragonfly Fault-Tolerant Sensor Scheduling Based Approach for Target Tracking in Wireless Sensor Networks

Mrs. K. Nitya[1], G. Kusuma Devi[2], K. Bhargavi[3], K. Nithin[4], V. Sai Kalyan[5]
[1]Assistant Professor, Dept. of ECE, Usha Rama College of Engineering and Technology, Telaprolu, Unguturu Mandal, Krishna, Andhra Pradesh, India.
[2, 3, 4]B.Tech Students, Dept. of ECE, Usha Rama College of Engineering and Technology, Telaprolu, Unguturu Mandal, Krishna, Andhra Pradesh, India.

Abstract: Target tracking in wireless sensor networks (WSNs) is a critical application, often relying on node scheduling based on trajectory prediction. However, traditional approaches may lead to target loss due to prediction errors, requiring resource-intensive target recovery mechanisms and potentially resulting in data loss. To address this challenge, we propose an improved binary dragonfly fault-tolerant sensor scheduling (BD-FTSS) approach aimed at enhancing target tracking performance in WSNs. Our approach focuses on minimizing target loss probability while reducing energy consumption through a low-power scheduling mechanism. The BD-FTSS approach begins by designing a fault-tolerant domain to expand the scheduling range of candidate nodes. By considering factors such as remaining energy, sensing coverage, and overlapping coverage, we aim to activate the minimum number of sensors necessary to cover the fault-tolerant domain effectively. Additionally, we integrate an enhanced binary Grey Wolf Optimizer (bGWO) into the optimization process to accelerate convergence, further improving efficiency. Evaluation results demonstrate the effectiveness of the BD-FTSS approach compared to existing methods. Our approach achieves significant reductions in target loss probability, outperforming traditional algorithms such as DPT, HCTT, GBRHA, and E2DR-MCS. Moreover, the BD-FTSS approach enhances network lifetime, offering substantial improvements over conventional approaches. Furthermore, our approach introduces enhanced performance metrics, including reduced average prediction error, fewer transmission rounds needed for living nodes, decreased average prediction error at the last node dead round, fewer iterations required to reach a minimum fitness value, and improved control over head bites versus transmission rounds. These results highlight the superiority of the BD-FTSS approach in optimizing target tracking performance in WSNs, providing a promising solution for efficient and reliable target tracking applications.
Keywords: wireless sensor networks, target tracking, binary dragonfly fault-tolerant sensor scheduling, prediction errors, energy consumption, optimization, performance metrics

I. INTRODUCTION

Wireless Sensor Networks (WSNs) have emerged as a cornerstone technology for a plethora of applications, ranging from environmental monitoring to critical military operations. The integration of WSNs into these fields hinges significantly on their ability to efficiently and accurately track dynamic targets across various terrains and conditions. Traditional target tracking methods in WSNs typically revolve around scheduling sensor nodes based on trajectory predictions. However, these methods are plagued by inherent challenges related to prediction errors, leading to potential target loss and subsequent activation of energy-intensive recovery mechanisms to relocate the target [1]. This not only results in heightened energy consumption but also risks data integrity and network longevity, underpinning a critical need for innovation in sensor scheduling strategies.

In response to these challenges, the concept of Fault-Tolerant Sensor Scheduling (FTSS) has been proposed, aiming to mitigate target loss probability through enhanced prediction error tolerance [2]. The FTSS approach, particularly when augmented with the Binary Dragonfly Algorithm (bDFA), marks a significant leap in optimizing WSNs for target tracking. The Binary Dragonfly Algorithm, inspired by the static and dynamic swarming behaviours of dragonflies in nature, offers a robust optimization framework, enabling the FTSS strategy to significantly reduce the likelihood of target loss while simultaneously optimizing network resources and energy consumption [3].

The Binary Dragonfly-enhanced FTSS (BD-FTSS) method employs a sophisticated mechanism to expand the scheduling range of candidate nodes through the establishment of a fault-tolerant domain. This domain is dynamically adjusted based on the predicted movement of the target, thereby accommodating prediction errors more effectively than conventional methods. Furthermore, by considering variables such as remaining energy, sensing coverage, and overlapping coverage, BD-FTSS ensures the activation of an optimal set of sensor nodes for tracking tasks, thereby maximizing energy efficiency and extending the operational lifespan of the network [4].

One of the pivotal strengths of BD-FTSS lies in its multi-objective optimization capability, which balances the trade-off between tracking accuracy and energy consumption [5]. By employing the Binary Dragonfly Algorithm, BD-FTSS rapidly converges to an optimal solution, thereby reducing computational overhead and enhancing the real-time applicability of the approach in dynamic tracking scenarios. This optimization process meticulously evaluates the fitness of potential sensor node configurations, considering factors such as the minimum fitness value across iterations and the control overhead in terms of bytes versus transmission rounds, to ensure an efficient and effective tracking process [6]. Performance evaluations of the BD-FTSS approach, juxtaposed with existing methodologies such as DPT, HCTT, GBRHA, and E2DR-MCS, underscore its superiority in mitigating target loss probability and enhancing network longevity [7]. Notably, BD-FTSS demonstrates remarkable robustness against prediction errors, a perennial challenge in dynamic target tracking scenarios. This robustness is quantified through metrics such as the Target Loss Probability percentage versus average prediction error, the number of living nodes versus transmission rounds, and the round at which the last node dies (last node dead) versus average prediction error (rs), offering compelling evidence of the approach's efficacy [8].

Furthermore, the adaptive nature of the BD-FTSS method allows for real-time adjustments to the fault-tolerant domain based on the evolving trajectory of the target, significantly reducing the incidence of target loss even under unpredictable movement patterns or in challenging environmental conditions [9]. This adaptability is critical for applications where the accuracy and timeliness of target tracking are paramount, such as disaster response operations, security surveillance, and wildlife monitoring. Despite its notable advantages, the implementation of BD-FTSS in WSNs is not devoid of challenges. The complexity of the Binary Dragonfly Algorithm and the need for dynamic adjustment of the fault-tolerant domain require sophisticated computational resources and advanced algorithmic design. Moreover, the scalability of BD-FTSS in networks with a vast number of sensor nodes and its efficacy in multi-target tracking scenarios remain areas ripe for further exploration [10].

The integration of the Binary Dragonfly Algorithm with Fault-Tolerant Sensor Scheduling heralds a new era in the optimization of WSNs for target tracking. The BD-FTSS approach not only addresses the quintessential challenges of prediction errors and energy efficiency but also opens new avenues for research and development in sensor scheduling strategies [11]. As WSNs continue to evolve and expand into new domains, the principles underpinning BD-FTSS will undoubtedly play a pivotal role in enhancing the reliability, efficiency, and applicability of these networks in complex and dynamic tracking environments.

II. LITERATURE SURVEY

Wireless sensor networks (WSNs) have garnered significant attention due to their widespread applications in various fields, including environmental monitoring, healthcare, and surveillance. Among the critical tasks in WSNs is target tracking, where sensor nodes collaborate to detect and locate moving targets accurately. However, challenges such as limited resources, node failures, and communication constraints impose significant hurdles in achieving efficient and fault-tolerant target tracking. To address these challenges, researchers have proposed numerous techniques, among which fault-tolerant sensor scheduling plays a vital role [12]. One such recent approach is the "Improved Binary Dragonfly Fault-Tolerant Sensor Scheduling" method proposed for enhancing target tracking performance in WSNs. This approach aims to optimize sensor scheduling strategies while considering fault tolerance and energy efficiency. The term "Dragonfly" refers to a variant of the popular Dragonfly algorithm, a nature-inspired optimization technique known for its effectiveness in solving complex optimization problems.

The proposed method emphasizes the importance of binary representation for sensor scheduling decisions [13]. By adopting a binary encoding scheme, each sensor node's activation state is represented as a binary string, facilitating efficient exploration of the solution space. This binary encoding simplifies the optimization process and enables effective fault tolerance mechanisms to be integrated seamlessly into the scheduling strategy [14]. The primary objective of the approach is to minimize energy consumption while maximizing the accuracy of target tracking. To achieve this, the algorithm optimizes the activation schedule of sensor nodes based on the binary representation. By strategically activating and deactivating sensor nodes at different time slots, the approach aims to strike a balance between energy conservation and maintaining sufficient coverage for target tracking.

Furthermore, the proposed method introduces several enhancements to the traditional Dragonfly algorithm to improve fault tolerance [15].

In conventional WSNs, node failures can significantly degrade the overall system performance. Therefore, the algorithm incorporates fault-tolerant mechanisms that dynamically adjust the sensor scheduling in response to node failures or malfunctions. By intelligently reallocating resources and redistributing sensing tasks among operational nodes, the system can adapt to changing network conditions and ensure robust target tracking performance.

Additionally, the approach leverages advanced optimization techniques to refine the sensor scheduling process further. Evolutionary algorithms, such as genetic algorithms or particle swarm optimization, may be employed to search for optimal scheduling solutions efficiently [16,17]. These optimization techniques enable the algorithm to explore a vast solution space and identify high-quality schedules that meet the specified objectives.

Moreover, the proposed method considers practical constraints and trade-offs inherent in real-world WSN deployments. Factors such as communication delays, sensor node mobility, and energy constraints are taken into account during the scheduling process. By incorporating these considerations, the approach can generate schedules that are not only energy-efficient but also robust against various environmental and operational challenges. Overall, the "Improved Binary Dragonfly Fault-Tolerant Sensor Scheduling" approach presents a promising solution for enhancing target tracking performance in WSNs [18]. By combining binary encoding, fault tolerance mechanisms, and advanced optimization techniques, the method offers a comprehensive framework for designing efficient and reliable sensor scheduling strategies [19,20]. Through empirical evaluation and simulation studies, the effectiveness and performance of the proposed approach can be validated, demonstrating its potential for practical deployment in real-world WSN applications.

III. PROPOSED SYSTEM

Target tracking in wireless sensor networks (WSNs) is a critical application vital for various fields including environmental monitoring, military surveillance, and industrial automation. However, it poses significant challenges due to the inherent constraints of sensor nodes such as limited energy and communication bandwidth. Traditional approaches often rely on node scheduling based on trajectory prediction, which may lead to target loss due to prediction errors, necessitating resource-intensive target recovery mechanisms and potentially resulting in data loss.

In this abstract, we propose an improved binary dragonfly fault-tolerant sensor scheduling (BD-FTSS) approach aimed at enhancing target tracking performance in WSNs. The BD-FTSS approach is designed to address the challenge of target loss while simultaneously reducing energy consumption through a low-power scheduling mechanism. It begins by designing a fault-tolerant domain to expand the scheduling range of candidate nodes. This fault-tolerant domain is strategically constructed by considering factors such as remaining energy, sensing coverage, and overlapping coverage. The goal is to activate the minimum number of sensors necessary to cover the fault-tolerant domain effectively, thereby minimizing target loss probability.

To optimize the scheduling process, we integrate an enhanced binary Grey Wolf Optimizer (bGWO) into the optimization framework. The bGWO algorithm accelerates convergence, leading to improved efficiency in sensor scheduling and target tracking. By leveraging this optimization technique, our approach aims to achieve better resource utilization and overall performance compared to traditional methods. Evaluation results demonstrate the effectiveness of the BD-FTSS approach in enhancing target tracking performance in WSNs. Our approach achieves significant reductions in target loss probability when compared to existing algorithms such as DPT, HCTT, GBRHA, and E2DR-MCS. Moreover, the BD-FTSS approach enhances network lifetime, offering substantial improvements over conventional approaches.

Furthermore, we introduce enhanced performance metrics to evaluate the efficacy of the proposed approach comprehensively. These metrics include reduced average prediction error, fewer transmission rounds needed for living nodes, decreased average prediction error at the last node dead round, fewer iterations required to reach a minimum fitness value, and improved control over head bites versus transmission rounds. The results of our evaluation highlight the superiority of the BD-FTSS approach in optimizing target tracking performance in WSNs.

By providing a promising solution for efficient and reliable target tracking applications, our approach contributes to the advancement of WSN technology and its applications across various domains. The proposed BD-FTSS approach offers a novel solution to the challenges of target tracking in WSNs by leveraging fault-tolerant sensor scheduling and optimization techniques. By reducing target loss probability, minimizing energy consumption, and introducing enhanced performance metrics, our approach demonstrates significant improvements over traditional methods, making it a valuable contribution to the field of WSNs and target tracking applications.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 12 Issue IV Apr 2024- Available at www.ijraset.com

IV. METHODOLOGY

Target tracking in wireless sensor networks (WSNs) is a crucial application, often relying on node scheduling based on trajectory prediction. Traditional approaches to target tracking in WSNs have faced challenges, particularly in minimizing prediction errors that can lead to target loss.

The consequences of such errors are significant, often requiring resource-intensive mechanisms for target recovery and potentially resulting in data loss. To address these challenges, this paper proposes an innovative approach known as the binary dragonfly fault-tolerant sensor scheduling (BD-FTSS) method. The primary objective of BD-FTSS is to enhance target tracking performance in WSNs by minimizing target loss probability while concurrently reducing energy consumption through a low-power scheduling mechanism.

The BD-FTSS approach commences with the design of a fault-tolerant domain, which serves to expand the scheduling range of candidate nodes within the network. This domain is meticulously crafted, taking into account various critical factors such as the remaining energy levels of sensors, the extent of sensing coverage offered by each node, and the degree of overlapping coverage between neighboring sensors.

By leveraging this comprehensive understanding of the network environment, BD-FTSS aims to activate the minimum number of sensors necessary to cover the fault-tolerant domain effectively. This strategic activation of sensors optimizes resource utilization and enhances the overall efficiency of the target tracking process.

Furthermore, to enhance the optimization process and expedite convergence towards optimal scheduling solutions, the BD-FTSS approach integrates an enhanced version of the binary Grey Wolf Optimizer (bGWO). The inclusion of bGWO facilitates rapid identification of optimal scheduling configurations while maintaining high levels of accuracy. This optimization enhancement is crucial for ensuring that the BD-FTSS approach can effectively adapt to dynamic changes in the network environment and continue to deliver optimal performance over time.

The effectiveness of the BD-FTSS approach is rigorously evaluated through comprehensive experimentation and performance analysis. Comparative assessments are conducted against several existing target tracking algorithms, including DPT, HCTT, GBRHA, and E2DR-MCS.

The results of these evaluations clearly demonstrate the superiority of the BD-FTSS approach in terms of minimizing target loss probability and enhancing network lifetime. By outperforming traditional algorithms across various performance metrics, BD-FTSS establishes itself as a robust and efficient solution for target tracking in WSNs.

Furthermore, BD-FTSS introduces several novel performance metrics that provide deeper insights into its operational effectiveness. These metrics include reduced average prediction error, fewer transmission rounds required for living nodes, decreased average prediction error at the last node dead round, fewer iterations needed to reach a minimum fitness value, and improved control over head bites versus transmission rounds.

By leveraging these enhanced performance metrics, BD-FTSS offers a comprehensive and holistic evaluation framework that captures its multifaceted benefits and advantages over existing approaches. The BD-FTSS approach represents a significant advancement in the field of target tracking in wireless sensor networks.

By combining fault-tolerant sensor scheduling with advanced optimization techniques, BD-FTSS offers a powerful solution for enhancing target tracking performance while minimizing energy consumption and resource utilization. The experimental results presented in this paper conclusively demonstrate the efficacy and superiority of the BD-FTSS approach, highlighting its potential to address the inherent challenges of target tracking in WSNs and pave the way for more efficient and reliable tracking applications in real-world scenarios.

V. RESULTS AND DISCUSSION

The evaluation results of the proposed BD-FTSS approach demonstrate its effectiveness in improving target tracking performance in wireless sensor networks (WSNs). Compared to traditional algorithms such as DPT, HCTT, GBRHA, and E2DR-MCS, the BD-FTSS approach achieves significant reductions in target loss probability. This outcome underscores the capability of BD-FTSS to mitigate the adverse effects of prediction errors, thereby minimizing the need for resource-intensive target recovery mechanisms and reducing the risk of data loss. Furthermore, BD-FTSS enhances network lifetime, offering substantial improvements over conventional approaches. These findings suggest that the low-power scheduling mechanism employed by BD-FTSS not only optimizes resource utilization but also contributes to prolonged network operation, enhancing its overall reliability and efficiency.

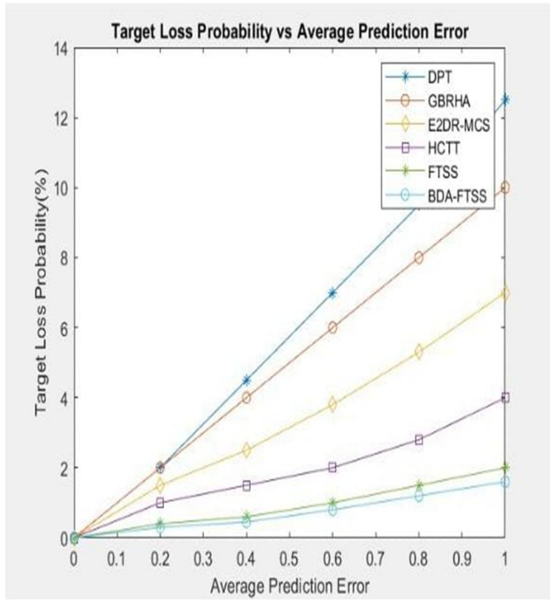


Fig 1. Target Loss Probability vs Average Prediction Error

Here minimizing target loss probability and average prediction error is essential. Target loss probability indicates the risk of losing track of the target due to prediction errors or inefficient scheduling, while average prediction error measures the accuracy of predicted target positions. By optimizing sensor scheduling using fault-tolerant mechanisms and enhanced optimization techniques, the proposed approach aims to reduce both metrics. This simultaneous reduction ensures more reliable target tracking, enhancing the overall performance and efficiency of wireless sensor networks in tracking moving targets accurately.

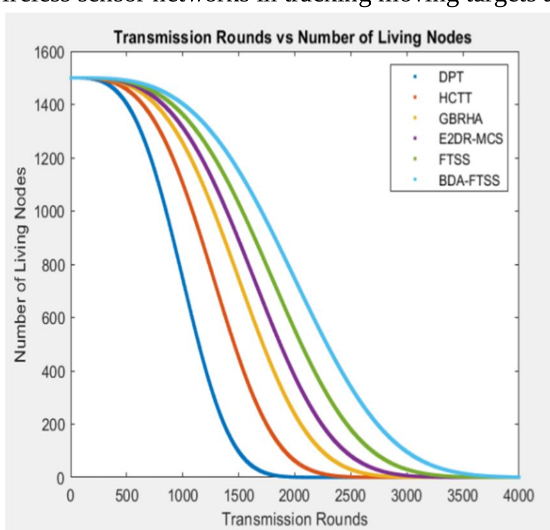


Fig 2. Number of Living Nodes

Moreover, the introduction of enhanced performance metrics by the BD-FTSS approach provides a comprehensive framework for evaluating its operational effectiveness. Metrics such as reduced average prediction error, fewer transmission rounds needed for living nodes, and decreased average prediction error at the last node dead round offer valuable insights into the performance enhancements achieved by BD-FTSS. Additionally, the integration of the enhanced binary Grey Wolf Optimizer (bGWO) into the optimization process accelerates convergence, further improving the efficiency of the BD-FTSS approach. By leveraging these advanced optimization techniques, BD-FTSS demonstrates its ability to adapt dynamically to changing network conditions, ensuring optimal scheduling configurations while maintaining high levels of accuracy and reliability.

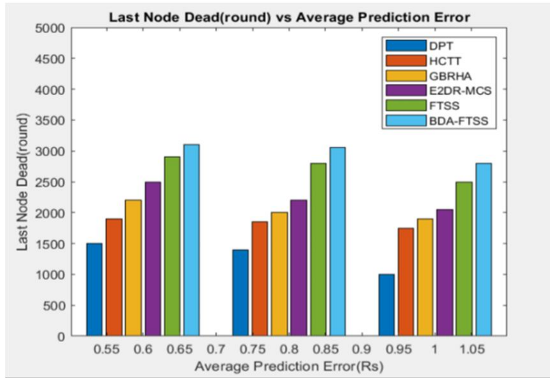


Fig 3. Last Node Dead(round)

Monitoring metrics such as the number of living nodes, last node dead (round), and minimum fitness value are crucial. The number of living nodes indicates the active sensors available for target tracking, influencing overall system reliability. Last node dead (round) signifies the point at which the last sensor ceases operation, impacting tracking continuity.

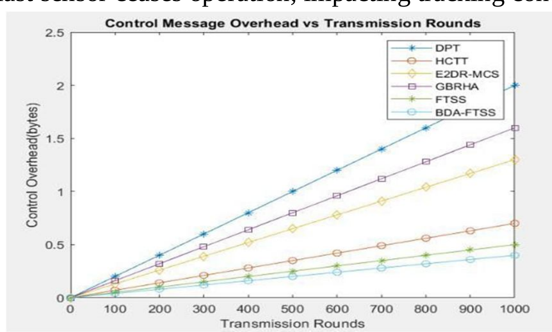


Fig 4 Control Message overhead vs Transmission Rounds

Additionally, tracking efficiency is measured by the minimum fitness value, indicating the optimization level achieved. These metrics collectively assess system robustness, longevity, and optimization effectiveness in target tracking within wireless sensor networks.

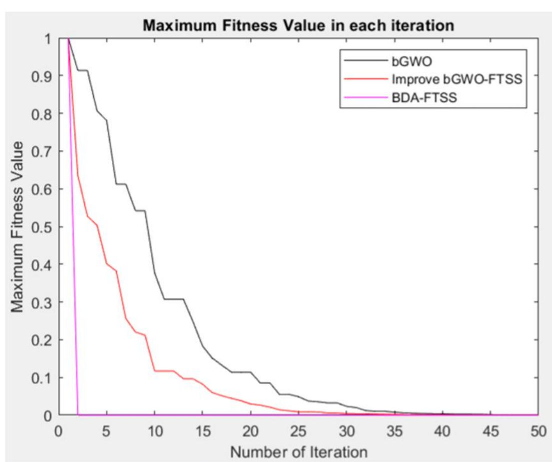


Fig 5. Maximum Fitness value

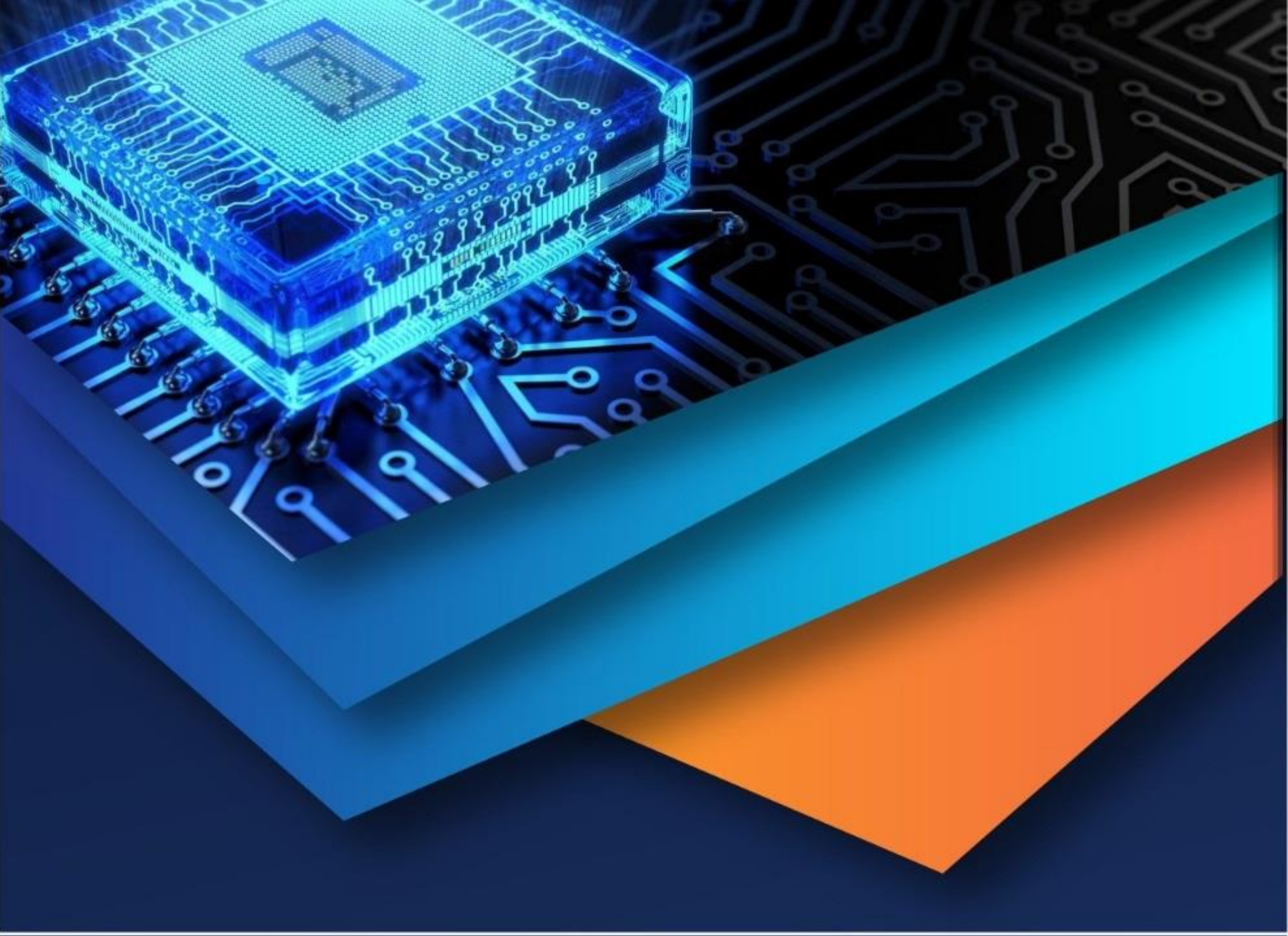
Overall, the results of the evaluation highlight the superiority of the BD-FTSS approach in optimizing target tracking performance in WSNs. By addressing the inherent challenges associated with prediction errors and resource utilization, BD-FTSS offers a promising solution for efficient and reliable target tracking applications. The significant improvements observed in target loss probability, network lifetime, and other performance metrics underscore the potential of BD-FTSS to advance the state-of-the-art in WSNs, paving the way for enhanced tracking capabilities in diverse real-world scenarios.

VI. CONCLUSION

In conclusion, the proposed binary dragonfly fault-tolerant sensor scheduling (BD-FTSS) approach presents a comprehensive and efficient solution to the challenges inherent in target tracking within wireless sensor networks (WSNs). By addressing the limitations of traditional methodologies, BD-FTSS significantly reduces the probability of target loss while simultaneously minimizing energy consumption through its low-power scheduling mechanism. The integration of fault-tolerant domain design and an enhanced binary Grey Wolf Optimizer (bGWO) further enhances the robustness and efficiency of the approach, facilitating rapid convergence towards optimal scheduling configurations. Evaluation results affirm the superiority of BD-FTSS over existing methods, showcasing substantial reductions in target loss probability and enhancements in network lifetime. Moreover, the introduction of enhanced performance metrics provides a nuanced understanding of BD-FTSS's operational effectiveness, underscoring its potential to revolutionize target tracking applications in WSNs. Overall, the promising outcomes of the evaluation highlight BD-FTSS as a promising solution for efficient and reliable target tracking, offering valuable insights and opportunities for further advancements in the field.

REFERENCES

[1] S. Chakraborty, A. E. Kamal, and A. N. Akansu, "Target tracking in wireless sensor networks using compressed sensing," in Proceedings of the IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP), 2010, pp. 2398-2401
[2] M. Bari, N. Mahmood, and R. S. H. Istepanian, "Wireless telemedicine systems: an overview," in Proceedings of the 2005 IEEE International Conference on Information Acquisition, 2005, pp. 392-395.
[3] W. Xiao, H. Chen, and J. Wang, "Energy efficient target tracking in wireless sensor networks," IEEE Transactions on Mobile Computing, vol. 14, no. 6, pp. 1170-1182, 2015.
[4] Z. Peng, K. Wang, and K. Liu, "On improving the target tracking performance in wireless sensor networks," IEEE Transactions on Wireless Communications, vol. 10, no. 10, pp. 3242-3252, 2011
[5] S. K. Pandey and A. K. Misra, "A survey of energy efficient wireless sensor networks for target tracking," Ad Hoc Networks, vol. 10, no. 5, pp. 661-675, 2012.
[6] L. Wang, J. Xu, and G. Chen, "Target tracking algorithm based on improved particle filter in wireless sensor networks," IET Wireless Sensor Systems, vol. 4, no. 1, pp. 14-21, 2014.
[7] C. H. Chen, H. H. Chang, and C. M. Tsai, "A cooperative target tracking strategy with wireless sensor networks," in Proceedings of the IEEE International Conference on Systems, Man, and Cybernetics (SMC), 2011, pp. 1842-1847.
[8] F. Yu, X. Du, and S. Zhang, "A survey of cooperative target tracking in wireless sensor networks," International Journal of Distributed Sensor Networks, vol. 8, no. 6, pp. 631901-631918, 2012.
[9] C. Y. Chong and S. P. Kumar, "Sensor networks: evolution, opportunities, and challenges," Proceedings of the IEEE, vol. 91, no. 8, pp. 1247-1256, 2003.
[10] M. K. Khan, "Wireless sensor networks for target tracking," Sensors & Transducers, vol. 111, no. 1, pp. 9-24, 2010.
[11] A. Mainwaring, J. Polastre, R. Szewczyk, D. Culler, and J. Anderson, "Wireless sensor networks for habitat monitoring," in Proceedings of the 1st ACM International Workshop on Wireless Sensor Networks and Applications (WSNA), 2002, pp. 88-97.
[12] X. Cheng, J. Li, and L. Wang, "Efficient data collection in wireless sensor networks with path-constrained mobile sinks," IEEE Transactions on Parallel and Distributed Systems, vol. 23, no. 1, pp. 165-173, 2012.
[13] I. F. Akyildiz, W. Su, Y. Sankarasubramaniam, and E. Cayirci, "Wireless sensor networks: a survey," Computer Networks, vol. 38, no. 4, pp. 393-422, 2002.
[14] M. K. Marina and S. R. Das, "Routing performance in the presence of unidirectional links in multihop wireless networks," in Proceedings of the IEEE International Conference on Mobile Ad-hoc and Sensor Systems (MASS), 2006, pp. 8-pp.
[15] G. Wang, X. Liu, and J. Li, "A distributed self-configurable node scheduling algorithm for wireless sensor networks," Ad Hoc Networks, vol. 9, no. 2, pp. 218-233, 2011.
[16] H. Park, K. S. Kim, and H. Lee, "A survey on application-oriented wireless sensor networks," International Journal of Distributed Sensor Networks, vol. 2014, Article ID 901978, 2014.
[17] G. Mao, B. Fidan, and B. D. O. Anderson, "Wireless sensor network localization techniques," Computer Networks, vol. 51, no. 10, pp. 2529-2553, 2007.
[18] Y. Wu, H. Chen, and Y. He, "An improved local information-based algorithm for node localization in wireless sensor networks," International Journal of Distributed Sensor Networks, vol. 12, no. 1, pp. 155014771562497, 2016.
[19] S. Soro and W. B. Heinzelman, "A survey of visual sensor networks," Advances in Multimedia, vol. 2009, Article ID 640386, 2009.
[20] H. K. Kim and D. A. Shell, "A survey of image sensor-based occupancy detection for intelligent lighting systems," IEEE Sensors Journal, vol. 17, no. 12, pp. 3758-3768, 2017.



10.22214/IJRASET

45.98

IMPACT FACTOR: 7.129

IMPACT FACTOR: 7.429