

Metaheuristic Optimization Algorithm for efficient Zero-Day Intrusion Detection and Adaptive Feature Learning in Dynamic IoT Networks

Kailash Pati Dutta
Jharkhand Rai University
India
kailash.dutta@jru.edu.in

ABSTRACT

In this advancing era, the Internet of Things (IoT) has developed as a crucial component of the modern digital-infrastructure, interconnecting billions of diverse devices. Consequently, it generates unceasing amount of huge network data. This extensive connectivity, on one hand, has made life easier by making things smart; but on the other hand, it has become a threat with regard to the cyberattacks. Conventional intrusion detection systems (IDS) generally rely on the static models or previously observed attack patterns. However, due to continuously changing network behaviour, it has made them less effective against zero-day attacks. Zero-day attacks exploit unknown security vulnerabilities in any networks and device.

Many recent published researches have explored different techniques based on machine learning, deep learning etc. for intelligent intrusion detection for IoT security. Although these approaches have improved detection performance, many existing systems are designed for relatively static data-sets and necessitate periodic or broad re-training. They often do not satisfactorily report the combined security threats and challenges related to unseen attacks, changing feature relevance, concept drift and recurrent model adaptation.

For addressing these limitations, Metaheuristic optimization algorithm are used for continual zero-day intrusion detection and adaptive feature learning in any dynamic IoT settings. The regular monitoring of IoT traffic and related identification of the behavioural changes should be done effectively. In this context, Metaheuristic optimization techniques are deployed to dynamically select the relevant features as well as attributes and optimize the detection parameters. A continual learning mechanism will then update the IDS model when new and unknown attack patterns emerge while ensuring that the previously acquired knowledge are preserved.

Unlike many other methods, the integration of adaptive feature learning with metaheuristic optimization algorithms for zero-day detection and continual learning within a unified IoT security framework does not treat the task as one time classification problem. Rather, this model considers IoT security challenges as a continuously evolving learning process. The major benefits include improved detection of new attacks, lower computational requirements as well as faster adaptation to changing traffic patterns, reduced dependence on complete model retraining, and improved suitability for resource-constrained IoT environments.

Index Terms— *Continual Learning, Zero-Day Intrusion Detection, Metaheuristic Optimization, Adaptive Feature Learning, Concept Drift, Internet of Things (IoT).*

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Speaker's short biography:



Dr. Kailash Pati Dutta is an Associate Professor with the Faculty of Computer Science Engineering and Information Technology at Jharkhand Rai University Ranchi, India. He completed B.Sc. Engineering & M.Tech from Vinoba Bhave University Hazaribag, India and earned a PhD degree from the National Institute of Technology (NIT) Durgapur, India under the Visvesvaraya PhD Fellowship Scheme of the Ministry of Electronics & Information Technology (MeitY), Govt. of India. Dr. Dutta has more than 16 years of academic, research and administrative experiences. To his credit, Dr. Dutta has 4 patent grants and a number of publications in reputed SCI & Scopus indexed international journals and conference proceedings. He is also the ‘Advisor’ to the Board of Directors of Electromotion e-Vidyut Vehicles Private Limited Pune, Maharashtra and founder of a startup Unati Global Connect Private Limited. He has worked as reviewer in many SCI indexed journals that include IEEE-AWPL, Springer’s Cluster Computing, Wiley’s International Journal of Communication Systems, Hindwai’s International Journal of Antennas and Propagation and International Journal of Electronics from Taylor and Francis. His area of interest counts soft computing including metaheuristic algorithms, evolutionary algorithms, blockchain and internet of things.