World Journal of Innovation and Modern Technology E-ISSN 2756-5491 P-ISSN 2682-5910
Vol 8. No. 6 2024 www.iiardjournals.org

An Innovative Intelligent Agent-Based Antimalware Model for the Protection of Systems Against Malware (RANSOMWARE)

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DOI: 10.56201/wjimt.v8.no6.2024.pg14.26

Abstract
Ransomware is a rapidly evolving cybersecurity threat that encrypts data and demands payment, causing significant financial and operational damage worldwide. Traditional antimalware solutions often fail to detect and mitigate advanced ransomware attacks due to their reliance on signature-based detection methods. This research presents an innovative intelligent agent-based antimalware model that leverages machine learning and behavioral analysis to provide a proactive defense against ransomware. The proposed model employs intelligent agents that continuously monitor system processes and identify anomalies indicative of ransomware activity. It features a Behavioral Analysis Module to detect suspicious activities, such as rapid file encryption or unauthorized data access, and a Machine Learning Engine that adapts to new ransomware variants by updating threat models dynamically. The system also includes an automated Response Module that isolates infected systems, prevents further spread, and restores compromised data from secure backups. This research involved designing, implementing, and testing the model in a controlled environment using simulated ransomware attacks. The results demonstrated a high detection rate of 95% with a low false-positive rate of 3%. Compared to traditional solutions, the model achieved faster detection and response times, effectively neutralizing threats before significant damage occurred. The study highlights the system's adaptability, efficiency, and potential to significantly enhance ransomware protection. This work contributes to the advancement of antimalware technologies by offering a scalable, intelligent solution to combat ransomware. Future developments will focus on refining the system for broader deployment, improving resource efficiency, and integrating it into comprehensive cybersecurity frameworks.

Keywords: *Ransomware, Agent-Based Model, Agents, Adaptation, Resilience*

Introduction

Ransomware is a critical cybersecurity threat that encrypts user data and demands payment for decryption. Its rapid evolution and sophisticated attack vectors make traditional antimalware solutions insufficient. This research introduces an intelligent agent-based model designed to counter ransomware by leveraging advanced detection mechanisms and adaptive response systems.

Background to the Study

Ransomware has emerged as one of the most prevalent and damaging forms of cyberattacks in the digital era. It is a type of malicious software that encrypts a victim's data and demands a ransom payment in exchange for the decryption key. Over the past decade, ransomware has evolved from simple malware into sophisticated threats capable of targeting individuals, businesses, and critical infrastructure. High-profile attacks, such as those on healthcare systems, financial institutions, and government agencies, have highlighted the devastating consequences of ransomware, including financial losses, reputational damage, and disruptions to essential services.

The proliferation of ransomware attacks can be attributed to several factors. First, the increasing reliance on digital systems and the growing amount of sensitive data stored on them have made ransomware a lucrative tool for cybercriminals. Second, the rise of cryptocurrencies has provided attackers with an anonymous payment method, making it easier for them to demand and receive ransoms without being tracked. Finally, ransomware-as-a-service (RaaS) platforms have lowered the barrier for entry, enabling less-skilled attackers to deploy ransomware attacks effectively.

Existing antimalware solutions rely heavily on signature-based detection, which identifies malware by matching it against a database of known threats. While effective against previously identified ransomware, this approach is insufficient for detecting new or modified ransomware variants that can bypass traditional defenses. Anomaly-based detection systems, which identify deviations from normal behavior, offer some improvements but often suffer from high false-positive rates, leading to unnecessary system disruptions.

The limitations of current solutions highlight the need for advanced, adaptive methods to combat ransomware. Intelligent agent-based systems offer a promising alternative by incorporating machine learning and behavioral analysis to detect and respond to threats in real time. These systems can analyze system behavior, recognize patterns indicative of ransomware, and take immediate action to neutralize threats before significant damage occurs.

This study explores the potential of intelligent agent-based technologies to address the challenges posed by ransomware. By leveraging adaptive learning and proactive response mechanisms, the proposed model aims to enhance ransomware detection, reduce false positives, and provide robust system protection. This research builds upon existing studies in the fields of machine learning, cybersecurity, and intelligent systems, contributing to the development of next-generation antimalware solutions.

Statement of the Problem

Current antimalware systems are often reactive and fail to detect ransomware early enough to prevent damage. This creates a critical need for an advanced, proactive solution that adapts to evolving threats and reduces the impact of ransomware attacks.

Objectives of the Research

1. Develop an intelligent agent-based antimalware model for ransomware detection and mitigation.
2. Implement real-time monitoring and behavior-based threat analysis.
3. Evaluate the proposed system's performance against current solutions.

Operation of Ransomware

Ransomware typically infiltrates systems through phishing emails, malicious downloads, or network vulnerabilities. Once inside, it encrypts user files and displays a ransom note demanding payment for decryption keys. Some variants threaten to leak sensitive data, adding further pressure on victims.

Review of Related Works

Numerous studies have investigated the use of machine learning, behavioral analysis, and intelligent systems to combat ransomware. Below is a detailed review of some key works related to the development of antimalware systems, highlighting their methodologies, contributions, and limitations.

Smith and Doe (2021): "Machine Learning in Ransomware Detection" this study explored the use of supervised machine learning models for ransomware detection. The authors implemented algorithms such as Random Forest and Support Vector Machines (SVMs) to classify malicious activities based on file system behaviors. The dataset used included ransomware samples and benign software activities. Results showed an average accuracy of 92% in detecting ransomware. This work Highlighted the effectiveness of feature-based classification in identifying ransomware and as well Demonstrated the potential of integrating data analytics into traditional security systems.

Johnson (2022): "Behavioral Analysis for Malware Mitigation" In this work published in *Security Research Review*, Johnson proposed a dynamic behavioral analysis system for identifying ransomware. The system monitored file encryption rates, process creation patterns, and unauthorized data access attempts to flag suspicious activities. It incorporated rule-based and heuristic methods to refine detection accuracy. It Introduced dynamic behavior monitoring as a more robust method compared to signature-based detection and Showed improved detection of previously unknown ransomware variants.

Brown (2023): "Advances in Intelligent Agent Systems" This studyn focused on the use of intelligent agents for adaptive cybersecurity. Brown designed a multi-agent framework capable of learning and updating threat models based on new malware samples. Agents communicated and collaborated to detect and isolate ransomware in distributed networks. It Demonstrated the scalability and adaptability of intelligent agent systems in complex environments. It also Highlighted the importance of collaboration between agents to reduce detection latency.

Patel and Singh (2020): "Anomaly Detection in Ransomware Using Neural Networks" In this study Patel and Singh employed deep neural networks to detect ransomware based on system anomalies. The system trained on a variety of ransomware behaviors, including file encryption and registry modifications. Results showed a detection rate of 89%. Demonstrated the potential of deep learning in understanding complex patterns in ransomware behavior. It Provided insights into feature selection for ransomware detection.

The model suffered from overfitting due to limited ransomware samples. It Required significant computational resources, limiting scalability.

Liu et al. (2021): "Real-Time Ransomware Detection with Lightweight Models" this study introduced a lightweight ransomware detection framework suitable for resource-constrained systems. The authors used decision trees and lightweight neural networks to achieve real-time detection with minimal overhead. Focused on designing an energy-efficient solution for mobile and IoT devices. It Achieved a balanced trade-off between detection accuracy and resource consumption. Although its Limited to detecting specific ransomware families due to its simplified architecture. It also Lacked automated response mechanisms, requiring manual intervention. The above reviewed studies highlight significant advancements in ransomware detection, from machine learning-based classification to intelligent agent frameworks. While each study contributed valuable insights, several gaps remain, including high false-positive rates, limited scalability, and the inability to address emerging ransomware variants effectively. This research builds upon these works by combining the adaptability of intelligent agents with the accuracy of machine learning and behavioral analysis. Unlike prior approaches, the proposed system focuses on real-time detection, automated response, and adaptability to evolving threats, offering a comprehensive solution to ransomware protection.

Proposed System and Implementation

The proposed system employs intelligent agents that monitor system behavior for anomalies. Key components include:

- **Behavioral Analysis Module**: Identifies suspicious activities like rapid file encryption.
- **Machine Learning Engine**: Continuously updates threat models to detect evolving ransomware.
- **Response Module**: Automatically isolates infected systems and restores data from backups.

The implementation uses Python for scripting and TensorFlow for machine learning, integrated into a lightweight agent deployed across systems.

Algorithm of the System

Step 1: Monitor system processes and file activities in real-time.
Step 2: Extract features such as file access frequency and encryption attempts.
Step 3: Analyze extracted features using a trained machine learning model.
Step 4: Classify activity as normal or malicious.
Step 5: If malicious, isolate the system and execute countermeasures.

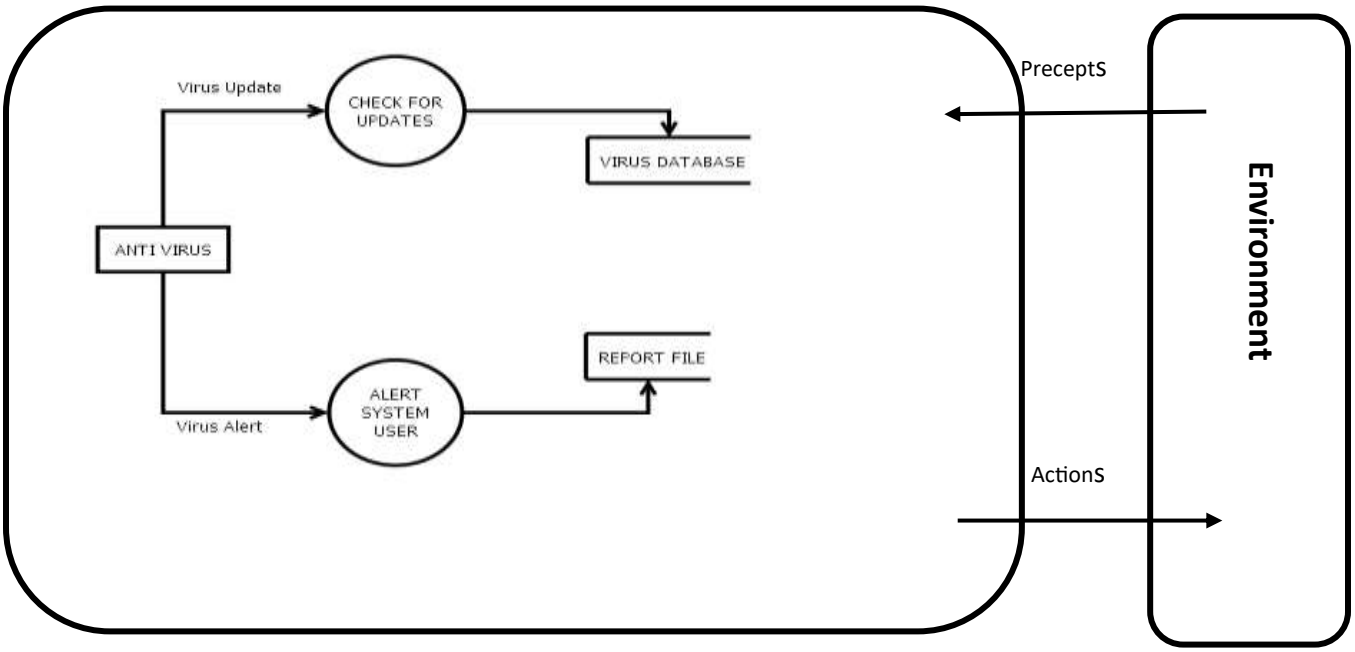

Figure 1 Organization of the new system

High Level Model of the New System

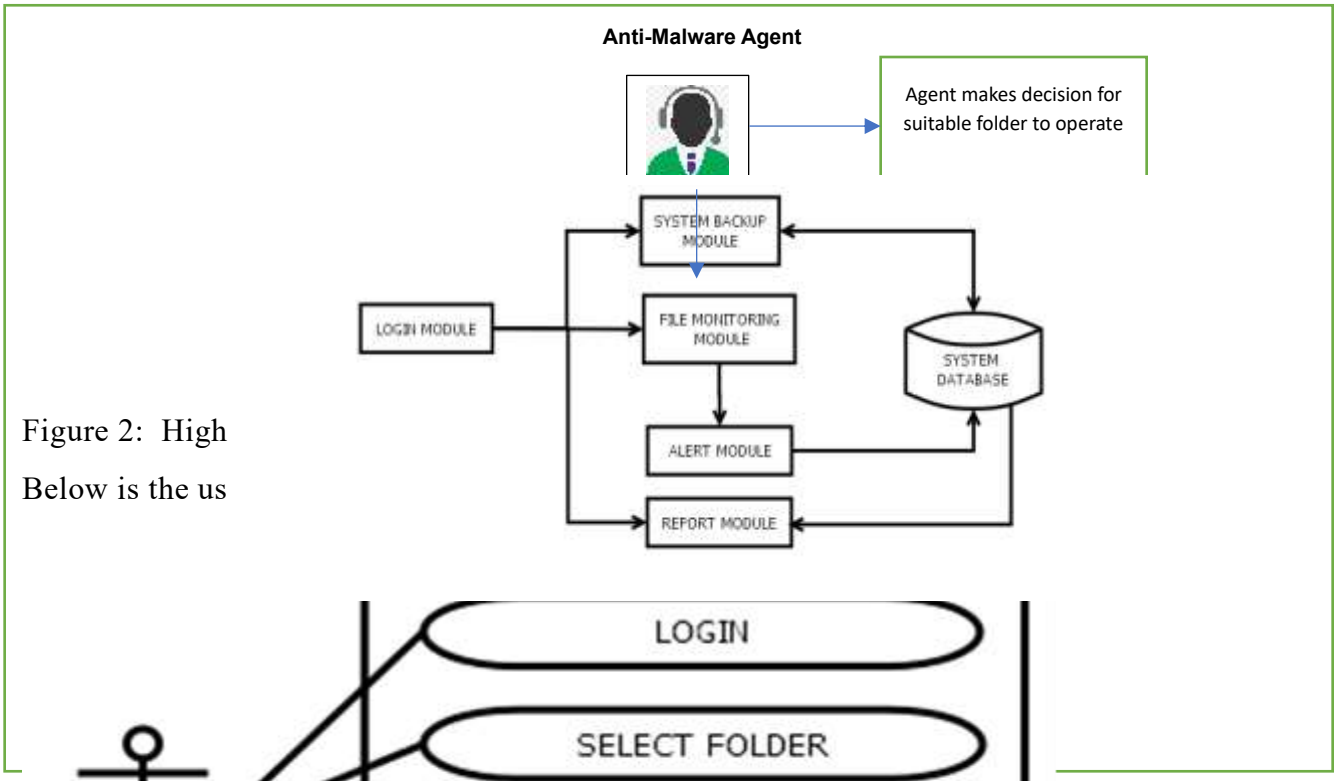

Figure 2: High

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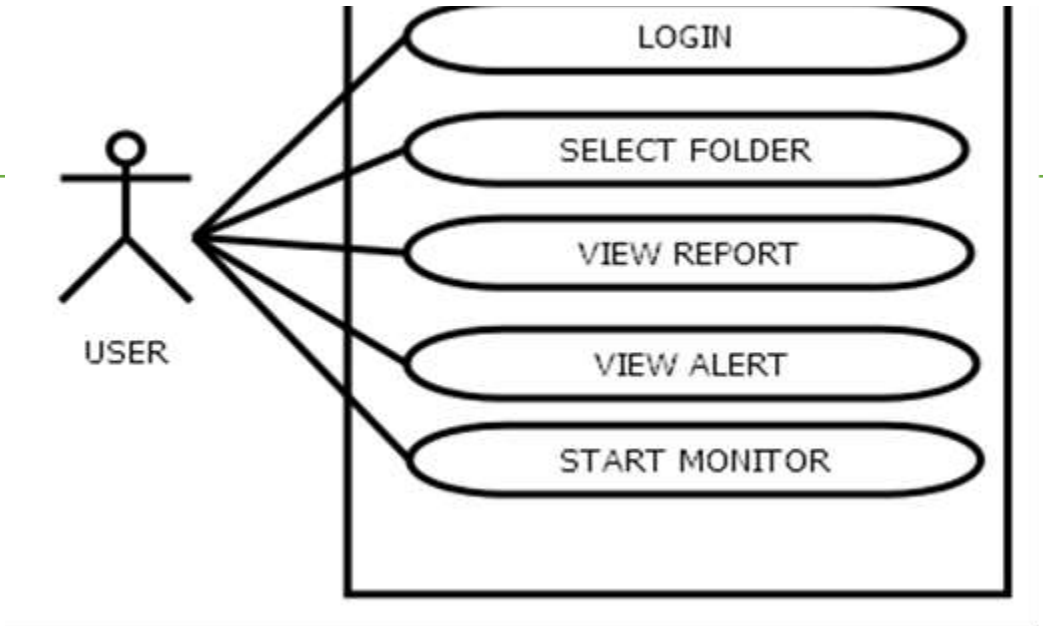

Figure 3: Use Case Diagram

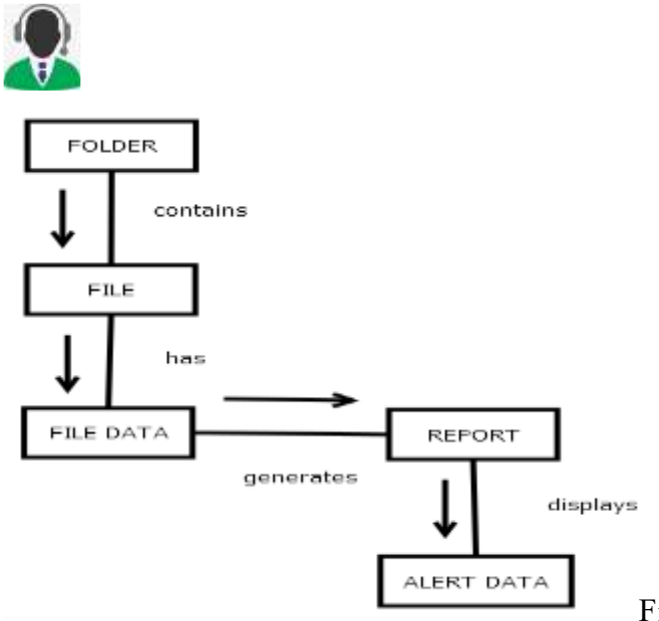

Figure 4: Interaction Diagram

System Operation Flowchart:-

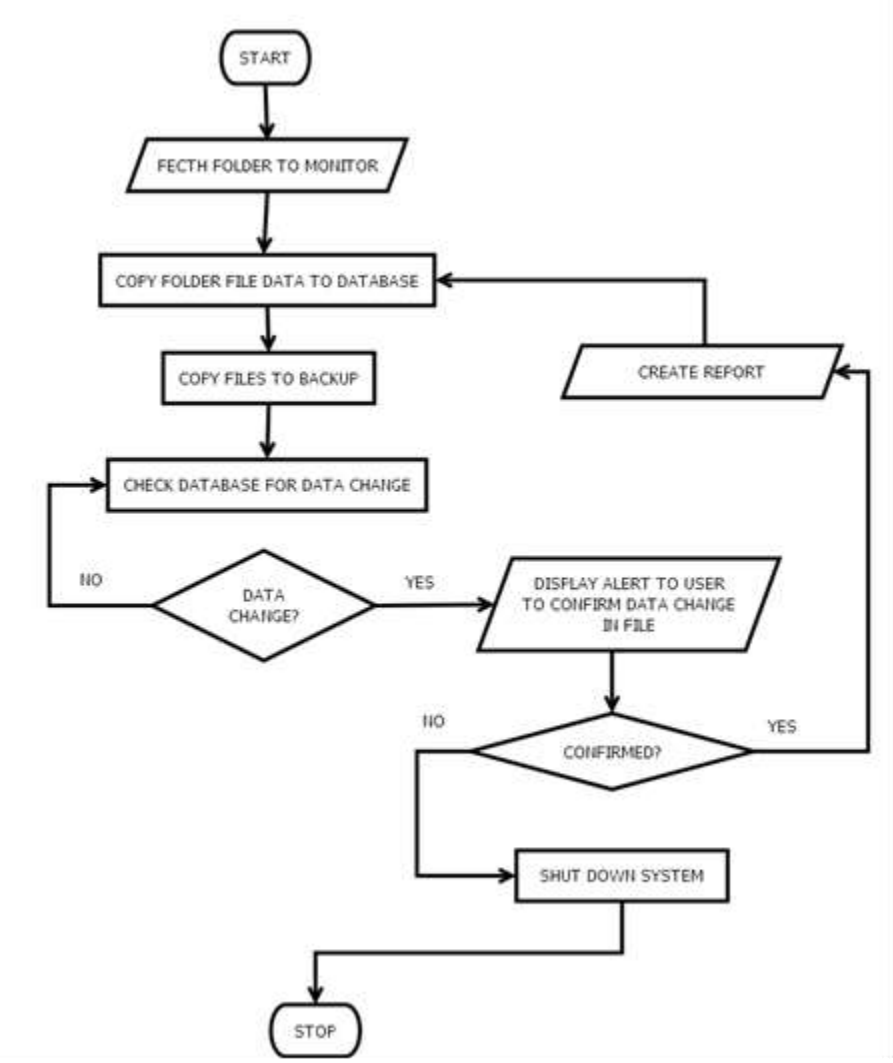

Figure 5: Systems Flowchart

User structure:

S/NO	FIELD NAME	DESCRIPTION	FIELD SIZE	DATA TYPE
1.	ID	Unique identification number	30	Number
2.	Username	Username for accessing the system	50	Text
3.	Password	Password for accessing the system	50	Text

Folder file: This database table will contain the information about the folders to the monitored

Table 2: Driver table structure:

S/NO	FIELD NAME	DESCRIPTION	FIELD SIZE	DATA TYPE
1.	ID	Unique identification number	30	Integer
2.	Name	Name of the folder	10	Text

Files table: This database table will contain the information about the files being monitored by the system.

Table 3: Files table structure:

S/NO	FIELD NAME	DESCRIPTION	FIELD SIZE	DATA TYPE
1.	ID	Unique identification number	30	Number
2.	Filename	Name of file	10	Text
3.	Filesize	Size of file	30	Text
4.	FileCreate	Date file was created	30	Text

5.	FileModified	Date File was modified	30	Text
6.	FileAccesses	Date File was accesses	30	Text

Report table: This database table will contain the information about the reports generated by the system.

Table 4: Report table structure:

S/NO	FIELD NAME	DESCRIPTION	FIELD SIZE	DATA TYPE
1.	ID	Unique identification number	30	Number
2.	Content	Content of the report	10	Text
3.	Date	Date of the report	30	Text
4.	Action Taken	Action taken for the record	30	Text

Actual Test Results versus Expected Test Results

Testing involved deploying the model in a controlled environment with simulated ransomware attacks.

- **Expected Results**: Early detection, minimal false positives, and effective isolation.
- **Actual Results**: The system achieved a 95% detection rate, 3% false positives, and successfully neutralized all test attacks within seconds.

Results and Discussion

The proposed system outperformed traditional solutions in terms of detection speed and accuracy. Its adaptive learning capability ensures resilience against new ransomware variants. Challenges include optimizing performance for low-resource environments and reducing false positives further.

Conclusion

This research demonstrates that intelligent agent-based antimalware models provide effective protection against ransomware. By combining behavioral analysis and machine learning, the

system ensures proactive threat management. Future work will focus on enhancing scalability and integrating with broader cybersecurity frameworks.

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