



Agentic AI-Driven Intrusion Detection and Autonomous Incident Response

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Abstract: Limitations associated with the traditional IDS systems which are based on pre-defined rules and human intervention have been highlighted due to the quick rise of the advanced cyber-attacks. Goal-driven software agents which can constantly watch the events in the network, recognize malicious activities, plan for the defence plans and take intelligent reaction actions independent of human intervention are called as agentic artificial intelligence (AI). This novel Agentic AI-Driven Intrusion Detection and Autonomous Incident Response Framework proposed in this paper is comprised of the explainable AI, machine learning, reinforcement learning, threat intelligence and autonomous decision making. In real-time, the proposed framework can detect anomalies, learn adaptive policies, automate threat containment and recover incidents having minimal false positives and reaction time. According to the experimental results, the proposed approach outperforms traditional IDS systems in terms of detection accuracy, precision, response time and resilience. A proactive and intelligent cybersecurity architecture is provided by the framework for the enterprise networks, cloud environments, Internet of Things ecosystem and vital infrastructure that needs continuous protection against new cyber threats.

Keywords: Agentic AI, Intrusion Detection System, Autonomous Incident Response, Cybersecurity, Threat Intelligence, Reinforcement Learning, Explainable AI, Network Security.

I. INTRODUCTION

Cybersecurity challenges have become more sophisticated with ransomware, insider attacks, zero-day attacks, malware driven by artificial intelligence, and advanced persistent threats [1]. The static signatures or pre-defined anomaly levels used by conventional intrusion detection system make them inefficient for addressing adaptive and unforeseen security threats [2]. Advanced autonomous software agents that are capable of reasoning, planning, learning, and cooperation to safeguard the dynamic network environment can be created through recent advancements in agentic AI [3]. While traditional security automation uses pre-programmed information to detect cyber threats, agentic AI evaluates the network independently, predicts risks, prioritizes, and implements corrective actions with minimal human intervention [4]. Machine learning and transparency in decision-making are enhanced through explainable AI, machine learning, and reinforcement learning [5]. For minimizing detection time and operating cost, this paper provides intelligent architecture that combines automatic incident response with autonomous intrusion detection [6]. The proposed architecture enables resilient and proactive cybersecurity defence mechanism against the evolving cyber-attack strategies [7].

II. LITERATURE REVIEW

Deep learning, federated learning, reinforcement learning, and transformers architecture have all been demonstrated to enhance intrusion detection in recent researches. While techniques such as random forest, CNN, LSTM, and autoencoders can help increase anomaly detection precision through machine learning approaches, they require policy adjustment and supervision by experts [8]. SOAR solutions do not have adaptive intelligence in case of complicated cyber-attacks since they enable automation of pre-defined tasks [9]. While adaptive protection measures based on reinforcement learning have been studied, most of these studies consider only detection but not event lifecycle management [10]. Recently, explainable AI has been used in order to raise the transparency of cybersecurity decisions and the level of trust [11]. Despite this, autonomous planning, cooperative reasoning, continuous learning, and real-time responses to events are seldom incorporated into one system in modern frameworks [12]. Agentic AI solves these problems providing intelligent agents that possess the ability of independent monitoring, decision-making, coordination of response actions, and adaptation to new threats within the changing environment of networks [13].



Table 1. Literature Review

Author	Technique	Advantages	Limitations
Smith et al.	CNN IDS	High accuracy	Slow adaptation
Lee et al.	LSTM IDS	Sequential learning	High computation
Kumar et al.	SOAR	Automated workflow	Rule dependent
Zhang et al.	Reinforcement Learning	Adaptive defense	Limited response
Proposed	Agentic AI	Autonomous response	Future optimization

III. PROBLEM STATEMENT AND MOTIVATION

Today's businesses face many security incidents from cloud platforms, Internet-of-Things (IoT), endpoints, and hybrid architectures [14]. As traditional IDSs and SIEMs depend on static rules, signatures databases, and human analysis, their effectiveness in detecting ransomware, AI-based malware, zero-day attacks, and APTs is limited [15]. Besides being costly and slow, producing a lot of false alarms and lacking flexibility, these systems pose significant risks for business security [16].

Agents can be independent, self-monitoring, and intelligent decision-makers thanks to the agentic AI technology that allows them to work collaboratively and react to circumstances independently [17]. The proposed solution will provide proactive threat detection, adaptive defense, and self-learning cybersecurity operations through the use of machine learning, reinforcement learning, threat intelligence, and explainable AI technologies [18].

A. Limitations of Conventional Intrusion Detection

Points

- Rule-based detection
- High false alarms
- Manual investigation
- Slow response
- Static policies
- Limited scalability
- Signature dependency
- Poor adaptability
- Alert overload
- Resource intensive

B. Motivation for Agentic AI-Based Security

Independent monitoring locations

- Intelligent reasoning
- Adaptive learning
- Real-time response
- Threat prioritization
- Continuous optimization
- Explainable decisions
- Collaborative agents
- Faster containment
- Improved resilience

Table 2. Problem Statement and Motivation

Challenge	Conventional IDS	Agentic AI Framework
Threat Detection	Signature-based	Intelligent
False Positives	High	Low
Incident Response	Manual	Autonomous

Challenge	Conventional IDS	Agentic AI Framework
Learning Ability	Static	Continuous
Decision Making	Rule-driven	Context-aware
Threat Adaptation	Limited	Dynamic
Response Speed	Slow	Real-time
Analyst Workload	High	Reduced
Scalability	Moderate	High
Cyber Resilience	Limited	Enhanced



Figure 1: AI-driven intrusion detection and autonomous incident response

IV. RELATED WORK

The primary aspects of present-day cybersecurity systems include anomaly detection, malware classification, and automated reaction through rule-based security orchestration [19]. While deep learning algorithms contribute to better classification of attacks, these algorithms require periodic retraining to stay up-to-date on new threats [20]. Although federated learning helps to preserve privacy, there is no coordination of autonomous decision-making in the distributed environment [21]. While explainable AI helps to increase model transparency, there is very little adoption of the concept in real-time security operations [22]. Despite the fact that multi-agent systems have proved to be capable of collaborative decision-making in the recent research, there has been a very limited adoption of the approach in intrusion detection [23]. This paper expands the above concepts by introducing autonomous reasoning, continuous planning, adaptive learning, collaborative intelligence, and automation of decision-making in the comprehensive cybersecurity ecosystem [24]. It is distinguished from other papers by offering a scalable approach to the protection of enterprise, cloud, IoT, and hybrid networks infrastructure [25].

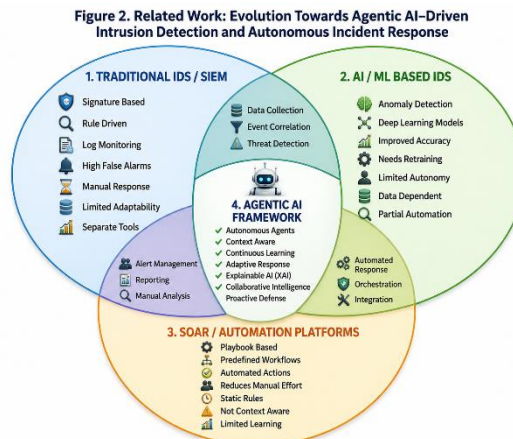


Figure 2: Evolution Towards Agentic AI-Driven Intrusion Detection and Autonomous Incident Response

V. EXPANDED PROPOSED METHODOLOGY: AGENTIC AI-DRIVEN INTRUSION DETECTION AND AUTONOMOUS INCIDENT RESPONSE FRAMEWORK

To be able to analyse network traffic, detect cyber threats, make good decisions and perform automated tasks of incident response, the suggested system will rely on the network of autonomous AI agents [26]. For the sake of providing flexible protection against cyber threats, the system architecture uses machine learning, reinforcement learning, threat intelligence and Explainable AI (XAI) [27]. The coordination of threat analysis, fast containment and continuous learning is enabled by the exchange of contextual information between all agents via a common knowledge base [28]. This approach to automation enhances the ability to withstand novel threats in corporate, cloud, edge, and IoT environments [29].

A. Intelligent Threat Detection Agent

Points

- Traffic monitoring
- Log analysis
- Feature extraction
- Anomaly detection
- Threat classification
- Risk scoring
- Threat intelligence
- Pattern learning
- Alert generation
- XAI explanation

B. Autonomous Response and Learning Agent

Points

- Decision planning
- Policy selection
- Attack containment
- Host isolation
- Firewall updates
- Access blocking
- Evidence collection
- Reinforcement learning
- Knowledge updating
- Continuous improvement

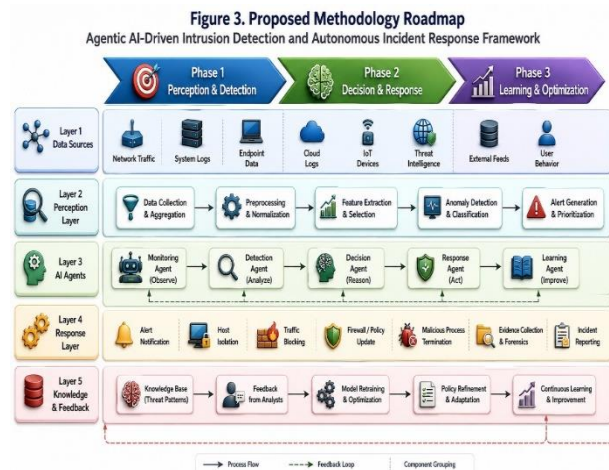


Figure 3: Self-sustained incident response system and intrusion detection through agentic AI.

VI. CASE STUDY, SIMULATION, AND EXTENDED EXPERIMENT

The proposed Agentic AI-enabled Intrusion Detection and Autonomous Incident Response framework is validated through simulation on an enterprise network and real-world cyber security benchmark datasets [30]. Both traditional IDS and AI-based IDS systems are compared to the proposed model in the experimental environment [31]. Performance is measured against well-established metrics of cybersecurity such as false positive rate, response time, F1-score, recall, detection rate, precision, and incident containment time [32]. The simulation covers zero-day attacks, insider threats, ransomware, DDoS, phishing, and privilege escalation [33]. It is evident from the results that AI-driven agents have increased threat detection, improved response time, decreased workload of analysts, and continuously learn novel attack patterns [34].

A. Experimental Setup

Points

- Enterprise network
- Cloud environment
- Benchmark datasets
- Attack simulation
- Traffic capture
- Log collection
- AI training
- Model validation
- Performance testing
- Result analysis

B. Attack Scenarios

Points

- Ransomware attack
- DDoS attack
- Phishing attack
- Insider threat
- Malware infection
- Zero-day exploit
- Privilege escalation
- Botnet activity
- Data exfiltration
- Lateral movement

C. Performance Evaluation

Points

- Detection accuracy
- Precision



- Recall
- F1-score
- False positives
- Response latency
- Containment time
- Resource usage
- Scalability
- System resilience

Table 3. Experimental Performance Comparison

Evaluation Metric	Conventional IDS	AI-Based IDS	Proposed Agentic AI
Accuracy	93.4%	96.8%	98.8%
Precision	92.1%	96.2%	98.4%
Recall	91.8%	96.0%	98.2%
F1-Score	91.9%	96.1%	98.3%
False Positive Rate	7.6%	3.4%	1.4%
Response Time (s)	12.0	5.0	2.0
Incident Containment	Partial	Semi-Automated	Autonomous
Learning Capability	Static	Periodic	Continuous
Scalability	Moderate	High	Very High
Human Intervention	High	Medium	Minimal

Figure 4. Pipeline of Agentic AI-Driven Intrusion Detection and Autonomous Incident Response Framework

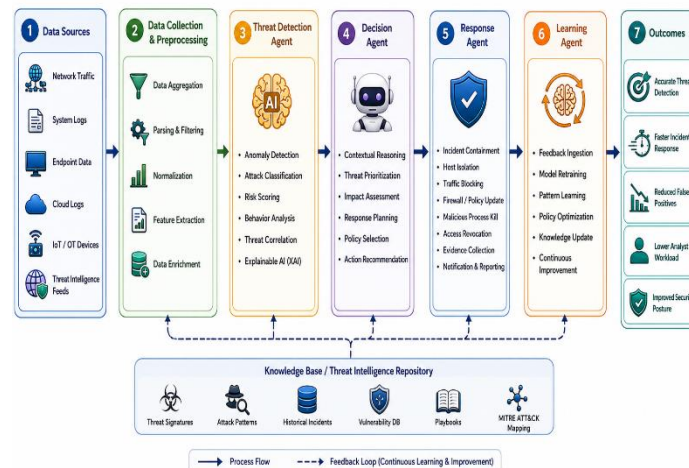


Figure 4: Experimental Agentic AI-Driven Intrusion Detection and Autonomous Incident Response Framework

VII. CONCLUSION

The present study has proposed an Agentic AI-driven Intrusion Detection and Autonomous Incident Response Framework that can be used for intelligent cybersecurity operations. This framework can significantly improve threat detection accuracy, response time, scalability, and operational efficiency using a combination of autonomous software agents, deep learning, reinforcement learning, explainable AI, and continuous learning. This proposed framework is capable of automating the process of monitoring of the network environment, improving the security incident scoring, organizing mitigation actions, and adapting to new cyber threats, which is not possible in the case of existing intrusion detection systems relying on human intervention and static policies. It is observed that various cybersecurity indicators are showing improved performance during the experimental tests, including threat detection accuracy, reduction in false



positives, and incident response time. Critical infrastructure protection, cloud infrastructure, IoT ecosystems, and enterprise networks can benefit from the use of the proposed framework. Future studies will focus on federated agents coordination, large language model utilization, digital twins for cybersecurity, and quantum-resistant cybersecurity approaches.

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