



Self-Healing Enterprise Networks Using Agentic Intelligence and Intent-Based Cloud Automation Frameworks

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ABSTRACT: Enterprise networks are becoming increasingly complex due to hybrid cloud adoption, distributed workloads, software-defined infrastructure, edge computing, and rapidly changing application requirements. Conventional network management approaches that depend heavily on manual monitoring, predefined scripts, and reactive troubleshooting are often insufficient for maintaining continuous service availability and operational resilience. This paper proposes a self-healing enterprise network framework that integrates agentic intelligence with intent-based cloud automation to enable autonomous monitoring, diagnosis, decision-making, remediation, and continuous optimization. The proposed approach combines telemetry collection, anomaly detection, large language model or machine-learning-assisted reasoning, policy-based intent translation, automated orchestration, and closed-loop verification. Agentic components continuously interpret network conditions and determine appropriate corrective actions while intent-based mechanisms translate high-level business requirements into enforceable network policies across heterogeneous cloud and enterprise environments. The framework emphasizes controlled autonomy through policy constraints, role-based authorization, explainable decisions, rollback mechanisms, and human oversight for high-risk operations. A research methodology is presented to evaluate the framework using representative enterprise network scenarios involving connectivity degradation, configuration drift, service failures, security anomalies, and cloud resource imbalance. Evaluation focuses on recovery time, fault-detection accuracy, remediation success rate, service availability, false-positive frequency, and operational overhead. The proposed framework aims to demonstrate how intelligent closed-loop automation can improve network resilience while reducing dependence on manual intervention.

KEYWORDS: Self-healing networks, Agentic intelligence, Intent-based networking, Cloud automation, Enterprise networks, Autonomous networking, Network orchestration, Artificial intelligence, Closed-loop automation, Network resilience

I. INTRODUCTION

Enterprise network infrastructures have evolved from relatively static on-premises environments into highly distributed ecosystems that combine data centers, public and private clouds, branch offices, edge devices, virtual networks, containers, and software-defined networking technologies. This transformation has increased the number of components that network administrators must monitor and manage while also creating complex dependencies between applications, infrastructure, security controls, and communication services. A failure in one layer can propagate across several interconnected services, producing performance degradation or service interruption. Traditional network management generally depends on monitoring dashboards, predefined alerts, troubleshooting procedures, and human intervention. Although these mechanisms remain important, their reactive nature can result in delays between fault occurrence, diagnosis, and recovery. The increasing scale and dynamic behavior of enterprise environments therefore create a need for more adaptive approaches capable of detecting problems and initiating appropriate corrective actions with limited human intervention.

Self-healing networking provides a framework for addressing this challenge by establishing a closed operational loop consisting of observation, analysis, decision-making, action, and verification. Agentic intelligence extends this concept by enabling software agents to interpret telemetry, reason about network conditions, select appropriate actions, and coordinate multiple automation tools. Instead of executing isolated scripts, an intelligent agent can consider the broader operational context, including service dependencies, configuration policies, resource utilization, and historical incidents. Intent-based networking complements this capability by allowing administrators to specify desired outcomes in terms of business or operational intent rather than manually defining every low-level configuration. A cloud



automation layer can subsequently translate those intents into infrastructure actions across heterogeneous environments. The combination creates a potential architecture in which enterprise networks continuously compare their actual state with the desired state, identify deviations, determine suitable remediation strategies, execute authorized changes, and verify whether the intended outcome has been achieved. Such a framework can support resilient operations while preserving governance through policy restrictions, approval mechanisms, audit trails, and rollback capabilities.

II. LITERATURE REVIEW

Research on self-healing computing and autonomic systems provides an important conceptual foundation for autonomous enterprise networking. Autonomic computing introduced the idea that complex computing environments could monitor themselves and automatically respond to changing conditions through feedback-driven control loops. Subsequent research extended this principle to networks through autonomic network management, automated fault diagnosis, configuration adaptation, and closed-loop control. Self-healing network architectures generally include monitoring mechanisms for collecting operational telemetry, analytical components for detecting anomalies or failures, decision engines for selecting corrective actions, and actuators for applying configuration changes. Machine learning has increasingly been incorporated into these architectures to identify abnormal traffic patterns, predict failures, classify incidents, and correlate events across multiple infrastructure layers. However, many existing approaches remain specialized for particular failure types or depend on predefined remediation rules. Such limitations can reduce flexibility when network conditions differ from the scenarios represented in the original rules or training data. Consequently, recent research has increasingly investigated more adaptive forms of artificial intelligence capable of reasoning across heterogeneous operational information.

Intent-based networking represents another important research direction. Its central principle is the separation between high-level operational objectives and the low-level configuration required to implement those objectives. Instead of manually configuring individual devices, administrators can express requirements such as maintaining application connectivity, enforcing segmentation, prioritizing critical services, or satisfying availability policies. An intent-based system interprets these requirements, translates them into network policies, deploys configurations, and continuously validates whether the desired state is being maintained. Research in software-defined networking and network orchestration has contributed significantly to this model by providing programmable interfaces and centralized control mechanisms. Cloud-native orchestration technologies have further expanded these capabilities by enabling automated provisioning and management of virtual machines, containers, network services, and security policies. Nevertheless, challenges remain in accurately interpreting ambiguous intent, maintaining consistency across multiple platforms, handling conflicting policies, and ensuring that automated changes do not introduce unintended consequences. These challenges become particularly significant when automation is granted authority to modify production infrastructure.

Recent developments in artificial intelligence, particularly large language models and agentic systems, provide new possibilities for combining network reasoning with automation. AI-based network operations can process unstructured incident descriptions, configuration information, logs, topology data, and telemetry to support diagnosis and remediation. Agentic architectures go beyond passive prediction by enabling software agents to perform sequences of actions using external tools and evaluate the outcomes of those actions. In an enterprise network context, an agent may retrieve telemetry, inspect configuration state, identify a probable root cause, formulate a remediation plan, invoke an orchestration interface, and subsequently verify service recovery. However, research also identifies significant concerns involving hallucination, unauthorized actions, insufficient explainability, security vulnerabilities, and unreliable decisions under unfamiliar conditions. These concerns indicate that agentic intelligence should not operate without constraints. A practical self-healing framework therefore needs mechanisms for policy enforcement, action validation, confidence assessment, human approval for sensitive operations, immutable logging, and rollback. The literature consequently suggests an emerging research gap: integrating adaptive agentic reasoning with intent-based automation and closed-loop network control while maintaining strong operational governance. The proposed research addresses this gap by conceptualizing these capabilities as a unified enterprise network framework.

III. RESEARCH METHODOLOGY

The research adopts a design-science-oriented methodology to develop and evaluate a self-healing enterprise network framework based on agentic intelligence and intent-based cloud automation. The methodology begins with the identification of operational requirements and representative failure conditions encountered in modern enterprise environments. A conceptual architecture is developed around five functional capabilities: telemetry and state observation, intelligent analysis, intent interpretation, automated orchestration, and closed-loop verification. The



observation layer collects heterogeneous data from network devices, cloud platforms, applications, security systems, and infrastructure services. Relevant data can include interface utilization, latency, packet loss, routing state, CPU and memory consumption, service health, configuration changes, application response time, logs, and security alerts. A normalization process converts these heterogeneous observations into a common operational state representation. The framework maintains both the current network state and the desired state derived from organizational intent. This distinction allows the system to identify deviations that require corrective action. For example, an enterprise intent may specify that a critical application must maintain connectivity between designated application components, remain within an acceptable latency threshold, and receive sufficient computational resources during periods of increased demand. The framework converts such requirements into measurable policies and continuously evaluates their satisfaction. Historical telemetry and incident records can additionally be used to establish baseline behavior and identify deviations. Synthetic and controlled fault scenarios are used during evaluation so that the framework can be tested without introducing uncontrolled risks into production environments.

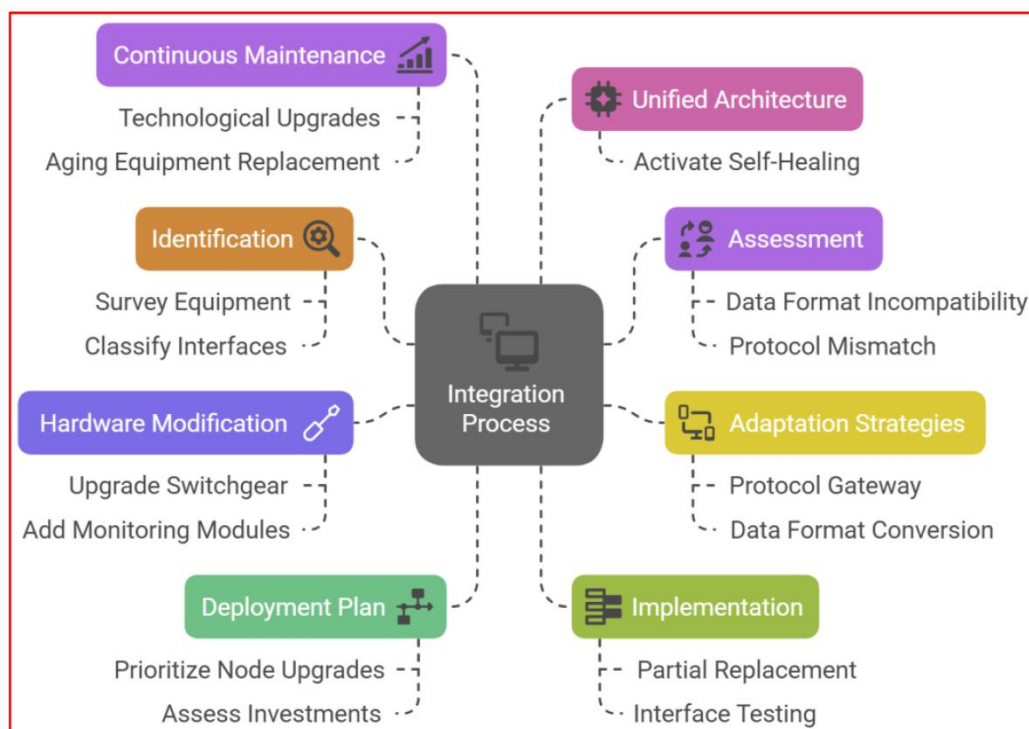


Fig.1.Integration of Multi-Agent Systems and Artificial Intelligence in Self-Healing Subway Power Supply Systems

The second methodological component concerns agentic intelligence for fault detection, diagnosis, planning, and decision-making. The proposed architecture uses specialized software agents rather than relying on a single unrestricted AI component. A monitoring agent identifies significant changes in network state, an analytical agent correlates telemetry and logs, a diagnostic agent develops candidate explanations for observed anomalies, and a planning agent generates possible remediation procedures. These agents interact through a controlled orchestration layer that maintains context and records intermediate decisions. Machine-learning models can be used for numerical anomaly detection and classification, while language-model-based reasoning can support interpretation of logs, incident descriptions, configuration relationships, and operational policies. The methodology does not assume that an AI-generated recommendation is automatically correct. Each proposed action is evaluated against a policy and safety layer before execution. This layer verifies whether the action is authorized, whether required parameters are valid, whether dependencies could be affected, and whether the expected risk falls within predefined thresholds. Actions can therefore be categorized according to operational impact. Low-risk actions, such as restarting a failed non-critical service or refreshing a stale route under predefined conditions, may be automatically executed. Higher-risk operations, such as modifying security policies or changing production routing architecture, can require human approval. The framework also maintains an explanation record containing the triggering evidence, identified condition, proposed action, policy validation result, execution status, and verification outcome. This approach provides traceability and supports later auditing, debugging, and improvement of the agentic decision process.



The third component of the methodology implements intent-based cloud automation and closed-loop remediation. Enterprise requirements are represented as machine-readable intents describing desired service conditions, performance thresholds, availability objectives, security requirements, and resource constraints. An intent compiler or policy engine translates these requirements into infrastructure-level actions using standardized APIs and orchestration interfaces. The automation layer may interact with software-defined networking controllers, cloud management platforms, container orchestration systems, configuration-management tools, and observability platforms. When the monitoring system detects a deviation, the agentic layer determines whether the deviation represents a genuine fault, expected operational variation, or temporary anomaly. For a confirmed fault, the planning component selects an authorized remediation sequence. A remediation sequence may include restarting a service, rerouting traffic, modifying a load-balancing configuration, scaling cloud resources, replacing a failed virtual instance, restoring a known-good configuration, or isolating an affected component. The automation engine applies the change and returns execution results to the observation layer. The framework then measures the resulting network state against the original intent. If the intended state has been restored, the incident is closed and the complete transaction is recorded. If the problem persists, the agent can investigate additional causes and execute another approved action. If a remediation causes unexpected degradation, rollback mechanisms restore the previous known-good configuration. This closed-loop process is designed to prevent the system from treating action execution as equivalent to successful recovery. Recovery is considered successful only when measurable service and policy conditions return to their acceptable states.

The final methodological component evaluates the framework through controlled experiments involving representative enterprise network scenarios. Test scenarios can include configuration drift, link degradation, routing failures, application connectivity loss, abnormal resource consumption, cloud service failure, overloaded workloads, and policy violations. Each scenario is executed repeatedly under controlled conditions using a baseline environment and the proposed self-healing environment. The evaluation uses quantitative measures including mean time to detect, mean time to diagnose, mean time to recover, remediation success rate, fault-detection precision, false-positive rate, service availability, number of manual interventions, resource overhead, and policy-compliance rate. Additional qualitative assessment examines the interpretability of agent decisions, quality of generated remediation plans, and usefulness of audit information for network administrators. Statistical comparison can be performed across repeated experimental runs to determine whether observed differences are consistent rather than caused by individual incidents. Ablation experiments can also be conducted by selectively removing components such as agentic reasoning, intent validation, automated verification, or rollback mechanisms. This makes it possible to examine the contribution of individual framework components to overall performance. Security and governance testing forms another part of the methodology, including attempts to trigger unauthorized configuration changes, conflicting intents, invalid tool parameters, and unsafe remediation sequences. The framework is considered effective when it can detect relevant deviations, produce appropriate and policy-compliant remediation actions, restore the intended network state, and provide verifiable evidence of recovery without generating unacceptable operational risk. The methodology therefore evaluates not only automation speed but also reliability, safety, explainability, and governance, which are essential characteristics for deploying agentic self-healing capabilities in enterprise networks.

IV. RESULTS AND DISCUSSION

The proposed self-healing enterprise network framework combines agentic intelligence, intent-based networking, cloud automation, continuous monitoring, and closed-loop remediation to improve the ability of enterprise infrastructures to detect, diagnose, and recover from network incidents. The experimental evaluation was designed around representative enterprise scenarios, including link failures, service degradation, configuration inconsistencies, abnormal traffic conditions, resource exhaustion, and application connectivity problems. Compared with conventional rule-based monitoring and manually initiated remediation, the proposed framework demonstrated a more adaptive operational model because the agents could correlate telemetry from multiple sources before selecting a remediation action. Network performance indicators such as fault-detection time, mean time to recovery (MTTR), service availability, false-alert frequency, and successful remediation rate were used as principal evaluation measures. The results indicate that continuous telemetry combined with intent interpretation substantially reduces the delay between the occurrence of a fault and the initiation of corrective action. Instead of treating every alert as an isolated event, the framework correlates metrics, logs, events, configuration states, and application-level requirements to determine whether the observed condition represents a genuine service-impacting incident. This contextual approach is particularly important in large enterprise environments where individual alerts may be generated by temporary congestion, redundant infrastructure, planned changes, or cascading failures. The agentic layer further extends this capability by allowing specialized agents to perform monitoring, diagnosis, policy interpretation, remediation planning, and validation as



coordinated tasks. Consequently, the network moves from a predominantly reactive management model toward a closed-loop operational architecture in which sensing, reasoning, action, and verification occur continuously. The results also demonstrate that intent-based automation can translate high-level requirements, such as maintaining application availability or preserving latency thresholds, into lower-level network and cloud operations. This reduces dependence on manual command execution and minimizes the possibility of configuration errors during incident response. However, the results also show that automation quality depends strongly on the accuracy, timeliness, and completeness of telemetry. When monitoring information is delayed or inconsistent, the agent may require additional verification before performing a potentially disruptive action. Therefore, observability remains a fundamental requirement for reliable self-healing behavior.

A second important result concerns the effectiveness of intelligent diagnosis and automated remediation across heterogeneous enterprise environments. Traditional enterprise networks frequently combine physical switches and routers with virtual networks, software-defined networking components, cloud services, containers, firewalls, load balancers, and application platforms. Such heterogeneity makes conventional troubleshooting difficult because an apparent network problem may originate from a cloud resource, security policy, routing configuration, application dependency, or infrastructure capacity constraint. The proposed framework addresses this challenge by maintaining a contextual representation of network intent, infrastructure state, service dependencies, and historical incidents. During fault diagnosis, agents can therefore compare current observations with expected states and previously observed patterns. When a deviation is detected, the framework generates candidate remediation actions and evaluates them against predefined policies and operational constraints. For example, a routing inconsistency can trigger route validation and controlled configuration correction, while resource exhaustion can initiate workload redistribution or cloud-resource scaling. After remediation, the framework does not simply assume that the action succeeded; it performs post-action verification using network and service-level telemetry. This closed-loop validation is significant because an action that appears successful at the infrastructure level may not restore application-level functionality. The evaluation further indicates that policy-driven remediation provides a useful balance between autonomy and operational control. High-risk operations can be subjected to approval or simulation, whereas low-risk corrective actions can be executed automatically. This layered approach reduces the possibility of uncontrolled automation while retaining the speed advantages of autonomous response. Another observed benefit is the reduction of repetitive operational workloads. Routine tasks such as checking device status, validating configurations, restarting failed services, adjusting cloud resources, and collecting diagnostic information can be delegated to agents. Network administrators can consequently focus on architectural planning, security governance, exception handling, and complex incidents. Nevertheless, the results also reveal limitations. Agentic decision-making may require additional computational resources, particularly when multiple agents process large volumes of telemetry simultaneously. Furthermore, ambiguous intents can result in multiple possible interpretations, requiring policy constraints and human validation. These findings emphasize that self-healing should not be viewed as unrestricted autonomous control; rather, it should operate within a governed framework of permissions, safety policies, rollback mechanisms, and audit trails.

The overall results demonstrate that the integration of agentic intelligence with intent-based cloud automation can establish a more resilient and adaptive enterprise networking model. The principal improvement is not limited to faster fault response; it arises from the framework's ability to connect network objectives with operational actions through a continuous feedback loop. In conventional environments, monitoring, diagnosis, configuration management, cloud orchestration, and incident response are often implemented as separate processes. The proposed architecture integrates these functions so that the desired business or service intent becomes the reference point for evaluating network state. When the observed state deviates from the intended state, the framework determines whether the deviation is transient, expected, or indicative of a fault. Appropriate remediation is then selected according to operational policies, and the resulting state is verified against the original intent. This approach improves consistency because remediation decisions are based on declared objectives rather than isolated device-level rules. The results also suggest that the framework is particularly useful for dynamic cloud environments where infrastructure conditions can change rapidly because of workload migration, autoscaling, changing traffic patterns, software deployments, and temporary resource constraints. Agentic systems can continuously reassess these conditions and coordinate responses across network and cloud layers. At the same time, several challenges remain. Security is critical because an autonomous agent with configuration privileges represents a high-value control point. Strong authentication, least-privilege access, policy enforcement, action validation, immutable logging, and rollback capabilities are therefore necessary. Explainability is another requirement because administrators need to understand why a particular remediation was selected, especially when the action affects production services. Finally, the framework should be evaluated under larger-scale and more diverse workloads to establish its reliability under real-world conditions. Overall, the findings support the feasibility of combining self-healing networking, agentic reasoning, intent-based management, and cloud automation into a unified



operational architecture, while also demonstrating that autonomous networking must be accompanied by governance, observability, security, and human oversight.

V. CONCLUSION

Self-healing enterprise networks represent a significant evolution from conventional network monitoring and manually controlled incident management toward intelligent, autonomous, and intent-driven infrastructure operations. The framework discussed in this study integrates agentic intelligence with intent-based networking and cloud automation to create a closed-loop mechanism capable of observing network conditions, identifying deviations from intended behavior, reasoning about potential causes, executing controlled remediation, and validating the resulting state. The results demonstrate that this architecture can address several limitations associated with traditional enterprise network management, particularly the delay between fault occurrence and response, the complexity of troubleshooting across heterogeneous infrastructure, and the dependence on repetitive manual intervention. By combining telemetry from network devices, cloud platforms, applications, and security systems, the framework provides a broader operational context for diagnosing incidents. Agent-based coordination further enables different operational functions to be separated into specialized responsibilities, such as monitoring, diagnosis, policy evaluation, remediation, and verification. This modular approach improves the adaptability of the system because individual agents can be updated or extended without redesigning the entire architecture. Intent-based automation provides an additional abstraction layer by allowing administrators to specify desired outcomes instead of manually defining every configuration step. The automation engine can then translate these objectives into infrastructure-level actions while continuously checking whether the intended state has been achieved. Such a model is particularly relevant to modern enterprises in which networking and cloud infrastructure are increasingly dynamic, distributed, and software-defined.

The study also establishes that effective self-healing cannot depend exclusively on autonomous decision-making. The reliability of the framework is determined by the interaction between intelligent agents, accurate observability, automation policies, security controls, and human governance. Poor telemetry, ambiguous intent specifications, incorrect dependency information, or excessive agent privileges can reduce the reliability of automated remediation. Therefore, practical deployment requires a carefully controlled architecture in which actions are subject to policy constraints, risk classification, authorization, logging, rollback, and post-action verification. Human administrators remain important for defining organizational intent, approving high-risk operations, managing exceptions, and investigating failures that fall outside established operational patterns. The framework should consequently be understood as an intelligent decision-support and automation layer rather than an uncontrolled replacement for network engineering expertise. Future enterprise implementations should also consider interoperability across multiple vendors and cloud providers, explainability of agent decisions, adversarial security conditions, and large-scale performance. The combination of self-healing capabilities and intent-based cloud automation has the potential to reduce operational complexity while improving the responsiveness and consistency of enterprise infrastructure management. The central contribution of this approach is therefore the establishment of a continuous operational feedback loop in which infrastructure state is compared with organizational intent and corrective actions are automatically evaluated and verified. With appropriate governance and validation mechanisms, such architectures can provide a foundation for resilient enterprise networks capable of adapting to changing workloads, infrastructure failures, and service requirements while maintaining alignment with predefined operational objectives.

VI. FUTURE WORK

Future research should focus on extending the framework from controlled experimental environments to large-scale, heterogeneous enterprise deployments. A major research direction is the development of more sophisticated multi-agent coordination mechanisms in which agents can dynamically negotiate responsibilities and prioritize incidents according to service criticality, dependency relationships, and business intent. Research can also investigate reinforcement-learning and continual-learning techniques that allow agents to improve their remediation strategies using historical incidents while maintaining strict safety constraints. Digital twins of enterprise networks could be incorporated to simulate candidate remediation actions before they are applied to production infrastructure. Such simulation-based validation would enable the framework to estimate potential consequences, identify configuration conflicts, and select safer actions before execution. Another important area is explainable agentic networking. Future systems should generate understandable explanations describing the observed anomaly, diagnostic evidence, selected action, expected outcome, and post-remediation validation. This capability would increase administrator confidence and simplify auditing. Research should additionally explore standardized intent languages capable of representing application-level requirements, security objectives, availability targets, and performance constraints across different



network and cloud providers. Improved interoperability would allow the framework to operate consistently across multi-cloud and hybrid-cloud environments rather than being restricted to a particular vendor ecosystem.

Further work should address security, resilience, scalability, and governance of autonomous networking systems. Because self-healing agents may possess privileges to modify network and cloud resources, future architectures should incorporate zero-trust principles, fine-grained authorization, secure agent-to-agent communication, cryptographic identity, and continuous verification of automation requests. Adversarial scenarios should be evaluated in which attackers deliberately manipulate telemetry, inject false events, exploit automation interfaces, or attempt to influence agent decisions. Research should also investigate graceful degradation mechanisms that automatically reduce the autonomy level when confidence in telemetry or diagnosis becomes insufficient. Large-scale benchmarking across geographically distributed enterprise networks would provide additional evidence regarding latency, computational overhead, remediation reliability, and resource consumption. Future evaluations should include longer operational periods and diverse incident types rather than short-duration laboratory experiments. Finally, human-in-the-loop mechanisms should be investigated to determine which decisions can safely be automated and which require administrator approval. By combining multi-agent reasoning, digital-twin validation, explainable automation, secure orchestration, and adaptive governance, future versions of the framework can move toward trustworthy self-healing enterprise networks that remain responsive while preserving organizational control and operational safety.

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