LFNETWORKING THE LINUX FOUNDATION NEPHIO

# Nephio and GenAI: Revolutionizing Cloud Native Network Automation

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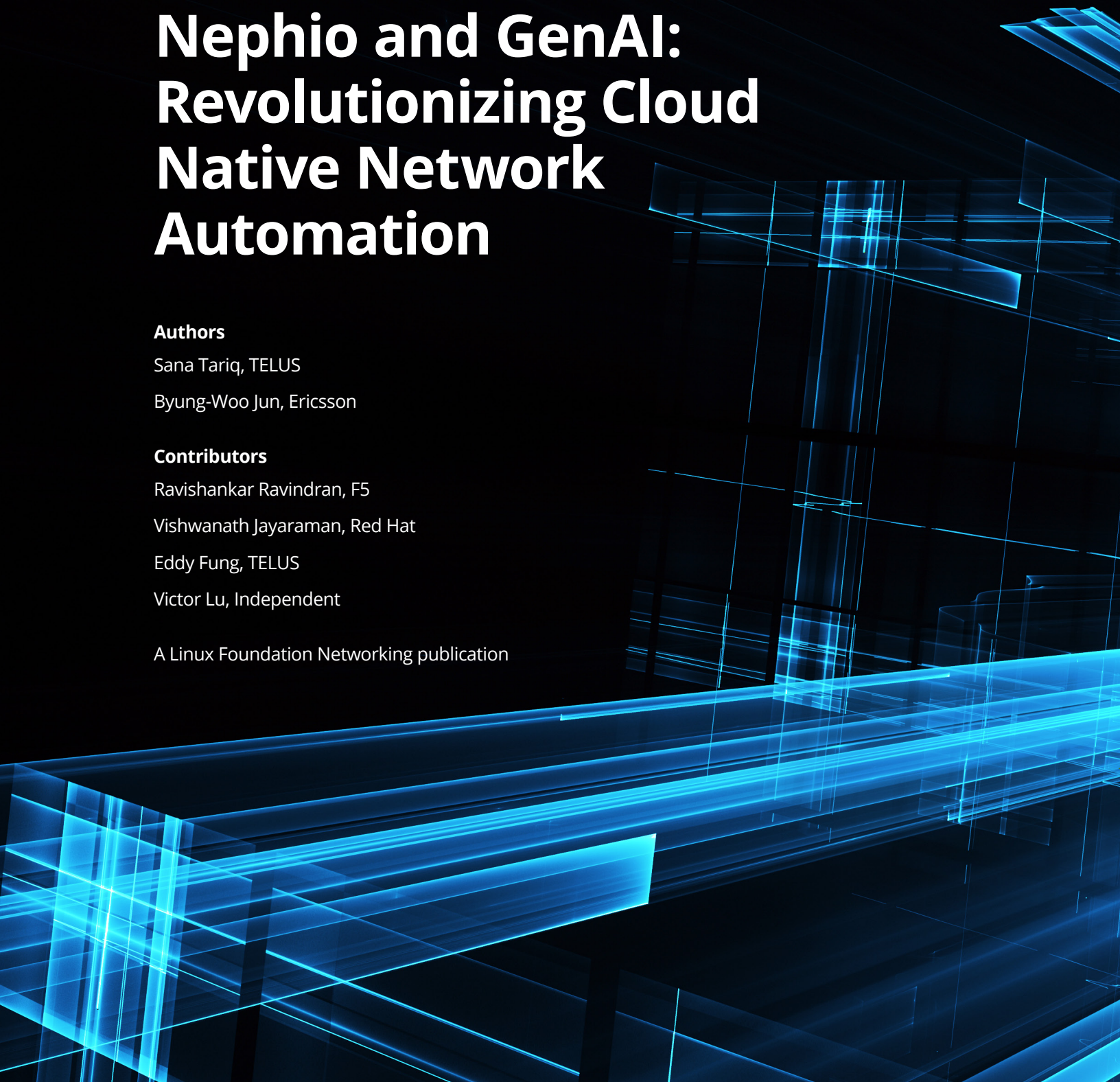

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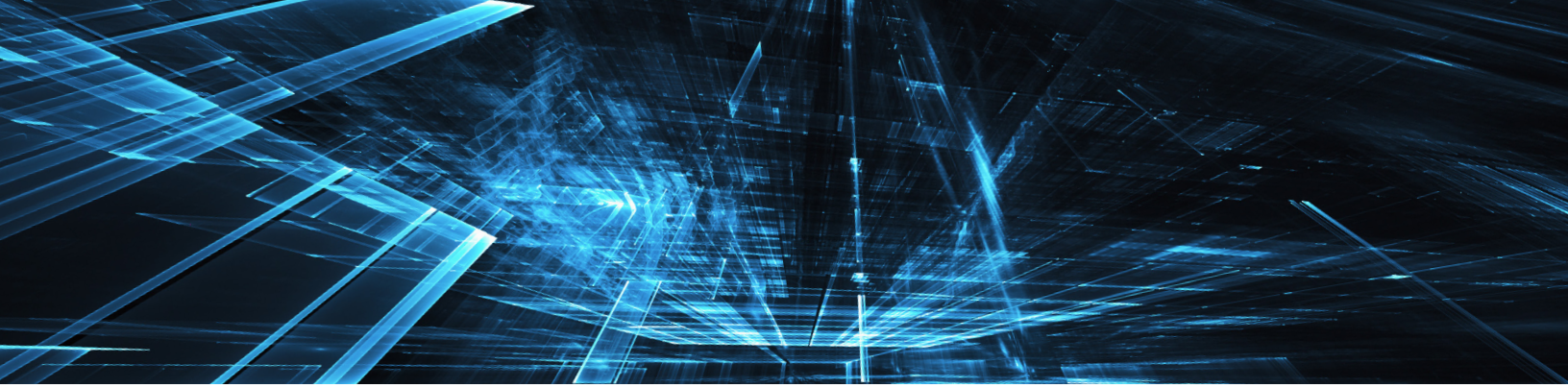


# Executive Summary

This white paper explores the synergies between **Nephio**, an open source project for cloud-native network automation under the **Linux Foundation**'s **LF Networking**, and Generative AI (GenAI). It examines how the integration of these technologies can transform network management, enhance user experience, and improve network efficiency. By leveraging GenAI, Nephio can enable AI-authored configurations, automated troubleshooting, and dynamic performance insights, significantly reducing manual intervention. The paper highlights key applications of GenAI within Nephio's GitOps-driven framework and outlines future possibilities, including intent-driven, closed-loop network management models that can revolutionize the telecom industry.

# Introduction

The telecommunications industry is undergoing a rapid transformation, driven by the adoption of 5G, edge computing, and cloud-native technologies. Nephio has emerged as a groundbreaking solution for network automation, addressing the challenges of scale and complexity in modern networks. Simultaneously, GenAI has burst onto the scene, promising to revolutionize various aspects of technology and business. This white paper explores the potential synergies between Nephio and GenAI, and how their combination could reshape the landscape of network automation.

# Project Nephio: Origin, Progress, and Future Outlook

## Background of Project Nephio

Project Nephio emerged in 2022 as a collaborative initiative between the Linux Foundation, Google Cloud, and other industry partners to address the growing challenges in cloud native network automation. The project's primary goal is to simplify the deployment and management of multi-vendor cloud infrastructure and network functions across large-scale edge deployments.

## The Problem Nephio Solves

Traditional approaches to network automation have struggled to keep pace with the increasing complexity and scale of modern telecommunications networks, particularly in the context of 5G and edge computing. Some key challenges include:

1. Imperative approach for deploying and configuring network functions. Lack of a declarative method to express desired network state that can grow and scale along the lifecycle of the network service
2. Difficulty in coordinating deployments across multi-vendor, multi-cloud environments
3. Slow response times to network changes and scaling requirements
4. Complexity in managing interconnected workloads at scale

Nephio addresses these challenges by introducing a unified, Kubernetes-based automation framework that leverages declarative intent-driven principles and cloud-native technologies.

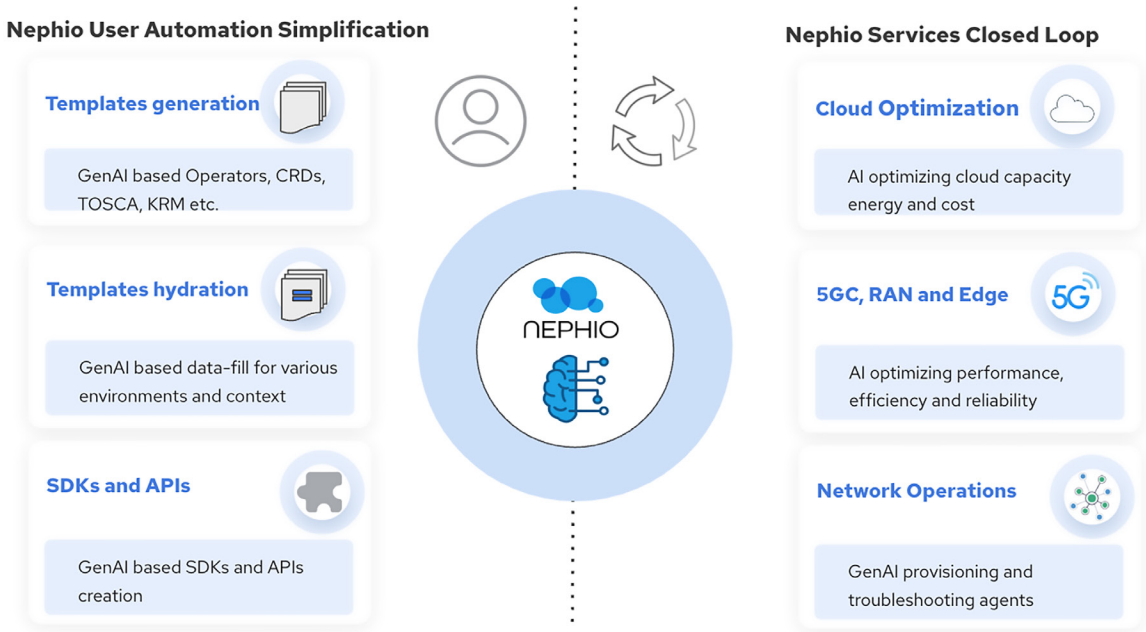
## Current Status and Future Direction of Project Nephio

As of January 2025, Project Nephio has made significant strides in realizing its vision:

1. Release Milestones: Nephio has successfully launched multiple releases, with Release 2 (R2) being a major milestone announced in February 2024. This release introduced enhanced multi-vendor and multi-cloud support, expanded end-to-end cloud-native automation capabilities, and improved integration with various cloud platforms. R3 in July 2024 added functionality enhancements and security hardening
2. Community Growth: The project has seen a 40% yearly increase in contributors, indicating growing interest and adoption within the telecommunications industry.
3. Real-World Applications: Major telecommunications companies have begun implementing Nephio in real-world 5G core deployments, demonstrating its practical applicability.
4. Expanded Scope: While initially focused on 5G core network functions, Nephio has expanded to include automation for Radio Access Network (RAN) components and multi-cloud frameworks.
5. Integration with Other Projects: Nephio is being positioned to complement existing open source projects like ONAP, contributing to a more comprehensive end-to-end automation ecosystem in telecommunication networking.
6. Future Directions: The project is exploring integration with Generative AI technologies to further enhance automation capabilities and user experience.

As Nephio continues to evolve, it is poised to play a crucial role in shaping the future of cloud-native network automation, offering a promising solution to the complex challenges faced by modern telecommunications networks.

# AI, ML, and GenAI: Understanding Their Roles and Applications in Nephio

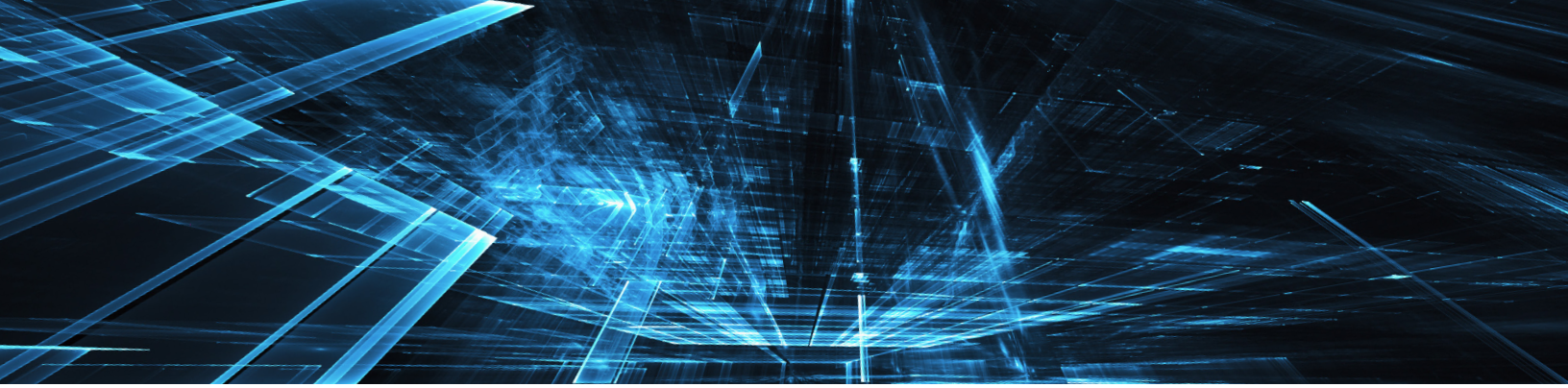



## Artificial Intelligence (AI)

Artificial Intelligence refers to the simulation of human intelligence in machines programmed to think and learn like humans. In the context of network automation and management, AI systems can analyze vast amounts of data, make decisions, and perform tasks that traditionally required human intervention, or were too complex for humans to accomplish.

Nephio can leverage AI capabilities to enhance its cloud-native network automation framework. AI algorithms can be integrated into Nephio to:

- Analyze network performance data and predict potential issues
- Optimize resource allocation across multi-vendor, multi-cloud environments
- Automate complex decision-making processes in network management
- Automatically generate network configurations based on human intent expressed in natural language



## Machine Learning (ML)

Machine Learning is a subset of AI that focuses on the development of algorithms and statistical models that enable computer systems to improve their performance on a specific task through experience, without being explicitly programmed.

In the Nephio ecosystem, ML can be applied to:

- Improve the accuracy of intent-driven automation by learning from past configurations and outcomes
- Enhance network slicing capabilities by dynamically adjusting resources based on learned patterns
- Optimize Kubernetes-based infrastructure management through predictive scaling and resource allocation

## Generative AI (GenAI)

Generative AI refers to AI systems capable of creating new content, including text, images, code, and configurations. These systems, often based on large language models (LLMs), can understand and generate human-like text and code.

The integration of GenAI with Nephio presents transformative opportunities for cloud-native network automation:

1. User Experience Enhancement:
    - Simplifying complex tasks for automation engineers
    - Generating and hydrating templates based on high-level requirements
    - Assisting in code generation and SDK development for Nephio
2. Network Optimization:
    - Improving cloud capacity management and energy efficiency
    - Enhancing 5G RAN and Edge performance through AI-driven configurations
    - Enabling more effective realization of intent-driven and closed-loop models

3. Advanced Automation:
    - Translating high-level intents into actionable network configurations
    - Writing Custom Resource Definitions (CRDs) and Kubernetes operators
    - Performing intelligent network troubleshooting and root cause analysis
4. Natural Language Interaction:
    - Enabling a next-generation Command Line Interface (CLI) for Nephio using LLMs
    - Allowing users to interact with Nephio using natural language queries
    - Interpreting and executing complex network management tasks based on human-semantic input

By leveraging GenAI, Nephio can evolve into a more intelligent, responsive, and user-friendly platform for cloud-native network automation, addressing the increasing complexity of modern telecommunications networks.

With the growing industry buzz around Gen AI and the availability of open source LLMs, its powerful ability to generate and manipulate text, create code, and streamline tasks presents significant opportunities for Nephio. In the following section, we take a deeper dive into the available GenAI tools and techniques, exploring why GenAI and Nephio are a perfect match, how GenAI tools can be applied to expand Nephio's use cases and enhance its capabilities in cloud-native network automation.

# Nephio GitOps and GenAI: A Perfect Match

## Realizing Intent and Closed Loop Model with Nephio

The implementation of intent-based networking and closed-loop models can be effectively achieved through Nephio's cloud native network automation platform. This approach enables the translation of high-level network requirements into actionable, lower-level configurations.

## Intent Translation Process

At the network slicing layer, a high-level intent, such as creating an enhanced Mobile Broadband (eMBB) network slice with specific Service Level Agreement (SLA) requirements, initiates the process. This intent is then cascaded through multiple layers of abstraction:

1. The subsequent layer interprets this intent, generating specifications for deploying a 5G network with particular attributes, potentially including configurations for Open Radio Access Network (O-RAN).
2. The Nephio layer further decomposes this intent into realizable components using operators and Custom Resource Definitions (CRDs).

## Closed Loop Implementation

The closed-loop model, as defined in 3GPP network slicing or ETSI service orchestration standards, can be effectively realized at the Nephio or GitOps layer. This implementation follows the well-established observe, analyze, and act loop:

1. Observe: Continuous monitoring of network state and performance.
2. Analyze: Evaluation of collected data against defined intents and SLAs.
3. Act: Automated adjustments to maintain desired network state.

## Nephio's Role in Intent Translation

Nephio translates intent through CRDs, which define the desired state of the network. This system can be continuously updated by a GenAI system that comprehends higher-layer intent. In the current GitOps paradigm, human operators are responsible for:

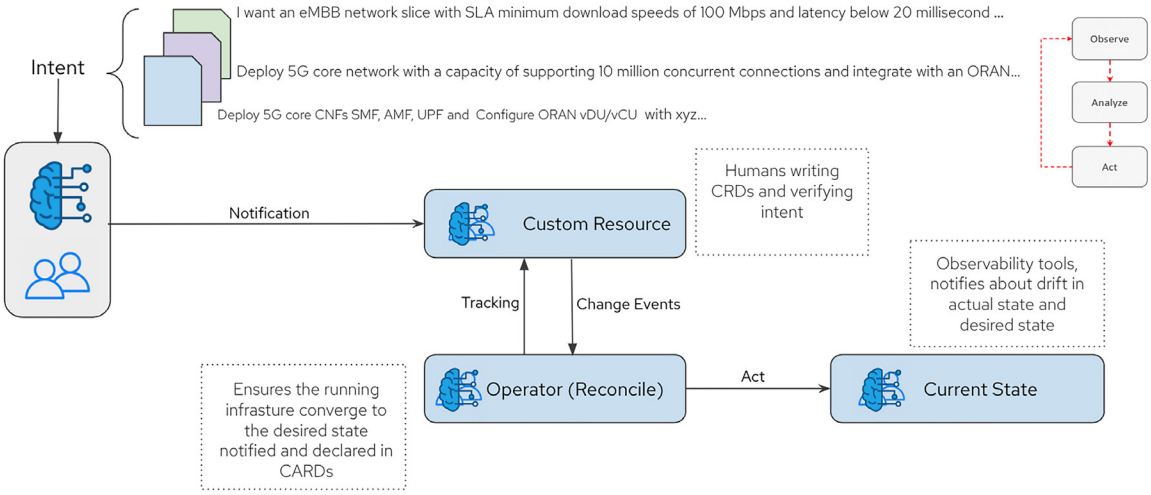
- Writing CRDs and Operators
- Performing network troubleshooting
- Utilizing analytics tools to identify discrepancies between actual and desired network states

## Future Evolution with GenAI

As the adoption of GenAI progresses, we anticipate a shift towards increased automation:

- GenAI-authored CRDs and Operators
- AI-driven network troubleshooting and analysis
- AI-generated insights into network performance and state

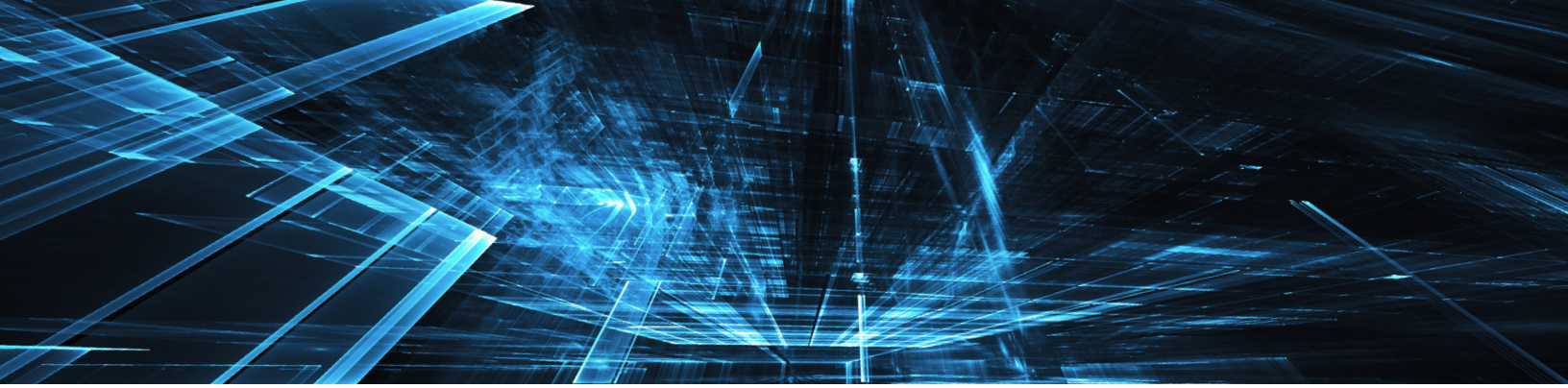
This evolution has the potential to significantly reduce human intervention in the network management loop, leading to more efficient and responsive network operations.




The combination of Nephio's GitOps approach and GenAI can realize intent-driven and closed-loop models:

- High-level intent (e.g., creating an eMBB network slice with specific SLAs) can be translated into lower-level intents for 5G network deployment and O-RAN configurations.
- Nephio decomposes these intents further into actionable items using operators and Custom Resource Definitions (CRDs).
- The closed-loop model (observe, analyze, act) can be implemented at the Nephio/GitOps layer, constantly updating the desired state based on real-time observations.

As GenAI adoption progresses, it can transform key aspects of the Nephio workflow by automating the generation of CRDs from high-level intents, creating Kubernetes operators, streamlining network troubleshooting, and providing real-time insights into deviations between actual and desired network states.



# GenAI Enhancing Nephio's User Experience and Optimization

GenAI, exemplified by LLMs, has shown remarkable potential across various domains. In the context of network automation, GenAI offers exciting possibilities for enhancing both user experience and network operations, such as adjusting network configurations based on traffic patterns, security needs, and business goals.

## User Experience Enhancement

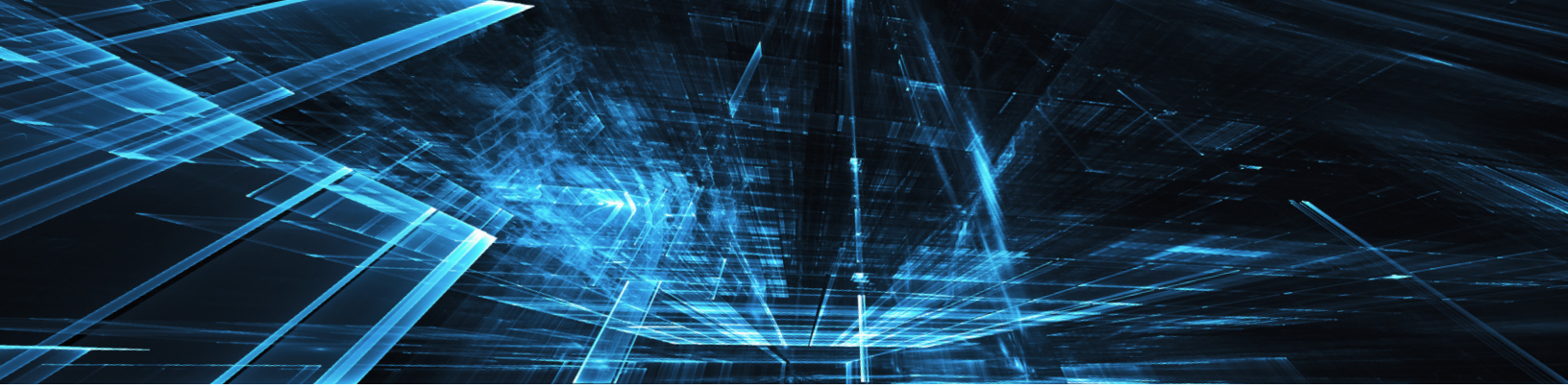
GenAI can significantly improve the experience for Nephio users and developers by streamlining complex tasks and automating time-consuming processes. Key areas of enhancement include:

- Template Generation and Hydration:
  - Generating templates based on high-level requirements
  - Performing template hydration with site-specific data
  - Automatically updating configurations

- Code Generation and SDK Development:
  - Simplifying the job of automation engineers
  - Offering a path of lower resistance for Helm to Operator conversion
  - Providing opportunities for automated code generation

- Simplified Automation:
  - Reducing the time spent on template creation (currently ~80% of cloud operations teams' time)
  - Leveraging Nephio's principle of decoupling data from automation

These enhancements can significantly reduce the workload on developers and operators, allowing them to focus on more strategic tasks and innovation.

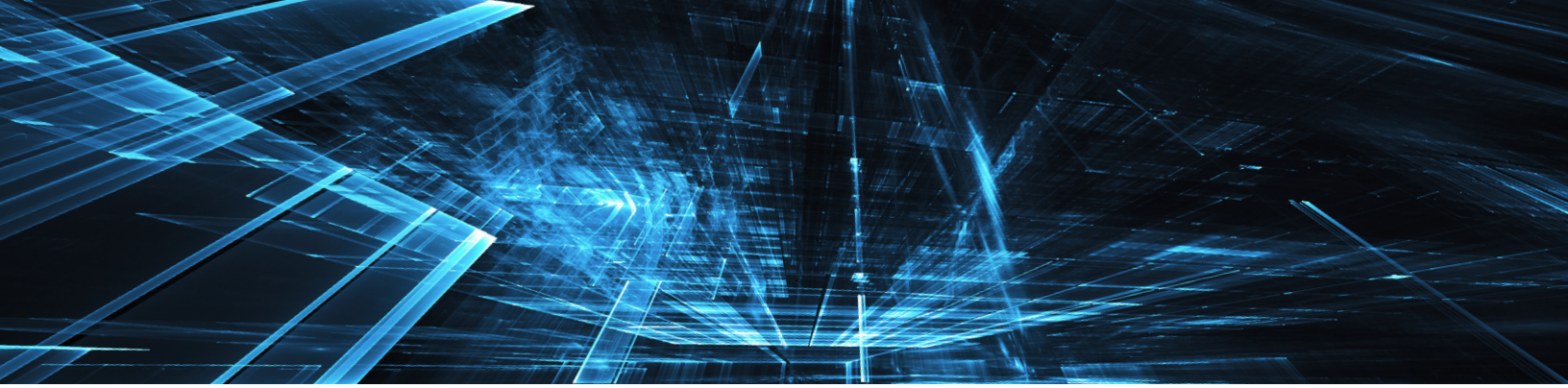


## Network Optimization

GenAI can play a crucial role in optimizing network performance and efficiency within the Nephio framework. Key areas of optimization include:

- Cloud Resource Management:
  - Optimizing cloud capacity and resource allocation
  - Improving cost efficiency in cloud operations
  - Enhancing energy usage and reducing operational costs
- 5G RAN and Edge Performance:
  - Improving the performance of 5G Radio Access Networks
  - Optimizing edge computing resources and capabilities
- AI-Driven Network Operations:
  - Enhancing network provisioning processes
  - Improving troubleshooting and root cause analysis
  - Implementing predictive maintenance
- Automated Decision-Making:
  - Enabling AI-driven provisioning based on real-time network conditions
  - Implementing closed-loop automation for network management

By leveraging GenAI in these areas, Nephio can achieve more efficient, responsive, and self-optimizing network operations, leading to improved overall network performance and reduced operational costs.



# Use Case: Nephio GenAI

## GenAI in Template Generation and Hydration

To prepare the GenAI framework for Nephio and revolutionize Cloud Native Network Automation, it's essential to consider legal risks to prevent future disruptions. Over the years, many projects have sought to tackle this issue by establishing code repositories and datasets with permissive licensing terms. A notable recent initiative is the "BigCode Project," which has developed "The Stack" dataset with careful attention to licensing and legal considerations. (You can find all the code used to create the BigCode datasets, including "The Stack," along with the necessary preprocessing for modeg, at https://github.com/bigcode-project/bigcode-dataset.)

### TEMPLATE HYDRATION SUPPORT THROUGH GENAI

The integration of Generative AI (GenAI) with Nephio's template hydration process represents a significant advancement in cloud native network automation. This integration builds upon a rich history of open source software development and legal considerations that have shaped the industry.

### THE STACK AND ITS RELEVANCE TO NEPHIO

The BigCode Project's "The Stack" dataset offers valuable insights for Nephio's GenAI implementation, particularly in template hydration. This dataset, along with its preprocessing code, is available here, providing a robust foundation for training GenAI models.

In the context of Nephio, leveraging such carefully curated datasets can significantly enhance the template hydration process. GenAI models trained on these datasets can generate and hydrate templates based on high-level requirements, perform site-specific data integration, and automatically update configurations. This approach aligns with Nephio's principle of decoupling data from automation, creating an ideal environment for GenAI integration.

### STREAMLINING TEMPLATE CREATION AND HYDRATION

Cloud operations teams currently spend a significant portion of their time (approximately 80%) on template creation. By integrating GenAI models trained on legally sound datasets like "The Stack," Nephio can potentially streamline this process, offering several benefits:

1. Automated template generation based on high-level network requirements
2. Efficient template hydration with site-specific data
3. Dynamic configuration updates in response to changing network conditions

Furthermore, the development of GenAI-powered SDKs for Nephio could offer a path of lower resistance for Helm to Operator conversion, opening up new possibilities for code generation and automation.

By building upon the lessons of open source history and leveraging carefully curated datasets, Nephio can harness the power of GenAI for template hydration while mitigating legal risks. This approach not only enhances efficiency but also ensures the sustainable and responsible development of cloud native network automation technologies

## The Future of Network Automation and Service Assurance

The combination of Nephio and GenAI drives the future of network automation and service assurance by enabling rapid service deployment, dynamic network slice optimization, and self-improving automation. GenAI enhances troubleshooting, root cause analysis (RCA), and provides real-time field tech assistance, ensuring faster, smarter, and more resilient network operations.

Generative AI plays a crucial role in network automation and service assurance by enabling more efficient network management through intent execution and translation. Nephio can utilize GenAI via LLMs to interpret high-level user intentions expressed in natural language. This capability allows Nephio to convert those intentions into actionable network configurations and policies. By leveraging LLMs, the need for manual configuration is reduced, which in turn accelerates the time to market.

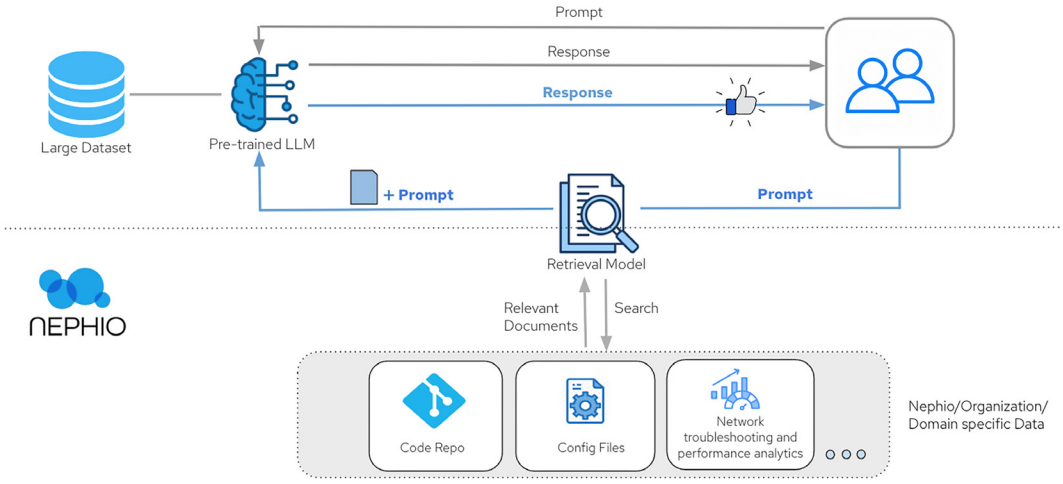
Additionally, LLMs can be trained to understand the semantic meaning of user intent, ensuring that they do not merely memorize intents but comprehend their context. Another significant benefit is that Nephio can harness generative AI for closed-loop automation, which facilitates self-monitoring, self-awareness, and self-management within networks. This allows for automatic adjustments to network configurations based on observability and telemetry data from Nephio.

Finally, generative AI enables Nephio to provide service assurance by predicting network behavior and proactively taking measures to maintain stability and reliability across network nodes. Furthermore, AI can perform end-to-end network assurance by continuously monitoring network behavior and making subtle adjustments based on optimal decision-making for network functions.

### IMPLEMENTING LLMS AND RAG FOR GENAI-POWERED NEPHIO EVOLUTION

To realize the full potential of GenAI in Nephio, the integration of LLMs and Retrieval-Augmented Generation (RAG) is crucial:

- LLMs can understand and generate human-like language and code
- RAG pipelines can augment LLMs with organization-specific data, including Git repositories, configuration data, security best practices, and analytics from FM/PM tools
- This combination can provide more accurate and context-specific responses to user prompts



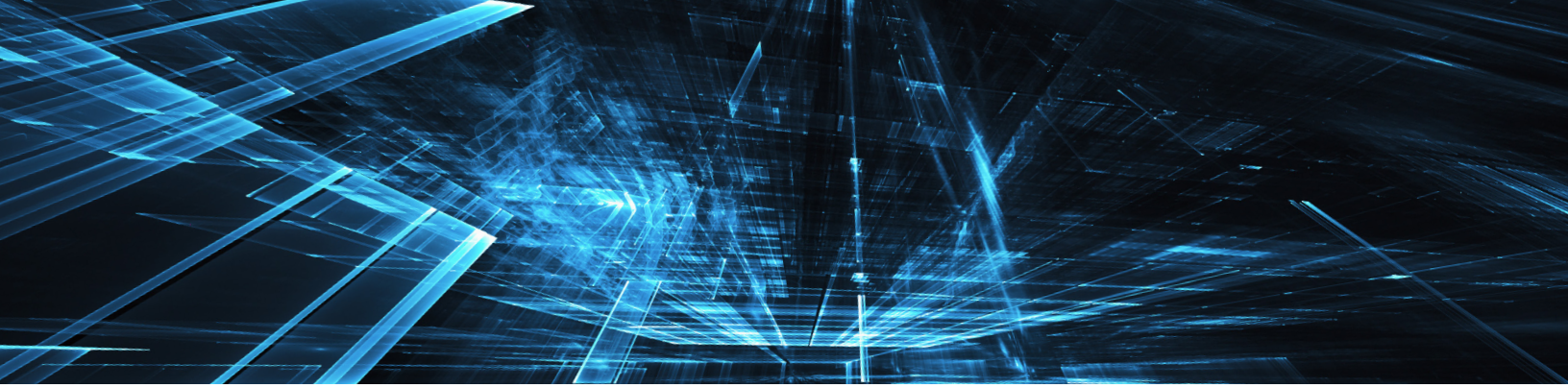

In addition, fine-tuning and grounding are techniques that should be explored to enhance response accuracy, and reduce hallucination.

## Nephio AI Assistant Use Case: Next-Gen Commmand Line Interface (CLI) for Nephio and Cloud Technologies

We can utilize the potential of LLMs to interpret human-semantic thoughts. Imagine a scenario where a user can request the creation of a Kubernetes cluster or any Network Function using plain, natural language. Such a request could be accurately interpreted, parsed (or negotiated) to determine the required parameters, translated into actionable steps (e.g., executing the Nephio API), and executed—all while keeping a human in the loop.

This capability would enable technical staff to work with a complex tool like Nephio without needing comprehensive knowledge of its APIs, interfaces, or CLI. It simplifies the upskilling process, making Nephio easier to use by providing a generic CLI that eliminates the need to memorize complex syntax.

Additionally, the Nephio AI Assistant can assist in creating or reconfiguring descriptions during the process of parsing user arguments.



## The Human and M2M Factor Use Case

Despite the rise of automation, human expertise will continue to play a vital role in network management with Nephio and GenAI. Humans will be essential for overseeing and guiding AI systems, developing new use cases and innovations, and ensuring the ethical and responsible implementation of AI. This collaboration between human expertise and machine-driven processes will foster continuous innovation while maintaining control and accountability in network operations.

### GENAI INTERACTION

Nephio will interact with GenAI through two types of Interfaces: Human Interface and Machine to Machine. Understanding the capabilities and focus areas of these interfaces must be considered when designing Nephio's interactions.

### HUMAN INTERFACE REQUIREMENTS

It focuses on enabling seamless, natural, and intuitive communication between users and machines. It leverages advanced AI models to interpret human intent, provide contextual responses, and simplify the user experience in complex environments.

- Nephio GenAI supports NLP to interpret and respond to human language, enabling users to interact naturally.
- Nephio GenAI interprets the context of user queries to provide accurate and relevant responses.
- Nephio GenAI reduces the cognitive load for users by handling complexity in the background, such as translating plan language requests into technical commands or API calls.
- Nephio GenAI supports the ability to learn from user behavior to predict and fulfill needs proactively.

## MACHINE TO MACHINE REQUIREMENTS

GenAI interaction for Machine-to-Machine (M2M) communication enhances automation, decision-making, and interoperability between systems by leveraging advanced AI capabilities.

- Nephio GenAI should act as a mediator to translate between different protocols, formats, or APIs, enabling seamless communication between heterogeneous systems.
- Nephio GenAI should generate and update configurations for one system based on the input from another, reducing manual intervention.
- Using predictive analytics and real-time data, Nephio GenAI should enable autonomous decisions in M2M interactions.
- Nephio GenAI should generate realistic synthetic data for training, testing, or simulating M2M systems
- Nephio GenAI should facilitate closed-loop processes where systems detect, analyze, and resolve issues without human involvement
- Nephio GenAI should infer the intent behind system communications to optimize interactions, by learning patterns of interaction between machines and adapting communication protocol dynamically.
- Nephio GenAI should enable systems to identify failures and collaborate to restore normal operations.

Nephio GenAI should support M2M communication security by identifying unusual patterns and responding to threats.

# GenAI Model Efficiency and Performance Requirements

Before adopting public or private LLMs or small language models (SLMs) for specific use cases, it is critical to evaluate their suitability for the intended tasks. For telecommunications operators, one key use case is the automation of service design and orchestration management functions. This includes generating service, transport, and IaaS/CaaS-level manifests, as well as PNF/VNF-level configurations to meet end-to-end SLA requirements. Automation in this domain optimizes time, reduces complexity, and minimizes human-induced errors during manual processes.

The complexity of these tasks increases significantly when service deployments span heterogeneous technology domains, such as access networks, transport networks, and distributed edge or regional cloud instances. These scenarios require the orchestration of multiple service layers, each with unique configurations and management needs. The efficiency of an automated system hinges on the accuracy and performance of the LLM, which acts as the system's "brain," interpreting user prompts or machine-generated requests and providing precise responses.

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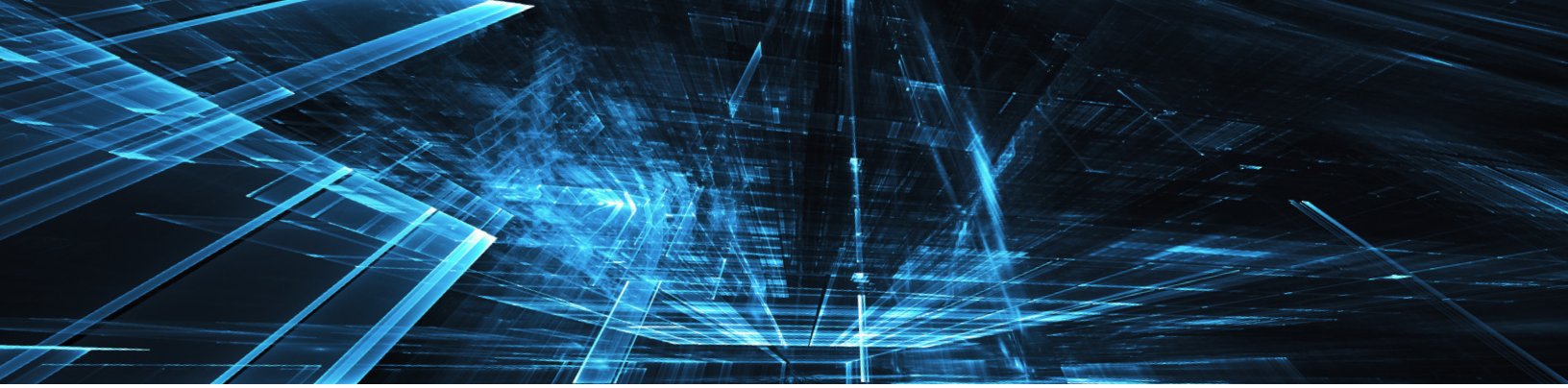


To ensure the optimal selection of LLMs for these tasks, operators must consider both public models and private, fine-tuned models using common benchmark test suites and metrics. This evaluation process involves assessing a range of performance and accuracy criteria, which will differ depending on whether deployments are man-in-the-loop (with human oversight) or fully automated (driven by virtual agents).

From an operator's perspective, key questions to address include:

- **Requirements for Service Design and Orchestration:** What are the specific requirements for LLMs when used for offline or real-time (online) service design and orchestration tasks?
- **Model Evaluation:** How can public models (e.g., GPTs, Claude, Gemini) be compared to fine-tuned, pre-trained open-source models (e.g., LLaMA, Mistral) in terms of accuracy, performance (latency), and hallucination rates?
- **Quantitative Metrics:** What are the quantitative measures for evaluation, including accuracy, resource requirements, and the trade-offs between cost and performance?
- **Qualitative Considerations:** How do factors such as data sovereignty, vendor lock-in, and the potential for LLM customization affect the decision-making process?
- **Localized Models vs. RAG Pipelines:** What criteria should be used to decide between localized, fine-tuned models and retrieval-augmented generation (RAG)-based LLM pipelines?
- **Human vs. Virtual Agent Use:** What performance requirements must be considered depending on whether the LLM is used by human operators or other virtual agents within agentic frameworks?
- **Large LLMs vs. Fine-Tuned Smaller Models:** When is it beneficial to use large, general-purpose LLMs versus smaller, fine-tuned models optimized for specific tasks?

By addressing these questions, operators can make informed decisions about selecting and deploying the most effective LLMs or SLMs for their needs, balancing accuracy, performance, cost, and operational constraints to achieve optimal automation outcomes.

# GenAI Security Requirements

Nephio will face security challenges as it adopts GenAI models and operations. This paradigm shift introduces new types of security issues and challenges. The following is a summary of potential challenges Nephio may encounter and considerations it should address to mitigate those security concerns.

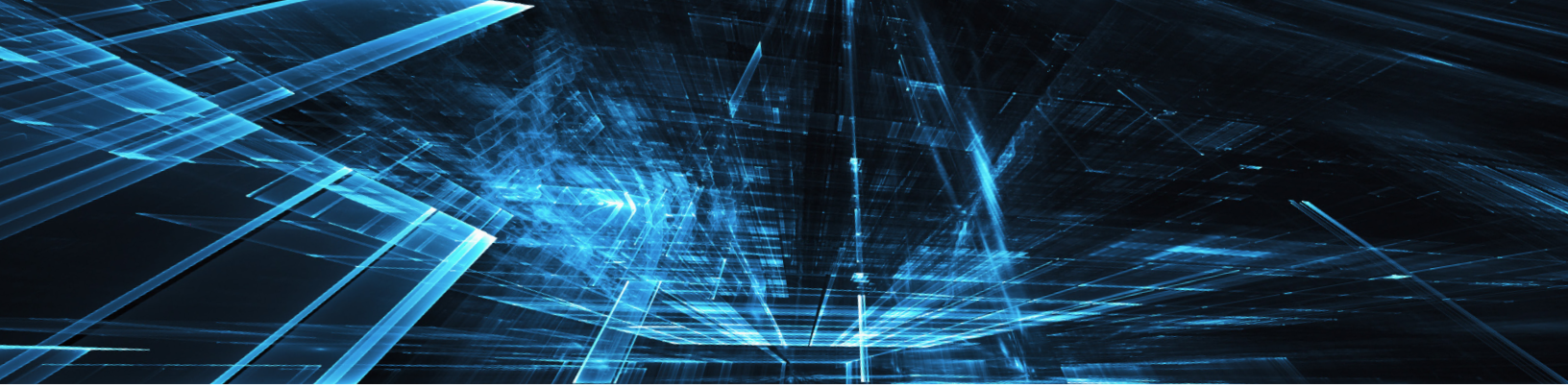
## Challenges

Gen AI (also Predictive AI) technologies are also vulnerable to attacks that can cause failures with dire consequences. LLMs are being integrated with large databases and documents to enable powerful RAG scenarios, which expose a new attack surface to potentially confidential and proprietary enterprise/network data that Nephio may manage both directly and indirectly. Manipulating the training data can make Nephio GenAI vulnerable to attacks. Data poisoning at scale by hackers can create vulnerabilities that allow for security breaches down the pipeline.

NIST[1] defined the attack classification: availability breakdowns, integrity violations, privacy compromise, violations of abuse. Those attacks can come during the training-time and inference-time through training data control, query access, source code control and resource control.

## Considerations for Secure use of GenAI

Nephio GenAI defense strategies have to be considered, such as training for alignment, prompt instruction and formatting techniques and detection techniques, working with the Linux Foundation's **LF AI & Data** project and GenAI Commons and other industry de factos. Secure supply chains of the Nephio GenAI LLM should be carefully chosen, and placing an LLM Gateway to mitigate the attacks thru LLM datasets could be an option to consider.



# GenAI Models and Open Source Compliance Requirements

## Challenges and Considerations

When Nephio adopts GenAI models and operations, it should consider utilizing open source GenAI models and frameworks, such as LF AI & Data and GenAI Commons specifications. Otherwise, the Nephio-specific GenAI models and operations may not be compatible with other systems, or could face regulatory restrictions.

Nephio's GenAI models and frameworks should align with LF AI & Data and GenAI Commons specifications and best practices. Compliance with LF MOF and MOT should also be a requirement.

Despite the significant advancement in AI, GenAI and ML, there are several issues and challenges because many AI models remain opaque "black box" and their inner workings are shielded for regulations, privacy, security and many other reasons. This lack of transparency makes it difficult to verify claimed capabilities, audit for potential biases and safety issues, and build on the work.

For more details, see the article, The Model Openness Framework: Promoting Completeness and Openness for Reproducibility, Transparency, and Usability in Artificial Intelligence.[2] The article explains why the MOF requires that the code, data, and documentation components of the model development lifecycle be released under specific open licenses.

## AI, GenAI and ML Open Source Communities

**LF AI & Data Foundation**[3] is formed to focus on open source AI, GenAI, ML and data projects, supporting the entire AI lifecycle (from data processing to AI model training development).

**GenAI Commons**[4] is under LF AI & Data, and the community focuses on "GenAI" specific for collaborating and building "responsible" GenAI solution architecture, standardized models and ecosystems. It provides tools, models, datasets, and best practices for developers, researchers, and industries to create GenAI systems.

**Model Openness Framework**[5] promotes completeness and openness for reproducibility, transparency and usability in AI. MOF defined three MOF classification levels, Class I, Class II and Class III).

| MOF Class | Components Included |
|---|---|
| **Class III. Open Model** | 1. Model Architecture<br>2. Model Parameters (Final Checkpoints)<br>3. Technical Report or Research Paper<br>4. Evaluation Results<br>5. Model Card<br>6. Data Card<br>7. Sample Model Outputs (Optional) |
| **Class II. Open Tooling** | 1. All Class III Components<br>2. Training, Validation, and Testing Code<br>3. Inference Code<br>4. Evaluation Code<br>5. Evaluation Data<br>6. Supporting Libraries & Tools |
| **Class I. Open Science** | 1. All Class II Components<br>2. Research Paper<br>3. Datasets<br>4. Data Preprocessing Code<br>5. Model Parameters (Intermediate Checkpoints)<br>6. Model Metadata (Optional) |

<source: MOF white paper[6]>

### MOF RECOMMENDED OPEN LICENSE

The table on page 13 in the MOF white paper[6] depicts the MOF recommended open license.

For more details on MOF specifications, see the working draft reference in.[7]

In addition, the Model Openness Tool (MOT) provides a user-friendly reference implementation to evaluate the openness and completeness of models against the MOF classification system for view models, evaluate models and submit models, see Istio Open AI and MOT AI.[8]

## CONSIDERATIONS

When we develop the following Nephio GenAI capabilities, Nephio should be aligned with the LF AI & Data Foundation, GenAI Commons guidance, and MOF on models, data sets, training and architecture. Otherwise, Nephio-specific GenAI models, data sets and other artifacts may be not able to be shared in an open source format.

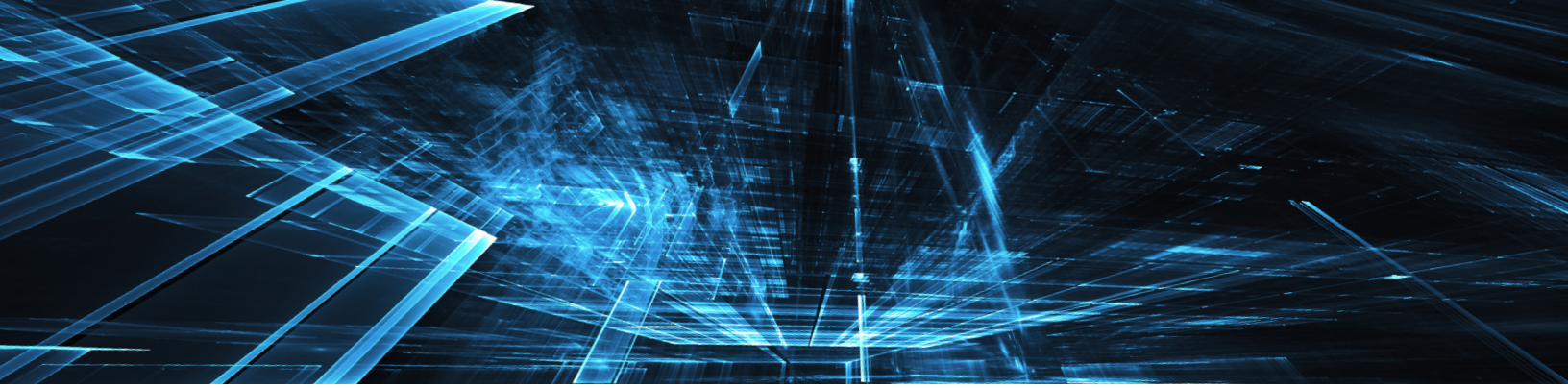
## FOCUS AREAS FOR THE MOF COMPLIANCE

- The MOF defines three classes (Class III, Class II and Class I), each building upon the previous one, representing ascending levels of model completeness and openness.
- Nephio should start with the Class III - Open Source Model, making sure Nephio developed genAI models are aligned with the MOF Class III, as a start.
- Nephio genAI models (both foundation and trained models), data, code, publication and access should be aligned with the MOF specification.
- The Nephio trained model parameters along with foundation models should be released under an open license, OSI-approved licenses and/or CDLA-Permissive-2.0.
- Nephio supporting AI-related code libraries, utilities or tools should be distributed under an OSI-approved open source license.
- The Nephio model architecture and the model parameters should be distributed separately, allowing each component to be managed independently of the other.
- The Nephio technical report should be included in the distribution under an open license, or made available on a permanent open access platform.
- Detailed quantitative metrics and qualitative results from evaluating the model should be reported.
- Any supporting code libraries, utilities, or tools developed in the course of the development of the model should be distributed under an open source software license.

In addition, Nephio genAI should be aligned with 3GPP and/or TMForum AI/ML initiatives for 5G systems, New Radio.

While the integration of GenAI with Nephio offers exciting possibilities, it also presents challenges:

- Ensuring the accuracy and reliability of AI-generated configurations
- Managing the complexity of AI models in distributed network environments
- Addressing potential biases in AI-driven decision-making
- Maintaining human oversight and control over critical network functions



# Conclusion

The integration of GenAI with Nephio presents a transformative opportunity for cloud native network automation, offering unprecedented potential for the telecommunications industry. This white paper has examined the powerful synergy between Nephio and GenAI and their ability to revolutionize network management, enhance user experience, and improve overall network efficiency.

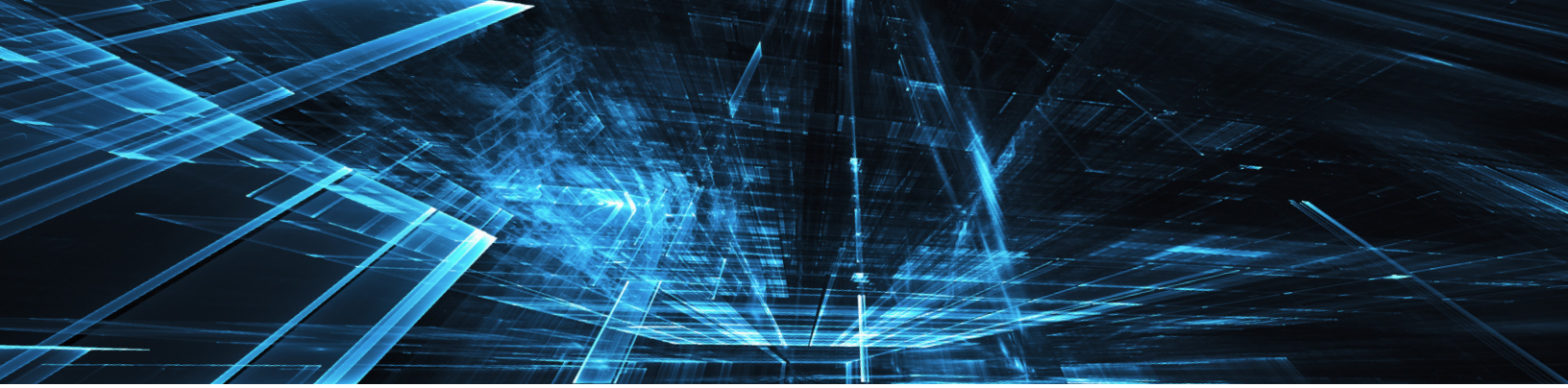
Nephio's intent-driven automation and Kubernetes-based infrastructure provide an ideal foundation for integrating GenAI. By simplifying complex tasks, generating templates, and assisting in code development, GenAI can significantly improve the user experience for operators and developers. In addition, GenAI enables advanced network optimization, enhancing cloud capacity management, energy efficiency, and 5G RAN performance. Through Nephio's GitOps-driven approach, GenAI can help realize intent-driven and closed-loop models, ensuring continuous, automated adjustments to meet performance requirements.

The role of LLMs and RAG is essential to maximize GenAI's effectiveness within Nephio. LLMs interpret high-level intents and translate them into actionable configurations, while RAG pipelines provide context-specific responses by integrating real-time organizational data. Careful evaluation of these models based on accuracy, performance, and security metrics is necessary to ensure successful deployment in network automation tasks.

Despite the increasing automation, human expertise remains critical for guiding AI systems, developing innovative use cases, and ensuring ethical and responsible AI implementation. Nephio's interactions with GenAI must balance both human oversight and machine-to-machine interfaces, ensuring seamless collaboration between human operators and automated systems.

For GenAI and Nephio to achieve widespread adoption and interoperability, open-source compliance and alignment with industry standards are vital. As the telecommunications industry evolves, this collaboration promises a future of more intelligent, efficient, and responsive network management. Operators can expect accelerated service deployment, optimized network slicing, and improved overall network performance.

However, challenges remain, including ensuring model accuracy, managing system complexity, and maintaining appropriate human oversight. By addressing these challenges and leveraging the strengths of Nephio and GenAI, the telecom industry can unlock new possibilities in network automation, paving the way for a more agile, scalable, and innovative telecommunications infrastructure.

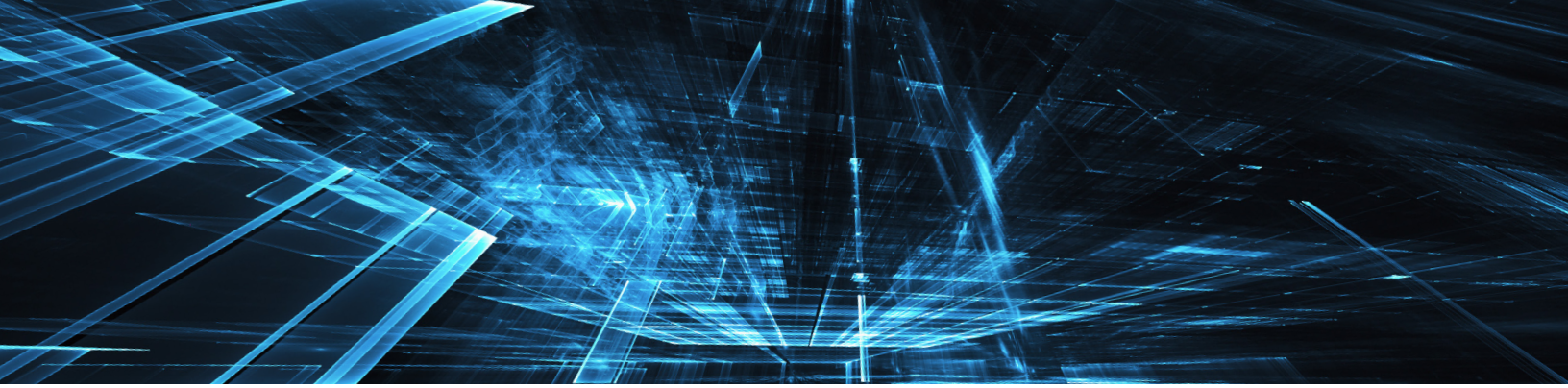


## Call to Action: Shaping the Future of Network Automation Together

The convergence of Nephio and Generative AI offers a groundbreaking opportunity to redefine cloud-native network automation. As we enter this transformative era, we invite telecom operators, vendors, AI startups, and forward-thinking technologists to join the Nephio project and contribute to shaping the future of network management. Broad industry expertise, creativity, and collaborative drive are essential to overcoming challenges and unlocking the full potential of AI-driven network automation.

Contributors to Nephio are at the forefront of developing intelligent, self-optimizing networks capable of adapting to the dynamic needs of our connected world. Together, the community can design a more efficient, resilient, and responsive telecommunications infrastructure to power the next generation of digital services and experiences.

**Join the Nephio and LF Networking community** on this exciting journey to push the boundaries of what's possible in network automation and play a pivotal role in creating the future of global connectivity. Let's work together to build a smarter, more adaptable world—one network at a time.



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8. Istio Open AI and MOT AI. Source Reference: **https://isitopen.ai/** and **https://mot.isitopen.ai/**


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