Autonomous network operations

A curated collection of thought leadership articles discussing

- Agentic AI
- Digital twins
- Knowledge graphs
- Modern telco inventory
- Real world case studies

Contents

Introduction

The telecom industry is accelerating toward operations that sense, think, and act with far greater autonomy. Achieving this requires more than incremental automation; it relies on utilizing agentic AI, digital twins, knowledge-driven operations, and modernized inventory solutions to manage increasing network complexity and customer expectations.

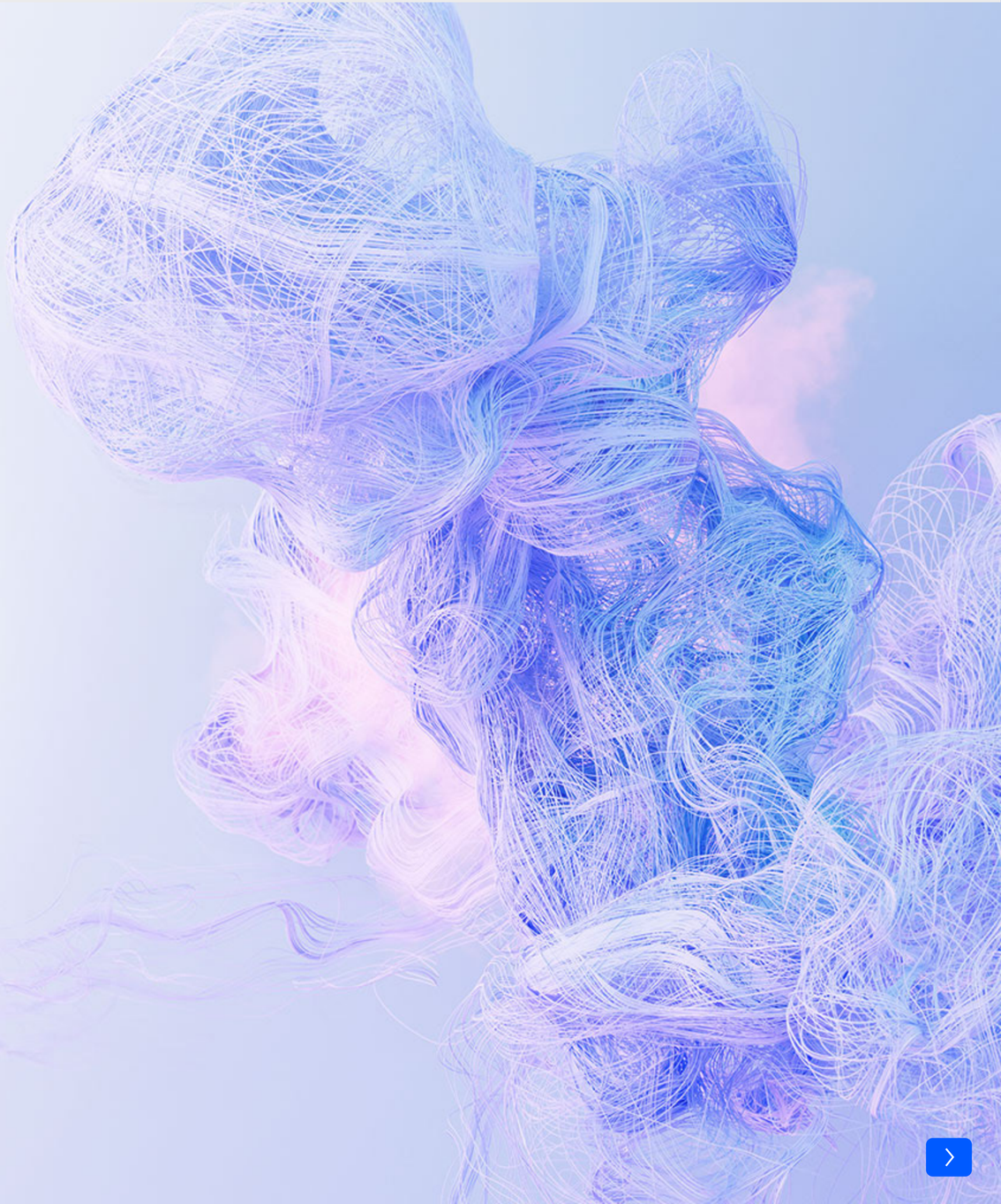
Agentic AI introduces collaborative, goal-driven agents that apply reasoning, memory, and tool use to move beyond reactive systems and enable true cognitive operations. Nokia's AgenticOps approach combines AIOps and agentic capabilities to deliver reliable, scalable autonomy. AIOps provides always-on detection and correlation, while AgenticOps adds deep reasoning, triage, adaptive execution, and human-aligned decision-making to drive measurable outcomes such as faster resolution, energy efficiency, and improved customer experience.

Digital twins bring a "twin-first" operational model where planning, assurance, optimization, and maintenance actions are simulated before being applied to the network. This reduces risk, increases agility, and enables proactive, predictive operations.

Knowledge graphs play a critical role in connecting complex data across network, service, topology, and customer domains. By enabling semantic reasoning and contextual analytics, they strengthen resilience, accelerate root cause analysis (RCA), and support advanced automation, even in emergency response scenarios.

A dynamic inventory system provides the foundation for autonomy. With real-time observability, normalization, and openness, it supports intent-based orchestration, ML-driven insights, and digital-twin-powered automation.

Through a selection of essays covering real-world case studies and catalyst projects, Nokia demonstrates how AI, automation, and standards come together to enable intent-driven, closed-loop, Level 4+ autonomous operations - unlocking agility, resilience, and new business value for telecommunication providers.



Agentic AI: Powering the next frontier in autonomous operations

In the pursuit of next-generation telecom operations, the industry is moving beyond traditional automation towards true autonomy, where networks don't just follow pre-programmed rules but can sense, think and act on their own. While intelligent systems leveraging forms of AI have been around for a while, they fall short in delivering the cognitive reasoning required for autonomous decision-making and action execution. Achieving the TMForum defined Level 4+ autonomy requires more than just smarter algorithms; it demands a shift towards systems that are goal-oriented, make context-aware decisions and generate actions so that humans can take their hands off the operations steering wheel and play a supervisory role and this is where Agentic AI comes in.

What is agentic AI?

Large Language Models (LLMs) are reshaping the way we interact with technology, enabling more natural, conversational networks and powering copilots that assist users effectively. However, they remain largely reactive: their decision-making is limited, their knowledge is bound to training data and embedded sources and is memoryless and responses are confined to the context of the given prompt or session.

Agentic AI marks a paradigm shift toward multi-agent ecosystems capable of collaborative reasoning, leveraging persistent memory and autonomous decision-making. An LLM powered autonomous agent system is comprised of an LLM functioning as the brain and other crucial components for planning, memory and the use of external tools.

Self-reflection is another vital aspect that allows autonomous agents to improve iteratively by refining past action decisions and correcting previous mistakes.

- Planning helps to break down large and complex tasks into smaller, manageable steps
- Memory helps LLM agents to learn between context in real-time and recall information over extended timeframes in the short term or long term to track trends
- LLMs leverage tools to call external resources like APIs and knowledge databases for additional information to help in dynamic decision-making. This allows the LLM to focus on tasks that it's best suited to and use other resources for complementary information. They also use tools to perform actions, turning intelligence into outcomes towards goal realization.

Redefining telco operations with agentic AI

To get the most out of AI, it must be tailored with telecom-specific domain expertise and knowledge. Nokia is uniquely positioned with deep domain insight to help operators successfully verticalize AI at scale and this is key when it comes to implementing agentic AI in operations, or AgenticOps.

AgenticOps adds a cognitive layer that bridges detection and action, where agents operate in structured workflows, applying contextual reasoning, synthesizing solutions and implementing them using appropriate tools. They follow an adaptive execution approach, monitoring actions for their effectiveness and adjusting approaches based on real-time feedback with continuous learning. Just as specialized professionals address specific challenges, for example, doctors in different disciplines treat specific problems, specialized agents can excel in targeted tasks, while swarms of agents coordinate to achieve broader goals. This division of responsibility reduces complexity, enhances traceability and elevates the effectiveness of AI-driven operations.

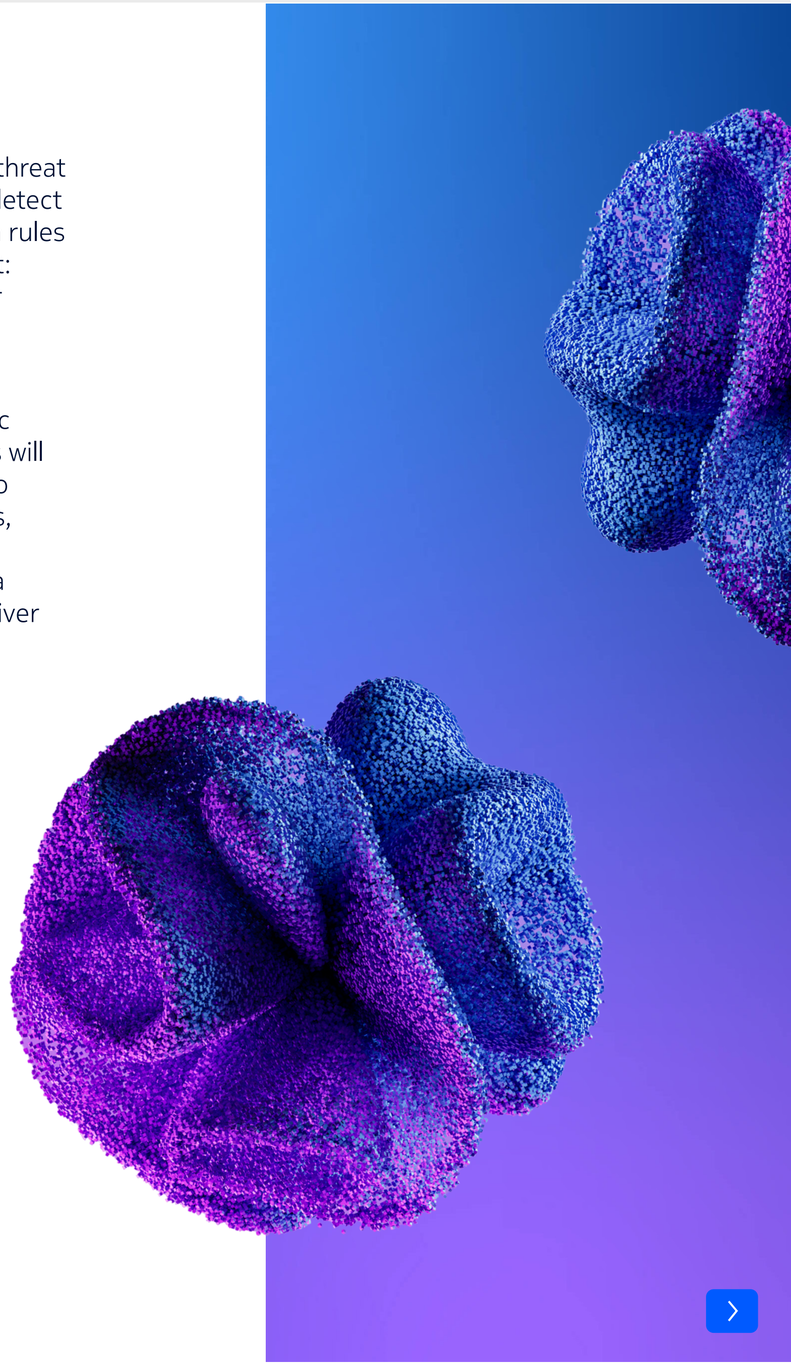
Telco agents can make decisions aligned with strategic business objectives, whether that's improving SLA adherence, accelerating time-to-resolution, or optimizing energy efficiency. The result is a step-change in business value, meaning fewer outages, faster service activation, better customer satisfaction and more scalable operations, even in increasingly complex network environments.

Agentic AI in telco operations is already shaping the future across several areas in the service operations space, like service orchestration, assurance and security, to name a few. A few powerful examples include:

- **Orchestration Agents:** autonomously translate business intent into actionable workflows, decomposing tasks across multivendor domains and executing them seamlessly. This accelerates service delivery while reducing operational complexity.
- **Assurance Agents:** move beyond proactive detection to providing anomaly reasoning, real-time recommendations and generating remediation steps, enabling the path to self-healing networks and delivering enhanced customer experience.
- **Security Agents:** continuously analyze threat intelligence and network telemetry to detect risks early, generate adaptive detection rules and guide rapid remediation. The result: reduced threat dwell time and stronger network resilience.

Bringing agentic AI to life

As networks become increasingly dynamic and multi-layered, operational challenges will only intensify. Agentic AI has the power to make operations intelligent and effortless, enabling telcos to shift their focus from wrestling with the mechanics of running a network to maximizing their ability to deliver customer value.



Leveraging AgenticOps for reliable Autonomous Networks

In the previous section we explored how Agentic AI is redefining telco operations. Now, we unveil Nokia's unique strategic approach to autonomy: one built on sound fundamentals and leveraging Agentic AI together with capabilities like AIOps, to deliver a realistic and sustainable path to reliable network autonomy.

The foundation: A robust data-driven architecture

Nokia's AgenticOps approach leverages a modular, end-to-end architecture purpose-built for telecom. It begins with a robust data governance framework ensuring high-quality data, which is critical for AI and automation. At its core lies a unified data fabric featuring a telco-specific data layer, an ontology engine, model management and an agentic framework with an agentic studio. This powerful combination empowers specialized, goal-driven agents with structured, semantically rich information, enabling advanced reasoning, intelligent correlations and effective decision-making within dynamic operational contexts. While the blueprint includes all the key elements, it is designed with flexibility to interwork with platforms and systems in telecommunication provider environments.

The agentic framework provides essential orchestration, guardrails and policy-based conflict management, guiding agent behavior while ensuring auditability, traceability and explainability for reliable, scalable operations. With flexible delivery models including as-a-service (aaS), hosted, or hybrid, this enables rapid onboarding, cloud-native scalability and a lower total cost of ownership. Designed for openness, it seamlessly ingests and acts on multi-vendor, multi-domain data, making true level 4+ autonomy a tangible reality, not just a faraway dream.

The hybrid advantage: AIOps and AgenticOps in harmony

While AIOps has delivered remarkable advancements in detection and monitoring, a critical "reasoning gap" has often hindered true end-to-end autonomation. This is precisely where AgenticOps steps in. At Nokia, we believe the path to self-managing networks lies in a powerful hybrid AIOps-AgenticOps approach, leveraging the right AI for the right task.

- AIOps as the foundation: For the sheer scale of telecom networks, processing millions of events and billions of performance counters daily, AIOps provides essential, continuous and resource-efficient monitoring. It acts as our always-on intelligence layer, correlating vast data streams, detecting anomalies and generating critical triggers for deeper intervention.
- AgenticOps for deep reasoning and action: When AIOps triggers activate, AgenticOps shines. We reserve these sophisticated, goal-driven agents for complex analysis, cognitive reasoning, nuanced understanding, precise decision-making and generating targeted actions. They operate with persistent context, ensuring intelligent and effective responses to critical incidents, enabling the leap to autonomous action, filtering operational noise, intelligently triaging, synthesizing optimal solutions and adaptively executing them.

Looking at a real-world example: AIOps predicts a VoLTE service degradation, triggering an agent to perform causality-based analysis for root cause identification. This input then activates another agent to generate the appropriate rectification action, which is validated for accuracy and subsequently executed in a closed-loop fashion.

This balanced design ensures scalable, real-time network operations while maintaining the analytical depth required for the most critical challenges. It's a testament to Nokia's strategic mindset: leveraging the right AI for the right task, building autonomous networks that are both efficient and profoundly intelligent.

What makes Nokia's approach superior?

Our unwavering commitment to taking the right action in the right manner sets Nokia's AgenticOps approach apart. It stands out through its pragmatic, safety-first and human-centric approach, reflecting our deep understanding of telco environments:

- **Progressive path to autonomy:** We don't demand an immediate, risky leap. AgenticOps supports a gradual progression through TM Forum's autonomy levels with explicit stage gates and measurable readiness criteria. Telcos build confidence through operational evidence, progressing from recommendations to supervised execution and ultimately to full autonomy based on demonstrated reliability.
- **Defense-in-depth safety mechanisms:** Our framework embeds multi-layered safety directly into the architecture: needed safety controls, guardrails governing agent operations, simulation of predicted outcomes against a digital twin and sophisticated mechanisms to monitor accuracy and confidence against calibrated thresholds.
- **Augmenting human expertise:** AgenticOps augments, rather than replaces, human expertise. Our design incorporates essential human intervention and supervision with approval points until models achieve greater maturity and determinism.
- **Comprehensive auditability:** A modular approach ensures full traceability, explainability and transparency for every decision and action taken by collaborating agents.

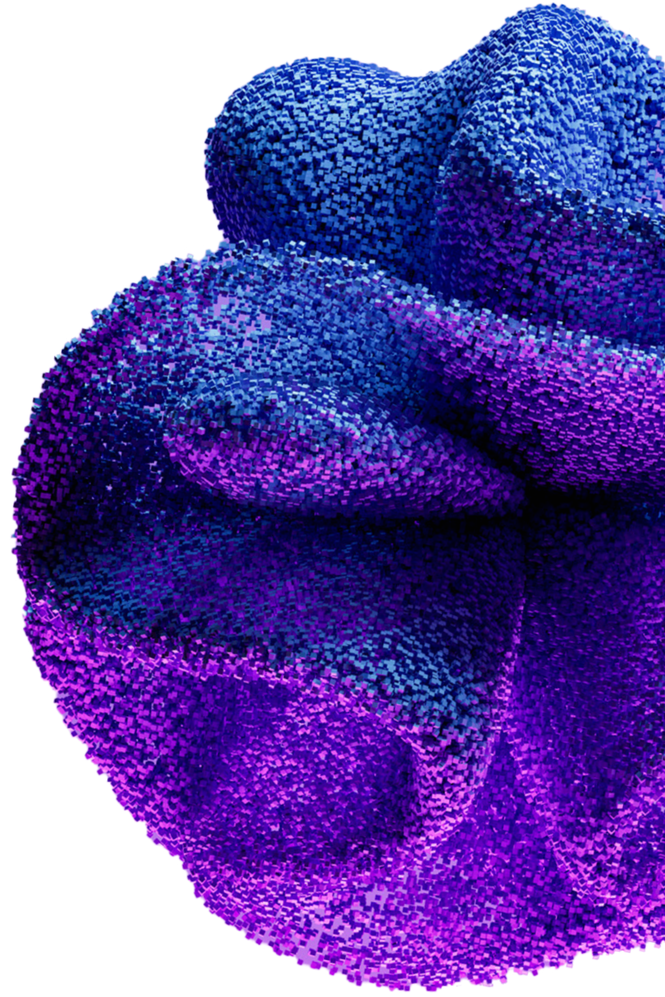
Is it time to go agentic?

Autonomous network operation is no longer a distant vision; it's a business imperative for telcos navigating escalating complexity and competitive pressures. AgenticOps is not just "smart automation"; it's a strategic transformation lever redefining how networks are managed and optimized and so the question is not 'if', but 'when', 'where' and 'how'. A very safe place to start would be with use cases that assist humans in dealing with topics that are tedious, time-consuming, or require context-sensitive actions. It might be wise to start with agents in a 'recommendation' mode until they demonstrate consistent performance with low failure rates, thereby earning the right to 'autonomous' execution.

To unlock its full potential, AgenticOps must be applied thoughtfully, starting with high-value areas where risks can be effectively managed. Nokia advocates a nuanced approach with suitable guardrails, policy gates and validation mechanisms, such as digital twins, ensuring that only actions demonstrating acceptable simulated outcomes advance to deployment. Robust security and risk mitigation strategies should be integrated from the outset, rather than being added as an afterthought.

Future-proofing autonomy with AgenticOps

Agentic AI not only accelerates the path to full autonomy but also lays the groundwork for the next frontier in intelligent operations. Think about agents for service design, intent resolution, multi-domain orchestration, proactive threat hunting and contextual issue analysis, all deriving auto recommendations and generating resolution actions. Fully autonomous networks are well within reach! This progression sets the stage for networks that not only execute tasks but also continuously learn, reason and refine their own objectives in alignment with business strategy. With AgenticOps at the core, telcos can future-proof their autonomation journey, ensuring the network remains agile, intelligent and ready for what comes next.



The “twin first” revolution: Reimagining network operations with digital twins

Network digital twins (NDTs) are emerging as a key catalyst on the journey to autonomous operations. While real-life twins, especially in their early years, can be quite a handful and require careful management, in the case of digital twins, it is just the opposite! They can be quite handy in simplifying network management by reducing the need for human attention. As the telecom industry continues to undergo a revolution, fueled by 5G, the evolution of cloud-native technologies and open ecosystems, the demand for “always-on” networks with guaranteed SLAs for personalized experiences, continues to grow. NDTs play a significant role in enabling these services and experiences.

What are network digital twins?

Network digital twins are virtual representations of real-world networks, that are constantly updated with real-time data. While network digital twins at the domain level have been around for a while, focusing on domain-specific planning, dimensioning, traffic and resource management aspects, emerging standards like ZSM and ITU-T are exploring "service digital twins" or "end-to-end digital twins," or “system twins”. These have a cross-domain focus and provide a holistic model for understanding impacts on service performance, potential issues due to changes in network behavior and means to optimize efficiency in operations. They provide a simulation environment for planning and operating networks while having a comprehensive view of network entities, their states, traffic and their interactions.

The end-to-end NDT offers the following key components:

- Data is used to create a digital replica of the physical entities leveraging network data models and network state.
- Models are used to deliver a summarized view of the network for a particular context.
- Intelligence brings the capabilities to predict behaviors of given scenarios and run what-if scenarios.
- Closed-loop management builds the interaction between the virtual and physical network, including providing recommendations on the actions to be performed.

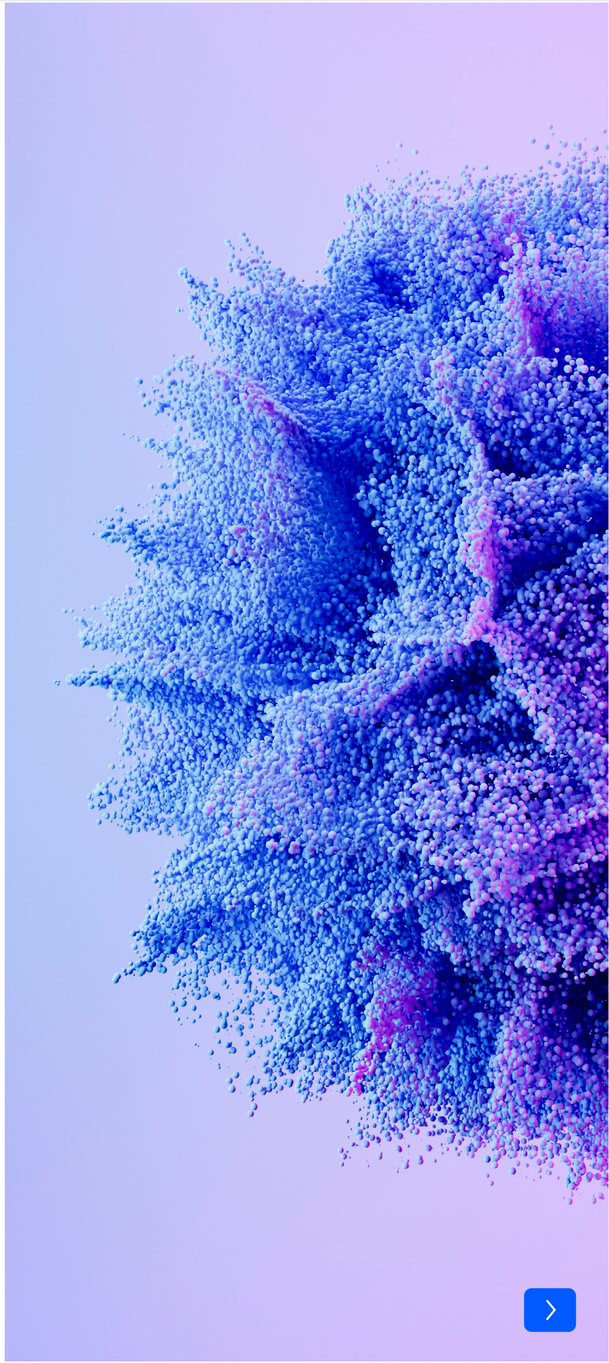
"Twin-first" approach to operations

End-to-end digital twins are no longer a futuristic concept; they're the key to unlocking a new era of network operations. Nokia's "twin first" approach puts digital twins at the heart of every decision, where operations are executed first in the twin environment. Imagine a world where:

- **Planning is risk-free:** Before a service is launched, you can assess the feasibility of a new service on a digital twin, ensuring smooth deployment and minimizing potential failures.
- **Maintenance is proactive:** Simulations on the digital twin reveal vulnerabilities before they impact real-world networks, eliminating the need for unplanned downtime and maximizing network uptime.
- **Operations are optimized:** Evaluate alternatives and pre-verify outcomes on the digital twin without impacting the real network to arrive at optimal recommendations to solve service problems or fine-tune the performance.
- **Care is predictive:** Potential failures are identified and addressed before they occur, ensuring a resilient and available network that's always one step ahead.

This ensures that potential issues are identified and mitigated, fine-tuned for improved accuracy thereby enabling a path to zero wait, zero trouble networks. Digital twins can be leveraged for several use cases:

- **Proactive planning and what-if analysis:** Consider the scenario of taking down a router for maintenance, without knowing the potential impact caused by this action. With NDTs, you can run a "what-if" analysis to assess the impact on end-user services, identify potential bottlenecks and ensure sufficient redundancy. This proactive approach eliminates surprises and ensures seamless service continuity. In the case of network slice operations, one can understand the impact on slice performance under various failure scenarios, from network function outages to link failures and overload conditions to identify potential vulnerabilities and propose solutions before they impact real-world operations.
- **Boosting business agility and customer engagement:** A service digital twin, powered by a NDT, can assess the network's readiness for a new service, identify potential capacity/resource bottlenecks and even suggest the best deployment strategy to meet agreed service level agreements (SLAs). This allows operators to be more agile in responding to market demands and deliver a superior customer experience.
- **Maximizing efficiency and service delivery:** NDTs can optimize network resource allocation, find optimal service configurations and ensure efficient service delivery. With a digital twin, policies and automation can be pre-validated in a sandbox environment to simulate their impact and identify potential issues before deploying them in production. This eliminates the need for multiple trial-and-error iterations, saving time and resources.



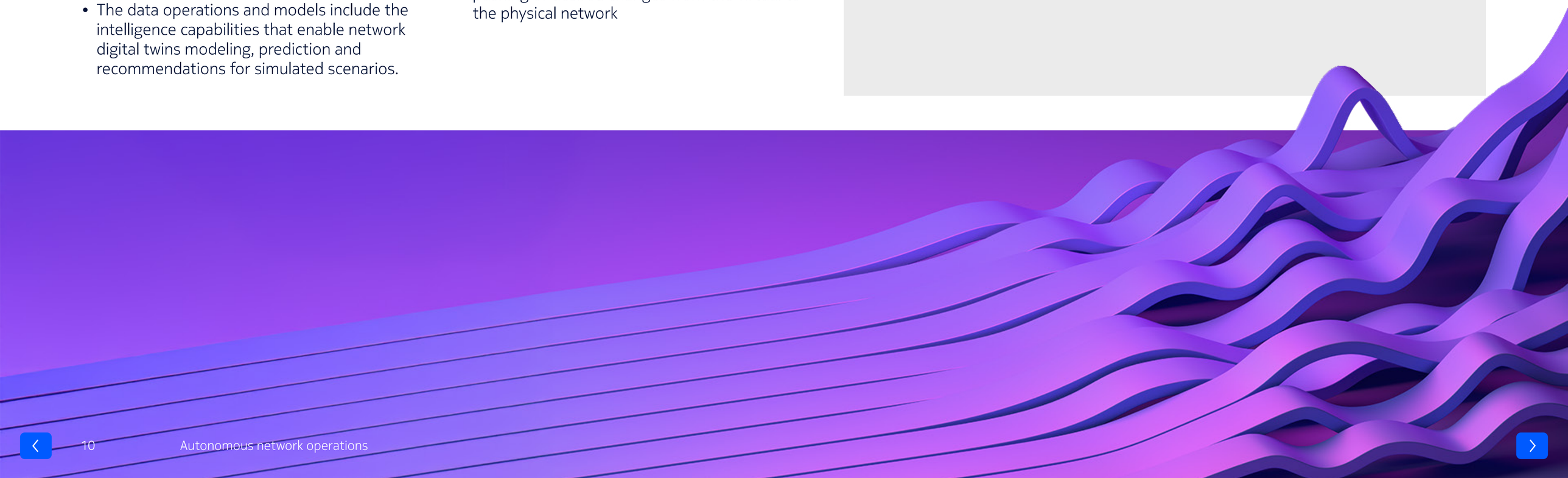
Our approach to realizing the service digital twin

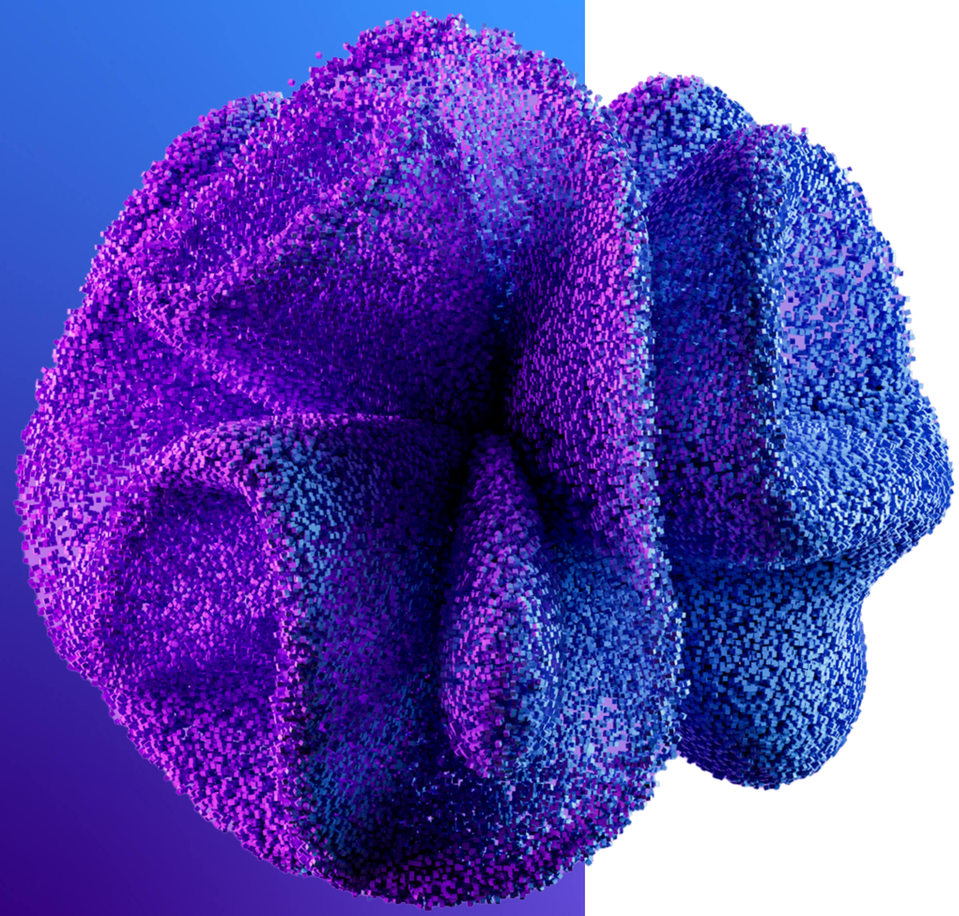
Nokia provides digital twins for service and the end-to-end network layer by leveraging the following capabilities.

- The unified data repository and entity management hold a near-real-time view of the data from the physical network. This forms the foundational layer for the virtual twin view, including the operational state, performance, configuration and topology of the network and relies on advanced observability concepts.
- The data operations and models include the intelligence capabilities that enable network digital twins modeling, prediction and recommendations for simulated scenarios.
- AIOps and intent management are two key pillars that incorporate the knowledge to support such intelligence, also relying on AI/ML and GenAI capabilities. GenAI helps to bring more autonomy in the form of autonomous agents, auto-generated policies and workflows, etc. This helps to turn the shared situation awareness and what-if predictions into business value, like in the case of end-to-end network planning & optimization under dynamic operating conditions.
- The automation layer enables the control and pushing of desired changes from the virtual to the physical network

The future of network operations

NDTs are not just a tool for network optimization; they represent a fundamental shift in how we approach end-to-end operations. Digital twins offer a powerful way to simulate real-world scenarios, predict outcomes and make informed decisions before any changes are implemented. The power of simulation and analysis will be transformative for operations in driving customer experience and service differentiation while optimizing costs and lowering the risk to operations. Telcos can embrace NDTs to improve their processes, workflows and decision making to increase operational speed, efficiency and to deliver a higher service quality.





Knowledge Graphs: The lifeline for resilient autonomous networks

Natural disasters are becoming increasingly frequent and devastating. They claim lives, cause immense economic damage and disrupt vital telecom networks, hindering rescue and recovery efforts. This is where knowledge graphs come in. This chapter explores how knowledge graphs can enhance network resilience to ensure reliable communication during both normal and disaster conditions.

Telecom networks are inherently complex with interconnected elements like devices, customers, services and locations. Network and service operations rely on vast amounts of data related to service delivery, assurance, security and regulatory compliance. This complexity makes operational decision-making challenging and prone to errors, slowing the evolution towards autonomous networks.

What is a knowledge graph?

A knowledge graph is a structured representation of knowledge that uses a graph-based data model to organize and connect information. It consists of entities (nodes) and the relationships (edges) between them, enabling the representation of facts, concepts and their interconnections in a machine-readable format. This enables semantic reasoning, data integration and context-aware insights.

Why are knowledge graphs well suited for telecom networks and their operation?

Knowledge graphs streamline the management of complex telecom networks by providing a unified view of the network, its services, customer usage, service agreements and relevant staff. This unified view provides a semantic representation of all aspects of networks and their operations, including defined relationships between them. In turn, this approach makes it easier to programmatically analyze these relationships, eliminating the need for humans to manually sift through countless data sets.

Knowledge graphs are ideally suited to represent complex relationships and to enable advanced analytics, automation and decision-making. As a result, they are becoming increasingly important in telecom operations.

Knowledge graphs facilitate contextual understanding by capturing and leveraging relationships between entities, enabling deeper insights. Their scalability allows them to handle the large, dynamic datasets typical in telecom networks. Furthermore, knowledge graphs promote interoperability by integrating data from diverse systems and formats, enabling intelligent automation of network operations and service management.

All this helps telecommunication providers to improve service delivery and experience while reducing operational expenses.

Knowledge graph capabilities and use cases

Capabilities of knowledge graphs for network and service operation include:

- Data integration from different OSS systems such as inventory, trouble ticket, fault or performance management into a single knowledge graph provides a unified view of network operations.
- By representing physical and logical network elements, their relationships and dependencies, knowledge graphs provide real-time network topology visualization.
- They enable fault diagnosis and root cause analysis by leveraging graph-based reasoning to identify the root cause of issues.

These capabilities can be applied to many different use cases, with some examples outlined below:

For service orchestration use cases, knowledge graphs can be used to model end-to-end service workflows and dependencies, automating service provisioning and lifecycle management. They also enable service assurance by mapping services to underlying network resources, enabling the detection and resolution of service degradation.

For predictive maintenance use cases, knowledge graphs leverage historical data to predict potential failures, allowing for proactive issue resolution before they impact services. They also improve customer experience management by linking customer profiles, service usage and network performance data, enabling the identification and resolution of issues impacting customer experience.

Knowledge graphs support network optimization by analyzing relationships between network performance metrics and configuration parameters, leveraging graph-based insights to recommend optimization strategies. Finally, they support compliance and auditing by tracking relationships between network configurations, policies and regulatory requirements, ensuring compliance with industry standards and regulations.

Example use case: emergency management

Emergency management solutions need to constantly monitor for natural emergencies like floods or fires and aim to restore telecom services on a priority basis in affected areas. For example, service restoration for hospitals could be prioritized over other services in affected locations.

Knowledge graphs can be used to effectively build a semantically connected data model that includes information about the network, location of equipment and customers and network events. When combined with information from government or private sources about the time and location of natural disasters, the resulting knowledge graph can then be used to quickly determine:

- impacted services in affected areas
- customers who are impacted
- high-priority customers who require prioritized service restoration, such as hospitals.

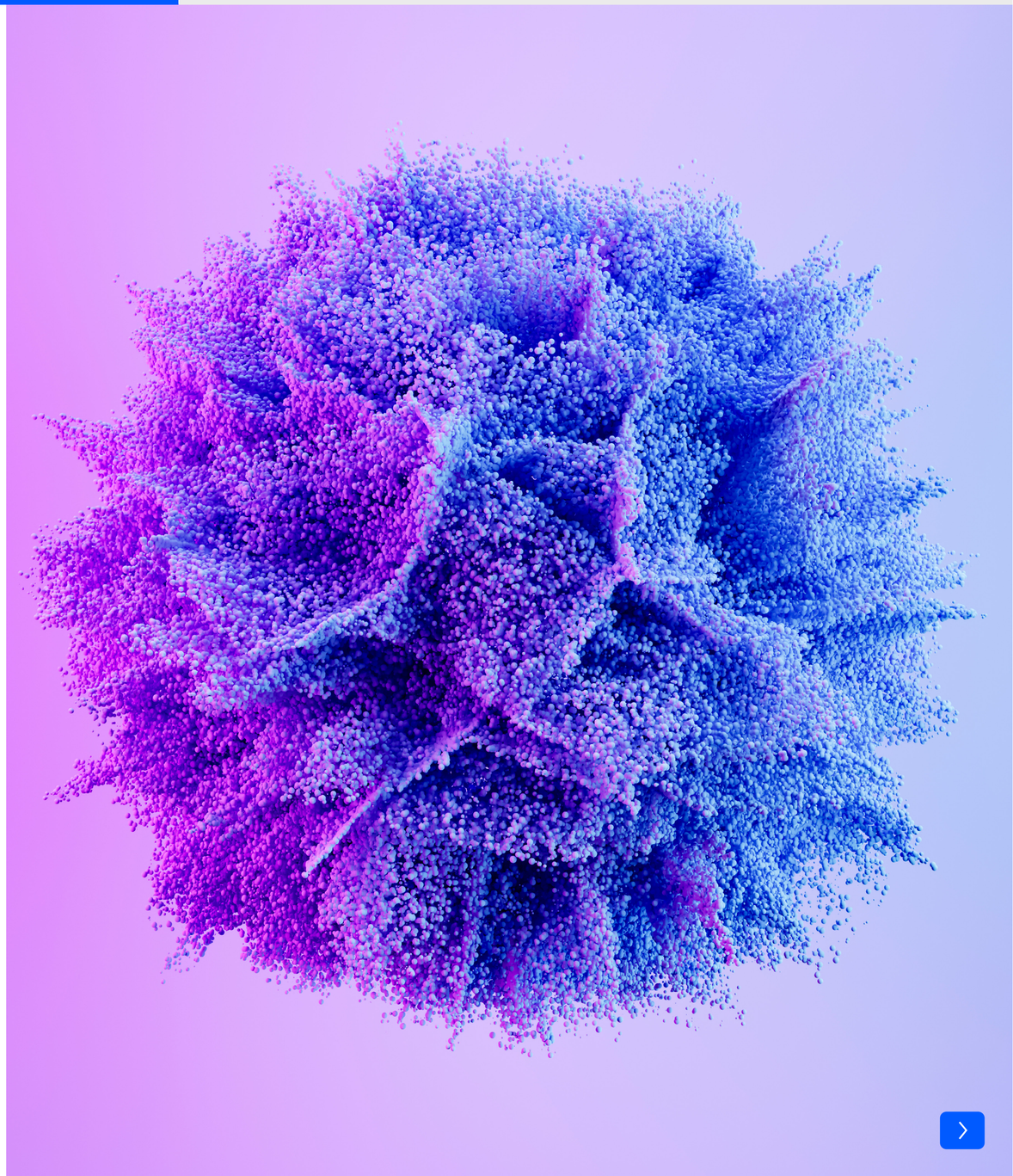
This information enables faster and prioritized restoration of services and avoids time-consuming and complicated coordination between different systems and departments.

Knowledge graphs are transforming telecom networks and operational systems

Knowledge graphs are transforming telecom networks and operational systems by providing a unified, contextualized view of complex data. They enable advanced analytics, automation and decision-making, helping telecom operators improve the service experience of their customers and to reduce operational costs.

Looking ahead, artificial intelligence can be used to automatically build and update knowledge graphs from unstructured data. Knowledge graphs will also be used for the creation of network digital twins to facilitate simulation and optimization efforts. Furthermore, graph-based reasoning will empower autonomous networks by enabling self-healing and self-optimizing capabilities.

As networks evolve towards autonomy, knowledge graphs play an increasingly critical role in managing complexity and enabling innovation even in disaster situations.



Autonomous network operation requires a new approach to telecom inventory management

In the modern digital age, seamless communication is the cornerstone of global connectivity. Today's complex and intricate telecom network needs to enable reliable services for consumers, enterprises and mission-critical purposes. Telecom inventory management is at the heart of this expansive modern communication infrastructure.

Defining dynamic telecom inventory management

Telecom inventory management solutions provide a comprehensive database tracking detailed information about physical and logical components. This traditionally includes cell towers, cables, switches, routers, antennas and network devices. Modern inventory solutions leverage a data-mesh approach to go beyond this, mapping end-to-end services to the physical network. This enables root cause analysis (RCA), domain stitching and correlation analysis for software configurations, network connections and relationships between elements. The inventory provides data aggregation, normalization and network observability, serving as a single source of truth for operational support systems (OSS) and business applications in communications service provider (telco) organizations.

Automation requirements for telcos

Today, telcos face the challenge of having to shrink operating costs while implementing new services faster and boosting revenues at the same time. Automation is critical to achieving these objectives. A precise and dynamic inventory system forms the foundation for effective automation by leveraging a deep understanding of network and services and real-time insights. Let's explore the characteristics of a modern inventory solution designed for autonomous networks.

Observability: The ability to discover existing and new network elements (physical, virtual or containerized) in a highly dynamic environment is crucial. Creating the relational connections and graphs for these elements provides the foundation for RCA, as well as further processing by machine learning (ML) platforms and other automation tools. The accuracy of models is directly linked to the quality of data, the oxygen for any modern system.

Normalization: Data aggregation, normalization and labeling are crucial to efficiently linking to northbound systems. For any network today, multi-domain and multi-vendor stitching and the creation of service abstraction are essential functions. Additionally, defining relationships between physical elements and logical services is crucial to establish the effects of a failure and to perform service impact analysis.

Optimization: The insights available in modern inventory solutions can be used to recommend the most efficient routes, optimize energy usage and perform spectrum optimization. ML tools can enable pattern recognition among similar services, facilitating suggestions for the best route or service path based on the knowledge graph of past service utilization. When integrated with intent-based orchestration, this results in a highly intelligent system capable of autonomously defining services and KPIs.

Openness: To avoid vendor lock-in for products or services, it's essential for inventory systems to work and integrate with multiple vendors while enabling telcos to create their own models, adapters and configurations. A powerful software development kit (SDK) assists in achieving this flexibility.

Digital twins: One notable feature of digital twins is the ability to emulate network elements and their corresponding behaviors. They also allow for the definition and emulation of service impact. Combined with RCA, this can provide insights into the future state of the network. Digital twins also aid the identification of critical network resources through prioritized monitoring, determined by the number of services utilizing each resource. They also enable redundancy simulation and planning for these critical resources and paths within the network.

Inventory is the foundation for autonomous networks

Inventory management might seem like a behind-the-scenes aspect of modern telecoms systems, but it's the backbone that upholds the seamless connectivity we often take for granted. As the world becomes more interconnected and reliant on robust communication, effective inventory management remains pivotal for enabling progress and ensuring a connected future.

A modern inventory solution provides the foundation for increased automation and improved service enablement. Nokia Unified Inventory provides all necessary capabilities for services and service assets in near real-time. This is essential for modern functions like MLOps, AIOps, orchestration and assurance. It also offers a common data plane to those applications, enabling better data integrity and driving the adoption of network automation.

Case study: Making tailored customer experiences a reality with 5G, AI and orchestration (Telenor Norway)

There is still a significant gap between the full potential of 5G and accessibility for customers with highly diverse use cases and requirements. Together with a partner ecosystem including Nokia, Telenor Research & Innovation in Norway aims to bridge this gap by abstracting underlying technical complexities through AI and automation to offer private 5G solutions that best address specific customer needs.

Leveraging an experimental platform to strengthen 5G uptake and monetization

Telenor worked with its partners to create iCORA, an innovative, cloud-native, open, resilient and automated experimental platform for end-to-end 5G services. This large-scale platform is now running live in the Telenor lab environment in Oslo. Most recently, it was used for a project that demonstrates how the ordering of private or dedicated/sliced 5G network capabilities can be simplified with a GenAI-enabled customer portal and end-to-end service orchestration capabilities.

For this project, Nokia Orchestration Center manages the end-to-end 5G service orchestration across the solutions from the various partners. In addition, the process of gathering requirements has been simplified. In the customer portal, an LLM-powered chatbot assistant captures the customer requirements (i.e., the intent) in natural language and translates them into an intent-based order towards the Orchestration Center using the TMF921 Intent Management API. Orchestration Center then leverages an LLM to translate the intent order to a technical order, specifying the technical parameters to create the required 5G network for a specific use-case.

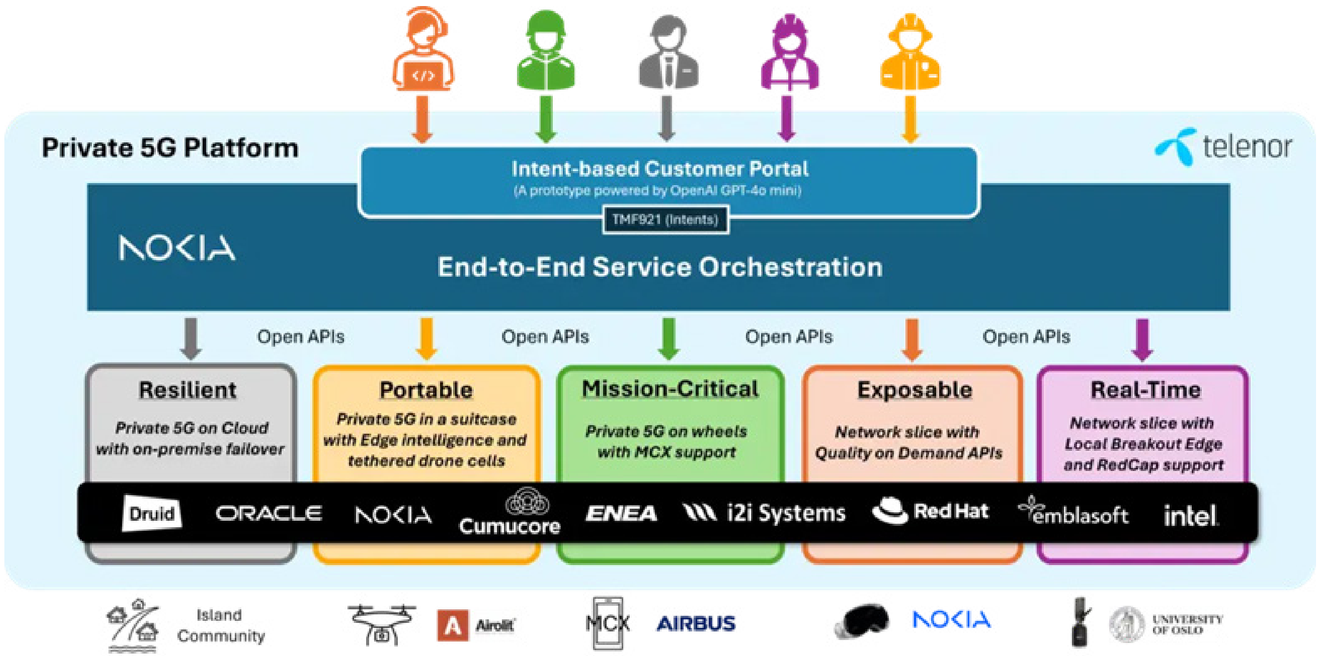
Use cases

Shown from left to right in the diagram below, the following use cases were implemented as part of the project:

1. Autonomous 5G for an island community: At Svalbard, an archipelago in the Arctic Ocean, a private 5G network was deployed with two 5G cores for high resilience: the main core on the cloud and an on-premises failover core.
2. Support of edge intelligence and drone cells: A portable 5G network with extendable coverage through a tethered drone offered support for AI-driven object detection at a disaster site.
3. Mission-critical applications: A mobile 5G network on wheels was driven to an emergency site, enabling mission-critical services for first responders.
4. Network exposure for forestry applications: With real-time monitoring, a mission-critical application can be given priority on demand over a surveillance application in an emergency.
5. Industry 4.0 robotics: A local breakout edge ensured low latency for a robotic arm, with RedCap monitoring.

Customer intent and requirements are extracted from the AI conversation, such as “mission-critical 5G” for an emergency network or “exposable 5G” for advanced capabilities such as quality-on-demand (QoD). Once the intent is confirmed with an order, the required API calls are automatically sent to the relevant 5G systems for service activation, including equipment reservation for portable solutions. For slice-based deployments, Orchestration Center triggers the relevant workflows for automated deployment of tailored slice configurations, user provisioning and service activation.

Orchestration Center operates on any cloud and across all network domains. When combined with assurance, it supports closed-loop automation and other capabilities required to achieve autonomous operations – the ultimate objective for Telenor and many telecommunication providers around the world. For this project, the implementation is mainly focused on orchestrating and provisioning the core domain including edge sites in a fully cloud-native environment. The slice-based private 5G network is delivered by network functions provided by various vendors, all triggered by the same order initiated through the customer portal. The orchestration of the edge site at the University of Oslo covers the user plane function (UPF) and other third-party applications.



Breaking down technology barriers

With this project, Telenor, Nokia and the broad partner ecosystem are enabling enterprises and public institutions to leverage the full potential of 5G by hiding the technical complexity with AI and automation. By breaking down technology barriers, the platform enables accelerated innovation for any type of 5G service.

Case study: Evolving to autonomy - a catalyst for the future of networks (Moonshot catalyst)

The telecom industry is on a journey to fully autonomous networks. This means the network operates independently with closed-loop automation across services, domains and lifecycle stages and requires minimal to no human intervention. Most telcos aim to achieve autonomous networks in the short to medium term and Nokia is playing a key role in driving this evolution.

A catalyst for innovation

The TM Forum has been propelling this journey and Nokia has been an active participant in TM Forum catalysts for several years. Catalyst projects bring together telcos and technology providers to co-create solutions with a specific focus on AI and automation. They are all about collaborating to drive innovation across our industry and beyond. In 2025, Nokia was leading a Moonshot Catalyst, Evolving to full network autonomy. Through this catalyst project and together with several technology partners and telco champions, we are revolutionizing network operations with fully autonomous, AI-driven, self-managing networks.

Business-focused use cases

Intent-driven autonomous networking (IDAN) promises to revolutionize how we manage and optimize our networks and intent management with TMF921 plays a crucial role in enabling this transformation. At Nokia, we've been at the forefront of IDAN innovation, conducting numerous TM Forum catalysts to explore different functionalities and opportunities that come with it. This Catalyst tackled one of the telecommunications industry's most ambitious challenges: achieving fully autonomous networks at scale; networks that can self-configure, self-heal and self-optimize, or, as we like to say, networks that can sense, think and act.

In the Catalyst, we showcased two highly interesting aspects and explained how digital twins fit into the intent negotiation and intent assurance processes.

Firstly, we looked at the time before the intent is created and supported the creation of the intent. There, we combined TMF921 probing with a network digital twin, enabling telcos to significantly enhance the reliability of their services and reduce the risk of customer dissatisfaction. This approach involves simulating the service intent against the digital twin to validate its feasibility before it's sold. This proactive approach ensures that the service can be delivered as promised, minimizing the risk of overselling or under-delivering.

Imagine an event organizer planning a large outdoor event, like a Formula 1 race and needing guaranteed connectivity for point-of-sale devices and streaming services. By using TMF921 probing, telcos can simulate the service intent, considering the event location, date and expected device usage. A digital twin, with its real-time data and historical information, can then assess the network capacity and identify potential bottlenecks.

Once a service intent is ordered and orchestrated, the process of assuring the intent begins. Data is collected and AIOps monitors the network for anomalies, predicting potential issues before they arise. Agentic AI and LLMs analyze the situation and generate dynamic actions to address any problems. We utilize the digital twin, which simulates these actions, to ensure that they have the predicted impact on the network. The most optimal actions out of those tests are then presented to the user for approval. Upon approval, the actions are automatically executed on the network, taking closed-loop autonomous management to the next level.

The power of combined technologies

TMF Catalyst projects are invaluable platforms for exploring new technologies and concepts, collaborating with partners and pushing the boundaries of innovation. This recent Catalyst showcased a powerful convergence of technologies, particularly in the realm of autonomous networks, intent management, agentic AI architecture and digital twins.

Our Catalyst delivered a bold yet practical implementation of Level 4+ autonomous network capabilities, demonstrating how telcos can evolve from reactive operations to proactive, intent-driven autonomy, powered by AI, Digital Twins and TM Forum standards. We do this through:

TMF921 Intent Management API: We've been actively testing the TMF921 Intent Management API, building upon the feasibility checks conducted with TMF645. This API enables sophisticated scenarios, allowing us to integrate knowledge bases, AI-driven traffic prediction and service simulations on the digital twin into the probing process.

Agentic AI architecture: The Catalyst showcases the use of LLMs and Retrieval-Augmented Generation (RAG) in the assurance process, highlighting our transition towards an agentic AI architecture. LLMs serve as the "brain" of these agents, enabling us to convert network anomalies into actionable insights.

BSS integration: The TMF APIs facilitate seamless integration with the business layer, ensuring a comprehensive and efficient solution.

Digital twin simulation: We demonstrate how AI Agents can simulate the impact of actions on the digital twin, verifying the effectiveness of generated actions before implementing them on the actual network.

Better together

Our Moonshot Catalyst project showcased the power of collaboration and the rapid evolution of technologies. It was a significant milestone in the telecommunications industry's pursuit of fully autonomous networks.

By integrating TMF APIs, GenAI and digital twins, telcos can unlock new business potential, enhance customer experience and achieve operational excellence, setting a new industry benchmark for intent-driven networks that continuously adapt to evolving demands.

Learn more

Nokia Autonomous Networks Suite

- Nokia Assurance Center - AI-driven automated network and service assurance for autonomous networks
- Nokia Orchestration Center - Intent-based service orchestration for autonomous networks
- Nokia Unified Inventory - a new approach to telecom inventory management for autonomous networks

Success stories

- stc case study
- Telenor case study
- Catalyst: Autonomy accelerated: Intent to impact - Phase II

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About Nokia

Nokia is a global leader in connectivity for the AI era. With expertise across fixed, mobile, and transport networks, we’re advancing connectivity to secure a brighter world.