

Intent-Based Networking: A Comprehensive Review of Autonomous Network Management

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Abstract - The increasing complexity of modern communication networks has created significant challenges for traditional network management approaches. The rapid adoption of cloud computing, Internet of Things (IoT) ecosystems, software-defined infrastructures, and next-generation mobile networks has resulted in environments that are difficult to manage through manual configuration and static policies. Consequently, organizations are seeking intelligent solutions capable of reducing operational complexity while maintaining performance, security, and reliability. Intent-Based Networking (IBN) has emerged as a promising paradigm that enables administrators to express desired business outcomes rather than device-specific configurations. By leveraging Software Defined Networking (SDN), Artificial Intelligence (AI), Machine Learning (ML), and network automation technologies, IBN translates high-level intents into executable policies and continuously verifies network behavior against intended objectives.

Key Words: IoT, ML, IBN, AI, SDN.

1. INTRODUCTION

Over the past decade, communication networks have undergone a dramatic transformation. The widespread adoption of cloud services, virtualization technologies, edge computing platforms, and Internet of Things (IoT) devices has fundamentally changed how networks are designed and managed [2], [3]. Modern enterprises operate highly distributed environments consisting of thousands of interconnected devices, applications, and services that must function reliably under continuously changing conditions [4].

Traditional network management approaches rely heavily on manual configuration and device-centric administration. Although these methods have been effective for relatively

static environments, they often struggle to meet the requirements of modern infrastructures [2]. Network administrators are required to configure numerous devices individually, enforce policies across heterogeneous environments, and troubleshoot increasingly complex systems. As network scale grows, manual operations become time-consuming, error-prone, and difficult to maintain [3], [4].

Several studies have identified configuration errors as a major contributor to network outages and security incidents [3]. Furthermore, the growing demand for rapid service deployment and dynamic resource allocation has exposed limitations in conventional management frameworks [4]. These challenges have motivated the development of more intelligent and automated approaches to network operations [5].

Intent-Based Networking (IBN) has emerged as a promising solution to these challenges. Unlike traditional networking approaches that require administrators to define low-level configurations, IBN enables users to express desired business outcomes through high-level intents [1], [5]. The network subsequently translates these intents into executable policies, deploys appropriate configurations, and continuously verifies whether the intended objectives are achieved [1].

2. Evolution of Network Management

Network management has evolved through several distinct phases, each addressing limitations of previous approaches [2].

Early communication networks relied almost entirely on manual administration. Network engineers configured routers, switches, and security devices individually using command-line interfaces. While suitable for small-scale deployments, this approach became increasingly difficult as networks expanded [2], [3].

The introduction of policy-based management systems represented an important step toward automation. Policies allowed administrators to define operational rules that could be applied across multiple devices. However, policy management still required detailed technical knowledge and often lacked flexibility [4].

Software Defined Networking (SDN) introduced a more significant transformation by separating the control plane from the data plane and enabling centralized network programmability [3]. Despite these improvements, administrators were still responsible for translating business requirements into technical policies [2].

Intent-Based Networking extends this evolution by introducing an abstraction layer between business objectives and network operations [1]. Instead of defining how a network should behave, administrators specify what outcomes should be achieved. This shift from configuration-centric management to outcome-oriented management represents a fundamental change in networking philosophy [1], [5].

3. Literature Review

Recent research demonstrates growing interest in Intent-Based Networking as a mechanism for achieving autonomous network management [1], [5].

Clemm et al. introduced foundational concepts and terminology for intent-based systems, emphasizing the importance of intent abstraction and continuous assurance [1]. Their work established a common framework for discussing intent-driven architectures and influenced subsequent standardization efforts.

Mestres et al. explored the integration of artificial intelligence with network management through the concept of Knowledge-Defined Networking [6]. Their findings highlighted the potential of intelligent analytics and machine learning techniques to improve network decision-making processes.

Several researchers have investigated the relationship between SDN and IBN. These studies generally conclude that SDN provides the programmability required for intent implementation, while IBN adds a higher level of abstraction that simplifies network administration [2], [3].

Recent studies have also focused on applying IBN in 5G environments. Researchers report that intent-driven management can significantly improve network slicing,

resource allocation, and service orchestration [4], [5]. However, challenges remain regarding scalability and interoperability across heterogeneous infrastructures [1].

4. Benefits and Challenges Benefits

Studies have shown that IBN can reduce operational complexity by automating policy translation, deployment, monitoring, and verification processes [1], [5].

Automated intent translation significantly accelerates service provisioning and reduces the likelihood of configuration errors, which are among the leading causes of network outages [3], [5].

The integration of AI and machine learning enables predictive analytics, intelligent resource allocation, and proactive fault management, contributing to improved reliability and network performance [4], [6].

Challenges

Despite its potential, IBN faces several technical and operational challenges. One of the most significant challenges is the accurate interpretation of human intent, as natural-language requirements may be ambiguous or context-dependent [1].

Interoperability remains another concern because many organizations operate heterogeneous infrastructures that include legacy networking equipment with limited automation capabilities [2], [5].

Researchers have also highlighted concerns regarding the explainability of AI-driven decisions, particularly in mission-critical networking environments where administrators require transparency and accountability [4], [6].

5. CONCLUSIONS

Intent-Based Networking (IBN) represents a significant advancement in the evolution of network management by shifting the focus from device-level configurations to high-level business objectives. As modern communication infrastructures continue to grow in complexity due to cloud computing, IoT ecosystems, edge computing, and next-generation mobile networks, traditional management approaches are increasingly unable to meet the requirements of scalability, agility, and operational efficiency.

The literature reviewed in this paper indicates that IBN has the potential to simplify network operations through automation, continuous assurance, and intelligent decision-making capabilities. By integrating Software Defined Networking (SDN), Artificial Intelligence (AI), Machine Learning (ML), and orchestration frameworks, IBN enables networks to automatically translate user intent into executable policies while continuously monitoring network behavior to ensure compliance with desired objectives. These capabilities contribute to reduced operational complexity, faster service deployment, improved reliability, and enhanced security policy enforcement across diverse networking environments.

Despite these advantages, several challenges continue to hinder widespread adoption. Issues such as intent ambiguity, interoperability across heterogeneous infrastructures, explainability of AI-driven decisions, and integration with legacy systems remain active areas of research. Furthermore, many existing studies have been conducted in controlled environments, highlighting the need for additional large-scale industrial evaluations to validate the long-term effectiveness of intent-based approaches.

Future developments in autonomous networking, digital twin technologies, explainable artificial intelligence, and 6G communication systems are expected to strengthen the practical applicability of Intent-Based Networking. As standardization efforts mature and implementation challenges are addressed, IBN is likely to become a foundational technology for self-managing and self-optimizing networks capable of operating with minimal human intervention.

In conclusion, Intent-Based Networking offers a promising pathway toward fully autonomous network management. Although the technology is still evolving, current research and industry developments suggest that IBN will play a central role in shaping the next generation of intelligent, adaptive, and resilient communication networks.

6. References Used

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