



AI-Enabled BOM Lifecycle for P4- Programmable Infrastructure Reliability

Revolutionizing network infrastructure reliability
through AI-driven Service Bill of Materials
methodologies adapted for P4-programmable data
planes

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The Evolution of Network Infrastructure

Traditional Networks

- Static configurations
- Manual provisioning
- Reactive maintenance
- Limited programmability

P4-Programmable Infrastructure

- Dynamic data plane programming
- Software-defined behavior
- Automated deployment
- Enhanced flexibility

P4 is revolutionizing how network infrastructure is defined, deployed, and managed. However, even the most advanced programmable data planes require predictable failure management and consistent provisioning to maintain service reliability.

The Challenge: Reliability in Programmable Networks

While P4 brings unprecedented flexibility to network programming, it also introduces new complexity in infrastructure management. Programmable data planes still depend on underlying hardware reliability, predictable failure patterns, and orchestrated lifecycle management.

Traditional reliability approaches fall short when applied to P4-backed infrastructure. Network engineers need methodologies that account for both the programmable nature of P4 and the physical realities of datacenter hardware.



Introducing AI-Driven Service BOM Methodologies

Service BOM Foundation

Proven datacenter-scale methodologies for managing infrastructure components and their interdependencies through structured bill of materials approaches.

AI-Powered Intelligence

Machine learning models that predict failures, optimize provisioning, and automate lifecycle management decisions based on historical patterns.

P4 Adaptation

Specialized integration with P4 control APIs and programmable data plane characteristics for enhanced reliability management.



Modular Bill of Materials Strategy

Component Modularization

Breaking down P4-programmable infrastructure into manageable, trackable components enables better lifecycle management and failure prediction. Each module maintains its own reliability profile and dependency mapping.

FRU-Based Approach

Field Replaceable Units form the foundation of our reliability strategy. By treating P4 switches and their programmable components as discrete FRUs, we can implement predictive replacement schedules.



Enhanced Reliability Through Modular Design

Component Classification

Catalog all P4-programmable elements with their reliability characteristics, failure modes, and interdependencies within the infrastructure stack.

Dependency Mapping

Establish clear relationships between hardware components, P4 programs, and service delivery to understand failure impact scope.

Lifecycle Integration

Align component replacement cycles with P4 program updates and service maintenance windows for minimal disruption.

Automated Orchestration

Implement systems that can automatically manage component life cycles while maintaining P4 program state and network service continuity.

AI-Powered Predictive Models

AI-powered predictive models analyze patterns across device telemetry, P4 program execution metrics, and historical failure data to forecast potential issues before they impact the data plane.

Failure Prediction

Machine learning algorithms process hardware metrics, environmental data, and P4 program behavior to identify devices approaching failure thresholds. This enables proactive replacement before service impact occurs.

Misconfiguration Detection

AI models trained on correct P4 program deployments can identify subtle misconfigurations that might not trigger immediate failures but could cause future reliability issues.



Integration with P4 Control APIs

P4 Runtime Integration

Direct integration with P4Runtime APIs enables real-time monitoring of data plane state and coordination with BOM lifecycle events.

Orchestration Layer

Middleware that coordinates between BOM lifecycle systems and P4 control plane operations for seamless infrastructure management.

Automated Provisioning

Streamlined deployment processes that handle both hardware provisioning and P4 program installation as unified operations.



Provisioning Automation Architecture

Core Components:

- P4 Control APIs (programmable forwarding)
- BOM Lifecycle (inventory & lifecycle tracking)
- AI Models (forecast failures & capacity needs)
- Hardware Monitoring (telemetry & health signals)
- Provisioning Automation (deployment & config)

Unified control plane ensures consistency between hardware and software lifecycles



Potential benefits

Reduced Onboarding Friction

Automated provisioning processes significantly streamline the deployment of new P4-programmable infrastructure, reducing manual configuration steps and potential human errors.

Improved Uptime

Predictive failure management and coordinated lifecycle orchestration minimize unplanned service interruptions and reduce mean time to recovery.

Streamlined Incident Recovery

When failures do occur, the integrated BOM approach enables faster root cause identification and automated recovery procedures.



Implementation Framework

Assessment & Planning – Evaluate infrastructure, migration strategy

Pilot Deployment – Validate AI-BOM on subset of infra

Scale & Optimize – Expand footprint, refine AI models

Continuous Improvement – Enhance predictive accuracy via telemetry



Key Benefits for Network Engineers

Practical Advantages

- Predictive maintenance capabilities reduce emergency interventions
- Automated provisioning eliminates repetitive configuration tasks
- Integrated lifecycle management provides single-pane visibility
- AI-driven insights enable proactive infrastructure optimization

Platform architects can gain comprehensive tools for scaling P4 deployments while maintaining reliability standards. The data-driven approach can provide measurable improvements in operational efficiency.



Your Data-Driven Blueprint for P4 Infrastructure

This methodology offers network engineers and platform architects an approach to scaling and automating P4 infrastructure reliability. The combination of AI-driven predictive capabilities and structured BOM lifecycle management creates a foundation for sustainable, high-performance programmable networks.

Start with **modular BOM strategies** (catalog components)

Implement **AI predictive models** (forecast failures)

Integrate **P4 APIs with lifecycle automation** (unified mgmt)

Foundation for sustainable, high-performance networks



Thank you!

