Enabling Open-Access Middle-Mile Networks

Introduction

Robust internet connectivity is essential for the growth and efficiency of our digital society. However, despite significant infrastructure investments by major ISPs, many rural and remote communities still face connectivity gaps. These disparities impede progress in education, healthcare, and economic development. These disparities can obstruct the advancement of essential societal needs, such as education, healthcare, and economic development. Open-access middle-mile networks offer a promising solution to bridge these gaps. These networks function as high-capacity, long-haul infrastructures, acting as digital highways that connect diverse access and last-mile networks to the Internet. This white paper examines the impact of open-access middle-mile networks and how Arista Networks' products and solutions can expand their reach, enhance their impact, and help providers modernize infrastructure and enable optimized business models.

What is an Open-Access Middle-Mile Network?

Open-access middle-mile networks are critical infrastructures that bridge local access networks to the broader internet. They consist of two key components: *a high-speed network infrastructure* and a *collaborative business model.*

Technically, a middle-mile network links end-user networks to regional or global networks. This infrastructure connects local access providers (e.g., residential broadband providers), wireless carriers, regional ISPs, and community anchor institutions—including governments, schools, and hospitals—to the Internet backbone.

Beyond the connectivity infrastructure, the open-access middle-mile features a business model that promotes equitable access and service for multiple broadband providers through a shared network. By utilizing shared infrastructure, the middle-mile business model reduces redundant investments, allowing providers to focus on building out the access layer, enhancing reach and quality of service while improving overall efficiency.

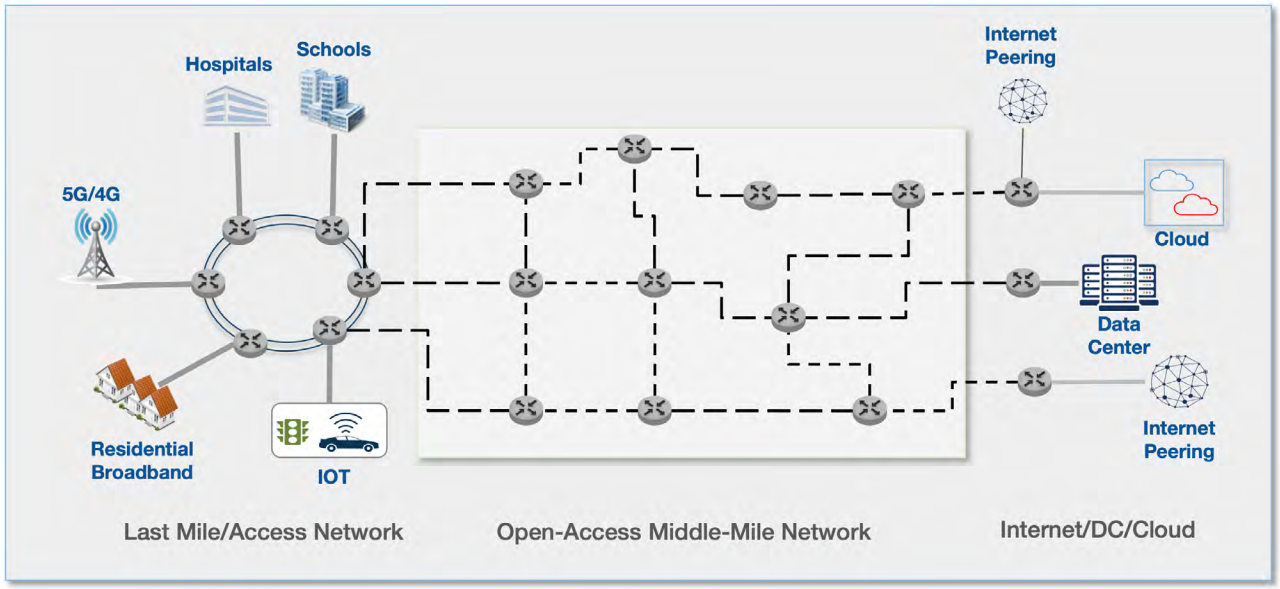


Figure 1: Open-Access Middle-Mile Network

Benefits and Efficiency of Open-Access Networks

The Open-Access Middle-Mile model democratizes infrastructure usage, improves cost efficiency, and promotes competition, benefiting a wide range of users including governmental bodies, educational institutions, and last-mile providers. This model accommodates a wide range of users, including governmental bodies, educational institutions, healthcare facilities, and last-mile broadband service providers.

- **Improved Cost Efficiency**
  By reducing transport costs, the model allows last-mile service providers to allocate more resources to network access layers, facilitating expansion and enhancing service reach and quality for underserved communities.
- **Promotes Competition**
  Encourages competition among last-mile providers, which drives down broadband access costs, improves service quality, and fosters broader socio-economic development.

Having outlined the transformative impact of the Open-Access Middle-Mile model, we now turn to the specific infrastructure capabilities required to fully realize these benefits.

Effective Middle-Mile Infrastructure

Middle-mile networks, essential for linking smaller networks to the broader internet, must continuously evolve to meet current and future demands.

Benefits and Efficiency of Open-Access Networks

Seamless, High-Bandwidth Connectivity

These networks require high bandwidth connectivity to support various participants, from large ISPs to community institutions and cloud providers, with the ability to dynamically adjust bandwidth.

High Availability

Continuously reliable service is critical, with designs that withstand challenges like fiber cuts and equipment failures to maintain connectivity between regional points and last-mile networks.

Equitable Access and Efficient Integration

Operating under an open-access model, these networks ensure fast, equal access for all service providers, promoting efficient management and smooth integration of last-mile providers.

Cost Efficiency

The model focuses on minimizing capital and operational expenses while expanding broadband to underserved areas, maintaining high service quality without excessive costs.

To address the infrastructure needs just described, Arista has developed an architectural strategy that not only meets but exceeds these demands through innovative technology and design. Let's delve into how Arista's approach is setting new standards in network architecture.

Open Access Middle-Mile - The Arista Way

Arista's architectural strategy is centered on a cloud-centric approach, simplifying and streamlining network components. This strategy delivers industry-leading scale and performance, addressing the evolving needs of middle-mile infrastructure, and enhancing its performance and scalability. Arista leverages an advanced network operating system - EOS and cutting-edge hardware technology to deliver significant cost savings and operational efficiencies.

Innovations for Reducing Total Cost of Ownership

Arista is revolutionizing network infrastructure by dramatically cutting capital expenditures with a combination of innovative merchant silicon technology and advanced network operating software stack.

Hardware Innovations

Arista's hardware innovations leverage rapid advances in merchant silicon to deliver faster, more reliable, and cost-effective service provider solutions. Figure 2 illustrates the performance-to-cost advantage of the Arista 7280R series routers, in line with Moore's Law. In less than four years, these routers have dramatically reduced cost ratios per Gbps by over 45%.

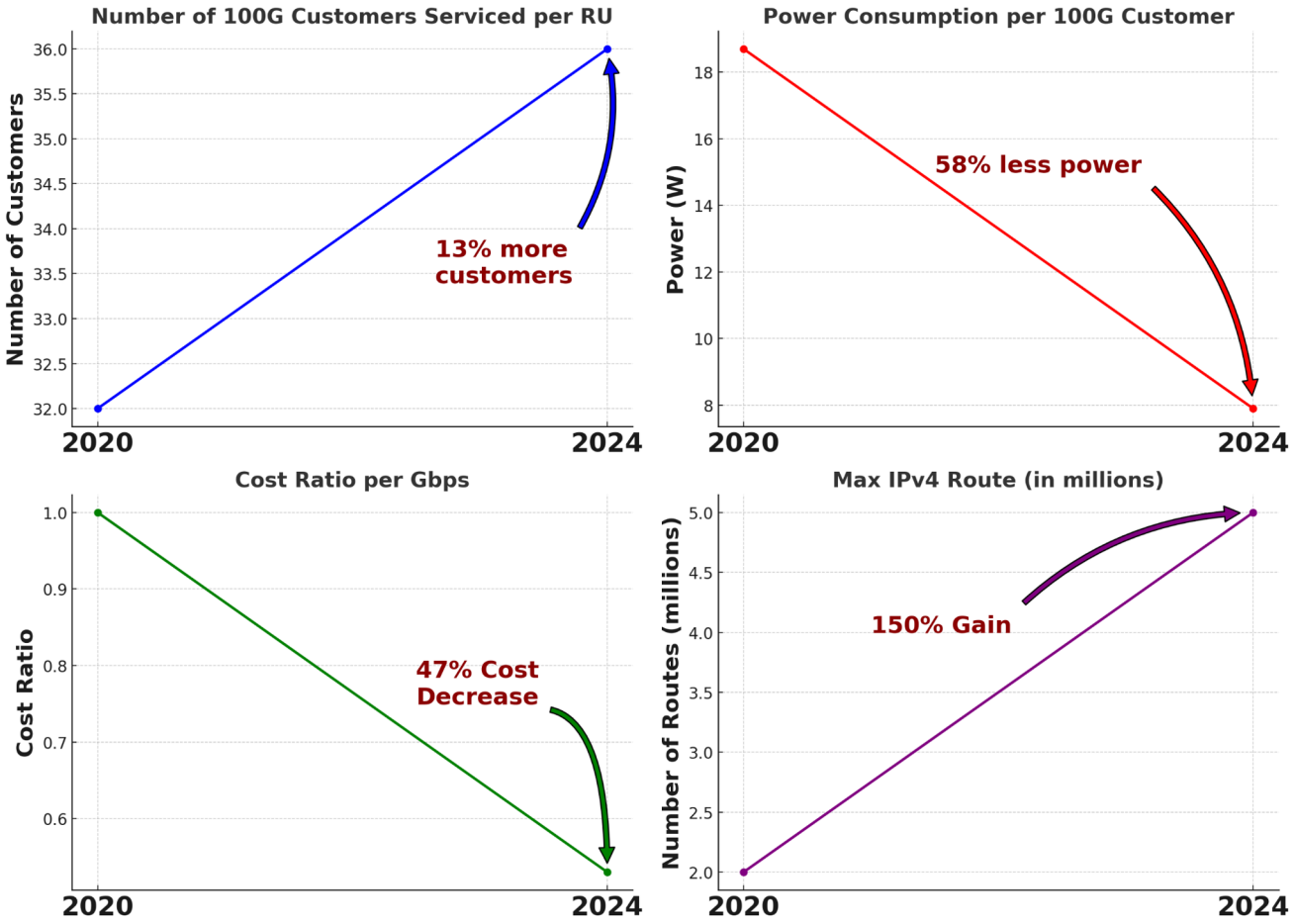


Figure 2: Innovations and Value Optimization in Arista's 7280R Routers (2020-2024)

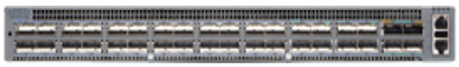
They have also increased the number of 100G customers served per rack unit by 13% and reduced power consumption per 100G port by 58%. As a result, the current cohort of 7280R3 family routers, shown in Figure 3, leads the industry in lowering operational costs, capital expenditures, and carbon footprints.

The current generation of Arista 7280R3 platforms, depicted in Figure 3, is exceptionally suited to meet the cost and technical demands of building high-performance, highly reliable middle-mile networks. These compact routers deliver outstanding performance while minimizing physical footprint, power consumption, and cooling requirements. Additionally, Arista 7280R3 routers seamlessly integrate packet optical technology via ZR/ZR+ coherent optics, simplifying networks and reducing power and space requirements in central offices.

Route Reflector/SD WAN
AWE-7220R

- 4x 10M/100M/1G (RJ45) Ethernet ports
- 1x 10M/100M/1G (RJ45) Ethernet Ports
- 2x 1/10G (SFP+) Ethernet ports
- n+1 redundant power supplies

100G Optimized Router
7280CR3-36S



- 32x 400G
- ZR/ZR+ support
- 2.7Tbps with 4GB of buffer
- 100/400G IPSec, MACSEC
- Less than 9W per 100G port
- FlexRoute - 2M / 5 Million+ Routes

400G Optimized Router
7280CR3A-24D12

- 24 QSFP + 12 x 400G
- 12 x ZR support
- 7.2 Tbps with 8GB of buffer
- 100/400G IPSec, MACSEC
- FlexRoute - 2M / 5 Million+ Routes

10G/25G Optimized Router
7280SR3-48YC8

- 48 port 25G and 8 port 100G in 1RU
- FlexRoute - 2M / 5 Million+ Routes
- Flexible choice of 1G/10G/25G and 40/100G
- 2.0Tbps with 4GB of buffer
- FlexRoute - 2M / 5 Million+ Routes

Figure 3: 7280R3 Platforms: High-Performance Compact Solutions for the Middle-Mile

Moreover, the 7280R3 platforms offer unmatched port density and superior performance. They provide flexible port speed options to accommodate diverse connectivity needs and are highly optimized to deliver one of the industry's densest ZR/ZR+ optics capacity , ensuring a cost-effective and high-performance packet optical architecture. This versatility enables service providers to maintain a cost-efficient and energy-efficient infrastructure, ultimately enhancing operational efficiency and service delivery.

Advanced Network Software Stack

Arista's advanced EOS architecture supports key requirements for modern network design by ensuring:

- *Uniform and Simplified Software*
  Arista's unique single-binary architecture across all platforms and devices provides a consistent software environment, simplifying network administration and reducing operational overhead.
- *Seamless Transitions*
  Facilitates smooth adoption of new chip innovations, ensuring middle-mile networks continuously benefit from performance and cost improvements driven by Moore's Law.
- *Open Standards*
  Supports a consistent and repeatable architecture, design, deployment, and operation, free from proprietary solutions. This avoids vendor lock-in, providing architectural choice and financial flexibility.

Network Simplification and Efficiency

Arista's approach revolutionizes traditional middle-mile network architectures by leveraging hardware and software innovations to remove complexities, enhance efficiency, and improve the cost structure of network deployment. Supported by Arista's advanced networking system, EOS, this architectural approach incorporates pluggable digital coherent optics (DCOs), eliminating the complexities of traditional multi-layer networks with separate optical and IP layers. Arista's platforms support 100G/400G Ethernet connections and employ industry-standard ZR/ZR+ optics, which improve signal transport efficiency. Additionally, integrating

IP and optical layers reduces component count, leading to lower power consumption, reduced cooling needs, and smaller space requirements.

Moreover, Arista's Services and Transport Architecture leverages Segment Routing (SR) and BGP EVPN to modernize network routing and service provisioning. This approach is highly advantageous for supporting large-scale greenfield networks with minimal resource overhead, optimized bandwidth utilization, and effective traffic load balancing. Features like TI-LFA (Topology-Independent Loop-Free Alternate) enable advanced availability through sub-second fast reroute capabilities, while simplifying network configuration, management, and troubleshooting.

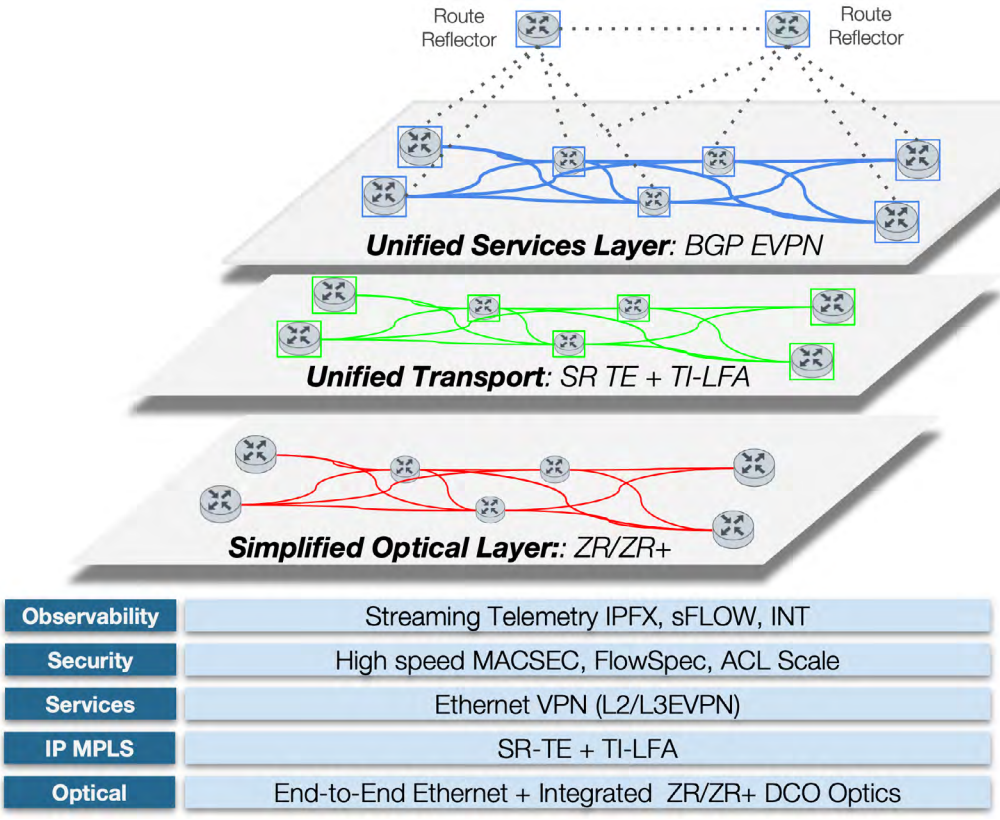


Figure 4: Arista's Middle-Mile Reference Architecture

Arista's EVPN-powered architecture simplification offers substantial benefits to Open-Access Middle-Mile operators, including accelerated provisioning of new services and customer onboarding. Additionally, robust multi-tenancy ensures secure and scalable traffic isolation to maintain high service quality across a diverse customer base. For example, Middle-mile operators can effectively use EVPN in conjunction with traffic-engineered segment routing to tailor services to specific needs, providing dedicated VPNs for residential ISPs to ensure sufficient bandwidth, offering latency and jitter guarantees for wireless service providers, and enabling enterprises to benefit from secure, isolated VPNs that enhance cloud access and secure connectivity to corporate headquarters.

Beyond its robust support for EVPN and segment-routed architectures, EOS offers unparalleled flexibility by simultaneously supporting legacy transport and control service protocols such as RSVP-TE, VPLS, and Pseudowires. This capability optimally supports brownfield service deployments and specialized use cases. The precise customization of service delivery meets the diverse requirements of different tenants in the Open-Access Middle-Mile. This strategic flexibility not only satisfies current demands but also enables middle-mile operators to swiftly adapt to changes in the connectivity landscape, ensuring they consistently deliver high-quality service to their customers.

Service Velocity

Arista enhances service velocity for middle-mile network operators by embedding robust automation within its EOS platform, facilitated by a comprehensive set of open APIs. These APIs enable seamless integration with management systems, streamlining automated service provisioning. Key options include a JSON-based RPC via eAPI, support for industry-standard protocols such as OpenConfig, NETCONF, and Restconf, and tools for native Linux scripting and custom development in Go and Python. EOS also features Zero Touch Provisioning (ZTP) and Zero Touch Replacement (ZTR) to automate device configuration and replacement, reducing operational costs and simplifying upgrades

Additionally, EOS standardizes network management processes across various deployments. This uniformity ensures consistent updates and maintenance across all devices, from small access platforms to large aggregation devices, reducing the need for extensive training and minimizing operational complexity. Arista's adoption of Continuous Integration/Continuous Development (CI/CD) methodologies further supports efficient network operations, facilitating the design, integration, testing, and delivery of network infrastructure changes at reduced costs.

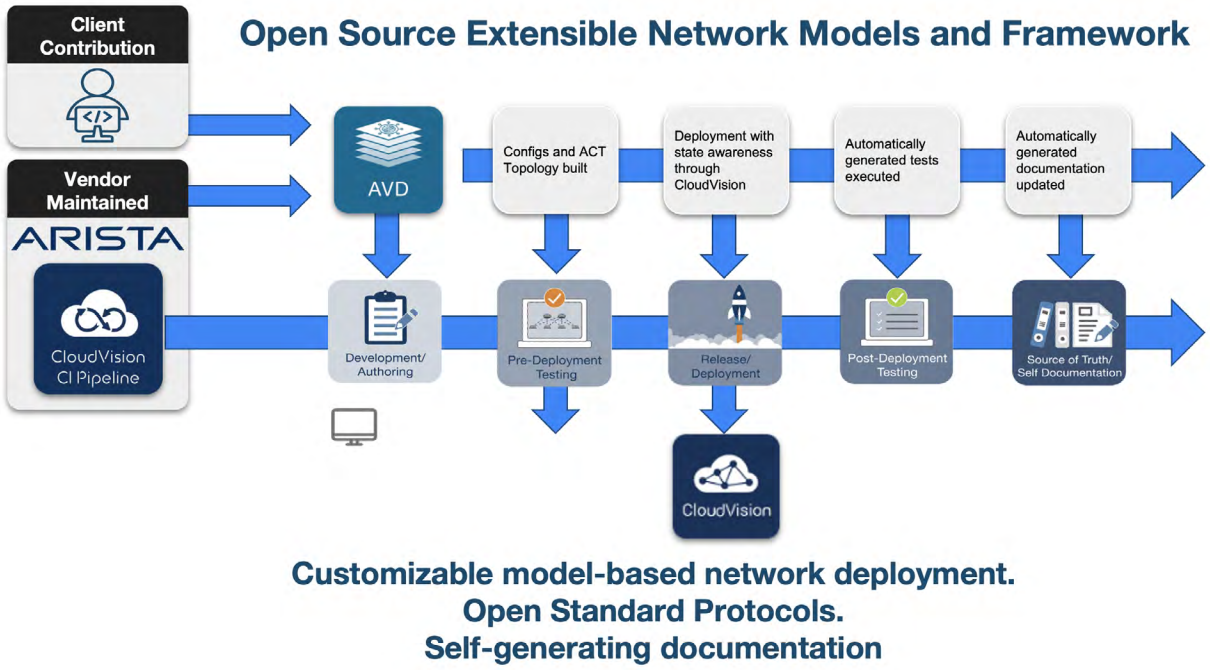


Figure 5: Infrastructure As A Code

Moreover, operators can utilize Arista's Validated Designs (AVD) or Cloud Vision Portal (CVP) to automate full network configurations with minimal input, making the entire network both driven by and consumable as code. For example, as part of the Arista CI Pipeline, AVDs offer flexible open data models and comprehensive workflows tailored to the remote access edge and core and aggregation devices of a middle-mile deployment, integrating seamlessly into the management ecosystem. Leveraging a consistent software image across all edge and core platforms, Arista's CI/CD approach simplifies and automates configuration, ensuring consistent, error-free deployment and maintenance of the geographically distributed middle-mile devices.

Advanced Observibility, Telemetry and Orchestration

Recognizing the need for comprehensive network observability and management, Arista developed NetDL (Network Data Lake) to address the need for comprehensive network observability and management. NetDL is a centralized, state-based platform that collects and stores real-time data across the entire infrastructure, gathering information such as device health metrics, control plane state and advanced data plane insights like granular flow data and full packet capture. Leveraging advanced streaming telemetry infrastructure offered by EOS, NetDL gathers a broad spectr of combination of near real-time and historical metrics, including

detailed device health metrics, granular control plane state, and advanced data plane metrics such as granular flow data and full packet capture. As an example. leveraging in-band (INT) telemetry and sFlow via real-time streaming, middle-mile operators can derive powerful insights across the network like pinpoint per user congestion , application performance, sources of jitter and packet loss. gaining granular visibility into their service behaviors. through open

NetDL provides vast amounts of data that, when combined with AI/ML, deliver deep insights to enable truly proactive and automated network management. Its rich API integration allows seamless collaboration with third-party network management systems, giving middle-mile service providers and operators comprehensive observability into network behavior, performance, and user/application experience. This empowers them to deliver a superior Quality of Experience (QoE) to users.

By integrating Arista EOS with NetDL, operators gain powerful, proactive tools to efficiently manage their networks, ensuring optimal performance and exceptional service quality.

Future-Proofing Middle-Mile Networks

In summary, the Open-Access Middle-Mile model offers a transformative solution to bridging the connectivity gap in underserved areas. By leveraging shared infrastructure, this model reduces costs and enhances service reach, providing democratized access, improved efficiency, and increased competition among last-mile providers.

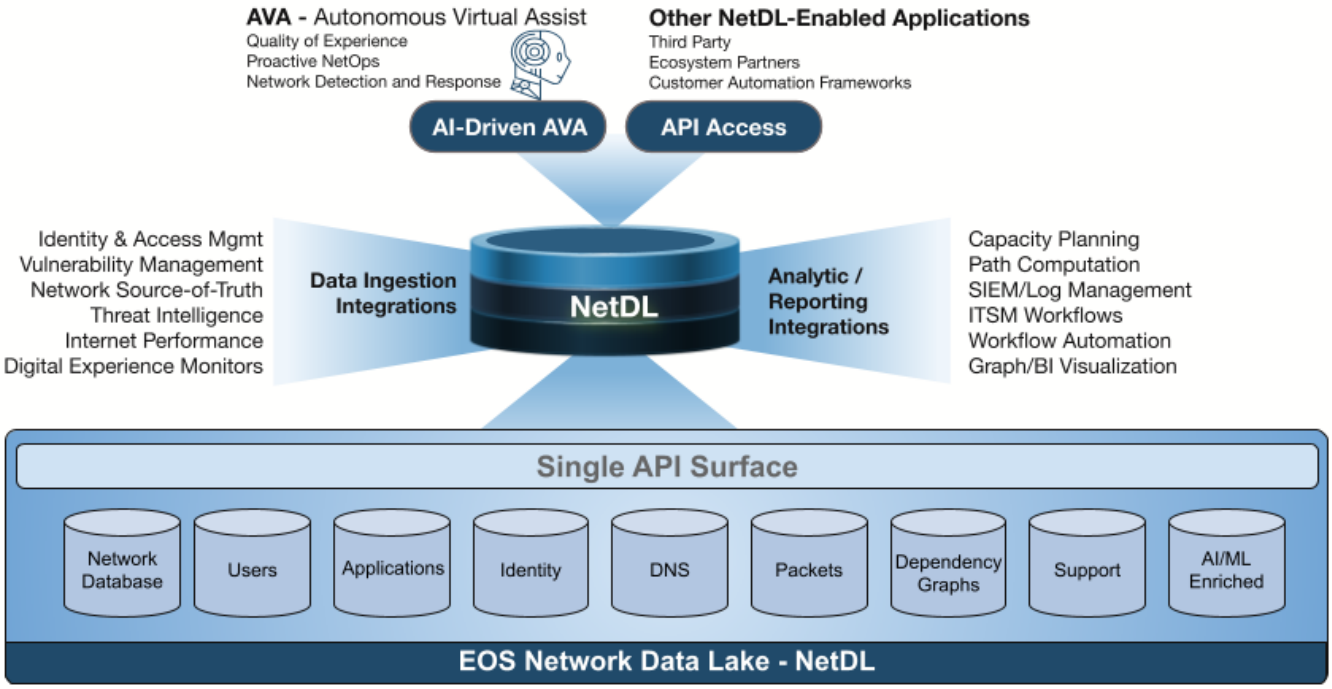


Figure 5: Infrastructure As A Code

Arista's innovative strategies, including coherent optics, and seamless network management leveraging Arista's advanced networking operating system - EOS, set new standards in middle-mile network performance and scalability. By integrating technologies like merchant silicon packet processors and Digital Coherent Optics, Arista facilitates the deployment of superior network infrastructure with optimized total cost of ownership.

Looking forward, the evolution of middle-mile networks will play a critical role in enabling digital equity and fostering innovation in rural and remote communities. Arista is poised to lead in creating resilient, efficient, and future-proof networks that meet the growing demands of the digital age. We invite you to connect with our team to explore how Arista can transform your network infrastructure and help you achieve unparalleled service quality and reliability.

Glossary

CI/CD (Continuous Integration/Continuous Deployment): A method to frequently deliver apps to customers by introducing automation into the stages of app development.

Coherent Optics: A technology used in optical fiber communication for high-speed data transmission over long distances with reduced signal loss and distortion.

DCO (Digital Coherent Optics): Advanced optical communication technology that uses digital signal processing to enable high-speed data transmission over optical fiber.

EOS (Extensible Operating System): Arista's network operating system designed for scalability and reliability in data center and cloud networking environments.

INT (In-band Telemetry): A method of collecting network telemetry data within the data packets themselves, providing real-time insights into network performance.

Merchant Silicon: Commercially available silicon chips used in networking equipment, providing cost-effective alternatives to custom-designed chips.

Middle-Mile Network: The segment of a telecommunications network that links local access points to the internet backbone.

NetDL (Network Data Lake): Arista's platform for collecting, storing, and analyzing network telemetry data to provide deep insights into network performance.

Network Telemetry: The process of collecting data from network devices to monitor and analyze network performance and health.

Open-Access Network: A network model that allows multiple service providers to use the same physical infrastructure under non-discriminatory terms.

Pluggable Optics: Modular optical transceivers that can be inserted into networking equipment to provide various types of connectivity and speed options.

RSVP-TE (Resource Reservation Protocol-Traffic Engineering): A network protocol that enables the reservation of resources across an IP network.

R3 Series Routers: Arista's advanced routers designed to double network bandwidth every 24 months, offering cost-effective alternatives to traditional designs.

Segment Routing (SR): A protocol that simplifies and enhances the efficiency of traffic routing in a network by using path information encoded in the packet header.

TI-LFA (Topology-Independent Loop-Free Alternate): A fast reroute mechanism in networking that ensures rapid failover to maintain network connectivity during disruptions.

VPN (Virtual Private Network): A secure network connection over the internet that allows remote users or networks to communicate as if they were directly connected to a private network.

ZR/ZR+ Optics: High-performance optical transceivers that support 100G and 400G Ethernet connections over long distances, enhancing signal transport efficiency.

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