Software Driven Cloud Networking

Arista Networks, a leader in high-speed, highly programmable datacenter switching, has outlined a number of guiding principles for network designs serving private cloud, public cloud, enterprise and high-performance network use cases. Arista's Software Driven Cloud Networking approach incorporates software capabilities of our Extensible Operating System (EOS®) and CloudVision® software to provide seamless and consistent operational experiences and workflow integration across any cloud infrastructure.

Emerging third-party cloud orchestration technologies and services, and cloud provider infrastructures, complement Arista's datacenter platforms by automating workgroup policies and provisioning within a broader integrated hybrid cloud IT infrastructure. Arista defines the combination of cloud automation technologies and Arista EOS-based Universal Cloud Network designs as Software Driven Cloud Networking.

Integration targets for our Cloud Networking solutions include standards-based network virtualization controllers, network security services, hypervisors, container management systems, automated compute and storage clusters, cloud orchestration middleware, IT support systems and customized flow-based forwarding agents.

Cloud Technology Shift

High-performance Ethernet networks have evolved significantly since their inception in the late 1980s, with many evolutionary changes leading to new networking solution categories. The datacenter switching category, now extending widely into the private and public cloud infrastructure, has emerged as a unique high-growth category, demanding dense 10-100Gbps Ethernet switching at massive scales and unprecedented price/performance levels as its leading enabling characteristic.

Beyond considerable speed progressions over the last two decades, datacenter switching also demands that networks support maximized performance at breakthrough economics, providing cost-effective expansion without redesign or reversals in architectural approaches. Other requirements include sub-microsecond switching latency (measured in nanoseconds instead of milliseconds), non-stop "hitless" failover when updating platforms or recovering connectivity over redundant links, seamless traffic load balancing for increased asset optimization, and automated scaling in support of large virtualized infrastructures.

The combination of these demands, along with the emergence of large hyperscale and hyper-dynamic cloud computing infrastructures from cloud titan companies like Facebook, Amazon (Amazon Web Services), Google (Google Cloud Platform), Microsoft (Azure Cloud), and Oracle (Oracle Cloud Infrastructure) have revolutionized the options available to enterprises as they design and build modern hybrid IT infrastructures to emulate and utilize the resources of these cloud titans.

Transforming from Legacy to Cloud Networking

Arista Networks was founded to deliver Software Driven Cloud Networking solutions for these high-performance, datacenter and cloud computing environments. Arista is focused on building 10/25/40/50/100 Gigabit Ethernet (GbE) switching platforms and software that redefine network architectures, bring extensibility to networking and dramatically change the price/performance of datacenter networks.

Arista's products, based on a transformational new approach to building high-speed network switches and cloud-grade routing platforms, were first used in financial trading applications for their wire speed performance, ultra-low latency and high reliability. Arista's solutions were subsequently adopted by six of the seven cloud titan infrastructures for their price/performance, scalability, programmability and resiliency. Now, as enterprises have aimed at replicating the efficiency of public cloud infrastructures, and as they seek the agility and cost efficiency of the hyperscale cloud providers, they are also discovering the benefits of breaking from the status quo and are applying Cloud Networking in their businesses as the new networking standard.

Arista EOS and CloudVision Software

Arista has disrupted the market for high-speed datacenter networking with two principal innovations – Arista EOS and CloudVision Software and Arista's award-winning merchant silicon based platforms. Our core software innovation has been to build a better network operating system, Arista EOS, which we have built from the ground up, using innovations in core technologies since our founding in 2004. We now have more than 10 million lines of code and ten thousand person-years of advanced distributed systems software engineering in our operating system. Arista EOS is built to be open and standards-based; its modern architecture delivers better reliability and is uniquely programmable at all system levels. Further, EOS provides an ideal platform for our customers to automate their IT workflows, while integrating with 3rd parties to achieve best-of-breed solutions in multi-vendor networks. Finally, EOS also enables our customers to gain improved visibility, faster problem isolation and correction, and greater visibility of network performance over time across their physical and virtual networks.

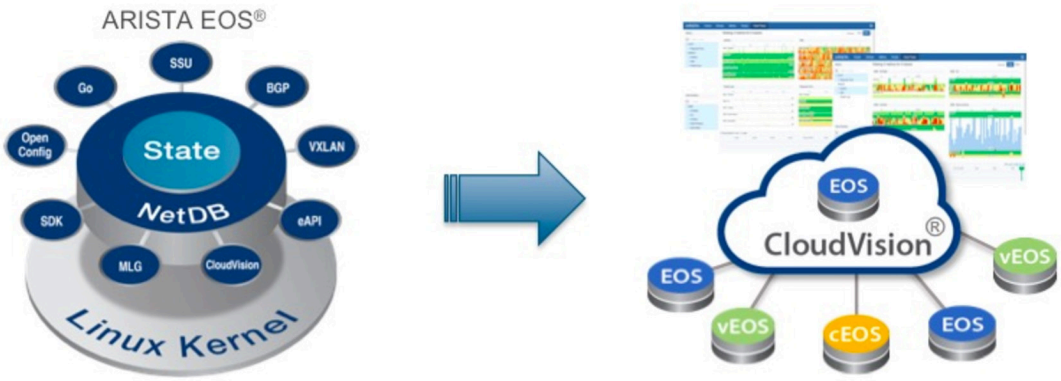

Figure 1: Software at the core of Arista Cloud Networking

Arista CloudVision – Software Platform for Automation, Visibility and Security

Complementing Arista EOS software, Arista provides our customers with CloudVision, a software platform for cloud automation and visibility. CloudVision extends EOS shared-state to a network-wide model for global automation, orchestration, visibility and analytics. In addition, CloudVision provides:

- A unified control-point for third party (Cloud/SDN/SDDC) network controllers, orchestration systems and security platforms
- Turnkey automation for provisioning and ongoing change management with network-wide snapshot and rollback, compliance validation and reporting
- Visibility and correlation of network state across physical, virtual and cloud network infrastructures with a rich suite of streaming telemetry and analytics features

Arista's Switching and Routing Portfolio

The other key innovation that Arista has brought to the industry is our use of merchant silicon switching hardware. Legacy approaches have relied on building teams of Application Specific Integrated Circuit (ASIC) engineers who laboriously release proprietary ASICs that are tightly coupled to proprietary software – creating vendor lock-in, increasing product cost and limiting customer choice. Elimination of these gratuitous interdependencies and the associated vendor lock-in that they create are the roots of the movement toward software defined networking and the basis for our Universal Cloud Networking architecture.

Arista's EOS software is uniquely suited to supporting multiple families of merchant silicon to optimize switch family price/performance and feature innovation – all with a single, binary software image that runs across all of Arista's products. This is possible because of the layer of abstraction that Arista has built between EOS and the drivers for the merchant silicon families that we use. This contrasts with the legacy approach of tightly coupling software to proprietary ASICs, resulting in multiple software images across families of switches. The Arista single image advantage results in simplified datacenter operations and an order of magnitude faster software release qualification by Arista and its customers. It also delivers higher quality software with a consistent feature set across the entire datacenter.

Our cloud networking platform portfolio consists of multiple fixed and modular configuration switches that provide densities of non-blocking 10/25/40/50/100 GbE switching and routing ranging from 24 to over 2000 Ethernet ports per platform. As described earlier, all of these platforms run a single binary image of EOS software for operational consistency and ease of management, packaged as a bundled offering on the switches or available in virtualized or containerized packaging for any production or simulation use case.

Figure 2: Cloud Networking Platform Portfolio

Arista's platforms are all fully featured and may all be used in any location in the network. Running a consistent single-image of Arista EOS software across our entire portfolio assures that operational complexity and compatibility issues are virtually eliminated. Arista 7280R and 7500R series platforms have additional capability and resources to extend their use cases to cloud-scale routing (replacing legacy routers), lossless connectivity under heavy load or burst conditions (with enhanced buffering and traffic management), and special features for network monitoring and TAP Aggregation (to provide better visibility and security in the cloud). We call these high-value platforms our Universal Spine and Leaf platforms.

Arista Any Cloud Platform – Hybrid Cloud solution for Any Cloud

As IT organizations have embraced the concept of cloud computing and increased the pace of migration of their workloads into public clouds, they have at the same time sought uniformity and comparable efficiency and agility in their on-premises environments. This movement to fully embracing the cloud has driven architectural changes and challenges that need to be addressed throughout the hybrid IT infrastructure.

Expanding into the public cloud presents accountability, cost and compliance challenges. Business policies governing network security, monitoring and service reliability must be consistent regardless of where workloads reside. Accountability cannot be compromised at the expense of the benefits of the public cloud. The CIO's office cannot be confronted with duplicate costs of parallel management systems, let alone procedures for monitoring, security, compliance and remediation.

Arista has extended the range of physical platforms that are offered in the on-premises network with the Any Cloud Platform for the hybrid cloud. Arista's hybrid cloud solution consists of the Arista EOS fully featured software deployed in all Arista Platforms, now deployed as a virtualized vEOS Router platform within any public cloud services. Arista vEOS Router supports native cloud API integration and full support for automation and visibility with Arista CloudVision.

Leveraging Arista's proven capabilities in the on-premises private cloud, the Arista Any Cloud platform provides unmatched operational consistency across public cloud, private cloud, and hybrid clouds including:

- Arista vEOS Router: hypervisor agnostic/cloud-native packaging of the EOS binary with a purpose-built software data plane for use as a standalone software on any cloud environment including Amazon AWS, Microsoft Azure, Oracle Cloud Infrastructure, and Google Cloud Platform.
- Cloud-grade routing solutions for interconnection of private, public and hybrid clouds across clouds using Arista Platforms in Equinix Cloud Exchange and similar services
- The Arista CloudVision platform that leverages the same automated provisioning, change management, analytics and telemetry for any EOS instance, including private, public, or hybrid cloud environments.

Attributes of all Arista Cloud Networking Solutions

As we have developed our Cloud Networking solutions, we have focused on five main attributes (five A's) that are critical to successful cloud deployments. These attributes are fundamental to the operational efficiencies and agility and drive dramatic reduction in total cost of ownership, compared to legacy approaches.

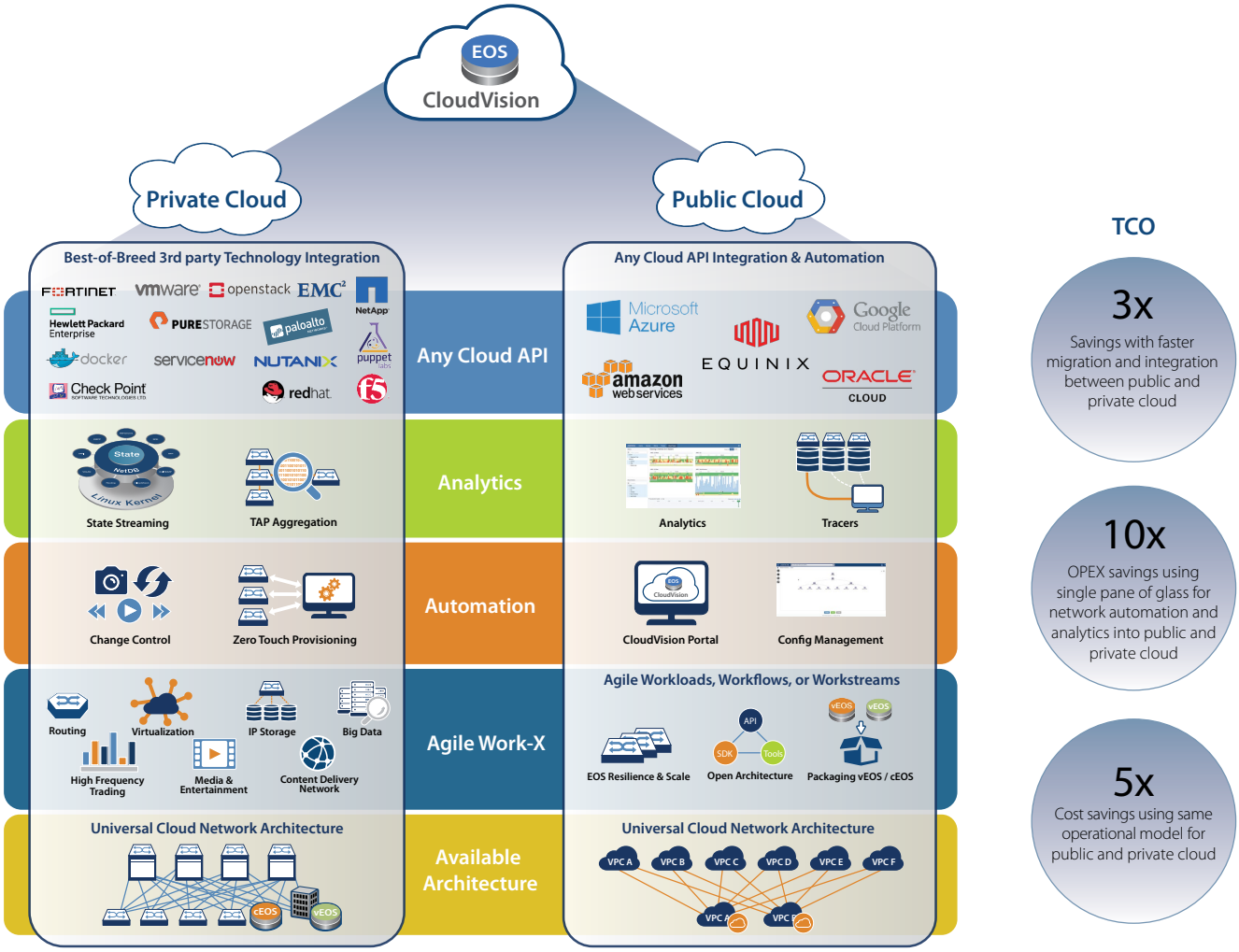

Figure 3: Key Attributes of the Arista Software-driven Cloud Networking Approach

Available Architectures

- High Availability – Open, predictable and efficient network designs with only modern, open and standards-based protocols using ECMP & VXLAN, with advanced hitless upgrade/update and auto-recovery features with 100% active-active utilization of all bandwidth, resources and links.
- Scalability – A state-sharing, highly resilient, multi-process architecture that enhances reliability, visibility and scalability that supports networks from a few nodes, to millions of VMs, containers and end-points at Internet scale and with linear expansion.
- Efficiency – Designed to utilize advancing developments in merchant silicon hardware, ensuring a path for customers to new advances in speed, scale and efficiencies with proven investment protection.

Agility – to support any workload, workflow, or workstream

- Proven agile solutions to address the needs of any Workload, Workflow or Workstream.
- Cloud-scale routing, enterprise datacenter switching, datacenter interconnect (DCI), dense virtualization and containers, IP storage and big data, high frequency trading, and supercomputing.
- Market-specific solutions for media and entertainment, cloud native micro-services, hybrid cloud (PaaS/SaaS), government defense systems, signals intelligence, carriers & CDN, monitoring and IOT.

Automation

- Cloud Automation for Everyone – CloudVision provides a turnkey automation hub for configuration and image management, change control simplification, operations compliance and much more.
- Tracers – Enable real-time visibility and automation for highly dynamic, virtualized, containerized big data and bare metal workloads that correlate network health and reachability information with workload placements in the public, private and hybrid cloud.
- TAP Aggregation and Advanced Mirroring – Provides precision access to raw and filtered packet data anywhere and anytime at industry-leading scale with both in-band and out-of-band capture, replication and analysis capabilities. Includes resources to generate and analyze high rate sFlow meta-data for macro-level visibility into performance trends and security threats.

Analytics

- Zero Touch Provisioning – Reduces operating costs and time-to-production with ZTP by eliminating human errors during rack expansion or replacement, and automates infrastructure scale-out using standards-based mechanisms that are customizable and scripted at any scale.
- DevOps Integration – Integrates development and operations workflows with DevOps and CI/CD tools including Docker, Ansible, Chef, Puppet and others. Also, automates network and server management with access to any virtualized, containerized or Linux tool running natively on EOS.
- Telemetry – Accesses and records network-wide state and and congestion information for every workload, workflow and workstream, and identifies and troubleshoots issues in underlay and overlay network topologies for real-times or forensic analysis.

Any Cloud API

- Fully programmable platforms allowing rapid, automated deployment and provisioning
- Open SDK/APIs for easy integration with third-party and customer extensions
- Single-OS consistency across use-cases for every place in the cloud
- Proven solutions and reference designs with a broad best-in-class ecosystem of partners

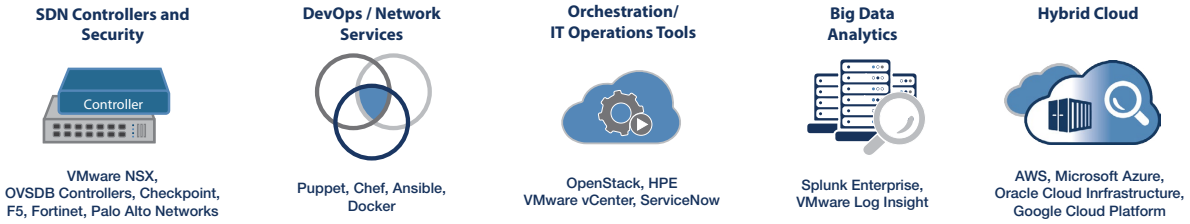

Figure 4: Any Cloud API – Networking Integrations in the Cloud Ecosystem

Arista Cloud Networking solutions deliver dramatic savings Total Cost of Ownership (TCO) with customer-reported savings of 3X in costs to migrate and integrate enterprise private cloud resources with multiple public clouds. Customers have identified that the use of CloudVision automation can reduce Operating Expense (OpEx) by 10X by simplifying change control and problem resolution with analytics engine and telemetry apps. Finally, because Arista provides a consistent operating model for all places in the customer's cloud networking infrastructure, they experience far greater agility and reduction of operational errors, providing an additional 5X in OpEx savings.

Arista Software Driven Cloud Networking Designs

Servers, storage and networks form the anchors of today's IT infrastructure. Companies around the world are constantly seeking to enhance this infrastructure. With 10-100GbE connectivity, the new infrastructure requirements are distinctive and differ in many ways from the needs of traditional enterprise IT. The new private, public and hybrid cloud environments often require unique compute density, power density and ultra-low latency. Such hyper-scale computing environments – where deployments are measured by up to millions of servers, storage and networking equipment – are changing the way they approach IT to drive growth and decrease operational expenses.

Spine/Leaf Network Scale

With Arista Universal Spine and Leaf platforms, it is possible to design a simplified two-tier cloud network topology with up to 15 Petabit/sec of capacity across the network Spine that can support over one million servers and over 10 million VMs.

Two-tier Spine/Leaf network designs enable horizontal scale-out with the number of spine switches growing linearly as the number of leaf switches grows over time. The maximum scale achievable is a function of the density of the spine switches, the scale-out that can be achieved (this is a function of cabling and number of physical uplinks from each leaf switch) and desired oversubscription ratio.

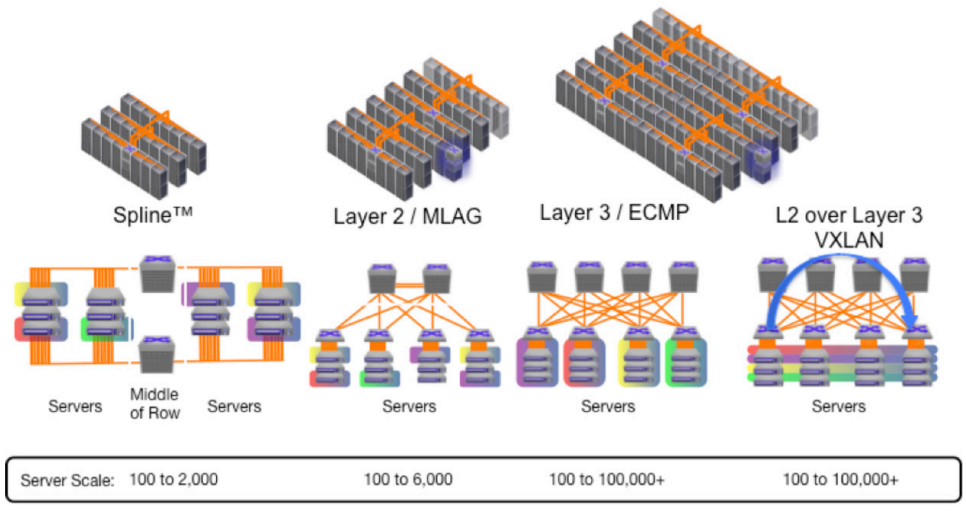

Figure 5: Design Scale for Software-driven Cloud Networking

For designs that do not fit a two-tier spline design, a larger two-tier Universal Spine design is the next logical step. A two-tier Spine design has spine switches at the top tier and spine and leaf switches at the bottom tier with servers/compute/storage always attached to leaf switches at the top of every rack (or for higher density leaf switches, top of every N racks) and leaf switches uplink to 2 or more mid-spine switches.

Large scale Spine/Leaf designs are how very large public clouds build out network topologies that can support millions of tenants and many thousands of hosted private clouds within their multi-site cloud infrastructures.

Network Virtualization Overlays with VXLAN

Network virtualization in the form of the VXLAN specification, co-authored by Arista and VMware, was a key turning point in enabling seamless workload mobility and enhanced security in cloud datacenters. Arista is capable of bringing any combination of physical servers, storage, load balancers, next generation firewalls and network monitors into any virtual network segment with all of the provisioning driven seamlessly in software, either natively or via central cloud orchestration controllers. These capabilities include hardware-accelerated virtual tunnel end-point and automated Macro-segmentation technologies which map between physical and virtual networking layers within VXLAN overlay/underlay networks.

Designed to integrate with VMware, OpenStack and Microsoft virtualization technologies, Arista's open network virtualization architecture allows for integration with any cloud orchestration approach. Built on top of the Arista Unified Cloud Network - enabling end-to-end network virtualization, now workloads can be portable while preserving their addressing and policies, and tenant groups can be isolated without location or topology restrictions - this enables simplified scale-out, and drastically simpler workload placement within any datacenter.

Software Driven Cloud Networking – Seamless Automation

Arista's Software Driven Cloud Networking approach provides automation across the entire IT stack with routed Spine and Leaf designs and standards-based VXLAN network virtualization. Standard EVPN, using BGP and ECMP standards, are used to interconnect and automate IP reachability, providing rapid recovery from link or nodal failures, full cross-sectional bandwidth of the network fabric always available to applications, simplified change control and maintenance, and scale from 2 way to 128 way spine width to achieve massive aggregate bandwidths.

Some of the highlights of our open Software Driven approach include:

- Automated Discovery of VMware and OpenStack Virtual Machines and Containers
- Automated Provisioning of VLANs via VM Tracer
- Auto-binding of VLAN to VXLAN in top of rack switch acting as Virtual Tunnel EndPoint
- Auto-deployment of the inter-VXLAN routing default gateway based on the configuration of the virtualization controllers
- Inter-VXLAN routing from one VNI to another
- Intelligent first-hop routing with no tromboning of traffic
- Elimination of IP Multicast for flooding of broadcast, unknown and multicast traffic
- Automating Learning of each MAC to VXLAN Virtual Tunnel End Point binding

All Arista software-driven Cloud Networking solutions provide:

- Auto-deployment of network switches via cloud APIs and CloudVision
- Auto-provisioning of network segmentation in VMware and OpenStack environments
- Inter-VXLAN routing between nodes in VMware, nodes in OpenStack and hardware virtual tunnel end points facing toward end-user computing and central storage targets
- Elimination of IP Multicast for Broadcast, Unknown, and Multicast traffic handling
- Stateful v-motion across network boundaries without traffic loss and without re-addressing real-time workloads

Arista Software Driven Cloud Networking allows the network to participate fully as an integrated foundation with the rest of the Cloud stack including servers, storage, virtualization, cloud controllers, load balancers and security systems. With Arista EOS, network engineers can adopt set-it and forget-it policies that automatically update it based on the real-time configuration of other parts of the IT infrastructure.

Impact of Software Driven Cloud Networking on IT Operations

Prior to the shift toward virtualization and elastic computing, there were highly specialized infrastructure administrators—including server, network, storage and application specialists. They configured services within their domains statically, based on infrequent change requests that came from the application community. This static and siloed approach to provisioning and operations of IT infrastructure is the antithesis of the cloud concept, which derives from elastic and hyperdynamic sharing of resources and assets across any tenant or workload.

With a legacy network operating system, it could take from two to four weeks to configure and release into production a fully integrated datacenter infrastructure for any new or refreshed application. With Arista software-driven cloud networking, this time-to-availability can be reduced to a matter of seconds.

Cloud Networking concepts leverage decades of progressive hardware and software technology evolution, and yet they reside in a complex continuously evolving ecosystem of compute, virtualization, management and security technologies. Making the cloud operate seamlessly, whether an on-premises or hosted private cloud, or a service provider public cloud, requires coordination and orchestration of all resources as a unified system.

Arista Cloud Networking represents the first open, extensible, externally programmable approach that allows seamless operations and provisioning by integrating with multiple cloud APIs. This open extensibility aspect is driven by the guiding principles of cloud datacenters in which resources are managed dynamically as one integrated system made up of compute, network and storage that is consumed on-demand.

Arista EOS interacts with any cloud infrastructure API, handling external updates and managing highly distributed switch forwarding states, tenant isolation and reachability in real time. The Arista approach provides service control to external cloud orchestration controllers, supporting highly virtualized and elastic instantiation of workloads, time-of-day application demands, and rapid provisioning while scaling with Spine/Leaf switching scale for the most demanding carrier-class cloud datacenters.

Table 1: A stack approach to Arista Cloud Networking

Stack	Examples	Benefits
Network controllers (SDN/SDDC)	OpenFlow, OpenStack, VMware, Hyper-V	Isolation, orchestration, service abstraction and workload management
Network Virtualization	Scalable, multi-tenant virtual networks using VXLAN overlay / underlays	Enables open workload mobility with integration between virtual and physical
Hypervisor and Container Runtimes	x86 bare metal server abstractions	Elastic computing, resource optimization, non-disruptive server upgrades
Telemetry Analytics	Real-time state streaming, machine learning, dynamic event correlation	Faster problem resolution, deeper visibility, compliance and security
Cloud-enabled network	Arista EOS and CloudVision	Open and programmable for custom flows, VM mobility, automated tenant onboarding

With the integrations of Software Driven Cloud Networking, requirements that are driven by service-catalog consumer-facing front ends are automatically provisioned by the network infrastructure. Administrators no longer need to manually coordinate provisioning events, manually update configuration databases and fully validate the network changes prior to hosting live in-production environments.

Arista's Continuous Software Innovation

Along with the overall operational efficiency gained from Arista's Software Driven Cloud Networking approach, we have delivered a rich history of innovation and leadership in extensible, open, scalable and unique features for our platforms that make operations' lives easier and provide continuous value. Examples of these are highlighted in figure 6.

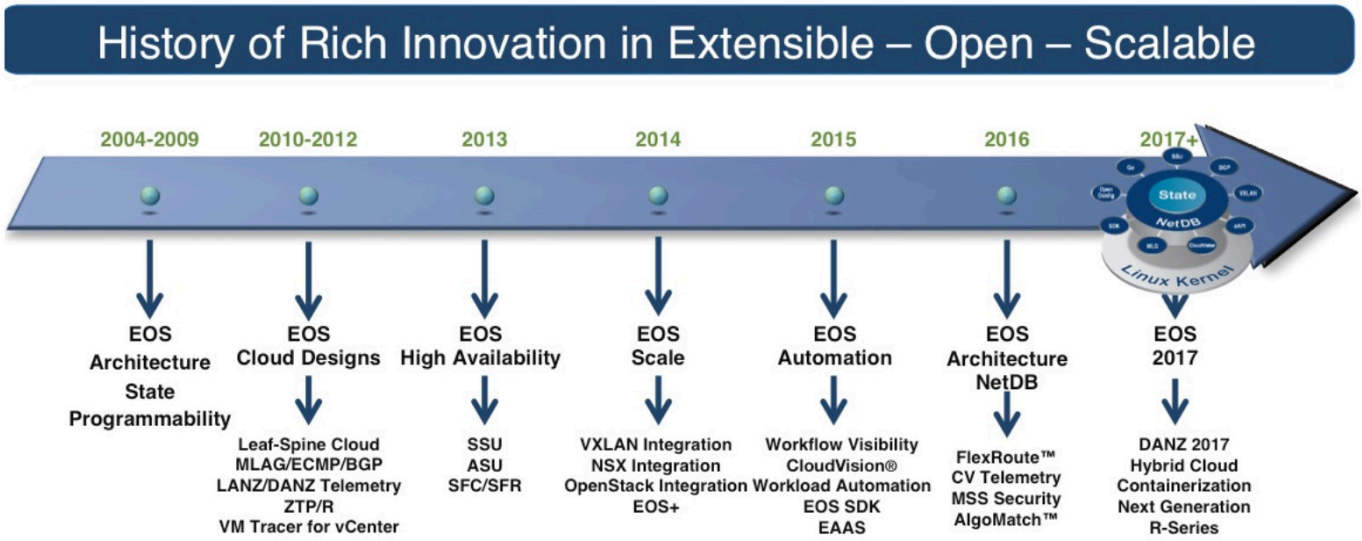

Figure 6: History of continuous software innovation in Arista EOS

Our track record shows a history of continuous innovation and integration within cloud environments at the core of our values, and we continue to provide more seamless integration both within enterprise and service provider networks and across private, public, and hybrid cloud environments.

Conclusion

Summary: The Network is Changing Silos to Places In the Cloud (PICs)

Arista fully embraces the principles and attributes described in this paper with solutions that are based upon our highly modular, resilient, open, state-centric network operating system – Arista EOS, into which our customers can add their own scripts, extensions and management tools. Arista continues to build upon this software leadership, which is the key building block for Cloud Networking.

The Arista Software Driven Cloud Networking approach embodies all of the core attributes that are required in order for our customers to deliver highly efficient, seamless and effective cloud IT infrastructures by integrating:

- Arista Software Driven solutions with proven Arista EOS and CloudVision software
- Cloud Networking Platforms that provide high-performance and scale for any environment and integrate with any cloud compute, storage and security solutions
- Five attributes of our Cloud Networking solutions critical to successful cloud deployments and significant savings OpEx and CapEx for lower TCO
- Scalable designs that can support any scale and performance requirement
- Continuous and proven history of innovations and investment protection

Arista's unique offerings address PICs (Places in the Cloud) that integrate LAN-WAN-SAN-MAN to provide workload mobility, workflow monitoring and visibility and real-time network telemetry for integration with cloud operations and administration tools. Software Driven Cloud Networking transforms legacy PINS (Places in the Network) to PICs to meet the needs of any cloud with extensive innovation and leadership to deliver on the five cloud (AAAAA) attributes that characterize all clouds, public and private, and drive the dramatic reduction in total cost of ownership demanded by our customers.

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