

Introduction to Cisco ASR 9000 Series Network Virtualization Technology

What You Will Learn

Service providers worldwide face high customer expectations along with growing demand for network services. The need for efficiency, high availability, and rapid time to deployment has never been greater, but the network has never been more complex. Too often, supporting the required density and high availability in access and edge networks means using hundreds of complicated routing platforms and protocols that increase operating costs and slow time to revenue.

Now, Cisco offers a revolutionary approach to high availability and access network density based on virtual network architecture. With the new Cisco® Network Virtualization (nV) technology in the Cisco ASR 9000 Series Aggregation Services Routers, service providers can radically simplify the network, reduce operating costs, and improve network and service resiliency, all while supporting greater scale and density. This document provides an overview of the Cisco virtual network architectural model and describes how Cisco nV capabilities can be used to optimize edge and access services.

Meeting the Challenges of the Modern Service Network

Managing today's service provider network is a complex and costly proposition. The scale and number of network services have never been greater, and customer demand continues to grow. To meet these demands, service providers must deliver:

- Unprecedented scale and density
- Support for a diverse mix of Layer 2 and Layer 3 services over a converged infrastructure
- High service availability to meet service-level agreements (SLAs) and deliver a high quality of experience to users

Today's edge and access networks achieve these objectives, but at significant cost to service providers. To deliver the scale and density required, network operators deploy a huge number of aggregation and access platforms, all of which must be managed, configured, and provisioned separately. To help ensure resiliency, service providers rely on conventional dual-homing techniques that require a long list of networking protocols to function, adding enormous complexity to the operation of the network.

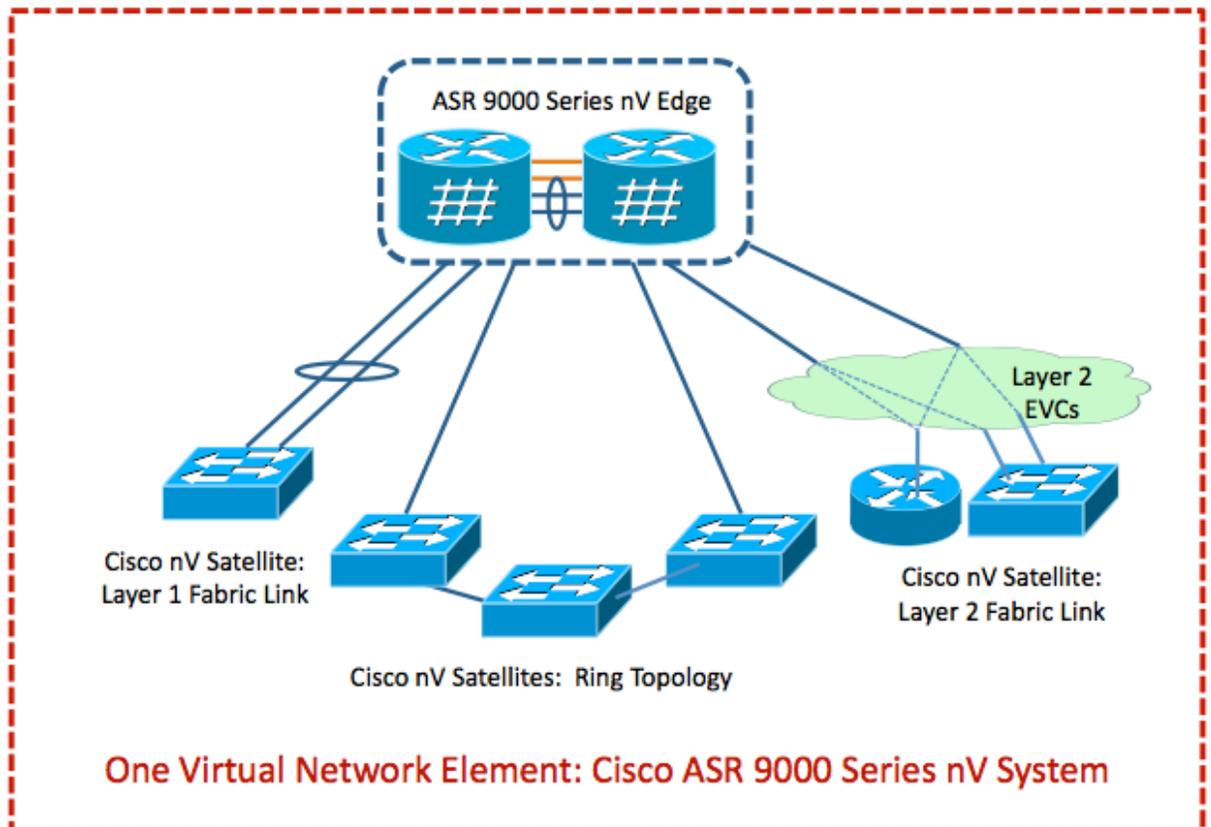
Many factors contribute to the complexity and cost of operating today's networks, but most arise from one primary problem: the need to provision and manage a huge number of separate physical platforms. Unfortunately, this problem is only getting worse, as the number of standalone network elements that must be separately managed and provisioned continues to grow linearly as services scale.

What if there was a way to consolidate many of those separate physical platforms and eliminate most of those protocols? What if network providers could shift from an operational approach based on coaxing standalone network elements to function efficiently together to an approach that views hundreds or even thousands of physically distinct chassis as a single virtual node? This is the vision behind Cisco nV technology.

Cisco Virtualized Network Architecture: Cisco ASR 9000 Series nV System

The Cisco virtualized network architectural model envisions self-protected and self-managed service nodes, enabled by Cisco nV technology. As shown in the Figure 1, a Cisco ASR 9000 Series nV system encompasses two components: Cisco nV edge and nV satellite devices.

Figure 1. Cisco ASR 9000 Series nV System



- Cisco nV edge virtualized edge: Service providers can operate two Cisco ASR 9000 Series platforms as a single virtual Cisco ASR 9000 Series system. Effectively, they can logically link two physical chassis with a shared control plane, as if the chassis were two route switch processors (RSPs) within a single chassis. As a result, service providers can double the bandwidth capacity of single nodes and eliminate the need for complex protocol-based high-availability schemes, while achieving failover times of less than 50 milliseconds for even the most demanding services and scalability needs.
- Cisco nV satellite virtualized access and aggregation: Cisco nV technology lets operators extend Cisco ASR 9000 Series system capabilities beyond the physical chassis with remote virtual line cards. These small form-factor (SFF) Cisco ASR 9000v cards can aggregate hundreds of Gigabit Ethernet or 10 Gigabit Ethernet connections at the access and aggregation layers, but they are provisioned and managed as distributed line cards of the host Cisco ASR 9000 Series device, rather than as standalone access-routing platforms. With the capability to deploy these high-density Gigabit Ethernet devices in the field—whether in a central office, an enterprise wiring closet, a building basement, or a remote terminal—operators can provision exactly the bandwidth they need, when and where they need it, with a single management and control plane. Network operators can scale thousands of Gigabit Ethernet interfaces without having to

separately provision hundreds or thousands of access platforms, radically simplifying the network architecture and reducing operating expenses (OpEx).

By combining these capabilities in a single virtualized platform, Cisco nV technology allows service providers to create an entirely new, virtualized transport architecture. Effectively, an entire cloud of previously separate physical devices can now be managed as a single, virtual network element. As a result, service providers can deliver:

- Superior scale: A virtual network element can easily support an enormous amount of traffic and an enormous number of interfaces to meet growing customer demand.
- Simplicity: With Cisco nV technology, service providers can add thousands of ports to the network without having to provision and manage hundreds of separate chassis. Network operators can manage a network cloud with hundreds of remote devices as a single logical network element, radically simplifying service provisioning, image upgrading, configuration, and ongoing management.
- Nonstop resiliency: Cisco nV technology allows service providers to replace protocol-based resiliency mechanisms with the same straightforward control plane-based approach used internally in their physical routing platforms. Using always-on virtual routers, they can achieve failover times of less than 50 milliseconds with very high service scale.
- Lower costs: Cisco ASR 9000v distributed line-card capabilities reduce the cost of access-layer devices by eliminating the need to manage complex features in access routing platforms, instead, using the Cisco ASR 9000 Series' ultra-high-density and control-plane scale and feature set. This capability also accelerates service deployment times and time to revenue with immediate, "plug-and-play" access. The capability to aggregate tens of thousands of Gigabit Ethernet circuits within a single virtual network element also lowers the cost of delivering Ethernet services.

Crucial to achieving these benefits is the Cisco IOS® XR Software at the heart of the Cisco ASR 9000 Series. Unlike operating systems designed for smaller-scale enterprise environments, Cisco IOS XR Software was designed from the beginning for massive scale and a distributed control plane. Optimized to support service provider core network systems with dozens of chassis and hundreds of terabits (Tb) of scale, the Cisco IOS XR Software-based control plane can more than meet the challenge of handling virtual aggregation nodes encompassing hundreds of physical devices and thousands of Gigabit Ethernet interfaces. Effectively, the Cisco virtual network architecture model brings core density and scale to edge and access networks to power the next generation of demanding network services.

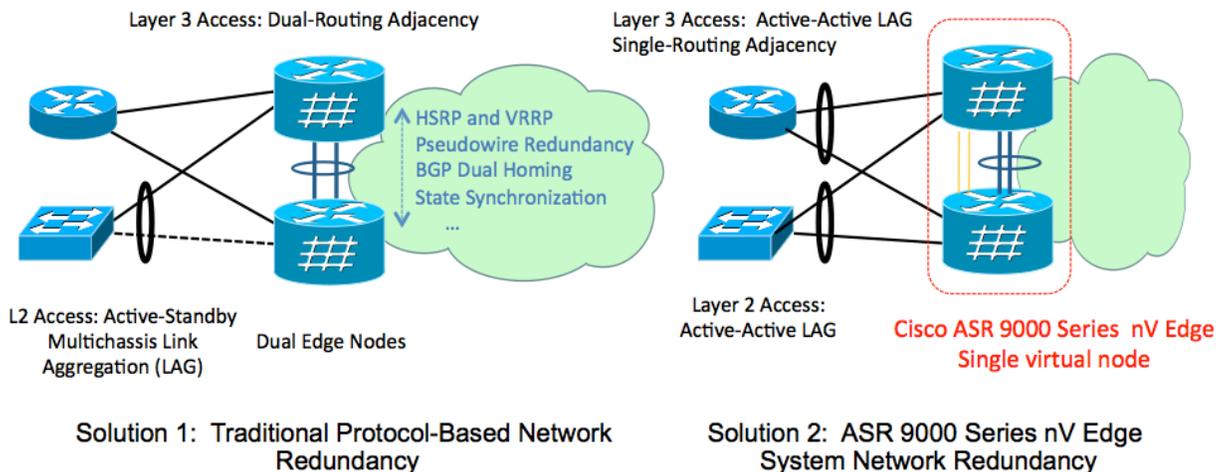
Building a Highly Available and Extensible Edge with a Cisco ASR 9000 Series nV Edge System

To achieve high availability, today's networks (as shown on the left side of Figure 2) use a dual-homed architecture and protocol-based resiliency approach that is inherently inefficient. At a minimum, this model requires three separate sets of protocols to control:

- Dual-homing of access-layer devices to each node
- Communication between nodes to achieve Layer 2 and Layer 3 service resiliency
- Synchronization of service states between the two nodes

Adding to this already complicated approach, network operators often must use different protocols for each of the many different Layer 2 and Layer 3 services in the environment. Each protocol may be more or less complex to provision, depending on the service and the network topology.

Figure 2. Network Redundancy Is Enhanced by Cisco ASR 9000 Series nV Edge



In addition to being extremely complex to operate, this approach is not always effective. For some services and scales, a protocol-based approach can achieve ideal network reconvergence in less than 50 milliseconds. For others (for example, multicast TV services that must communicate with the viewer's set-top box to restore state, or a Layer 2 VPN [L2VPN] service with tens of thousands of circuits), reconvergence might be measured in seconds or even minutes. A protocol-based approach also employs more Layer 3 routing adjacencies, which means that the Layer 3 topology changes during a link or node failure, further slowing convergence times.

A Cisco ASR 9000 Series nV edge system provides an alternative approach that addresses all these concerns, both reducing complexity and improving convergence times. Using Cisco nV technology, network operators can link two physical chassis as a single virtual chassis, replacing dual homing with single homing, using a single control and management plane and a fully distributed data plane. Ultimately, operators can use the Cisco IOS XR Software multichassis software infrastructure (an infrastructure designed for the massive scale of service provider core networks) to enable a simpler, self-protected service resiliency model (as shown on the right side of Figure 2).

With the Cisco ASR 9000 Series nV edge system, operators can:

- **Simplify operations:** By aggregating multiple physical chassis in a single virtual chassis, operators can eliminate the need for dual homing and node-level Layer 2 and Layer 3 service resiliency protocols, even as they eliminate service node failures. Operators need no longer worry about synchronizing service states between two dual-homed nodes, since all Layer 2 and Layer 3 states are synchronized naturally using the single shared control plane of the virtual node. At the same time, this model enables a fully distributed and resilient data plane with more line cards and bandwidth.
- **Improve availability and resiliency:** The virtual node model enabled by Cisco nV technology provides stateful protection of latency of less than 50 milliseconds for all services, independent of service scale. Since this model employs only a single Layer 3 routing adjacency, the Layer 3 network topology does not change during a link or node failure, allowing superfast convergence. Like the traditional dual-homed protocol-based model, Cisco nV supports both co-located and geographically redundant models: clustered chassis can be deployed in the same rack or in different buildings miles apart. The virtual chassis approach also allows in-service

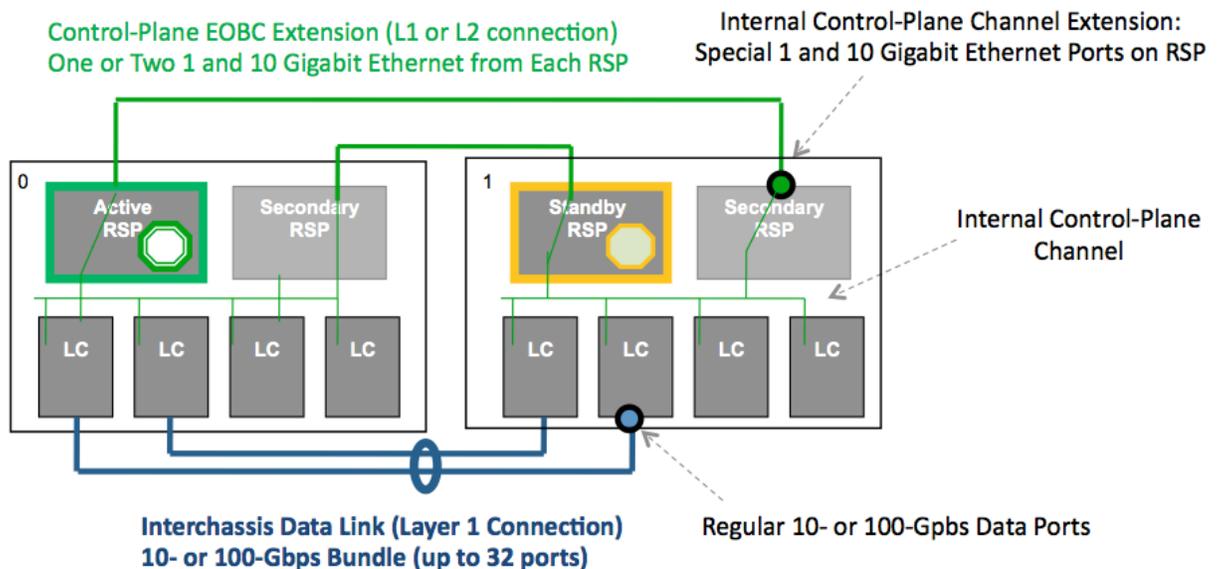
software updates (ISSU), allowing operators to help ensure nonstop operation even when the entire virtual system is being updated.

- Extensible edge node capacity: with the Cisco ASR 9000 Series nV edge system, providers can extend existing edge node capacity by simply adding a new Cisco ASR 9000 Series chassis to the virtual node, without any operation outage and without additional management- and control-plane configuration. The two Cisco ASR 9000 Series chassis in the same Cisco ASR 9000 Series nV edge system do not need to be the same type. This feature can provide additional operational flexibility. For example, a full-rack Cisco ASR 9922 chassis can join the existing Cisco ASR 9010 chassis as one virtual Cisco ASR 9000 Series nV edge system for capacity growth.

Cisco nV High Availability in Action

Figure 3 provides an overview of the Cisco nV high-availability function as deployed in a hypothetical network. As illustrated in the figure, the two physical chasses are linked using a Layer 1 10-Gbps or 100-Gbps connection, with RSPs communicating using a Layer 1 or Layer 2 Ethernet out-of-band channel (EOBC) extension to create a single virtual control plane. This EOBC extension uses an RSP in the Cisco ASR 9000 Series chassis with onboard Gigabit Ethernet or 10 Gigabit Ethernet ports. The data-plane extension uses standard line-card ports. Operators can even mix regular data ports and virtual chassis data-plane ports on the same line card, increasing deployment flexibility.

Figure 3. Inside Cisco ASR 9000 Series nV Edge



Through this Cisco ASR 9000 Series nV edge capability, the virtual chassis model can provide a highly manageable, high-availability solution for a variety of deployment scenarios. These include:

- L2VPN deployments, including “triple-play” (Internet, television, and telephone) residential service and Layer 2 business VPN; enterprise and service provider data center interconnect (DCI); and Ethernet exchange deployments
- Wire-line aggregation deployments

- Distributed or centralized broadband network gateway services
- Wireless backhaul
- Layer 3 aggregation of customer premises equipment (CPE)

Building a Virtualized Access and Aggregation Network with a Cisco ASR 9000 Series nV Satellite System

Service providers have long had the benefit of extremely scalable, powerful routing systems such as the Cisco ASR 9000 Series in edge networks. Efficient support for the access and aggregation layers, however, remains a constant challenge. Although the Cisco ASR 9000 Series can support more than 400 Gbps per slot, it is optimized for 10 and 100 Gigabit Ethernet interfaces, not dense sub-Gigabit Ethernet sites. In practice, as service providers strive to accommodate growing demand for diverse Gigabit Ethernet services, they are likely to run out of physical slots on the Cisco ASR 9000 Series long before they approach their back-end bandwidth limitations.

In most cases today, when provisioning services in the access and aggregation layers (whether in an enterprise wiring closet, a multidwelling unit [MDU] building basement, or a remote terminal), service providers use a separate access platform, typically a smaller router or packet optical transport platform. This approach results in a vast number of access platforms in the network, each with its own separate management and control planes, and each requiring its own provisioning—and ultimately, a huge operational effort and expense.

Now, Cisco offers a revolutionary approach to access and aggregation layer provisioning based on the new Cisco nV distributed scalability capabilities of the Cisco ASR 9000 nV Series satellite system. With Cisco nV technology, operators can virtualize hundreds of access platforms and manage them through the edge router, just as if they were internal line cards on the Cisco ASR 9000 Series router.

To use this virtual network capability, service providers deploy low-profile remote devices at access and aggregation locations instead of full-featured access routers with separate management and control planes. These remote devices use internal software to communicate with the Cisco ASR 9000 Series system edge platform, effectively enabling the Cisco ASR 9000 Series router to identify them as a distributed line card. Cisco has released the first of these remote devices, the Cisco ASR 9000v (Figure 4), which provides four 10 Gigabit Ethernet and 44 Gigabit Ethernet interfaces.

Figure 4. Cisco ASR 9000v



Cisco ASR 9000v: The First Cisco ASR 9000 nV Satellite Hardware, with 44 10/100/1000 Ports and 4 10-Gbps Enhanced Small Form-Factor Pluggable (SFP+) Ports

With a Cisco ASR 9000 Series nV satellite system, service providers gain:

- **Simplicity:** Distributed devices (including potentially hundreds of remote virtual line-card devices in a single node) are represented to the operator as part of the host Cisco ASR 9000 Series system and can be virtually managed through it as part of a single network element. Operators can use a single management interface, element management system (EMS), OS, and OS release schedule for the entire edge and access segment.

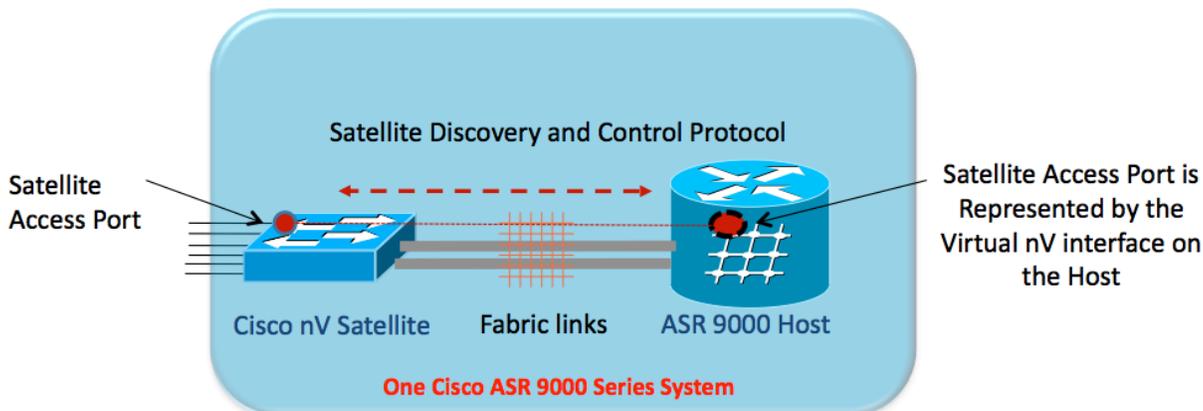
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- **Reduced OpEx:** Use of distributed devices radically simplifies the network architecture and operation requirements compared to requirements when conventional standalone access platforms are used. By reducing or eliminating the cost and effort involved in acquisition, engineering, integration, installation, software maintenance, and software and event troubleshooting, Cisco has calculated that a typical deployment can achieve up to 70 percent OpEx savings compared to the cost of using standalone network elements.
 - **Single software feature set:** with Cisco ASR 9000 Series nV satellite distributed virtual architecture, a single software feature set is populated across the Cisco ASR 9000 Series edge platform and remote-access platform. This approach eliminates software feature interoperability problems and dramatically reduces operation management and configuration time.
 - **Faster time to revenue for new services:** With the distributed capabilities of the Cisco ASR 9000v, all access-layer features and software functions are processed at the back end on the host Cisco ASR 9000 Series router. As a result, deployment of access devices is much simpler. No local configuration or expertise is needed, so service providers can bring up new services much more quickly.
 - **High density and scalability:** A virtual network that supports Cisco nV allows service providers to deliver much more bandwidth in a smaller form factor. With a Cisco ASR 9000v distributed device, service providers can deliver up to 44 Gigabit Ethernet interfaces and four 10 Gigabit Ethernet uplinks in a single 1-rack-unit (1RU) device. A single virtual node can be scaled to support hundreds of distributed Cisco ASR 9000v devices and thousands of ports, all managed and provisioned as a single network element.
 - **Reduced cost of delivering Gigabit Ethernet services:** With many customers using just a single Gigabit Ethernet circuit, operators need tools to make the most efficient use of the Cisco ASR 9000 Series' high-bandwidth interfaces. With the capability to provision dozens of individual Gigabit Ethernet circuits (up to 44 with the Cisco ASR 9000v) with a single 10 Gigabit Ethernet uplink port, operators can retain the access-layer flexibility they need to meet customers' needs, while reducing the overall cost of Gigabit Ethernet services.
 - **Reliability and flexibility:** Since distributed devices that support Cisco nV basically operate as a cross-connect with no advanced software functions, they are inherently simple, with little potential for failure. Additionally, Cisco has exhaustively tested the Cisco ASR 9000v with the Cisco ASR 9000 Series to validate the remote devices and the larger virtual network model. Operators also have the flexibility to deploy distributed devices co-located with or remote from the host platform.

As with the virtual network architecture model itself, these Cisco nV distributed scalability benefits are largely enabled by the unique capabilities of Cisco IOS XR Software. Traditional operating systems are not designed to deliver this degree of control-plane scalability. With Cisco IOS XR Software, however, Cisco has created a fully distributed software architecture to accommodate the massive density and scale of service provider edge and access networks.

Cisco ASR 9000 Series nV Satellite in Action

Figure 5 provides an overview of the distributed Cisco ASR 9000 Series nV satellite function, illustrating the connection between a host Cisco ASR 9000 Series router and a single distributed device. As illustrated in the figure, the remote access port (either 1 or 10 Gigabit Ethernet) is represented by the virtual port on the host. The uplink between the remote device and the host is treated as an internal port, automatically extending the benefits of autodiscovery, autoprovisioning, automatic image upgrading, and other Cisco ASR 9000 Series internal protocols to the remote device. The host software fully manages the remote device using client and host control protocols. The remote device autoregisters with the host and tunnels all traffic to the host in a manner that is transparent to the end user. From the point of view of the user, the host and remote devices operate as a single network element.

Figure 5. Cisco ASR 9000 Series nV Satellite



In the Cisco nV distributed satellite model, the remote device provides very simple functions: local connectivity and limited (and optional) local intelligence such as quality of service (QoS), multicast replication, operation, administration, and maintenance (OAM) performance measurement; and SyncE and IEEE 1588 timing. All network control-plane protocols and advanced features are applied at the remote device's virtual port on the host chassis. The host Cisco ASR 9000 Series router manages communication between virtual ports (and their corresponding access ports on the distributed device) and the physical uplink port. Note that the remote device performs no local switching or routing. It provides only local connectivity between the access port and the uplink port. Communication from one access port to another on a distributed device is processed through the host chassis.

With these capabilities, network operators can provide Gigabit Ethernet and 10 Gigabit Ethernet services at the access layer much more efficiently, support greater scalability and density, and reduce OpEx for a variety of applications. These include:

- Fiber-to-the-building (FTTB) and fiber-to-the-home (FTTH) deployments
- Cell-site router and backhaul deployments
- Wire-line aggregation and pre-aggregation deployments
- Video distribution deployments
- Any deployment with huge Gigabit Ethernet density

Conclusion: Revolutionizing Edge and Access and Aggregation Networks

The market for Ethernet services will continue to grow as customers consume more video, cellular, and conventional broadband network connectivity services. By employing new mechanisms to consolidate standalone equipment and eliminate complex protocols and operation processes, service providers can better position themselves to capitalize on these trends.

Enterprises are now reaping the benefits of virtualizing their data centers and applications, and Cisco can extend similar benefits to service providers by providing a means to virtualize edge and access networks. With a revolutionary virtual network approach based on next-generation Cisco nV technology, Cisco can help service providers build fully self-protected, self-managed edge and access services that simplify network operations and dramatically lower costs.

For More Information

To find out more about Cisco ASR 9000 Series nV technology, visit www.cisco.com/go/asr9000 or contact your Cisco account manager.



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