Executive Summary

Cloud computing is now the norm for agile IT services. Enterprises have set aside early concerns as private and public clouds have proven to be secure, manageable and cost effective. The next wave of cloud computing is rapidly emerging – hybrid clouds - consisting of both private and public cloud resources that are connected via “best effort” solutions such as the public internet, or “guaranteed services” solutions such as direct connections.

Enterprise applications and workloads are also rapidly transforming. Applications are now loosely connected and late binding. This allows placement of workloads in different cloud models to optimize cost and improve time to market, as well as improve customer service. And with new edge applications such as IoT, Industrial IoT, immersive experiences, video processing, etc., performance and service response times are critical, which drives the need to mitigate latency and ensure application uptime. Close-proximity placement of virtualized services closer to the edge is becoming a key factor in cloud strategies.

Service providers are well positioned to compete with public cloud providers such as Amazon Web Services, Microsoft Azure and VMware vCloud Air. Leveraging the global footprint of their highly distributed wide area networks, service providers are now building cloud centers on the edge of their global networks to mitigate latency and create value-added network edge services. Combined with the ability to offer integrated connectivity between cloud centers and public clouds, service providers can now offer “end-to-end” quality of service.

Building Blocks for a Distributed OpenStack Cloud
Enterprises are delivering new edge solutions for manufacturing (e.g., Industrial IoT), traffic management, connected cars, augmented/virtual reality and much more. These new applications are placing demands for compute, storage and resource (e.g., battery life) on edge devices and networks than can’t be met. Highly-distributed edge clouds are essential to provide on-demand virtualized resources to enable these new devices and applications to off-load critical functions to ensure performance, responsiveness and sustainability.

The key to building distributed cloud services lies in the unified delivery of several key components:

- A robust, certified OpenStack distribution
- Scalable data center and edge cloud networking services
- Integrated connectivity to external networks and resources
- Automated provisioning of WAN services with quality of service
- Coordinated management of distributed, customer-centric clouds
- Seamless placement of value-added services at the network edge

In this white paper we’ll examine how CPLANE’s portfolio of cloud services automation products addresses each of these components, enabling service providers and enterprises to quickly and reliably deploy globally-distributed OpenStack clouds.

**Certified OpenStack Distribution**

CPLANE utilizes certified OpenStack distributions from industry-leading partners Red Hat, Canonical and Mirantis. These robust solutions dramatically accelerate the deployment of the OpenStack ecosystem, including all of the management services and the underlay infrastructure as a service (IaaS) components.

The associated CPLANE components and services are included with the certified distributions, making the OpenStack cloud deployment process a single, integrated process. All of the CPLANE components utilize a “light-touch” configuration process, meaning that they require little or no manual intervention to deploy OpenStack networking services. This ensures faster cloud deployments with fewer errors and less costly rework.
The first step to building a globally-distributed OpenStack cloud is the deployment of a robust data center networking service. CPLANE’s Dynamic Virtual Networks – Data Center (DVNd) delivers unmatched performance, scalability and security for OpenStack clouds.

DVNd integrates with OpenStack as a Neutron plugin (ML2 and Layer 3) and provides secure multi-tenancy through VXLAN overlays. All networking services are handled by DVNd and there are no dependencies on OpenStack databases or schemas.

DVNd utilizes CPLANE’s SDN Service Orchestration Platform to proactively build a complete topology map of the OpenStack compute ecosystem. This is accomplished through auto-registration of each compute node via a small footprint agent on each node, which provides all communications services between the compute node and the SDN Service Orchestration Platform. As OpenStack networking requests are processed the SDN Service Orchestration Platform creates optimized flow rules which are then pushed to only the associated compute nodes in the subnet. The flow rules are then instantiated in the Open vSwitch (OVS) on each node using standard OVS-DB and OVS-CTL mechanisms. CPLANE has enhanced OVS for performance (DPDK) and functionality (e.g., ARP Proxy, DDoS detection).

Since the flow rules have been optimized based on the compute node topology, there is no need for external services traditionally provided by the OpenStack Network node. DVNd supports both Layer 2 virtual switching and Layer 3 virtual routing at each compute node, allowing application workloads to be strategically placed on specific compute nodes to maximize performance and throughput. And DVNd can utilize any Layer 2 or Layer 3 physical network structure (e.g., leaf/spine), which allows full vendor and underlying routing technology independence.

Multi-tenancy security is provided through VXLAN overlay segregation, so there is no chance of any traffic crossover. ARP requests are processed locally at each compute node, eliminating the risk of external ARP poisoning. And since VXLAN eliminates the constraints of VLANs and Spanning Tree protocols, virtual networks can scale to thousands of compute nodes and millions of virtual machines.
By utilizing standard OpenStack distributions, CPLANE has made the DVNd installation process fast and easy, and since all compute nodes auto-register there is no need for time consuming and error-prone configuration. In the event a compute node fails, upon reboot the node once again auto-registers with the Orchestration Platform, eliminating the need for any manual intervention.

DVNd enables secure separation of tenants and applications through VXLAN running on vendor-independent leaf/spine architectures and supports both L2 virtual switching and L3 virtual routing.

**External Resource Connectivity**

Hybrid clouds require connectivity to other resources such as other private clouds, public clouds, legacy infrastructure and emerging service delivery platforms such as containers. This connectivity was traditionally provided by a dedicated hardware platform which acted as a gateway across network boundaries. Given the dynamic nature of software-driven clouds, implementing expensive dedicated hardware-based gateways is no longer an option – from both a cost and operational perspective.
CPLANE’s software-only gateway solution, Overlay Gateway Router (OGR), delivers an optimal price/performance solution that can be instantiated as a virtualized network function on any x86 platform. For situations that require a dedicated solution, OGR can also be run as an x86-based physical network function. OGR utilizes the same architecture as DVNd compute nodes, creating a seamlessly-integrated solution managed by a common user interface and APIs.

OGR participates as a node on any VXLAN overlay within a tenant network, providing VXLAN to BGP translation. Thus, any L3 network can quickly and securely connect to any tenant subnet. For tenants that require multiple subnets, a single OGR instance can be shared across the subnets.
Typical use cases for OGR gateway services include:

- Integration of OpenStack cloud networks with legacy VMware infrastructure (non-NSX).
- Connecting OpenStack tenant networks to external customer or service networks or container/micro-service platforms.
- Connecting OpenStack tenant networks to public clouds via IPSEC VPNs (Cloud Bursting).
- Connecting multiple distributed, discrete OpenStack instances in different geographic locations (Multi-Site OpenStack).

Multi-Site OpenStack with Cloud Bursting - Distributed cloud sites with multiple tenants connected via Overlay Gateway Router
In the above example service providers and enterprises may deploy customer instances in multiple sites to create separate or distinct cloud services. For example, Tenant A may have discrete instances in both Site 1 and Site 2 for business continuity or data replication purposes. Tenant B in Site 1 and Tenant D in Site 2 might be suppliers or partners that need to connect discrete OpenStack cloud instances to exchange services. Or, as is often the case, customers may need to maintain discrete instances (e.g., Tenant B may need connectivity to a new site (e.g., Tenant D) as part of a merger or acquisition that need to operated independently. And in many cases, customers may need to connect OpenStack clouds to resources in public clouds (Tenant C) or to other infrastructure resources (Tenant E).

OGR enables easy integration of discrete OpenStack sites through simple BGP/VRF configuration and route advertisement. OGR is easily provisioned via the SDN Service Orchestration Platform user interface, or using open ReST APIs, eliminating the need for error-prone manual scripting.

Automated WAN Provisioning

By placing cloud centers closer to the customer, edge clouds solve latency issues and create a platform for value-added services. As distributed OpenStack clouds continue to gain popularity, seamless “end-to-end” connectivity between them becomes a top priority. Application workloads need to access resources in other cloud centers, legacy hosting environments, and public clouds. Provisioning of WAN services to satisfy these connectivity requirements must meet the same rigorous service requirements that customers expect for cloud center compute, storage and network services.

Most service providers and enterprises have a variety of operational support systems (OSS) to configure WAN services. However, these systems often require manual configuration and use a variety of disjointed methods (e.g., spreadsheets) to maintain an inventory and topology of both the deployed and available networking resources. And they often lack key operational oversight capabilities to enforce policies and ensure operational integrity.

CPLANE’s WAN automation and provisioning solution, Dynamic Virtual Networks - Interconnect (DVNi), delivers a full range of features for global-scale Multi-Protocol Label Switching (MPLS) networks. Like all CPLANE solutions, DVNi utilizes the SDN Service Orchestration Platform as a common base for all networking services. This ensures consistency of performance, scale and operational ease of use, and eliminates the need for costly and time consuming integration with other platforms.
DVNi delivers key WAN services that allow service providers to quickly and efficiently create connectivity services that easily integrate with cloud center compute, storage and networking services and provide end-to-end quality of service.

- Automatic discovery of network topology and device capabilities
- Drag and drop or auto-generated mesh LSP networks
- LSP traffic optimization and what-if analysis and modeling
- Dynamic Layer 2 and Layer 3 VPNs with QoS and backup
- Full traffic engineering with patented path computation
- Bandwidth management with resource-based admission control
- Edge policy and class of service management
- Pre-deployment modeling, simulation and validation
- Transactional end-to-end service activation with rollback
- Historical logging and auditing
- Multi-vendor support (Cisco, Juniper, Arista, etc.)
- Rich southbound device communications (CLI, SNMP, XML, Netconf, etc.)

As with all CPLANE solutions, DVNi provides a rich drag-and-drop user interface for operational ease of use, and a complete set of APIs that allow full orchestration of all WAN automation and provisioning services by external management systems and business support systems (BSS).

DVNi also provides a full-feature service development kit (SDK) which allows service providers and enterprises to quickly create new solutions. The SDK supports algorithmic and function development using popular languages such a Python, and enables sophisticated event and condition-based composite workflows via an integrated logic construction platform.
CPLANE’s DVNi delivers full WAN automation and provisioning with seamless integration through OGR to provide end-to-end connectivity with QoS between cloud centers.
Multi-Site Management

Service providers and enterprises are rapidly shifting from traditional “ticket-based” service requests (which normally take days or weeks to fulfill) to a “self-service” model where customers can directly request new cloud services in real time. Enabling the self-service model requires several key features:

- Tight integration between customer-facing service management systems and infrastructure as a service (IaaS) orchestration systems
- Simultaneous orchestration of all IaaS elements within a service package
- A customer-centric view of all the services and IaaS elements which comprise a service package

CPLANE’s Multi-Site Manager (MSM) provides coordination and orchestration of OpenStack compute, storage and networking across distributed cloud centers. MSM sits between northbound business support systems that provide customer-facing services (e.g., service portal) and distributed southbound IaaS resources that are used to create customer-specific private cloud instances.

CPLANE’s Multi-Site Manager provides coordinated orchestration across multiple distributed OpenStack instances.
MSM receives the customer service requests generated by the BSS front-end and then translates them into the appropriate OpenStack API calls for compute, storage, and networking. MSM then builds and executes associated workflows for each distributed cloud site, ensuring that all requests are successfully completed.

In each target OpenStack cloud center, CPLANE’s Dynamic Virtual Networks – Data Center creates virtual overlay networks for each customer subnet. Then, to create end-to-end connectivity for each subnet in a distributed cloud center, MSM automatically creates and configures an Overlay Gateway Router. For service providers that are utilizing CPLANE’s Dynamic Virtual Networks – Interconnect, connectivity to Layer 3 VPNs can also be automatically configured, including connections to dedicated cloud services such as AWS Direct Connect.

A key aspect of MSM is the integrated, customer-centric topology model, which provides a complete view of all the resources allocated to a customer across multiple distributed cloud centers. This integrated view is passed upstream to the BSS and can be presented to the customer via the service portal, and it can also be used for resource management, accounting, and billing.

Multi-Site Manager includes key features to ensure service and operational integrity:

- Automatic propagation of new customer requests to OpenStack
- Customer credentials synchronization and management across multiple OpenStack sites
- Automatic creation of OpenStack virtual network objects to support new virtual machine requests
  - Network, subnet and router, floating IP, etc.
- Automatic provisioning of dedicated OGR VM
- Query operations for OpenStack components
  - Virtual machine flavor definitions per site
  - Virtual machine image definitions per site
  - Site specific storage options
- Query Operation of OpenStack inventory
  - Virtual machines
  - OGR / route definitions
  - Network definitions
  - Storage definition and use
  - State and status of virtual machines
Creating globally-distributed cloud centers allows services providers to offer new value-added network edge services such as firewalls, load balancers, traffic shaping, and even industry-specific data management or security solutions. Integrating these services with their overall customer-centric, self-service model is key.

CPLANE delivers a complete Network Function Virtualization Infrastructure (NFVI) and Virtualized Network Function (VNF) orchestration and management platform that addresses the full Network Edge Services life cycle, from initial infrastructure deployment through NFV application configuration and maintenance.

CPLANE partners with industry-leading NFVI platform providers such as Telco Systems to create a fully-integrated Network Edge Services solution that includes powerful networking, a high-performance application platform, and a rich suite of virtualized network functions. Utilizing OpenStack as the NFVI orchestration platform provides a consistent service architecture that seamlessly integrates with CPLANE’s Multi-Site Manager cloud orchestration solution.
NFV Services

- Life cycle management (create, delete, modify) of CE2.0 transport services on the network edge device
- Monitoring and management (add, remove, modify) of SLA profile on per EVC/QoS basis
- Management (create, initiate, stop, terminate, modify, protect) of VNFs on NFV edge infrastructure

VNF Life Cycle Management

- Configuration management
- Resource management
- Traffic management
- Service chaining and modification
- Backup and restore of VNF instances and configurations

- Initial setup includes base connectivity to the service provider access network or through an access provider’s ENNI connection
- Registration and initial setup via simple script configuration or via zero-touch DHCP-based provisioning
- Acceleration and offload methods (Telco Systems)

The explosion of NFV at the network edge is driving new architecture requirements for managing the virtual infrastructure required to support micro-services. While scale-up is critically important in large cloud centers, scale-out to thousands of endpoints is equally important for NFV and IoT. The architecture required to support this hyper-distributed model demands open integration of multiple systems, all working in concert to quickly and reliably deploy dynamic services, which are often comprised of many services linked together in complex service chains.
The European Telecommunications Standards Institute Industry Specification Group (ETSI ISG) working group for Management and Orchestration (MANO) is defining the architecture model for NFV orchestration. This model defines the integration points for the various functions that define NFV service orchestration. CPLANE’s Service Orchestration Platform seamlessly integrates into the architecture, providing complete cloud and NFV lifecycle service management. Through open northbound APIs, the Platform provides full service abstraction for all other MANO functions. With fully-integrated policy management and workflow, the Platform ensures reliable orchestration of complex service functions that span multiple distributed sites. The northbound APIs also enables easy integration of NFV ecosystem partners that provide value-added VNFs. And through a rich set of southbound protocols and interfaces, the Platform easily integrates with and manages a wide variety of virtual infrastructure managers (VIM) and VNF managers.

The MANO Architecture

The MANO Architecture

Globally-distributed clouds are a combination data center, WAN and edge infrastructure services that require end-to-end orchestration to deliver a true customer-centric user experience.
Through its Dynamic Virtual Networks family of products, CPLANE delivers a seamlessly-integrated service orchestration solution that leverages the power and flexibility of OpenStack. CPLANE’s Multi-Site Manager extends that power and flexibility to enable service providers and enterprises to deliver cloud services closer to the customer (or user), improving performance and creating a platform for value-added services.

CPLANE provides an ideal single-solution platform for creating a complete cloud service life cycle, starting with data center networking orchestration and then extending the cloud ecosystem to include full WAN integration, resource connectivity and network edge services.
About CPLANE.ai

CPLANE.ai orchestrates and manages highly-distributed clouds for Edge Computing, IoT, Industrial IoT, MEC, Fog, and intelligent edge applications. We eliminate the complexity associated with deploying cloud resources to millions of Edge Computing end points, allowing enterprises and service providers to focus on value-added business and IT services.

To learn more about our fully-integrated cloud orchestration and software-defined networking solutions, visit us at: www.cplaneai.com

Contact us:
info@cplaneai.com
+1 408.475.4950