WHITE PAPER

OPTIMIZING CLOUD INFRASTRUCTURE WITH SOFTWARE-DEFINED NETWORKING

Cloud administrators can leverage new technologies to make fundamental changes to data center network infrastructure, reducing costs and improving efficiency, while supporting existing and next generation applications and clients.
Vello Systems recommends the OpenFlow standard to implement a software-defined networking (SDN) strategy that provides a basic set of management constructs to enable value-added capabilities for data center local and wide-area networks.

Network automation and virtualization of data center LAN and WAN connections can deliver a dynamic, flexible, application-aware infrastructure to meet operational challenges. The OpenFlow routing protocol championed by the Open Network Foundation (ONF) industry consortium provides foundation technology for software-defined networking that enables users, applications, and network owners to take control of network traffic flows.

Vello Systems offers open, scalable network virtualization solutions for connecting storage and compute resources in data centers within public and private cloud environments. Through a combination of optical and networking innovation, Vello CX cloud switching systems are purpose-built platforms that address cloud data center interconnection challenges, including capacity relief, capability, complexity and cost.

The extensible, software-defined networking capabilities of Vello cloud switching leverage OpenFlow-based software-defined networking in order to enable unified control of the global cloud for WAN resource optimization.
The Cloud Infrastructure Challenge

Network automation and virtualization of LAN and WAN connections can deliver the dynamic, flexible, application-aware infrastructure needed to solve cloud operational challenges. However, the architecture of existing routers and switches deployed in LAN and WAN environments is ‘closed’ with a limited degree of user programmability for traffic engineering and management, and inconsistent traffic management between equipment from multiple vendors.

This is a challenge for organizations deploying private and multi-tenant, public cloud computing infrastructures that require end-to-end traffic engineering across heterogeneous networks to dynamically define flows, determine what path those flows take through a network, and control which types of network services are applied to specific flows.

Software-defined networking utilizes the OpenFlow standard to provide a basic set of management constructs that implement value-added capabilities for data center local and wide-area networks, applying network features at a fine-grained flow level, and enabling end-to-end visualization and automation.

The result is a dynamic, flexible cloud infrastructure that protects existing applications investments, while optimizing operating expenses. In addition, SDN can enhance existing applications that take advantage of its superior flexibility, while it enables the evolution of a new class of network-aware applications.

Vello System’s CX family of cloud infrastructure modules provide a portfolio of public and private cloud network deployment solutions. Transforming cloud data centers into globally-pooled resources with extensible software control, cloud switching delivers over 30% lower cost, 4X scalability, 2-4X density, and 30% less power when compared to traditional optical wide-area networking offerings.

The CX cloud switching family of modules is powered by the Vello real-time network operating system. VellOS is architected to provide a framework for software-defined networking by allowing rapid development and integration of end-to-end network features, such as storage replication for business continuity and disaster recovery, geographic server load balancing, content acceleration, and network visualization. The result is a highly automated and resilient infrastructure through deployment of a new class of optimized network-aware management applications.

The extensible, software-defined network management capabilities of Vello CloudMaster leverages the OpenFlow standard to enable unified control of the global cloud for WAN resource optimization. Private and public cloud providers see open, extensible networking as a major benefit since Vello cloud switching simplifies management of multi-vendor networks, while speeding up the introduction of innovative services.

Large-scale Data Center Consolidation

The adoption of more virtualized, dynamic application environments is impacting traditional enterprise and hosted/multi-tenant data center designs. This is also enabling new cloud-based delivery models that drive a new set of technology requirements across servers, storage, and networking domains. These increasingly popular usage models allow enterprises to provision applications more flexibly within a private infrastructure while enabling hosted application and service providers to build entire businesses based on delivering services via a public cloud model. Given the range of use cases and options, enterprises often deploy a combination of public and private cloud computing architectures to address varied requirements and to optimize operations.

By exploiting virtualization and commodity servers, cloud computing enables deployment of more and more sophisticated applications on a larger scale. Now, thousands of virtual machines (VMs) can be deployed in a single data center to consolidate infrastructure and streamline operations. These large-scale solutions have dramatically increased network performance requirements at the server edge and across the extended network. Likewise, virtualization and VMotion/Live Migration tools for moving virtual servers have introduced high-volume machine-to-machine traffic flows that have impacted existing administrative practices creating a new ‘virtual edge’ that blurs the traditional boundaries between network and server administration.

To reduce the sheer complexity and cost of operating cloud deployments, public and private cloud providers are seeking to consolidate fragmented, dispersed facilities into fewer, centralized data centers. These new ‘hyper-scale’ data centers are challenging network architects in fundamental ways. Today’s networks must be designed to deliver much higher levels of performance, scalability, and availability than before to meet service-level agreements.
(SLAs) and maintain continuity of operations. Beyond sheer performance, these data center networks must quickly recover from hardware- or software-related faults and protect against server, storage, network, and application vulnerabilities to ensure continued performance and minimize service disruptions.

Cloud Networking Challenges and Requirements

The main advantage of cloud computing is on-demand access to resources, and virtualization plays a key role in providing those resources. With hundreds or even thousands of virtualized applications supported across multiple, consolidated data centers, network resiliency and high availability take on a new, heightened level of importance. To maintain continuity of service and business continuity, network platforms and designs must be able to recover quickly from hardware and software faults.

Cloud-based applications, server virtualization and on-demand services are pushing conventional hierarchical data center networks to their limits. Legacy networks designed to enable client-server communications (or ‘North-South’ traffic, in and out of the data center) cannot accommodate the bandwidth-intensive, latency-sensitive intra and inter-data center server-to-server flows (‘East-West’ traffic) imposed by inter-host, intra-VM, and synchronized inter-VM servers communicating with each other within the same network and also across geographically distributed networks.

Beyond driving the need for better server-to-server connections, server virtualization provides customers flexible tools for migrating virtual machines within the data center to optimize operations and improve availability. The advantage of on-demand resources can be greatly magnified. An infrastructure with mobile, active virtual machines can respond to new requirements much more quickly and very cost-effectively.

Cloud computing users can gain even greater advantages from mobile virtual machines when they can be moved not only within a cloud data center, but over greater distances to connect multiple cloud data centers. Virtual machine movement between cloud data centers enables applications such as disaster recovery and data replication.

Intra and inter-cloud data center migration of virtual machines dictate very specific network design requirements: networks must be ‘flat’—which means that they have to be designed to connect potentially thousands of physical servers hosting tens of thousands of virtual servers within a single Layer 2 network domain. Network platforms and architectures not built to scale to these levels can limit deployment flexibility and increase management complexity.

Moving live virtual machines within (and across) data centers has traditionally been a complex task because of the requirements of storage accessibility and moving the network-level policies associated with each virtual machine to its new location. The data storage location including the boot device used by the virtual machine must be active and accessible by both the source and destination virtual servers at all times.

In addition, virtual machine policies, such as performance, security and quality of service (QoS), differ with different users and applications, making the movement of such policies with the virtual machine critical. Moreover, in cloud data centers supporting multi-tenancy environment, the dynamic policy provisioning becomes necessary for each tenant and its management becomes more complicated.

Beyond virtual machine migration, with virtualization and cloud-like service delivery, business continuity confronts new elements of complexity. Data protection strategies for virtualized applications must be evaluated together with their specific content and associated storage, along with the network connectivity for local and remote storage locations. The same types of challenges apply when performing backup operations across the network to a disaster recovery site, or deploying stretched storage clusters across multiple sites.

Leveraging OpenFlow for Cloud Optimization

A key imperative for public and private cloud administrators is a modern, flexible infrastructure to support their existing and next generation applications and client devices. To enable this imperative, cloud providers require a resilient IT network infrastructure that can lower the costs of operation as they scale out compute and storage virtualization.

Data centers support the computational power, storage, networking and applications that form the basis of enterprise and cloud provider IT infrastructure. To reduce costs and increase the efficiency of this business-critical resource, IT organizations commonly implement new technologies and also make fundamental architectural changes.
Network automation and virtualization of LAN and WAN connections can deliver the dynamic, flexible, application-aware infrastructure to meet these operational challenges. However, the router and switch architectures deployed in LAN and WAN environments are ‘closed’ with a limited degree of user programmability for traffic engineering and management, and inconsistent traffic management between equipment from multiple vendors. This is an obstacle for organizations deploying private and multi-tenant, public cloud computing infrastructures that require end-to-end traffic engineering between equipment from multiple vendors to dynamically define flows, determine what path those flows take through a network, and control the types of network services that are applied to specific flows.

While Multi-Protocol Label Switching (MPLS) provides WAN-based traffic management and engineering, the programmability of the MPLS capabilities of a particular vendor’s platform is specific to that vendor. Also, MPLS is a Layer 3 technology, whereas what is really required is a Layer 2 method, which has particular applicability to virtualized data centers.

In response to this challenge, the OpenFlow routing protocol championed by the Open Network Foundation (ONF) industry consortium provides foundation technology for software-defined networking that enables users, applications, and network owners to take control of network traffic flows. This capability allows users to craft policies that find paths, for example, with available bandwidth, less latency or congestion, or fewer hops. The OpenFlow standard also provides a basic set of global management constructs that can be used to control features, such as topology changes or packet-filtering.

Software-defined networking utilizes the OpenFlow standard, which provides a basic set of management constructs to enable value-added capabilities for data center local and wide-area networks, such as applying network features at a fine-grained flow level, or enabling end-to-end visualization and automation. The result is a dynamic, flexible cloud infrastructure that protects existing applications investments while optimizing operating costs. In addition, it enables transformation of existing applications that can take advantage of its superior flexibility, while enabling a new class of network-aware applications.

The UBS Q42011 Enterprise Networking CIO Survey found that while SDN/OpenFlow is still in the development/trial phase, awareness among CIOs is significant. About half of the respondents were aware of SDN/OpenFlow, while 27% of respondents felt it will be disruptive to the networking industry in the next three years. While OpenFlow/SDN will initially be utilized by large, public cloud and data center providers seeking to have more control over the networking layer, that phase will be followed by SDN/OpenFlow deployment within enterprise data centers.

**WAN Resource Optimization for Cloud Computing**

Vello Systems offers open, scalable network virtualization solutions for connecting storage and compute resources in data centers within public and private cloud environments. Through a combination of optical and networking innovation, Vello CX cloud switching systems are purpose-built platforms that address a range of wide-area networking problems associated with cloud data center interconnection, including capacity relief, capability, complexity and cost.

**Capacity**: The CX family offers economical low-latency gigabit to multi-terabit capacity for interconnecting cloud data center resources across metro and long-haul networks. At the heart of the CX family is Vello Systems’ state-of-the-art grid-less optical transmission technology enabling high-density Nx10G solutions capable of scaling to multiple terabits of capacity over existing 10G fiber and DWDM networks, on old and unconditioned fiber, and even when multiplexed onto fiber shared with other vendor’s equipment.

**Capability**: With CX cloud switching, cloud providers can partition and virtualize capacity in the wide-area as needed for cloud-based compute and storage resources, which can enable highly-flexible, economical, any-to-any connectivity. Additionally, with the CX family’s comprehensive portfolio of access interfaces, providers have a complete foundation for residential, commercial and mobile cloud services.

**Complexity**: For element and network management, CX cloud switching is fully manageable through comprehensive element management capabilities combined with point-and-click service provisioning. This enables cloud providers to simplify cost. The Vello CX family is architected to deliver a much more cost-effective solution vis-à-vis alternative wide-area optical switching systems for cloud data center interconnection. CX switches leverage industry-standard merchant digital and optical ICs with a focus on highly efficient integration. The result is highly dense system-on-a-card capabilities that consume less power.

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**Figure 3.**

Vello cloud switching enables seamless VM and storage mobility across cloud data centers.
Vello CX Cloud Switching Overview
The CX family of cloud infrastructure systems forms the foundation for Vello Systems’ product portfolio for wide-area network deployment for public and private clouds. Transforming cloud data centers into globally-pooled resources with extensible software control, cloud switching delivers over 30% lower cost, 4X scalability, 2-4X density, and 30% less power when compared to traditional optical wide-area networking offerings.

The CX cloud switching family is powered by the VellOS real-time network operating system. The highly extensible and flexible VellOS operating system is architected to provide a framework for software-defined networking by allowing rapid development and integration of end-to-end network features such as storage replication for business continuity and disaster recovery, geographic server load balancing, content acceleration, and network visualization. The result is a highly automated and resilient infrastructure implemented by deployment of a new class of optimized network-aware management applications.

The extensible, software-defined networking capabilities of Vello cloud switching and CloudMaster leverage OpenFlow-based software-defined networking in order to enable unified control of the global cloud for WAN resource optimization. Private and public cloud providers see open, extensible networking as a major benefit since Vello cloud switching simplifies management of multi-vendor networks, while speeding-up introduction of innovative new services.

Vello Cloud Switching SDN Use Cases
Traditionally, inter-Data Center L3-based solutions have been preferred to L2-based solutions. However, because VMs cannot be moved outside their L2 network, there are implications influencing the choice of L2 solutions that enable high-performance and scalability, and the means to seamlessly extend Layer 2 domains across multiple data center sites.

A simpler approach to extending Layer 2 storage networks across distances uses Layer 1 networks to create WANS or MANs with mesh connectivity. The Vello Systems CX family with cloud switching technology delivers a software defined network that manages Ethernet and Fibre Channel links across distances at rates up to 40G with the lowest network latency.

By converging the management and transport of Layer 2 and Layer 1 networks, Vello cloud switching creates a flatter network design than traditional Layer 3 networks for cloud server and storage infrastructure. Thus, East-West communications can employ a dynamic, dedicated Layer 2 infrastructure that can scale across campus, metro, and long haul distances.

L2 Extension for Inter-Data Center VM Mobility
The traditional approach for extending Layer 2 domains across data center sites is to use Layer 3 routing in the core-networking layer for inter-data center server-to-server communications. However, facilitating VM migration across physical infrastructure boundaries and data centers, L3 routing poses specific challenges for intra-data center connectivity, the data center network and storage designs.

The availability of data to the two virtualized servers is critical to a successful migration of the virtual machine. However, enabling distributed workloads and replicating data and applications across multiple, geographically-dispersed data centers presents challenges. Conventional Layer 3-oriented WAN solutions cannot meet the stringent performance and low latency requirements for seamless VM migration across data center boundaries, which require active-active storage failover solutions incorporating synchronous replication technologies that make synchronized data actively available at both the local and remote data centers at all times.

Vello cloud switching enables cloud providers and enterprises to seamlessly extend Layer 2 domains across multiple data center sites. Such end-to-end L2 networks can enable high-performance, direct-flight server-to-server connectivity for high-volume server-to-server communications and enable large L2 domains for flexible virtual server migration. The storage networking design using extended L2 networking can encompass all the properties and parameters of the data for inter-data center communications, which enable seamless VM migration. This results in strict adherence to application delivery SLAs across consolidated data centers.

OpenFlow support of Vello cloud switching will enable the cloud wide-area network to gain virtualization-awareness as well as migration of performance, security, and QoS policies concurrently with VM migration. Traditionally, moving policies along with virtual machines requires extensive manual configuration and carries with it a significant opportunity for misconfiguration and security breaches if it is not implemented correctly. In the fluid cloud environment, administrators need tools that can manage mobile virtual machines with their associated policies across data centers and scale to potentially tens of thousands of physical servers. Such tools and the ability to automate mobile virtual machine management will be critical to administrator productivity.

Storage Replication for Business Continuity
Enterprises and cloud providers that continuously replicate to duplicate data stores require a network solution that places the replicated data store at a remote site in the most reliable, high-performance fashion possible. Current remote site networking strategies require the use of routing or Layer 3 network elements, while the data plane carrying the storage for replication resides at Layer 2.
The tunneling of Layer 2 connectivity through various Layer 3 protocol options leads to complexity, as well as increased end user capital and operational expenditures. In addition, if end users (or cloud providers) try to solve the network problems of Layer 2 connectivity with three or more data centers (peers or active-active data centers with tertiary backup), traditional L3 networking approaches, for example using MPLS, add complexity and performance limitations.

Vello cloud switching is designed to virtualize wide-area capacity, enabling highly-flexible, economical, any-to-any connectivity for multi-point storage applications. The Vello cloud switching optical mesh network provides over 30% savings compared with the cost of traditional wide-area optical infrastructure for any-to-any connectivity. It also enables lossless low latency wide-area networking for intra-metro (<100km) and inter-metro (>100km to 10,000km) links using the same open network infrastructure.

Vello CloudMaster management console supports software-defined networking for policy-based wide-area network provisioning, which enables cloud providers to dynamically program paths in the wide-area by reconfiguring topologies and bandwidth profiles on the fly for wide-area storage replication applications. Support of OpenFlow enables integration with higher-level IT management applications and virtualization environments along with holistic management of LAN/WAN network resources.

Conclusion

To reduce costs and improve efficiency, while supporting existing and next generation applications and client devices, public and private cloud administrators can leverage new technologies to make fundamental architectural changes to data center network infrastructure.

• Network automation and virtualization of data center LAN and WAN connections can deliver the dynamic, flexible, application-aware infrastructure to meet network operational challenges

• The OpenFlow routing protocol championed by the Open Network Foundation (ONF) industry consortium provides foundation technology for software-defined networking that enables users, applications, and network owners to take control of network traffic flows.

Vello Systems offers open, scalable network virtualization solutions for connecting storage and compute resources in data centers within public and private cloud environments.

• Through a combination of optical and networking innovation, Vello CX cloud switching systems are purpose-built platforms that address cloud data center interconnection challenges, including capacity relief, capability, complexity and cost.

• The extensible, software-defined networking capabilities of Vello cloud switching leverage OpenFlow-based software-defined networking in order to enable unified control of the global cloud for WAN resource optimization.
The Vello CX Family

With its suite of highly dense 10G and 40G solutions, combined with a complete set of Ethernet and Fiber Channel client interfaces, the CX family enables high performance wide area networking at a fraction of the cost and power of traditional Layer 2-3 solutions.

This makes the CX family ideal for boosting the performance of MAN or WAN, or for enabling real time low-latency inter-site connectivity supporting wide-area HPC, as well as high-performance low latency storage stretch cluster replication, backup and recovery of business-critical data.

About Vello Systems

Vello Systems provides network virtualization solutions that simplify networking and deliver greater application efficiency, agility, and resiliency.

Vello’s CX family of systems deliver greater capacity and scalability for multipoint WAN connections and are latency-optimized for mission-critical data center applications.

Based in Menlo Park, California, Vello Systems provides networks to enterprise and service provider customers in North America, Europe, and Asia. To learn more, contact your Vello Systems sales representative at sales@vellosystems.com, or visit us at www.vellosystems.com.