Cloud interconnect for communications service providers

Data center interconnect for the cloud era

Strategic white paper

Many communications service providers (CSPs) offer a range of managed and unmanaged data center interconnect (DCI) services to enable enterprises, industries and public sector customers to interconnect their data centers. They also interconnect their own data centers to support service delivery and back office functions. But data centers and IT are moving to the cloud, and CSPs need to offer new cloud DCI services to take full advantage of the cloud ecosystem.

CSPs are ideally placed at the heart of the cloud ecosystem to offer cloud interconnect — or DCI for the cloud era — to all participants and thereby drive additional revenues and profitability. But to be successful and make the most of the cloud opportunity, CSPs need to recognize that cloud interconnect services must be more scalable, agile and flexible than current DCI services.
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The cloud interconnect opportunity

Data center interconnect (DCI) services are widely used to link and transport traffic between enterprise, industry and public sector customers’ data centers. With the continued growth of data centers across all segments of the market and the adoption of cloud, DCI is the fastest-growing application for optical transport and is projected to grow at twice the rate of the global optical network market. In a recent update to its study of metro network traffic growth, Nokia Bell Labs predicts that data center interconnect and user-to-data center traffic will increase by 430 percent from 2015 to 2020, mostly due to customer adoption of cloud.

Many communications service providers (CSPs) already provide a wide range of optical DCI services, including dark fiber, managed wavelengths and Carrier Ethernet. IP-based approaches to DCI are also becoming increasingly important to interconnect data centers. IP DCI has emerged as a growing router application for CSPs who need to connect cloud-based data centers across existing IP/MPLS WANs. Several industry analysts estimate that routers for IP DCI will make up an increasing percentage of the overall DCI and router markets over the next few years due to cloud.

CSPs have the advantage of incumbency in regions and locations where securing dark fiber and offering managed DCI services is difficult for other participants. Managed DCI services represent a high-revenue, high-margin business for CSPs and have enabled them to retain customers due to the business-critical nature of the business continuity and disaster recovery capabilities that DCI provides. This has created a level of “stickiness” that makes it difficult for organizations to move DCI services from one provider to another. DCI services are also very competitively priced, and CSPs are often willing to reduce prices or offer add-on incentives such as hosting to retain customers.

But as customers move data centers and IT to the cloud, CSPs need new approaches to DCI to enable customers to take full advantage of the agility, flexibility and lower cost benefits that cloud offers. CSP fiber, optical and IP networks span the globe, and CSPs have central offices (COs) and points of presence in thousands of locations to maximize footprint and reach.

Many CSPs can leverage existing data centers that support service delivery and back office functions to deliver their own cloud services. Some are also looking to leverage their data centers and repurpose central offices to support next-generation software-defined network (SDN) and network functions virtualization (NFV) server-based architectures that improve agility, flexibility and costs when delivering cloud services.

As a result of all these circumstances, CSPs are ideally placed to benefit from the cloud ecosystem by offering a new type of cloud DCI — cloud interconnect — to all participants to connect their distributed data centers in private, virtual private, public and hybrid clouds.

Cloud interconnect provides scalable, cost-effective bandwidth with high performance, reliability and low latency. It also offers security, QoS and end-to-end management to run business-critical applications in the cloud — characteristics that the internet cannot provide. And cloud interconnect provides the ability to increase and decrease bandwidth as needed, with multi-site and multi-technology capabilities to help share data, distribute applications and balance workloads. Most important, cloud interconnect provides agile, dynamic provisioning with support for orchestration of network resources quickly and easily, particularly across multiple cloud types and administrative domains in the cloud ecosystem.

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The cloud ecosystem

The cloud ecosystem comprises private, virtual private, public and hybrid clouds that all have unique benefits to offer, such as agility, flexibility, greater control and lower costs. The different types of cloud and the various participants in the cloud ecosystem are shown in Figure 1.

Cloud is a service delivery model, not a product, and the definitions of the different types of cloud can be confusing. Some generally understood definitions are:

- **Private cloud**: The data centers and DCI network that interconnect them are completely dedicated to and controlled by a single organization such as an enterprise, or a group of organizations with a common interest such as an industry body or a government agency.

- **Virtual private cloud**: The organization’s data centers are virtualized, which allows them to include remote IT resources in data centers owned by other organizations, such as a CSP or a carrier-neutral provider (CNP).

- **Public cloud**: An internet cloud content provider (ICP) offers cloud services to organizations to use on a pay-as-you-go basis.

- **Hybrid cloud**: This model combines public with private and virtual public clouds, with orchestration of resources across the private-public cloud boundary.

Figure 1. The cloud ecosystem and the various participants

In addition, the various participants in the cloud ecosystem each have their own specific role to play:

- CSPs are focusing mainly on providing managed DCI and cloud interconnect services, and are using their data center assets and central office resources to offer virtual private cloud services. They are also colocating in CNP facilities with other CSPs to provide main cloud interconnect points.

- CNPs are building and expanding their data centers and colocation facilities, particularly in metro areas and smaller cities. They are also implementing private metro DCI for intra- and inter-data center connectivity.
• ICPs have hyper-scale data centers and are building private terabit DCI to interconnect their data centers on campuses, in metro areas, and regionally, nationally and internationally. ICPs also see the benefits of collocating in CNP facilities to expand local capacity and reach more customers.

• Enterprises, industries and public sector customers are building private, virtual private and hybrid clouds. Using private DCI to build private clouds with control and security, they are also expanding into CSP and CNP colocation facilities and implementing virtual private and hybrid clouds for greater agility and flexibility.

The different types of cloud and the various participants in the cloud ecosystem are described in the Nokia white paper Cloud ecosystem and the role of cloud interconnect, and their key roles are summarized in Figure 2.

Figure 2. The various participants and their roles in the cloud ecosystem

The role of CSPs and cloud interconnect in the cloud ecosystem

Cloud interconnect presents an ideal opportunity for CSPs to increase revenues and drive profitability. For example, they can offer enterprises, CNPs and ICPs cost-effective, highly scalable and high-performance cloud interconnect services to connect data centers, colocation facilities and exchange points in the cloud ecosystem, as shown in Figure 3. Specifically, cloud interconnect helps CSPs to:

• Offer direct connect and managed DCI services to connect multiple data centers in private, virtual private, public and hybrid clouds

• Deploy data center gateways to extend customer data center virtualization over IP/MPLS services and connect remote sites and end users to applications in the cloud

• Connect distributed data centers and COs to optimize resource pools and improve efficiency when delivering cloud services.
• Expand footprint to reach more customers by collocating in CNP facilities to create cloud interconnect and exchange points

However, CSPs must ensure their cloud interconnect services are more scalable, agile and flexible than traditional DCI services if they are to make the most of the opportunity presented by the dynamic nature of cloud services and the cloud ecosystem.

Figure 3. The role of CSPs in the cloud ecosystem

Offer cloud interconnect to enable the cloud ecosystem:
- Offer direct connect/managed DCI to connect multiple data centers in private, virtual private, public and hybrid clouds

Connect data centers, remote sites and users to the cloud:
- Deploy data center gateways to extend virtualization over the WAN and connect remote sites and users to cloud applications

Deliver efficient and cost effective cloud services:
- Connect own data centers and central offices, improve resource efficiency, optimize cloud services delivery

Create exchange points by collocating in CNP facilities:
- Reach more customers, expand ICPs partnerships, extend public cloud services and enable hybrid clouds

Offer cloud interconnect to enable the cloud ecosystem

To fully capitalize on the cloud opportunity, CSPs need to build private cloud interconnect networks with massive scalability, reliability and low latency to support the cloud IT model. The reason is that the cloud drives bandwidth needs between data centers. For example, a single database request can spawn additional database lookups, multiple related remote procedure calls and a significant increase in machine-to-machine communication both within data centers and between data centers, particularly when applications are distributed in the cloud. While the internet scales massively and provides any-to-any connectivity, it does not provide the cost-effective bandwidth, security, performance and QoS needed by enterprises, industries and public sector customers to run business-critical applications in the cloud.

Also, as customers adopt SDN and virtualize their data centers, they need highly scalable bandwidth between IT resources whether those are in private, virtual private, public or hybrid clouds. CSPs can leverage their dark fiber, wavelength, Ethernet and IP/MPLS services to offer high-revenue, high-margin managed cloud interconnect and DCI services to all participants in the cloud ecosystem depending on their specific need.

By providing multi-layer cloud interconnect, CSPs can deploy the most appropriate service to enable customers to share data, distribute applications and balance workloads across different cloud types, between multiple locations and between different cloud providers while ensuring high performance, reliability and QoS for business-critical applications.
The business benefits to CSPs of implementing cloud interconnect include the capability to:

- Offer secure, scalable, flexible direct connect and managed DCI services that enterprises, industries, public sector customers and SIs need to build private, virtual private and hybrid clouds, and connect to public cloud services
- Deliver highly scalable, high-performance DCI services to CNPs, who need to connect their data centers and colocation facilities across campus and metro areas
- Deliver highly scalable, high-performance metro and long haul DCI services that ICPs need to connect their regional, national and international data centers, and expand their footprint to provide higher performance and lower latency for public and hybrid cloud services

**Connect customer data centers, remote sites and end users to the cloud**

Server and storage virtualization in the data center has made IT resources much more dynamically consumable, and SDN has enabled data center networks to be configured as quickly as IT resources. SDN virtualizes the data center network and automates network service delivery, enabling a more robust and scalable multi-tenant data center networking infrastructure. Together, server, storage and network virtualization have paved the way for dynamic resource sharing and the move to cloud services.

The value of cloud services is the capability to rapidly and cost-effectively enable applications that can be consumed by customers and end users anywhere. But to deliver the full value of cloud services, the virtualized network inside the data center must operate seamlessly with and extend across the network that connects data centers. It must also integrate and connect to the WAN that connects data centers to customer remote sites and end users. Currently, this WAN is typically a managed IP/MPLS Layer 2 or Layer 3 VPN service provided by a CSP.

Using cloud interconnect with data center gateway functionality, CSPs can enable seamless IP connectivity between SDN-enabled data centers and existing IP/MPLS WAN services to deliver enhanced cloud services. Data center gateway supports virtual extensible LAN (VXLAN), a network virtualization overlay (NVO) technology used to virtualize data center networking. VXLAN encapsulates Ethernet in IP and can use IP as an underlay network.

NVO and VXLAN can be combined with Ethernet VPN (EVPN), an emerging technology that provides an overlay control plane based on well-established routing protocols and operational experience used in IP/MPLS networks. When combined with VXLAN, EVPN enables data center virtualization to be extended across the cloud with the benefits of existing routing, resiliency and load balancing mechanisms.

The benefits of using cloud interconnect with data center gateway include the capability to:

- Deliver flexible virtual private cloud services to enable multiple enterprise, industry and public sector customers to complement their private clouds
- Extend tenant subnets across the WAN to enable virtualized data center resources to be consumed and repurposed by customers on demand
- Support multi-tenant applications and distribute workloads across servers between different data centers
- Enable customers to move applications between data centers with no perceivable effect on end users
- Offer innovative services, such as combining cloud and business VPN services or collaborating with third-party data center operators such as CNPs and ICPs
For more information about data center gateways, see the Nokia application note [Seamless Data Center Interconnect: Delivering unrestricted data center networking across the WAN](#).

Note that while data center gateway extends data center virtualization across the cloud and integrates with existing IP/MPLS VPN services, these services have not kept pace with the dynamic nature of the cloud. The WAN must also become more agile, flexible and dynamic to match the capabilities of the cloud.

As cloud services become more widely deployed and more important to customers’ IT operations, new dynamic approaches to WAN networking — such as carrier SDN and software-defined WAN (SD-WAN) — will enable CSPs to automate and orchestrate network resources to deliver dynamic provisioning, flexible bandwidth and usage-based charging for cloud interconnect and WAN services.

**Deliver cloud services more efficiently and cost-effectively**

Many CSPs use their own data centers to offer services to customers. The largest also operate separate data centers to support their back-office systems and to support services such as content and video delivery. In addition, they are repurposing their COs so they can improve footprint to offer cloud services to customers.

Cloud interconnect will become more important as CSPs deploy NFV to implement higher-level network functions and features in software. These run on general-purpose servers that can be hosted in CSP back office data centers and repurposed COs instead of on specialized devices or appliances in the network.

Many CSPs are interested in repurposing COs as part of the CORD™ (Central Office Re-architected as a Datacenter) initiative, which aims to bring data center economics and cloud agility to the Telco CO. In much the same way as applications, servers and storage are virtualized in the data center today, the servers and functions in CSP data centers and repurposed COs can themselves be virtualized in the cloud. This will not only require high performance, low latency and secure bandwidth between virtualized data centers and the CO, but also the more agile, flexible and dynamic bandwidth that cloud interconnect provides.

Cloud networks will need to be managed through a layer of abstraction using carrier SDN. Instead of being managed as widely distributed physical network devices, as they are today, virtualized network functions in cloud networks will be managed as logical groupings of network resources. With NFV and carrier SDN, CSPs will be able to automate the end-to-end process of provisioning, delivering, managing and billing customers for the use of cloud services, including cloud interconnect.

CSPs can use cloud interconnect internally to leverage their data center assets and repurposed COs to build more efficient cloud service platforms. They can offer virtual private cloud services while at the same time increasing business agility and resiliency by leveraging these data center resources and central office IT assets across their entire network and infrastructure. In addition, CSPs can automate and improve the efficiency of cloud service delivery as they move to SDN and NFV. They can also improve virtual machine mobility, making it easier to move groups of virtual machines seamlessly between data centers and balance cloud service workloads between facilities.

The business benefits of using NFV and SDN to offer cloud services include:

- Increasing operational efficiency and reducing costs by deploying multiple customers or departments on the same machine to maximize data center resource utilization
- Optimizing compute and storage resources across all data centers by extending virtualization beyond a single data center and balancing workloads between facilities
- Easily configuring, moving, and scaling up or scaling down resources across data center and CO infrastructure

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Table: Stratégie blanche — Interconnexion en nuage pour les fournisseurs de services de télécommunications

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Strategic white paper

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• Improving business continuity and providing transparent workload mobility to enable customers to access services even during major failures

Create cloud exchange points to expand footprint and reach

By colocating in CNP facilities, CSPs can further expand their cloud interconnect service footprint to reach more customers. They can access more peering points, increase their peering options, interconnect with each other to provide main cloud exchange points and thereby better participate in the cloud ecosystem.

Peering points are mutual exchange points governed by peering agreements among ICPs, CNPs and CSPs to exchange traffic. For example, an enterprise on a CSP network may want to connect to a public cloud service such as Amazon Web Services (AWS) or Microsoft® AZURE™. Amazon and Microsoft have established many peering agreements with many CSPs, making it possible to efficiently route customer traffic to and from their data centers. In some cases this traffic is user-to-data center traffic, but in many cases it is data center-to-data center traffic.

Many CSPs have multiple, bilateral private interconnect arrangements with each other for IP transit and peering. IP transit involves end-user traffic that originates on one party's network traversing the other party's network to reach its destination, whereas IP peering is simply the exchange and advertising of each party's routing information. While two parties may charge each other for IP transit depending on the amount of end-user traffic, IP peering typically does not incur any charges because each party exchanges much smaller amounts of routing information.

Private interconnect at the IP layer typically uses private cross-connects in CNP facilities. CSPs also have public peering arrangements, whereby multiple parties connect to each other through internet exchange points that operate shared switching infrastructure such as Ethernet switching to enable one-to-many connections. Public peering is often less costly than setting up a large number of bilateral private peering and interconnect arrangements. Once connected, there is relatively little cost to interconnect with other CSPs in the same internet exchange.

With the increase in traffic and bandwidth that cloud brings, and with the additional players in the cloud ecosystem, current private and public peering arrangements need to become more open, agile and flexible to meet the on-demand environment of the cloud. Virtualization is also creating a demand for bandwidth-on-demand and network-as-a-service options that combine physical and virtual network elements in an agile and flexible way while also delivering performance, security and QoS.

Cloud interconnect can facilitate the creation of these private, multi-layer inter-exchange points for CSPs, ICPs and CNPs. The benefits include the capability to:

• Create more open multilateral peering arrangements, giving participants more options to interconnect and exchange data
• Enable enterprises, systems integrators, industries and public sector organizations to colocate and create communities of interest
• Expand cloud partnerships, extend connections to public cloud services and enable hybrid cloud environments

As the cloud interconnect model becomes more widespread, it will become more automated to provide agile, flexible and secure interconnection within clouds and across clouds. This requires orchestration of network resources across administrative boundaries to simplify operations as well as the optimization of network functions to increase efficiency, driving the wider adoption of technologies such as carrier SDN and NFV.
Nokia cloud interconnect architecture and solutions for CSPs

Traditionally, DCI networks have focused on bandwidth and latency as part of ensuring business continuity and disaster recovery. But the move to the cloud demands new objectives and requirements. Cloud interconnect provides some key capabilities to meet the dynamic nature of cloud:

- **Scalable, flexible bandwidth**: Mobility, personal devices, new applications and explosive data growth demand more scalable and flexible bandwidth. Cloud interconnect solutions must be able to deliver very high bandwidth — and increase and decrease bandwidth flexibly as needed.

- **Multi-site, multi-technology, multi-cloud**: Cloud interconnect solutions need to share data, distribute applications and balance workloads across different cloud types, between multiple locations and between different cloud providers. They must provide multi-layer, integrated IP and optical capabilities with high performance, reliability and QoS, as well as multiple client interfaces such as Ethernet, Fiber Channel and InfiniBand, to accommodate legacy and future requirements.

- **Agile, dynamic provisioning**: Cloud interconnect solutions must support orchestration of network resources across cloud boundaries to ramp up resources when and where required (and then ramp them down again). That means they must provision bandwidth and orchestrate network resources dynamically, quickly and easily — between different locations, across multiple data centers and across different clouds and cloud providers.

Figure 4. Nokia cloud interconnect architecture and solutions
Nokia offers a choice of cloud interconnect solutions to meet the varying needs of CSPs, CNPs, ICPs and also enterprises, industries and public sector organizations, as shown in Figure 4. These solutions provide a scalable, high performance and secure cloud interconnect architecture with the capacity, flexibility and agility needed to support different cloud types.

Nokia cloud interconnect solutions include packet optical transport and IP/MPLS routing solutions covering metro, regional, national and international connectivity requirements, along with SDN solutions for both the data center and the WAN. The Nokia solutions support a choice of wavelength, Ethernet and IP options to provide the best cloud interconnect solution to meet different business needs. By offering IP/optical management and automated and on-demand IP/optical networking with carrier SDN and SD-WAN solutions, Nokia can deliver agile, dynamic, flexible and cost-effective solutions to enable CSPs to deliver cloud interconnect to all participants in the cloud ecosystem.

Nokia cloud interconnect solutions are used by many leading service providers and network operators for metro and long haul applications. Many large enterprises in the financial, healthcare, consumer and industrial sectors also use Nokia solutions for business-critical DCI applications such as business continuity and disaster recovery. They are widely deployed in the government, oil and gas, transportation and utility sectors for mission-critical DCI applications.

To find out more, please visit https://networks.nokia.com/portfolio/solutions/cloud-data-center-interconnect or see the relevant Nokia cloud interconnect solution white paper for your sector.

### Acronyms

- **CNP**: carrier-neutral provider
- **CSP**: communications service provider
- **DCI**: data center interconnect
- **EVPN**: Ethernet VPN
- **ICP**: internet cloud content provider
- **IP**: Internet Protocol
- **IT**: information technology
- **MPLS**: multiprotocol label switching
- **NFV**: network functions virtualization
- **NVO**: network virtualization overlay
- **QoS**: quality of service
- **SDN**: software-defined network
- **SD-WAN**: software-defined WAN
- **VPN**: virtual private network
- **WAN**: wide area network
- **XLAN**: eXtensible local area network
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Document code: SR1905035110EN (May) CID194935