What You Make Possible
Data Center Design for the Small and Medium Business

BRKDCT-2218
Session Objectives

What do we plan to accomplish here?

- Improve understanding of key technological innovations happening in Data Center networking
- Discuss how these innovations apply to the design of small to midsize Data Center environments
- Provide a scalable reference model for growing a Data Center from sub-100 physical ports up to ~800 ports
- Discuss product options to fill the roles in the reference model as requirements grow.

This session is an architecture and design discussion, we will provide pointers to related product and configuration-detail sessions.

Are you in the right room? Good, let’s begin…
Mid-Market Data Center Design

One size does not fit all

- **Gartner**
  - Small Business: In the United States, less than $50 million in annual revenue and up to 100 employees; in Europe, less than $10 million in annual revenue and up to 75 employees.
  - Midsize Business: In the United States, between $50 million and $300 million in annual revenue and between 100 and 1,000 employees; in Europe, between $10 million and $150 million in annual revenue and between 75 and 300 employees.

- **Wikipedia**
  - In New Zealand: has to be 19 or fewer people.
  - In India: About 39% of the manufacturing output and 33% of the total export of the country.

- **Cisco Categorization: Customers with 1 to 999 Employees**
  - Small = 1 to 99
  - Medium = 100 to 249
  - Mid Market = 250 to 999
Session Agenda
Next 90 minutes of our time together

- **Data Center networking requirements**
  - Characteristics of network design unique to the Data Center

- **Data Center networking features and solutions**
  - Elements of Cisco feature innovations, and progress in the standards bodies

- **Reference Topologies: starting out small and scaling up**
  - Entry-level models: sub-100 to 300 server ports
  - Scaled up options 300 – 500 server ports
  - Full_featured solution, 500 – 800 server ports

- **Building blocks to implement needed features**
  - Product choices to balance scale and feature requirements with cost
Hypervisor-Based Server Virtualization
De-coupling applications from physical hardware

Virtualization benefits

- Better hardware utilization and application availability
- Workload Mobility, within or across DC’s
- Reduced provisioning time/effort

Increasing demands on the network:

- Larger Layer-2 domains
- Focus on shared storage systems
- Software switching redefining the network edge
- L2 extension between physical DC’s
Virtualization and Software Switching
Redefining the “network edge”

Traditional Model
- NIC
- HBA
- PCI-E Bus
- Operating System and Device Drivers

Add Hypervisor
Software Switch
- pNIC
- HBA
- Hypervisor provides virtualization of PCI-E resources
- PCI-E Bus
- Edge of the Fabric

Add CNA for virtual interface density
- Converged Network Adapter
  provides virtualization of the physical Media
- Still 2 PCI Addresses on the BUS
- Still 2 PCI Addresses on the BUS

Move switching function back upstream with FEX-Link
- SR-IOV adapter
  provides multiple PCIe resources

Compute and Fabric Edge are Merging
Storage Networking
From separate networks to a converged fabric

- Another wave of network convergence
- Flexibility to support dynamic connectivity requirements
- Block-level protocols:
  - Fibre Channel
  - Fibre Channel over Ethernet (FCoE)
  - iSCSI
- File-based protocols:
  - CIFS
  - NFS
The Goal of a Unified Data Center Fabric

Keep storage connectivity options open

- Flexibility to support a range of storage systems
- Connectivity for IP/Ethernet and Fibre Channel Endpoints
- ‘Any Server/RU to Any Storage Spindle’
New Application Models

New database models, “Big Data” applications

- Increasing East-West traffic between servers in the data center
- High performance requirements driving 10 Gbps migration
- Performance demands on buffering and oversubscription:
  - Many-to-one port data patterns
  - Speed mismatches 10/1Gbps between nodes (also a common storage issue)
- Demand for low network latency
  - Clustered applications
  - High Frequency Trading
Data Center Network Services
Integrating service functions into a virtualized fabric

- In the non-virtualized model, services were inserted into the Data Path at network ‘choke points’
- The Logical Topology matched the Physical Topology
- Migration to higher server speeds push the limits of physical service appliances
- Virtualized workloads may require a re-evaluation of where the services are applied and how they are scaled
Data Center Interconnect
Active/Active Workloads and Disaster Recovery

- Virtualization and workload mobility open up greater flexibility in using multiple locations.
- Active/Active workload sharing can be constrained by application latency requirements and storage replication.
- Managing Layer-2 extension and Layer-3 address mobility presents many of the same challenges facing larger customers.
- Advanced networking features are required to address these needs.
Traditional Data Center Conceptual Layers

Classic Enterprise Model terminology for reference

- **Core**: Connection to the “rest of the network” at a main location
- **Aggregation**: Boundary between Layer-2 and Layer-3 switching; servers IP default gateway lives here.
- **Access**: Provides physical connections for physical servers (or now logical ports for virtual servers)

Goals for Small and Medium Data Center Designs:

- Take advantage of current data center feature set while targeting a smaller port count.
- Consolidate conceptual layers into fewer physical devices where possible
- Consider future needs and design to allow the network to scale as business requirements grow.
- Control costs through platform selection and virtualized switching.
Session Agenda
Features to address Data Center challenges

- Data Center networking requirements
  - Characteristics of network design unique to the Data Center

- Data Center networking features and solutions
  - Elements of Cisco feature innovations, and progress in the standards bodies

- Reference Topologies: starting out small and scaling up
  - Entry-level models: sub-100 to 300 server ports
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- Building blocks to implement needed features
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Virtual Port Channel - vPC
Increasing stability and throughput in the Layer-2 domain

- vPC allows a pair of switches to create a port-channel as if they were a single device
- Spanning Tree Protocol (STP) no longer providing the primary loop prevention mechanism
- Eliminates the STP blocked links in traditional topologies, increasing usable bandwidth
- vPC maintains independent control planes and switch management, switches are “vPC peers”
Fibre Channel over Ethernet and vPC
SAN “A” / “B” Support

- LAN and SAN utilize **different** High Availability Models
- SAN is dual fabric, LAN is fully meshed fabric
- vPC enables ‘both’ architectures at the edge (single device models not acceptable to SAN engineers)
- Campus technologies VSS and Stackwise are not SAN-aware
The FEXLink Architecture provides the ability to extend the bridge (switch) interface to downstream devices.

FEXLink associates the Logical Interface (LIF) to a Virtual Interface (VIF).

- Bridges that support Interface Virtualization ports must support VNTag and the VIC protocol.
- NIV uplink ports must connect to an NIV capable bridge or an NIV Downlink.
- NIV may be cascaded extending the port extension one additional level.
- NIV capable adapters may extending the port extension.

NIV downlink ports are assigned a virtual identifier (VIF) that corresponds to a virtual interface on the bridge and is used to forward frames through NIV's.

Note: Not All Designs Supported in the FEXLink Architecture Are Currently Implemented.
FEX Link: Virtualized Access Switching
Changing the boundaries of the Ethernet switch

- De-coupling of the Layer-1 and Layer-2 topologies
- Line Card Portability (N2K supported with Multiple Parent Switches – N5K, 6100, N7K)
- Unified access for any server (100M1GE→10GE→FCoE): Scalable Ethernet, unified fabric or virtualized servers

- Simplified Management Model
- Plug and play provisioning
- Centralized configuration
FEX Link and vPC Virtualized Access

Nexus 7000-based vPC topologies

- Redundancy model – Dual Switch (each switch supports redundant supervisors)
- vPC port channel to host interfaces supported in NX-OS 5.2 or greater
- Fabric links supported on N7K-M132XP-12, N7K-M132XP-12L & N7K-F248XP-25
- Nexus 7000 does not require or support dual-homing of FEX
FEX Link and vPC Virtualized Access
Nexus 5000/5500 Topologies prior to 5.1.(3)N1

- Redundancy model – Dual Switch with redundant fabric
- Provides FCoE isolation for Storage topologies (SAN ‘A’ and ‘B’)
- Port Channel and Pinning supported for Fabric Link

- Redundancy model – Single switch with dual ‘supervisor’ for fabric, data control & management planes
- No storage SAN ‘A’ and ‘B’ isolation
- No active/active dual-home was allowed
Enhanced Virtual Port Channel (EvPC)
Currently available on Nexus 5500 in NX-OS 5.1(3)N1 and later

- In an Enhanced vPC configuration any and all server NIC teaming configurations will be supported on any port. No ‘orphan ports’ in the design
- All components in the network path are fully redundant.
- Supported FEX parent switch is **Nexus 5500 only**
- Provides flexibility to mix all three server NIC configurations (single NIC, Active/Standby and NIC Port Channel)
EvPC and FCoE SAN Traffic

Maintaining SAN A / B isolation

- In an Enhanced vPC (EvPC) SAN ‘A/B’ isolation is configured by associating each FEX with either SAN ‘A’ or SAN ‘B’ Nexus 5500
- FCoE & FIP traffic is forwarded only over the links connected to the specific parent switch
- Ethernet is hashed over all FEX fabric links
Cisco Adapter-FEX
Fabric Extender implemented in the server NIC

- Adapter-FEX presents standard PCIe virtual NICs (vNICs) to servers
- Adapter-FEX virtual NICs are configured on the server and managed via Nexus 5500
- Forwarding, Queuing, and Policy enforcement for vNIC traffic by Nexus 5500
- Adapter-FEX can be connected to Nexus 2000 Fabric Extender for a cascaded FEX-Link deployment
- Forwarding, Queuing, and Policy enforcement for vNIC traffic still done by Nexus 5500
Cisco VM-FEX
Virtual Machine Fabric Extender

- Allows Nexus 5500 pair to register as a DVS in vCenter
- Extends Cisco Adapter FEX technology to the Virtual Machine with vMotion support
- Consolidated management of network, server, and virtual server interfaces
- Offload I/O processing from Server CPU with Cisco Nexus hardware performance
- Technology from the UCS Blade system extended to UCS Rack servers and Nexus 5500
FCoE and Unified Ports
Nexus 5500 flexible definition of port function

- Fibre Channel over Ethernet (FCoE) allows encapsulation and transport of Fibre Channel traffic over a shared Ethernet network
- Traffic may be extended over Multi-Hop FCoE, or directed to an FC SAN
- SAN “A” / “B” isolation is maintained across the network
- Unified Ports may be configured to support either native Fibre Channel or Ethernet
Nexus 1000v and vPATH
Traffic Interception for Data Center services

- Intelligence built into Virtual Ethernet Module (VEM) of Cisco Nexus 1000V virtual switch (version 1.4 and above.)
- vPATH performs traffic interception and redirection for multiple virtual service nodes:
  - Virtual Security Gateway (VSG)
  - Virtual WAAS (vWAAS)
  - Virtual Network Analysis Module (vNAM)
- vPATH is Multi-tenant Aware.
- Leveraging vPATH can enhance the service performance by moving the processing to hypervisor.
Nexus 7000 Virtualization with VDCs

Single physical switch acting as multiple virtual devices

- VDC – Virtual Device Context
- Flexible separation/distribution of hardware resources and software components
- Complete data plane and control plane separation

- Complete software fault isolation
- Securely delineated administrative contexts
- Forwarding engine scalability with appropriate interface allocation

![Diagram of VDCs with Layer 2 and Layer 3 Protocols](image-url)
Cisco FabricPath
The best characteristics of both Layer-2, and Layer-3 switching

- Easy Configuration
- Plug & Play
- Provisioning Flexibility
- Multi-pathing (ECMP)
- Fast Convergence
- Highly Scalable

• FabricPath brings Layer 3 routing benefits to flexible Layer 2 bridged Ethernet networks.
• Key features such as vPC+ and multiple topologies make FabricPath a deployable solution; support will be extended to TRILL as it matures.
Cisco FabricPath
Flexibility in the Fabric with Layer-2 Routing
Building the Data Center Interconnect

Complementary Innovations

- FabricPath: Scalable Fabrics for Application Deployment Flexibility
- OTV: Layer 2 extensions over Layer 3 for Distributed Clustered Applications
- LISP: IP mobility, optimized routing and segmentation within the flexible Fabric
Session Agenda

Example designs to implement Data Center features

- Data Center networking requirements
  - Characteristics of network design unique to the Data Center
- Data Center networking features and solutions
  - Elements of Cisco feature innovations, and progress in the standards bodies
- Reference Topologies: starting out small and scaling up
  - Entry-level models: sub-100 to 300 server ports
  - Scaled up options 300 – 500 server ports
  - Full-featured solution, 500 – 800 server ports
- Building blocks to implement needed features
  - Product choices to balance scale and feature requirements with cost
Entry-Level Data Center Models
Collapsed Core and Virtualized Data Center Switch sub-100 server ports

- Nexus 5500 virtual chassis combined core and DC pair
- Data Center specific feature set:
  - FEX (Physical ports, Adapter-FEX, VM-FEX)
  - Virtual Port Channel (vPC)
  - Storage networking with FC, FCoE, Unified Ports, DCB
  - Nexus 1000v with vPATH
  - FabricPath support
  - WAN router required for DCI and other transport services
Entry-Level Data Center Models
Nexus 5500 Layer 3 DC, FEX, and Storage support; 100 to 300 server ports

- Nexus 5500 virtual chassis
  - Scale port count with additional FEX virtual line cards

- Data Center specific feature set:
  - FEX (Physical ports, Adapter-FEX, VM-FEX)
  - Virtual Port Channel (vPC)
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Entry-Level Data Center Models

Nexus 5500 Layer-3 Configuration Considerations

- Ensure a separate link is configured for Layer-3 peering outside of the vPC links.
- Set COS value with QoS policy to ensure that queuing is correct for traffic passing to and from the L3 module (see layer-3 Nexus 5500 doc example).
- Base Layer-3 license is limited to 256 OSPF routes, or EIGRP Stub-only
  - Enterprise Layer-3 license for greater OSPF scale or full EIGRP
- Turn on vPC enhancements; peer-gateway, arp table sync, auto-recovery
- Leverage vPC+ if multicast PIM-SSM support is required (FabricPath license needed)
- Make sure to use the “bind-vrf” command if design has multicast sources attached to the N5K or N2K
Entry-Level Data Center Models
Nexus 5500 Layer-3 Scaling Considerations

- Support for up to 16 FEX when Layer-3 enabled in Nexus 5500.
  - 16 total dual-homed FEX.
  - Or 8 single-homed FEX per physical 5500 for a total of 16 active FEX.

- Nexus 5500 Layer-3 module version 1 up to 8000 IPv4 hosts, 4000 Multicast routes.
  - 16000 IPv4 hosts / 8000 Multicast routes on V2 Layer-3 module with updated software.
  - Layer-3 + FEX + vPC designs limited to 1000 multicast groups.

- Operational consideration, In-Service Software Upgrade (ISSU) not supported with Layer-3 on the 5500.
Scaled-up Models, Hierarchical Data Center
Nexus 5500 Collapsed Core/Aggregation; 300 – 500 server ports

- Nexus 5500 virtual chassis
  - Scale port count with FEX virtual line cards

- Data Center specific feature set:
  - Virtual Port Channel
  - FEX (Physical ports, Adapter-FEX, VM-FEX)
  - Storage integration FCoE, Unified Ports, DCB
  - Nexus 1000v with vPATH
  - FabricPath support
Scaling Designs with Access Block Variants

Mix and match Layer-2 compute connectivity for migration or scale requirements
Scaling an Access Block with FEX

Evaluate port density, speed, and oversubscription requirements

- Increase density of 1GE or 10GE ports through additional FEX.
- High-traffic 10GE servers may be attached directly to Nexus 5500 for line-rate switching.
- Consider oversubscription:
  - 2232 FEX, 32-port 10GE with 8 10GE uplinks; 4:1 oversubscribed
  - 2248 FEX, 48-port 1GE with 4 10GE uplinks; 1.2:1 oversubscribed
- Consider Nexus 5500 port consumption:
  - 6 2248’s x 4 uplinks = 24 ports
  - 2 2232’s x 8 uplinks = 16 ports
  - 4 5k-port dual-homed= 8 ports
Scaled-up models, VDC - Hierarchical DC
Nexus 7000 VDC-based Core/Aggregation, 300-500 server ports

- Nexus 7000 VDC’s
  - Hierarchical logical design with physical device consolidation
  - Design positioned to scale out to the next level

- Data Center specific feature set:
  - Single-homed Physical FEX
  - OTV, LISP, ISSU, MPLS
  - FabricPath support
  - Nexus 1000v with vPATH

(Not configured for FC/FCoE, Adapter-FEX)
Full-Featured Nexus and UCS Data Center
Nexus 7000 VDC-based Core/Aggregation, 500-800 server ports

- Nexus 7000 VDC’s
- Nexus 5500 Virtual Chassis
- Full Cisco DC feature set:
  - vPC, Enhanced vPC
  - FEX, Adapter-FEX, VM-FEX
  - Storage integration FCoE, Unified Ports, DCB
  - Nexus 7000 OTV, LISP, ISSU, MPLS
  - FabricPath support
  - Nexus 1000v with vPATH
  - UCS FC into Nexus 5500 until direct FCoE is supported
Session Agenda
Component options for building the Unified Data Center fabric

- Data Center networking requirements
  - Characteristics of network design unique to the Data Center

- Data Center networking features and solutions
  - Elements of Cisco feature innovations, and progress in the standards bodies

- Reference Topologies: starting out small and scaling up
  - Entry-level models: sub-100 to 300 server ports
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- Building blocks to implement needed features
  - Product choices to balance scale and feature requirements with cost
Nexus 7000 and 5000 Series Key Features

Overlapping capabilities for Data Center optimization

Nexus 7000
Core/Aggregation focus
Scalability
DCI capabilities

Nexus 5500
Access/Aggregation focus
Storage Integration
Virtualized Edge Features

- OTV
- LISP
- MPLS
- VDCs
- L3-ISSU

- vPC/vPC+
- FLEX Virtual Chassis
- FCoE
- FabricPath
- Layer 2/3 Ethernet

- Fibre Channel
- Unified Ports
- Adapter-FEX
- VM-FEX
- Enhanced vPC

Enhanced vPC
L3-ISSU
FEX Virtual Chassis
FabricPath
Layer 2/3 Ethernet
FCoE
VDCs
MPLS
LISP
OTV
Cisco Nexus Switching Family
Building blocks for today’s unified data center fabric

- **Nexus 7000 Series**: Chassis-based, highly scalable multilayer NX-OS switch
- **Nexus 5500 Series**: Modular 1-2 RU Ethernet, Fibre Channel, and FCoE multilayer NX-OS switch
- **Nexus 3000 Series**: Ultra low-latency, high-performance multilayer NX-OS switch
- **Nexus 2000 Fabric Extenders**: 10Gbps, 1Gbps, 100Mbps virtual line cards for 7000/5000 Series
- **Nexus 1000v**: Virtual machine NX-OS switching for hypervisor environments with service integration
Nexus 7000 Series
Platform Overview

- 9, 10 and 18 slot chassis switch
- 550 Gbps per slot
- 1G, 10G, 40G, and 100G Ethernet
- Hitless Software Upgrades (ISSU)
- Virtual Device Contexts (VDCs)
- Fibre Channel over Ethernet (FCoE)
- FabricPath
- Overlay Transport Virtualization (OTV)
- Locator/ID Separation Protocol (LISP)
- Multiprotocol Label Switching (MPLS)
Nexus 7000 Series I/O Module Options
Choices based on performance, feature, and cost requirements

- M1 Series cards provide Layer-2/3 switching and services, large scale routing tables and advanced features
- F1 Series modules provide Layer-2 switching, and can be paired with M1 modules for Layer-3 services
- F2 Series modules provide high performance, low latency, high density Layer-2/3 switching.
- M2 Series modules provide full-featured, high-performance 40 and 100 GE
Nexus 5500 Series
Platform Overview

- 1 and 2-RU Modular switches
- Lossless Ethernet, Fibre Channel, FCoE switching, IEEE DCB
- 100M/1G/10G Ethernet, 1/2/4/8 G Fibre Channel
- Unified Ports (Ethernet/FC)
- FabricPath
- Adapter-FEX
- VM-FEX
- Expandable to Layer-3 Switching
Cisco Nexus 2000 Series
Line Cards for the Virtualized Access Switch

N2148T
48 Port 1000M Host Interfaces
4 x 10G Uplinks

N2248TP
48 Port 100/1000M Host Interfaces
4 x 10G Uplinks

N2232PP
32 Port 1/10G FCoE Host Interfaces
8 x 10G Uplinks

N2224TP
24 Port 100/1000M Host Interfaces
2 x 10G Uplinks

N2232TM
32 Port 1/10GBASE-T Host Interfaces
8 x 10G Uplinks (Module)

N2248TP-E
48 Port 100/1000M Host Interfaces
4 x 10G Uplinks
32MB Shared Buffer

FET-10G
Cost Effective Fabric Extender Transceiver

B22HP
16 x 1/10G Host Interfaces
8 x 10G Uplinks
10 Gigabit Ethernet Migration

10GBaseT – Power and EMI Considerations

- Undesired coupling of signal between adjacent cables
- Main electrical parameter limiting the performance of 10G
- Cannot be cancelled
- Re-Training is the major barrier to use of 10GBaseT for block level storage (FCoE)
- Can be prevented or mitigated by:
  - Space (Cat6a solution)
  - Shield (Cat6/Ca6a/Cat7 shielded solutions)

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<th>Distance</th>
<th>Power (each side)</th>
<th>Transceiver Latency</th>
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<td>~4-5W</td>
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Virtualized Adapter Card Choices
For Cisco UCS C-Series and Nexus 5500 switching

Cisco P81E
- vNICs are presented to the host like standard PCIe devices
- In A-FEX mode: supports up to 16 Eth vNIC and 2 FC vHBA
- Adapter Failover feature: in failure scenarios, the vNIC is mapped to the other port transparently to the OS
- In VM-FEX mode: supports up to 96 Virtual Interfaces (vNICs + vHBAs)
- No need to trunk all VLANs to the server interface (improving security and scalability)

Broadcom BCM57712
- 3rd Party adapter supporting VN-TAG
- vNICs are presented to the host like standard PCIe devices
- In A-FEX mode supports up to 8 Virtual Interfaces total
  - Max of 8 vEth
  - Max of 2 vHba
- No adapter failover
Nexus Switching for Virtualized Servers
Nexus 1000v for VMware environments (Microsoft Hyper-V future)

- **Embedded Virtual Bridge - Nexus 1000V**
  - 802.1q standards based bridge
  - Policy Based port profile applies port security, VLAN, and ACLs, policy maps for QoS treatment for all systems traffic including VM traffic, Console & Vmotion/Vmkernel
  - Includes VXLAN switching capability

- **Standard 802.1q based upstream switch**
  - Leveraging standard switch to switch links (QoS, trunking, channeling, ..)
  - Policy on upstream switch looks like standard ‘aggregation’ configuration
Small and Medium Data Center Design

Summary and key takeaway points

- Data center design for small to mid-market customers requires solving many of the same challenges larger customers face.
- Data center specific features from Cisco are available on the Nexus family of switching platforms to address these challenges in varying levels of scale.
- Design elements of the example models covered today allow customers to scale their data center footprint from entry level through hundreds of server ports.
- Cisco has extended many of the capabilities of the Unified Computing System into the Nexus switching family to allow a single switching fabric to support all variants of compute and storage connectivity needs.
Related Sessions
For your reference…. 

- BRKDCT-2223  Evolution of the Data Center Edge
- BRKDCT-2048  Deploying Virtual Port Channel in NXOS
- BRKDCT-2081  Cisco FabricPath Technology and Design
- BRKDCT-2048  Overlay Transport Virtualization
- BRKDCT-3045  LISP – A Next Generation Networking Architecture
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Final Thoughts

 Get hands-on experience with the Walk-in Labs located in World of Solutions, booth 1042
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