OpenVMS best practices

Designing and building OpenVMS systems and clusters

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Introduction

My business has been leading systems and infrastructure projects, many of them involving VMS based disaster-tolerant systems. It’s been technically complex and demanding work with a high level of responsibility.

As a designer or trouble-shooter, it’s essential to understand how everything that makes up the complete system functions and interacts.

The intention is to help other people who get involved with VMS systems and clusters. I hope it’s useful.

Agenda

1. **Planning ahead**

2. Hardware platforms
3. Network infrastructure
4. Storage infrastructure
5. Installation and setup
6. Boot, startup and shutdown
7. Hints and tips
8. Multi-site clusters

Design goals

- Availability is generally more important than performance

- Never corrupt or lose data

- Build in capability for:
  - Remote operation (lights-out)
  - Hardware maintenance
  - Patching and upgrades
  - Stand-alone backup and restore
  - Migration and hardware replacement

Design principles

- Design for change, not steady-state
- Operational safety – minimise risk of errors and disruption
- Understand the purpose and the target environment
- Build in logging and information gathering
- Adapt to changing requirements (performance, scalability)
- Think long-term (e.g.: company mergers)

Naming conventions

- Choose your naming conventions very carefully – they are the hardest thing to change later
- Don’t tie nodenames to physical locations. Physical server names should be different to nodenames.
- Choose disk IDs that identify meaningful things (e.g.: environment, site, array and purpose)
- Choose network addresses and hostnames that identify meaningful things and make sense in your context

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OpenVMS versions (Alpha and Integrity)

- Alpha:
  - HPE V8.4
  - VSI V8.4-2L1 (for all generations of Alpha hardware)
  - VSI V8.4-2L2 (for EV6 and later – and emulators)

- Integrity:
  - HPE V8.4 (up to -i2 servers, NOT –i4 and –i6 servers)
  - VSI V8.4-1H1 and later (supports –i4 and –i6 servers)
  - VSI V8.4-2L3 is latest release

Integrity Server firmware

- Older hardware (prior to –i2) will require USB flash drive media for all firmware components

- Newer hardware (-i2 onwards) can use HPSUM firmware bundles for the base system, loaded over the network from Windows / Linux via the ILO

- Some firmware components will not load from the HPSUM bundle, but require USB flash drive media (SAS controller, LOM controller, HDDs, etc.)

Making use of CPU

- Hyperthreading – very workload dependent, “threads off” is a good starting point
- Fastpath IO devices and distributed interrupt handling
- Introduce parallelism into your code flow and batch jobs where possible
- Dedicated CPU for lock manager (local locking)
- Compression and encryption, eg: SCS compression, BACKUP compression
- QUANTUM, workload dependent – many SYSGEN parameter defaults changed in V8.2
- Power management

Making use of memory

- NUMA – “mostly UMA” is a good starting point
- Use memory (XFC, resident images, DECram etc.)
- Revisit working set sizes - WSMAX and process quotas Use RMS global buffers
- Revisit RMS system defaults
- GH regions – map lots of memory with a small number of page table entries
- INSTALL /RESIDENT and GH region size
- 64bit P2 space and memory reservations
- DECram and shadowing to fast disc

Making use of storage IO

- FC bandwidth is important – what else are you sharing your storage bandwidth with? Why?
- Rotational latency no longer matters, nor does balancing the IO load to the spindles
- Array controller cache size and volume characteristics (cluster factor, extend quantity, volume expansion etc.)
- HBVS – only shadow what you really need to
- HBVS – many shadow sets let you control how rapidly shadow copying proceeds during recovery
- HBVS mini-copy and mini-merge policies
- HBVS block count to match array controller cache size

Making use of network IO

- Network bandwidth and latency matter:
  - Use jumbo frames
  - Split the traffic across multiple NICs
  - What else are you sharing your bandwidth with ?
  - Are the switches over-subscribed ?
  - Need to avoid retransmits
- Multiple path networks:
  - Packets may not arrive in the order in which they were sent
- Beware bus speed limitations in servers

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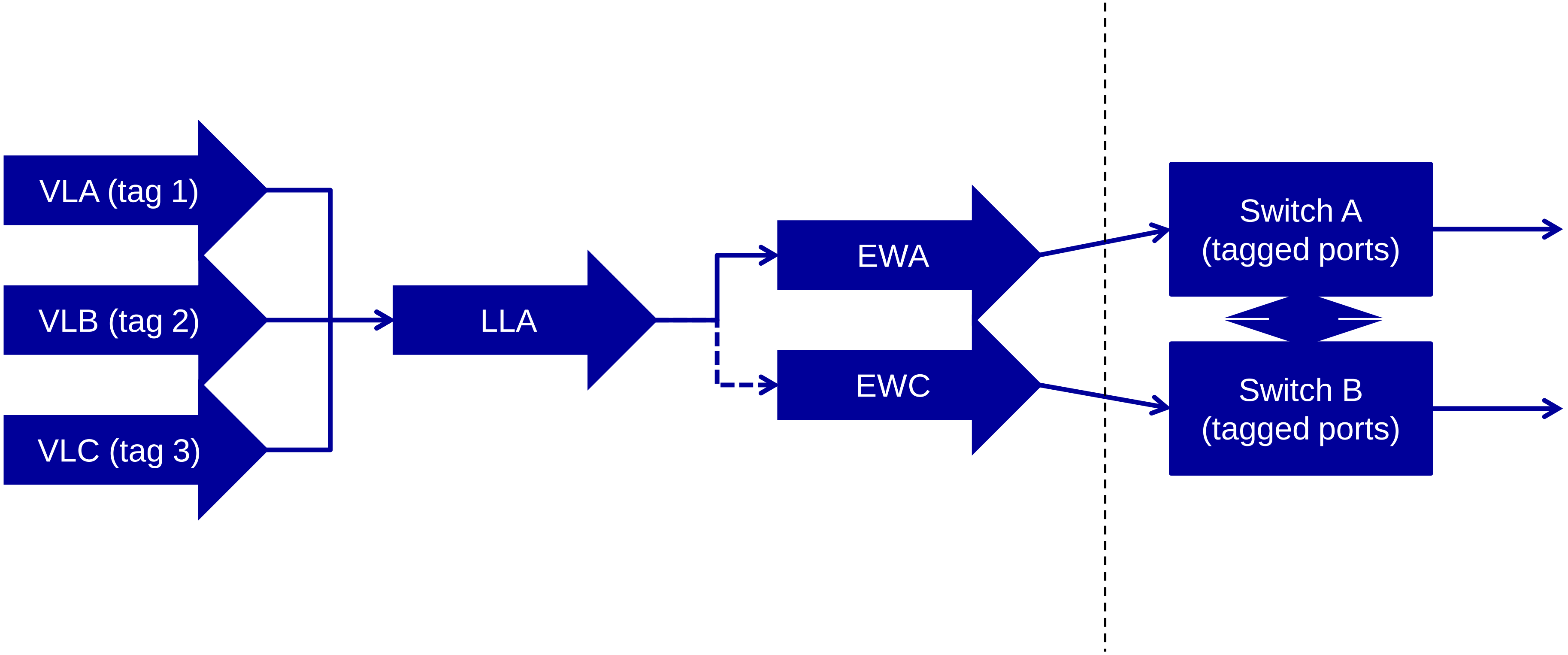
Network connectivity

- Multiple protocols: SCS, TCPIP, DECnet, AMDS
- Use LAN failover with multiple NICs for hardware resilience
- Use VLAN tagging and/or LAN failover sets to separate traffic flows
- VL / LL devices map to physical NICs, do not configure protocols on physical NICs.
- Use “service addresses” to separate data flows
- Use QoS in data network for different data flow types
- Use SCACP to control which port(s) SCS runs on
- Use LATCP to control which port(s) LAT runs on
- Disable unused protocols (eg: DECdns, DTSS)

OpenVMS networking: VLAN / LAN failover



Network switch configuration

- Split traffic flows into different VLANs:
  - ILO and management
  - Cluster interconnects
  - Data feeds
  - External access

- Tagged ports using VLdriver, or untagged ports ?

- Failover sets using LAN failover

Network infrastructure – multiple paths

- Cisco: etherchannel
- HP / Aruba: Procurve meshing
- Extreme: EAPS ring

- VMS: LAN failover
- Other operating systems: NIC teaming, bonds, LACP

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Fibrechannel switch configuration

- OpenVMS only supports fibrechannel switched fabric
- Zoning connects HBA ports with storage array ports:
  - Single initiator, multiple target zoning
  - Soft zoning by WWID, not by port number
  - Zone by WWPN, not WWNN
- Zone all nodes with all storage arrays
- Consistent use of LUN IDs and UUIDs

Storage connectivity

- Fibrechannel uses WWIDs:
- WWN = World Wide Name
- WWNN = World Wide Node Name (points to entire array or tape drive or multi-port HBA)
- WWPN = World Wide Port Name (point to specific port in array controller or tape drive or HBA)

- Zoning – single initiator, multiple target, use WWPN

- Storage element presentation to HBA
- OpenVMS uses UUID to set device name

Fibrechannel storage array configuration

- 3PAR: virtual volumes, exported to HBAs
- EVA: vdisks, presented to HBAs

- Multipath devices
- Consistent use of LUN IDs and UUIDs

- VMS does not support “thin provisioning”.
- VMS “erase on delete” can return blocks to pool if absolutely necessary, with performance overhead

- Volume expansion

Array configuration

- Use RAID 0+1 (EVA vRAID1) for best performance
- Use double sparing, single disk group (EVA)
- Snaps are only a short-term point in time temporary entity – they can hurt array controller performance
- Clones have better performance, but require more space
- Consider explicit path specification and explicit controller preference for preferred path configuration

Example naming convention – FC disks

- $1$DGA<n1><n2><nn3>

  <n1> = site / environment (1 … 3 = Production A, B, C;
  4 … 6 = Test A, B, C;
  7 … 9 = Development A, B, C)
  <n2> = array within site (1 … 9)
  <nn3> = disk, matches DSA<nn> shadow set name

Note: UUID must be unique across the fabric, ALLOCLASS = 1

Example disk naming – DSA and FC disks

- DSA10 ($1$DGA1010, 2010, 1110, 2110) – common disk

- DSA11 - system disk, site A
- DSA12 - alternate system disk, site A
- DSA13 - system disk, site B
- DSA14 - alternate system disk, site B
- DSA15 - system disk, site C
- DSA16 - alternate system disk, site C

- DSA21 … DSA39 – data (small shadow sets)
- etc.

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Example server (ILO) naming convention

S<nn2>DC<n3>, where:

“S” = Server (the physical machine and ILO)

<nn2> = 01 … 99 (physical machine number within site)

“DC” = “data centre” (site)

<n3> = 1 … 9 (site number)

Example node naming convention

<n1><nn2>DC<n3>, where:

<n1> = “P” (Production), or
“T” (Test), or
“D” (Development)

<nn2> = 01 … 99 (node number within site)

DC = “data centre” (site)

<n3> = 1 … 9 (site number)

Quorum and voting

- Is application “cluster aware” or rapid failover ?
- What do you want to happen when a site fails ?
- Avoid quorum disk if possible
- Availability manager / DTCS quorum adjustment
- <Ctrl-C> quorum adjustment on Integrity

SCS at layer 2 or “clusters over IP” ?

- SCS at layer 2 needs extended LAN between sites. This may not be possible.

- Some network switches (Cisco) can drop layer 2 multicast packets when congested

- SCS starts on all NICs, so disable SCS on non-cluster connection NICs early in boot (SYCONFIG)

- IPCI (IP cluster interconnect) at layer 3

Shadowing

- Many shadow sets for performance with multi-path disks
- Small shadow sets to minimise copy/merge time (especially common disk)
- Enough arrays per site to always have local source
- Only mount system disks on nodes booted from that disk
- System disk at a site is shadowed to other sites
- Use mini-copy and mini-merge for performance

Bootable environments

- External storage (SAN) - separates bootable system and data from server hardware
- Local storage (RAID) for node specific and temporary purposes

- Normal operation: boot from SAN, shadowed system discs, alternate system discs for mixed version running (upgrades etc.)
- Local “maintenance boot” system with full capabilities

- Integrity servers:
  - Local USB flash drive “installation boot”, can then reconfigure local storage controller and reinstall from pre-built system backup
  - Local USB flash drive for firmware updates (FAT32 format)

Disc layout

- SAN devices, common, shadowed:
  - System disc
  - Common disc
  - [alternate system disc]

- Local RAID devices, not shadowed:
  - Page/swap/dump disc(s)
  - T4 data disc

- Always move the common files and the page / swap / dump files off the system disc

Local RAID storage

- Usually faster than SAN storage (lower write latency)

- RAID 0+1 or RAID 6
- RAID 6 may require a licence key for the RAID controller

- Local page and swap files
- Local dump files (dump off system disc – DOSD)

- Local T4 data files
- Local staging area for backups (eg: backup to local storage, compressed, then encrypt, then copy elsewhere)

Local RAID controllers

- Battery-backed or flash-backed cache
- Set up as RAID 0+1 or RAID 6
- RAID 6 may need a licence key, depends on hardware
- Partition into logical units using all discs
- Bias read/write cache ratio in favour of write (80% / 20%). VMS has lots of read caches (XFC, RMS)

Local RAID controllers - example

- Booted from USB flash drive

```
$ mcr msa$util
set controller pka
add unit 0 /part=0/disk=(1,2,5,6)/adg/size=50gb     ! DKA0 LMB system
add unit 1 /part=1/disk=(1,2,5,6)/adg/size=10gb     ! DKA1 install media
add unit 2 /part=2/disk=(1,2,5,6)/adg/size=100gb    ! DKA2 T4 data
add unit 3 /part=3/disk=(1,2,5,6)/adg/size=500gb    ! DKA3 pgswpdmp
add unit 4 /part=4/disk=(1,2,5,6)/adg               ! DKA4 Staging area
!
set globals/write=80/read=20                        ! Write / read cache
exit
```

Scanning SAN fabric pre-boot (Integrity)

- Fibrechannel HBAs can be configured to scan entire fabric looking for devices

- May be faster to only scan devices that appear in boot and dump lists

- Choose fibre scan option in ILO by setting scan level in HBAs

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Booting

- Requires firmware support for SAN (HBA and array)
- Boot drivers are lightweight
- View from EFI shell is extremely hard to interpret
- Use BOOT_OPTIONS.COM to configure boot paths, or use efi$bcfg.exe directly (see command line help)
- When adding a node to an existing cluster, ALWAYS mount the target system disk READ ONLY
- Delete root <SYS0> to avoid unexpected booting with unconfigured hardware

OpenVMS boot and startup

- Power-up sequence
- Console view of hardware and devices
- Boot process
- Base system startup
- Device configuration
- LAN devices, pseudo-devices and IPCI (if needed)
- Cluster formation
- STARTUP.COM and site-specific SY*.COM files
- Network transports startup
- Layered products startup
- Application startup

Power-up sequence

- Hardware tests: CPUs, memory, devices, etc.
- Can disable tests for speed of power-up
- Auto-boot – disable in HA/DT environments
- Alpha console:
    - serial port (or MBM on last Alphas)
        - >>> prompt, some commands are machine specific
        - partitioning and galaxy
        - wwidmgr for FC devices
- Integrity console:
    - ILO
        - EFI / UEFI menu interface
        - Make EFI shell the first option (safe)

Finding devices to boot from

- Alpha console:
  - wwidmgr for FC devices
  - boot* environment variables (bootdef_dev etc.)

- Integrity console:
  - Decoding the view from EFI shell (FS<nn> devices)
  - FS<nn>: \efi\vms\ EFI scripts

- Boot flags to specify system root etc.

Boot loader

- Alpha:
  - APB on target system disk / root

- Integrity:
  - IPB on target system disk / root
  - EFI shell sees a FAT partition
  - FS<nn>:\efi\vms\vms_loader.efi is the initial loader
  - VMS sees the ODS2/5 file system
  - SYS$EFI.SYS is a container file within the VMS file system
  - EFI$CP is an undocumented tool to access SYS$EFI.SYS

OpenVMS early stages of boot

- Minimalist drivers for boot (and dump)
- Reads system parameter file
- If flag set, enters SYSBOOT> to make parameter changes
- Obtains paths to all system disks and dump device (all system disk shadow set members need to be in the list)
- Configures LAN devices (LL, VL, IPCI), before clustering
- Loads MSCP for disk serving, before clustering
- Forms / joins cluster
- Activates local page files (if present)

- Hands over to SYS$SYSTEM:STARTUP.COM

OpenVMS post-boot startup

- SYS$SYSTEM:STARTUP.COM
- Startup database and phases (SYSMAN STARTUP)
- Devices (SYS$DEVICES.DAT and SYSMAN IO EXCLUDE)
- SY*.COM files (site specific, system platform actions):
  - SYCONFIG
  - SYLOGICALS
  - SYPAGSWPFILES
  - SYSTARTUP_VMS

- Application startup actions separated from system platform actions (disks, queues, databases, service addresses, etc.)

SYS$SYSTEM:STARTUP.COM

- STARTUP_P2 sysgen parameter, or
- SYSMAN STARTUP SET OPTIONS

- Enable log output to SYS$SPECIFIC:STARTUP.LOG

- Enable information output re startup stages (checkpoints)

- SYSMAN STARTUP SHOW OPTIONS

STARTUP database

- SYSMAN STARTUP SHOW FILE /FULL
- Some layered products add themselves to the startup database
- Personal preference – call layered product and application startup from SYSTARTUP_VMS.COM

SYCONFIG.COM

- Called very early in startup, also called by AUTOGEN, so check if running in startup mode

- Typical uses:
  - Disable SCS on unused paths with SCACP STOP LAN <dev>
  - Set RMS defaults
  - Configure Audit Server (eg: disable)
  - Configure DECdtm transaction journaling (eg: disable)
  - Configure DECwindows (eg: disable workstation components)
  - Configure DECnet-Plus (eg: prevent DECdns and DTSS starting on unused interfaces)

SYLOGICALS.COM

- Called after SYCONFIG

- Typical uses:
  - Set mini-copy / mini-merge policies
  - Check / mount system disk shadow set members
  - Mount common disk shadow set members
  - Define logical names for files on common disk (UAF etc.)

- Keep this for system platform logical names etc.

SYPAGSWPFILES.COM

- Called after SYLOGICALS

- Typical uses:
  - Mount page / swap / dump disks (eg: local SAS RAID)
  - Create directory structures and page / swap / dump files if needed (;32767 prevents modification)
  - Delete page / swap / dump files from system disk if they still exist (rename, then delete after reboot)
  - Install page / swap files

SYSTARTUP_VMS.COM

- Called at end of startup sequence

- Typical uses:
  - Mount additional shadow sets
  - Start network protocols
  - Start queue manager
  - Start layered products
  - Start 3rd party products
  - Call application startup sequence

Application startup after system startup

- Separated from system startup sequence
- Called by SYSTARTUP_VMS.COM as final action
- Easy to control application startup on boot with SYSGEN user defined system parameters, so no need to edit SYSTARTUP_VMS etc.
- Calls <APPNAME>_STARTUP.COM

Application startup sequence

- Top level command file <APPNAME>_STARTUP.COM
- Calls a set of command files for actions, eg:
  - <APPNAME>_DISK_MOUNTS.COM
  - <APPNAME>_LOGICALS.COM
  - <APPNAME>_BATCH_QUEUES.COM
  - <APPNAME>_PRINT_QUEUES.COM
  - <APPNAME>_ENABLE.COM

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Monitoring and alerting – Why it matters

- Monitoring is essential in a high availability system with no single points of failure.

- HA and DT systems do their best to survive failures.

- The second failure kills you if you don't detect the first!

- You need to know what's going on, even if it's nothing

- You need good information to understand what happened when something fails

Monitoring and alerting

- Application availability, depends on:
  - All related physical equipment
  - Cluster interconnects
  - Storage volumes
  - Network connections
  - Performance behaviour
  - Queues, databases, 3rd party products, etc. …

- It’s the combination of data from different sources that enables you to understand what’s happening
- Implement periodic tests and checks

Console logging and monitoring

- Console logging can alert you to a developing situation or a transient problem.

- Consider how much OPCOM output you want – if logging all consoles, maybe restrict OPCOM output to be per-node

- Find a set of tools that works for you, for example:
  - DTCS includes IAM Consoles
  - Cockpit Manager
  - TDI Consoleworks
  - Networking Dynamics

DTCS for OpenVMS (now with DXC)

- Per-node software with:
  - Control of multi-site shadow set formation on boot, supporting up to 6-way shadowing
  - Rule based monitoring of cluster member nodes

- Windows management station (typically one per site) with:
  - Rule based monitoring:
    - storage arrays (WEBES, SNMP etc.)
    - Storage infrastructure (SNMP)
    - Network infrastructure (SNMP)
    - reachability (PING etc.)
  - Console access and logging via ILO
  - Alerts and notifications (email etc.)

Availability manager

- Windows management stations (typically one per site)
- Gives “real time” view of nodes in management group(s)
- Uses AMDS protocol (layer 2 – use LL or VL device)
- Interacts with OpenVMS driver at high IPL
- Permits modification of running system:
  - Quotas
  - Dynamic parameters
  - Quorum

Backups and data copies

- Shadow sets – up to six members
- Drop and reintroduce members for backup and data copy
- Mini-copy and mini-merge
- Use alternate members in rotation for data copy

- Use storage array snapshots or use shadowing ?

- Array based operations can reduce need for operating system based IO, but require careful synchronisation with other operations
- Beware SSH algorithm incompatibility

House keeping

- Disk space usage / free space
- File fragmentation
- Disk fragmentation
- Shadow set consistency
- Log files
- Audit files
- Backup / archive records
- Etc. …

- Don’t let log and audit files become too big and unwieldy
- Clean up files on a cycle time that makes sense in the context of your operational regime

Log file management

- Fragmentation is a problem worth avoiding
- Use LD containers: write log files to the LD device, then simply move containers to archive.
- Block net$server.log (and others) by creating an empty ;32767 version

BOOT_OPTIONS – BOOT and DUMP lists

- Use ANALYZE/SHADOW to check if all shadowset members are consistent
- Ensure that all members of a shadowed system disc appear in the boot and dump lists
- Need enough paths to each device for minimalist boot/dump drivers to write errorlog buffers
- Can prune the list to make it less complicated

Avoiding data corruption

- When adding a new IA64 node to a cluster, mount target system disc READ ONLY before using BOOT_OPTIONS to set up boot paths

- Use SET DEVICE /NOAVAILABLE to prevent access to discs and other devices if <u>not</u> booted as a cluster member but with discs visible to booted node (eg: stand-alone backup or local maintenance boot)

Devices

- Fibrechannel tape:
  - SYSMAN IO FIND_WWID and IO CREATE_WWID
  - See SYS$DEVICES.DAT

- Exclude unused devices:
  - SYSMAN IO SHOW EXCLUDE
  - SYSMAN IO SET EXCLUDE = “<list>”

- LANCP DEFINE LL<nn> / VL<nn> etc.

SYSMAN IO EXCLUDE list

- Disable unused devices to prevent allocating memory resources for the data structures and buffers. Especially important on big blades for unused ethernet devices.

- Also useful for security, eg: prevent USB device use.

- To disable the USB subsystem drivers:

```
      mc sysman io set exclude=(UH*,EH*,DNA*,USB*,UCM*)
```

Fastpath

- Try to keep all interrupt handling on the same socket as the primary CPU (0)
- Think about what happens if hyperthreads are enabled
- Same device types on the same CPU (core)

- Example (-i4 or –i6, threads = off):
  - CPU 0 = primary
  - CPU 1 = ERA, ERB, BG
  - CPU 2 = EIA, EIB, EIC, EID, PE
  - CPU 3 = FGA, FGB, FGC, FGD
  - CPU 4 = PKA, PKB, PKC, PKD

Lock Manager

- Dedicated CPU for lock manager may be useful
- Try to keep it on the same socket as the primary CPU (0)
- Also consider fastpath CPU settings
- Think about what happens if hyperthreads are enabled

TCPI/IP stack

- TCPIP (BG device) on the same CPU as the network interfaces
- Keepalives can solve a lot of dropped connection problems
- SYSCONFIGTAB mechanism and “stanza file”:

```
socket:
        somaxconn=65535
        sominconn=65535
inet:
        tcbhashsize=16384
        tcbhashnum=16
        tcp_keepalive_default=1
        tcp_keepidle=1200
```

Memory reservations

- Useful to pre-allocate memory regions
- Allows placement of regions in specific RADs on a NUMA machine
- Large memory machines can benefit from bigger XFC
- Large memory machines can benefit from RAMdisc
- Some applications / databases use global sections, which can be sized and placed in RADs appropriately

External authentication

- Allows integration with a Windows AD or similar
- Set up ACMELDAP so that VMS can reach the AD for authentication
- Kits and configuration file templates in SYS$UPDATE:
- Map VMS usernames to AD entry fields
- Set “EXTAUTH” flag in UAF

DECwindows

- Do you need DECwindows at all ?

- Prevent using ILO as graphics device for DECwindows:

  mc sysman io set exclude=(GHA*)

  Note: device name is hardware platform specific

- Disable workstation components on startup

Performance engineering

- Without good data you cannot do good performance work

- Avoid guesswork - run T4 all the time
- If needed, use T4 “expert mode” and SDA extensions

- A faster machine just waits more quickly!
- Don’t make it go faster, stop it going slower
- The fastest IO is the IO you don’t do
- The fastest code is the code you don’t execute
- The idle loop is anything but idle

Performance monitoring

- Free T4 for long-term monitoring and trend analysis
- Implement your own modules to instrument your application

- Availability Manager (AMDS)

- More comprehensive performance monitors, eg:
  - TDC
  - Perfdat

- Find a set of tools that works for you.

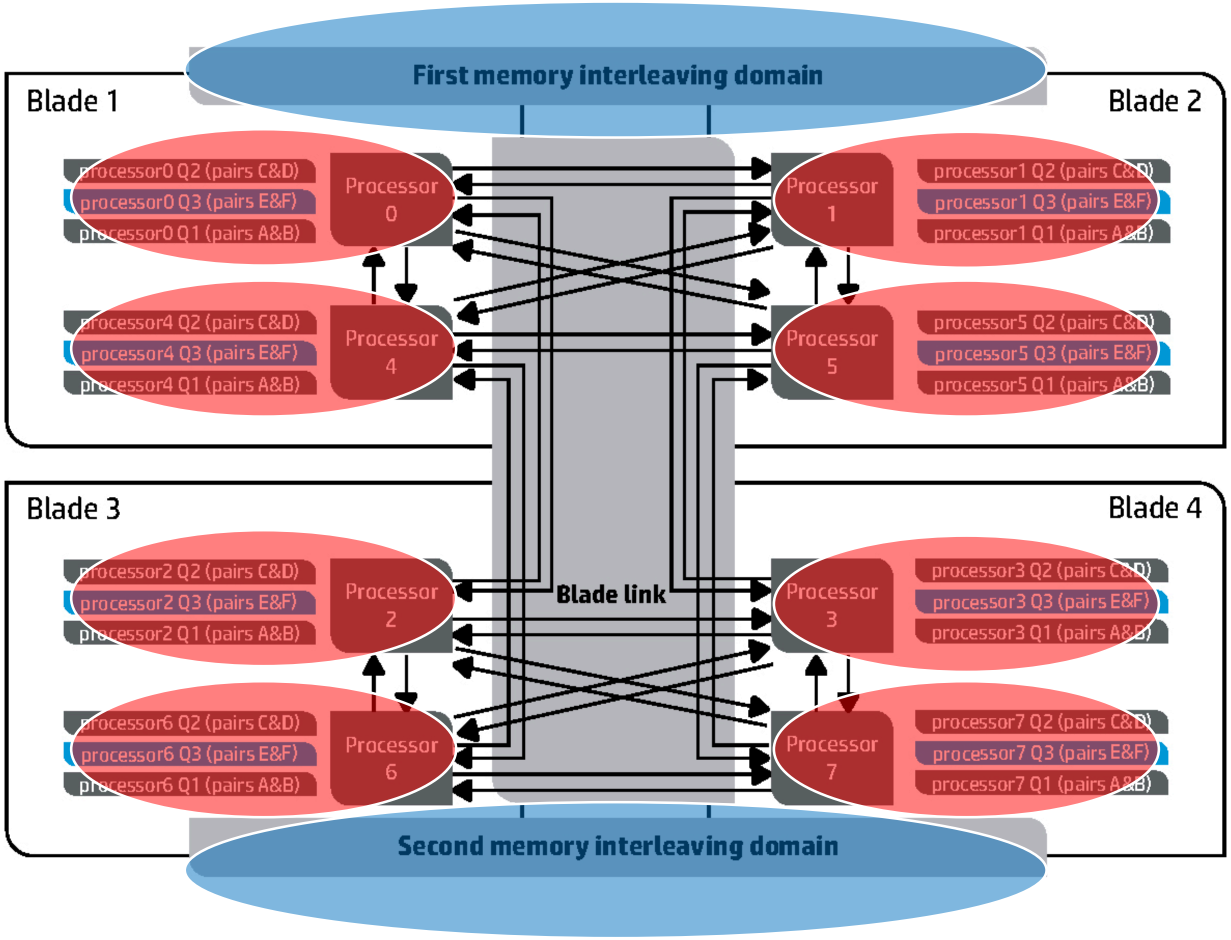
Contention for resources

- Many processes running in parallel can create contention for access to data files and shared data structures
- Look for high MP SYNC (or disguised MP SYNC which may show up as high INTERRUPT or KERNEL modes)
- Fast systems with a high level of parallelism can create conditions where a lot of things ”bunch up” and the overall effect is to slow the whole system down
- Look closely at the workload and flow of activities through the system

NUMA (non-uniform memory access)

- OpenVMS uses large shared memory regions:
  - XFC (50 % available memory by default)
  - RMS global buffers
  - Global sections (especially database caches)
  - Memory disc driver (MD devices)
- Set memory interleave behaviour with “memconfig” at EFI shell (requires reboot)
- Ensure physical memory installation is correct!
- Useful starting point for OpenVMS is “mostly UMA”

Memory architecture – bl890c-i4


First memory interleaving domain
Blade 1
Blade 2
processor0 Q2 (pairs C&D)
processor0 Q3 (pairs E&F)
processor0 Q1 (pairs A&B)
Processor 0
Processor 1
processor1 Q2 (pairs C&D)
processor1 Q3 (pairs E&F)
processor1 Q1 (pairs A&B)
processor4 Q2 (pairs C&D)
processor4 Q3 (pairs E&F)
processor4 Q1 (pairs A&B)
Processor 4
Processor 5
processor5 Q2 (pairs C&D)
processor5 Q3 (pairs E&F)
processor5 Q1 (pairs A&B)
Blade 3
Blade 4
processor2 Q2 (pairs C&D)
processor2 Q3 (pairs E&F)
processor2 Q1 (pairs A&B)
Processor 2
Blade link
Processor 3
processor3 Q2 (pairs C&D)
processor3 Q3 (pairs E&F)
processor3 Q1 (pairs A&B)
processor6 Q2 (pairs C&D)
processor6 Q3 (pairs E&F)
processor6 Q1 (pairs A&B)
Processor 6
Processor 7
processor7 Q2 (pairs C&D)
processor7 Q3 (pairs E&F)
processor7 Q1 (pairs A&B)
Second memory interleaving domain

Hyperthreading

- Hyperthreading is extremely workload dependent

- In general the OpenVMS scheduler does a better job

- Enable / disable hyperthreading with “cpuconfig” at EFI shell (requires reboot)

- “CPU” count will appear to double when enabled
  - V8.4-2 supports 64 “scheduling units”
  - V8.4-1H1 supports 32 “scheduling units”
  - Can “STOP/CPU <nn>” to selectively shut down co-threads

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Inter-site links - storage

- MSCP over PEdriver:
  - Poor for performance, useful fallback
  - Requires cluster member nodes at remote site
- FC extension (DWDM over dark fibre):
  - Best for performance
  - Set inter-switch link port characteristics
- FC over IP:
  - Need low latency and low jitter IP network
  - Use “fast write” in FCIP devices

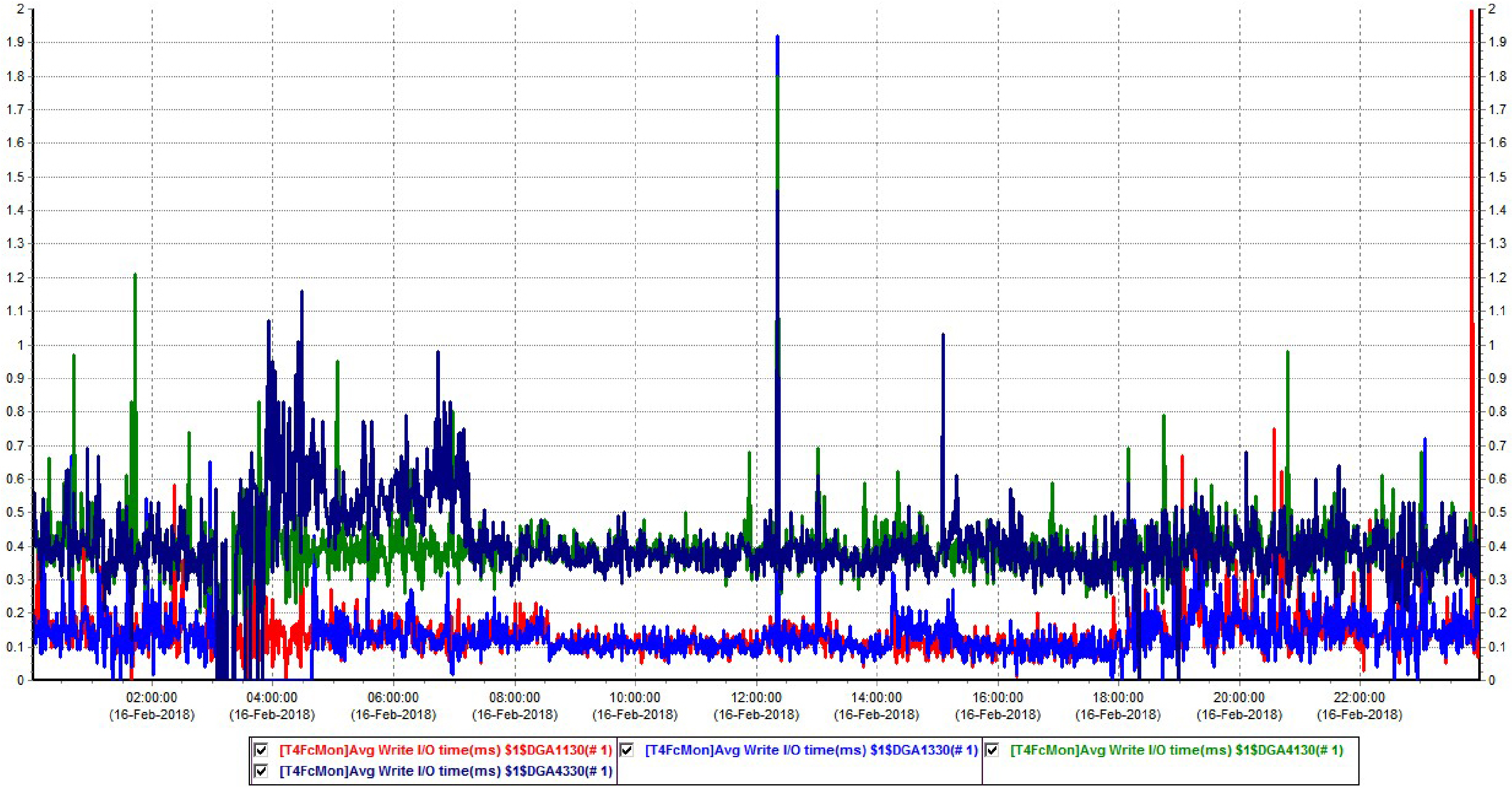
Multi-site cluster – storage

- MSCP over PEdriver:
  - No direct path to MSCP served devices at remote sites
  - Greater probability of triggering shadow merge
- FC extension and FC over IP:
  - Multi-path fibrechannel devices
  - Direct path to devices from all nodes
  - Set the SITE value to bias reads from local site

Multi-site cluster – storage performance

- Reads should be biased from local storage
- Shadowing writes are synchronous, so remote shadow set members are the limiting factor.
- Write latency is a combination of:
    - Local IO write latency (system to local storage array)
    - ISL endpoint latency (FC switches etc.)
    - Distance latency
- IO write rate: 1ms = 1000 IOs per second, 2ms = 500, …

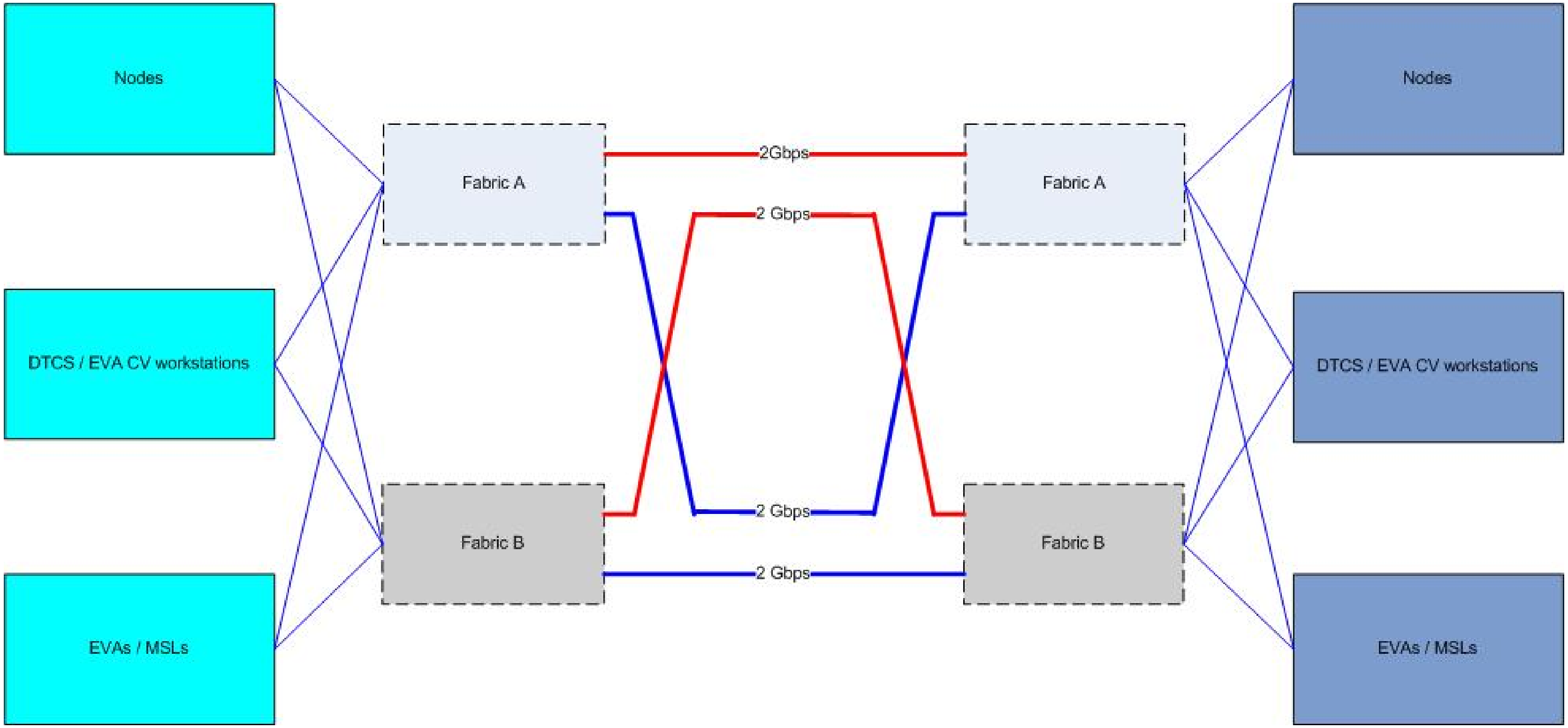
Multi-site shadow set (4 members)



Inter-site storage (SAN) links

- Use direct path fibrechannel with SAN extension
- Avoid path switching by dual-path connection per fabric
- Enable MSCP as an alternate path mechanism
- Use mini-copy and mini-merge
- Avoid cross-site booting
- Only mount site-specific disks at their site, even if shadowed to all sites (eg: per-site shadowed system disks)

Example SAN connectivity



Inter-site links – data networking (1)

- Extended layer 2 or routed layer 3 ?
- SCS at layer 2 or “clusters over IP” ?
- Preference is to use extended layer 2 with QoS on specific VLANs to control latency and bandwidth
- LAT is a useful protocol to test connectivity paths at layer 2
- AMDS (Availability Manager) is a layer 2 protocol
- Avoid MSCP serving, especially with shadow sets

Inter-site links – data networking (2)

- LAN extension – layer 2 (DWDM over dark fibre):
  - Best for performance, lowest latency
  - Passes all layer 2 protocols, so use SCS, AMDS, etc.

- LAN extension – layer 2 (MPLS pseudo-wire):
  - Variable latency, depends on topology and contention
  - Passes all layer 2 protocols, so use SCS, AMDS, etc.

- TCP/IP – layer 3:
  - Variable latency, depends on topology and contention
  - IP only, use IPCI, no AMDS or other layer 2 protocols

Extended layer 2 LANs

- DWDM over dark fibre
- MPLS

- Traffic separation with VLAN 802.1Q tags

- Use QoS to control traffic flows

- Switches have manufacturer specific features:
  - HP Procurve has “meshing”
  - Cisco has “etherchannel”
  - Extreme has “EAPS ring”

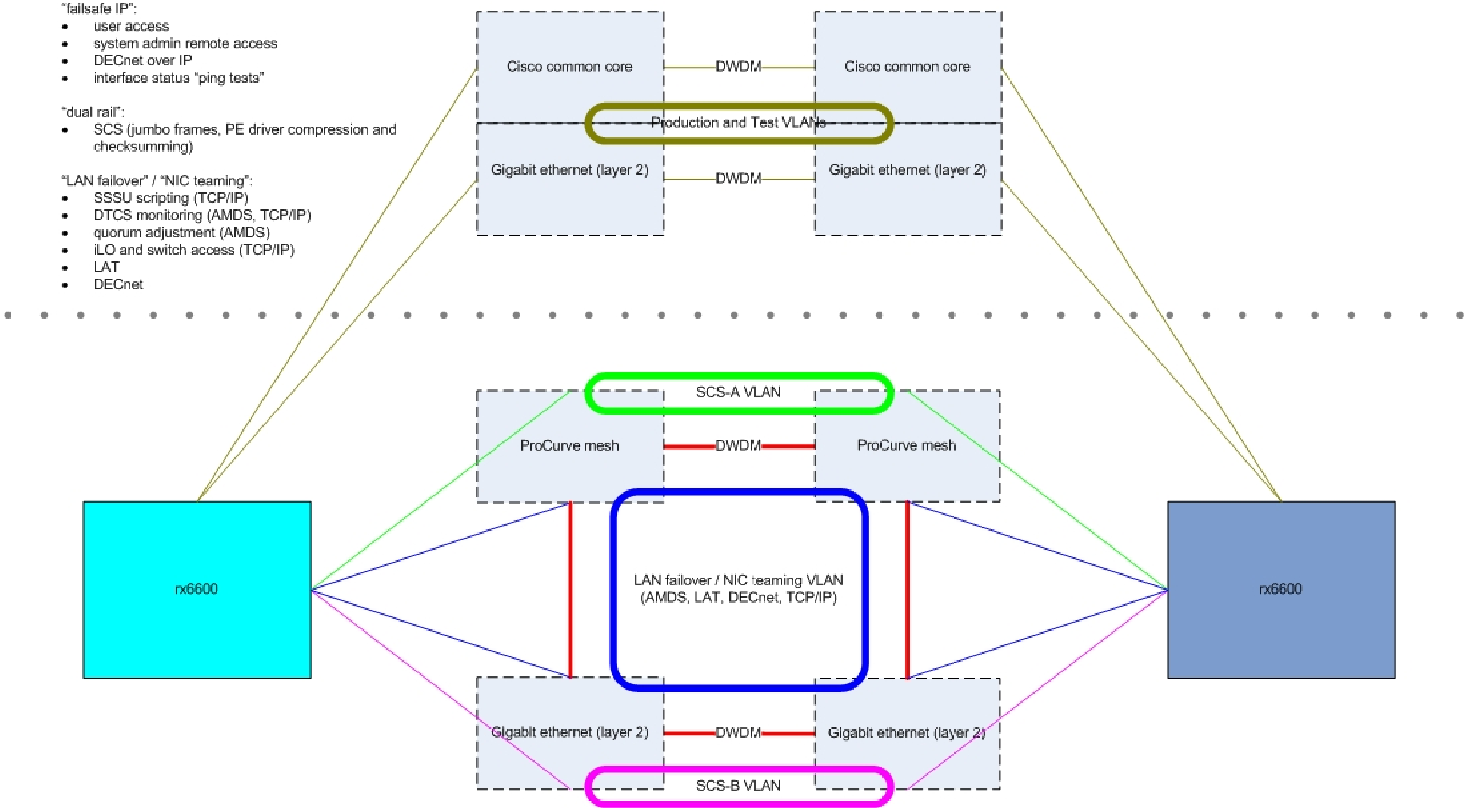
Multi-site cluster – data networking

- LANCP to configure and manage LAN devices
- LLDRIVER for LAN failover
- VLDRIVER for VLANs

- PEDRIVER implements channels and virtual circuits
- SCACP to manage PEDRIVER
- Disable SCS on unused LAN devices

- Enable jumbo frames if network infrastructure permits

Example data network connectivity



"failsafe IP":

- user access
- system admin remote access
- DECnet over IP
- interface status "ping tests"

"dual rail":

- SCS (jumbo frames, PE driver compression and checksumming)

"LAN failover" / "NIC teaming":

- SSSU scripting (TCP/IP)
- DTCS monitoring (AMDS, TCP/IP)
- quorum adjustment (AMDS)
- iLO and switch access (TCP/IP)
- LAT
- DECnet

Cisco common core
DWDM
Cisco common core
Production and Test VLANs
Gigabit ethernet (layer 2)
DWDM
Gigabit ethernet (layer 2)
SCS-A VLAN
ProCurve mesh
DWDM
ProCurve mesh
rx6600
LAN failover / NIC teaming VLAN
(AMDS, LAT, DECnet, TCP/IP)
rx6600
Gigabit ethernet (layer 2)
DWDM
Gigabit ethernet (layer 2)
SCS-B VLAN

Multi-site cluster – cluster interconnects

- How many channels should we have?
- Depends on network infrastructure

- Single LAN failover device – simple, single channel, multiple NICs, performance and failover behaviour depends on LLDRIVER

- Multiple LAN devices – more NICs (or VL devices), multiple channels, better performance and failover behaviour

- VLANs – tagged (VLDRIVER) or untagged?

Best practices for OpenVMS clusters

The design, build, operation and support of OpenVMS systems and clusters

Connect Germany 2021 online conference

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