SAS cabling rules, worksheets, and examples

Install and maintain

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SAS cabling rules, worksheets, and examples

Overview of cabling rules - DS212C, DS224C, or DS460C

To help you cable your SAS drive shelves with IOM12/IOM12B modules to your storage system, you can use any of the available SAS cabling rules, worksheets, and examples content as needed.

SAS cabling rules and concepts

- Configurations
- Controller slot numbering
- Shelf-to-shelf connections
- Controller-to-stack connections
- Mini-SAS HD SAS optical cables
- Tri-path HA connectivity

Cabling worksheets and examples

- Multipath HA configurations
- Platforms with internal storage
- Quad-path HA configurations

Cabling worksheet templates

- Multipathed connectivity
- Quad-pathed connectivity
- How to read a worksheet for multipathed connectivity
- How to read a worksheet for quad-pathed connectivity

SAS cabling rules and concepts - DS212C, DS224C, or DS460C

Disk shelves with IOM12/IOM12B modules can be cabled in HA pair and single-controller configurations (for supported platforms) by applying the SAS cabling rules: configuration rules, controller slot numbering rules, shelf-to-shelf connection rules, controller-to-stack connection rules, and if applicable, mini-SAS HD SAS optical cable rules.

> The SAS cabling rules regarding controller slot numbering rules, shelf-to-shelf connection rules, and controller-to-stack connection rules described in this guide are the same rules that apply to all SAS disk shelves, whether they have IOM12 or IOM12B modules. However, the information in this guide is specific to the unique characteristics of disk shelves with IOM12/IOM12B modules and their use in supported configurations.

The SAS cabling rules regarding configuration rules and mini-SAS HD SAS optical cable rules described in this

guide are specific to disk shelves with IOM12/IOM12B modules.

The SAS cabling rules described in this guide balance SAS cabling between the on-board SAS ports and host bus adapter SAS ports to provide highly available storage controller configurations and meet the following goals:

- Provide a single, easily understood universal algorithm for all SAS products and configurations
- Yield the same physical cabling when generating the Bill of Materials (BOM), followed in the factory, and in the field
- Are verifiable by configuration-checking software and tools
- Provide maximum possible resilience to maintain availability and minimize the reliance on controller takeovers

You should avoid deviating from the rules; deviations might reduce reliability, universality, and commonality.

Configuration rules

Disk shelves with IOM12/IOM12B modules are supported on specific types of HA pair and single-controller configurations.

> For current information about supported cabling configurations for your platform model, see the Hardware Universe.
>
> NetApp Hardware Universe

- HA pair configurations must be cabled as multipath HA or quad-path HA configurations with the following exceptions:
  - Platforms with internal storage do not support quad-path HA connectivity.
  - A FAS2820 HA pair can be cabled as tri-path HA.

    Information about the FAS2820 connectivity can be found in the Tri-path HA connectivity section.

  - Platforms with internal storage can be cabled as single-path HA configurations (from port 0b/0b1 to external shelves) to support connectivity to an external SAS tape backup device (from port 0a).

> For FAS2820 HA pairs, although the cabling to external shelves is single-path HA, because of each controller's internal connection of port 0b to its local expander (IOM12G) and port 0c to its partner's expander, the HA pair configuration is multipath HA.

- Single-controller configurations must be cabled as multipath or quad-path configurations, with the following exceptions:
  - FAS2600 series single-controller configurations can be cabled as single-path configurations.

    Because the internal storage uses single-path connectivity, ONTAP issues occasional warnings that mixed paths are detected. To avoid these warnings, you can use single-path connectivity to the external disk shelves. Additionally, you can use single-path connectivity when an external SAS tape backup device is used.

  - FAS2600 series single-controller configurations do not support quad-path connectivity.

Controller slot numbering rules

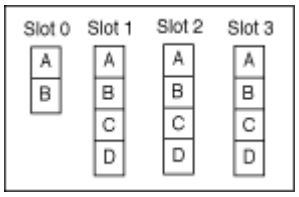
For the purpose of applying cabling rules across all supported HA pairs and single-controller configurations, a controller slot numbering convention is used.

- For all HA pairs and single-controller configurations, the following applies:
  - A SAS HBA in a physical PCI slot is defined as occupying PCI slot 1, 2, 3, and so on regardless of the slot's physical label on a controller.

    For example, if SAS HBAs occupied physical PCI slots 3, 5, and 7, they would be designated as slots 1, 2, and 3 for the purpose of applying the SAS cabling rules.

  - An onboard SAS HBA is defined as occupying PCI slot 0 just as it is labeled on a controller.
  - Each port in each slot is defined just as it is labeled on a controller. For example, slot 0 with two ports is referred to as 0a and 0b. Slot 1 with four ports is referred to as 1a, 1b, 1c, and 1d.

    In this document, slots and the slot ports are depicted as follows:



Shelf-to-shelf connection rules

When you have more than one disk shelf in a stack of disk shelves, they connect to each other through each SAS domain (IOM A and IOM B) using the applicable "standard" or "double-wide" shelf-to-shelf cabling. Your use of "standard" or "double-wide" shelf-to-shelf cabling depends on the configuration you have.

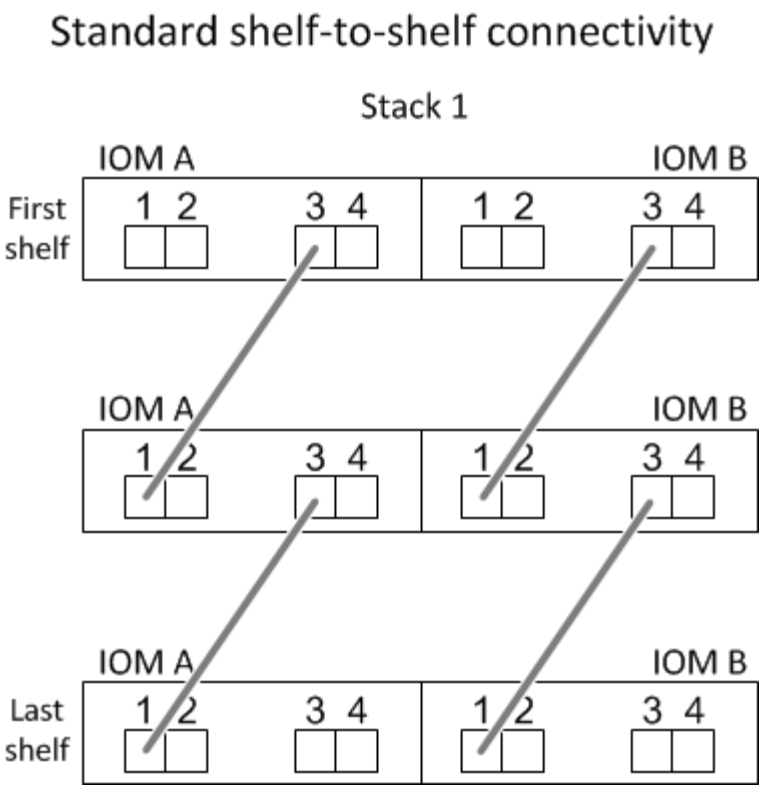
Standard shelf-to-shelf connectivity

- Standard shelf-to-shelf connectivity is used in any stack of disk shelves with more than one disk shelf.

  One cable connection is needed between disk shelves in each domain—domain A (IOM A) and domain B (IOM B).

- Best practice is to use IOM ports 3 and 1 for standard shelf-to-shelf connectivity.

  From the logical first shelf to the logical last shelf in a stack, you connect IOM port 3 to the next shelf's IOM port 1 in domain A and then domain B.



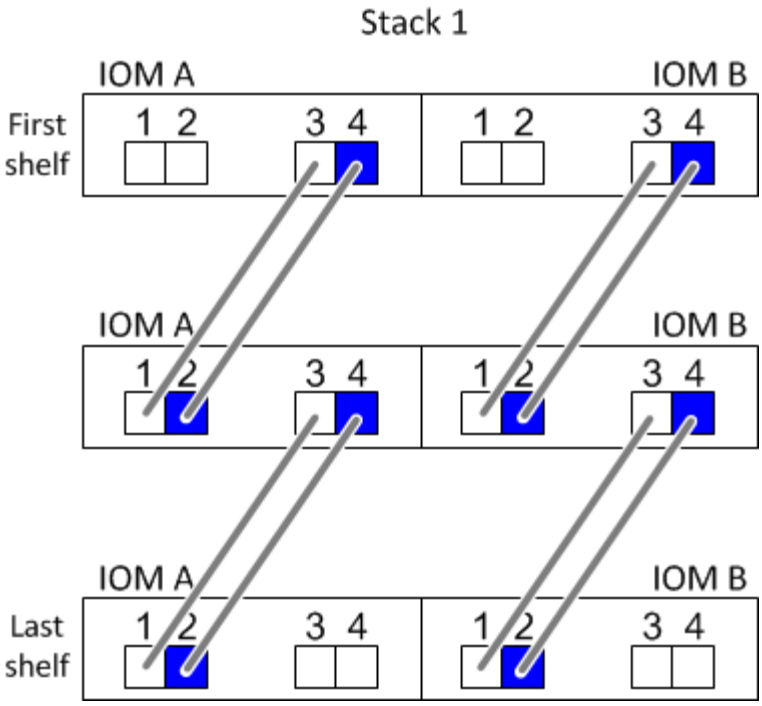
Double-wide shelf-to-shelf connectivity

- Double-wide shelf-to-shelf connectivity is used in quad-pathed (quad-path HA and quad-path) configurations.
- Double-wide shelf-to-shelf connectivity requires two cable connections between disk shelves in each domain—domain A (IOM A) and domain B (IOM B).

  The first cable connection is cabled as standard shelf-to-shelf connectivity (using IOM ports 3 and 1); the second cable connection is cabled as double-wide shelf-to-shelf connectivity (using IOM ports 4 and 2).

  From the logical first shelf to the logical last shelf in a stack, you connect IOM port 3 to the next shelf's IOM port 1 in domain A and then domain B. From the logical first shelf to the logical last shelf in a stack, you connect IOM port 4 to the next shelf's IOM port 2 in domain A and then domain B. (IOM ports cabled as double-wide connectivity are shown with blue.)

Double-wide shelf-to-shelf connectivity



Controller-to-stack connection rules

You can correctly cable the SAS connections from each controller to each stack in an HA pair or in a single-controller configuration by understanding that SAS disk shelves use software-based disk ownership, how controller ports A/C and B/D are connected to stacks, how controller ports A/C and B/D are organized into port pairs, and how platforms with internal storage have their controller ports connected to stacks.

SAS disk shelf software-based disk ownership rule

SAS disk shelves use software-based disk ownership (not hardware-based disk ownership). This means that disk drive ownership is stored on the disk drive rather than it being determined by the topology of the storage system's physical connections (as it is for hardware-based disk ownership). Specifically, disk drive ownership is assigned by ONTAP (automatically or by CLI commands), not by how you cable the controller-to-stack connections.

SAS disk shelves should never be cabled using the hardware-based disk ownership scheme.

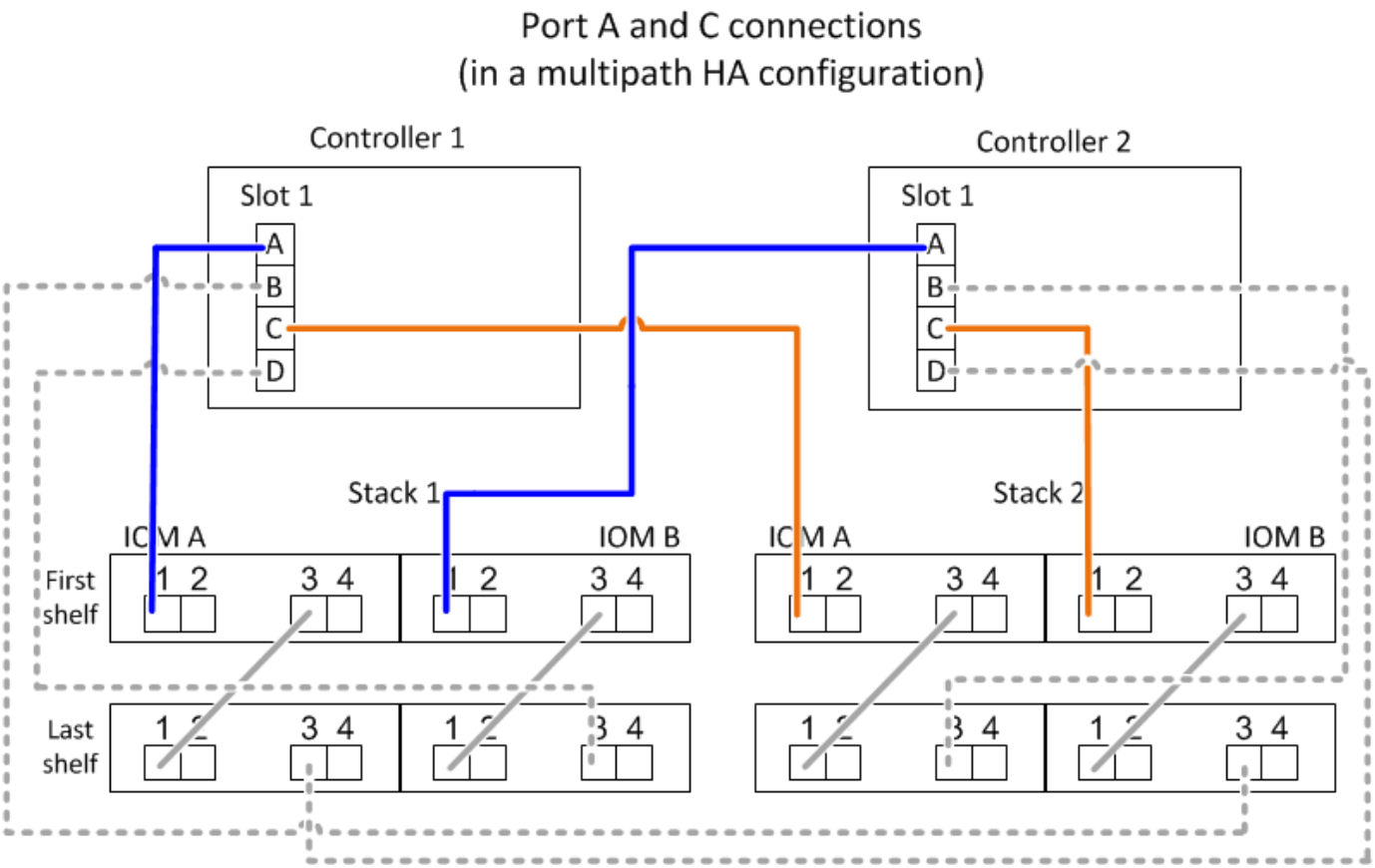
Controller A and C port connection rules (for platforms without internal storage)

- A and C ports are always the primary paths to a stack.
- A and C ports always connect to the logical first disk shelf in a stack.
- A and C ports always connect to disk shelf IOM ports 1 and 2.

  IOM port 2 is only used for quad-path HA and quad-path configurations.
- Controller 1 A and C ports always connect to IOM A (domain A).
- Controller 2 A and C ports always connect to IOM B (domain B).

The following illustration highlights how controller ports A and C connect in a multipath HA configuration with

one quad-port HBA and two stacks of disk shelves. Connections to stack 1 are shown in blue. Connections to stack 2 are shown in orange.



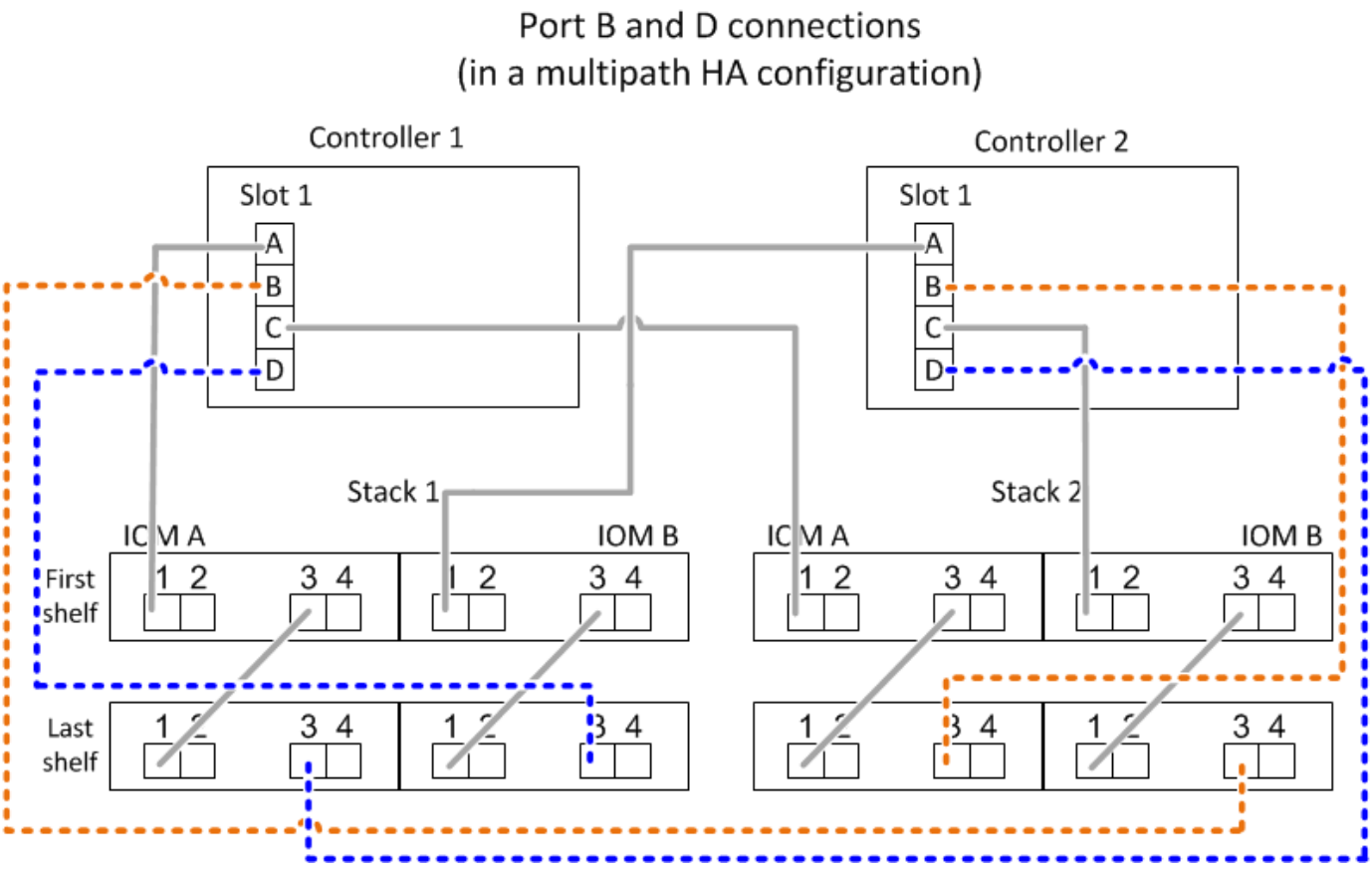
Controller B and D port connection rules (for platforms without internal storage)

- B and D ports are always the secondary paths to a stack.
- B and D ports always connect to the logical last disk shelf in a stack.
- B and D ports always connect to disk shelf IOM ports 3 and 4.

  IOM port 4 is only used for quad-path HA and quad-path configurations.

- Controller 1 B and D ports always connect to IOM B (domain B).
- Controller 2 B and D ports always connect to IOM A (domain A).
- B and D ports are connected to the stacks by offsetting the order of the PCI slots by one so that the first port on the first slot is cabled last.

The following illustration highlights how controller ports B and D connect in a multipath HA configuration with one quad-port HBA and two stacks of disk shelves. Connections to stack 1 are shown in blue. Connections to stack 2 are shown in orange.



Port pair connection rules (for platforms without internal storage)

Controller SAS ports A, B, C, and D are organized into port pairs using a method that leverages all of the SAS ports for system resiliency and consistency when cabling controller-to-stack connections in HA pair and single-controller configurations.

- Port pairs consist of a controller A or C SAS port and a controller B or D SAS port.

  A and C SAS ports connect to the logical first shelf in a stack. B and D SAS ports connect to the logical last shelf in a stack.

- Port pairs use all SAS ports on each controller in your system.

  You increase system resiliency by incorporating all SAS ports (on an HBA in a physical PCI slot [slot 1-N] and on board the controller [slot 0]) into port pairs. Do not exclude any SAS ports.

- Port pairs are identified and organized as follows:

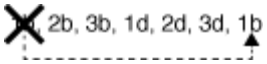
  a. List A ports and then C ports in sequence of slots (0,1, 2, 3, and so on).

     For example: 1a, 2a, 3a, 1c, 2c, 3c

  b. List B ports and then D ports in sequence of slots (0,1, 2, 3, and so on).

     For example: 1b, 2b, 3b, 1d, 2d, 3d

  c. Rewrite the D and B port list so that the first port in the list is moved to the end of the list.

For example: 

Offsetting the order of the slots by one balances port pairs across multiple slots (physical PCI slots and on board slots) when more than one slot of SAS ports is available; therefore, preventing a stack from being cabled to a single SAS HBA.

d. Pair the A and C ports (listed in step 1) to the D and B ports (listed in step 2) in the order that they are listed.

For example: 1a/2b, 2a/3b, 3a/1d,1c/2d, 2c/3d, 3c/1b.

> For an HA pair, the list of port pairs you identify for the first controller is also applicable to the second controller.

- When cabling your system, you can use port pairs in the order in which you identified them or you can skip port pairs:
  - Use port pairs in the order in which you identified (listed) them when all port pairs are needed to cable the stacks in your system.

    For example, if you identified six port pairs for your system and you have six stacks to cable as multipath, you cable the port pairs in the order in which you listed them:

    1a/2b, 2a/3b, 3a/1d,1c/2d, 2c/3d, 3c/1b

  - Skip port pairs (use every other port pair) when not all port pairs are needed to cable the stacks in your system.

    For example, if you identified six port pairs for your system and you have three stacks to cable as multipath, you cable every other port pair in your list:

    1a/2b, ~~2a/3b~~, 3a/1d, ~~1c/2d~~, 2c/3d, ~~3c/1b~~

> When you have more port pairs than you need to cable the stacks in your system, the best practice is to skip port pairs to optimize the SAS ports on your system. By optimizing SAS ports, you optimize your system's performance.

Controller-to-stack cabling worksheets are convenient tools for identifying and organizing port pairs so that you can cable the controller-to-stack connections for your HA pair or single-controller configuration.

Controller-to-stack cabling worksheet template for multipathed connectivity

Controller-to-stack cabling worksheet template for quad-pathed connectivity

Controller 0b/0b1 and 0a port connection rules for platforms with internal storage

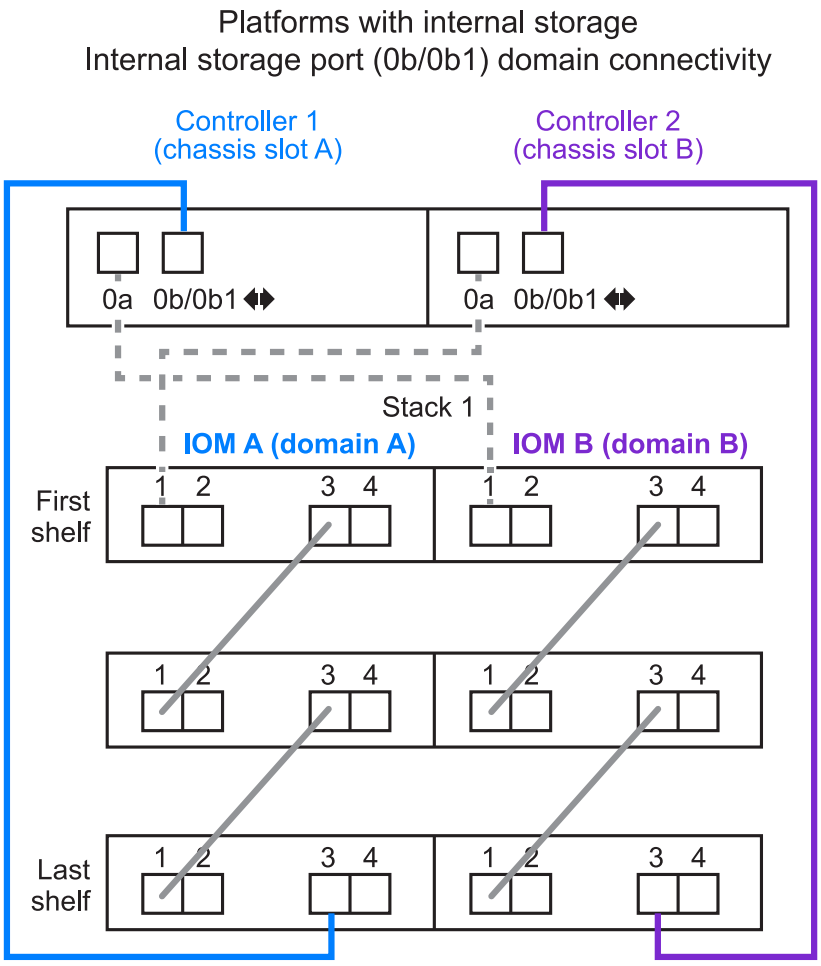
Platforms with internal storage have a unique set of connection rules because each controller must maintain same domain connectivity between the internal storage (port 0b/0b1) and the stack. This means that when a controller is located in slot A of the chassis (controller 1) it is in domain A (IOM A) and therefore port 0b/0b1 must connect to IOM A in the stack. When a controller is located in slot B of the chassis (controller 2) it is in domain B (IOM B) and therefore port 0b/0b1 must connect to IOM B in the stack.

FAS25XX platforms are not addressed in this content.

If you do not connect the 0b/0b1 port to the correct domain (cross-connect domains), you expose your system to resiliency issues that prevent you from performing nondisruptive procedures safely.

- Controller 0b/0b1 port (internal storage port):
  - Controller 1 0b/0b1 port always connects to IOM A (domain A).
  - Controller 2 0b/0b1 port always connects to IOM B (domain B).
  - Port 0b/0b1 is always the primary path.
  - Port 0b/0b1 always connects to the logical last disk shelf in a stack.
  - Port 0b/0b1 always connect to disk shelf IOM port 3.
- Controller 0a port (internal HBA port):
  - Controller 1 0a port always connects to IOM B (domain B).
  - Controller 2 0a port always connects to IOM A (domain A).
  - Port 0a is always the secondary path.
  - Port 0a always connects to the logical first disk shelf in a stack.
  - Port 0a always connect to disk shelf IOM port 1.

The following illustration highlights internal storage port (0b/0b1) domain connectivity to an external stack of shelves:



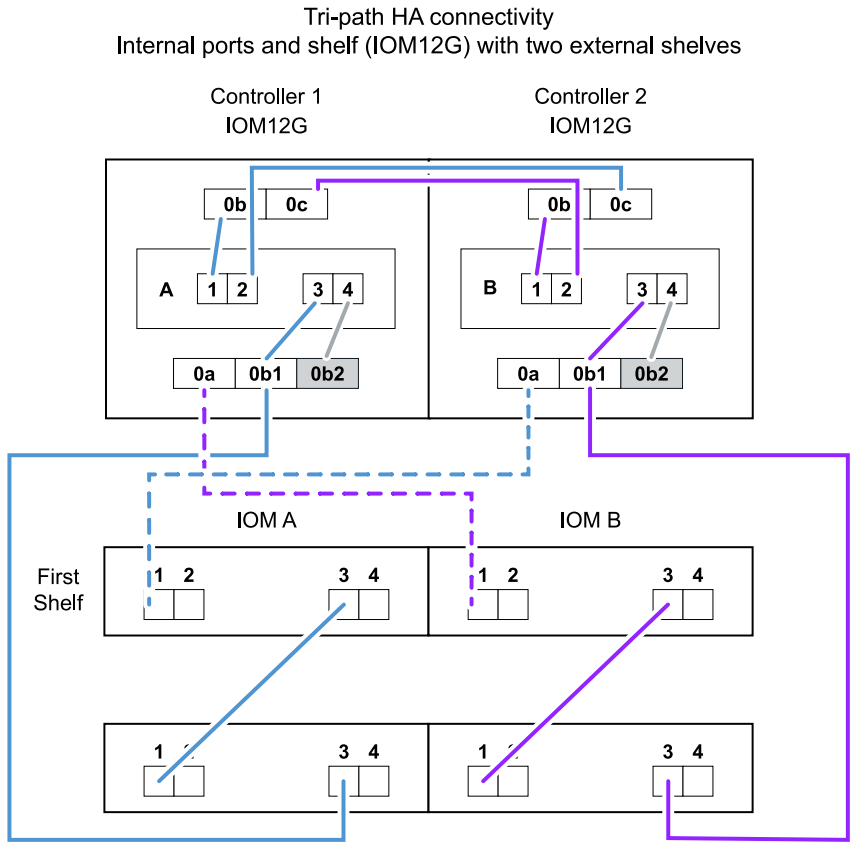
Tri-path HA connectivity

Tri-path HA connectivity is available on FAS2820 HA pairs. Tri-path HA connectivity has three paths from each controller to internal (IOM12G) and external shelves:

- Each controller's internal connection of port 0b to its local IOM12G and port 0c to its partner's IOM12G gives an HA pair multipath HA connectivity.
- The cabling of each controller's external storage ports, 0a and 0b1, gives an HA pair tri-path HA connectivity.

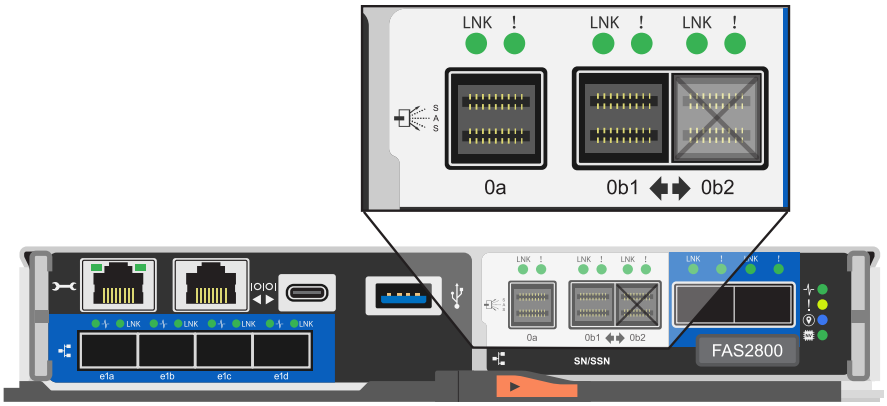
  Ports 0a and 0b1 are cabled across the two controllers when there are no external shelves, or they are cabled to external shelves to achieve tri-path HA connectivity.

The following shows the controller's internal connections and external cabling that achieves tri-path HA connectivity:



The FAS2820 external SAS ports:

- The 0a port is from the internal HBA (like other platforms with an internal shelf).
- The 0b1 port is from the internal shelf (like the 0b ports on other platforms with an internal shelf).
- The 0b2 port is not used. It is disabled. If a cable is connected to it, an error message is generated.



FAS2820 HA pair cabling examples can be found in the Controller-to-stack cabling worksheets and cabling examples for platforms with internal storage section.

Mini-SAS HD SAS optical cable rules

You can use mini-SAS HD SAS optical cables—multimode active optical cable (AOC) cables with mini-SAS HD-to-mini-SAS HD connectors and multimode (OM4) breakout cables with mini-SAS HD-to-LC connectors—to achieve long distance SAS connectivity for certain configurations that have disk shelves with IOM12

modules.

- Your platform and version of ONTAP must support the use of mini-SAS HD SAS optical cables: multimode active optical cable (AOC) cables with mini-SAS HD-to-mini-SAS HD connectors and multimode (OM4) breakout cables with mini-SAS HD-to-LC connectors.

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- SAS optical multimode AOC cables with mini-SAS HD-to-mini-SAS HD connectors can be used for controller-to-stack and shelf-to-shelf connections, and are available in lengths up to 50 meters.
- If you are using SAS optical multimode (OM4) breakout cables with mini-SAS HD-to-LC connectors (for patch panels), the following rules apply:
  - You can use these cables for controller-to-stack and shelf-to-shelf connections.

    If you use multimode breakout cables for shelf-to-shelf connections, you can only use them once within a stack of disk shelves. You must use multimode AOC cables to connect the remaining shelf-to-shelf connections.

    For quad-path HA and quad-path configurations, if you use multimode breakout cables for the shelf-to-shelf double-wide connections between two disk shelves, the best practice is to use identically paired breakout cables.

  - You must connect all eight (four pairs) of the LC breakout connectors to the patch panel.
  - You need to supply the patch panels and inter-panel cables.

    The inter-panel cables must be the same mode as the breakout cable: OM4 multimode.

  - Up to one pair of patch panels can be used in a path.
  - The point-to-point (mini-SAS HD-to-mini-SAS HD) path of any multimode cable cannot exceed 100 meters.

    The path includes the set of breakout cables, patch panels, and inter-panel cables.

  - The total end-to-end path (sum of point-to-point paths from the controller to the last shelf) cannot exceed 300 meters.

    The total path includes the set of breakout cables, patch panels, and inter-panel cables.

- The SAS cables can be SAS copper, SAS optical, or a mix.

  If you are using a mix of SAS copper cables and SAS optical cables, the following rules apply:

  - Shelf-to-shelf connections in a stack must be all SAS copper cables or all SAS optical cables.
  - If the shelf-to-shelf connections are SAS optical cables, the controller-to-stack connections to that stack must also be SAS optical cables.
  - If the shelf-to-shelf connections are SAS copper cables, the controller-to-stack connections to that stack can be SAS optical cables or SAS copper cables.

Cabling worksheets for multipath HA configurations - DS212C, DS224C, or DS460C

You can use the controller-to-stack cabling worksheets and cabling examples to cable your HA pair as a multipath HA configuration. This applies to shelves with IOM12/IOM12B modules.

This information applies to platforms without internal storage.

- If needed, you can refer to SAS cabling rules and concepts for information about supported configurations, the controller slot numbering convention, shelf-to-shelf connectivity, and controller-to-shelf connectivity (including the use of port pairs).
- If needed, you can refer to How to read a worksheet to cable controller-to-stack connections for multipathed connectivity.
- Cabling examples show controller-to-stack cables as solid or dashed to distinguish controller A and C port connections from controller B and D port connections.

Controller-to-Stack Cable Type Key	
Cable Type	Description
	▪ Connects controller **A** and **C** ports to the logical **first** disk shelf in a stack ▪ The **primary** path from a controller to a stack
	▪ Connects controller **B** and **D** ports to the logical **last** disk shelf in a stack ▪ The **secondary** path from a controller to a stack

- Cables in the cabling examples and their corresponding port pairs in the worksheets are color-coded to distinguish connectivity to each stack in the HA pair.

Controller-to-Stack Cable Color Key			
Cable Color		Connects to...	From...
	Dark blue	Stack 1	Each controller by a unique port pair
	Orange	Stack 2	
	Green	Stack 3	
	Light blue	Stack 4	

- Worksheets and cabling examples show cabling port pairs in the order in which they are listed in the worksheet.

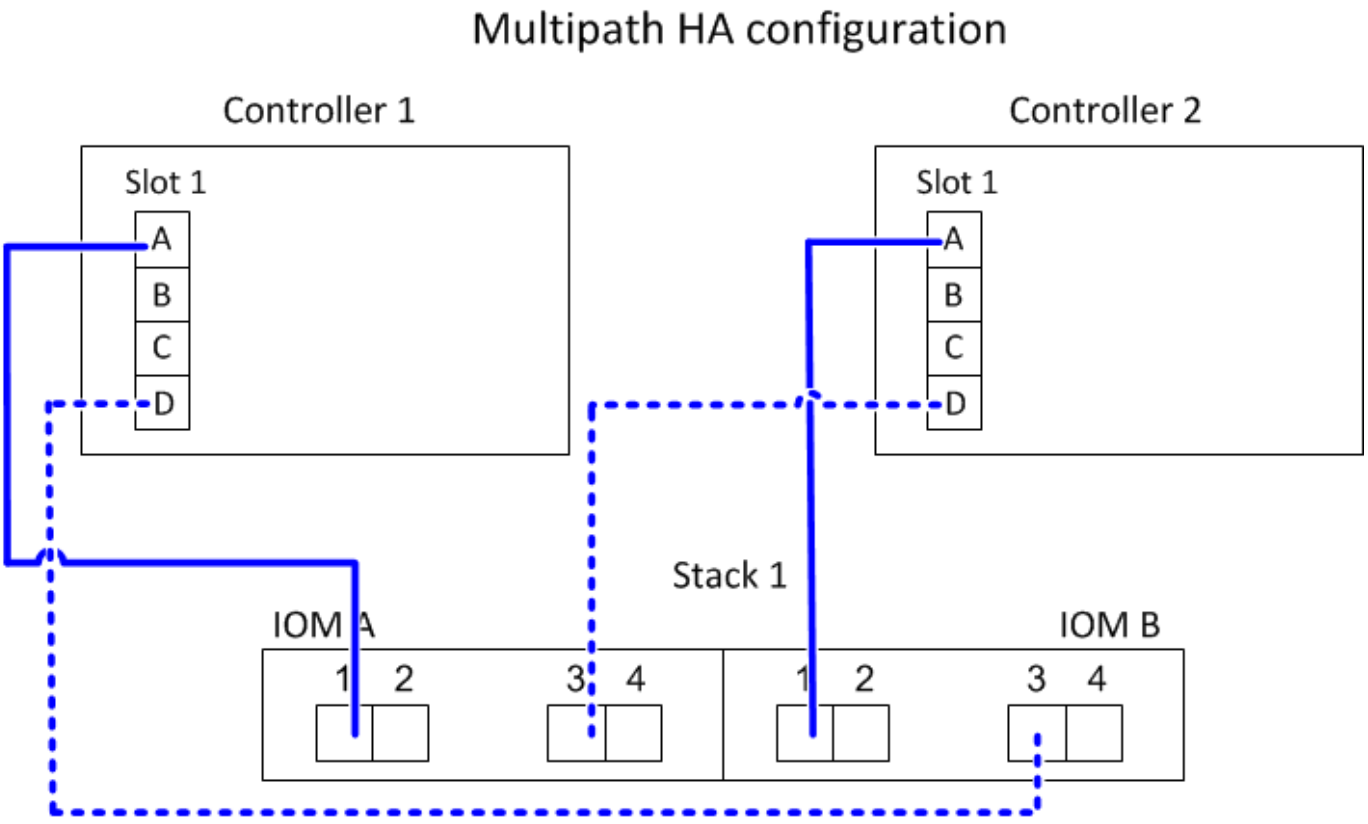
Controller-to-stack cabling worksheets and cabling examples for multipath HA configurations with quad-port SAS HBAs

You can use the completed controller-to-stack cabling worksheets and cabling examples to cable common multipath HA configurations that have quad-port SAS HBAs. These controllers do not have onboard SAS ports.

Multipath HA with one quad-port SAS HBA and one single-shelf stack

The following worksheet and cabling example uses port pair 1a/1d:

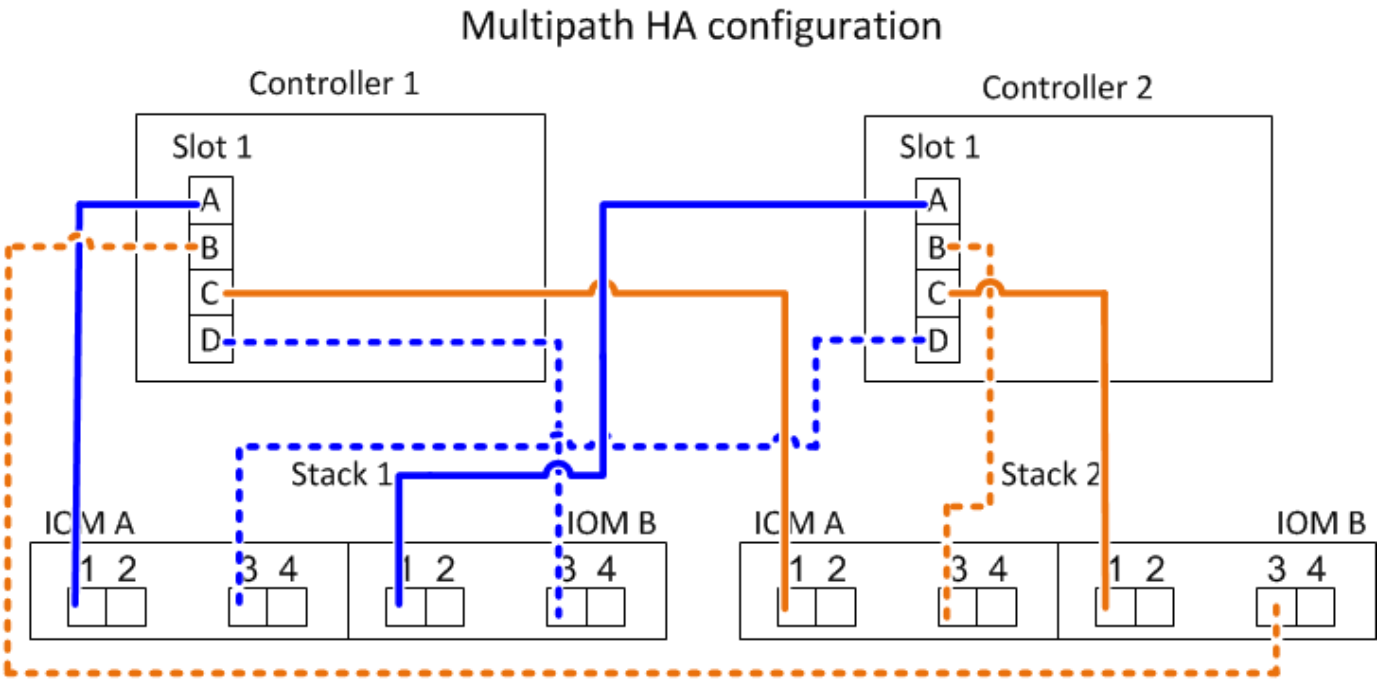
Controller-to-Stack Cabling Worksheet for Multipathed Connectivity											
Controller SAS ports	Controllers	Cable to disk shelf IOMs			Stacks						
					1	2	3	4	5	6
		Shelf	IOM	Port	Port pairs					
A and C	1	First	A	1	1a	1c				
	2	First	B	1						
B and D					~~1b~~	~~1d~~				
	1	Last	B	3	1d	1b				
	2	Last	A	3						



Multipath HA with one quad-port SAS HBA and two single-shelf stacks

The following worksheet and cabling example uses port pairs 1a/1d and 1c/1b:

Controller-to-Stack Cabling Worksheet for Multipathed Connectivity											
Controller SAS ports	Controllers	Cable to disk shelf IOMs			Stacks						
					1	2	3	4	5	6
		Shelf	IOM	Port	Port pairs					
A and C	1	First	A	1	1a	1c				
	2	First	B	1						
B and D					~~1b~~	~~1d~~				
	1	Last	B	3	1d	1b				
	2	Last	A	3						



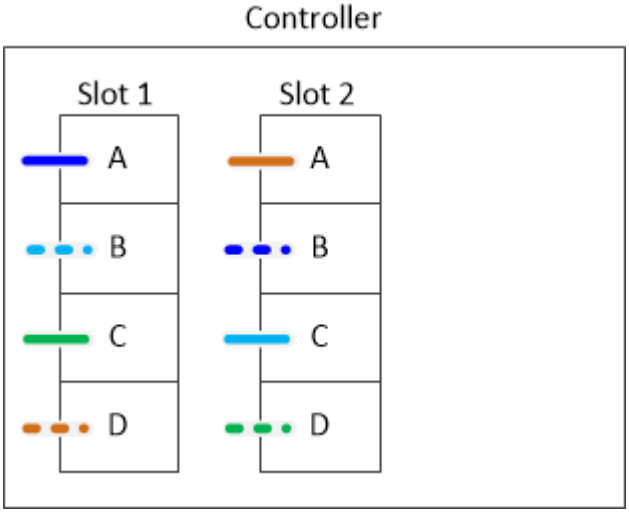
Multipath HA with two quad-port SAS HBAs and two multi-shelf stacks

Four port pairs are available for this configuration: 1a/2b, 2a/1d, 1c/2d, and 2c/1b. You can cable port pairs in the order in which they are identified (listed in the worksheet) or you can cable every other port pair (skip port pairs).

When you have more port pairs than you need to cable the stacks in your system, the best practice is to skip port pairs to optimize the SAS ports on your system. By optimizing SAS ports, you optimize your system's performance.

The following worksheet and cabling example shows port pairs being used in the order in which they are listed in the worksheet: 1a/2b, 2a/1d, 1c/2d, and 2c/1b.

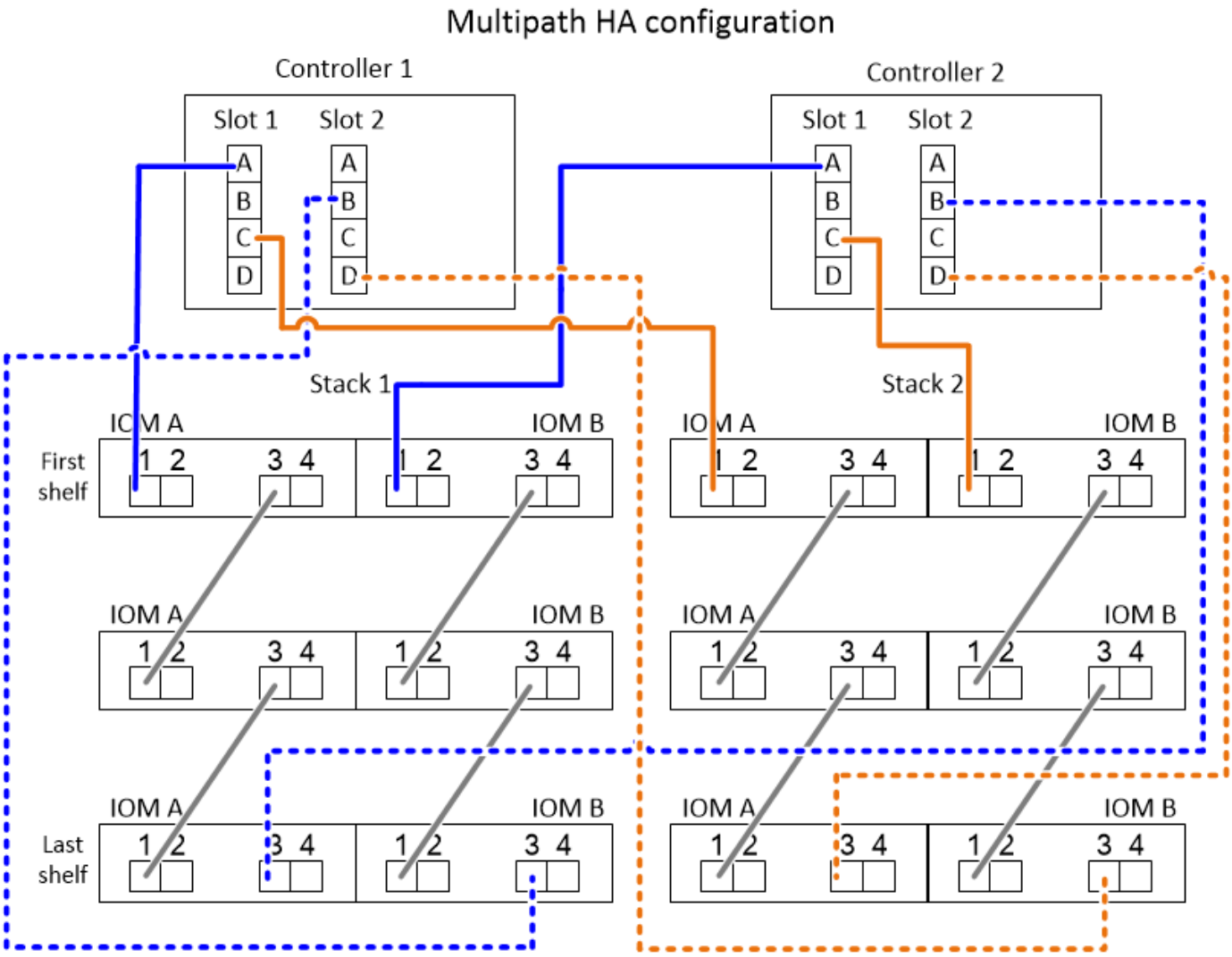
Controller-to-Stack Cabling Worksheet for Multipathed Connectivity											
Controller SAS ports	Controllers	Cable to disk shelf IOMs			Stacks						
					1	2	3	4	5	6
		Shelf	IOM	Port	Port pairs					
A and C	1	First	A	1	1a	2a	1c	2c		
	2	First	B	1						
B and D					~~1b~~	~~2b~~	~~1d~~	~~2d~~		
	1	Last	B	3	2b	1d	2d	1b		
	2	Last	A	3						



The following worksheet and cabling example shows port pairs being skipped to use every other one in the list: 1a/2b and 1c/2d.

If a third stack is added later, you use the port pair that was skipped.

Controller-to-Stack Cabling Worksheet for Multipathed Connectivity											
Controller SAS ports	Controllers	Cable to disk shelf IOMs			Stacks						
					1	3 ~~2~~	2 ~~3~~	4	5	6
		Shelf	IOM	Port	Port pairs					
A and C	1	First	A	1	1a	2a	1c	2c		
	2	First	B	1						
B and D					~~1b~~	~~2b~~	~~1d~~	~~2d~~		
	1	Last	B	3	2b	1d	2d	1b		
	2	Last	A	3						



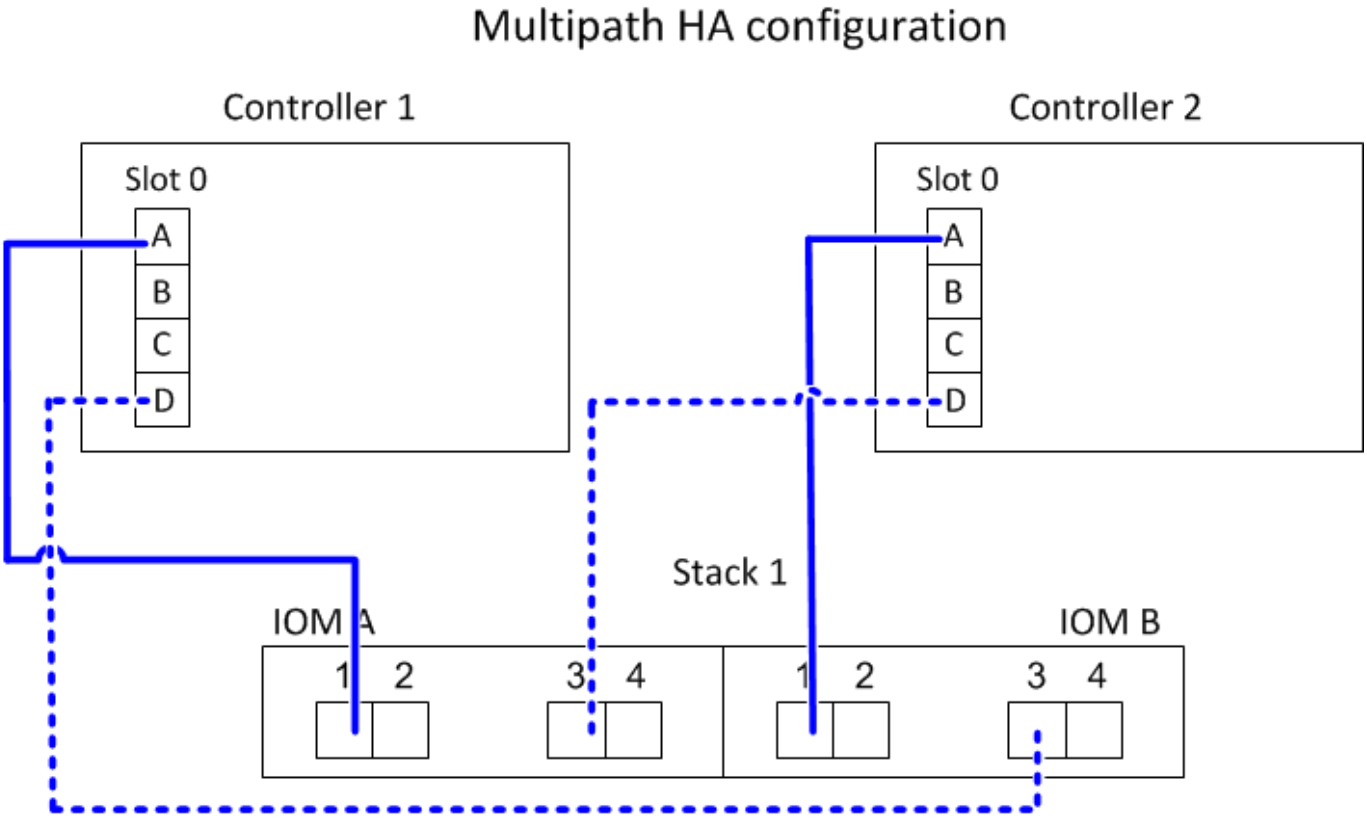
Controller-to-stack cabling worksheets and cabling examples for multipath HA configurations with four onboard SAS ports

You can use the completed controller-to-stack cabling worksheets and cabling examples to cable common multipath HA configurations that have four onboard SAS ports.

Multipath HA with four onboard SAS ports and one single-shelf stack

The following worksheet and cabling example uses port pair 0a/0d:

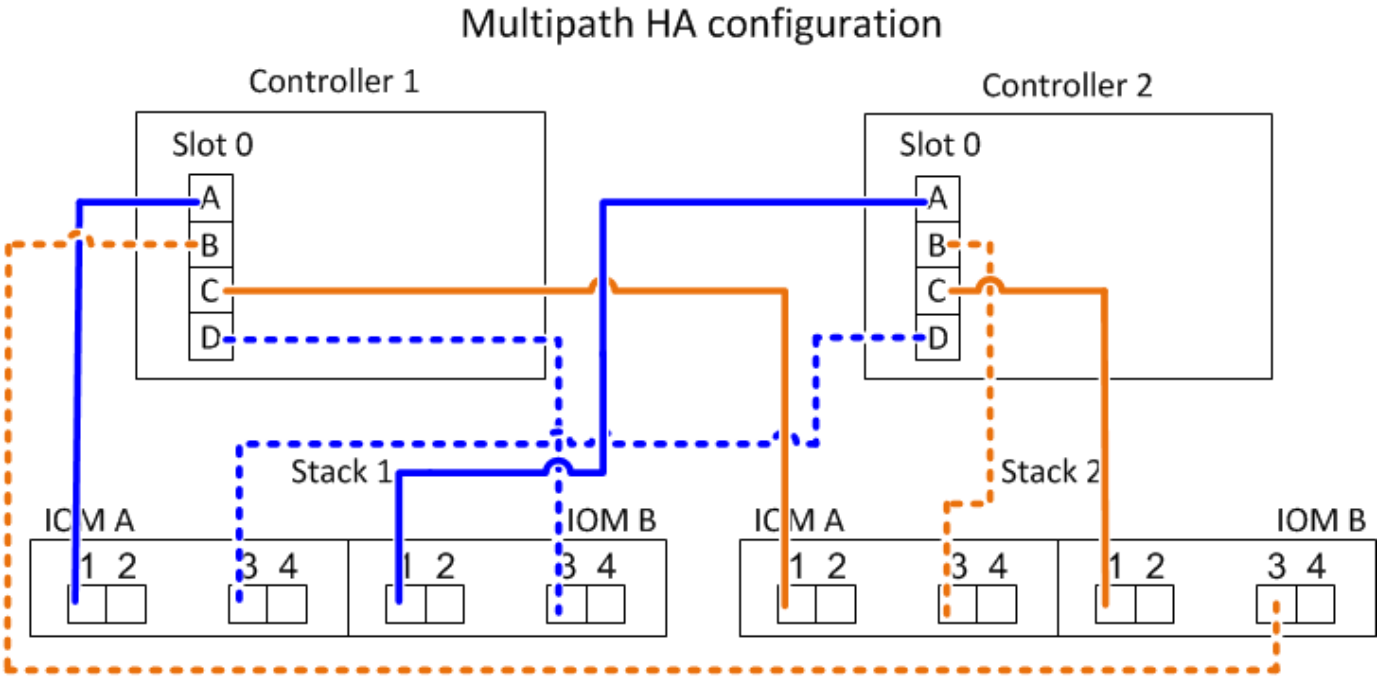
Controller-to-Stack Cabling Worksheet for Multipathed Connectivity											
Controller SAS ports	Controllers	Cable to disk shelf IOMs			Stacks						
					1	2	3	4	5	6
		Shelf	IOM	Port	Port pairs					
A and C	1	First	A	1	0a	0c				
	2	First	B	1						
B and D					~~0b~~	~~0d~~				
	1	Last	B	3	0d	0b				
	2	Last	A	3						



Multipath HA with four onboard SAS ports and two single-shelf stacks

The following worksheet and cabling example uses port pairs 0a/0d and 0c/0b:

Controller-to-Stack Cabling Worksheet for Multipathed Connectivity											
Controller SAS ports	Controllers	Cable to disk shelf IOMs			Stacks						
					1	2	3	4	5	6
		Shelf	IOM	Port	Port pairs					
A and C	1	First	A	1	0a	0c				
	2	First	B	1						
B and D					~~0b~~	~~0d~~				
	1	Last	B	3	0d	0b				
	2	Last	A	3						



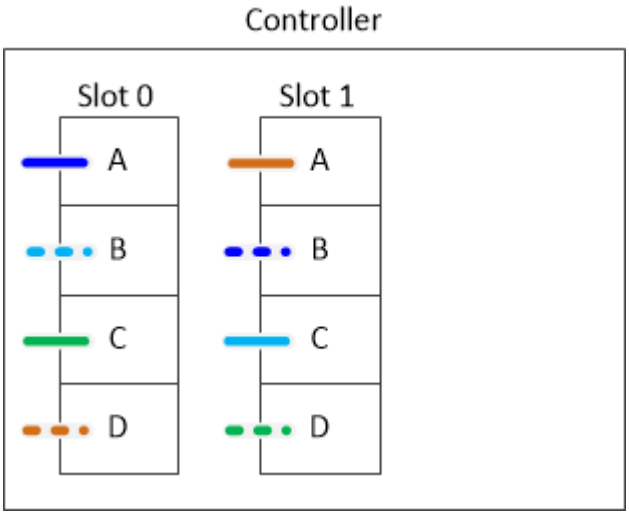
Multipath HA with four onboard SAS ports, a quad-port SAS HBA, and two multi-shelf stacks

Four port pairs are available for this configuration: 0a/1b, 1a/0d, 0c/1d, and 1c/0b. You can cable port pairs in the order in which they are identified (listed in the worksheet) or you can cable every other port pair (skip port pairs).

When you have more port pairs than you need to cable the stacks in your system, the best practice is to skip port pairs to optimize the SAS ports on your system. By optimizing SAS ports, you optimize your system's performance.

The following worksheet and cabling example shows port pairs being used in the order in which they are listed in the worksheet: 0a/1b, 1a/0d, 0c/1d, and 1c/0b.

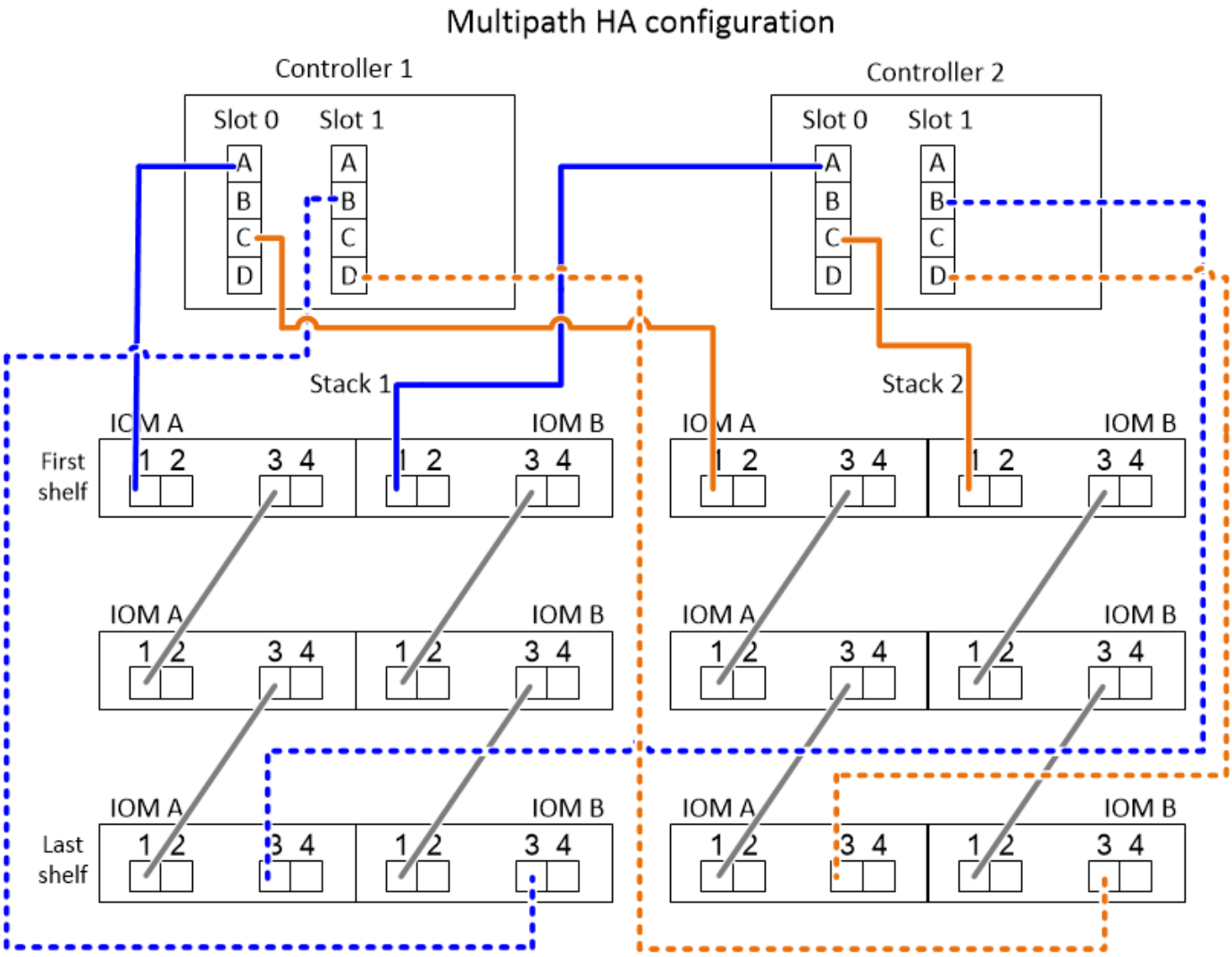
Controller-to-Stack Cabling Worksheet for Multipathed Connectivity											
Controller SAS ports	Controllers	Cable to disk shelf IOMs			Stacks						
					1	2	3	4	5	6
		Shelf	IOM	Port	Port pairs					
A and C	1	First	A	1	0a	1a	0c	1c		
	2	First	B	1						
B and D					~~0b~~	~~1b~~	~~0d~~	~~1d~~		
	1	Last	B	3	1b	0d	1d	0b		
	2	Last	A	3						



The following worksheet and cabling example shows port pairs being skipped to use every other one in the list: 0a/1b and 0c/1d.

If a third stack is added later, you use the port pair that was skipped.

Controller-to-Stack Cabling Worksheet for Multipathed Connectivity											
Controller SAS ports	Controllers	Cable to disk shelf IOMs			Stacks						
					1	3 ~~2~~	2 ~~3~~	4	5	6
		Shelf	IOM	Port	Port pairs					
A and C	1	First	A	1	0a	1a	0c	1c		
	2	First	B	1						
B and D					~~0b~~	~~1b~~	~~0d~~	~~1d~~		
	1	Last	B	3	1b	0d	1d	0b		
	2	Last	A	3						



Cabling worksheets for internal storage - DS212C, DS224C, or DS460C

You can use the completed controller-to-stack cabling worksheets and cabling examples to cable platforms with internal storage. This applies to shelves with IOM12/IOM12B modules.

This information does not apply to FAS25XX platforms.

- If needed, you can refer to SAS cabling rules and concepts for information about supported configurations, shelf-to-shelf connectivity, and controller-to-shelf connectivity.
- Cabling examples show controller-to-stack cables as solid or dashed to distinguish controller 0b/0b1 port connections from controller 0a port connections.

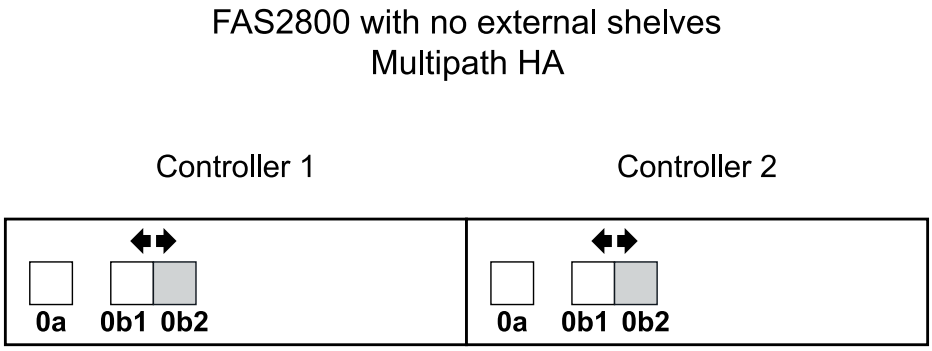
Controller-to-stack cable type key: AFF and FAS platforms with onboard storage (except FAS25XX)	
Cable Type	**Description**
———	• Connects controller **0b** or **0b1** port to the logical **last** disk shelf in the stack • The **primary** path from a controller to the stack The internal storage connection
— — — —	• Connects controller **0a** port to the logical **first** disk shelf in the stack • The **secondary** path from a controller to the stack The internal HBA connection

- Cabling examples show controller-to-stack connections and shelf-to-shelf connections in two different colors to distinguish connectivity through IOM A (domain A) and IOM B (domain B).

Cable color key: AFF and FAS platforms with onboard storage (except FAS25XX)		
Cable Color		**Connects...**
	Light blue	IOM A (domain A)
	Purple	IOM B (domain B)

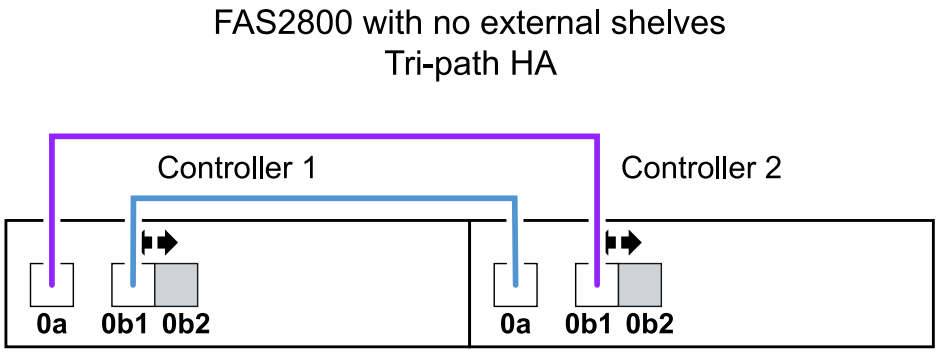
FAS2820 platform in a multipath HA configuration with no external shelves

The following example shows that no cabling is needed to acheive multipath HA connectivity:



FAS2820 platform in a tri-path HA configuration with no external shelves

The following cabling example shows required cabling between the two controllers to achieve tri-path connectivity:

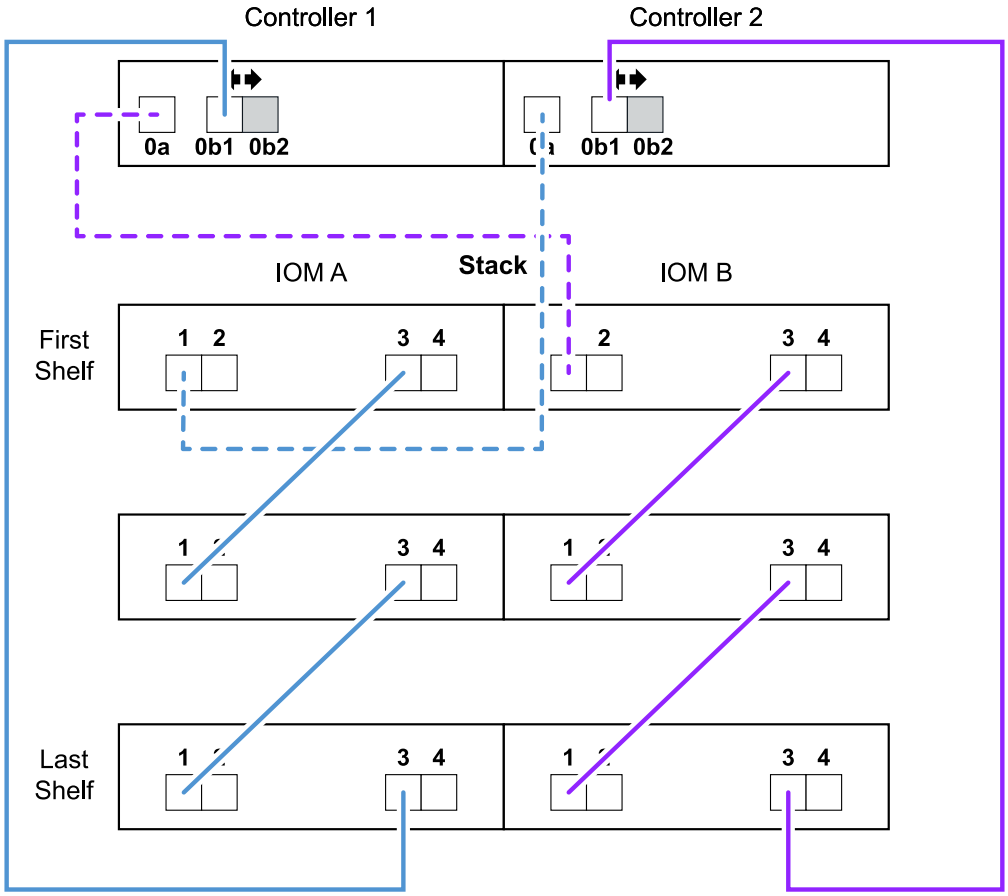


FAS2820 platform in a tri-path HA configuration with one multi-shelf stack

The following worksheet and cabling example uses port pair 0a/0b1:

Controller-to-stack cabling worksheet: FAS2800 platform											
Controller SAS ports	Controllers	Cable to disk shelf IOMs			Stacks						
					1	2	3	4	5	6
		Shelf	IOM	Port	Port pairs					
A and C	1	First	B	1	0a					
	2	First	A	1						
B and D	1	Last	A	3	0b1					
	2	Last	B	3						

FAS2800 platform
Tri-path HA configuration



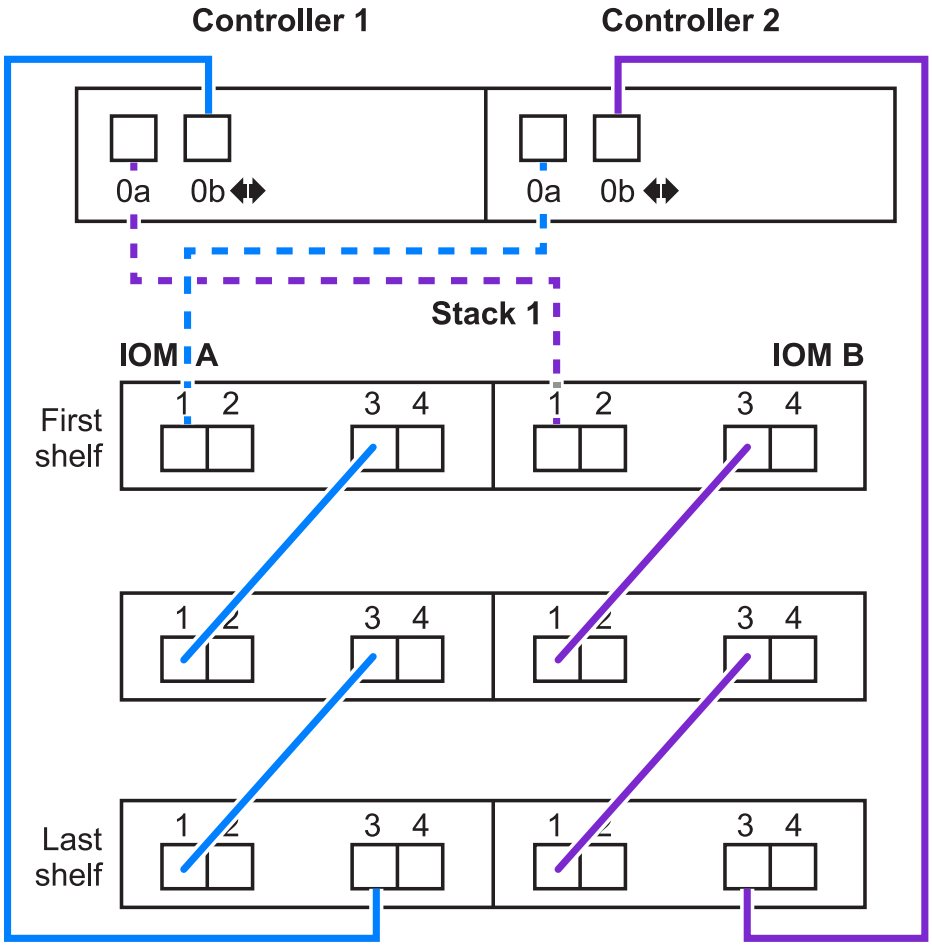
Platforms with internal storage in a multipath HA configuration with one multi-shelf stack

The following worksheet and cabling example uses port pair 0a/0b:

This section does not apply to FAS2820 or FAS25XX systems.

Controller-to-stack cabling worksheet: AFF and FAS platforms with onboard storage											
Controller SAS ports	**Controllers**	**Cable to disk shelf IOMs**			**Stacks**						
					1	2	3	4	5	6
		Shelf	**IOM**	**Port**		**Port pairs**				
A and C	1	First	B	1	0a					
	2	First	A	1						
B and D	1	Last	A	3	0b					
	2	Last	B	3						

AFF and FAS platforms with onboard storage
Mulitpath HA Configuration



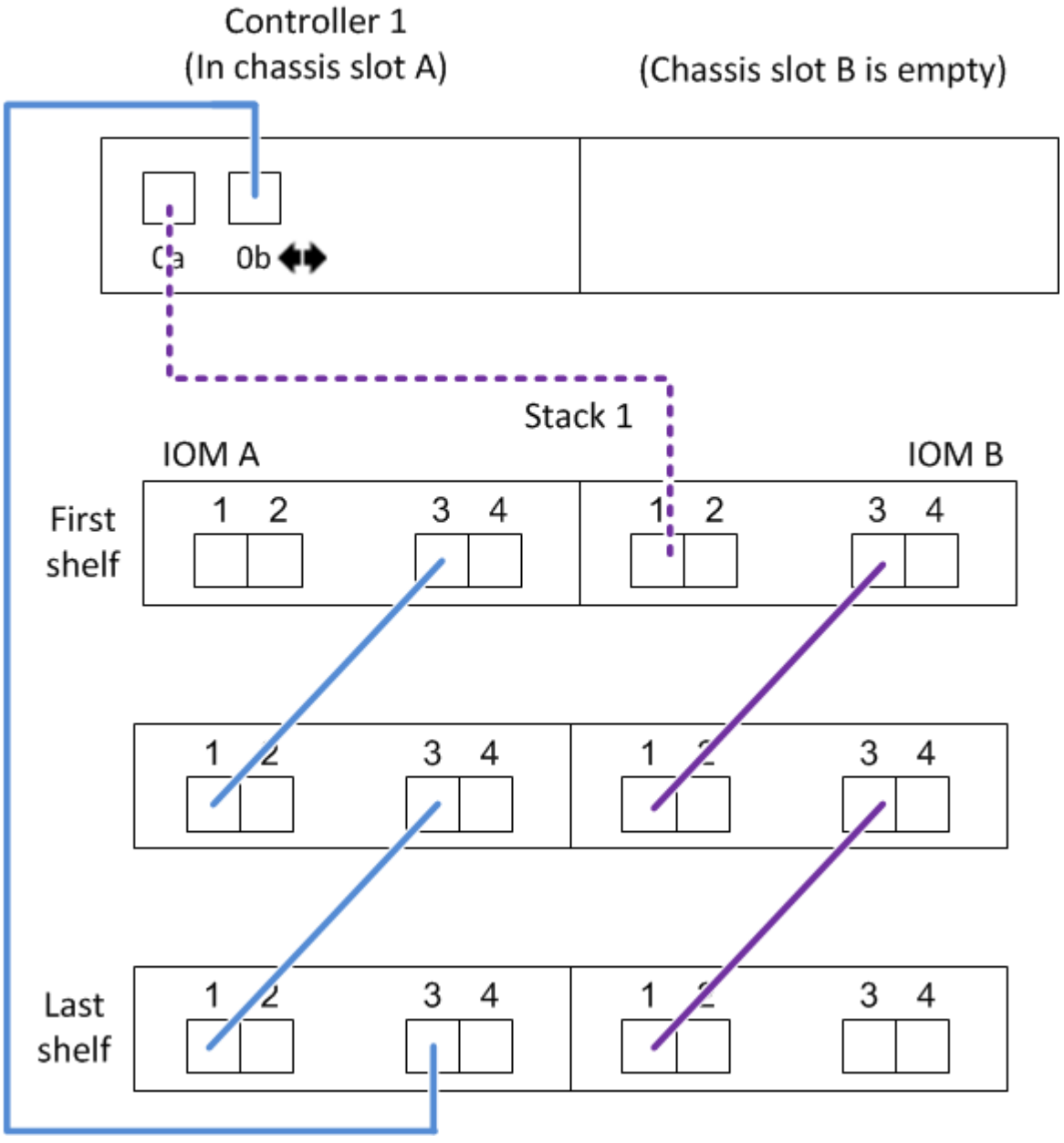
FAS2600 series multipath configuration with one multi-shelf stack

The following worksheets and cabling examples use port pair 0a/0b.

In this example, the controller is installed in slot A of the chassis. When a controller is located in slot A of the chassis, its internal storage port (0b) is in domain A (IOM A); therefore, port 0b must connect to domain A (IOM A) in the stack.

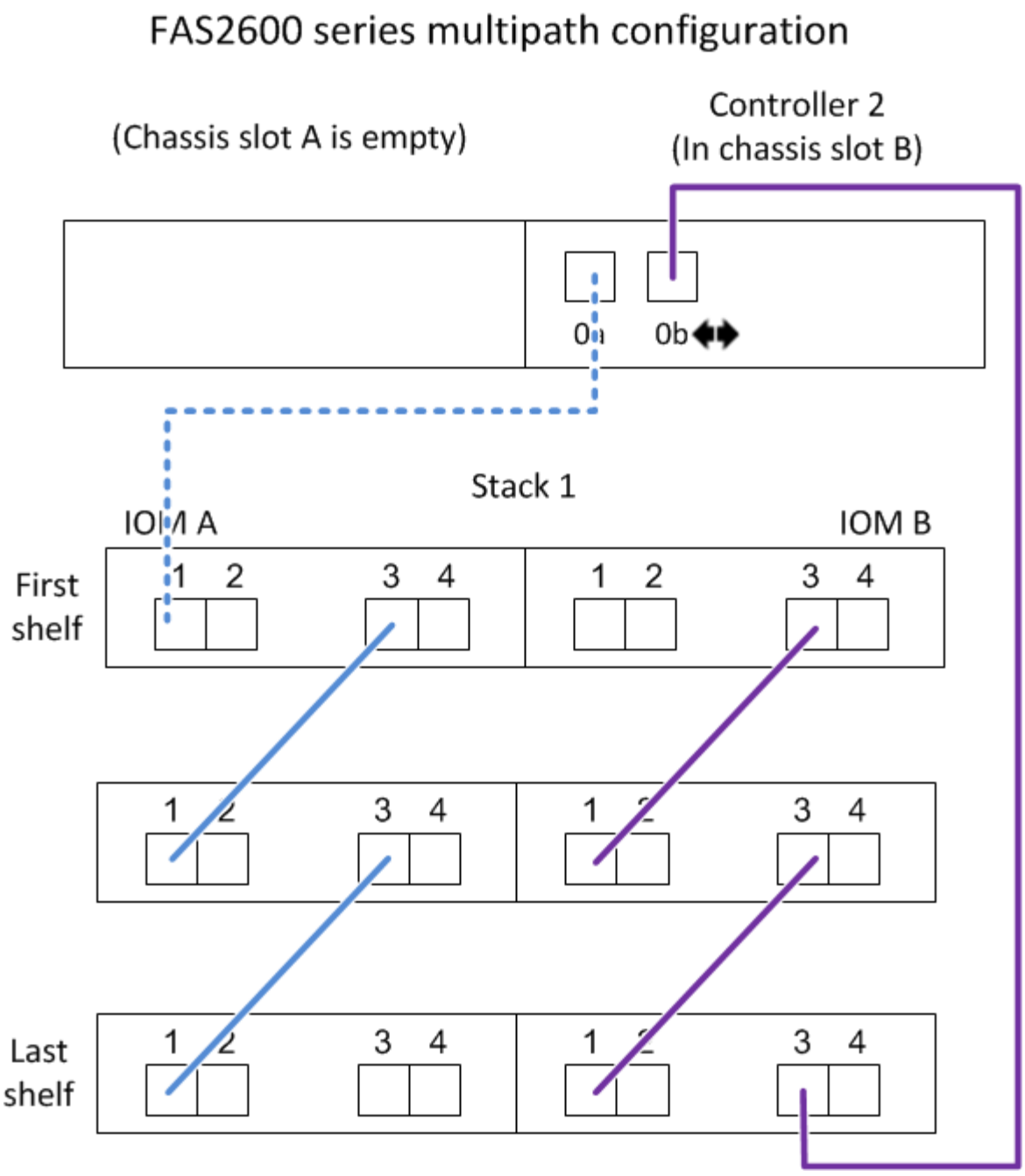
Controller-to-Stack Cabling Worksheet (FAS2600 series)											
Controller SAS ports	Controllers	Cable to disk shelf IOMs			Stacks						
					1	2	3	4	5	6	
		Shelf	IOM	Port		Port pairs					
A and C	1	First	B	1	0a						
	~~2~~	~~First~~	~~A~~	~~1~~							
B and D	1	Last	A	3	0b						
	~~2~~	~~Last~~	~~B~~	~~3~~							

FAS2600 series multipath configuration



In this example, the controller is installed in slot B of the chassis. When a controller is located in slot B of the chassis, its internal storage port (0b) is in domain B (IOM B); therefore, port 0b must connect to domain B (IOM B) in the stack.

Controller-to-Stack Cabling Worksheet (FAS2600 series)											
Controller SAS ports	Controllers	Cable to disk shelf IOMs			Stacks						
					1	2	3	4	5	6
		Shelf	IOM	Port		Port pairs				
A and C	1	First	B	1	0a					
	~~2~~	~~First~~	~~A~~	~~1~~						
B and D	1	Last	A	3	0b					
	~~2~~	~~Last~~	~~B~~	~~3~~						



Cabling worksheet for a quad-path HA configuration with two quad-port SAS HBAs - DS212C, DS224C, or DS460C

You can use the completed controller-to-stack cabling worksheet and cabling example to cable a quad-path HA configuration that has two quad-port SAS HBAs. This applies to shelves with IOM12/IOM12B modules.

- If needed, you can refer to SAS cabling rules for information about supported configurations, the controller slot numbering convention, shelf-to-shelf connectivity, and controller-to-shelf connectivity (including the use of port pairs).
- If needed, you can refer to How to read a worksheet to cable controller-to-stack connections for quad-pathed connectivity.

- The cabling example shows controller-to-stack cables as solid or dashed to distinguish controller A and C port connections from controller B and D port connections.

Controller-to-Stack Cable Type Key	
Cable Type	Description
	▪ Connects controller **A** and **C** ports to the logical **first** disk shelf in a stack ▪ The **primary** path from a controller to a stack
	▪ Connects controller **B** and **D** ports to the logical **last** disk shelf in a stack ▪ The **secondary** path from a controller to a stack

- Cables in the cabling examples and their corresponding port pairs in the worksheets are color-coded to distinguish connectivity to each stack in the HA pair.

Controller-to-Stack Cable Color Key			
Cable Color		Connects to...	From...
	Dark blue	Stack 1	Each controller by a unique port pair
	Orange	Stack 2	

- The cabling example visually distinguishes the two sets of multipathed cabling needed to achieve quad-pathed connectivity for each controller to each stack in an HA pair or single-controller configuration.

  The first set of multipathed cabling is referred to as “multipathed”. The second set of multipathed cabling is referred to as “quad-pathed”. The second set of cabling is referred to as “quad-pathed” because completing this set of cabling gives you the quad-pathed connectivity.

Controller-to-Stack Quad-Pathed Connectivity Key			
Quad-pathed connectivity consists of two sets of cabling		Shown by color-coded ports on controllers and IOMs	Description
Set 1	Multipathed	No color	Ports (on controllers and IOMs) cabled with multipathed connectivity are shown without a color.
Set 2	Quad-pathed	The cable color associated with the applicable stack	Ports (on controllers and IOMs) cabled with quad-pathed connectivity are the same color as the cables connecting the stack, as shown in the “Controller-to-Stack Cable Color Key”.

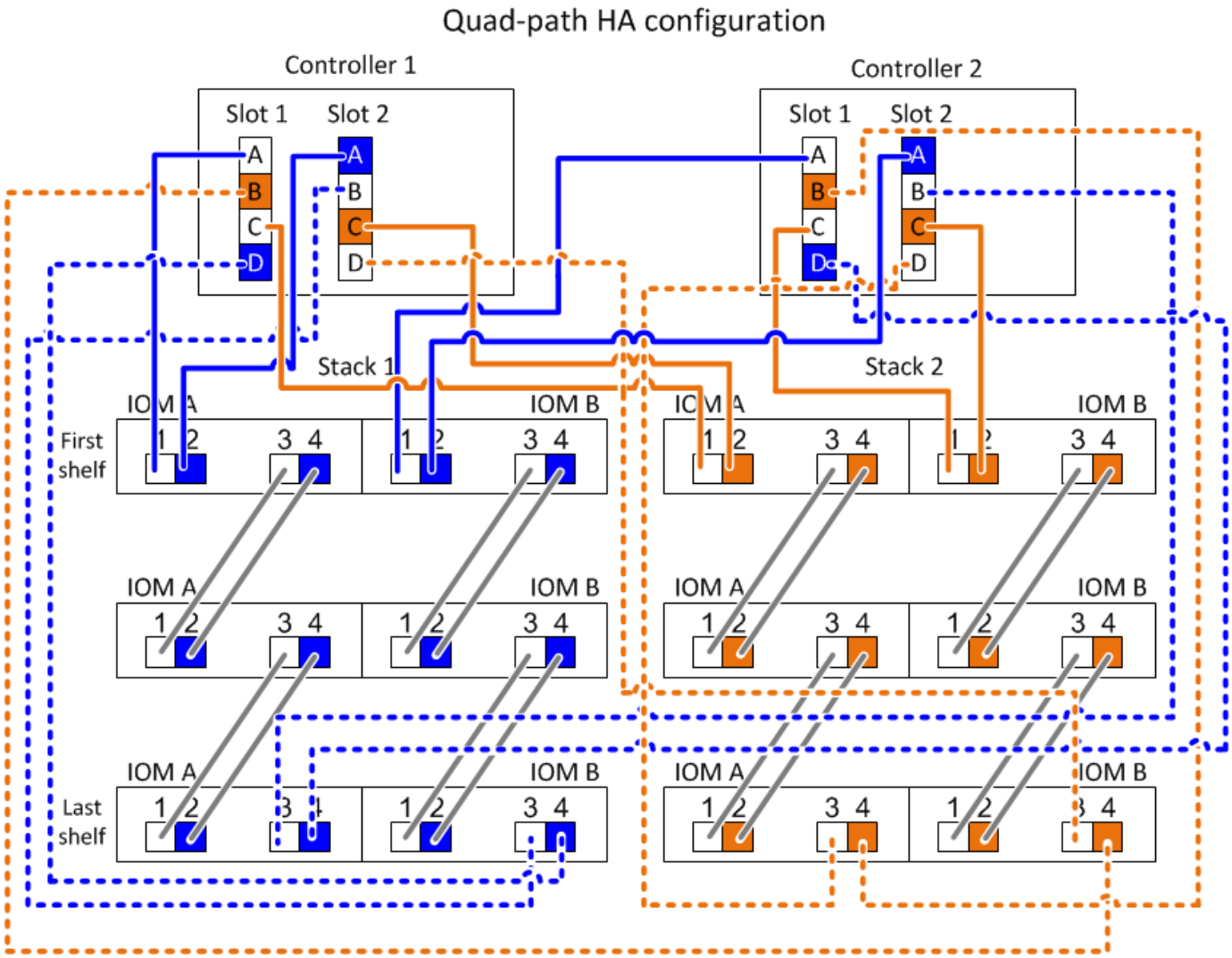
- The worksheet example shows port pairs designated for multipathed cabling or quad-pathed cabling to the applicable stack.

Each port pair designated for multipathed cabling is encircled by an oval that is the color associated with the stack it is cabled to. Each port pair designated for quad-pathed cabling is encircled by a rectangle that is the color associated with the stack it is cabled to.

Quad-path HA with two quad-port SAS HBAs and two multi-shelf stacks

The following worksheet and cabling example uses port pairs 1a/2b (multipathed) and 2a/1d (quad-pathed) for stack 1, and port pairs 1c/2d (multipathed) and 2c/1b (quad-pathed) for stack2.

Controller-to-Stack Cabling Worksheet for Quad-Pathed Connectivity									
Controller SAS ports	Controllers	Cable to disk shelf IOMs				Stacks			
		Shelf	IOM	Port		1		2	
				Multipathed	Quad-pathed	Port pairs			
A and C	1	First	A	1	2	1a	2a	1c	2c
	2	First	B	1	2				
B and D						~~1b~~	~~2b~~	~~1d~~	~~2d~~
	1	Last	B	3	4	2b	1d	2d	1b
	2	Last	A	3	4				



Cabling worksheet for multipathed connectivity - DS212C, DS224C, or DS460C

By completing the worksheet template, you can define the controller SAS port pairs you can use to cable controllers to stacks of disk shelves with IOM12/IOM12B modules to achieve multipathed connectivity in an HA pair or single-controller configuration. You can also use the completed worksheet to walk yourself through cabling the multipathed connections for your configuration.

Before you begin

If you have a platform with internal storage, use the following worksheet:

Controller-to-stack cabling worksheets and cabling examples for platforms with internal storage

About this task

- This procedure and worksheet template is applicable to cabling multipathed connectivity for a multipath HA or multipath configuration with one or more stacks.

  Examples of completed worksheets are provided for multipath HA and multipath configurations.

A configuration with two quad-port SAS HBAs and two stacks of disk shelves with IOM12/IOM12B modules is used for the worksheet examples.

- The worksheet template allows for up to six stacks; you need to add more columns if needed.
- If needed, you can refer to the SAS cabling rules and concepts for information about supported configurations, the controller slot numbering convention, shelf-to-shelf connectivity, and controller-to-shelf connectivity (including use of port pairs).
- If needed, after you complete the worksheet, you can refer to How to read a worksheet to cable controller-to-stack connections for multipathed connectivity

Controller-to-Stack Cabling Worksheet Multipathed Connectivity											
Controller SAS ports	Controllers	Cable to disk shelf IOMs			Stacks						
					1	2	3	4	5	6
		Shelf	IOM	Port	Port pairs					
A and C	1	First	A	1						
	2	First	B	1						
B and D										
	1	Last	B	3						
	2	Last	A	3						

Steps

1. In the boxes above the gray boxes, list all SAS A ports on your system, and then all SAS C ports on your system in sequence of slots (0, 1, 2, 3, and so on).

   For example: 1a, 2a, 1c, 2c

2. In the gray boxes, list all SAS B ports on your system, and then all SAS D ports on your system in sequence of slots (0, 1, 2, 3 and so on).

   For example: 1b, 2b, 1d, 2d

3. In the boxes below the gray boxes, rewrite the D and B port list so that the first port in the list is moved to the end of the list.

   For example: 2b, 1d, 2d, 1b

4. Circle (designate) a port pair for each stack.

   When all port pairs are being used to cable the stacks in your system, circle port pairs in the order in which they are defined (listed) in the worksheet.

   For example, in a multipath HA configuration with eight SAS ports and four stacks, port pair 1a/2b is cabled to stack 1, port pair 2a/1d is cabled to stack 2, port pair 1c/2d is cabled to stack3, and port pair 2c/1b is cabled to stack 4.

Controller-to-Stack Cabling Worksheet for Multipathed Connectivity											
Controller SAS ports	Controllers	Cable to disk shelf IOMs			Stacks						
					1	2	3	4	5	6
		Shelf	IOM	Port	Port pairs					
A and C	1	First	A	1	1a	2a	1c	2c		
	2	First	B	1						
B and D					~~1b~~	~~2b~~	~~1d~~	~~2d~~		
	1	Last	B	3	2b	1d	2d	1b		
	2	Last	A	3						

When not all port pairs are needed to cable the stacks in your system, skip port pairs (use every other port pair).

For example, in a multipath HA configuration with eight SAS ports and two stacks, port pair 1a/2b is cabled to stack 1 and port pair 1c/2d is cabled to stack 2. If two additional stacks are hot-added later, port pair 2a/1d is cabled to stack 3 and port pair 2c/1b is cabled to stack 4.

When you have more port pairs than you need to cable the stacks in your system, the best practice is to skip port pairs to optimize the SAS ports on your system. By optimizing SAS ports, you optimize your system's performance.

Controller-to-Stack Cabling Worksheet Multipathed Connectivity											
Controller SAS ports	Controllers	Cable to disk shelf IOMs			Stacks						
					1	3 ~~2~~	2 ~~3~~	4	5	6
		Shelf	IOM	Port	Port pairs					
A and C	1	First	A	1	1a	2a	1c	2c		
	2	First	B	1						
B and D					~~1b~~	~~2b~~	~~1d~~	~~2d~~		
	1	Last	B	3	2b	1d	2d	1b		
	2	Last	A	3						

You can use your completed worksheet to cable your system.

5. If you have a single-controller (multipath) configuration, cross out the information for controller 2.

Controller-to-Stack Cabling Worksheet Multipathed Connectivity											
Controller SAS ports	Controllers	Cable to disk shelf IOMs			Stacks						
					1	2	3	4	5	6	
		Shelf	IOM	Port	Port pairs						
A and C	1	First	A	1	1a	2a	1c	2c			
	~~2~~	~~First~~	~~B~~	~~1~~							
B and D					~~1b~~	~~2b~~	~~1d~~	~~2d~~			
	1	Last	B	3	2b	1d	2d	1b			
	~~2~~	~~Last~~	~~A~~	~~3~~							

You can use your completed worksheet to cable your system.

Cabling worksheet for quad-pathed connectivity - DS212C, DS224C, or DS460C

By completing the worksheet template, you can define the controller SAS port pairs you can use to cable controllers to stacks of disk shelves with IOM12/IOM12B modules to achieve quad-pathed connectivity in an HA pair or single-controller configuration. You can also use the completed worksheet to walk yourself through cabling the quad-pathed connections for your configuration.

About this task

- This procedure and worksheet template is applicable to cabling quad-pathed connectivity for a quad-path HA or quad-path configuration with one or more stacks.

  Examples of completed worksheets are provided for quad-path HA and quad-path configurations.

  A configuration with two quad-port SAS HBAs and two stacks of disk shelves with IOM12/IOM12B modules is used for the worksheet examples.

- The worksheet template allows for up to two stacks; you need to add more columns if needed.
- Quad-pathed connectivity for controller-to-stack connections consists of two sets of multipathed cabling: the first set of cabling is referred to as “multipathed”; the second set of cabling is referred to as “quad-pathed”.

  The second set of cabling is referred to as “quad-pathed” because completing this set of cabling gives you the quad-pathed connectivity from a controller to a stack in an HA pair or single-controller configuration.

- Disk shelf IOM ports 1 and 3 are always used for multipathed cabling and IOM ports 2 and 4 are always used for quad-pathed cabling, as designated by the worksheet column headings.
- In the worksheet examples, port pairs are designated for multipathed cabling or quad-pathed cabling to the applicable stack.

  Each port pair designated for multipathed cabling is encircled by an oval that is the color associated with

the stack it is cabled to. Each port pair designated for quad-pathed cabling is encircled by a rectangle that is the color associated with the stack it is cabled to. Stack 1 is associated with the color blue; stack 2 is associated with the color orange.

- If needed, you can refer to SAS cabling rules and concepts for information about the controller slot numbering convention, shelf-to-shelf connectivity, and controller-to-shelf connectivity (including the use of port pairs).
- If needed, after you complete the worksheet, you can refer to How to read a worksheet to cable controller-to-stack connections for quad-pathed connectivity.

Controller-to-Stack Cabling Worksheet for Quad-Pathed Connectivity									
Controller SAS ports	Controllers	Cable to disk shelf IOMs				Stacks			
		Shelf	IOM	Port		1		2	
				Multipathed	Quad-pathed	Port pairs			
A and C	1	First	A	1	2				
	2	First	B	1	2				
B and D									
	1	Last	B	3	4				
	2	Last	A	3	4				

Steps

1. In the boxes above the gray boxes, list all SAS A ports on your system, and then all SAS C ports on your system in sequence of slots (0, 1, 2, 3, and so on).

   For example: 1a, 2a, 1c, 2c

2. In the gray boxes, list all SAS B ports on your system, and then all SAS D ports on your system in sequence of slots (0, 1, 2, 3 and so on).

   For example: 1b, 2b, 1d, 2d

3. In the boxes below the gray boxes, rewrite the D and B port list so that the first port in the list is moved to the end of the list.

   For example: 2b, 1d, 2d, 1b

4. Identify the two sets of port pairs to connect to stack 1 by drawing an oval around the first set of port pairs and a rectangle around the second set of port pairs.

   Both sets of cabling are needed to achieve quad-pathed connectivity from each controller to stack 1 in your HA pair or single-controller configuration.

   The following example uses port pair 1a/2b for the multipathed cabling and port pair 2a/1d for the quad-pathed cabling to stack 1.

Controller-to-Stack Cabling Worksheet for Quad-Pathed Connectivity									
Controller SAS ports	Controllers	Cable to disk shelf IOMs				Stacks			
		Shelf	IOM	Port		1		2	
				Multipathed	Quad-pathed	Port pairs			
A and C	1	First	A	1	2	1a	2a	1c	2c
	2	First	B	1	2				
B and D						~~1b~~	~~2b~~	~~1d~~	~~2d~~
	1	Last	B	3	4	2b	1d	2d	1b
	2	Last	A	3	4				

5. Identify the two sets of port pairs to connect to stack 2 by drawing an oval around the first set of port pairs and a rectangle around the second set of port pairs.

   Both sets of cabling are needed to achieve quad-pathed connectivity from each controller to stack 1 in your HA pair or single-controller configuration.

   The following example uses port pair 1c/2d for the multipathed cabling and port pair 2c/1b for the quad-pathed cabling to stack 2.

Controller-to-Stack Cabling Worksheet for Quad-Pathed Connectivity									
Controller SAS ports	Controllers	Cable to disk shelf IOMs				Stacks			
		Shelf	IOM	Port		1		2	
				Multipathed	Quad-pathed	Port pairs			
A and C	1	First	A	1	2	1a	2a	1c	2c
	2	First	B	1	2				
B and D						~~1b~~	~~2b~~	~~1d~~	~~2d~~
	1	Last	B	3	4	2b	1d	2d	1b
	2	Last	A	3	4				

6. If you have a quad-path (single-controller) configuration, cross out the information for controller 2; you only need controller 1 information to cable the controller-to-stack connections.

   The following example shows that the information for controller 2 is crossed out.

Controller-to-Stack Cabling Worksheet for Quad-Pathed Connectivity									
Controller SAS ports	Controllers	Cable to disk shelf IOMs				Stacks			
		Shelf	IOM	Port		1		2	
				Multipathed	Quad-pathed	Port pairs			
A and C	1	First	A	1	2	1a	2a	1c	2c
	~~2~~	~~First~~	~~B~~	~~1~~	~~2~~				
B and D						~~1b~~	~~2b~~	~~1d~~	~~2d~~
	1	Last	B	3	4	2b	1d	2d	1b
	~~2~~	~~Last~~	~~A~~	~~3~~	~~4~~				

How to read a worksheet to cable controller-to-stack connections for multipathed connectivity - DS212C, DS224C, or DS460C

You can use this example to guide you through how to read and apply a completed worksheet to cable controller-to-stack connections for disk shelves with IOM12/IOM12B modules for multipathed connectivity.

Before you begin

If you have a platform with internal storage, use the following worksheet:

Controller-to-stack cabling worksheets and cabling examples for platforms with internal storage

About this task

- This procedure references the following worksheet and cabling example to demonstrate how to read a worksheet to cable controller-to-stack connections.

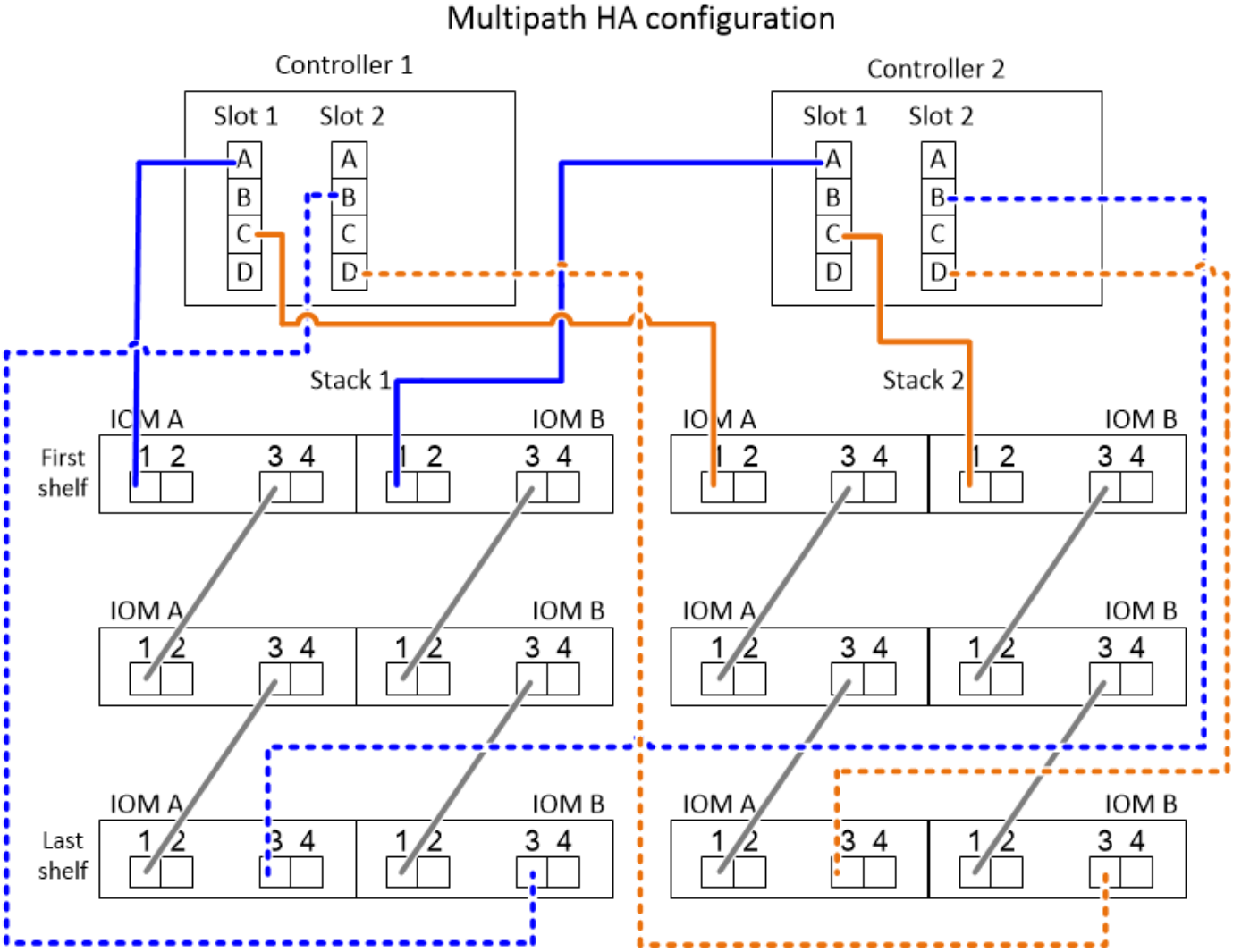
  The configuration used in this example is a multipath HA configuration with two quad-port SAS HBAs (eight SAS ports) on each controller and two stacks of disk shelves with IOM12/IOM12B modules. Port pairs are cabled by skipping every other port pair in the worksheet.

  When you have more port pairs than you need to cable the stacks in your system, the best practice is to skip port pairs to optimize the SAS ports on your system. By optimizing SAS ports, you optimize your system's performance.

- If you have a single-controller configuration, skip substeps b and d for cabling to a second controller.
- If needed, you can refer to SAS cabling rules and concepts for information about the controller slot numbering convention, shelf-to-shelf connectivity, and controller-to-shelf connectivity (including the use of port pairs).

The port pairs are cabled using every other port pair in the worksheet: 1a/2b and 1c/2d.

Controller-to-Stack Cabling Worksheet Multipathed Connectivity											
Controller SAS ports	Controllers	Cable to disk shelf IOMs			Stacks						
					1	3 ~~2~~	2 ~~3~~	4	5	6
		Shelf	IOM	Port	Port pairs					
A and C	1	First	A	1	1a	2a	1c	2c		
	2	First	B	1						
B and D					~~1b~~	~~2b~~	~~1d~~	~~2d~~		
	1	Last	B	3	2b	1d	2d	1b		
	2	Last	A	3						



Steps

1. Cable port pair 1a/2b on each controller to stack 1:
   a. Cable controller 1 port 1a to stack 1, first shelf IOM A port 1.
   b. Cable controller 2 port 1a to stack 1, first shelf IOM B port 1.

c. Cable controller 1 port 2b to stack 1, last shelf IOM B port 3.

d. Cable controller 2 port 2b to stack 1, last shelf IOM A port 3.

2. Cable port pair 1c/2d on each controller to stack 2:

a. Cable controller 1 port 1c to stack 2, first shelf IOM A port 1.

b. Cable controller 2 port 1c to stack 2, first shelf IOM B port 1.

c. Cable controller 1 port 2d to stack 2, last shelf IOM B port 3.

d. Cable controller 2 port 2d to stack 2, last shelf IOM A port 3.

How to read a worksheet to cable controller-to-stack connections for quad-pathed connectivity - DS212C, DS224C, or DS460C

You can use this example to guide you through how to read and apply a completed worksheet to cable stacks of disk shelves with IOM12/IOM12B modules for quad-pathed connectivity.

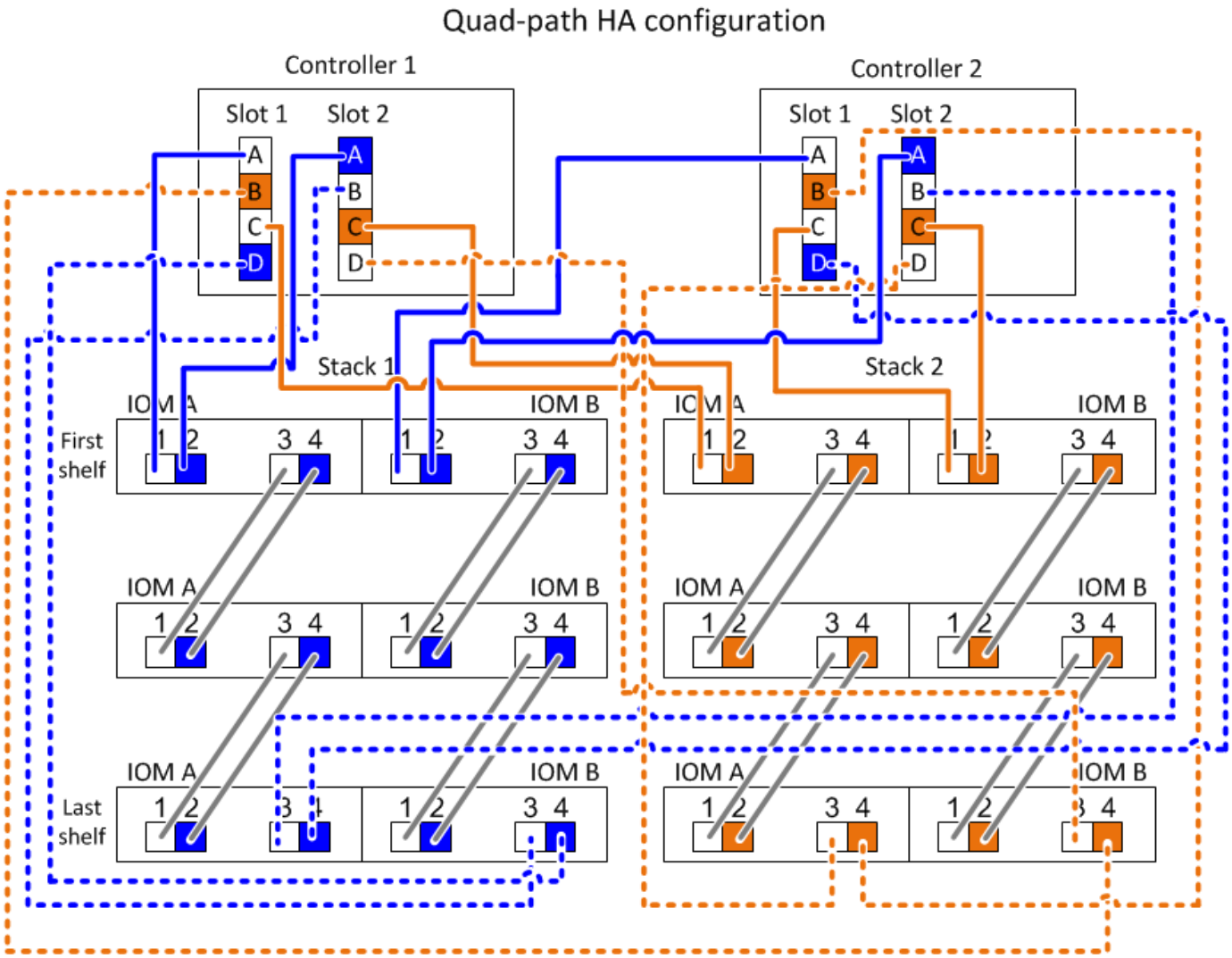
About this task

- This procedure references the following worksheet and cabling example to demonstrate how to read a worksheet to cable controller-to-stack connections.

  The configuration used in this example is a quad-path HA configuration with two quad-port SAS HBAs on each controller and two stacks of disk shelves with IOM12 modules.

- If you have a single-controller configuration, skip substeps b and d for cabling to a second controller.
- If needed, you can refer to SAS cabling rules and concepts for information about the controller slot numbering convention, shelf-to-shelf connectivity, and controller-to-shelf connectivity (including the use of port pairs).

Controller-to-Stack Cabling Worksheet for Quad-Pathed Connectivity									
Controller SAS ports	Controllers	Cable to disk shelf IOMs				Stacks			
		Shelf	IOM	Port		1		2	
				Multipathed	Quad-pathed	Port pairs			
A and C	1	First	A	1	2	1a	2a	1c	2c
	2	First	B	1	2				
B and D						~~1b~~	~~2b~~	~~1d~~	~~2d~~
	1	Last	B	3	4	2b	1d	2d	1b
	2	Last	A	3	4				



Steps

1. Cable port pair 1a/2b on each controller to stack 1:

   This is the multipathed cabling for stack 1.

   a. Cable controller 1 port 1a to stack 1, first shelf IOM A port 1.
   b. Cable controller 2 port 1a to stack 1, first shelf IOM B port 1.
   c. Cable controller 1 port 2b to stack 1, last shelf IOM B port 3.
   d. Cable controller 2 port 2b to stack 1, last shelf IOM A port 3.

2. Cable port pair 2a/1d on each controller to stack 1:

   This is the quad-pathed cabling for stack 1. Once completed, stack 1 has quad-pathed connectivity to each controller.

   a. Cable controller 1 port 2a to stack 1, first shelf IOM A port 2.
   b. Cable controller 2 port 2a to stack 1, first shelf IOM B port 2.
   c. Cable controller 1 port 1d to stack 1, last shelf IOM B port 4.
   d. Cable controller 2 port 1d to stack 1, last shelf IOM A port 4.

3. Cable port pair 1c/2d on each controller to stack 2:

   This is the multipathed cabling for stack 2.

   a. Cable controller 1 port 1c to stack 2, first shelf IOM A port 1.
   b. Cable controller 2 port 1c to stack 2, first shelf IOM B port 1.
   c. Cable controller 1 port 2d to stack 2, last shelf IOM B port 3.
   d. Cable controller 2 port 2d to stack 2, last shelf IOM A port 3.

4. Cable port pair 2c/1b on each controller to stack 2:

   This is the quad-pathed cabling for stack 2. Once completed, stack 2 has quad-pathed connectivity to each controller.

   a. Cable controller 1 port 2c to stack 2, first shelf IOM A port 2.
   b. Cable controller 2 port 2c to stack 2, first shelf IOM B port 2.
   c. Cable controller 1 port 1b to stack 2, last shelf IOM B port 4.
   d. Cable controller 2 port 1b to stack 2, last shelf IOM A port 4.

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