

EXERCISES ON DIRECTORY-BASED PROTOCOL

Question 1 (format Multiple Choice – Single answer) from 19/07/2019

Let's consider a directory-based protocol for a distributed shared memory system with 4 Nodes (N0, N1, N2, N3) where we consider the block B0 in the directory of N0:

Directory N0 Block B0 | State: Shared | Sharer Bits: 1001 |

During a **Write Miss** on B0 from N1, please indicate which are the home node, the local node and the remote node(s):

(SINGLE ANSWER)

1 point

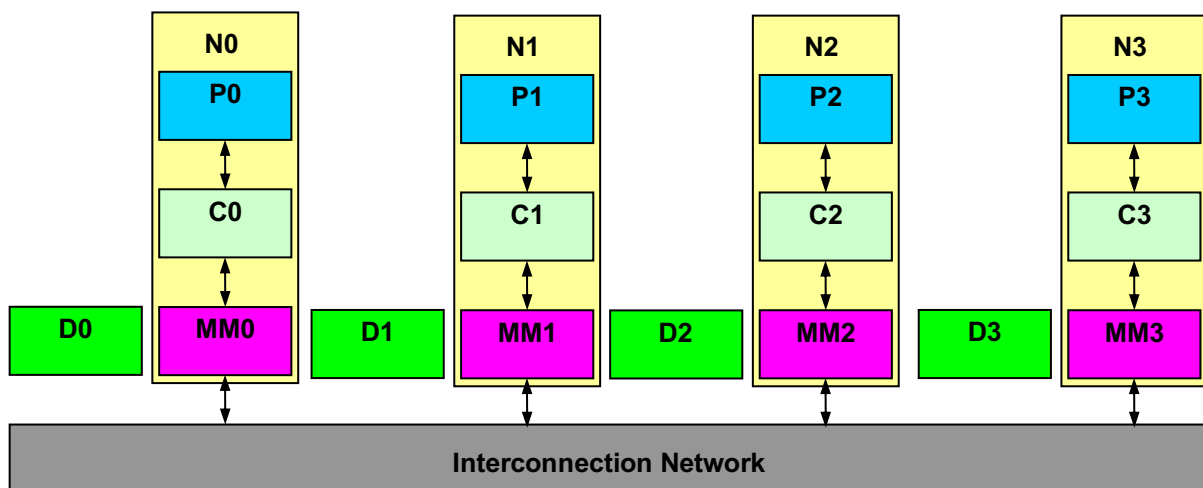
Answer 1: N0 home node, N1 local node; N3 remote node.

Answer 2: N0 home node; N0 local node; N1 remote node.

Answer 3: N0 home node; N1 local node; N0 and N3 remote nodes.

Answer 4: N1 home node; N0 local node; N3 remote node.

Answer 5: N1 home node; N1 local node; N3 remote node.



Solution:

Answer 1: N0 home node, N1 local node; N3 remote node.

Answer 2: N0 home node; N0 local node; N1 remote node.

Answer 3: N0 home node; N1 local node; N0 and N3 remote nodes. **(TRUE)**

Answer 4: N1 home node; N0 local node; N3 remote node.

Answer 5: N1 home node; N1 local node; N3 remote node.

Question 2 (format Multiple Choice – Single answer) from 21/06/2021

Let's consider a directory-based protocol for a distributed shared memory system with 4 Nodes (N0, N1, N2, N3) where we consider the block B1 in the directory of N1:

Directory N1 Block B1 | State: Modified | Sharer Bits: 0100|

During a **Write Miss** on B1 from N0, please indicate which are the home node, the local node and the remote node:

(SINGLE ANSWER)

1 point

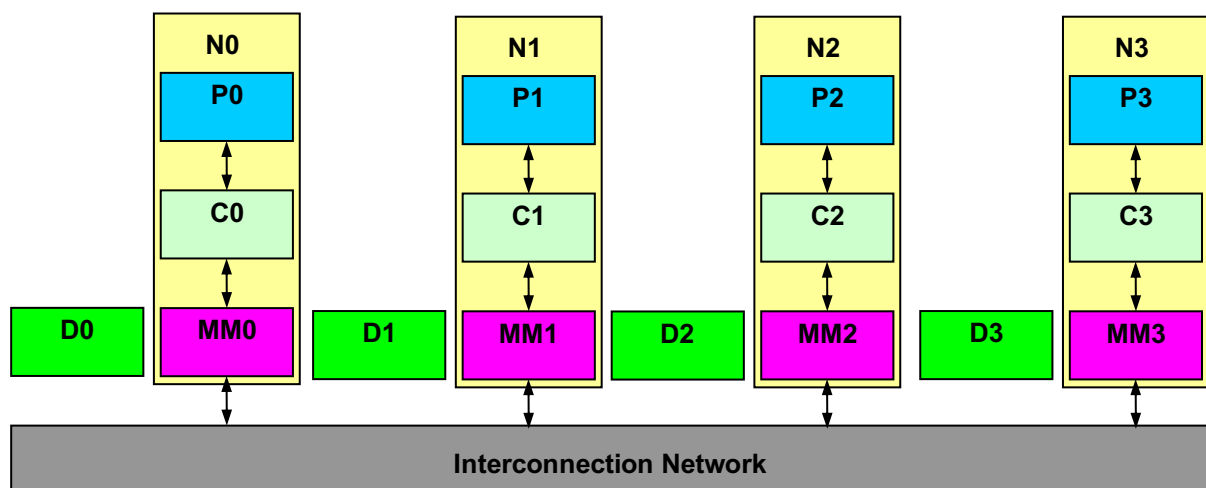
Answer 1: N0 home node, N1 local node; N1 remote node.

Answer 2: N0 home node; N0 local node; N1 remote node.

Answer 3: N1 home node; N0 local node; N1 remote node.

Answer 4: N1 home node; N0 local node; N2 and N3 remote nodes.

Answer 5: N1 home node; N1 local node; N0 remote node.



Solution:

Answer 1: N0 home node, N1 local node; N1 remote node.

Answer 2: N0 home node; N0 local node; N1 remote node.

Answer 3: N1 home node; N0 local node; N1 remote node. **(TRUE)**

Answer 4: N1 home node; N0 local node; N2 and N3 remote nodes.

Answer 5: N1 home node; N1 local node; N0 remote node.

Question 3 (format Multiple Choice – Single answer) from 21/06/2021

Let's consider a directory-based protocol for a distributed shared memory system with 4 Nodes (N0, N1, N2, N3) where we consider the block B0 in the directory of N0:

Directory N0 Block B0 | State: Shared | Sharer Bits: 0101 |

During a **Write Miss** on B0 from N0, please indicate which are the home node, the local node and the remote node/nodes:

(SINGLE ANSWER)

1 point

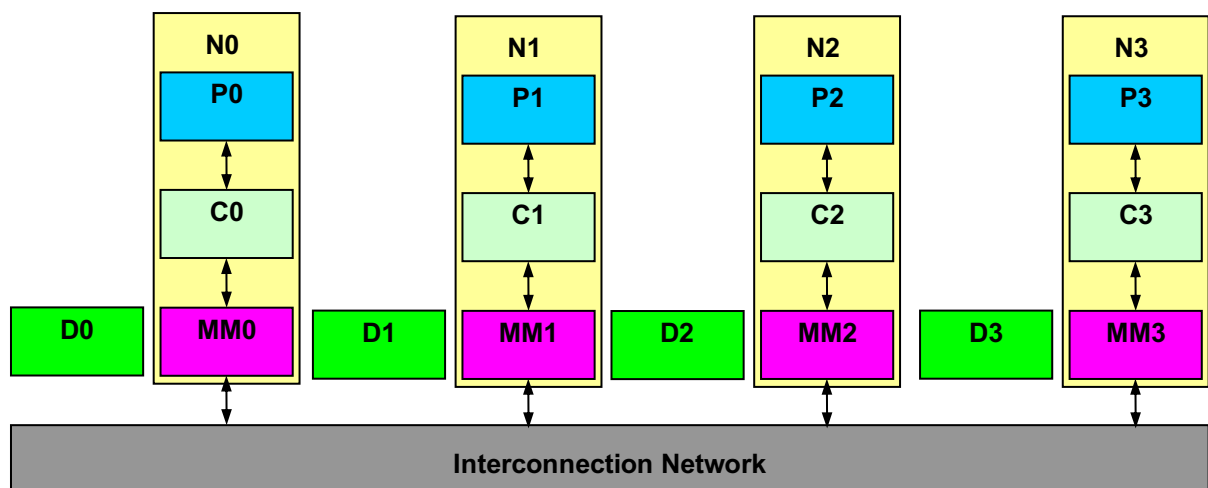
Answer 1: N0 home node, N1 local node; N3 remote node.

Answer 2: N0 home node; N0 local node; N1 remote node.

Answer 3: N0 home node; N0 local node; N1 and N3 remote nodes.

Answer 4: N1 home node; N0 local node; N3 remote node.

Answer 5: N1 home node; N1 local node; N3 remote node.



Solution:

Answer 1: N0 home node, N1 local node; N3 remote node.

Answer 2: N0 home node; N0 local node; N1 remote node.

Answer 3: N0 home node; N0 local node; N1 and N3 remote nodes. **(TRUE)**

Answer 4: N1 home node; N0 local node; N3 remote node.

Answer 5: N1 home node; N1 local node; N3 remote node.

Question 4 (format Multiple Choice – Single answer) from 19/07/2019

Let's consider a directory-based protocol for a distributed shared memory system with 4 Nodes (N0, N1, N2, N3) where we consider the block B1 in the directory of N1:

Directory N1 Block B1 | State: Shared | Sharer Bits: 1001

*Which are the state and the sharer(s) of the block **B1** in **N1** after this sequence:*

Read Miss B1 from local cache N1;

Read Miss B1 from local cache N2;

Write Hit B1 from local cache N1;

Write Miss B1 from local cache N2;

(SINGLE ANSWER)

1 point

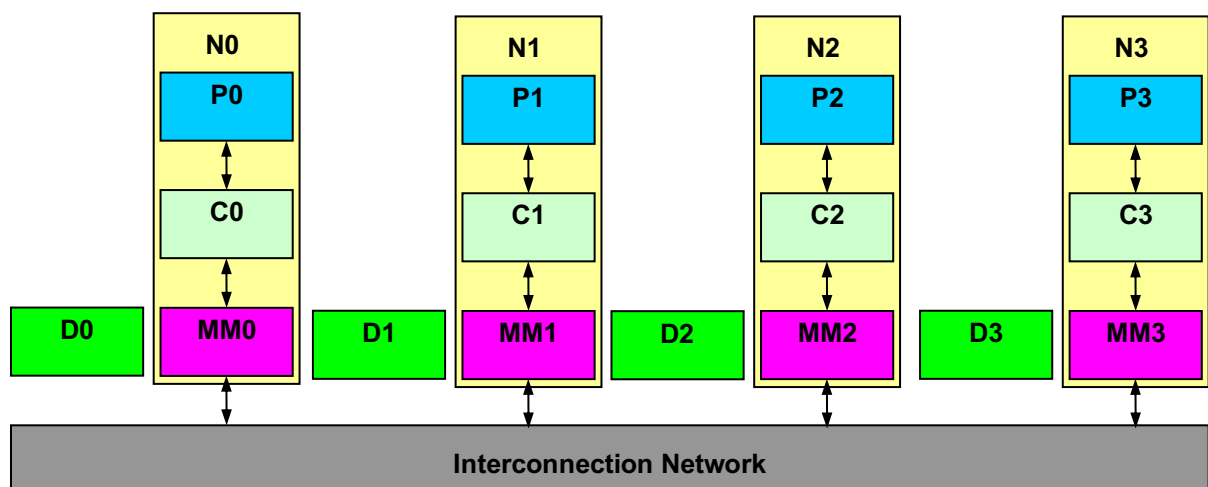
Answer 1: Directory N1 Block B1 | State: Modified | Sharer Bits: 0100

Answer 2: Directory N1 Block B1 | State: Modified | Sharer Bits: 0010

Answer 3: Directory N1 Block B1 | State: Shared | Sharer Bits: 1111

Answer 4: Directory N1 Block B1 | State: Modified | Sharer Bits: 0110

Answer 5: Directory N1 Block B1 | State: Shared | Sharer Bits: 1101



Solution:

Answer 1: Directory N1 Block B1 | State: Modified | Sharer Bits: 0100

Answer 2: Directory N1 Block B1 | State: Modified | Sharer Bits: 0010 **(TRUE)**

Answer 3: Directory N1 Block B1 | State: Shared | Sharer Bits: 1111

Answer 4: Directory N1 Block B1 | State: Modified | Sharer Bits: 0110

Answer 5: Directory N1 Block B1 | State: Shared | Sharer Bits: 1101

Question 5 (Open Text Answer) FROM 21/06/2021

Let's consider a directory-based protocol for a distributed shared memory system with 4 Nodes (N0, N1, N2, N3) where:

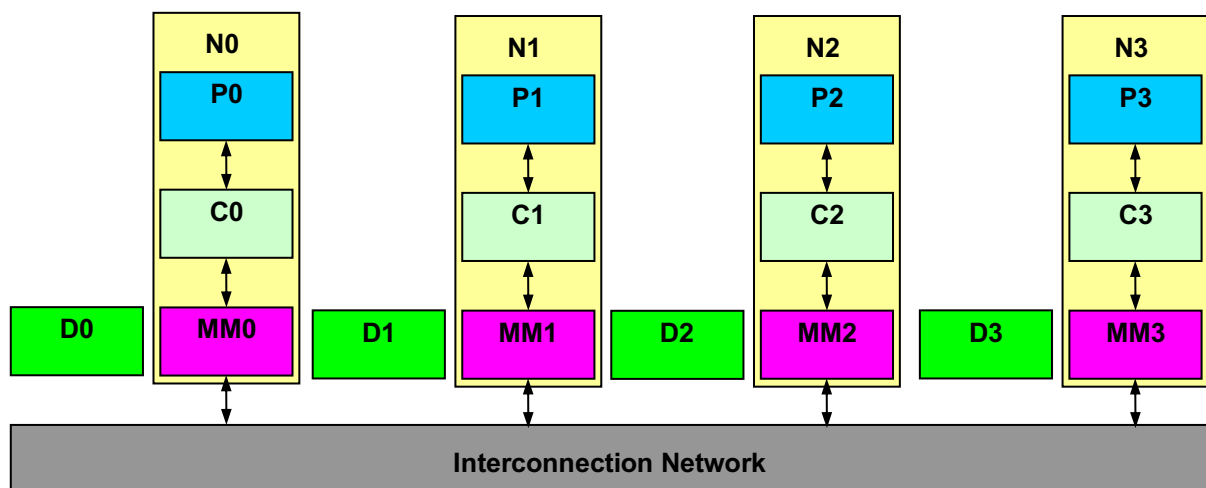
Directory N0 Block B0 | State: Shared | Sharer Bits: 0111 |

After a **Write Hit B0** from N2, please answer to the following questions:

- What are the home node, the local node and the remote nodes?
- What are the messages sent among the nodes?
- Which is the state of the block B0 in the remote caches?
- Which is the state of the block B0 in the directory N0?

(OPEN TEXT ANSWER: max 100 words)

2 points



Solution:

- N0 is the home node of the block B0; N2 is the local node (sharer); N1 and N3 are the remote nodes (other sharers).
- Due to the **Write Hit B0** from local node N2 to home node N0, there is an **Invalidate** message from local N2 to home N0 to request to send an invalidate to remote caches, then there is an **Invalidate** message sent from the home node N0 to the sharer remote caches C1 and C3. Then, the processor P2 will write in Block B0 of cache C2 becoming **Modified**.
- The state of the block B0 in the remote caches C1 and C3 become **Invalid**.
- The state of the block B0 in the home directory N0 changes from Shared to **Modified** with the requesting node (N2) becoming the **owner**:

Directory N0 Block B0 | State: Modified | Sharer Bits: 0010

Question 6 (format Multiple Choice – Single answer) FROM 21/06/2021

Let's consider a directory-based protocol for a distributed shared memory system with 4 Nodes (N0, N1, N2, N3) where:

Directory N1 Block B1 | State: Modified | Sharer Bits: 1000

After a **Write Miss** on B1 from node N2, what are the states of:

| Cache N0 Block B1 | Dir N1 Block B1 |

(SINGLE ANSWER)

2 points

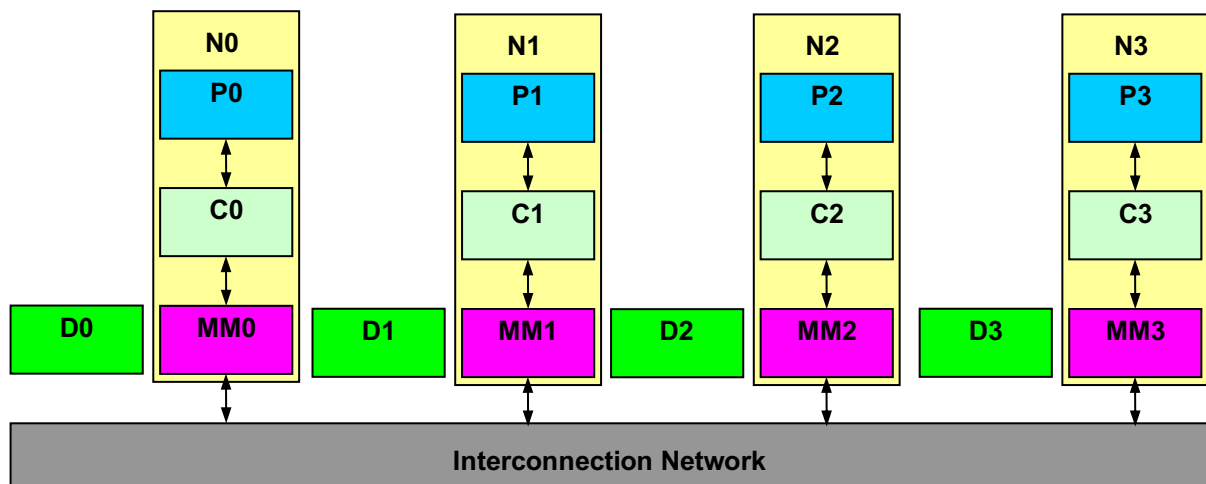
Answer 1: | Cache N0 Block B1 State: Modified || Dir N1 Block B1 | State: Shared | Sharer Bits: 1010 |

Answer 2: | Cache N0 Block B1 State: Modified || Dir N1 Block B1 | State: Modified | Sharer Bits: 0010 |

Answer 3: | Cache N0 Block B1 State: Invalid || Dir N1 Block B1 | State: Modified | Sharer Bits: 0010 |

Answer 4: | Cache N0 Block B1 State: Uncached || Dir N1 Block B1 | State: Modified | Sharer Bits: 0010 |

Answer 5: | Cache N0 Block B1 State: Invalid || Dir N1 Block B1 | State: Uncached | Sharer Bits: ----|



Solution:

Answer 1: | Cache N0 Block B1 State: Modified || Dir N1 Block B1 | State: Shared | Sharer Bits: 1010 |

Answer 2: | Cache N0 Block B1 State: Modified || Dir N1 Block B1 | State: Modified | Sharer Bits: 0010 |

Answer 3: | Cache N0 Block B1 State: Invalid || Dir N1 Block B1 | State: Modified | Sharer Bits: 0010 |

(TRUE)

Answer 4: | Cache N0 Block B1 State: Uncached || Dir N1 Block B1 | State: Modified | Sharer Bits: 0010 |

Answer 5: | Cache N0 Block B1 State: Invalid || Dir N1 Block B1 | State: Uncached | Sharer Bits: ----|

Due to the Write Miss on B1 from the Local Node N2 to home node N1, there is a **Fetch/Invalidate** message sent from the home node N1 to the remote node N0 (**past owner**) to get the most recent copy of the block in the home node N1 through a **Data Write Back** message and invalidating the state of the block B1 in the past owner's cache C0. Then there is a **Data Value Reply** from home node N1 to local cache N2.

The state of the block B1 in the directory N1 stays **Modified** but the **owner is changed** from N0 to N2 as follows: Directory N1 Block B1 | State: **Modified** | Sharer Bits: **0010**.

Question 7 (Open Text Answer) from 01/07/2021

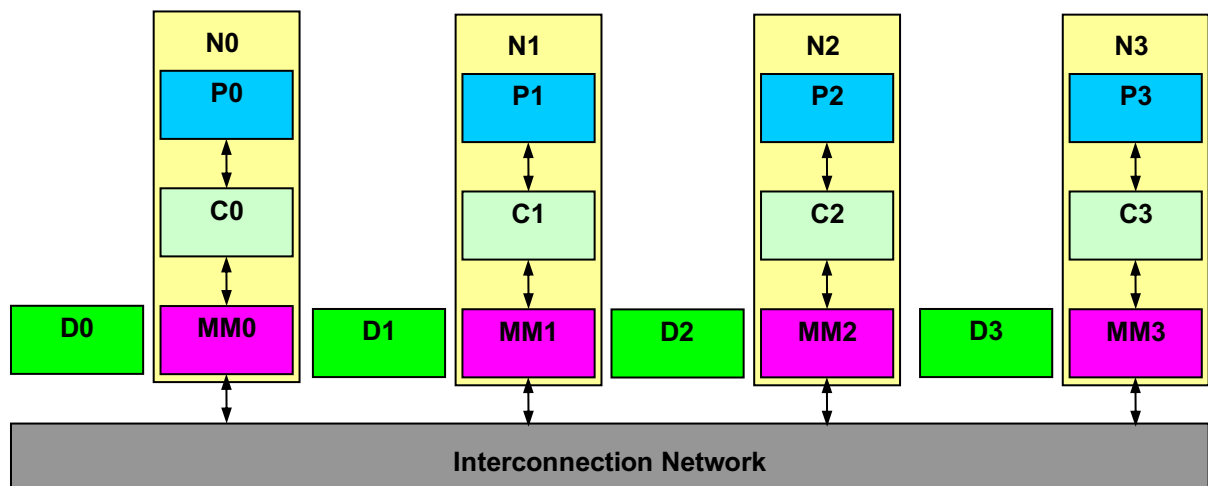
Let's consider a directory-based protocol for a distributed shared memory system with 4 Nodes (N0, N1, N2, N3) where: **Directory N1 Block B1 | State: Uncached | Sharer Bits: ---- |**

After a **Write Miss on B1 from node N2**, please answer to the following questions:

- What are the home node, the local node and the remote node(s)?
- What are the messages sent among the nodes?
- Which is the state of the block B1 in the home directory?
- Which is the state of the block B1 in the local cache?

(OPEN TEXT ANSWER: max 100 words)

2 points



Solution:

- N1** is the home node of B1 and **N2** is the local node (requestor); There are no remote cache(s) because the block is **Uncached**;
- Being the block B1 in the **Uncached** state, the only copy of the block in the home memory is up to date in N1. Due to the **Write Miss on B1** from the local node N2 to home node N1, the requested data are sent by a **Data Value Reply** from home memory N1 to the local cache of node N2 which becomes the **owner**.
- The state of the block B1 in the home directory N1 becomes **Modified** and the **owner** is N2: **Directory N1 Block B1 | State: Modified | Sharer Bits: 0010**.
- The state of the block B1 in the local cache C2 of N2 also becomes **Modified**.