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:

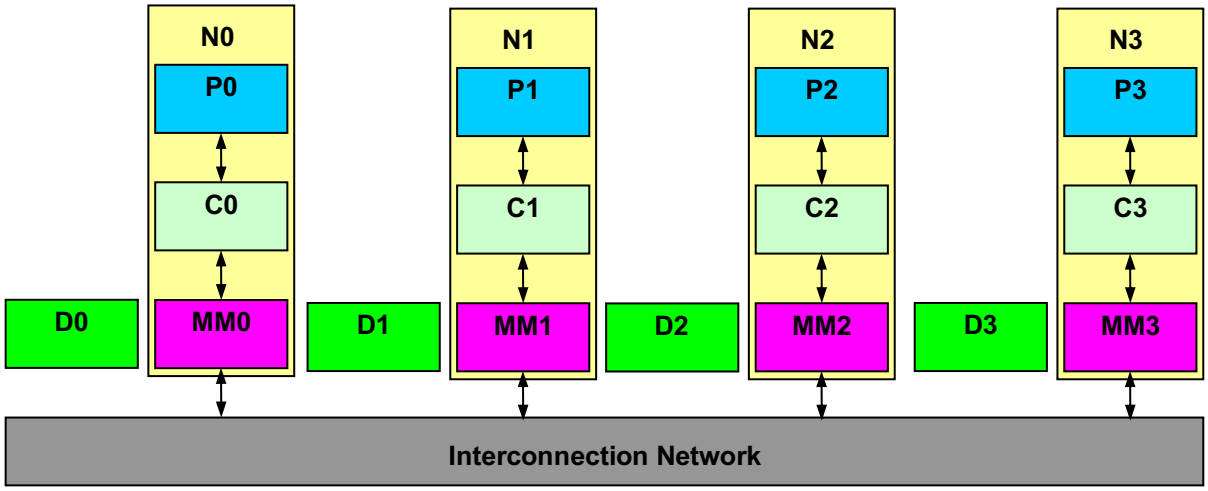
Directory N0 Block B0 | State: Shared | Sharer Bits: 1001 |

*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:

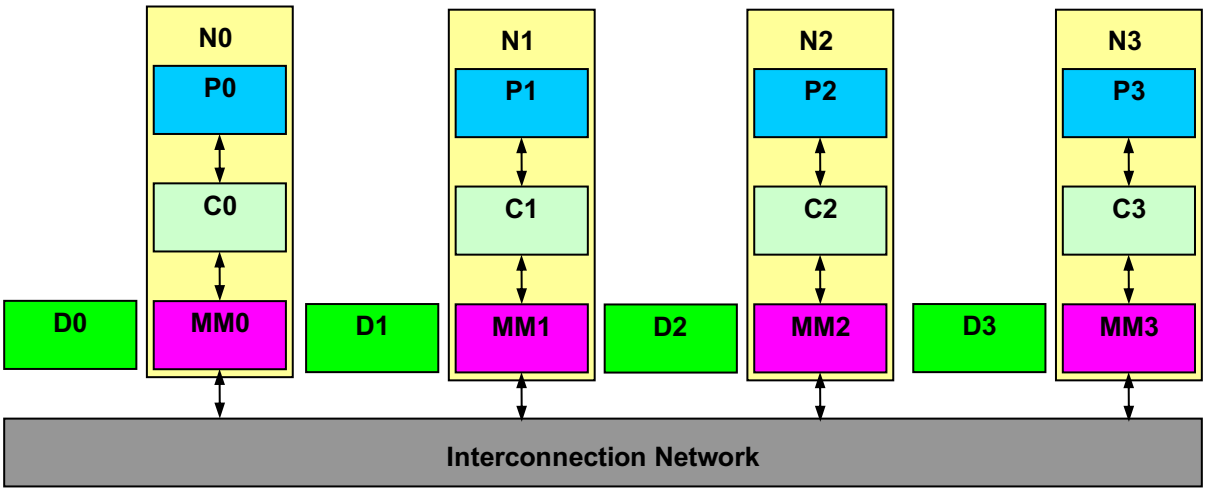
Directory N1 Block B1 | State: Modified | Sharer Bits: 0100|

*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:

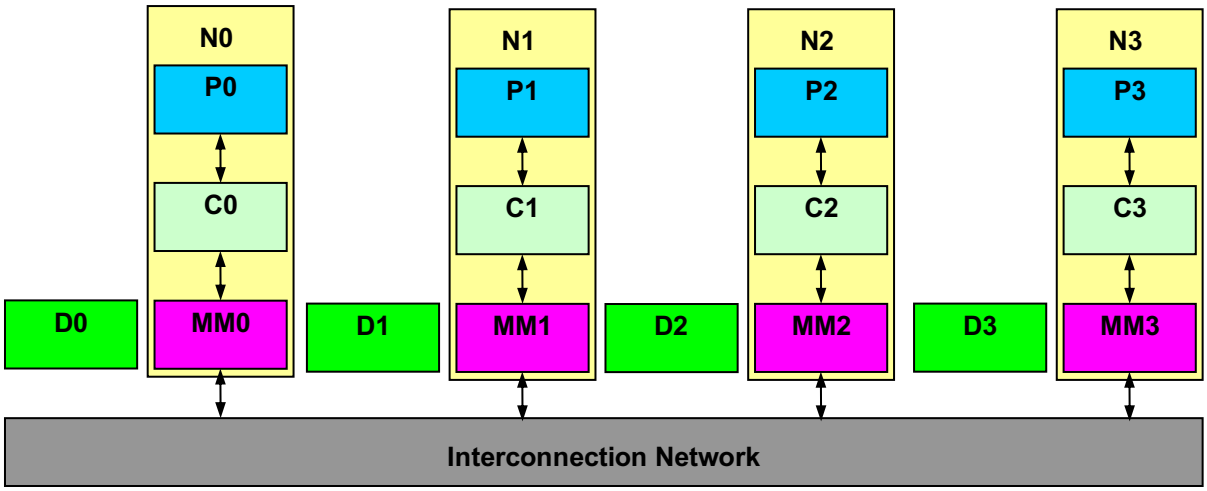
Directory N0 Block B0 | State: Shared | Sharer Bits: 0101 |

*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.

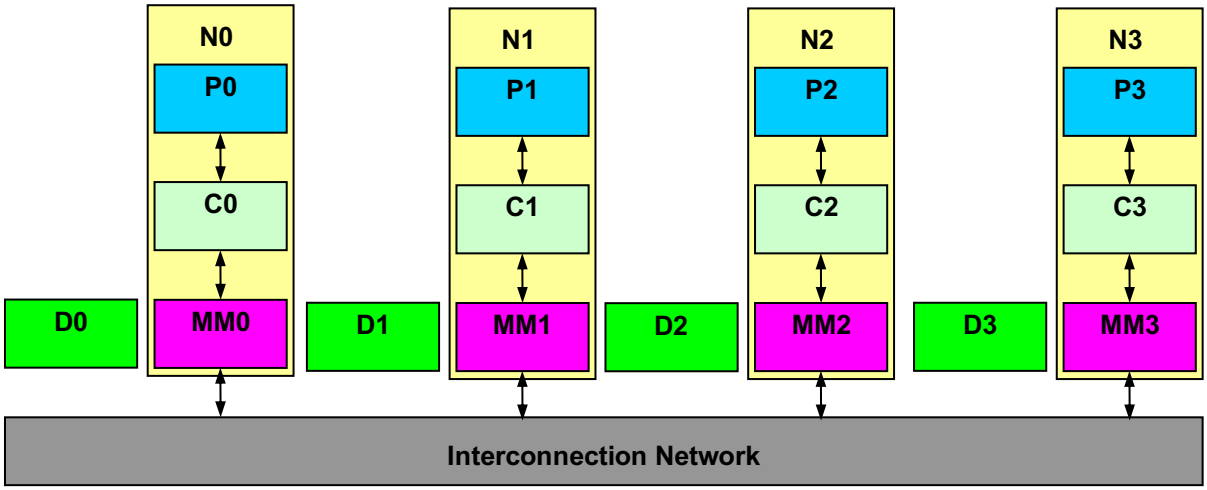
Question 4 (format Multiple Choice – Single answer) from 19/07/2019

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

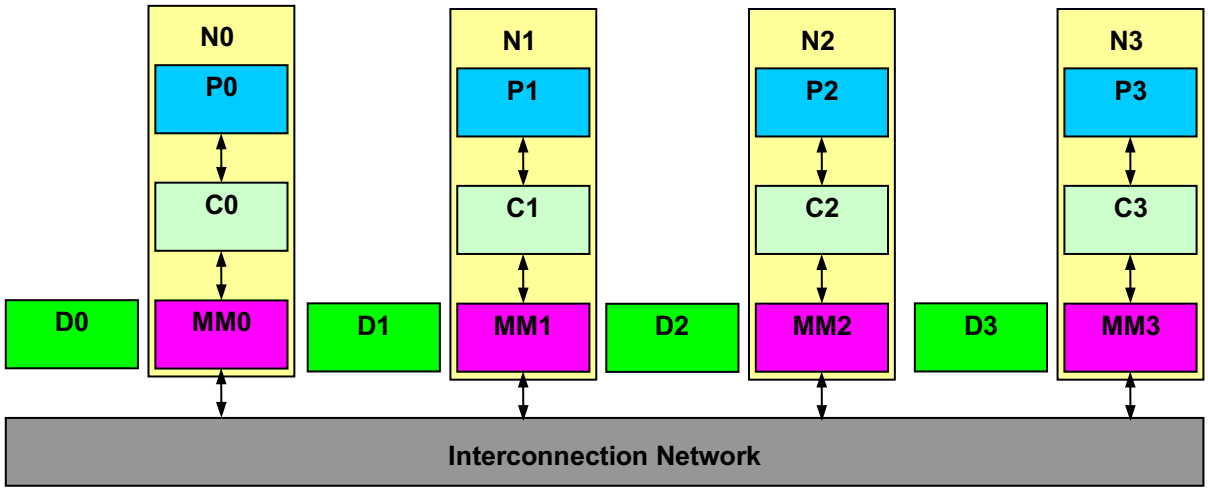
Answer 1: Directory N1 Block B1 | State: Modified | Sharer Bits: 0100
Answer 2: Directory N1 Block B1 | State: Modified | Sharer Bits: 0010
Answer 3: Directory N1 Block B1 | State: Shared | Sharer Bits: 1111
Answer 4: Directory N1 Block B1 | State: Modified | Sharer Bits: 0110
Answer 5: Directory N1 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:
a) What are the home node, the local node and the remote nodes?
b) What are the messages sent among the nodes?
c) Which is the state of the block B0 in the remote caches?
d) Which is the state of the block B0 in the directory N0?
(OPEN TEXT ANSWER: max 100 words)
2 points



Solution:

a) **N0 is the home node of the block B0; N2 is the local node (sharer); N1 and N3 are the remote nodes (other sharers).**

b) 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**.

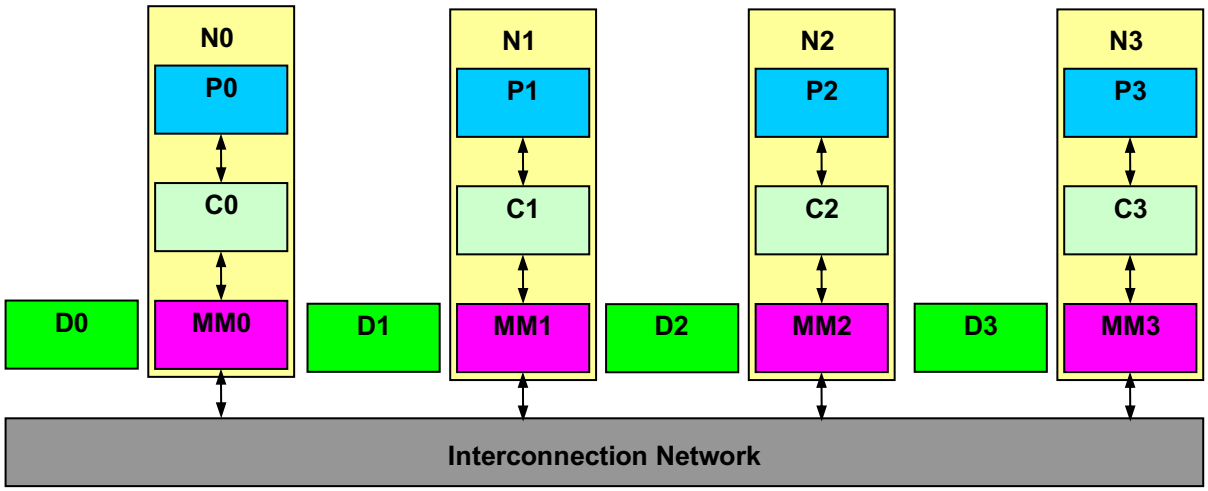
c) The state of the block B0 in the remote caches C1 and C3 become **Invalid**.

d) 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: ----|

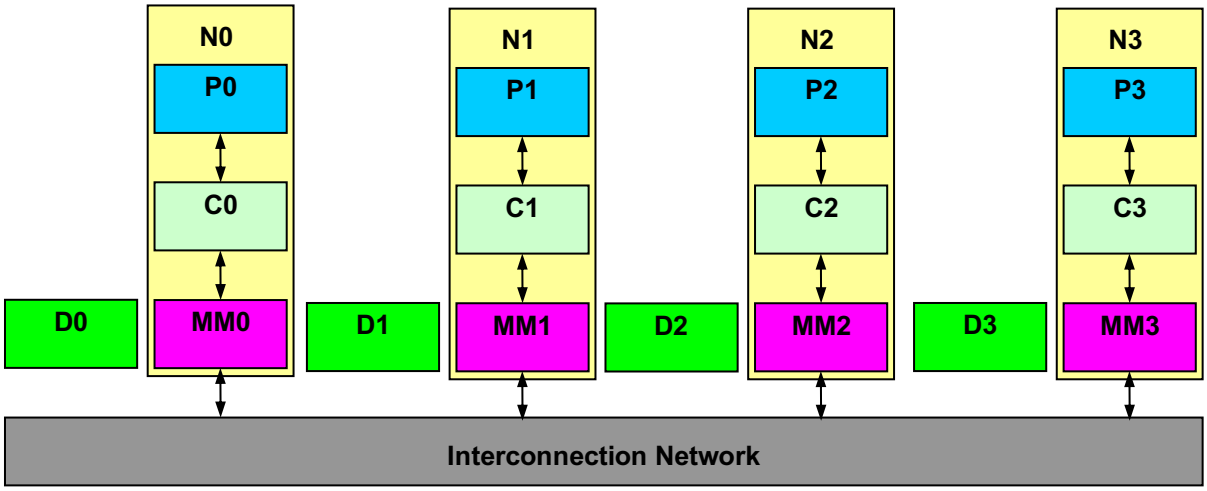
Due to the Write Miss on B1 from the Local Node N2 to home node N1, there is **a Fetch/Invalidate** message sent from the home node N1 to the remote node N0 **(past owner)** to get the most recent copy of the block in the home node N1 through a **Data Write Back** message and invalidating the state of 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:*
a) What are the home node, the local node and the remote node(s)?
b) What are the messages sent among the nodes?
c) Which is the state of the block B1 in the home directory?
d) Which is the state of the block B1 in the local cache?

(OPEN TEXT ANSWER: max 100 words)
2 points



Solution:

a) **N1** is the home node of B1 and **N2** is the local node (requestor); There are no remote cache(s) because the block in **Uncached**;

b) 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.**

c) 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.**

d) The state of the block B1 in the local cache C2 of N2 also becomes **Modified**.