

CS 574
Final Exam
Solution to Question 4

4. (20 points) In a computer system using the DASH consistency protocol, variable x is homed (has its directory) on cluster C_1 , while y is homed on C_2 . Initially, they are both in state *uncached-remote* in their respective directory controllers. Processor P_2 is located in cluster C_2 , while P_3 is located in cluster C_3 (the lack of a processor P_1 is not an error. I wanted to have some particular interactions happen in this question, which required the layout of processors and clusters I've selected). The two processors execute the following program:

P_2	P_3
S; $y = x + 1;$	$x = 1;$ S;

The S; statements represent synchronization between the programs and are only there to assure the ordering of the statements; for purposes of this exam you should ignore any messages they might cause to be sent.

Questions:

- (a) **What messages need to be transferred between the directory controllers as a result of these statements?**

From	Message	To	Variable	New State
$x = 1;$				
C_3	Read Exclusive	C_1	x	
C_1	Data	C_3	x	<i>dirty-remote</i>
$y = x + 1;$				
C_2	Read	C_1	x	
C_1	Read (forward)	C_3	x	
C_3	Data	C_2	x	
C_3	Sharing writeback	C_1	x	<i>shared-remote</i>

Notes:

Initially, the two variables are both in the uncached-remote state. When the first statement is executed, C_3 needs to get exclusive access to x ; to do this, it follows the steps described in section 4.2 of the paper. It sends a read-exclusive request to x 's home cluster (C_1); the data and ownership are both transferred to cluster C_3 in response. As stated in the problem, the synchronization is only for purposes of making sure events happen in the specified order, and should be ignored in your solution.

When processor P_2 executes its statement, it needs to get shared access to x . It sends a read request to C_1 , which forwards the request to C_3 as specified in section 4.1 of the paper. C_3 responds by sending the data to C_2 and a sharing-writeback request to C_1 . x is now in the shared-remote state.

As y is homed on cluster C_2 and is in state uncached-remote, no messages are necessary for a processor in C_2 to get access to it.

- (b) **What are the final states of the variables in the directory controllers?**

x is in shared-remote; y is in uncached-remote.