1. Assume a write-invalidate cache-coherence protocol.
   a) For the processor containing a memory block in its cache, when would it send “invalidate messages” to the bus?

   b) For the processor containing a memory block in its cache and snooping the bus, when would it change the blocks state based on messages snooped off of the bus?

2. Show actions for each situation: (assume write-allocate in the 2nd and 4th cases)
   1st: assume write-invalidate protocol with Proc 2 having a read miss on A
   2nd: assume write-allocate protocol with Proc 2 having a write miss on A
   3rd: assume write-invalidate protocol with Proc 2 having a read miss on A
   4th: assume write-allocate protocol with Proc 2 having a write miss on A

   1st:

   2nd:

   3rd:

   4th:
Assumptions:
• \( n \) is a shared variable initialized to the number of processors,
• \( \text{count} \) is a shared variable initialized to 0,
• \( \text{arrive} \) is a shared spin-lock variables which is initially unlocked
• \( \text{depart} \) is a shared spin-lock variables which is initially locked

procedure synch()

lock(arrive);
    count := count + 1; /* count the processors as
    if count < n /* they arrive at barrier
        then unlock(arrive)
        else unlock(depart);

lock(depart);
    count := count - 1; /* count the processors as
    if count > 0 /* they leave barrier
        then unlock(depart)
        else unlock(arrive);

3. On which spin-lock variable are processors “waiting” at the “barrier” for all processors to arrive?

4. What is the value of \( \text{count} \) when all processors have arrived at the “barrier”?

5. How does \( \text{count} \) get reset to equal 0?

6. For a synch() within a loop as in the vector summation example, what prevents a “fast” processor from leaving the barrier and getting through the next barrier before all the other processors leave the barrier?