Computer Science 605.411

Module 11 Example Set 6

1. On what concepts are RAID systems based?
   RAID systems employ multiple disk drives each of which can perform a separate access in parallel. By acting in parallel the array of smaller less expensive independent disks can provide improved performance over a single large more expensive disk. The interface presented by the RAID controller appears to the programmer or operating system to be the same as that for a single disk system. One or more of the disk drives in the array can be used to hold parity information that allows data lost, due to some event such as a head crash, to be reconstructed.

2. Which of the RAID levels or categories is not capable of providing fault tolerance?
   RAID 0 systems include no parity or error correcting information and therefore become inoperable due to lost data. RAID 0 improves performance by striping or distributing data across multiple disk drives operating in parallel, but provide no data recovery capability.

3. Which of the RAID levels is the most expensive for a given amount of data storage?
   RAID 1 is most expensive since it duplicates each of the data disk to produce mirror images or shadow disks. The mirror images serve as backups in the event of data loss. So RAID 1 doubles the cost for a given amount of stored data.

4. Why do reads tend to be faster than writes on RAID 1 systems?
   Since the disks are not synchronized (i.e., the access heads are not at the same position on a data disk and on its mirror image), data to be read is taken from the first of the two copies that is encountered. Writes require that the data be written twice (to the desired block on both images) which takes longer because the two writes are not totally overlapped.

5. Why is RAID 2 not used commercially?
   RAID 2 employs striping at the bit level (as few as one bit from each record may be on separate disks) and employs error correcting codes that have relatively high overhead. For example, four data disks may require as many as 3 parity disks for a 75% overhead. While this is less than the 100% overhead for RAID 1, it is still unacceptably high. Current inexpensive disk drives include their own internal error-correcting capability at the bit level, so RAID 2 is not used.

6. For what type of I/O operations is RAID 3 most attractive?
   In a RAID3 system the access heads on all disk drives are ganged together and synchronized. Each transfer involves all of the disks. Hence RAID 3 works best when transferring large data blocks that span all or several of the disk drives. This means that only blocks or strips within the same stripe or row can be accessed at the same time in parallel. Accessing strips within different stripes requires separate I/O operations.

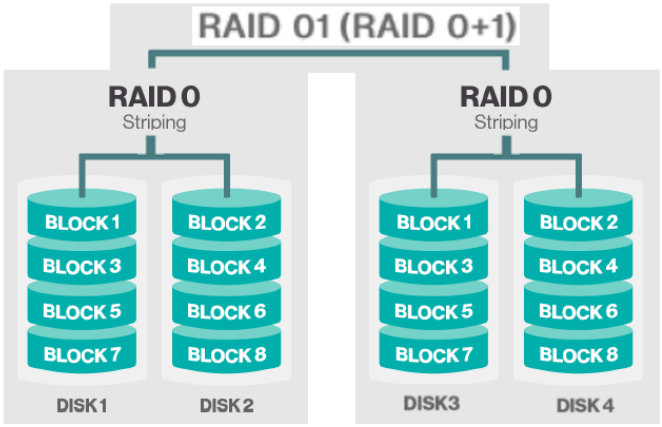
7. What is the main differences between RAID 4 and RAID 3?
   RAID 4 uses striping at the block level while RAID 3 uses bit-level striping. Hence the blocks or strips on a RAID 4 system tend to be larger than the RAID 3 counterparts. Both systems employ a single parity disk that must be accessed any time a stripe is modified. The access head on the disks within a RAID 4 system can move independently of each other, while those on the RAID 3 system move in unison.

8. What is one of the main advantages of RAID 4 over RAID 3?
   RAID 4 can support both large data transfers that span multiple blocks or multiple small transfers that map to separate blocks. However, the single parity disk can be a bottleneck and limit which writes can be done in parallel. Writing blocks in different stripes would require updating the parity block for each stripe; but the parity disk, as well as the other disks, can only perform one read or write at a time.

9. How is the parity disk bottleneck problem for RAID 4 eliminated in RAID 5?
   The parity blocks in RAID 5 systems are distributed among all of the disks rather than being concentrated on a single disk. This allows some combinations of writes to blocks within different stripes to be done in parallel along with updating the corresponding parity blocks.

10. When updating a stripe within a RAID 4 or RAID 5 system, the corresponding parity block for the stripe must also be updated. How can the new parity block be computed?
    The new parity block can be computed as the cumulative XOR of the new data block with all of the other data blocks within the stripe (this requires reading all of the other data blocks). Alternatively, the old data block and the old parity block for the stripe can be read and XORed. This has the effect of removing or subtracting out the old data block. The result can then be XORed with the new data block to obtain the new parity block.

11. How does a RAID01 (0+1) system differ from a RAID10 (1 + 0) system?
A RAID 01 system can be viewed as a RAID1 system in which each of the disks is a RAID0 system.



A RAID10 system can be viewed as a RAID0 system in which each of the disks has a mirror image.