CSC 370

Activity Worksheet:
RAID Schemes

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Notes

In this worksheet, you will practice recovering from disk failures using RAID techniques. Each question provides a RAID scheme and set of disks, some of which feature data loss. You should indicate the contents of all disks after restoration or that it is not possible. The first question has been answered already as an exemplar.

Questions

1. You have five disks (including the redundant disk) using a RAID 4 scheme. After a disk failure, you have the contents below. What would be the contents of the disks after restoring those that failed?

```
Disk 0: 0101 0101 0110 1011
Disk 1: 1110 0101 1111 1000
Disk 2: ???? ???? ???? ????
Disk 3: 1010 0000 0000 1010
Disk 4: 1011 0000 1110 0110
```

Solution:

With a RAID 4 scheme, we can recover a missing disk by calculating the xor of the other disks. Thus we have:

```
Disk 0: 0101 0101 0110 1011
Disk 1: 1110 0101 1111 1000
Disk 2: 1010 0000 0111 1111
Disk 3: 1010 0000 0000 1010
Disk 4: 1011 0000 1110 0110
```

2. You have five disks (including the redundant disk) using a RAID 5 scheme. After a disk failure, you have the contents below. What would be the contents of the disks after restoring those that failed?

```
Disk 0: 1011 0001 0000 1111
Disk 1: 1000 1111 1111 1010
Disk 2: ???? ???? ???? ????
Disk 3: 1000 0000 0000 1010
Disk 4: 1000 0000 1110 0110
```

Solution:

3. Assume that you have a RAID 6 scheme with the layout below:

```
Disk 0: 1 0 1
Disk 1: 0 1 1
Disk 2: 1 0 1
Disk 3: 1 1 0
Disk 4: 1 1 1
Disk 5: 1 0 0
Disk 6: 0 1 0
Disk 7: 0 0 1
```

Indicate for each disk how you would restore it if it were to fail.

Solution:

4. Assume that you have a RAID 6 scheme with the layout below:

```
Disk 0: 1 0 1
Disk 1: 0 1 1
Disk 2: 1 0 1
Disk 3: 1 1 0
Disk 4: 1 1 1
Disk 5: 1 0 0
Disk 6: 0 1 0
Disk 7: 0 0 1
```

Two of your disks fail, after which the content is as shown below. What would be the contents of the disks after restoring those that failed?

```
Disk 0: 1011 0001 0000 1111
Disk 1: 1000 1111 1111 1010
Disk 2: ???? ???? ???? ????
Disk 3: 1000 0000 0000 1010
Disk 4: 1000 0000 1110 0110
Disk 5: ???? ???? ???? ????
Disk 6: 1010 0110 1110 0111
Disk 7: 1100 1110 1010 0000
```

Solution:

Solutions

Question 1

With a RAID 4 scheme, we can recover a missing disk by calculating the xor of the other disks. Thus we have:

```
Disk 0: 0101 0101 0110 1011
Disk 1: 1110 0101 1111 1000
Disk 2: 1010 0000 0111 1111
Disk 3: 1010 0000 0000 1010
Disk 4: 1011 0000 1110 0110
```

Question 2

With a RAID 5 scheme, recovery is identical to RAID 4: we can recover a missing disk by calculating the xor of the other disks. Thus we have:

```
Disk 0: 0101 0101 0110 1011
Disk 1: 1110 0101 1111 1000
Disk 2: 0001 0000 1001 1010
Disk 3: 1010 0000 0000 1010
```

Question 3

With a RAID 6 scheme, we can recover by finding other disks with the same active bit. Thus, the solution is non-unique with only one disk failure. Some examples could be:

```
Disk 1: Disk 2 ^ Disk 4 ^ Disk 7
Disk 2: Disk 1 ^ Disk 4 ^ Disk 7
Disk 3: Disk 1 ^ Disk 4 ^ Disk 6
Disk 4: Disk 1 ^ Disk 3 ^ Disk 6
Disk 5: Disk 2 ^ Disk 3 ^ Disk 4
Disk 6: Disk 1 ^ Disk 3 ^ Disk 4
Disk 7: Disk 1 ^ Disk 2 ^ Disk 4
```

The first three disks would have one extra option and disk 4 has two other choices.

Question 4

With a RAID 6 scheme, we can recover from simultaneous disk failures. We need to find a redundant array in which the two failed disks, in this case Disk 2 and Disk 5, do not both participate. We see that, although Disk 2 and Disk 5 both participate in the first array and neither participate in the second array, only Disk 2 participates in the third array. Thus we can restore Disk 2 using that array as follows:

```
Disk 2: Disk 1 ^ Disk 4 ^ Disk 7

Disk 1: 1000 1111 1111 1010
Disk 2: 1100 0001 1011 1100
Disk 4: 1000 0000 1110 0110
Disk 7: 1100 1110 1010 0000
```

With disk 2 restored, we can then restore disk 5 using the first arrays as follows:

```
Disk 5: Disk 2 ^ Disk 3 ^ Disk 4

Disk 2: 1100 0001 1011 1100
Disk 3: 1000 0000 0000 1010
Disk 4: 1000 0000 1110 0110
Disk 5: 1100 0001 0101 0000
```