Homework - 6

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CS-230 Distributed Computer Systems

Problem Statement

We are provided with 5 physical processors which will be referred to in this assignment as $\pi_1,\ \pi_2, \ldots \pi_5$. In addition to this we have 6 SPMD Jobs to run. The number of VP's

$$
\begin{aligned}
J_1 &: \text{has 4 VPs}\\
J_2 &: \text{has 3 VPs}\\
J_3 &: \text{has 4 VPs}\\
J_4 &: \text{has 1 VPs}\\
J_5 &: \text{has 7 VPs}\\
J_6 &: \text{has 2 VPs}
\end{aligned}
$$

Problem 1

The spatial schedule is given below:

$$
\begin{aligned}
A(J_1) &= (0,0,1,1,2)\\
A(J_2) &= (1,1,0,1,0)\\
A(J_3) &= (1,1,0,1,1)\\
A(J_4) &= (0,0,1,0,0)\\
A(J_5) &= (2,2,2,1,0)\\
A(J_6) &= (0,0,1,0,1)
\end{aligned}
$$

The temporal schedule for this allocation is given below for two periods:

Time/PE	π_1	π_2	π_3	π_4	π_5
1	5	5	5	5	1
2	5	5	5	1	1
3	3	3	1	3	3
4	3	3	6	3	3
5	2	2	4	2	6
6	5	5	5	5	1
7	5	5	5	1	1
8	3	3	1	3	3
9	2	2	2	4	6
10	3	3	6	3	3

The period of the above temporal schedule is 5. Also it has an idling ratio of zero as no physical processor stays idle at any time slice of the period. The schedule is also fair because each job executes at least once in a period. Also it is legal because for any time slice no VP of a job is more than one global communication ahead of the same job. All the jobs execute exactly once in a period, meaning $k = 1$, Except for job 3 which executes $k = 2$ times in period, here k is the number of steps for a job. This is done to minimize the idling ratio because in total we have to run 21 VPs that means we need a temporal schedule with a period of at least 5 which would give us 25 potential time slots to run the VPs. This means that we are left with 4 time slots idle which can be filled with another job. In this case I increase job 3's step by one.

Problem 2

Part A

In this problem we are also allowed to reassign VPs of the physical processor which did not fail. Below I provide a new spatial and temporal schedule which minimizes the idling ratio too.

The new spatial allocation is given below: (Notice how all entries for processor 3 are now zero)

$$A(J_1) = (0, 0, 0, 2, 2)$$
$$A(J_2) = (1, 1, 0, 1, 0)$$
$$A(J_3) = (1, 1, 0, 1, 1)$$
$$A(J_4) = (0, 0, 0, 0, 1)$$
$$A(J_5) = (3, 3, 0, 1, 0)$$
$$A(J_6) = (0, 0, 0, 0, 2)$$

The temporal schedule for this allocation is given below for one period:

Time/PE	π_1	π_2	π_4	π_5
1	5	5	5	1
2	5	5	1	1
3	5*	5*	1*	6*
4	2	2	2	6
5	2	2	2	4*
6	3	3	3	3

The values which have a * written beside to them indicate that they were migrated. The migration could be from π_3 or an other processor to any another processor. This temporal schedule has a period of 6. All the jobs execute exactly once in the period, meaning $k = 1$, Except for job 2 which executes $k = 2$ times in a period, here k is the number of steps for a job. This temporal schedule is fair because each job executes at least once in a period. Also it is legal because for any time slice no VP of a job is more than one global communication ahead of the same job. The idling ratio for this temporal schedule is zero. The number of migrating VPs in this case are 5. The achieve a 0% idling ratio we have to decrease the step of job 3 by one and increase the step of job 2 by one. This does not add to the number of migrating VPs as job 2 originally ran on processors 1,2 and 4 so the failure of processor 3 has nothing to do with it.

Part B

In this problem we are only allowed to migrate VPs from the failing processor only. I will be using the original 0% idling ratio, given in Problem 1 as a basis.

The new spatial allocation is given below: (Notice how all entries for processor 3 are now zero)

$$A(J_1) = (0, 1, 0, 1, 2)$$
$$A(J_2) = (1, 1, 0, 1, 0)$$

$$A(J_3) = (1, 1, 0, 1, 1)$$
$$A(J_4) = (0, 0, 0, 0, 1)$$
$$A(J_5) = (2, 2, 0, 2, 1)$$
$$A(J_6) = (2, 2, 0, 0, 1)$$

The temporal schedule for this allocation is given below for one period:

Time/PE	π_1	π_2	π_4	π_5
1	5	5	5	1
2	5	5	5*	1
3	6*	1*	1*	5*
4	2	2	2	6
5	3	3	3	3
6	2	2	2	4*

The values which have a * written beside to them indicate that they were migrated. The migration could only be from π_3 to any other processor. This temporal schedule has a period of 6. All the jobs execute exactly once in the period, meaning $k = 1$, Except for job 2 which executes $k = 2$ times in a period, here k is the number of steps for a job. This temporal schedule is fair because each job executes at least once in a period. Also it is legal because for any time slice no VP of a job is more than one global communication ahead of the same job. The idling ratio for this temporal schedule is zero. The number of migrating VPs in this case are 5. The achieve a 0% idling ratio we have to decrease the step of job 3 by one and increase the step of job 2 by one. This does not add to the number of migrating VPs as job 2 originally ran on processors 1,2 and 4 so the failure of processor 3 has nothing to do with it.

Problem 3

Since, I choose a spatial allocation in problem 1 in such a way that for both problems of part 2 (a and b) the the only migrations that are needed to minimize the idling ratio (0%) are the ones which originate from π_3 only, after its failure. For both parts of problem 2 I do have different spatial and temporal schedules but the migrating costs for both of them are same. Since, to achieve minimum idling ratio I just re-assign the VPs of π_3, meaning 5 migrations are made only. The migrating costs for both the parts are 5 because of this. There are some cases for Problem 2 part A where there can be more than 5 migrating VPs but those lead to an increase in the period.