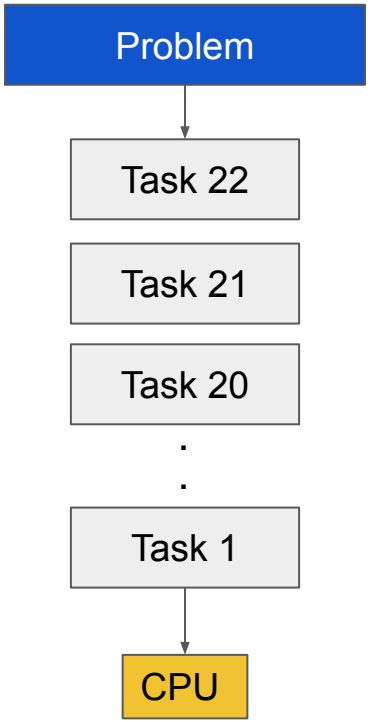
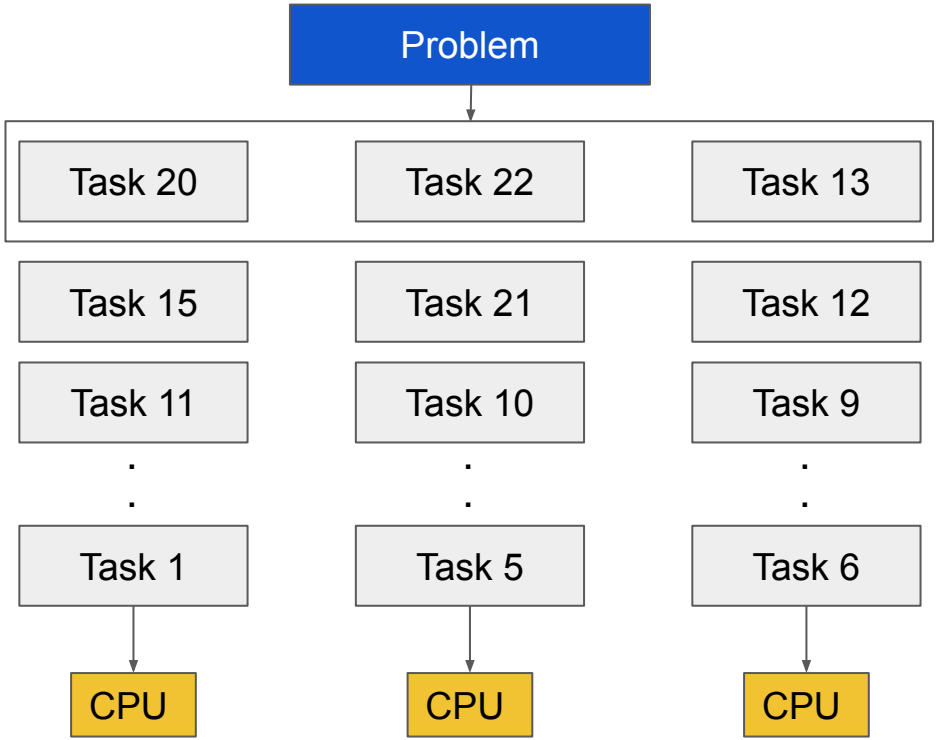
Basics of Parallelization





Basics of Parallelization

1. Task parallelism
    - Partition the various tasks among the processors
    - Each processor performs different tasks
2. Data Parallelism
    - Partition the data among the processors
    - Each processor performs the same task on different data

Grading exam papers

6 questions

150 students

3 TAs

Task Parallelization

TA 1

150 papers
1,2 questions

TA 2

150 papers
3,4 questions

TA 3

150 papers
5,6 questions

Data Parallelization

TA 1

50 papers

TA 2

50 papers

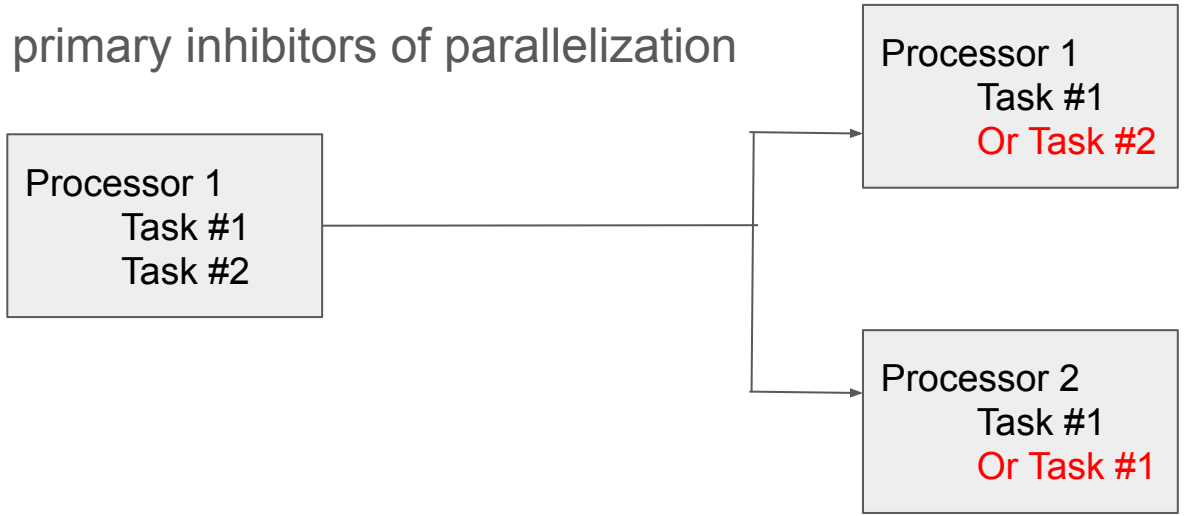
TA 3

50 papers

Is the task parallelizable?

The order of execution must not matter! - Dependency Analysis

- A dependency exists in the program when the order of statement execution affects the results of the program
- Dependencies are primary inhibitors of parallelization



Dependency analysis

Example 1.

```
a = 10;
b = 1;
```

Tasks can run independently

```
a = 10;
b = a;
```

Tasks can not run independently

Dependency analysis

Example 2.

```
for (i=0, i<100, i++)
{
        a[i] = 5*i;
        b[i] = i-1;
}
```

Iterations, tasks within loop can run independently

```
for (i=0, i<100, i++)
{
        a[i] = a[i-1];
        b[i] = i-1;
}
```

Tasks within loops but Iterations can run independently

```
for (i=0, i<100, i++)
{
        a[i] = 5*i;
        b[i] = a[i-1];
}
```

Iterations, tasks within loop can not run independently

Dependency analysis

Example 3.

```
for (i=0, i<100, i++)
{
    a[i] = i;
}

for (j=0, j<100, j++)
{
    b[j] = 3*j-1;
}
```

Both loops and iterations can run independently

```
for (i=0, i<100, i++)
{
    for (j=0,j<10,j++)
    {
        a[i][j] = a[i-1][j-1];
    }
}
```

Both outer and inner loop are dependent

```
for (i=0, i<100, i++)
{
    for (j=0,j<10,j++)
    {
        a[i][j] = 3*a[i][j-1];
    }
}
```

Inner loop is dependent, outer loop is independent

Synchronization

- Managing the “serialization” segments of work
- Used to enforce dependencies
- Controls the ordering of events on different processors