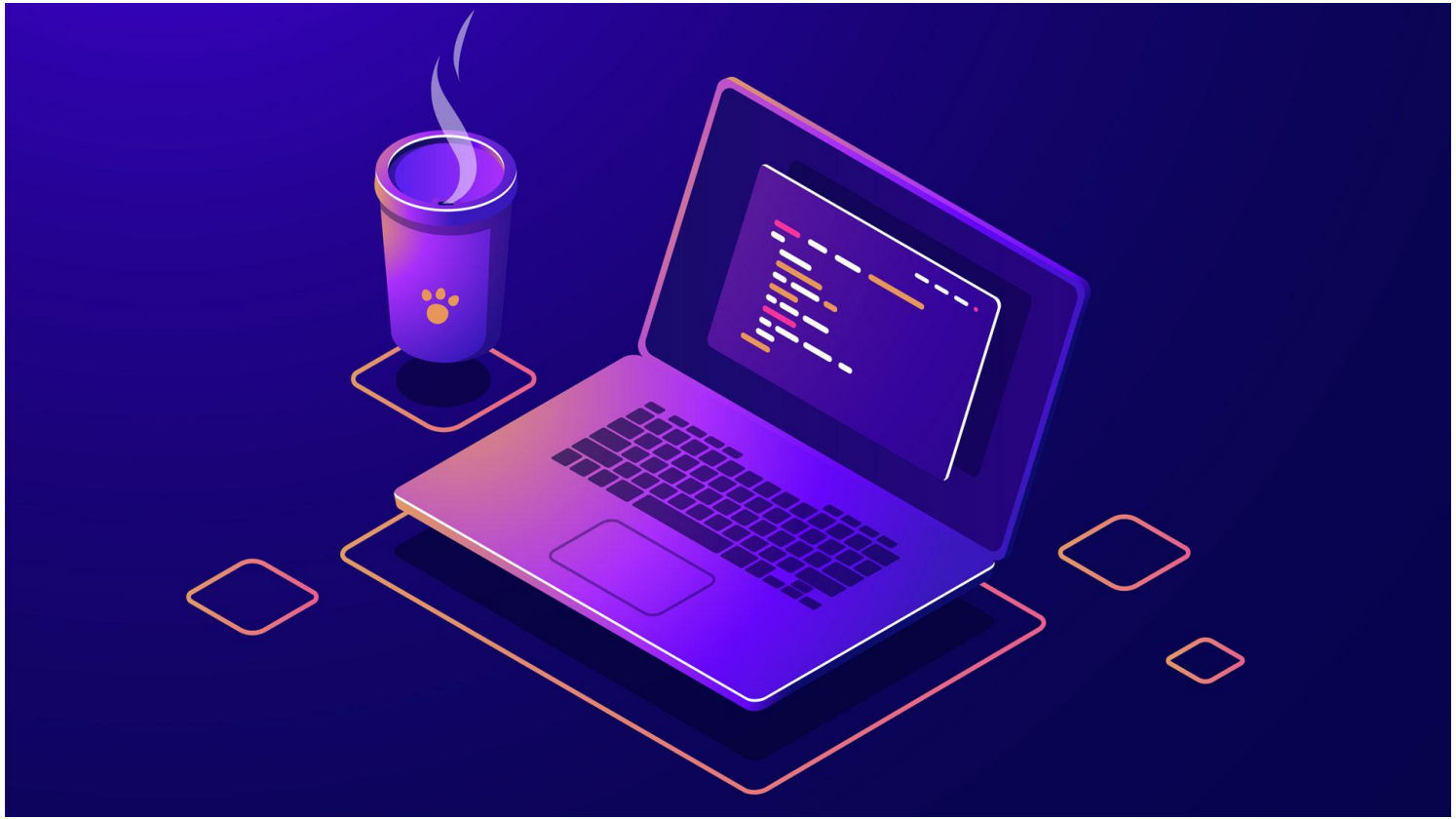
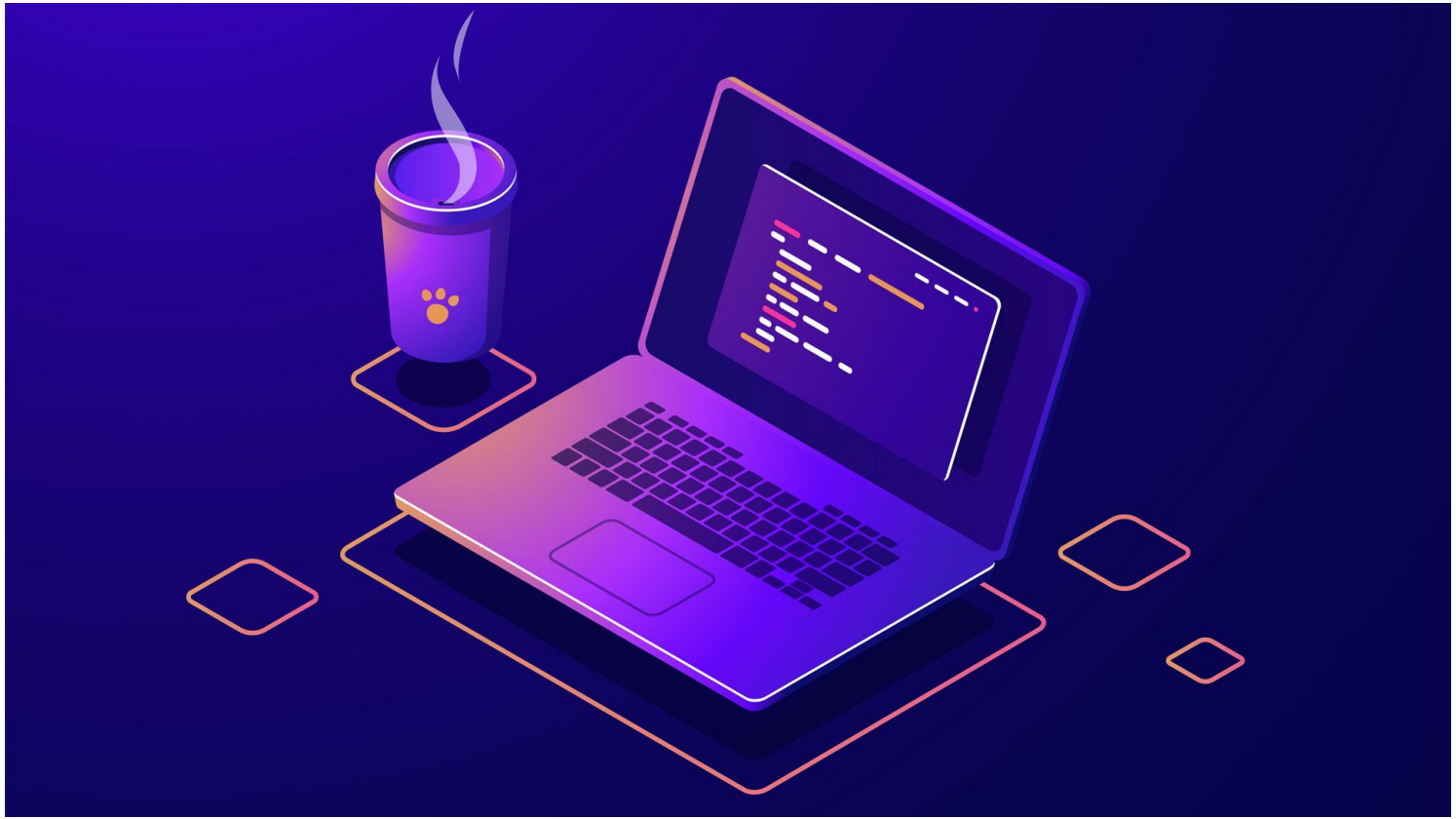
OpenMP Problems



Problem 5



Problem 5

We ask to parallelize the computation of the histogram of values appearing on a vector. The histogram is another vector in which each position counts the number of elements in the input vector that are in a certain value range. The following program shows a possible sequential implementation for computing the histogram (vector `frequency`) of the input vector `numbers`:

```
#define MAX_ELEM 1024*1024
#define HIST_SIZE 250
unsigned int numbers[MAX_ELEM];
unsigned int frequency[HIST_SIZE];

void ReadNumbers (int * input, int * size);
void FindBounds(int * input, int size, int * min, int * max) {
for (int i=0; i<size; i++)
      if (input[i]>(*max)) (*max)=input[i];

for (int i=0; i<size; i++)
      if (input[i]<(*min)) (*min)=input[i];
}

void FindFrequency(int * input, int size , int * histogram, int min, int max) {
int tmp;
for (int i=0; i<size; i++) {
      tmp = (input[i] - min) * (HIST_SIZE / (max - min - 1));
      histogram[tmp]++;
      }
}
```

Problem 5

```
void DrawHistogram(int * histogram, int minimum, int maximum);
void main() {
    int num_elem, max, min;

    ReadNumbers(numbers, &num_elem); // read input numbers
    max=min=numbers[0];
    FindBounds(numbers, num_elem, &min, &max); // returns the upper and lower
                                               // values for the histogram
    FindFrequency(numbers, num_elem, frequency, min, max); // compute histogram
    DrawHistogram(frequency, min, max); // print the histogram
}
```

Problem 5

a) Write a parallel version with OpenMP for function FindBounds using an iterative task decomposition, in which you only generate as many tasks as threads in the parallel region, as you minimize the possible synchronization overheads.

b) Write a parallel implementation for the function FindFrequency using OpenMP.

Problem 5 - Point A - Solution

```
void FindBounds(int * input, int size, int * min, int * max) {
    int chunk_size = (size + omp_get_max_threads() - 1) / omp_get_max_threads();
    int local_min = input[0], local_max = input[0];

    #pragma omp parallel num_threads(omp_get_max_threads())
    {
        int tid = omp_get_thread_num();
        int start = tid * chunk_size;
        int end = (tid + 1) * chunk_size;
        if (end > size) end = size;

        for (int i = start; i < end; i++) {
            if (input[i] > local_max) local_max = input[i];
            if (input[i] < local_min) local_min = input[i];
        }

        #pragma omp critical
        {
            if (local_max > *max) *max = local_max;
            if (local_min < *min) *min = local_min;
        }
    }
}
```

Problem 5 - Point A - Solution

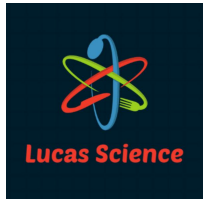
In this parallel version of FindBounds, we first determine the chunk size based on the input size and the number of threads in the parallel region. Then, we create a parallel region using #pragma omp parallel with the number of threads specified by omp_get_max_threads(). Inside the parallel region, each thread computes the minimum and maximum values of a subset of the input vector, as determined by its thread ID (omp_get_thread_num()) and the chunk size. To avoid race conditions when updating the global minimum and maximum values, we use a critical section (#pragma omp critical) to ensure mutual exclusion.

Mutual Exclusion

Mutual exclusion: mechanism to ensure that only one task at a time executes the code within a region.

Instructor Social Media

Youtube: Lucas Science



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