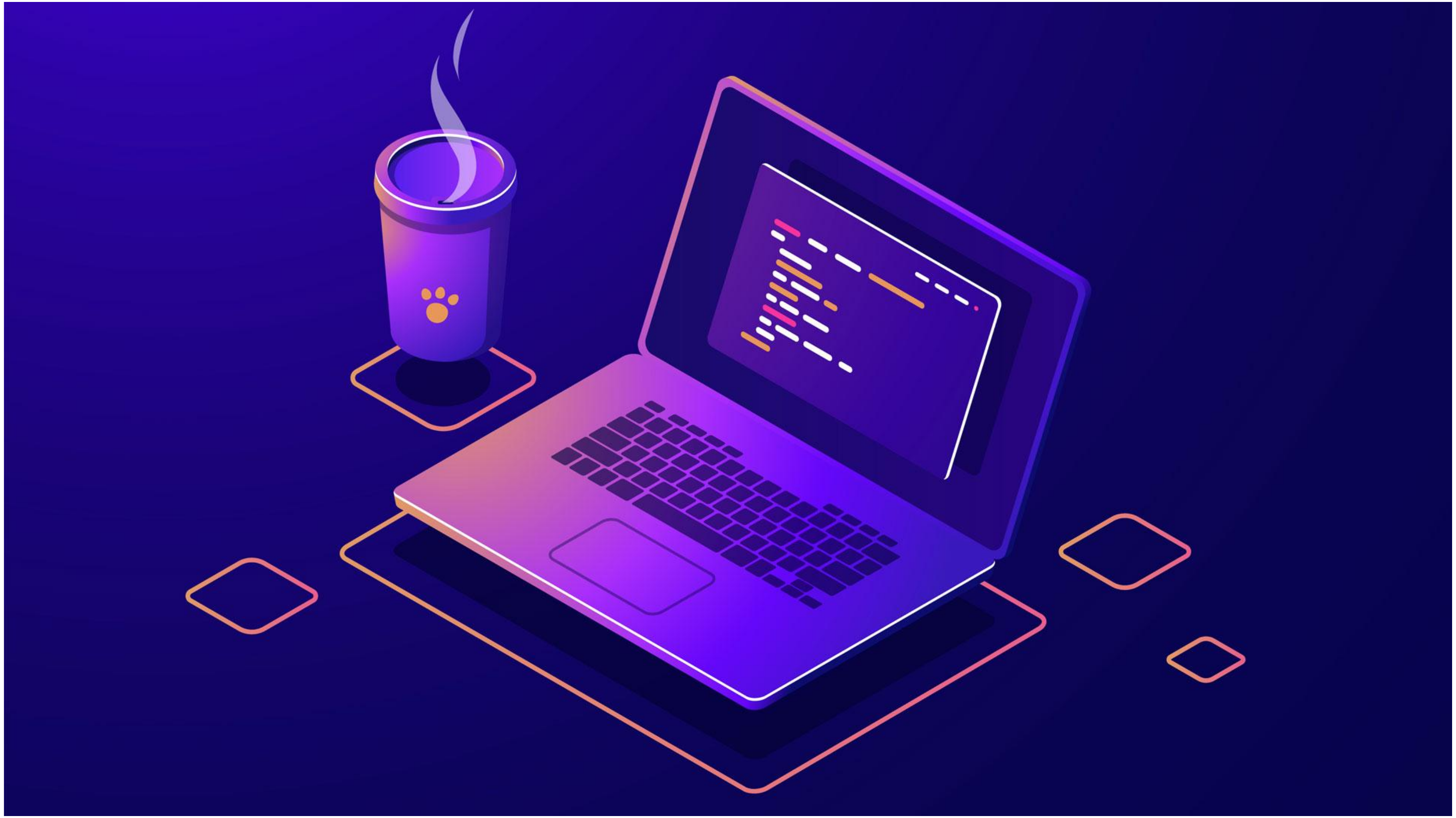
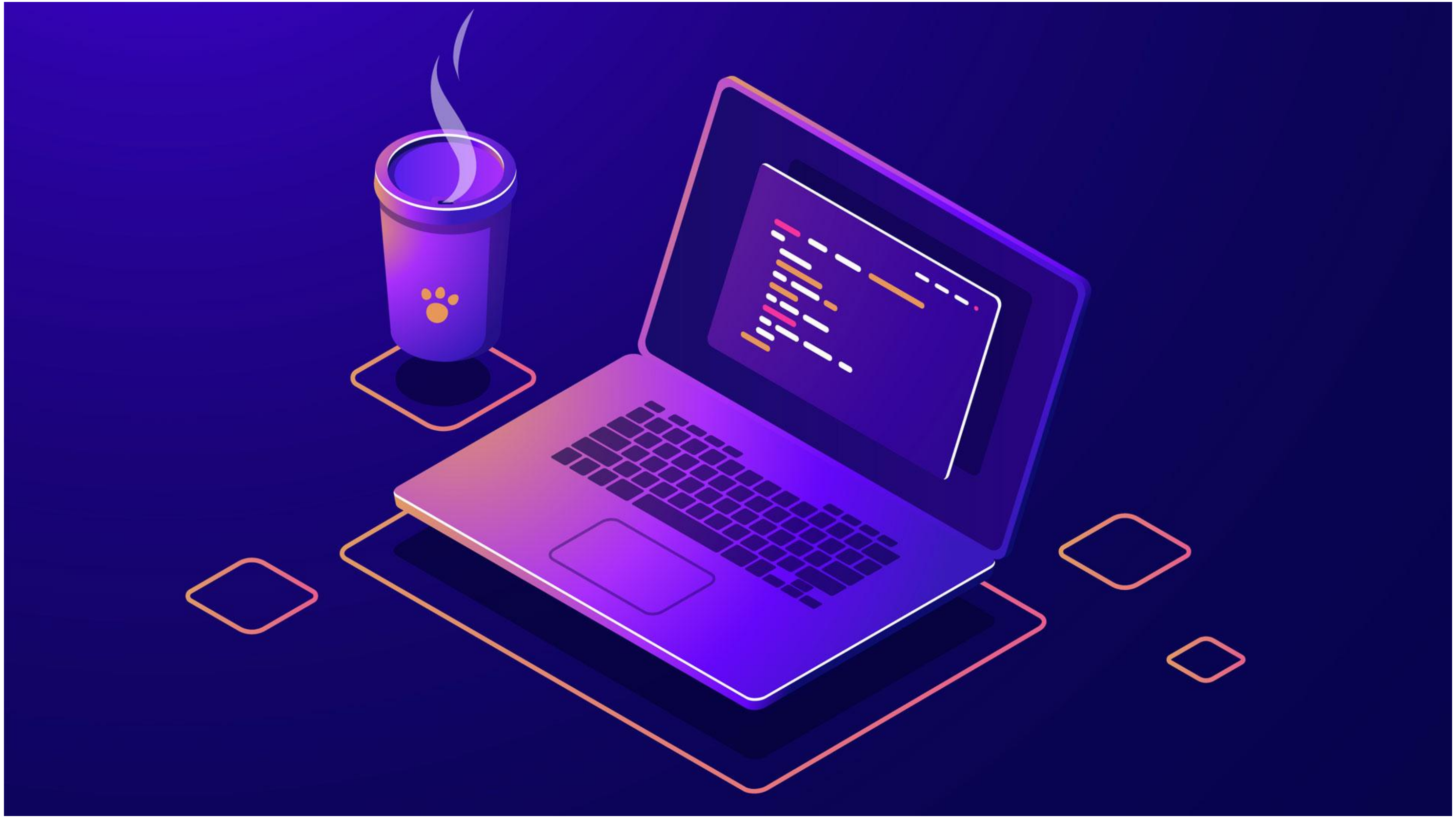
OpenMP Problems



Problem 2



Problem 2

The following sequential code in C finds all positions in vector `DBin` in which a set of keys (contained in vector keys) appear. Positions where keys appear are stored in a new vector `DBout` (the order in `DBout` of the positions found is irrelevant).

```
int main() {
    double keys[nkeys], DBin[DBsize], DBout[nkeys][DBsize];
    unsigned int i, k, counter[nkeys];

    getkeys(keys, nkeys);                   // get keys
    init_DBin(DBin, DBsize);                // initialize elements in DBin
    clear_DBout(DBout, nkeys, DBsize);      // initialize elements in DBout
    clear_counter(counter, nkeys);          // initialize counter to zero

    for (i = 0; i < DBsize; i++)
        for (k = 0; k < nkeys; k++)
            if (DBin[i] == keys[k]) DBout[k][counter[k]++] = i;
}
```

Problem 2

```
#define DBsize 1048576
#define nkeys 16 // the number of processors can be larger than the number of keys

 int main() {
     double keys[nkeys], DBin[DBsize], DBout[nkeys][DBsize];
     unsigned int i, k, counter[nkeys];

     getkeys(keys, nkeys);                   // get keys
     init_DBin(DBin, DBsize);                // initialize elements in DBin
     clear_DBout(DBout, nkeys, DBsize);      // initialize elements in DBout
     clear_counter(counter, nkeys);          // initialize counter to zero

     for (i = 0; i < DBsize; i++)
         for (k = 0; k < nkeys; k++)
             if (DBin[i] == keys[k]) DBout[k][counter[k]++] = i;
 }
```

Problem 2

(a) Write a first *OpenMP* parallelisation that implements an **iterative task decomposition strategy** of the outermost loop `i`, making use of the `taskloop` directive, in which you minimise the serialisation introduced by the synchronisation that you may introduce. **Note:** you are not allowed to change the structure of the two loops.

(b) Write a second *OpenMP* parallelisation that also implements an **iterative task decomposition strategy**, but this time applied to the innermost loop `k`, again making use of the `taskloop` directive, in which you maximise the parallelism that can be exploited. **Notes:** 1) `taskloop` has an implicit `taskgroup` synchronisation that you can omit with the `nogroup` clause; 2) observe that the number of keys is not large when compared to the possible number of processors to use; and 3) you are not allowed to change the structure of the two loops.

(c) Finally, write a third *OpenMP* parallelisation that implements a `task`–based **recursive divide–and–conquer decomposition strategy**, with the following requirements: 1) the recursion splits the input vector `DBin` in two almost identical halves, with a base case that corresponds to checking a single element of `DBin`; 2) uses a **cut–off strategy based on the size of the input vector**, so that tasks are only generated while that size is larger than `CUT_SIZE`; 3) only uses *OpenMP* pragmas and clauses for the implementation of the cut–off strategy; and 4) you have to use the synchronisation mechanism, if needed, that maximises the parallelism in the program.

Mutual Exclusion

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

Mutual Exclusion

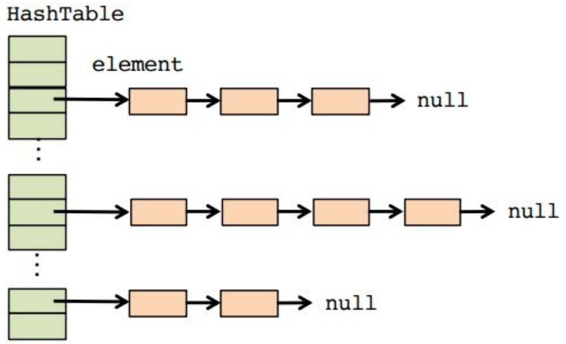
Associate a lock variable with each slot in the hash table, protecting the chain of elements in an slot

```
omp_lock_t hash_lock[SIZE_HASH];

#pragma omp parallel
#pragma omp single
{
for (i = 0; i < SIZE_HASH; i++) omp_init_lock(&hash_lock[i]);

#pragma omp taskloop
for (i = 0; i < SIZE_TABLE; i++) {
     int index = hash_function (dataTable[i], SIZE_HASH);
     omp_set_lock (&hash_lock[index]);
     insert_element (dataTable[i], index, HashTable);
     omp_unset_lock (&hash_lock[index]);
}

for (i = 0; i < SIZE_HASH; i++) omp_destroy_lock(&hash_lock[i]);
}
```



Threads may be inserting elements into the hash table in parallel, as long as these elements hash to different slots

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