Dynamic tasks in OpenMP

- OpenMP specification version 3.0 introduced a new feature called **tasking**. The 4.0 version and beyond significantly extended tasking. Tasks are generated dynamically in **recursive** structures or **while** loops.

- The **parallel** construct is the early version of tasks.

- In OpenMP, an **explicit task** is specified using the task directive. It defines the code associated with the task and its data environment. The task construct can be placed anywhere in the program; whenever a thread encounters a task construct, a new task is generated.
**Primitive tasks: parallel**

- The parallel construct creates/spawns tasks, one per thread.
- Each such task executes the same code, is assigned to a different thread, and become “tied” to that thread.
- The parallel construct may be nested. For this to work as intended:
  - The implementation must support nested parallelism
  - Teams of threads must be dynamically created

**Task Execution**

- When a thread encounters a task construct, it “spawns” a task to execute one instance of the region of that construct.
- It is assigned to one of the threads in the current team that may choose to execute it immediately or defer its execution until a later time.
- If task execution is deferred, then the runtime systems places it in a pool of active tasks.
- A thread that executes a task may be different from the thread that originally spawned it.
- Unless the task is “tied” to the thread that was initially assigned to it.
The task directive takes the following data attribute clauses that define the data environment of the task:

- `default (private | firstprivate | shared | none)`
- `private (list)`
- `firstprivate (list)`
- `shared (list)`

All references within a task to a variable listed in the `shared` clause refer to the variable with that same name known immediately prior to the task directive.

For each `private` and `firstprivate` variable, new storage is created and all references to the original variable in the lexical extent of the task construct are replaced by references to the new storage. A `firstprivate` variable is initialized with the value of the original variable at the moment the task is encountered.

The OMP parallel construct creates “implicit” tasks.

The OpenMP specification describes how the data-sharing attributes of variables referenced in parallel and task

The rules for how the default data-sharing attributes of variables are implicitly determined may not always be obvious. To avoid any surprises, it is recommended that the programmer explicitly scope all variables that are referenced in a task construct using the data sharing attribute clauses, rather than rely on the OpenMP implicit scoping rules.
The TASKWAIT Directive

The taskwait directive specifies a wait on the completion of children tasks generated since the beginning of the current (implicit or explicit) task.

The taskwait directive specifies a wait on the completion of direct children tasks, not all descendant tasks.

Example: `nfib`

```c
// nfib counts the number of nodes in the fib call tree
int nfib(long n) {
    long i, j;
    if (n<2) return 1;
    else {
        #pragma omp task shared(i)
        i=nfib(n-1);
        #pragma omp task shared(j)
        j=nfib(n-2);
        #pragma omp taskwait
        return i+j+1;
    } }
```
nfib’s main

```c
int main(int argc, char **argv) {
  ...
  #pragma omp parallel shared(n,v)
  {
    #pragma omp single
    v = nfib(n);
  }
  ...
}
```

create the pool of parallel threads executing the tasks

one thread executes the initial nfib(n) call

Number of tasks in nfib

- `#tasks nfib(n) = nfib(n)`

```
nfib(30) = 2,692,537
```

WAY too many tasks created

tasks do nothing but tasks creation

We need to prune the task tree
Pruning the task tree 1

```c
int nfib(long n) {
    long i, j;
    if (n<2) return 1;
    else {
        #pragma omp task shared(i) if (n>33)
        i=nfib(n-1);
        #pragma omp task shared(j) if (n>33)
        j=nfib(n-2);
        #pragma omp taskwait
        return i+j+1;
    }  }
```

Two tasks get spawned and the parent task does nothing!
Better if the parent task does one of the nfibs

Pruning the task tree 2

```c
int nfib(long n) {
    long i, j;
    if (n<2) return 1;
    else {
        #pragma omp task shared(i) if (n>33)
        i=nfib(n-1);
        j=nfib(n-2);
        #pragma omp taskwait
        return i+j+1;
    }  }
```