Open64 Workshop @ CGO '09

OpenMP 3.0 Tasking Implementation in OpenUH

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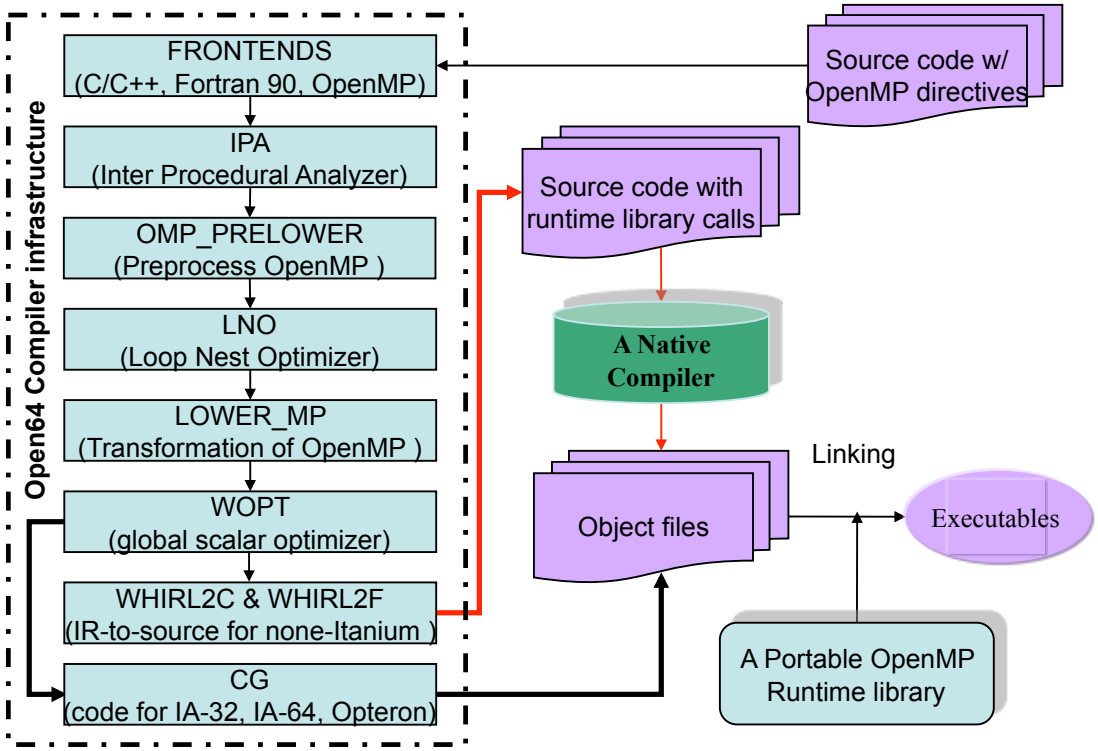
Outline

- OpenUH compiler
- OpenMP and new features
- Implementing OpenMP tasks in OpenUH
  - Methodology, Frontend, RTL, and Translation
- Results

OpenUH Compiler

- OpenUH is an Open64-based open source compiler suite
- C, C++, Fortran 77/90/95
- OpenMP 2.5 compliant



Projects with OpenUH in HPCTools Group

- OpenMP 3.0 and extensions
- OpenMP Collector API
- Performance tools integration
- Parallel DFA
- Co-Array Fortran
- UPC
- Embedded OpenMP

OpenMP

- *De facto* standard for shared-memory programming
- C, C++, Fortran
- Directives, runtime library, & env. variables
- Gaining acceptance in multicore era
- Easy to incrementally add parallelism to existing code

OpenMP

```
<initialize data>


for(i = 0; i < n; ++i)
{
   <do work here>
}
```

OpenMP

```
#pragma omp parallel
{
   <initialize data>

   #pragma omp for schedule(static,n/2)
   for(i = 0; i < n; ++i)
   {
      <do work here>
   }
}
```

OpenMP 3.0

- *Tasks*
- Loop construct changes
  - allow collapsing of perfectly nested loops
  - enhanced schedules
- Improved nested parallelism support
- Improved C++ support
- Other
  - stack size control, idle thread control

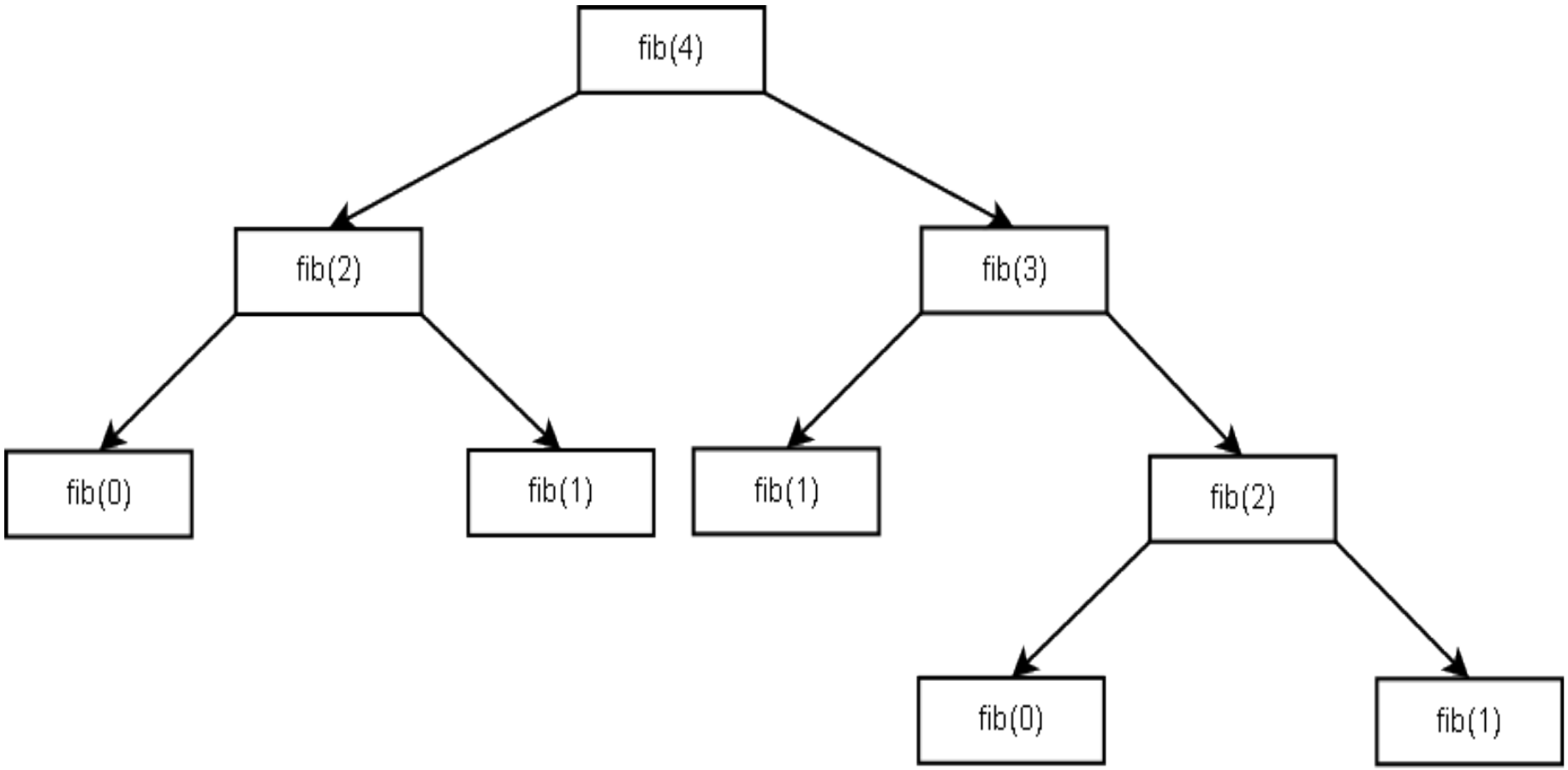
OpenMP Tasks

- Simplifies parallelization of irregular algs.
  - recursion, ptr-based data structures
- OpenMP 3.0 – adds explicit tasks + sync
- A task executes at some future time
  - Execution can be tied to a thread or stolen by another
  - Execution can be suspended
- A task construct can appear anywhere
- Sync with **`taskwait`**

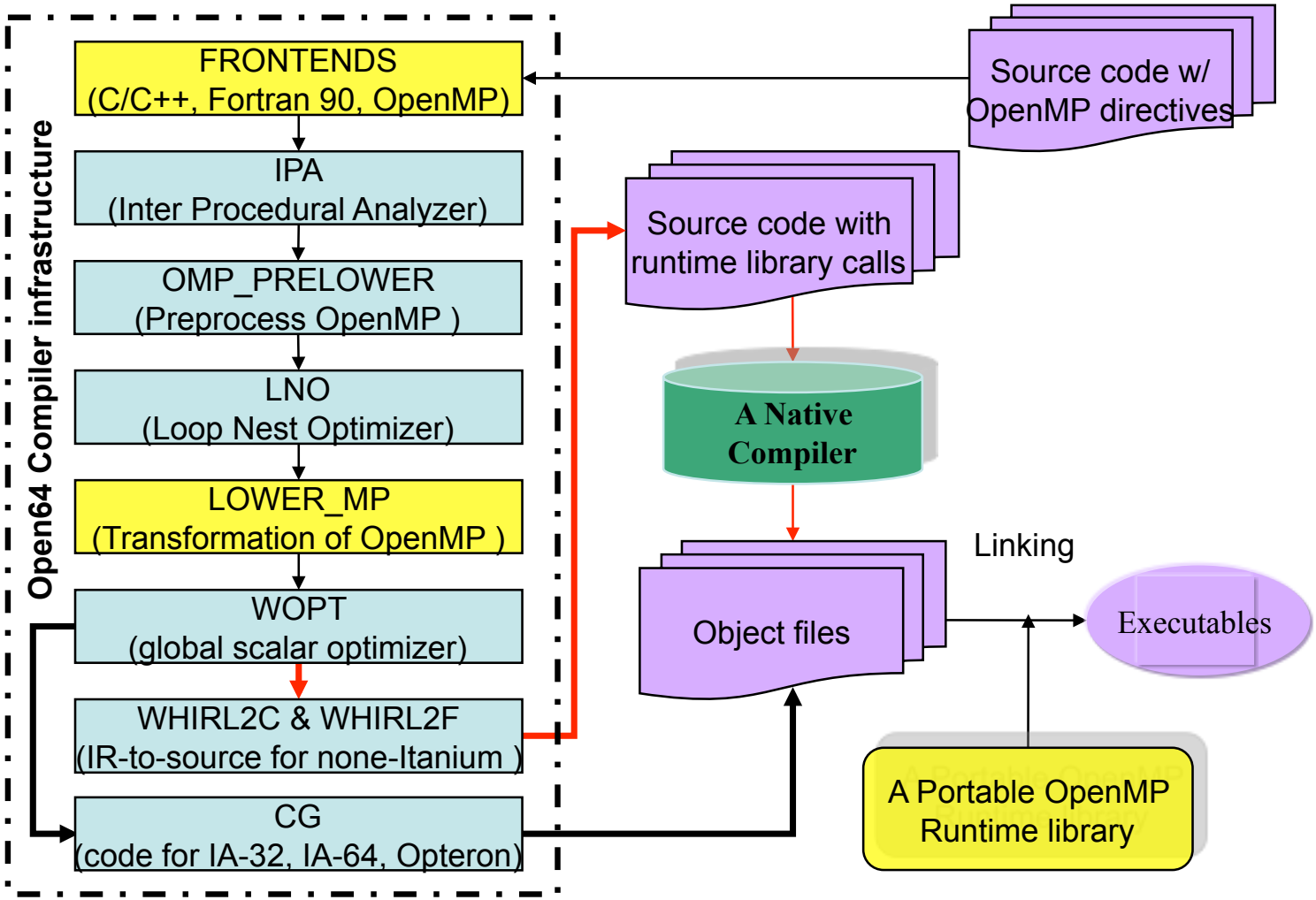
OpenMP Tasks

```
int fib(int n) {
    int x, y;
    if (n < 2)
      return n;
    else {
        #pragma omp task shared(x)
            x = fib(n - 1);
        #pragma omp task shared(y)
            y = fib(n - 2);
        #pragma omp taskwait
            return x + y;
    }
}
```

Fibonacci Task Graph



OpenMP in OpenUH



Frontend

- C/C++
  - Uses GCC 3.3 frontend
  - Extended to fully support OpenMP tasks
- Fortran
  - Cray fe90 frontend
  - In progress

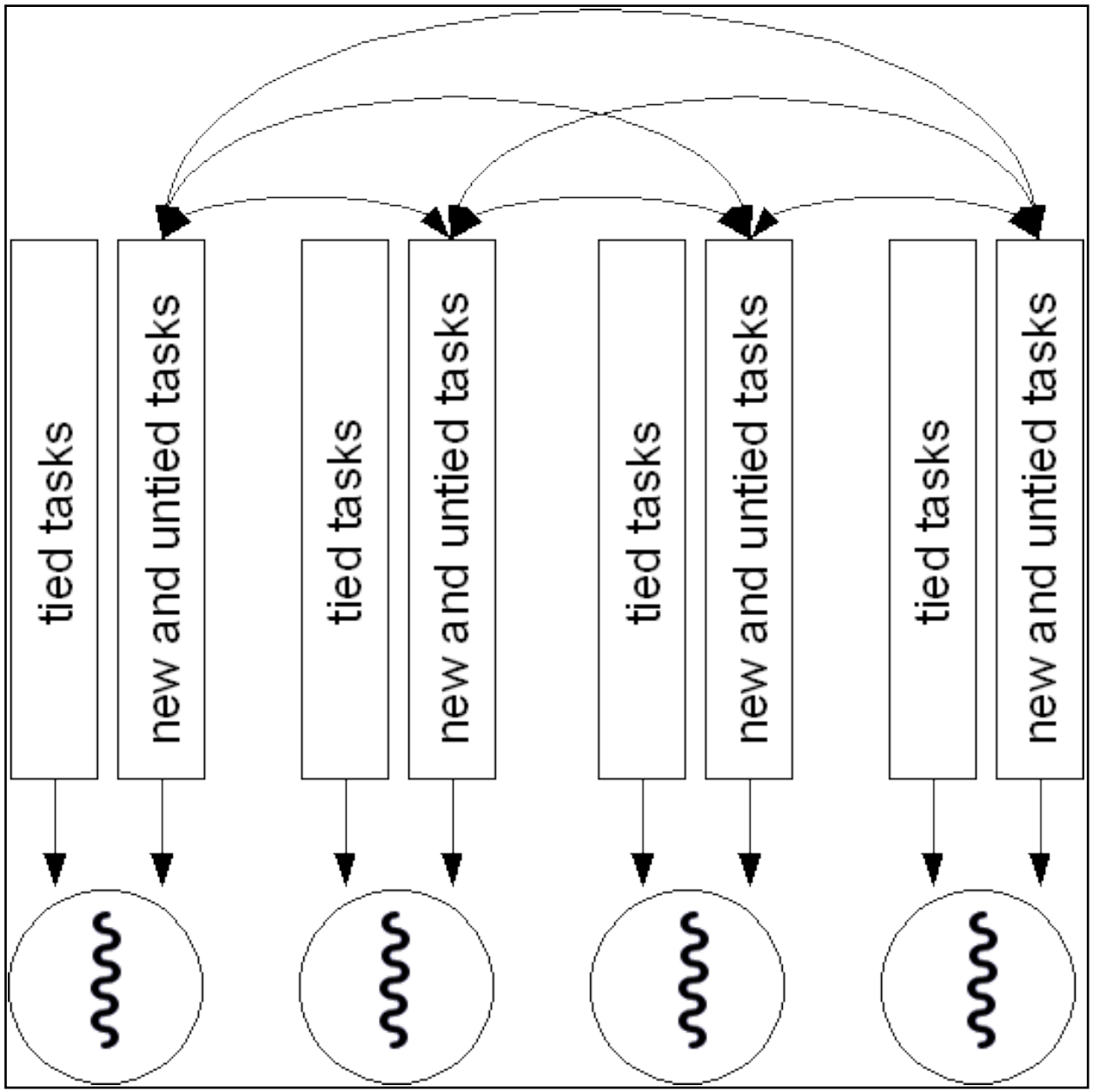
OpenUH does not yet support GCC 4.2 F.E.

```
REGION 1 (kind=4)
 REGION EXITS
  BLOCK
  END_BLOCK
 REGION PRAGMAS
  BLOCK
  PRAGMA 2 184 <null-st> 0 (0x0) # BEGIN_TASK
  PRAGMA 2 187 <null-st> 0 (0x0) # UNTIED
  PRAGMA 2 54 <2,2,x> 0 (0x0) # SHARED
  END_BLOCK
 REGION BODY
  BLOCK
 LOC 1 7
    BLOCK
       I4I4LDID 0 <2,1,n> T<4,.predf_I4,4>
       I4INTCONST -1 (0xffffffffffffffff)
      I4ADD
     I4PARM 2 T<4,.predef_I4,4> #  by_value
    I4CALL 126 <1,41,fib> # flags 0x7e
    END_BLOCK
    I4I4LDID -1 <1,40,.preg_return_val> T<4,.predef_I4,4>
   I4COMMA
  I4STID 0 <2,2,x> T<4,.predef_I4,4>
  END_BLOCK
 END_REGION 1
```

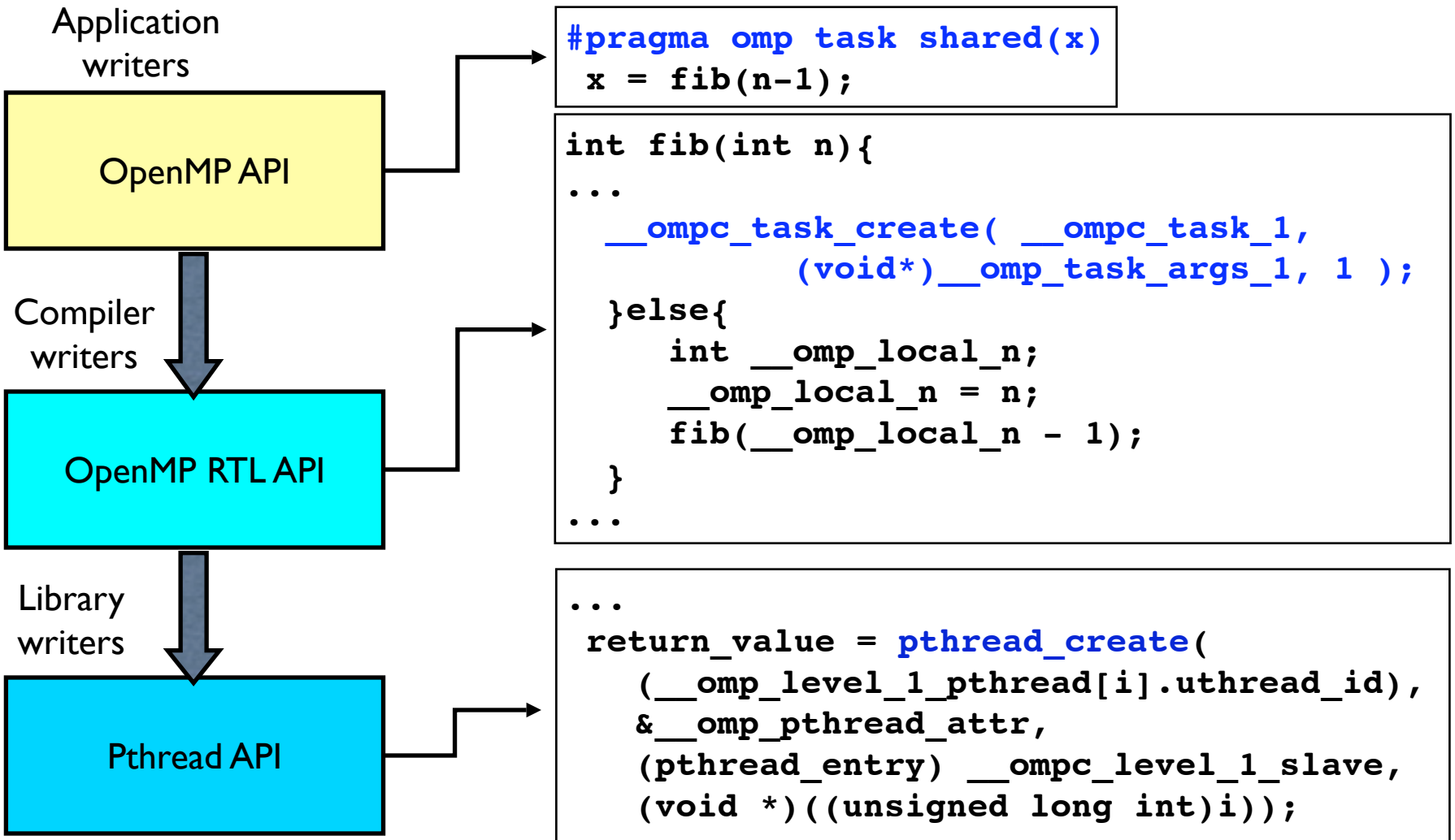
Tasking Runtime

- Task Scheduling
  - distributed, work-stealing scheduler
  - breadth-first creation, depth-first execution
- Task Synchronization
  - **`taskwait`** and **`barrier`**
- Task Switching
  - Portable Coroutines Library
    - setjump/longjmp or ucontext

Task Queues in OpenUH



Role of OpenMP Runtime



Translation Methodology

- Decide on (manual) translation of construct
- Implement runtime with selected translation
  - Test & evaluate
- Modify front ends
- Implement translation
- Test, evaluate, & improve

Translation of Tasks

```
struct omp_task_1_args_ty{
    int n;
    int *x;
};

void __ompc_task_1(void *fp){
  struct omp_task_1_args_ty *args;
  int n, *x;

  args = (struct omp_task_1_args_ty *)fp;
  n = args->n;
  x = args->x;
  *x = fib( n - 1 );
  __ompc_task_exit();
}
```

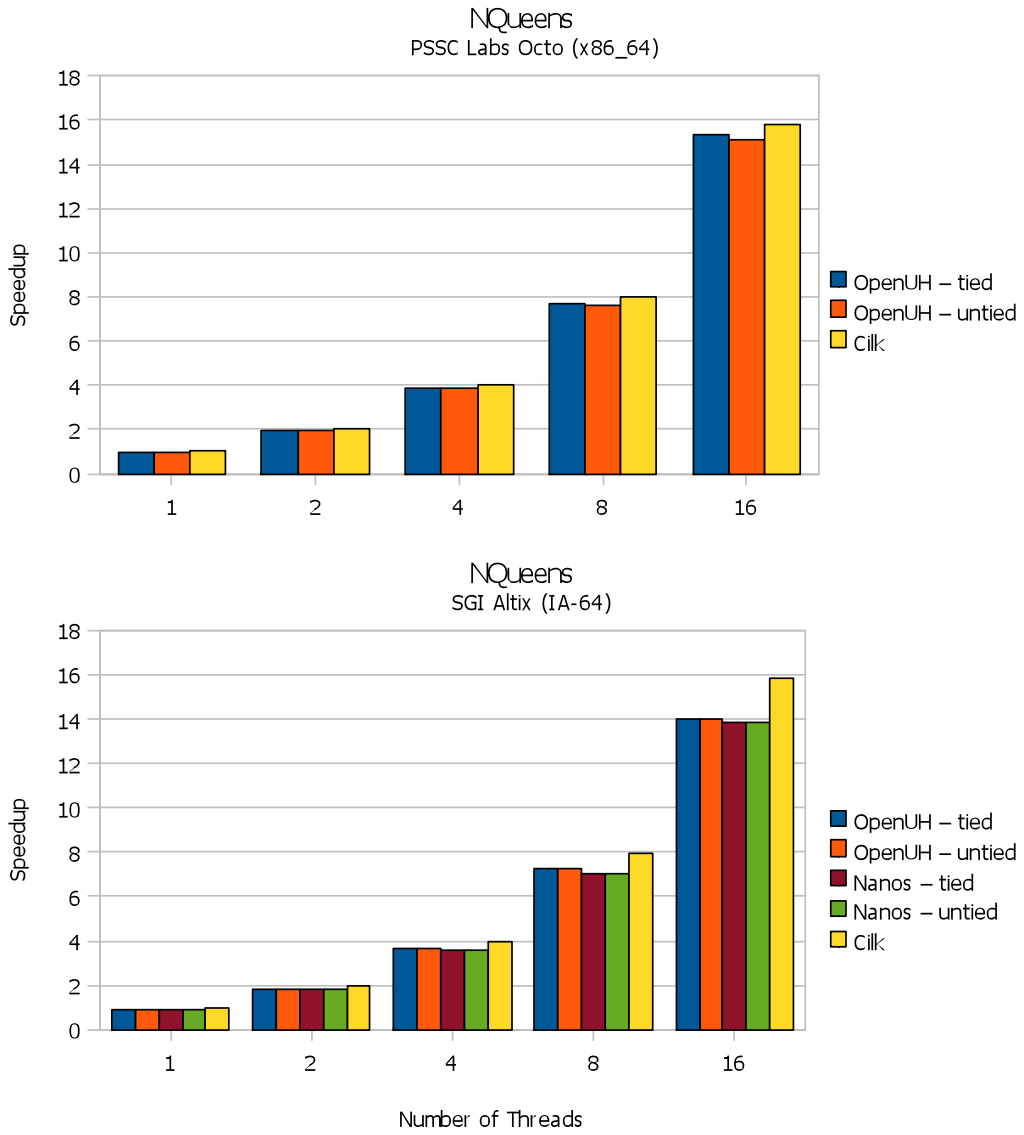
Translation of Tasks

```
int fib(int n){
  int x, y, sum;
  if (n < 2)
     return n;

  if (__ompc_task_create_cond() ){
     struct omp_task_1_args_ty *__omp_task_args_1;
     __omp_task_args_1 =
              malloc( sizeof(struct omp_task_1_args_ty));
     __omp_task_args_1 -> n = n;
     __omp_task_args_1 -> x = &x;
     __ompc_task_create( __ompc_task_1,
                         (void*)__omp_task_args_1, 1 );
  }else{
     int __omp_local_n;
     __omp_local_n = n;
     fib(__omp_local_n - 1);
  }
  .....
  __ompc_task_wait();
  return x + y;
}
```

Results

- NQueens, Multisort, SparseLU, Strassen
- Compared to
  - Cilk 5.4.6
  - Nanos 4.2 (src2src)



Thank you!

- Questions???