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# Surveying On-Node Task Runtimes Towards a New Tasking Mini-App

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## What is Tasking?

- Define units of serial work (tasks) of an application and dependencies among the tasks
- Problem-centric decomposition vs. data-centric (SPMD)

## On-Node

- Tasks do not migrate across nodes
- Tasks coordinate with MPI to communicate with other nodes
- Further decompose the domain of an MPI rank and assign tasks to the second-level decomposition

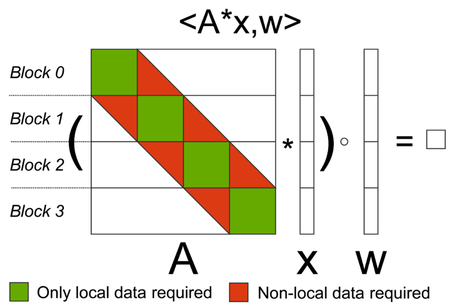
## Why use tasks?

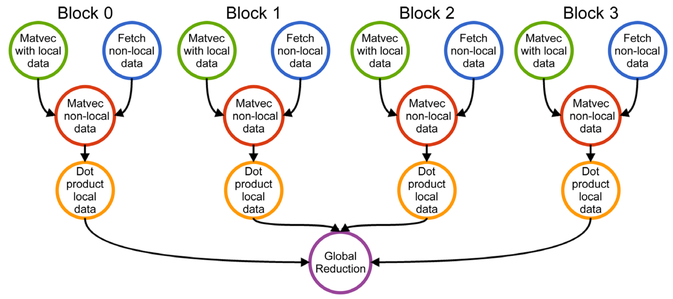
- Separates exposing parallelism (programmer) and mapping parallelism onto the architecture (runtime)
- Transparently adjust to the level of concurrency on the node, including heterogeneous accelerators
- Load balancing is natural by migrating tasks

## Primary Challenges

- How to express and submit tasks?
  - fork/join
  - Dynamic Task Graph
- How to encode dependencies?
  - Dataflow: inferred from task access mode to data
  - Control flow: barriers, sync, futures

## Modern Runtimes Example




### OpenMP[1]

```
#pragma omp parallel{
   #pragma omp master{
      for(int i = 0; i < num_blocks; ++i){
                start = i * block_size;

  #pragma omp task depend(out:x_externals[i])
                fetch_externals(A_external[i],
                                x_externals[i]);

  #pragma omp task depend(out:y[start:block_size])
                local_matvec(A_local[i], x_local[i],
                             &y[start]);

  #pragma omp task depend(in: y[start:size], x_externals[i])
                matvec_with_externals(A_external[i],
                                      x_externals[i]);

  #pragma omp task depend(in:y[start:size], w[start:size]) \
                   depend(out:local_sums[i])
                local_dot_product(&y[start], &w[start],
                                  &local_sums[i]);
       }
  #pragma omp task in(local_sums[0:num_blocks])
           global_reduction(local_sums[]);
    }}
```

### Cilk Plus[2]

```
block_function(int i){
    cilk_spawn fetch_externals(A_external[i], x_external[i]);
    cilk_spawn local_matvec(A_local[i], x_local[i], &y[start]);
    cilk_sync;
    cilk_spawn matvec_with_externals(A_external[i],
                                     x_externals[i]);
    cilk_sync;
    local_dot_product(&y[start], &w[start], &local_sums[i]);
    //implicit sync
}

cilk_for (int i = 0; i < num_blocks; ++i){
    block_function(i);
}
cilk_sync;
global_reduction(local_sums[]);
```

## **miniFutures**: A new task-based mini-application

- Proxy for unstructured finite element method
  - Discretization, element analysis, assembly
  - Pre-conditioned conjugate gradient solver
    - Gauss-Seidel pre-conditioner
- Runtime agnostic
  - Goal is to evaluate modern runtimes
  - Study how to design future task-based applications

[1] http://openmp.org/wp/
[2] https://www.cilkplus.org/

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