Intel Threading Building Blocks (TBB)
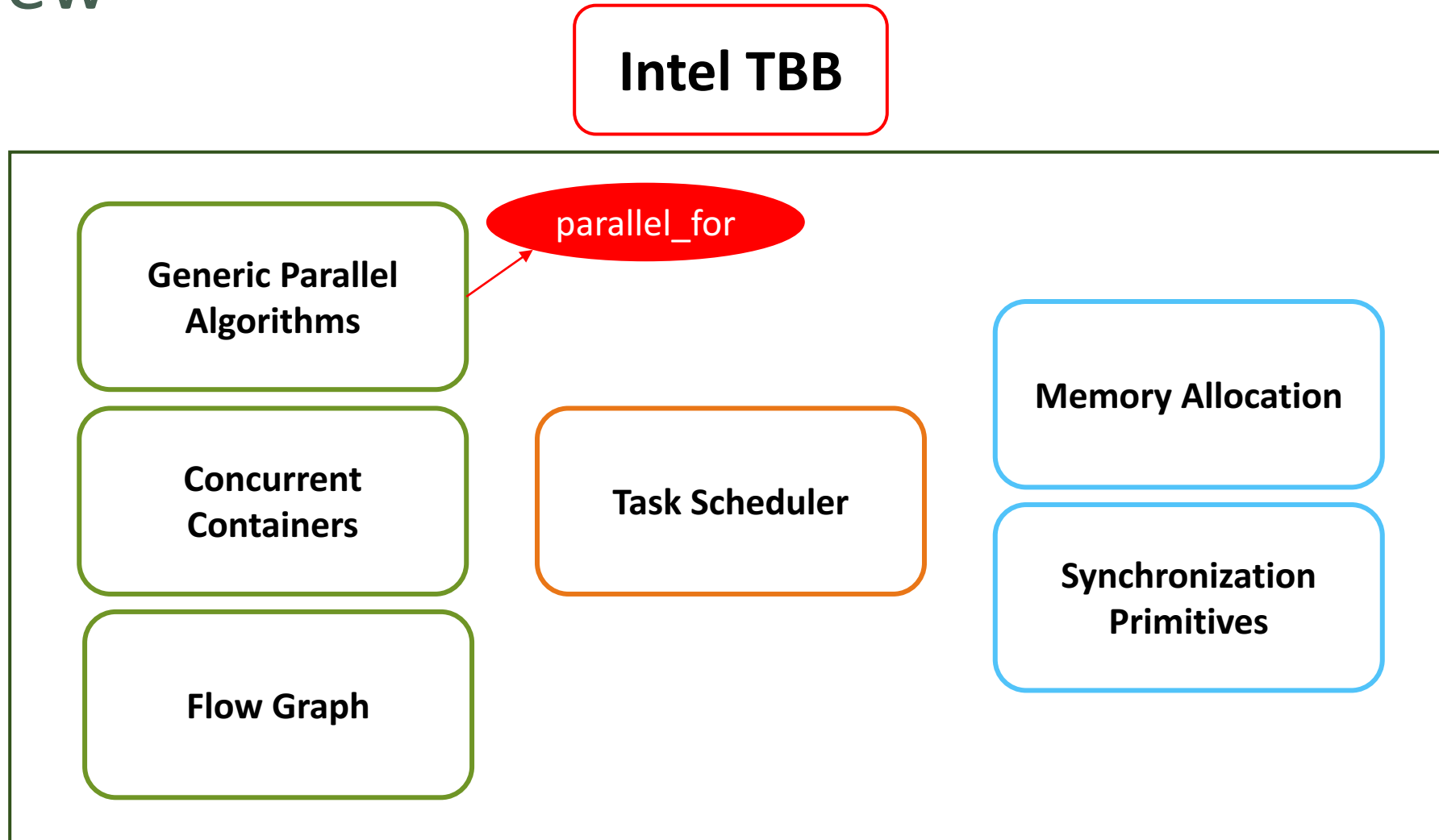
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UTK CS462 project

What is TBB?

- TBB is a library that supports scalable parallel programming using standard C++ code.
  - Specify logical parallelism instead of threads
  - Target threading for robust performance
  - Emphasize on scalable, data-parallel programming
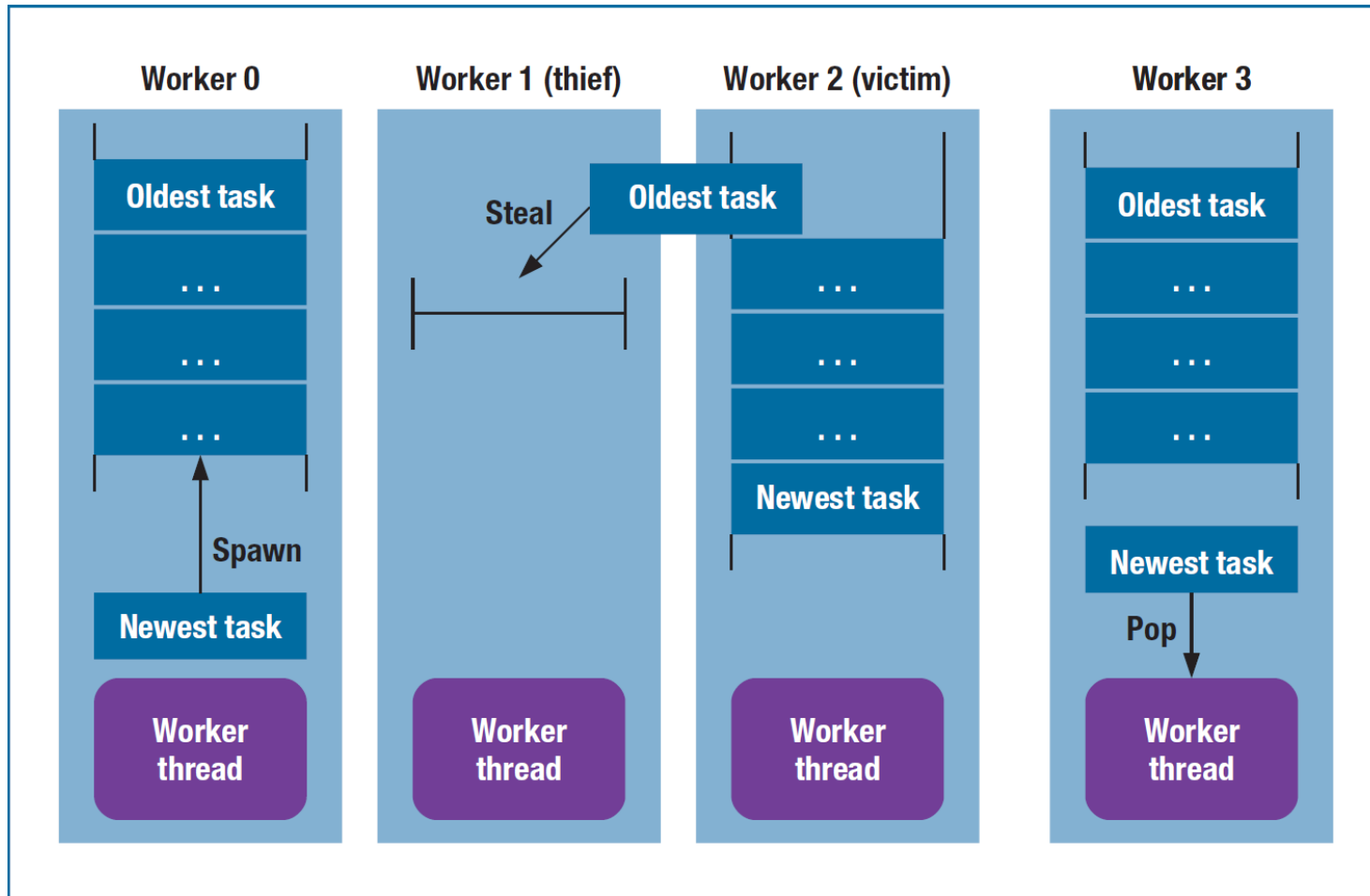 - Shared memory
  - Portable and open source

Overview

Intel TBB

Generic Parallel Algorithms

parallel_for

Concurrent Containers

Task Scheduler

Memory Allocation

Flow Graph

Synchronization Primitives

Code Example

Parallel code:

```
#include "tbb/tbb.h"
using namespace tbb;
class ApplyFoo {
        float *const my_a;
public:
        void operator() ( const blocked_range<size_t>& range ) const {
                float *a = my_a;
                for( size_t i = range.begin(); i!= range.end(); ++i )
                        Foo(a[i]);
        }
        ApplyFoo( float a[] ) :  my_a(a) {}
};

void ParallelApplyFoo( float a[], size_t n ) {
        parallel_for ( blocked_range<size_t>(0,n),  ApplyFoo(a) );
}
```
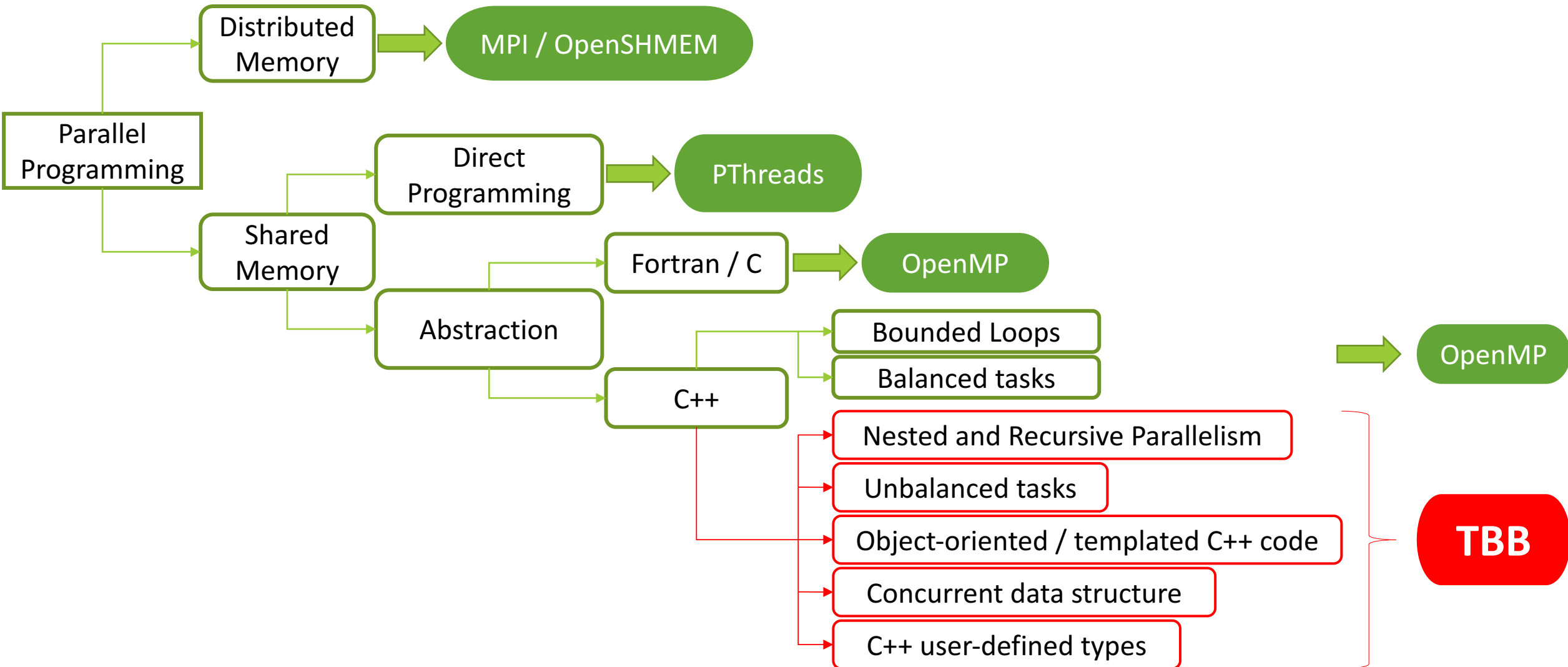
Body object

Sequential code:

```
void SerialApplyFoo( float a[ ], size_t  n) {
        for( size_t  i=0;  i!=n;  ++i)
                Foo(a[i]);
}
```

Sample node from: https://software.intel.com/en-us/node/506057

Dynamic Task Scheduler – *Task Stealing*

(Kim and Voss, 2011)

Is TBB right for you?

TBB vs. OpenMP Performance

Matrix Multiplication (8 cores)

(Ali et al., 2012)

Fibonacci 47 (cutoff 2048)

(Tousimojarad and Vanderbauwhede, 2014)
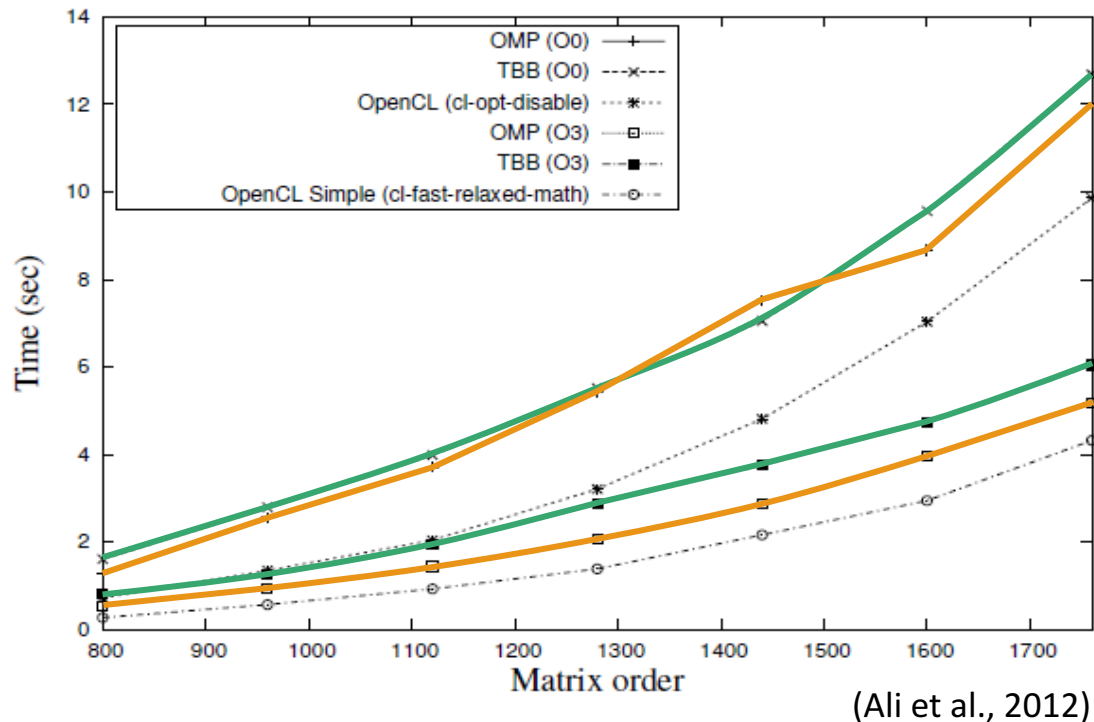
Fixed number of loop iterations
Equally distributed tasks ➡ **OpenMP**
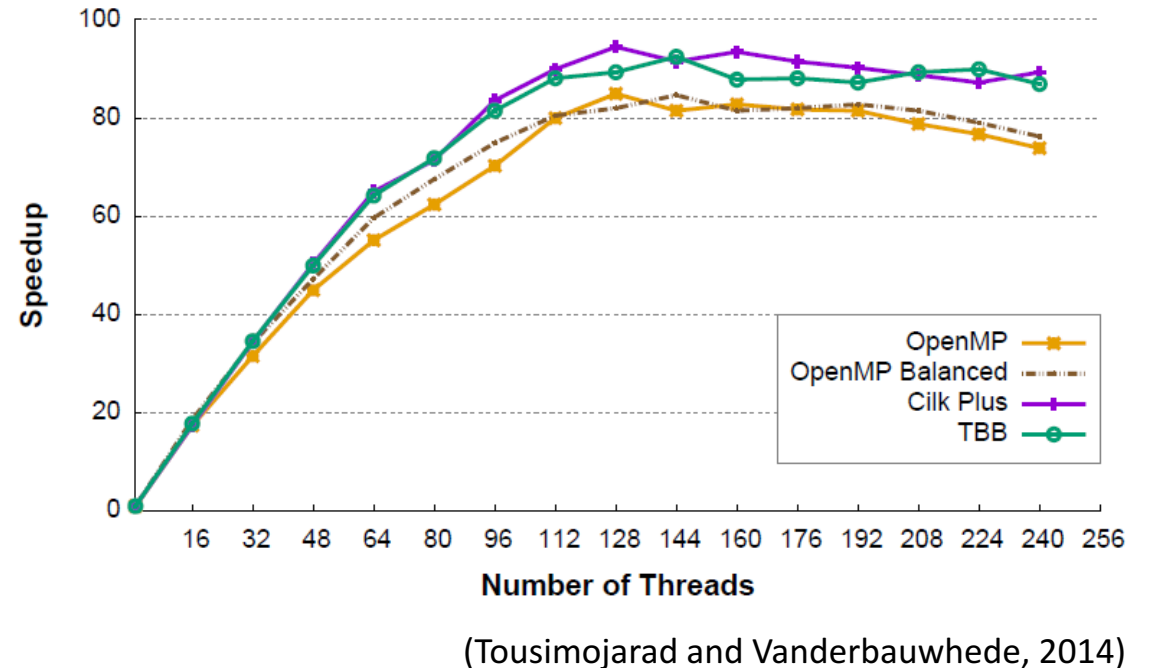
Nested and Recursive Parallelism
Unbalanced tasks ➡ **TBB**

More information:

- Tutorial:
  - https://www.threadingbuildingblocks.org/docs/help/index.htm#reference/threads.html
  - https://www.threadingbuildingblocks.org/intel-tbb-tutorial
  - Reinders, James. *Intel threading building blocks: outfitting C++ for multi-core processor parallelism*. " O'Reilly Media, Inc.", 2007.
- Concise introduction:
  - Kim, Wooyoung, and Michael Voss. "Multicore desktop programming with intel threading building blocks." *IEEE software* 28.1 (2011): 23-31.
  - http://www.cs.cmu.edu/afs/cs/academic/class/15499-s09/www/handouts/TBB-HPCC07.pdf
- Performance test:
  - Ali, Akhtar, Usman Dastgeer, and Christoph Kessler. "OpenCL for programming shared memory multicore CPUs." *Proceedings of the 5th Workshop on MULTIPROG*. 2012.
  - Tousimojarad, Ashkan, and Wim Vanderbauwhede. "Comparison of Three Popular Parallel Programming Models on the Intel Xeon Phi." *Euro-Par Workshops (2)*. 2014.
- Task Scheduling optimization:
  - Robison, Arch, Michael Voss, and Alexey Kukanov. "Optimization via reflection on work stealing in TBB." *Parallel and Distributed Processing, 2008. IPDPS 2008. IEEE International Symposium on*. IEEE, 2008.
  - Contreras, Gilberto, and Margaret Martonosi. "Characterizing and improving the performance of intel threading building blocks." *Workload Characterization, 2008. IISWC 2008. IEEE International Symposium on*. IEEE, 2008.