Hybrid parallism on BG/Q with OpenMP

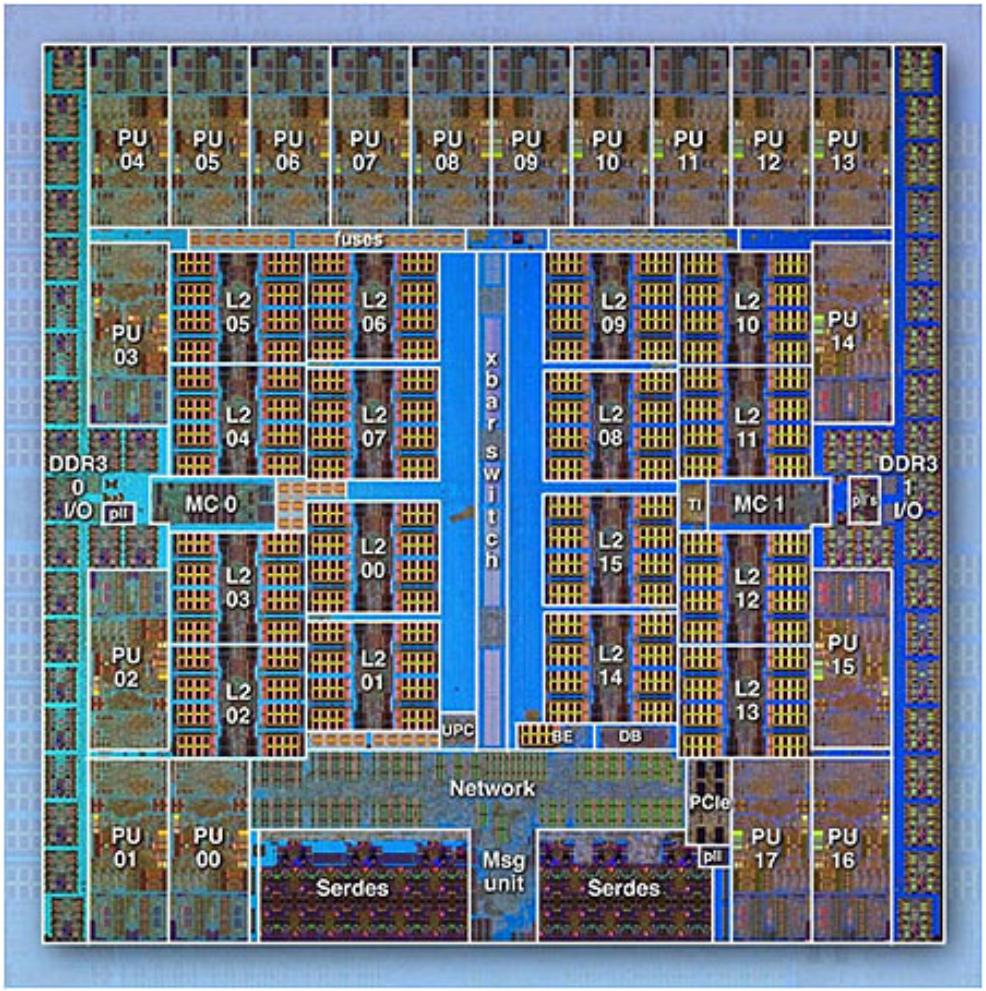
February 3, 2014 | T. Hater | EIC

Outline

- BG/Q hardware
- Shared memory parallelism
- OpenMP tutorial
- Hints for optimization
- BG/Q specific OpenMP topics

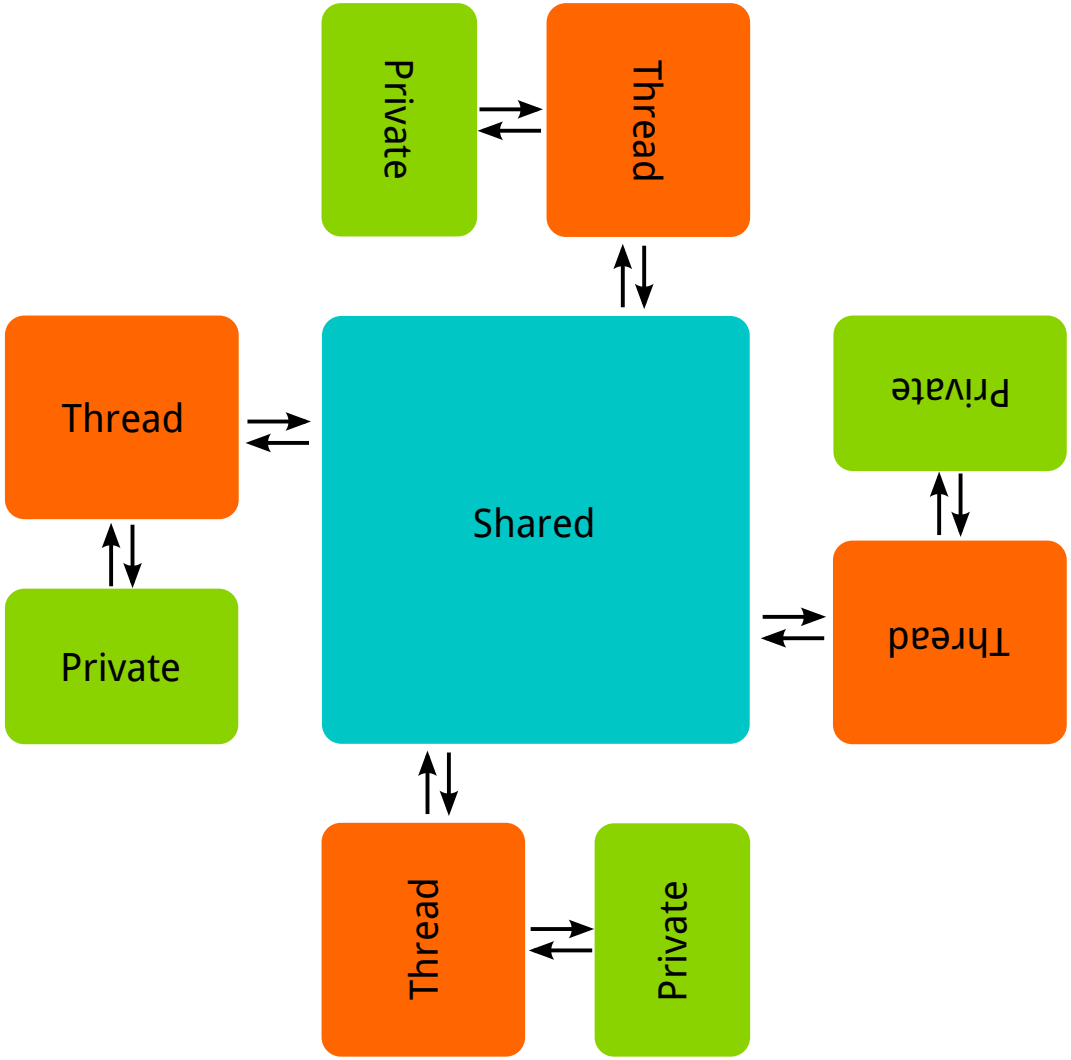
Motivation

The BG/Q Compute Chip



- SoC
- $1.6\,GHz$ in-order
- 16×4 threads
- 2 pipelines
- 200 $GFlop/s$
- 30 GB/s (42 GB/s)

Symmetric multiprocessing



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- Supported by most major compilers
- Platform independent
- Supports FORTRAN, C, C++
- Annotation based
  - Non-invasive
  - Incremental
  - Low development overhead

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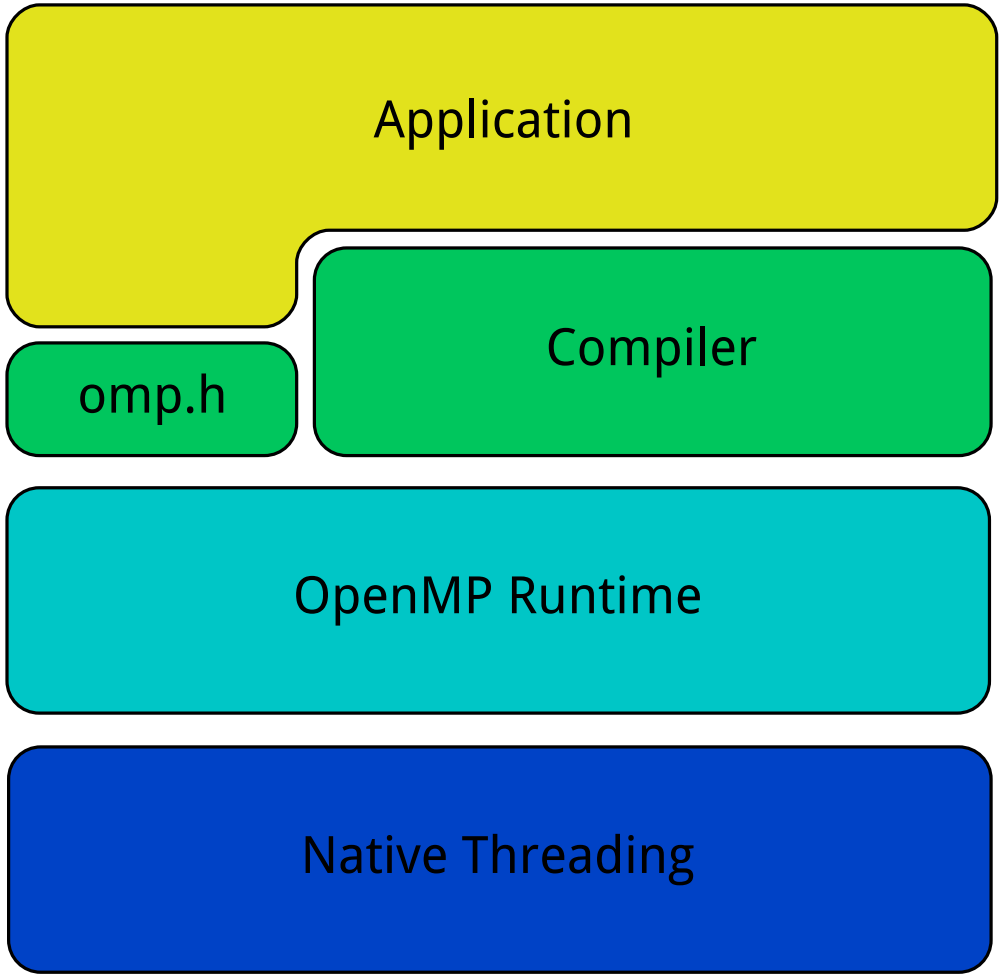
- Compiler generates calls to OMP runtime
- Runtime abstracts native threading
- Abstracts shared memory parallelism
  - False sharing
  - Race conditions

Organization



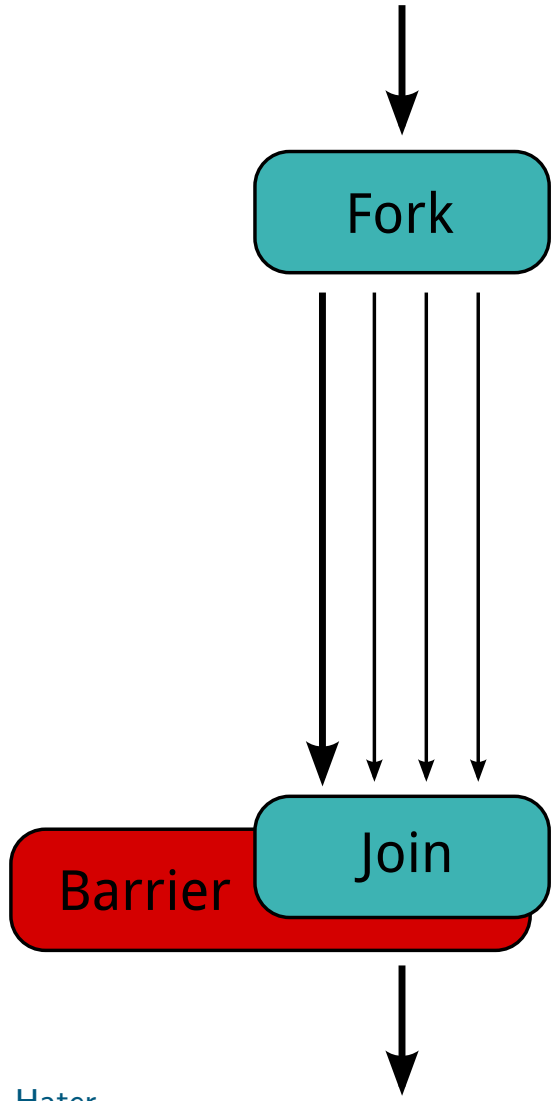
How do I parallelize my code?

1. Indentify bottleneck
2. Annotate hotspot
3. Profile for gains
4. Goto 1

OpenMP Introduction

The parallel region

```
#pragma omp parallel
{
   /* ... */
}
```

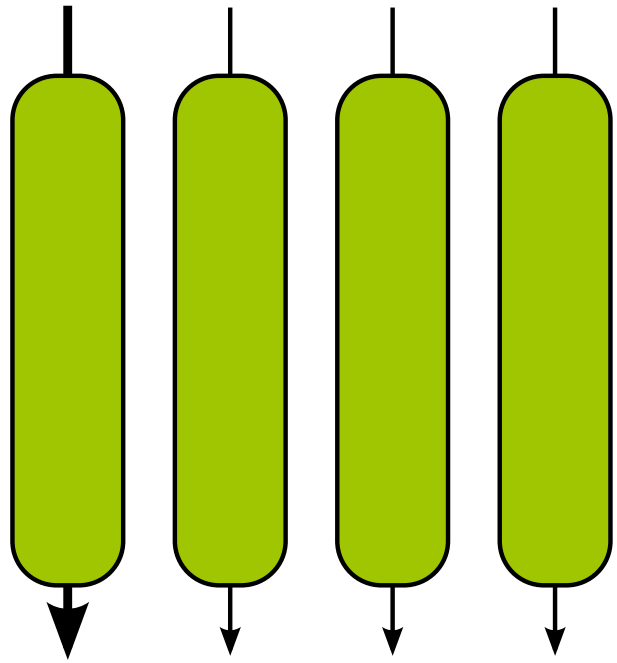


OpenMP Clauses

- Modify OpenMP statements
  `#pragma omp statement clause1(arg1,...)`
- Example: variable scope
  `shared/private(x,y,...)`
  `default(shared/private/...)`
- More available, depending on construct

The parallel loop

```
#pragma omp for
for(i = 1; i <= N; ++i)
{
   /* ... */
}
```



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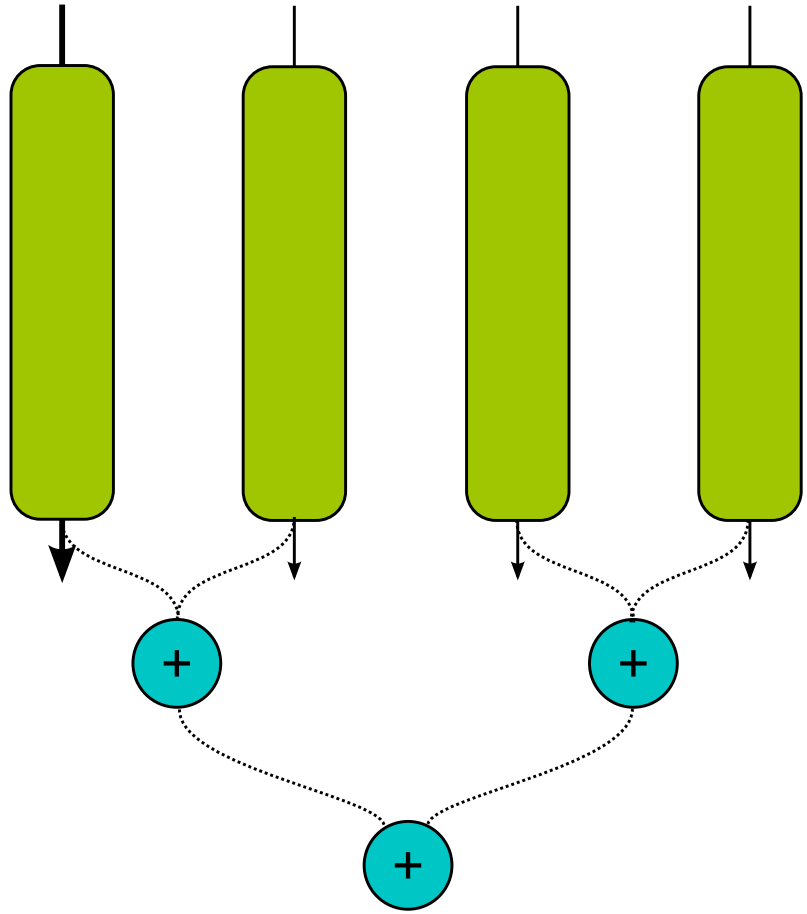
Reduction

```
#pragma omp for reduction(+:c)
for(i = 0; i < N; ++i)
{
   c += a[i]
}
```



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  Each idle thread picks up a new chunk.
- If threads start at different times: `guided`.
  Like `dynamic`, but chunk size decreases exponentially.

Limiting parallelism

```
#pragma omp parallel
{
  #pragma omp single
  {
    // Arbitrary, but unique thread
  } // Barrier

  #pragma omp master
  {
    // Master thread
  } // No barrier
}
```

Ordering threads

```
#pragma omp parallel
{
  #pragma omp critical
  {
    // One thread at a time, arbitrary order
  } // Barrier

  #pragma omp atomic read|write|update|capture
    // Atomic access to memory
}
```

Sections

Static worksharing

```
#pragma omp sections
{
  #pragma omp section
  {
     // Thread 1
  }
  #pragma omp section
  {
     // Thread 2
  }
}
```

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- `#pragma omp taskwait` waits for all sibling tasks.

Optimizing OpenMP

Fork/Join

- Fork/Join take time.
- May combine multiple regions.

```
#pragma omp parallel for
for(i=0; i<n; ++i) a[i] = 2*b[i];
c = 0;
#pragma omp parallel for reduction(+: c)
for(i=0; i<n; ++i) c += a[i];
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Fork/Join

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- Combine multiple regions into one to amortize

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- **But:** correctness comes first. Be careful.

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- Either number of iterations or effort per iteration
- If workload varies: try to tune `schedule`

OpenMP on BG/Q

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- Automatically parallelizes on top of OpenMP if given `-qsmp`

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- No nested OpenMP

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- Waiting threads go to sleep.
- Thread local storage using
  `#pragma ibm threadlocal`
- For hard to parallelize loops: speculation & TM (later talk)

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Rule of thumb

$100\mu s$ for tasks, $10\mu s$ for loops and $1\mu s$ everything else.

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- Do not use `strict` math for reductions

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- Compile with `-qsmp`
- The rest *should* happen automagically

Closing words

- Extremely fast and incomplete introduction to OpenMP.
- Deceptively easy looking!
- We did not talk about memory consistency.
- On JUQUEEN you *must* go hybrid.

Resources

- XL compiler manuals
  `http://pic.dhe.ibm.com/infocenter/compbg/v121v141/`
- OpenMP standard
  `http://www.openmp.org/mp-documents/OpenMP3.1.pdf`
- OpenMP overview card
  `http://openmp.org/mp-documents/`
  `OpenMP3.1-CCard.pdf`
  `OpenMP3.1-FortranCard.pdf`