Is the Intel Xeon Phi right for me?

Fei Mao
SHARCNET

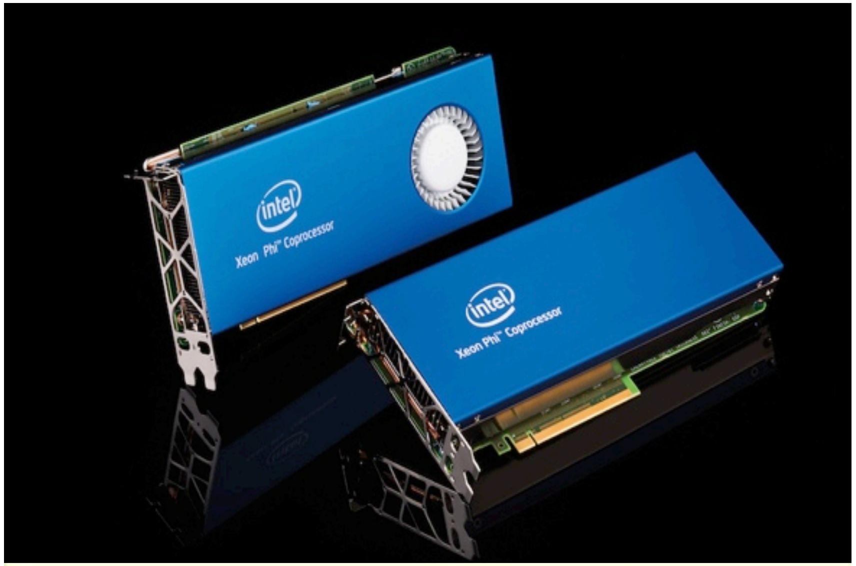
E-mail: feimao@sharcnet.ca

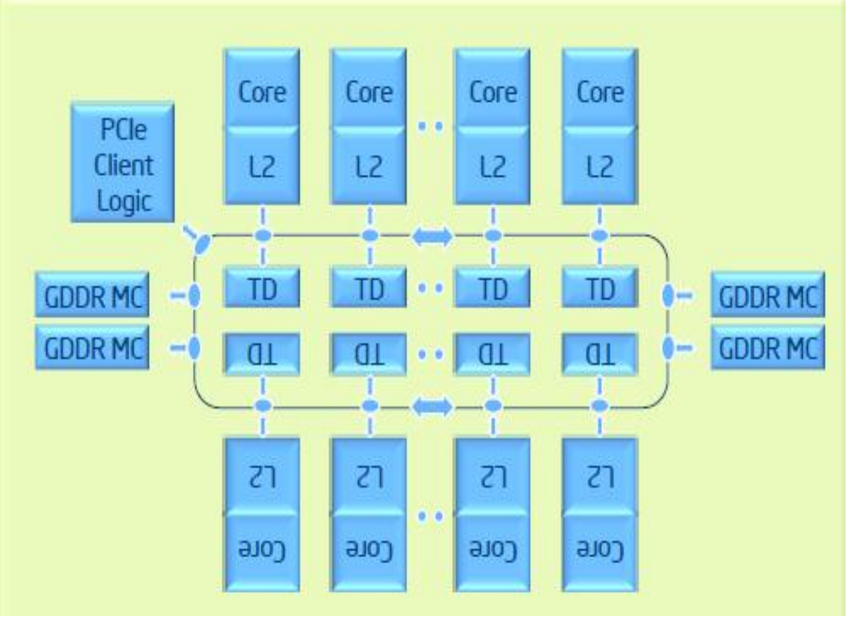
List of Topics:

- What is Xeon Phi?
- Hardware matters!
- Recompile and run?
- Simple codes and benchmarks
- Phi? CPU? GPU?

What is Xeon Phi?

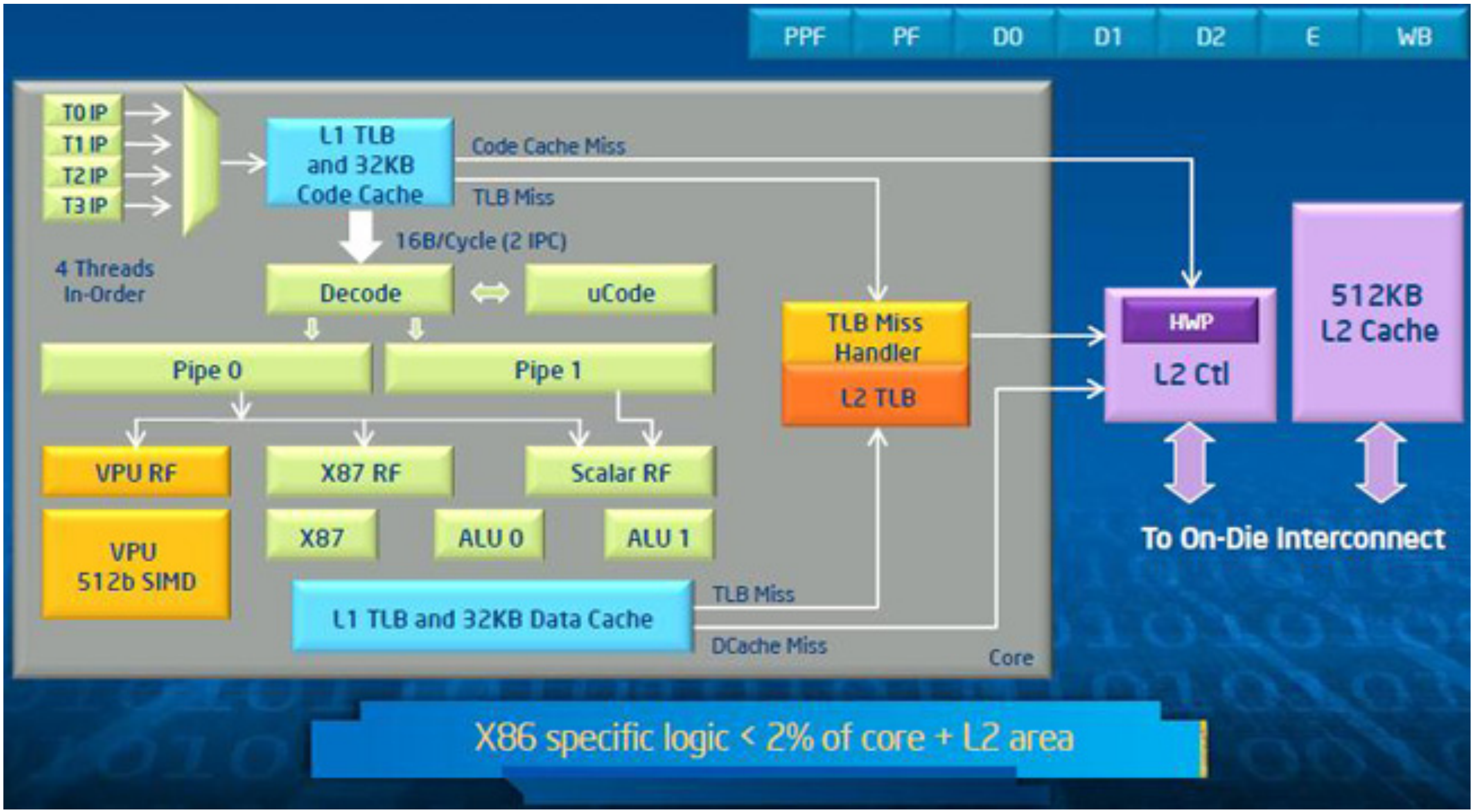
- MIC (Many Integrated Core) architecture
- ~60 (P5110) small X86 cores
- 4x the core count threads (240 threads)
- 8GB GDDR5 memory
- 2 P5110 on Goblin 49





Hardware matters!

- 3 levels of parallelism
  - 1-Thread, 2-SIMD, 3-Cache/Memory



Recompile and run?

- Execution Modes
  - Coprocessor <---PCI-E BUS---> Host
  - Native mode
  - Offload mode
  - Symmetric mode

Recompile and run?

- Native mode:
  - Recompile your previous code and run!
  - Only adding "–mmic" flag
  - Execution can only be running on Phi
  - SSH to Phi's OS from host and run
  - Serial job(e.g. disk IO) is painfully slow

Recompile and run?

- Offload mode:
  - Add offload directives:
    - #pragma offload target(mic:0) in(a:length(a))

```
{
  massive_parallel_code_running_on_mic()
}
```

- Symmetric mode:
  - Different executable binary files for host and Phi
  - MPI: 12 ranks on host, 240 ranks natively on Phi

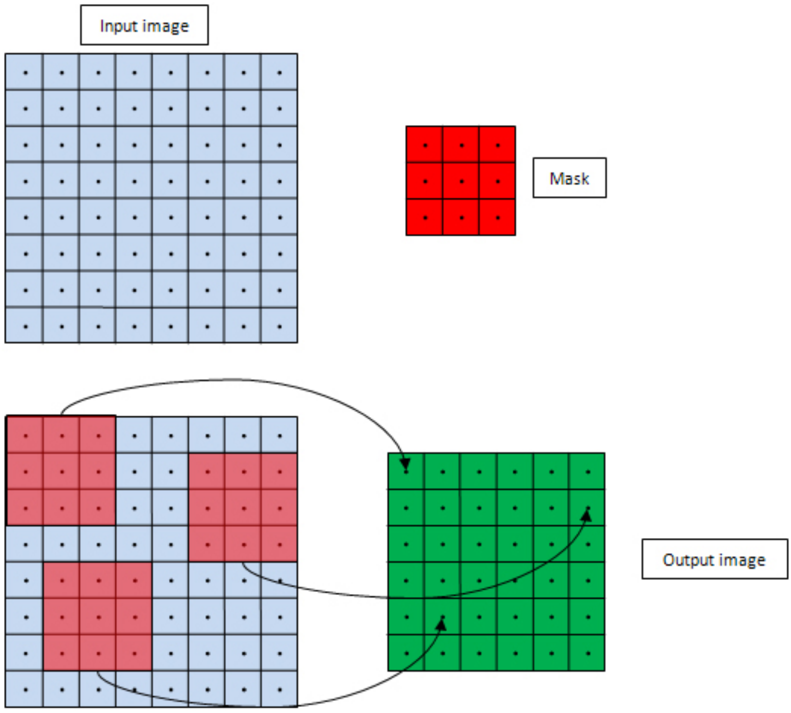
Simple codes

- 2D convolution:
  - OpenMP
  - OpenCL
- MPI:
  - Monte Carlo Estimation of PI

Simple codes

- OpenMP(1 thread for 1 row)

```
#pragma omp parallel for
for (yOut = halffilter; yOut < imgh; yOut++)
   {
#pragma simd
      for (xOut = halffilter; xOut < imgw; xOut++)
      {
         float sum = 0;
#pragma unroll
         for (r = -3; r < 4; r++)
         {
            for (c = -3; c < 4; c++)
            {
               sum += inputImage[(yOut+r)*imageWidth+xOut+c]
                   * filter[(r+halffilter)*filterWidth+c+halffilter];
            }
         }
         outputImage[yOut * imageWidth + xOut] = sum;
      }
   }
```



Simple codes

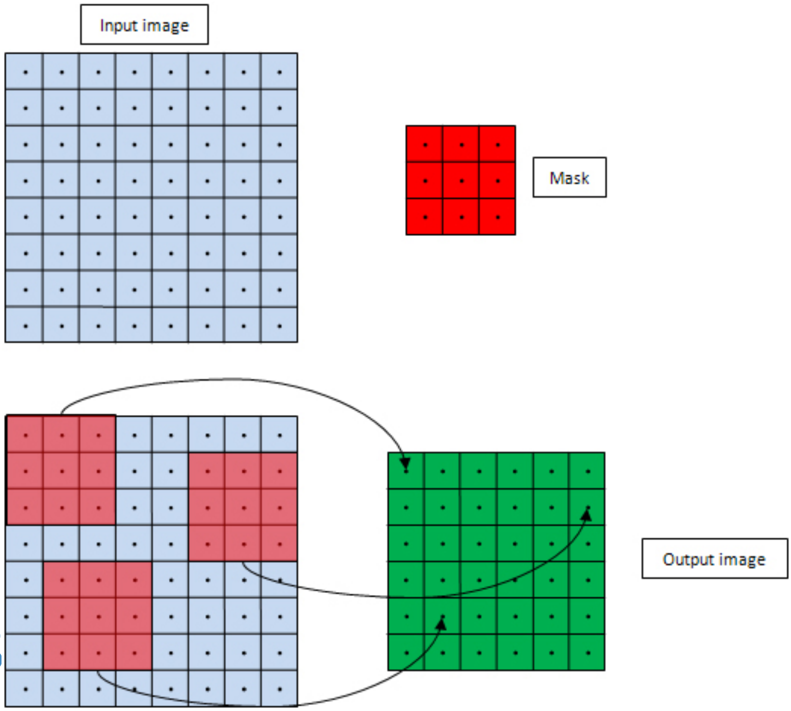
- 2D convolution
  - OpenMP (120M pixels in grey scale, 7x7 filter):

Hardware	Time (ms)	Unrolled Time (ms)
2 x E5-2630(12 cores,AVX)_12threads	504	95
Phi_60threads	555	165
Phi_120threads	483	192
Phi_240threads	579	310

  - CPU 15MB L3 shared, Phi 512KB private L2

Simple codes

- OpenCL
  - 1 work-group maps to 1 HW thread (4 threads each core)
  - Work-items run on SIMD
  - 1D 1 work-group /per row
  - 2D 1 work-item /per pixel
- 1D 1024 workitems: 202ms
- 2D 32x32 workitems: 70ms
- 2D 32x32 with local mem and sync: 82ms



Simple codes

- MPI:
  - 1 rank maps to 1 HW thread
  - Phis and CPUs can communicated
  - Each rank(thread on phi) compute one part

Hardware	Time (s)
2 x E5-2630(12 cores,AVX)_12threads	6.41
1 x Phi_120_threads	7.11
2 x Phi_120_threads	3.74

Simple codes

- ## MPI:

```
for (point=0; point<num_local_points; point++)
{
    temp = (rand() % (rand_MAX+1));
    p_x = temp / rand_MAX;
    p_x = p_x / num_procs;

    temp2 = (float)id / num_procs;  // id belongs to 0, num_procs-1
    p_x += temp2;

    temp = (rand() % (rand_MAX+1));
    p_y = temp / rand_MAX;

    temp = (rand() % (rand_MAX+1));
    p_z = temp / rand_MAX;

    // Compute the number of points residing inside of the 1/8 of the sphere
    result = p_x * p_x + p_y * p_y + p_z * p_z;

    if (result <= 1)
   {
       inside++;
   }
 }
```

- ## SIMD:

```
#pragma simd private(temp,temp2,pi,p_x,p_y,p_z,result)
 for (unsigned int point=0; point<num_local_points; point++)
  {
    temp = (rand() % (rand_MAX+1));
    p_x = temp / rand_MAX;
    p_x = p_x / num_procs;

    temp2 = (float)id / num_procs;              // id belongs to 0, num_procs-1
    p_x += temp2;

    temp = (rand() % (rand_MAX+1));
    p_y = temp / rand_MAX;

    temp = (rand() % (rand_MAX+1));
    p_z = temp / rand_MAX;

    // Compute the number of points residing inside of the 1/8 of the sphere
    result = p_x * p_x + p_y * p_y + p_z * p_z;

    int t = 0;
    if (result <= 1)
   {
       t =1;
   }
    tt[point] = t;
  }
#pragma simd reduction(+:inside)
for (int j=0;j<num_local_points;j++)
{
   inside += tt[j];
}
```

Simple codes

- SIMD speed up:

Hardware	Time (s)	SIMD (s)
2 x E5-2630(12 cores,AVX)_12threads	6.41	6.7
1 x Phi_120_threads	7.11	4.24
2 x Phi_120_threads	3.74	2.14

- Memory bandwidth:
  - PHI : ~160GB/s
  - CPU: ~50GB/s

Phi? CPU? GPU?

- CPU v.s. Phi:
  - Code natively run or only adding offload directives
  - Library MKL for large size?
  - 100 more threads?
  - 100 threads and Large vector?
  - 100 threads and Memory bandwidth?

Phi? CPU? GPU?

- GPU v.s. Phi
  - Previous CPU code?
  - Learning CUDA/OpenCL?
  - Memory/cache? (more time for optimization)

Hardware	Time (ms)
Phi 32x32	70
K20 32x32	101
K20 32x32 local-mem	38

Conclusion

- What is Xeon Phi?
  - Many x86 cores
- Hardware matters!
  - Thread, SIMD, Cache/Mem
- Recompile and run?
  - Native, Offload, Symmetric
- Simple codes and benchmarks
- Phi? CPU? GPU?

References:

- Goblin wiki:
  - https://www.sharcnet.ca/help/index.php/Goblin#The_Phi_Co-processors
- Programming Xeon Phi wiki:
  - https://www.sharcnet.ca/help/index.php/Programming_Xeon_Phi
- Porting CUDA to OpenCL:
  - https://www.sharcnet.ca/help/index.php/Porting_CUDA_to_OpenCL