

# Tips and Tricks for FORTRAN on the Intel KNL

Dane Skow

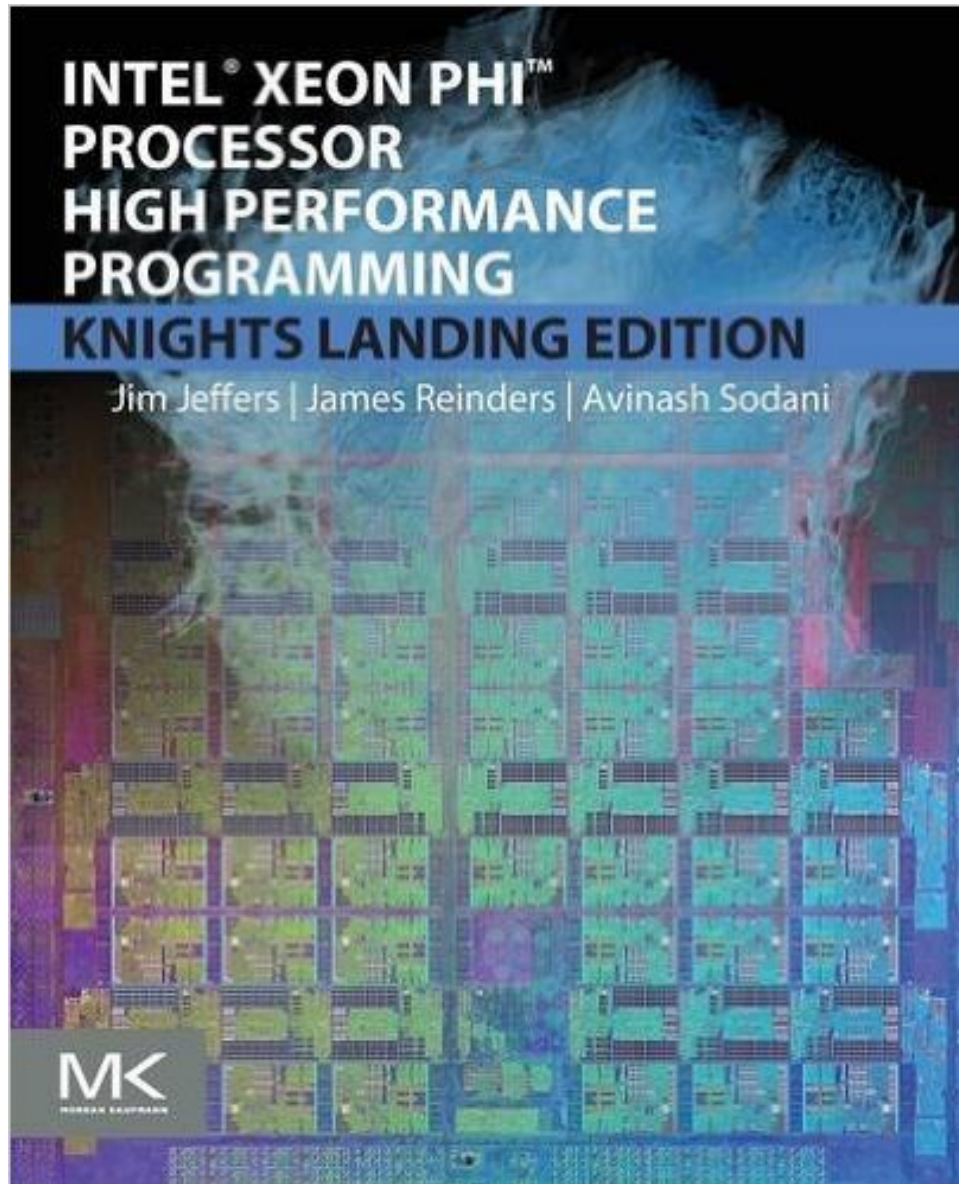
16 March 2017

Research Computing Meetup

# What is KNL ?

- “Knight’s Landing” is the code name for the newly released Intel Xeon Phi Processor
- It has up to 72 cores with 16GB onboard fast memory (MCDRAM).
- It is able to run all x86 code natively
  - NOT a coprocessor (unlike its predecessor)
- It has 512-bit wide registers for increased vectorization possibilities

# A Door Prize !!



Useful book covering parallelization, vectorization, optimization techniques in general and for the KNL.

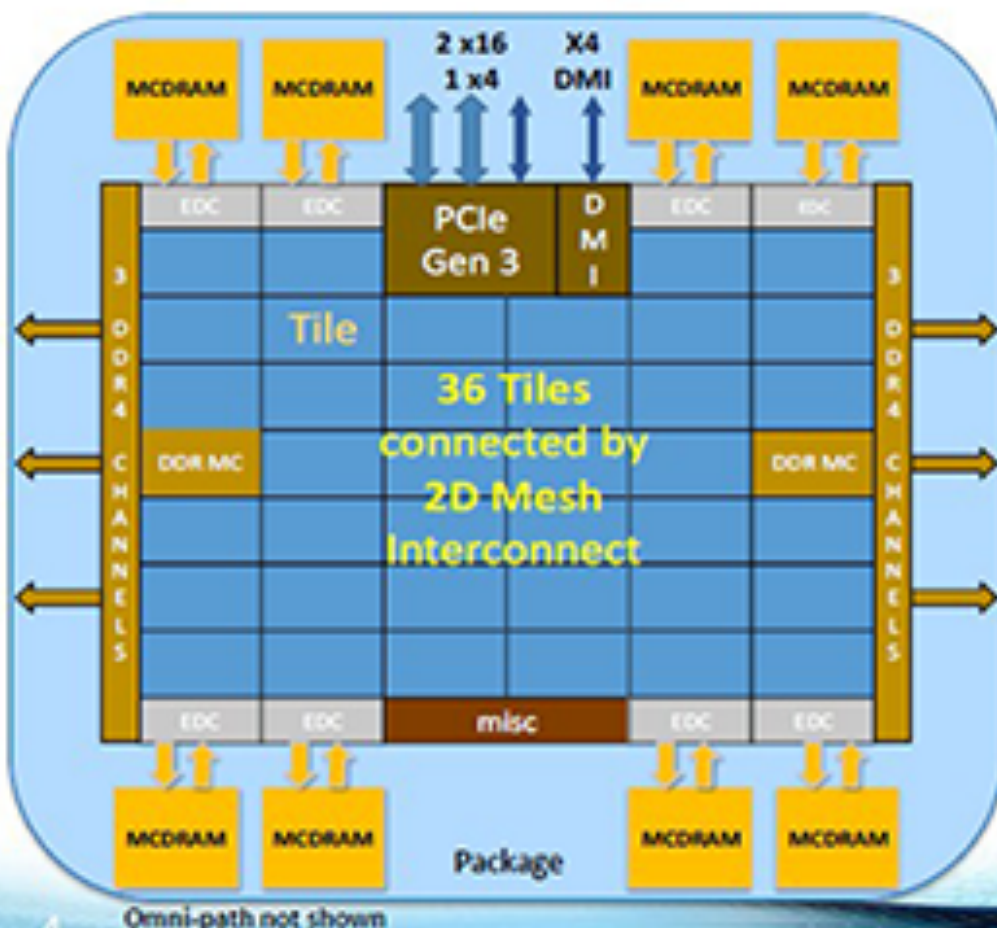
Everyone attending the meetup may have one. Pick it up before you leave.

# KNL on Summit

- Summit will have 20 KNL nodes operational by June 1, 2017
  - 1 KNL 7250 processor per node (86 cores)
  - 96 GB of RAM
  - 100+ GB local SSD disk
  - 1 OPA low latency interconnect (100 Gbps)
  - 10 Gbps Ethernet connection

# KNL Architecture

## Knights Landing Overview



### TILE

|       |        |       |
|-------|--------|-------|
| 2 VPU | CHA    | 2 VPU |
| Core  | 1MB L2 | Core  |

Chip: 36 Tiles interconnected by 2D Mesh

Tile: 2 Cores + 2 VPU/core + 1 MB L2

Memory: MCDRAM: 16 GB on-package; High BW

DDR4: 6 channels @ 2400 up to 384GB

IO: 36 lanes PCIe Gen3. 4 lanes of DMI for chipset

Node: 1-Socket only

Fabric: Omni-Path on-package (not shown)

Vector Peak Perf: 3+TF DP and 6+TF SP Flops

Scalar Perf: ~3x over Knights Corner

Streams Triad (GB/s): MCDRAM : 400+; DDR: 90+

Source Intel: All products, computer systems, dates and figures specified are preliminary based on current expectations, and are subject to change without notice. KNL data are preliminary based on current expectations and are subject to change without notice. Binary Compatible with Intel Xeon processors using Intel® Advanced Vector Extensions (AVX-512). Performance numbers are based on STREAM-like memory access pattern software running on KNL. Results have been estimated based on internal Intel analysis and are not intended for use in commercial or other purposes. Any difference in system configuration or software may affect performance.

# What is Vectorization ?

- Vectorization is the application of a single operation to multiple data elements (the “vector”)
- Think of it as the “bite-size” of the math unit inside the CPU.
  - The processor takes a “bite” of data (64 bytes long in the case of the KNL) and operates on all that data at the same time.
  - This means that 8 normal math operations get done at the same time inside the math unit of the CPU.

# Vector Math

|   |   |  |       |        |  |  |  |
|---|---|--|-------|--------|--|--|--|
| 2 | 4 |  | Bytes | A(1-8) |  |  |  |
|---|---|--|-------|--------|--|--|--|

+

|   |   |  |       |        |  |  |  |
|---|---|--|-------|--------|--|--|--|
| 4 | 3 |  | Bytes | B(1-8) |  |  |  |
|---|---|--|-------|--------|--|--|--|

=

|   |   |  |       |        |  |  |  |
|---|---|--|-------|--------|--|--|--|
| 6 | 7 |  | Bytes | C(1-8) |  |  |  |
|---|---|--|-------|--------|--|--|--|

# Enemies of Compiler Vectorization

- Try to have the largest loop be the innermost loop.
- Try to avoid “IF/THEN” constructs
  - Multiplying by a mask is one alternate technique.
- Avoid data dependent exit conditions
- Avoid backward loop-carried dependencies
  - ie. statement 2 of iteration 1 should not require statement 1 of iteration 2 to be done after it.
- Try to use code that accesses contiguous memory locations
  - “Striding” in “bite-sized chunks” is most efficient



# Vectorization Tools

- Intel
  - Advisor
  - VTune Accelerator
- Allinea
- Valgrind
  - Useful for memory usage investigations
- HPC Toolkit
  - (<http://www.hpctoolkit.org/>)

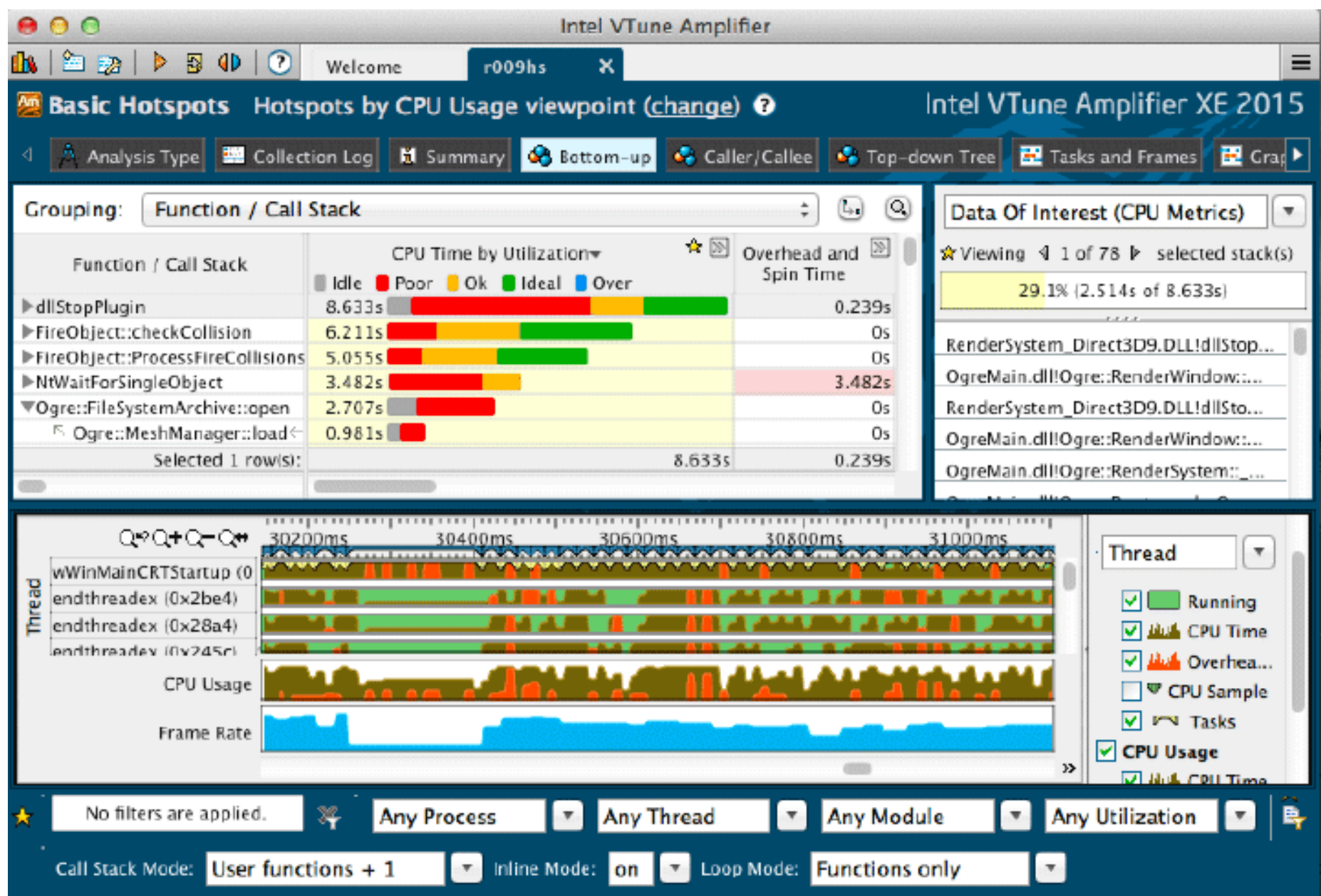
# 6 Step method to vectorizing your code

- Measure baseline performance
  - Use release code not debugging code
- Determine hotspots
  - Intel Vtune Amplifier a useful tool here
- Determine loop candidates
  - Intel compiler vec-report useful tool here

## 6 step method (cont'd)

- Get advice
  - Intel advisor can be used here
- Implement vectorization recommendations
  - One useful test is to see if executing the loop backwards would change the results.
- Repeat

# Intel VTune Amplifier



# Helpful URLs

- List of useful Environment Variables for Intel FORTRAN compiler
  - <https://software.intel.com/en-us/node/680054>
- Vectorization Toolkit
  - <http://lotsofcores.com/intelvectkit>
- HPC Toolkit
  - <http://hpctoolkit.org/>
- Stack Overflow
  - <https://stackoverflow.com/>