



# Elmer on Intel® Xeon-Phi

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# Porting Elmer to MIC



- Porting work started already Q2/12
- Focus to build ElmerSolver on a MIC
  - MIC = Many Integrated Cores
- Cooperation with Mikko Byckling (Intel) within *Intel Parallel Computing Center (IPCC)*



Stanford University

ETH zürich

TACC

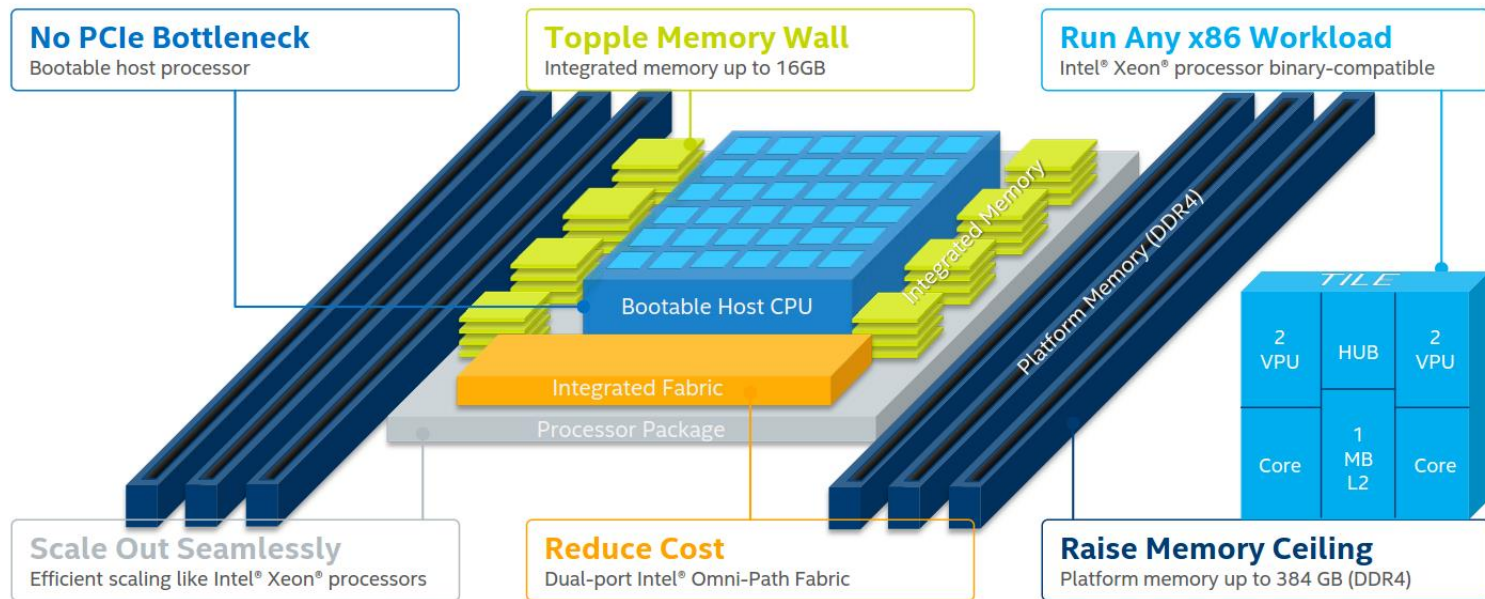


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Korea Institute of Science and Technology Information

# Porting Elmer to MIC



<sup>1</sup>Reduced cost based on Intel internal estimate comparing cost of discrete networking components with the integrated fabric solution

# Porting Elmer to MIC



- Internally OpenMP threading supported by
  - Solver API routines related to element assembly
  - Element assembly loop of some solvers already implemented
  - Time integration routines
  - Sparse matrix vector products
- Library support for OpenMP exists in
  - External BLAS routines
  - External LAPACK routines
  - Direct solvers such as Cholmod, SPQR and Pardiso

# Porting Elmer to MIC



- Perform disruptive changes if necessary
  - Maintain backwards compatibility
  - Build backwards compatible interfaces to new methods if necessary
- Optimization order
  - Vectorization
  - Threading
- Tools currently in use
  - Intel Vtune (to find hotspots and non-vectorizable parts of the code on the time critical path)
  - Intel Inspector XE (to find threading bugs)
- Targeting both Xeon and Xeon Phi

# Porting Elmer to MIC



- Modern Fortran code with a modular structure
  - Initial focus on Finite element assembly
  - Improve the vectorization properties by changing the key data structures
  - Add OpenMP multithreading
- All ~50 solvers in Elmer need to be modified



**= AHLOW!**

```
!$omp parallel do private(Element,n,nd)
  DO t=1,active
    Element => GetActiveElement(t)
    n = GetElementNOFNodes(Element)
    nd = GetElementNOFDOfs(Element)
    CALL LocalMatrix(Element, STIFF, FORCE, n,
nd)
    CALL DefaultUpdateEquations(STIFF,FORCE,&
                                UElement=Element)
  END DO
!$omp end parallel do
```

# Porting Elmer to MIC



- Poisson (elliptic problem) solver
  - Large vectors (FEM Gauss points)
  - Mesh colouring (avoid race conditions)
  - Tested on Xeon Phi developer N platform
    - Intel® Xeon Phi (™) CPU 721 1.30GHz
    - 64 cores (256 HT 4x)
    - 96GB DDR4, 16GB MCDRAM
    - KNL (KNights Landing)

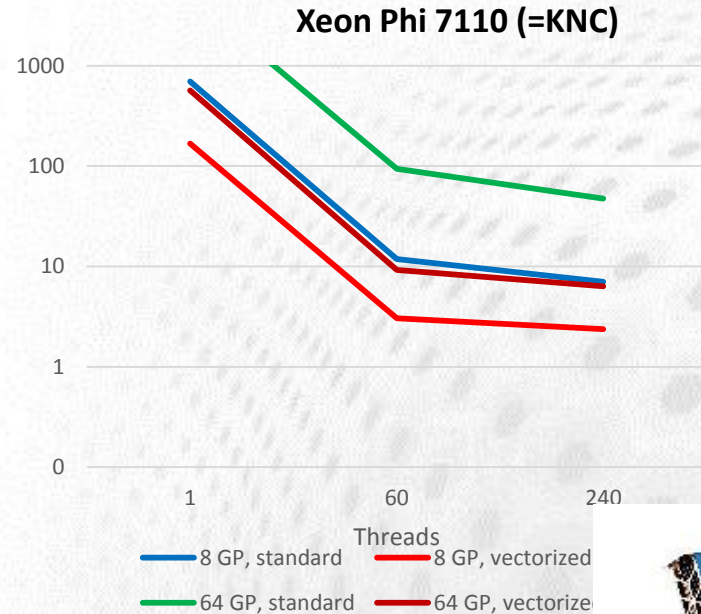
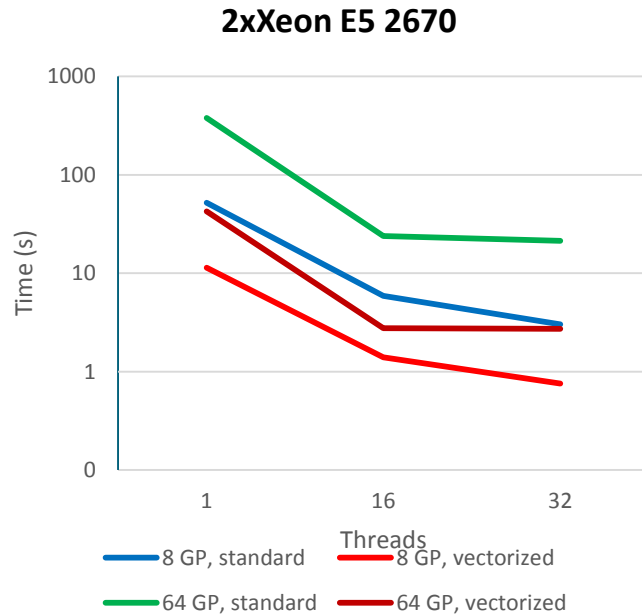
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htop (on ninja.csc.fi)
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Sep1 Load average: 0.18 0.18 0.21
Mem: 1.6Gg, 95502536

PID USER PPID NI PRI RES SHR S CPU% MEM% TIME+ Command
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53544 zwinger 20 0 50LH 472H 9676 S 3,5 0.4 0100.57 ElmerSolver_mpi
F1H618 F2Secur F3Secur F4Elmer F5Elmer F6Secur F7Hose F8Hose F9H111 F10H111
```

# Porting Elmer to MIC



## ➤ Poisson model problem, 1M Hexahedral elements



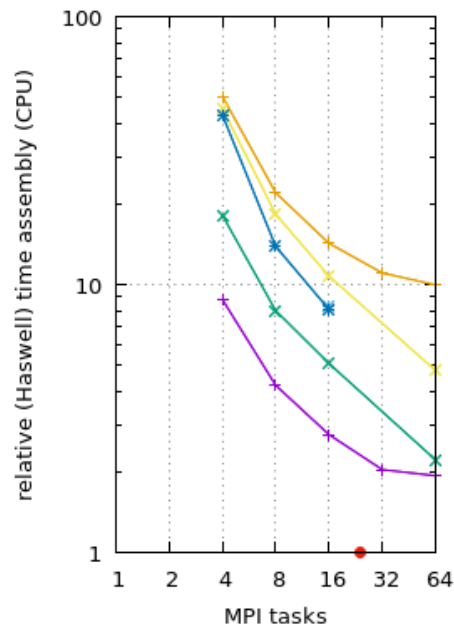


# Porting Elmer to MIC



## ➤ Poisson model problem, 1M Hexahedral elements

2xXeon E5 2670



Xeon Phi 7210 (=KNL)

- "L3\_scatter\_ht1\_8GP" u 1:(\$3/6.31873) — purple line with '+' markers
- "L3\_scatter\_ht2\_8GP" u 1:(\$3/6.31873) — green line with 'x' markers
- "L3\_scatter\_ht4\_8GP" u 1:(\$3/6.31873) — blue line with '\*' markers
- "L3\_scatter\_ht1\_64GP" u 1:(\$3/6.31873) — orange line with '+' markers
- "L3\_scatter\_ht2\_64GP" u 1:(\$3/6.31873) — yellow line with 'x' markers
- "L3\_scatter\_ht4\_64GP" u 1:(\$3/6.31873) — blue line with '\*' markers
- "L3\_sisu\_8GP" u 1:(\$3/6.31873) — red line with 'o' markers
- "L3\_sisu\_64GP" u 1:(\$3/6.31873) — black line with '▲' markers



# Porting Elmer to MIC



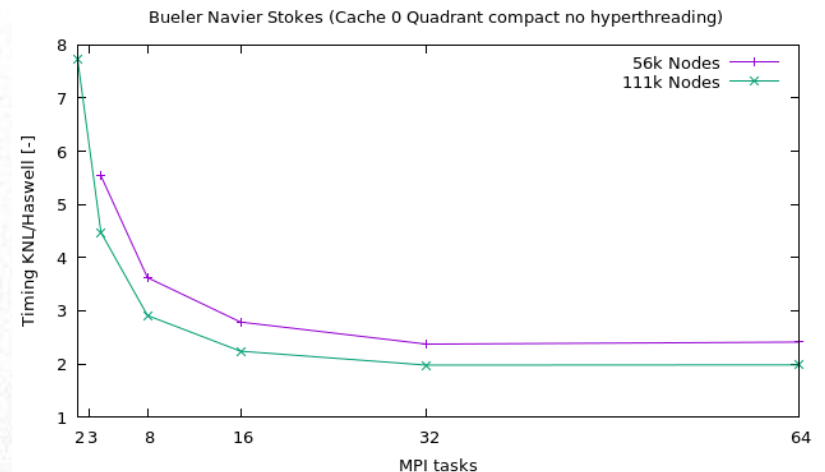
Activity supported by



norden

NordForsk

- Production solver used in Elmer/Ice
- Synthetic ice-sheet geometry (Bueler-profile) with (Navier-)Stokes solver with non-linear rheology law
- Utilize (C)Pardiso
- Timing of linear system solve
- Compare with Haswell node 24 cores



# Conclusions



- If you have a system based on MIC's, you can deploy Elmer/Ice with reasonable performance (similar between Xeon and Xeon Phi)
- Multi-threading (OpenMP) has been introduced to many solvers and will continue
- Assembly can utilize SIMD (=vector units) if we apply p-bubbles for stabilization
- Improvements have equally positive impact on traditional CPU's (Xeon Haswell, Broadwell)