OpenMP* Support in Clang* / LLVM*

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What Is Clang / LLVM?

- LLVM: “Collection of modular and reusable compiler and toolchain technologies”
  - Created by Chris Lattner and Vikram Adve at UIUC
  - Developed by Apple*, Google*, Intel, IBM*, Sony*, ARM*, …
  - Interests of major players are mostly outside HPC
- Clang: “…a new C, C++ Objective C and Objective C++ front-end for LLVM compiler”
  - First to implement full C++11 (and now C++14) support
- “UIUC” BSD-style license

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OpenMP In Clang: Some History

- There were a few proprietary implementations (Pathscale, Cray), but no open-source one
- "OpenMP in Clang" project
  - Started in late'12, by AMD* and Intel
  - Now ANL*, IBM*, Micron*, Pathscale*, TI* and UoHouston* are involved
- Early outlining
  - It is hard to introduce changes to LLVM IR
  - New stuff should be very general and "universal"
  - There were some proposals with late outlining, all rejected by community

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clang-omp Github Repo: Home Of OpenMP-enabled Clang Compiler

- clang-omp.github.com
  - Based on clang/llvm 3.5 release
  - Also, trunk-based branch is available (maintained by Hal Finkel)
- Full OpenMP 3.1 implemented
- Partial OpenMP 4.0 implemented
- Initially developed for x86 and x86-64; ported to POWER* and ARM*
- Patches are gradually upstreamed to clang / llvm trunk
  - OpenMP 3.1 planned for llvm 3.6; OpenMP 4.0 for llvm 3.7

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OpenMP 4.0: Supported Features

- Task enhancements, thread affinity, user-defined reductions
  - Done
- #pragma omp simd
  - Functionally complete
    - Support for “#pragma omp declare simd” and “reduction” clause missing in llvm back-end
  - Performance depends on vectorizer
  - Partially available in clang / llvm 3.5 release
    - Only basic pragma and “safelen” clause supported
  - Partially available in clang / llvm trunk
    - Support for “collapse” and “aligned” clauses added

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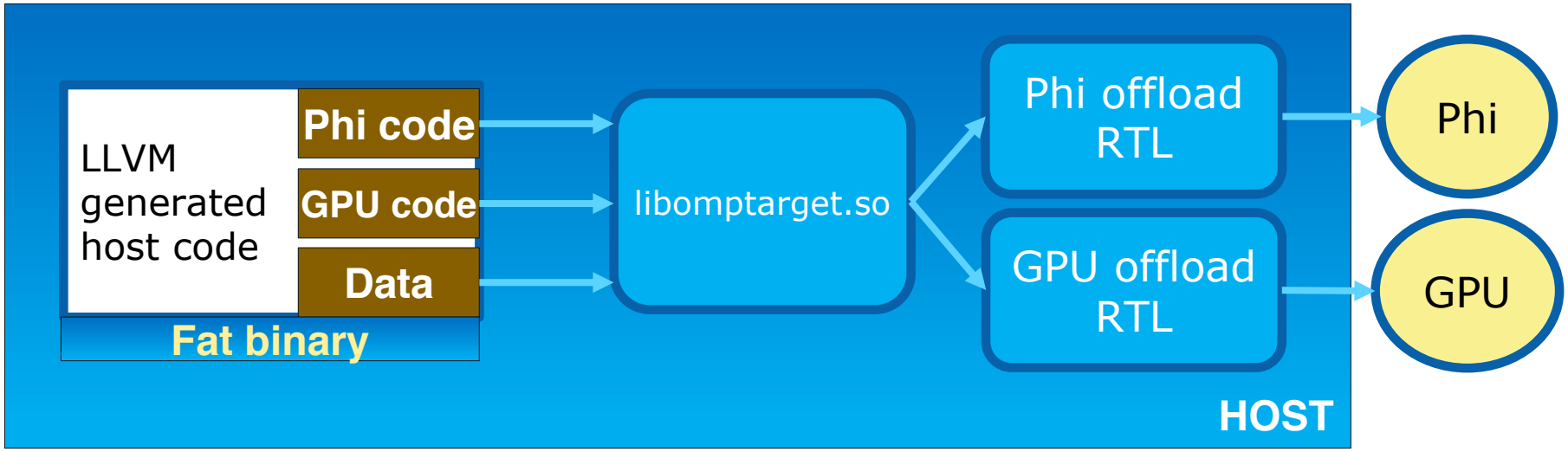
OpenMP 4.0: Offloading

- Under development
- Plan to support x86, x86-64, POWER and ARM as hosts, multiple targets (Intel® Xeon Phi™ coprocessor, GPUs, FPGAs, ...)
- Offloading library open-sourced under LLVM license



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OpenMP Runtime Library

- openmp.llvm.org
- Tried and true Intel OpenMP runtime
  - Production runtime used by icc and ifort
- Continual development / tuning since before the OpenMP language existed (>15 years)
- Highly scalable
  - Used on Intel® Xeon Phi™ coprocessor with 244 threads, large SGI* and Bull* ccNUMA SMP machines)
- Full OpenMP 4.0 support
- In addition to x86 and x86-64, ported to POWER and ARM
- Open-sourced under LLVM license

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You Are Welcome!

- A lot of people already involved
- Help with development
  - Code, tests, bug reports
- Use OpenMP-enabled clang!
  - Get performance boost
  - Report your results to us
  - Influence future developments
  - Innovate on top of what we did
- clang-omp.github.com
  openmp.llvm.org

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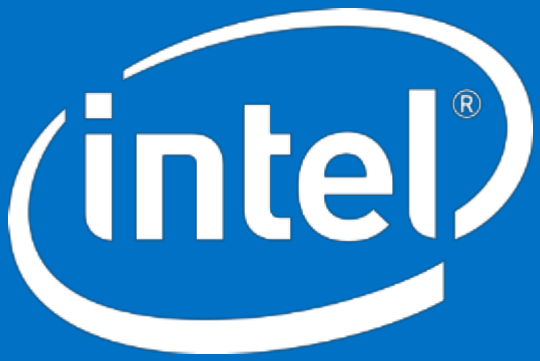
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