

# OpenMP<sup>®</sup>

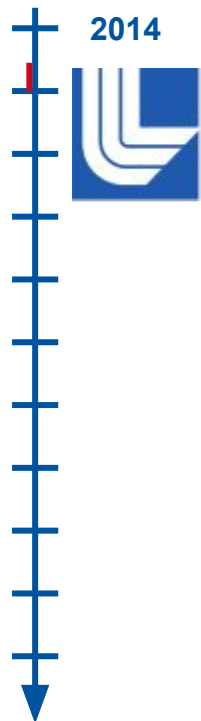
## SC24 Booth Talk Series



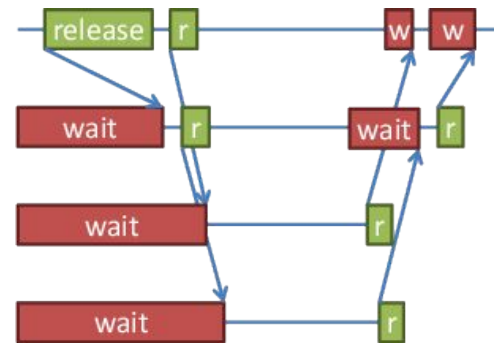
10 Years of  **archer**:  
Data Race Detection for OpenMP

**Dr. Joachim Jenke, RWTH Aachen University**

## First implementation

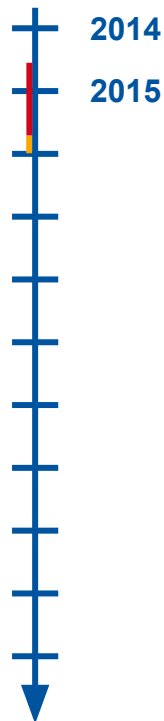


- Internship at LLNL 6/14 - 9/14
- Initial implementation using TSan annotations in libomp
  - OFF by default, configure with LIBOMP\_TSAN\_SUPPORT
  - Complementary compiler pass to whitelist race-free pieces of code
  - Presented as paper at 1st LLVM@SC 2014 workshop
- Code available from separate github repo
- Student poster rejected @SC'14
  - didn't show performance numbers !?!

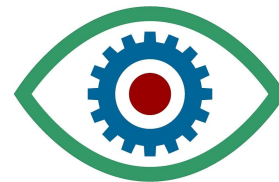


## Upstreaming into LLVM

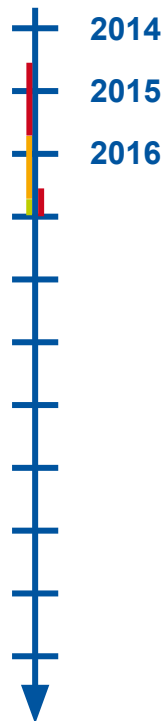
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- September: Patch for libomp submitted to phabricator
  - Some discussion and open questions regarding licencing
  
- OpenMP fall meeting in Aachen:
  - Starting efforts to ensure OMPT is can be used for correctness analysis in Archer

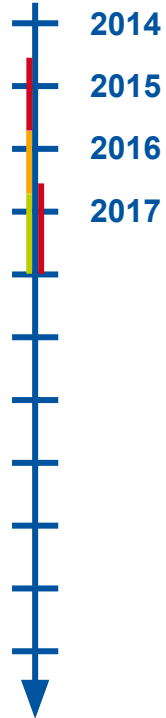


## Upstreamed to LLVM

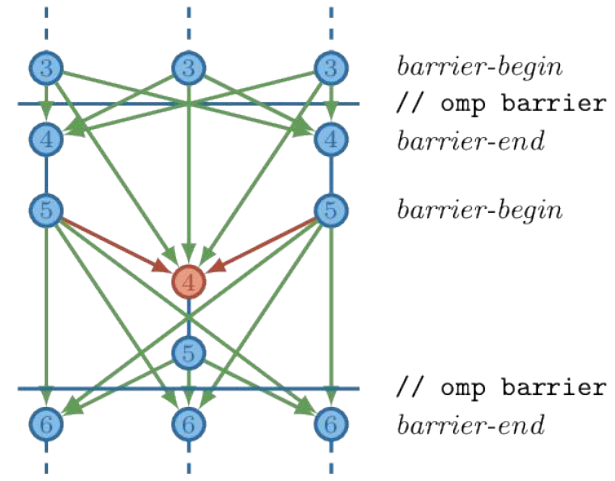


- May: IPDPS paper about static analysis
- June: First commit for the OMPT-based tool
- October: libomp patch pushed to llvm repository
  - Available with LLVM 4.0 release
  - Disabled in default build



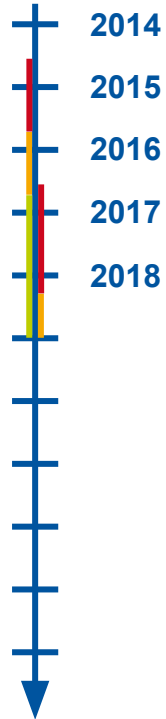


- OMPT-based tool available in PRUNERS repository
- IWOMP paper reasoning about synchronization semantics derived from OMPT

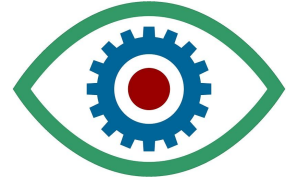


## Review of OMPT-based Archer

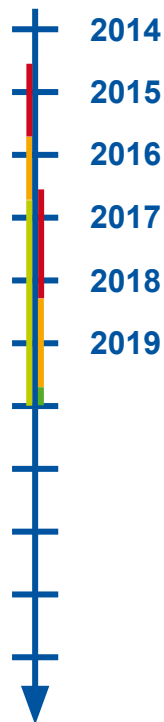
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- April: Patch submitted to phabricator
- December: First comments



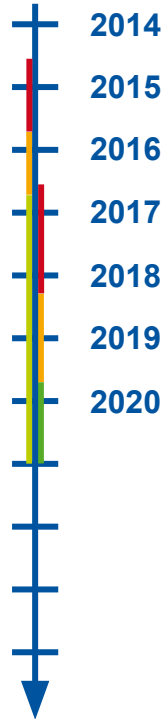
## Finally in LLVM



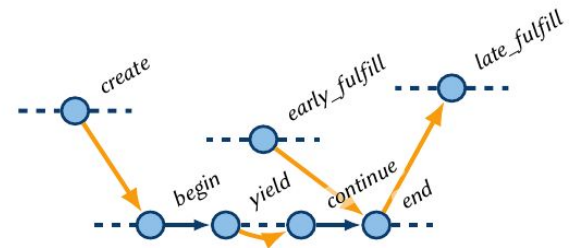
- March: Updates to make the tool compatible with OMPT 5.0
- November: OMPT-based Archer landed
  - Archer is active by default now (if application is built with TSan)
  - Available since LLVM 10 release



## Development continues in LLVM project



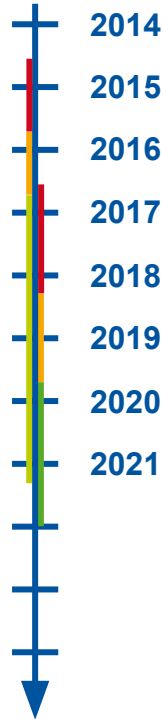
- Adding support for detached tasks (OMPT + Archer)
- Adding option to ignore sequential code
- Fix handling of task dependencies for non-sibling tasks





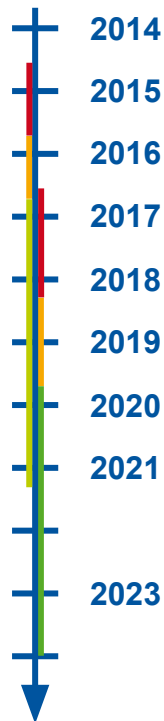
## Dropping old implementation from LLVM

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- March: Removed TSan annotations from libomp
- July: PhD defence

## Improving analysis for tasking applications



- Support for new task dependencies:
  - `omp_all_memory` and `taskwait` depend

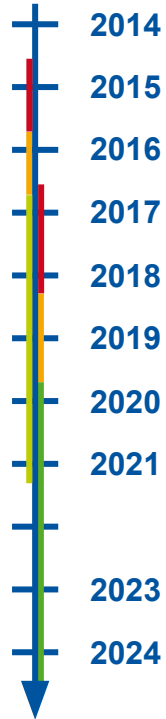
- New task-centric analysis (patch under review)

Version	FP	TP	TN	FN	Accuracy	Precision	Recall	F1 Score
1.4.0	1	69	89	20	89	99	78	87

Mode	FP	TP	TN	FN	Accuracy	Precision	Recall	F1 Score
Thread	0	85	109	20	91	100	81	89
Tasking	0	92	109	13	94	100	87	93

## Today

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- Intel seems to shift towards sanitizers
  - Inspector announced to be discontinued
  - Archer is available and on by default with Intel compilers (2024.2)
- HPE/Cray compiler supports use of Archer
- AMD's AOCC compiler packages include Archer
  
- Several patches (e.g., AVX512 for TSan) pending in review

## Further Reading

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- How to use Archer:
  - <https://hpc-wiki.info/hpc/index.php?title=Archer>
  - <https://git-ce.rwth-aachen.de/hpc-public/sanitizer-tutorial>
- Papers:
  - [Towards providing low-overhead data race detection for large OpenMP applications](#). LLVM@SC 2014
  - [ARCHER: Effectively Spotting Data Races in Large OpenMP Applications](#). IPDPS 2016
  - [OpenMP Tools Interface: Synchronization Information for Data Race Detection](#). IWOMP 2017
  - [Mapping High-Level Concurrency from OpenMP and MPI to ThreadSanitizer Fibers](#). Correctness@SC'23

## Thanks to all the mentors, contributors and sponsors!

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- Prof. Martin Schulz (mentor at LLNL, now at TUM)
- Dong Ahn (mentor at LLNL)
  
- Simone Atzeni (co-intern, static analysis, now at NVIDIA)
- Jonas Hahnfeld (student worker, OMPT-tsan, now at CERN)
- LLVM community submitting patches
  
- LLNL, ANL, EU, BMBF

The logo for OpenMP, featuring the word "Open" in a white sans-serif font and "MP" in a larger, bold white sans-serif font, both underlined with a white horizontal line. A registered trademark symbol (®) is located to the right of the "P".

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