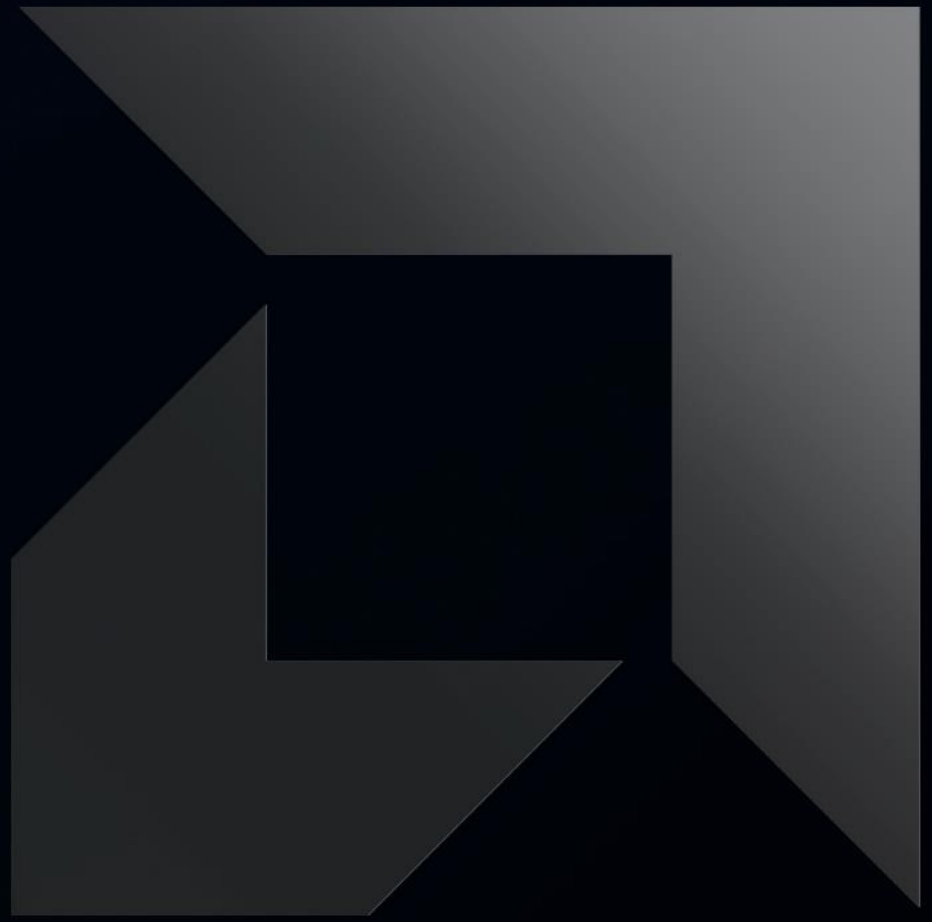


OMPT Support in ROCm™

Past, Present & Future

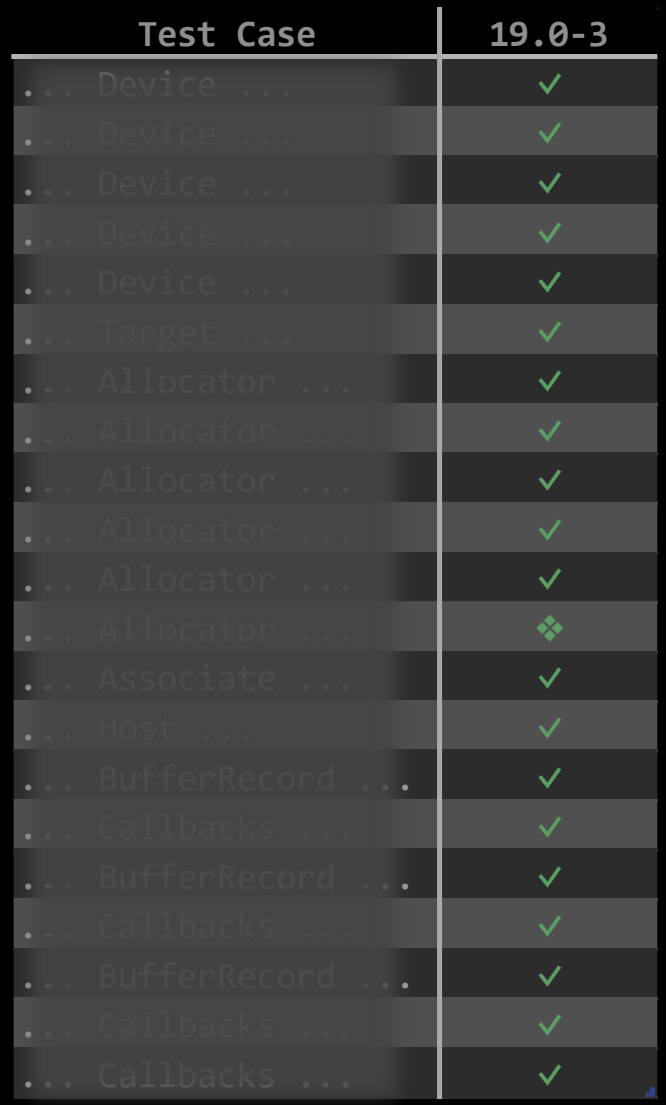
ROCm OpenMP© GPU Compiler Team

Michael Halkenhäuser, Dhruva Chakrabarti,
Jan-Patrick Lehr, Ron Lieberman

AMD
together we advance_

„OMPT is important to us“

- **Our Goals:**
  - **Improve OMPT** { **feature support**, **test coverage**
- **Ensure a solid foundation for tool developers**



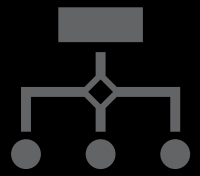
Introduction

ROCm

AMD ROCm is an open software platform for GPU compute consisting of compilers, libraries, tools, etc.

(https://www.amd.com/en/products/software/rocm.html)

AOMP

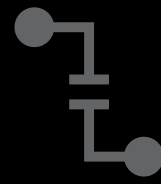


AOMP is an open-source Clang/LLVM-based compiler with added support for the OpenMP® API on Radeon™ GPUs that builds on top of ROCm

Releases are more frequent than **ROC**m

(https://github.com/ROCm/aomp)

LLVM



Since AOMP is Clang/LLVM based, the high-level software architecture of OpenMP target offload support is identical

AOMP is both ahead and behind LLVM mainline trunk (upstream)

“downstream”

“upstream”

OMPT Events 101

```
int main(int argc, char **argv) {
  int Values[1024] = {0};

  #pragma omp target loop
  for(int i = 0; i < 1024; ++i) {
    Values[i] = 1;
  }

  return 0;
}
```

CALLBACKS
- synchronous
- ordered

TRACE RECORDS
- asynchronous
- unordered

Fun fact: Code snippet generates more than 30 device events

OMPT Device Events 101

CALLBACKS
- synchronous
- ordered

TRACE RECORDS
- asynchronous
- unordered

```
Callback Kernel Submit EMI
  endpoint=1
  req_num_teams=1
  …
```

```
rec=0x1257a00
  type=10 (Target kernel)
  time=821383491484741O
  …
```

EMI Callbacks
- **Provide event information directly**
- **Become default in OpenMP 6.0**

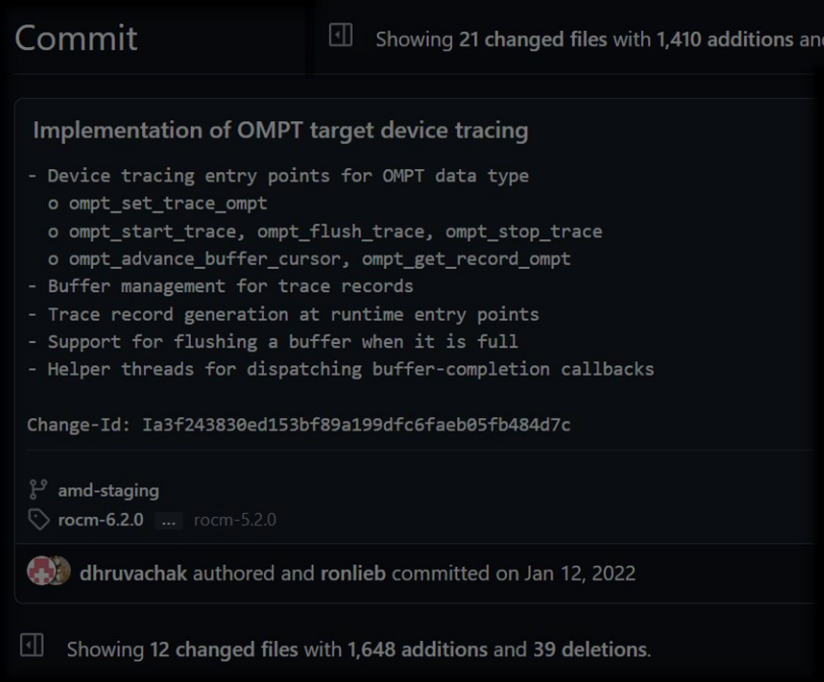
Trace Records
- **Provide info on extended events**
  - **Begin- & End-time**
  - **Misc. data structures**
  - **…**

Tools using OMPT events, e.g.
- **score-p, TAU and HPCToolkit**

Beginning of Downstream OMPT Support

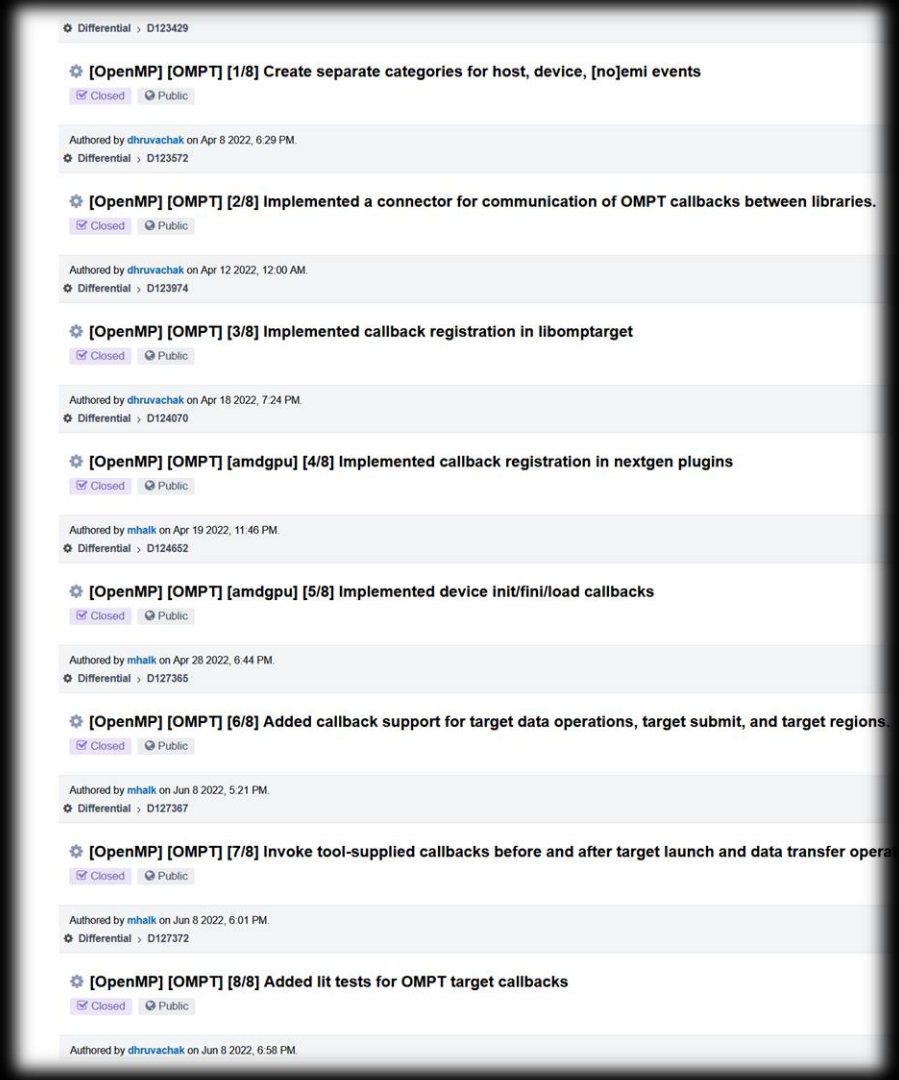
- **Callbacks implemented in HPCToolkit's LLVM fork (by John Mellor-Crummey)**
- **Callbacks refactored for downstream**
- **Trace Records implemented in downstream**
- **Commitment to open-source software**

  ⟶ **Upstream our changes**



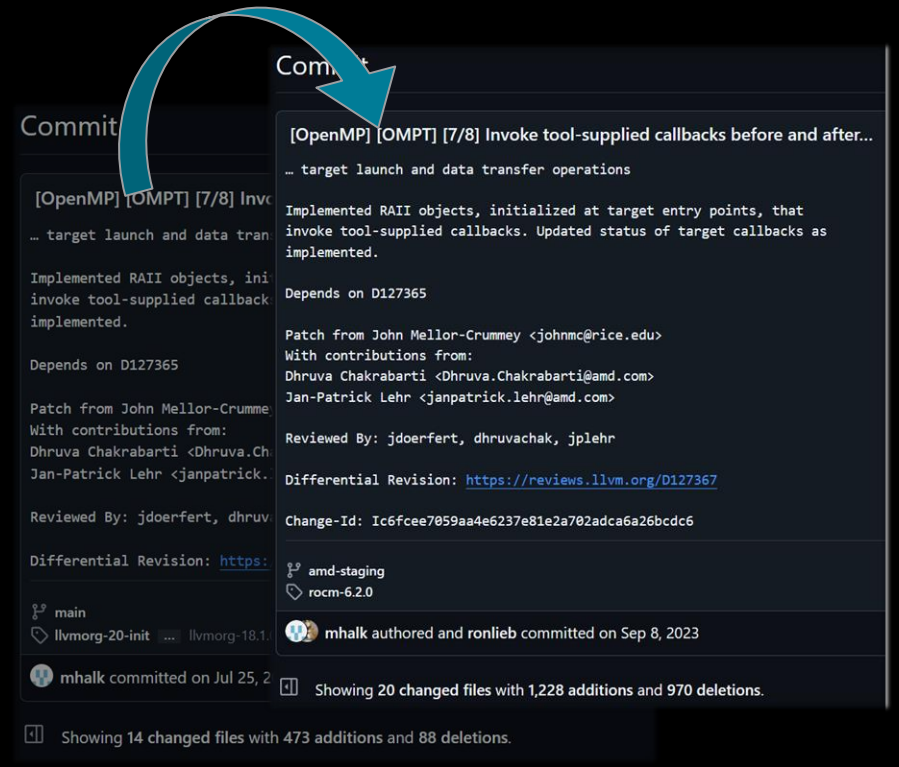
Upstreaming of OMPT Device Callback Support

- Segmentation of downstream-diff
  - Result: 8 Phabricator patches
- Upstream is a moving target
  - Addition of ‘nextgen-plugins’ needed refactoring of patches 4-7
- Refactoring
  - Templated design desired (by Johannes Doerfert)
- Reordering
  - “Test first, add callbacks later”

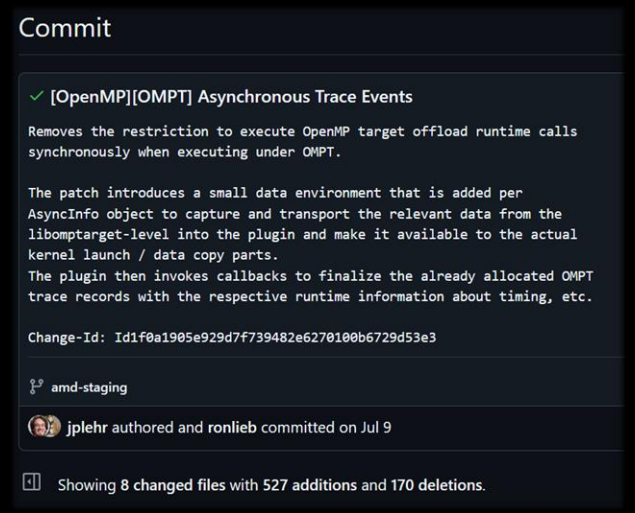


Meanwhile “behind the scenes”

- Adoption of upstream callback support
  - Refactor trace record handling
  - Prepare downstream set of OMPT patches



- Expansion of OMPT capabilities
  - Implement asynchronous trace records



Downstream OMPT Support History

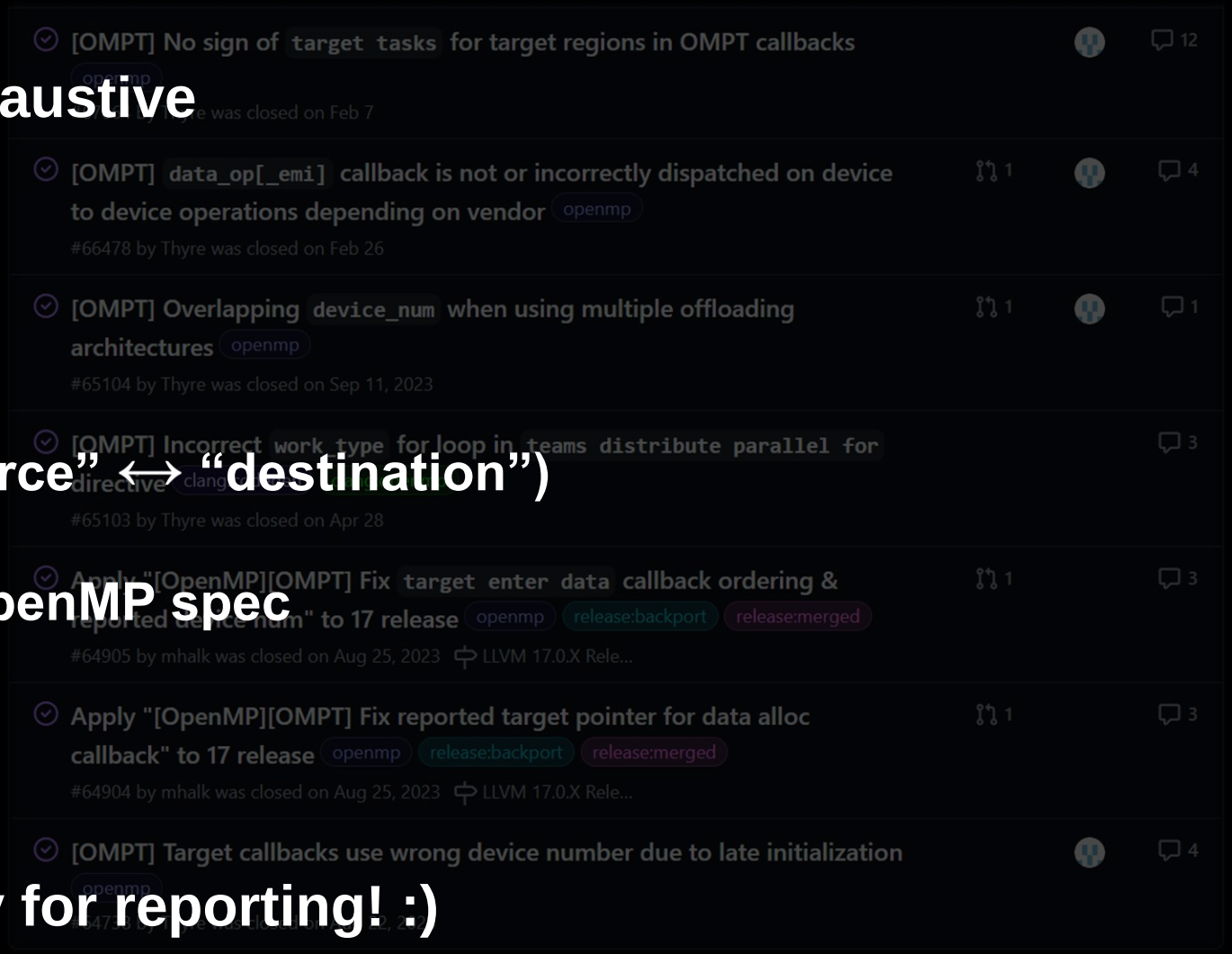
Test Case	18.0-1	19.0-0	19.0-2	19.0-3
OnDeviceDefaultTeams_Sequenced	✓	✓	✓	✓
OnDeviceSetNumTeams_Sequenced	✓	✓	✓	✓
OnDevice_Sequenced_Grouped	✓	✓	✓	✓
ExplicitDefaultDevice	✓	✓	✓	✓
Multi…es	✓	✓	✓	✓
DeclareTargetGlobalAndUpdate	✓	✓	✓	✓
ExplicitAllocatorAPI	✓	✓	✓	✓
ExplicitAllocatorAndCopyAPI	✗	✓	✓	✓
Expli…AndUpdate_NoDataOp	✗	✗	✗	✓
ExplicitAllocatorAndUpdate_DataOp	✗	✗	✗	✓
ExplicitAllo…AndUpdate_DataOpStack	✗	✗	✗	✓
Explicit…ce	❖	❖	❖	❖
ExplicitAssociateDisassociatePtrAPI	✗	✗	✗	✓
OnHost_On…	✓	✓	✓	✓
OnDeviceBufferRecord_parallel_for	✓	✓	✓	✓
OnDeviceCallbacks_parallel_for	✓	✓	✓	✓
OnDeviceBufferRecord_teams_distribute_parallel_for	✓	✓	✓	✓
OnDeviceCallbacks_teams_distribute_parallel_for	✓	✓	✓	✓
OnDeviceBufferRecord_teams_distribute_parallel_for_nowait	✓	✓	✓	✓
OnDeviceCallbacks_teams_distribute_parallel_for_nowait	✓	✓	✓	✓
DeviceLoad	✓	✓	✓	✓

- Host
- Device
  - API
  - Callbacks
  - Trace Records

Testing & Regressions

- Test coverage almost never exhaustive
  - Regressions happen(ed)

- Regression examples
  - Missing EMI callback endpoints
  - Switched device numbers (“source” ↔ “destination”)
  - RAII object lifetimes
  - “Wrong” interpretation of the OpenMP spec
  - …



- Big *thank you* to the community for reporting! :)

OMPT Testing

- **Test scenarios rarely straightforward**
  - **LLVM lit & FileCheck may prove cumbersome**

- **Key features**
  - **Maintainability**

    ”For each desired change, make the change easy (warning: this may be hard), then make the easy change.“

    -- Kent Beck

  - **Robustness**

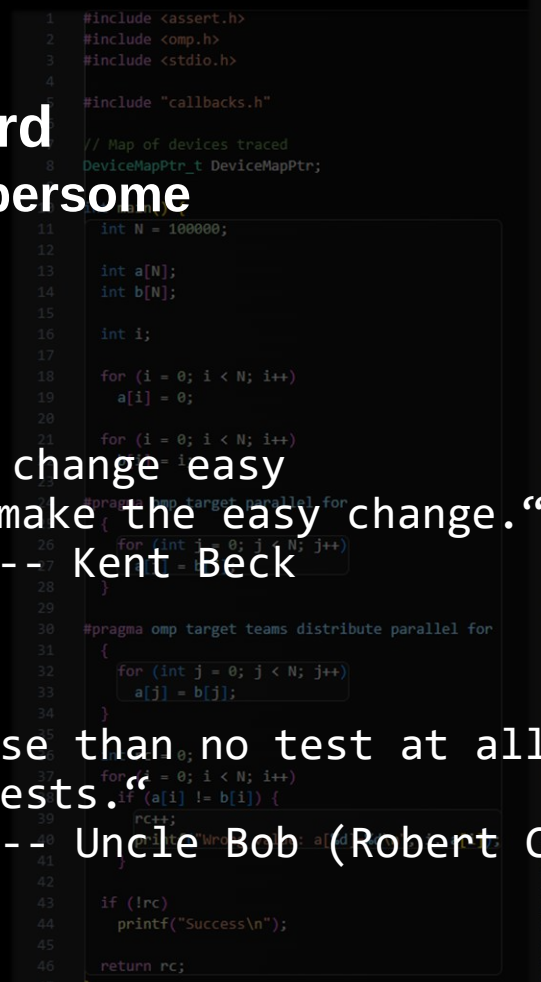
    ”A test that fails randomly is worse than no test at all. It teaches you to distrust your tests.“

    -- Uncle Bob (Robert C. Martin)

  - **Speed**

    ”The faster you can run your tests, the more tests you will run.“

    -- Kent Beck



ompTest

- Goal: OMPT unit testing library
  “GoogleTest-like”

- Own set of advantages
  - Unified event creation & verification
  - Improved readability & ease-of-use
  - Customized equality operators

- Limitations due to library-nature
  - OpenMP RT init / fini: out of scope

```
// Check for callback
OMPT_ASSERT_SET(TargetSubmit)

// Check for trace record
OMPT_ASSERT_SET(BufferRecord,
                /*Type=*/CB_KERNEL)
```

```
#pragma omp target loop
for(int i = 0; i < N; ++i) {
  Values[i] = 1;
}
```

ompTest

- **Related papers for SC'24**
  - **Correctness Workshop**
    https://correctness-workshop.github.io/2024

    "ompTest – Unit Testing with OMPT"

  - **HPC Bugs Fest**
    https://sites.google.com/view/hpc-bugs-fest/home

    "OMPTBench – OpenMP Tool Interface Conformance Testing"

```
// Check for callback
OMPT_ASSERT_SET(TargetSubmit)

// Check for trace record
OMPT_ASSERT_SET(BufferRecord,
                /*Type=*/CB_KERNEL)
```

```
#pragma omp target loop
for(int i = 0; i < N; ++i) {
  Values[i] = 1;
}
```

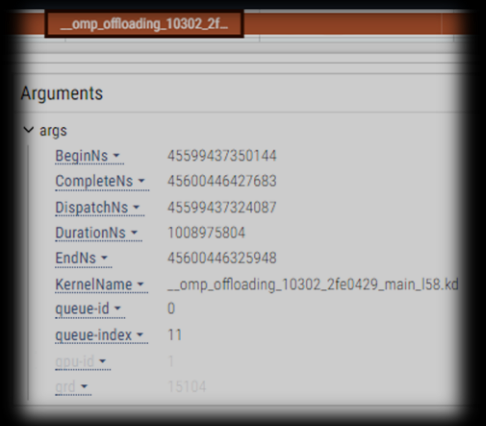
Possible Future of OMPT

- Device-side tracing support (upstream)
- “ompTest” library (upstream)
- OMPT “native” data type

```
libomptarget_ompt_set_trace_ompt(/*DeviceId=*/i,
                                 /*Enable=*/1,
                                 /*EventyTy=*/0

OMPT_ASSERT_SET_GROUPED("R1", TargetEmi, /*Kind=*/TARGET,
                        /*Endpoint=*/BEGIN)

OMPT_ASSERT_SET_GROUPED("R1", BufferRecord, /*Type=*/CB_TARGET,
                        /*Kind=*/TARGET,
                        /*Endpoint=*/BEGIN)
OMPT_ASSERT_SET_GROUPED("R1", BufferRecord, /*Type=*/CB_DATAOP,
                        /*OpType=*/ALLOC, /*Bytes=*/sizeof(a),
                        /*MinimumTimeDelta=*/10)
OMPT_ASSERT_SET_GROUPED("R1", BufferRecord, /*Type=*/CB_DATAOP,
                        /*OpType=*/H2D, /*Bytes=*/sizeof(a),
                        /*Timeframe=*/{10, 100000})
OMPT_ASSERT_SET_GROUPED("R1", BufferRecord, /*Type=*/CB_DATAOP,
                        /*OpType=*/ALLOC, /*Bytes=*/sizeof(b),
                        /*MinimumTimeDelta=*/10)
OMPT_ASSERT_SET_GROUPED("R1", BufferRecord, /*Type=*/CB_DATAOP,
                        /*OpType=*/H2D, /*Bytes=*/sizeof(b),
                        /*Timeframe=*/{10, 100000})
```



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