14th International Workshop on OpenCL and SYCL

IWOCL 2026

Lightweight Tracing Interface for SYCL's USM Model Implemented in AdaptiveCpp

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May 6-8, 2026 | Heilbronn, Germany | iwocl.org

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- Statistical code analysis

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Shouldn't there be vendor non-specific standardized tooling layer for the SYCL API?

Intel's XPTI: Vendor Specific

- OneAPI: XPTI
  - Dispatcher/Subscriber
  - Builds DAG explicitly
  - Tracepoints
  - UID (Can be propagated all the way to driver level)
- Assumes a certain architecture for the SYCL runtime
- Hard to standardize via SYCL (also implement)

Basic Setup

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  Environment variable `SYCL_TOOL_LIBRARIES` with paths to tools

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  Environment variable `SYCL_TOOL_LIBRARIES` with paths to tools
  Tools are loaded in the form of `*.so`-files (or eqv. in other OSs)

Developer Side

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- Expose functions without name mangling `extern "C"`
- Keep tracer state in struct and type cast inside function

```
struct state_t{...};
...
Callback_function(void* usr_state, ...){
  state_t* state_ptr = (state_t*) usr_state;
  ...
}
```

Developer Side

```
struct state_t{...};
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Callback_function(void* usr_state, ...){
  state_t* state_ptr = (state_t*) usr_state;
  ...
}

...

void init_register(){
 ...
}
```

Developer Side

```
...

void init_register(){
  auto* state = new state_t

  init_CallbackName(Callback);
  init_state(state);
  init_finalizer(Finalizer_function);

   ...
}
```

Two types of trace points

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- Construction and destruction of SYCL runtime objects

Define start and end trace points

- Entry and exit points for API function calls
- Tracer takes some additional arguments to allow for more context

- `sycl::event`
  - `wait`
- `sycl::queue`
  - `submit`
  - `submit_secondary`
  - `wait`
- `sycl::malloc_*`

- `sycl::handler`
  - `memset`
  - `memcpy`
  - `copy`
  - `depends_on`
  - `parallel_for` / `parallel_for_work_group`
  - `single_task`
  - `fill`

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Execute callback only when a unique new object is created!

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  - start-function and initializer in order in which they appear in `ENV`-variable
  - end-function and finalizer in inverse order

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- Combining with Boosts stack-trace utility, pointer allocation and file-lines can be associated

```
#include <sycl/sycl.hpp>

int main() {
  sycl::gpu_selector selector;
  sycl::queue q{selector};

  auto j = sycl::malloc_device<double>(100, q);
  auto k = sycl::malloc_shared<int>(100, q);
  auto l = sycl::malloc_host<float>(100, q);

  sycl::free(j, q);
  sycl::free(k, q);
}
```

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```
Memory leak detector activated
memory allocated at:
main at
~/SYCL_tracing-examples/memory_leak.cc:9
but never freed!
```

Tally Tracer

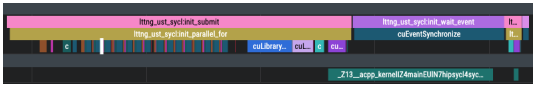
Name	Time	Time(%)	Calls	Average	Min	Max
submit	564.86ms	49.85%	18218	31.01us	6.38us	1.55ms
memcpy	457.85ms	40.41%	6074	75.38us	60.95us	1.54ms
parallel_for	54.79ms	4.84%	6072	9.02us	7.66us	173.39us
wait_event	53.72ms	4.74%	6072	8.85us	3.13us	14.89us
malloc_device	1.02ms	0.09%	3	338.51us	275.59us	402.26us
free	794.93us	0.07%	3	264.98us	223.55us	305.65us
wait_queue	14.85us	0.00%	2	7.42us	3.37us	11.48us
Total	1.13s	100.00%	36444			

Tally output of a Jacobi program from HeCBench on A100 GPU

- Measrues time spent and counts number of calls to an API function
- Example: Jacobi program from HecBench

Timeline visualization

```
sycl::queue Q{in_oder};
double *a = sycl::malloc_shared<double>(1, Q);
for (int i = 0; i < 2; i++) {
  Q.parallel_for(sycl::range<1>(1),
    [=](sycl::id<1> idx){
  a[0] = 42.0;
}).wait();
}
```



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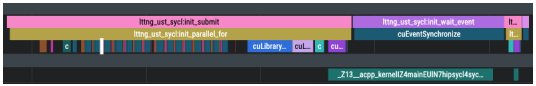

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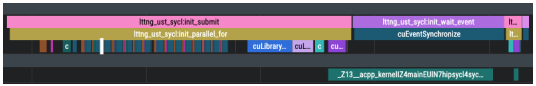

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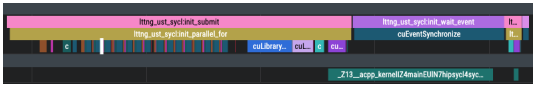

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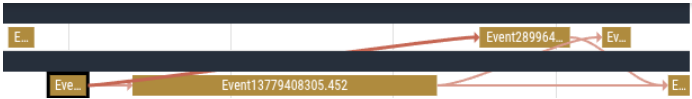
With the help of perfetto UI: Task graph visualizer

- Tracing the creation of (unique) events by hash value



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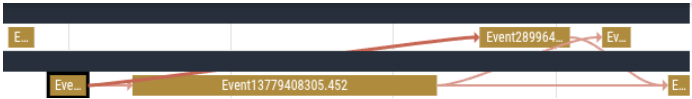

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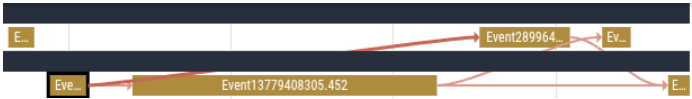

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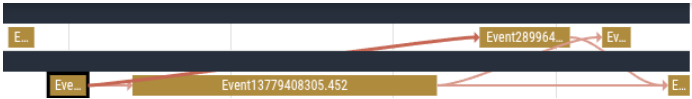

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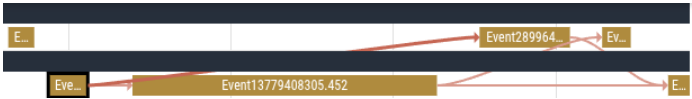

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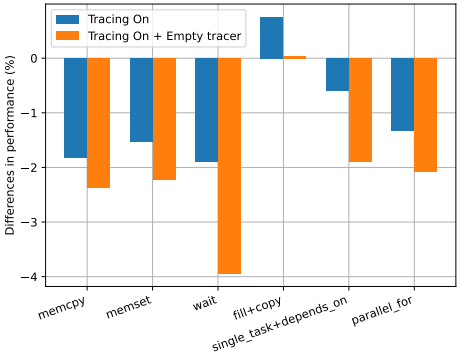
- Tracks represent queues
- With lower queue out-of-order) $\approx 30\%$ faster

Performance overhead negligible



- Performance comparison for trivial commands.
- API calls made per second in percent compared to AdaptiveCpp's develop branch
- Blue only tracing interface
- Orange: empty callbacks hooked in
- Tracing interface consisently introduces less 2% overhead

Contributions

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- Showed that it brings minimal performance overhead
- Implemented some useful tools as a p.o.c.

Future Work

- Extent this interface to the buffer-accessor model

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- Implement more tools
- Start a discussion on whether and how this might become part of the standard

Acknowledgements

Thomas Applencourt

Aksel Alpay

Argonne NATIONAL LABORATORY

UNIVERSITÄT HEIDELBERG ZUKUNFT SEIT 1386