


PRACE Workshop:
HPC code optimisation workshop
Introduction to Likwid

Thomas Gruber, Carla Guillen

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Likwid – Like I knew what I am doing


- Lightweight command line tools for performance measurements.
- Open source. Software available at: https://github.com/RRZE-HPC/likwid

Philosophy:

- Simple
- Efficient
- Portable
- Extensible

Why Likwid?


Provides several functionalities:

- Performance profiling: Serial, MPI, OpenMP, Hybrid.
- Pinning
- Topology
- Energy Measurements
- Change processor frequency settings
- Provides a set of benchmarks (stream, daxpy, ddot, …)

API to C, C++, Fortran, Python, Java

- There are several tools available for HPC applications.
- Profiling via advanced tools is often overkill
- A coarse overview is often sufficient

The likwid tools (binaries)


Gather node architecture information:

- likwid-topology
- likwid-powermeter

Force affinity control and data placement:

- likwid-pin
- likwid-mpirun

Query and alter system settings:

- likwid-features
- likwid-setFrequencies

Performance profiling:

- likwid-perfctr
- Benchmarking:
- likwid-memsweeper
- likwid-bench

Loading Likwid on Meggie

- You can check available versions:
  `module av likwid`
- We will use the 5.0.1 version
  `module load likwid/5.0.1`

Exploring likwid-perfctr


- Simple end-to-end measurement of hardware performance metrics
- Preconfigured and extensible metric groups, list with

```
likwid-perfctr -a
```

- Operating modes:
  - Stethoscope
  - Timeline
  - Wrapper
  - Marker API

Example of available groups:



```
BRANCH: Branch prediction miss rate/ratio
CLOCK: Clock of cores
DATA: Load to store ratio
FLOPS_DP: Double Precision MFlops/s
FLOPS_SP: Single Precision MFlops/s
L2: L2 cache bandwidth in MBytes/s
L2CACHE: L2 cache miss rate/ratio
L3: L3 cache bandwidth in MBytes/s
L3CACHE: L3 cache miss rate/ratio
MEM: Main memory bandwidth in MBytes/s
ENERGY: Energy consumption (RAPL)
```

Stethoscope mode:

- likwid-perfctr measures on core base and has no notion what runs on the cores
- This enables to listen on what currently happens without any overhead:

```
likwid-perfctr –c N:0-11 –g FLOPS_DP -S 10s
```

- It can be used as cluster/server monitoring tool
- A frequent use is to measure a certain part of a long running parallel application from outside

Timeline mode:

- Outputs the performance metrics in a specified frequency.

```
likwid-perfctr -C N:0-11 -g MEM –t 500ms ./a.out 2> out.txt
```

Wrapper mode:


Use `likwid-perfctr` as a wrapper of your serial or multi-threaded application.

```
likwid-perfctr –C S0:1 –g BRANCH ./a.out
```

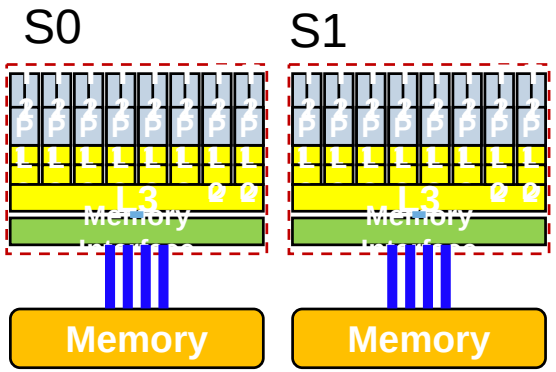
Wrapper for MPI (only available with mpi.intel)

```
likwid-mpirun –np 32 –nperdomain S:8 –g CLOCK ./mympiexec
```

and Hybrid (only available with mpi.intel)

```
likwid-mpirun –np 32 –t 4 –g CLOCK ./mympiexec
{0,1,2,3},{4,5,6,7},{8,9,10,11}, …
```

Topology



`likwid-topology`
`likwid-pin –p`

physical numbering: processors are numbered according to the numbering in the OS
logical numbering in node: processors are logical numbered over whole node (N prefix)
logical numbering in socket: processors are logical numbered in every socket (S# prefix, e.g., S0)
logical numbering in cache group: processors are logical numbered in last level cache group (C# prefix, e.g., C1)
logical numbering in memory domain: processors are logical numbered in NUMA domain (M# prefix, e.g., M2)
logical numbering within cpuset: processors are logical numbered inside Linux cpuset (L prefix)
Example: `S0:0,1`

Marker API mode:

Modify your code by inserting calls to:

```
LIKWID_MARKER_INIT; //serial

LIKWID_MARKER_REGISTER("process"); //parallel
LIKWID_MARKER_START("process"); //parallel
[…]
LIKWID_MARKER_STOP("process"); //parallel

LIKWID_MARKER_CLOSE; //serial
```

Compile with –DLIKWID_PERFMON and execute with likwid-perfctr –m …

What to measure


- Likwid predefined performance groups help you.
- Performance groups compute derived metrics on a set of event.
- Examples:

`MEM, L3, L2, FLOPS_DP, FLOPS_SP, FLOPS_AVX`

- These groups have been validated by micro benchmarking.
- Performance measurements do not solve our performance problems. But: we get hints as to what problems we may have.

Performance questions?


- ALU/Memory saturation?
- Load Imbalance?
- Vectorized floating point operations?
- Inefficient data access?
- Data between L1 and L2 Cache?
- Bad ccNUMA placement?
- Access between caches, memory and remote memory?
- Single or double precision? Flops/s ?
- Control flow problems?

```
for (int i=0;i<N;++i) {
    array[i] *= array[i];
}
```

Demo on usage…

Download example from github:

> git clone https://github.com/carlabguillen/hellolikwid.git

And now …


Thank you!