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Tools Hands-on

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Getting a trace with Extrae

Extrae features

- Parallel programming models
  - MPI, OpenMP(*), pthreads, OmpSs, CUDA, OpenCL, Java, Python…
- Platforms
  - Intel, Cray, BlueGene,, Fujitsu Sparc, Xeon Phi,, ARM, Android…
- Performance Counters
  - Using PAPI
- Link to source code
  - Callstack at MPI routines
  - OpenMP outlined routines
  - Selected user functions (Dyninst)
- Periodic sampling
- User events (Extrae API)

No need to recompile / relink!

How does Extrae work?

- Symbol substitution through LD_PRELOAD
  - Specific libraries for each combination of runtimes
    - MPI
    - OpenMP
    - OpenMP+MPI
    - …

Recommended

- Dynamic instrumentation
  - Based on DynInst (developed by U.Wisconsin/U.Maryland)
    - Instrumentation in memory
    - Binary rewriting

- Alternatives
  - Static link (i.e., PMPI, Extrae API)

Extrae overheads

	Average values	Cori (intel – gnu)
Event	120-200 ns	120 - 140 ns
Event + PAPI	725 ns – 1 us	730 - 725 us
Event + callstack (1 level)	600 ns	570 - 518 ns
Event + callstack (6 levels)	2 us	1.8 us

How to use Extrae

1. Adapt the job submission script

2. (Optional) Tune the Extrae XML configuration file
   - Examples distributed with Extrae at $EXTRAE_HOME/share/example

3. Run with instrumentation

- For further reference check the **Extrae User Guide**
  - Also distributed with Extrae at $EXTRAE_HOME/share/doc
  - http://www.bsc.es/computer-sciences/performance-tools/documentation

Log in to cori and copy the example to your home

@ your laptop

```
> ssh -X <USER>@cori.nersc.gov
```

- Copy the examples to your home folder:

@ cori.nersc.gov

```
> cp -r ~judit/handson_extrae $HOME

> ls -l $HOME/handson_extrae
    … lulesh
    … mpi_ping
    … extrae
```

Adapt the job script to load Extrae (LD_PRELOAD)

@ cori.nersc.gov

```
> vi $HOME/handson_extrae/lulesh/job1n.sh
```

job1n.sh

```
#!/bin/bash -l
#SBATCH --partition=debug
#SBATCH --nodes=1
#SBATCH --time=00:10:00
#SBATCH --license=SCRATCH  #note: specify
license need for the file systems your job
needs, such as SCRATCH,project

module swap PrgEnv-intel PrgEnv-gnu




srun -n 27 ./lulesh2.0 -i 10 -p -s 65
```

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module swap PrgEnv-intel PrgEnv-gnu
module load extrae

TRACE=../extrae/trace.sh
export TRACE_NAME=lulesh27_1node.prv

srun -n 27 $TRACE ./lulesh2.0 -i 10 -p -s 65
```

Adapt the job script to load Extrae (LD_PRELOAD)

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module load extrae

TRACE=../extrae/trace.sh
export TRACE_NAME=lulesh27_1node.prv

srun -n 27 $TRACE ./lulesh2.0 -i 10 -p -s 65
```

trace.sh

```
#!/bin/bash

export EXTRAE_HOME=$EXTRAE_DIR
export EXTRAE_CONFIG_FILE= $HOME/
handson_extrae/extrae/extrae.xml

export LD_PRELOAD=${EXTRAE_HOME}/lib/
libmpitrace.so
# For C apps
#exportLD_PRELOAD=${EXTRAE_HOME}/lib/
libmpitracef.so
# For Fortran apps

## Run the desired program
$*
```

Pick tracing library

Library selection

- Choose depending on the application type

Library	Serial	MPI	OpenMP	pthread	CUDA
libseqtrace	✓				
libmpitrace[f][1]		✓			
libomptrace			✓		
libpttrace				✓	
libcudatrace					✓
libompitrace[f] [1]		✓	✓		
libptmpitrace[f] [1]		✓		✓	
libcudampitrace[f] [1]		✓			✓

[1] include suffix “f” in Fortran codes

Extrae XML configuration

```
<mpi enabled="yes">
  <counters enabled="yes" />
</mpi>

<openmp enabled="yes">
  <locks enabled="no" />
  <counters enabled="yes" />
</openmp>

<pthread enabled="no">
  <locks enabled="no" />
  <counters enabled="yes" />
</pthread>

<callers enabled="yes">
  <mpi enabled="yes">1-3</mpi>
  <sampling enabled="no">1-5</sampling>
</callers>
```

Trace MPI calls + HW counters

Trace call-stack events @ MPI calls

Extrae XML configuration (II)

```
<counters enabled="yes">
   <cpu enabled="yes" starting-set-distribution="cyclic">
     <set enabled="yes" domain="all" changeat-time="500000us">
       PAPI_TOT_INS,PAPI_TOT_CYC,PAPI_L1_DCM,PAPI_L3_TCM,PAPI_BR_CN,PAPI_BR_UCN
     </set>
     <set enabled="yes" domain="all" changeat-time="500000us">
   PAPI_TOT_INS,PAPI_TOT_CYC,PAPI_BR_MSP,PAPI_SR_INS,PAPI_LD_INS,RESOURCE_STALLS:SB
     </set>
     <set enabled="yes" domain="all" changeat-time="500000us">
       PAPI_TOT_INS,PAPI_TOT_CYC,PAPI_L2_DCM,RESOURCE_STALLS:ROB,RESOURCE_STALLS:RS
     </set>
     <set enabled="yes" domain="all" changeat-time="500000us">
        PAPI_TOT_INS,PAPI_TOT_CYC,RESOURCE_STALLS
     </set>
   </cpu>
   <network enabled="no" />
   <resource-usage enabled="no" />
   <memory-usage enabled="no" />
 </counters>
```

Select which HW counters are measured

Extrae XML configuration (III)

```
<buffer enabled="yes">
  <size enabled="yes">500000</size>
  <circular enabled="no" />
</buffer>

<sampling enabled="no" type="default" period="50m" variability="10m" />

<merge enabled="yes"
       synchronization="default"
       tree-fan-out="16"
       max-memory="512"
       joint-states="yes"
       keep-mpits="yes"
       sort-addresses="yes"
       overwrite="yes"
> $TRACE_NAME$
</merge>
```

Trace buffer size

Enable sampling

Merge intermediate files into Paraver trace

Run with instrumentation

Submit your job

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```
> cd $HOME/handson_extrae

> sbatch job1n.sh
```

- Once finished (check with “squeue”) you will have the trace:
  - Lulesh27_1node.{prv,pcf,row} (3 files)

First steps of analysis

- Start Paraver

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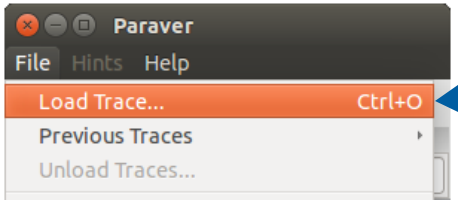
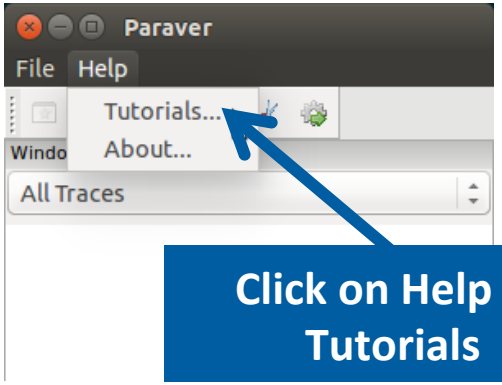
```
> source $HOME/handson_extrae/setup_bsctools.sh
> wxparaver &
```

- Load the trace



Click on File → Load Trace → Browse to lulesh27_1node.prv

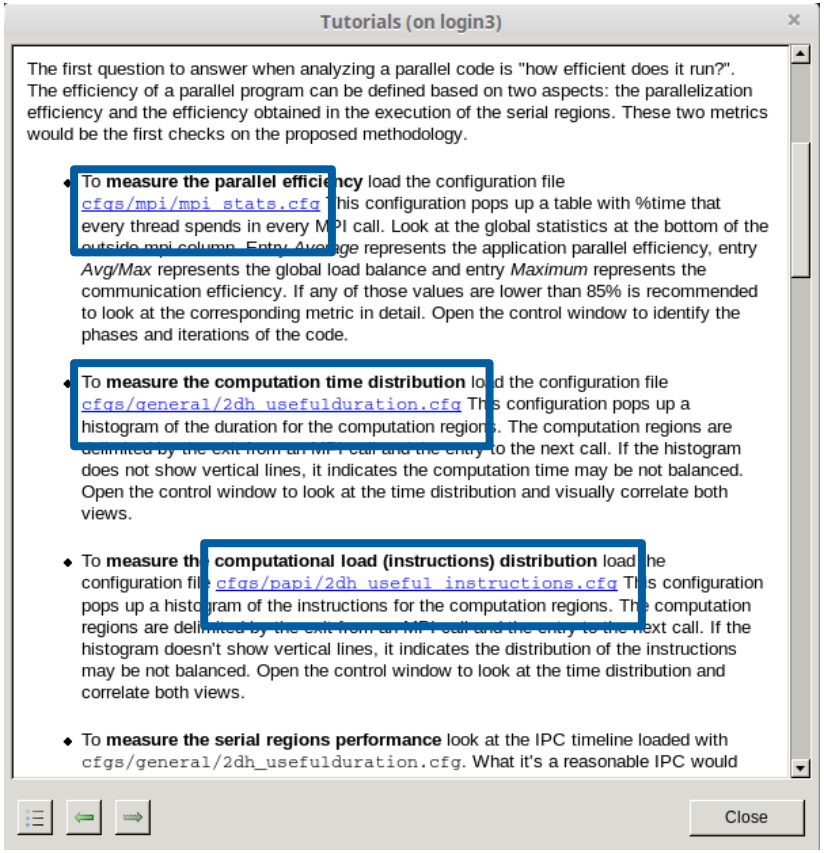
- Follow Tutorial #3
  - Introduction to Paraver and Dimemas methodology



Click on Help → Tutorials

Is the application efficient?

- Click on “mpi_stats.cfg”
  - Check the Average for the column labeled “Outside MPI”
    - Parallel efficiency is high?
- Click on “2dh_usefulduration.cfg”
  - Histogram of duration of the computing regions
    - Vertical lines or dispersion? Fast/slow processes?
- Click on “2dh_useful_instructions.cfg”
  - Histogram of instructions of the computing regions
    - Work is well distributed?



The trace is HUGE?

- Chop a region of interest from the trace-file
  1. Filter the trace discarding very small regions

```
> $PARAVER_HOME/bin/paramedir -f filter.xml <trace.prv>
```

Example file in cori:
~judit/handson-extrae/tools_cfgs/filter.xml

- This gets a trace showing only the most relevant regions for the whole run

2. On the filtered trace: File → Load configuration → cfgs/General/view/useful-duration.cfg
   - Identify a periodic pattern / small region of interest

3. Apply the "scissors" tool → Cut the region of interest from the big trace
   - This gets a small trace with all the details for a small time interval

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Installing Paraver in your laptop

Installing Paraver in your laptop (I)

- Download the Paraver binaries to your laptop

@ your laptop

```
> scp <USER>@cori.nersc.gov:~judit/packages/<VERSION> $HOME
```

Pick your version

Linux 64 bits	`wxparaver-4.6.2-linux-x86_64.tar.gz`
Linux 32 bits	`wxparaver-4.6.2-linux-x86_32.tar.gz`
Mac	`wxparaver-4.6.2-mac.zip`
Windows	`wxparaver-4.6.2-win.zip`

Installing Paraver in your laptop (II)

- Uncompress the package into your home directory

@ your laptop

```
> tar xvfz wxparaver-4.6.2-linux-x86_64.tar.gz -C $HOME

> ln -s $HOME/wxparaver-4.6.2-linux-x86_64 $HOME/paraver
```

- Download Paraver tutorials and uncompress into the Paraver directory

@ your laptop

```
> scp <USER>@cori.nersc.gov:~judit/packages/paraver-
tutorials.tar.gz $HOME

> tar xvfz $HOME/paraver-tutorials.tar.gz -C $HOME/paraver
```

Check that everything works

- Start Paraver

@ your laptop

```
> $HOME/paraver/bin/wxparaver &
```

- Check that tutorials are available