Performance Analysis on Energy Efficient High-Performance Architectures

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Cluster Computing Workshop
Lviv, Ukraine
May 3rd, 2013

Outline

Is Energy Consumption the Issue? (I)

K supercomputer at the RIKEN AICS (#1 in 2011)

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- Annual support cost: \$$9$ m (**-10 %**)
- Annual support cost of Titan without GPUs – \$$30$ m!

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Accelerators

- NVIDIA GPUs

Alternative Solutions

Use **alternatives** to the standard HPC architectures:

Accelerators

- NVIDIA GPUs

Low-power CPUs

- ARM CPUs

Sources: `www.green500.org`, `www.top500.org`, `www.montblanc-project.eu`

New Alternatives – New Challenges

- **Programmability.** Efficiently combining different programming models is not an easy task
- **Portability.** Adjusting applications to the new HPC systems may require major changes to applications
- **Efficiency.** Some HPC applications run better on standard HPC architectures

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Solution: Thorough **performance analysis** of applications

Performance Analysis

- **Understanding** the application behavior is **necessary** to debug and optimize it
- Two approaches
  - Debug at the code level (gdb, Valgrind, Totalview)
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We aim at supporting **performance tracing** on both *GPU accelerators* and *low-power ARM CPUs*

Profiling Issues

- Profiling may require **source code** instrumentation
- That requires to **recompile** the application

An EZTrace Framework

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EZTrace Features

- **No recompilation**
- Plugin-based – allows to profile custom functions
- Performance tracing in two steps
  - **Trace collection**: Record raw events
  - **Post-mortem** trace **analysis**: Interpret events

EZTrace: Trace Collection

- Load appropriate plugins:

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export EZTRACE_TRACE="mpi omp pthread memory stdio"
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- Generate raw traces: one per process

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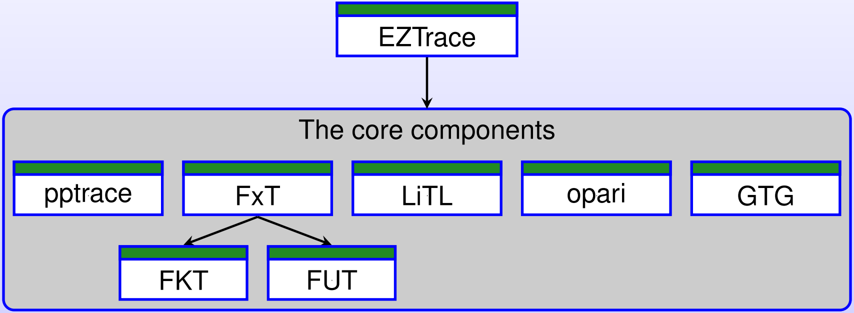
- Post-mortem analysis does **not impact** on the application execution

EZTrace: Structure



EZTrace: An Example

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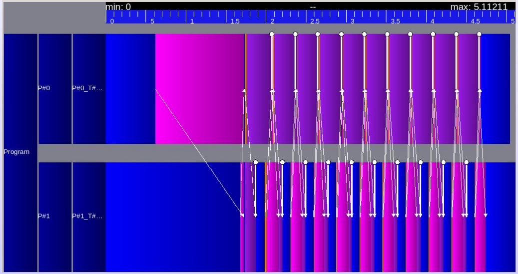
ViTE: 

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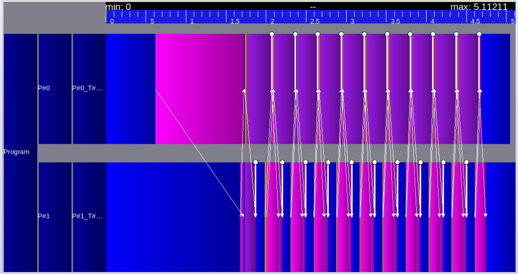
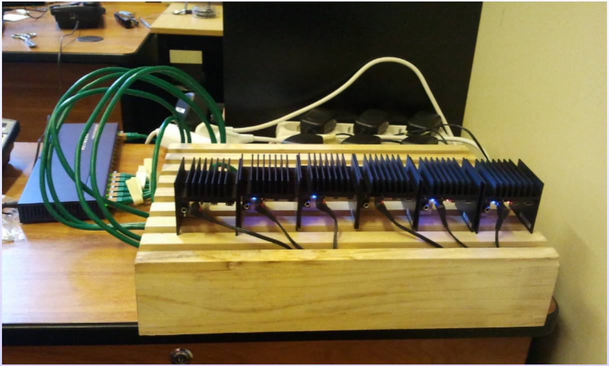



```
eztrace_stats /tmp/iakymchuk_eztrace_log_*
  MPI_SEND               :20 calls
  MPI_RECV               :20 calls
  MPI_BARRIER            :22 calls
  Time spent sending (ns):  min: 7.717  max: 22.623
       average: 10.186  total: 101.863
```

Experimental Setup



Source: http://www-public.it-sudparis.eu/~trahay_f/odroid_supercomputer/

Figure: Odroid-U2 cluster equipped with six quad-core ARM Cortex-A9 @1.7GHz

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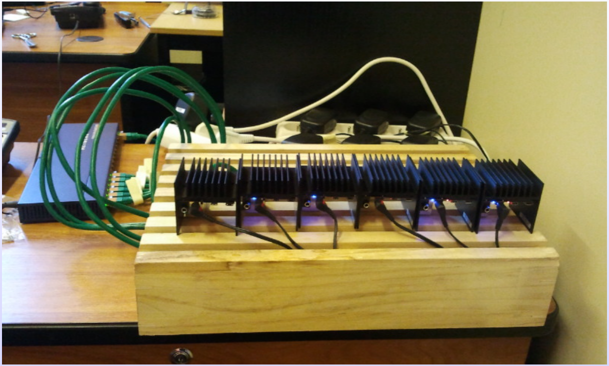

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Figure: Odroid-U2 cluster equipped with six quad-core ARM Cortex-A9 @1.7GHz

Energy consumption per node:

- Idle: 2 W
- Computing: 7 W

NAS Parallel Benchmarks (NPB)

Kernel	#Events	NPB (secs)	EZTrace (secs)	Overhead (%)
BT	3,645,137	295.97	297.74	0.60
MG	632,425	20.83	21.12	1.39
LU	8,003,726	324.27	310.41	−4.27
FT	12,678,743	283.01	284.00	0.35
IS	1,601,371	28.80	28.87	0.24
SP	4,438,161	483.02	484.10	0.22
CG	7,675,754	529.75	529.26	−0.09
EP	135,138	19.98	19.85	−0.65

Table: The results of running NAS Parallel Benchmarks on the 4-node of the odroid cluster. Settings: CLASS=B; NBPROCS=16

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Execution	`min` (secs)	`max` (secs)
Raw LU	305.65	326.34
With EZTrace	304.63	327.77

Table: Variation in the time measurements

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- **EZTrace** – an open-source framework for performance analysis
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Future Work

- **Enhance** the performance of the CUDA module
- Develop an **OpenCL** module
- Port EZTrace to Intel Phi and Kalray **MPPAs**

References

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Questions?

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