ALICE experiences with ARM

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Acknowledgement and disclaimers

- Many thanks to the UKI-SCOTGRID-GLASGOW site (Dwayne Spiteri and colleagues) for the super-stable setup provided for the ALICE first tests of ARM processing on a large scale

- What was done
  - Extensive test of MC simulation jobs - comparison of run times, efficiency, memory use
- What wasn’t done
  - Data processing and analysis workflows
  - Multiple software releases (this will become important later)

Jobs efficiency (cpu time / wall time)

Site	Number of jobs Running	Saving	Done	Error	RSS Min	Avg	Max	Virtual Min	Avg	Max	Average Running
ALICE::CERN::Capella	211	1	2618	9	26.8 MB	3.51 GB	17.16 GB	1.18 GB	1.18 GB	1.18 GB	3:16
2839 jobs on 1 sites	**211**	**1**	**2618**	**9**	**26.8 MB**	**3.51 GB**	**17.16 GB**	**1.18 GB**	**1.18 GB**	**1.18 GB**	**3:16**

Site	Number of jobs Running	Saving	Done	Error	RSS Min	Avg	Max	Virtual Min	Avg	Max	Average Running
ALICE::CERN::Capella			5995	5							2:06
6000 jobs on 1 sites			**5995**	**5**							**2:06**

Site	Number of jobs Running	Saving	Done	Error	RSS Min	Avg	Max	Virtual Min	Avg	Max	Average Running
ALICE::CERN::Capella	200		1272	14	13.79 MB	2.955 GB	173 GB	1.117 GB	1.117 GB	1.117 GB	1:14
1487 jobs on 1 sites	**200**		**1272**	**14**	**13.79 MB**	**2.955 GB**	**173 GB**	**1.117 GB**	**1.117 GB**	**1.117 GB**	**1:14**

- Memory consumption within the 16GB limit
- Job completion rate unchanged for the three trials and is about 98%

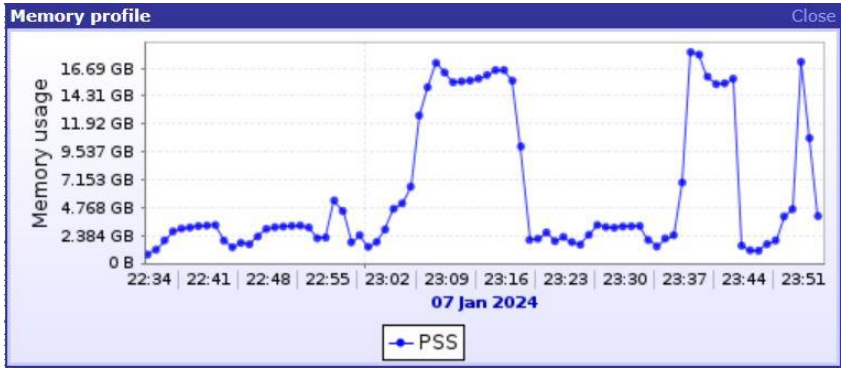
Site	Number of jobs: Running	Saving	Done	Error	RSS: Min	Avg	Max	Virtual: Min	Avg	Max	Average: Running
ALICE::CERN::Capella	198		2175	84	13.13 MB	2.939 GB	188.7 GB	8 KB	231.1 MB	1.126 GB	2:05
2457 jobs on 1 sites	**198**		**2175**	**84**	**13.13 MB**	**2.939 GB**	**188.7 GB**	**8 KB**	**231.1 MB**	**1.126 GB**	**2:05**

Site	Number of jobs: Running	Saving	Done	Error	RSS: Min	Avg	Max	Virtual: Min	Avg	Max	Average: Running
ALICE::CERN::Capella	220		293		173.5 MB	3.921 GB	17.05 GB	4 KB	17.89 MB	54.15 MB	5:02
513 jobs on 1 sites	**220**		**293**		**173.5 MB**	**3.921 GB**	**17.05 GB**	**4 KB**	**17.89 MB**	**54.15 MB**	**5:02**

Site	Number of jobs: Running	Saving	Done	Error	RSS: Min	Avg	Max	Virtual: Min	Avg	Max	Average: Running
ALICE::CERN::Capella	188		993	88	16.39 MB	2.477 GB	7.677 GB				1:26
1271 jobs on 1 sites	**188**		**993**	**88**	**16.39 MB**	**2.477 GB**	**7.677 GB**				**1:26**

Comparison of p-p, high event number MC job behaviour

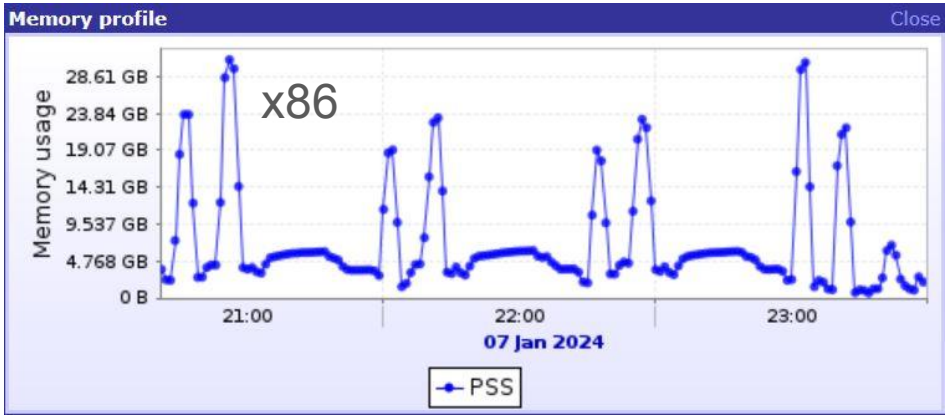
x86: 65% job efficiency,78% job success rate

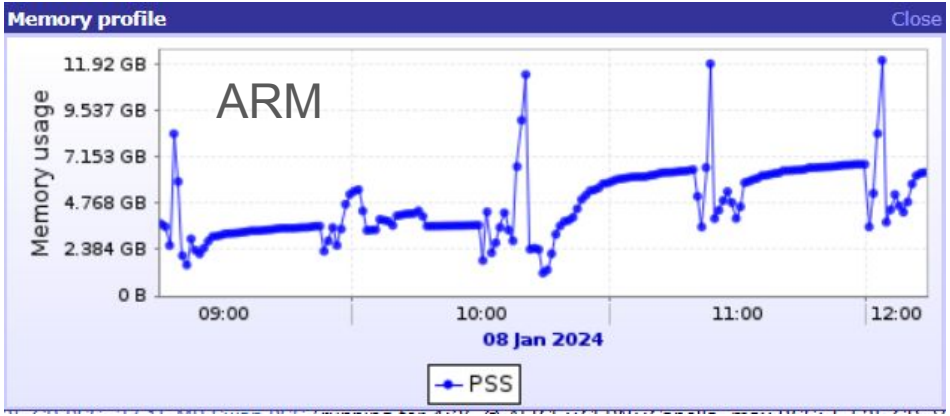


ARM: 50% job efficiency, 99% job success rate

- Average running time on x86 (14HS23/core) is ~20% faster than ARM Ampere Altra Q80-30 (80 cores);
- Different ARM memory management avoids the high memory spikes, which kill a large fraction (~20%) of all jobs on average x86 site, while on ARM 99% of jobs are successful
- CPU efficiency on x86 site for the same type of job is 15% higher than on ARM, both efficiencies are low for MC-type jobs (this is a code issue)

Comparison of Pb-Pb, high event number MC job behaviour





- x86 MC is hampered by memory spikes and is thus limited in number of TFs - less probability of job being killed
- 8% job success rate (all other killed for memory overuse)
- The successful jobs ran only at sites with very generous memory allocation policies (40GB+/8 core slot)

- MC on ARM can be of arbitrary length and duration, up to the 24TTL limit, with what appears to be a slight memory leak
- Well below the 16GB memory limit of the job slot

Operation on ARM

- Software build and test - ALICE standard CI (aarch64)
  - Multiple OS versions (EL7, AlmaLinux9, Ubuntu24)
  - Distribution through CVMFS
- Containers for payload execution
  - Same as above
- Detection of platform and CPU type
  - Transparent setup of SW build and container - users do not differentiate between CPU types - same treatment as AMD, Intel CPU
    - However users can specifically select ARM

- Automatic detection and setup is the only viable option for adding new CPU types to the Grid sites

Issues and further tests

- After the December 2023 successful test
  - Subsequent software release produced a (quite unhelpful) segmentation fault, only on ARM and only with a specific (the default for Alma9) kernel version
  - We now have a reproducer and know with a relatively high level of certainty where the issue is

- Currently testing the behaviour of data processing and analysis jobs
  - ARM resources available at CNAF, CERN and ALICE local
  - Should gain experience and understanding of (subtle) differences for wider adoption

Conclusions and recommendations

- Current status of ALICE tests on ARM
  - Very good performance of the CPU, compatible with the average HS23 on the Grid
  - Possible improvements of memory management observed
  - Integration of ARM clusters/queues into the ALICE build and Grid machinery is complete and was not problematic
  - Subtle differences of code behaviour on ARM point to the need for more and detailed tests before wide and uncontested adoption

- Management of ARM machines/queues on the sites
  - We recommend that ARM machines are either segregated behind a separate CE or
  - In a mixed queue there is an option, which enables/disables ARM hosts