

Load Balancing for ALICE

Software for Science, CERN

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Load
Balancing for
ALICE

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Introduction

Load
Balancing for
ALICE

- Mitchell Puls
 - 500659986
 - mitchpuls@upcmail.nl
 - mitch.puls@hva.nl
 - +31615050310
- Mentor
 - C.J. Rijsenbrij
- Company Supervisor
 - Dr. M. Teitsma



ALICE

Load
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ALICE

- CERN
- LHC
- ALICE



ALICE

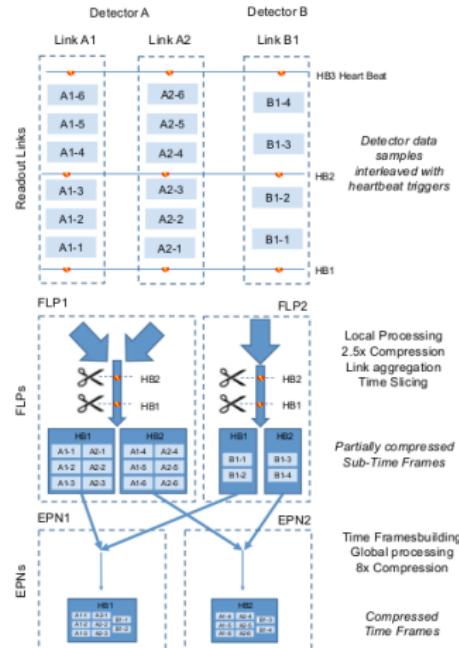
1

¹<http://alice-collaboration.web.cern.ch/>



Load Balancing

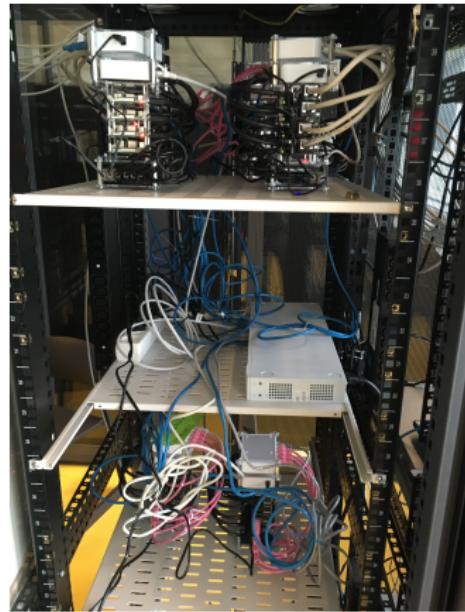
- Setup
 - First Level Processors (FLP)
 - Event Processing Nodes (EPN)
 - Information Node (IN)
- Blacklist Algorithm



Cluster

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- Raspberry Pi
- Cluster
- 2nd Ethernet Interface



Cluster

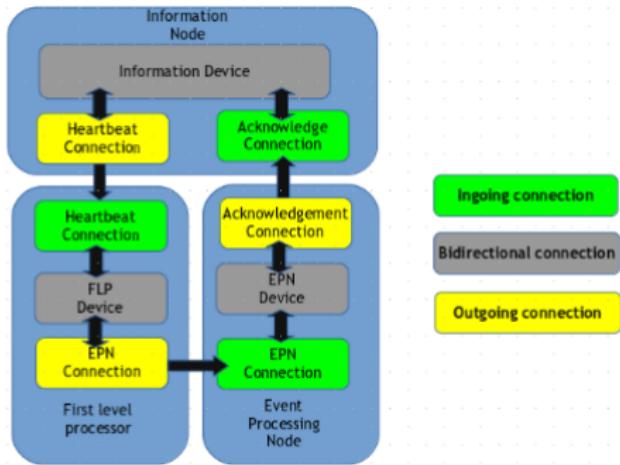
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Experiments

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- Ratio
- Compare
- Expand



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³ Block diagram of the cluster connections (van der Heijden, 2016 p. 22)



Experiments

Experiment 1

Load

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ALICE

■ Definition

Ticktime influence on the
Blacklist algorithm with one
fail-over

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⁴Effects of the EPNs and FLPs on the Information Node for ALICE
(Puls, 2018, p. 21)



Experiment 1

Results

Experiment one (2/12) using a cluster of Raspberry Pi's

Ticktime	Mean TF loss	Standard Deviation
5	2.16	0.49
10	2.13	0.47
15	3.08	0.2
20	3.0	0
25	3.52	0.51
30	4.32	0.57
35	4.13	0.79
40	4.56	0.16

Table 6.1: Results of the TFs lost with 1 fail over using a cluster of Raspberry Pi's

Experiment one (2/12) using a cluster on Nikhef

Ticktime	Mean TF loss	Standard Deviation
5	1.24	0.4271
10	1.84	0.731
15	2.16	0.3666
20	2.12	0.325
25	2.708	0.4545
30	3	0
35	3.52	0.4996
40	3.76	0.4271

Table 6.2: Results of the TFs lost with 1 fail over using a cluster of Intel Xeons
(van der Heijden, 2018, p. 36)



Experiment 1

Results

Experiment one (3/18) using a cluster of Raspberry Pi's

Ticktime	Mean TF loss	Standard Deviation
5	1.13	0.34
10	1	0
15	1.92	0.50
20	2.08	0.28
25	2.08	0.28
30	2.08	0.28
35	2.52	0.51
40	2.84	0.37

Table 6.7: Results of the TFs lost with 1 fail over using a cluster of Raspberry Pi's

Experiment one (4/24) using a cluster of Raspberry Pi's

Ticktime	Mean TF loss	Standard Deviation
5	1	0
10	1.08	0.28
15	1.76	0.53
20	2.12	0.44
25	2	0
30	2	0
35	2.16	0.37
40	2.33	0.48

Table 6.10: Results of the TFs lost with 1 fail over using a cluster of Raspberry Pi's



Experiments

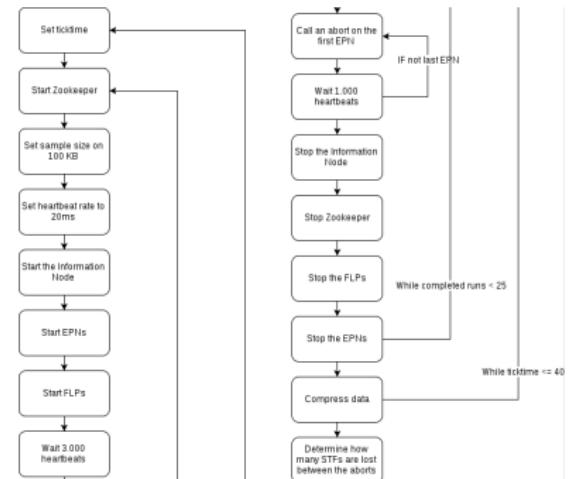
Experiment 2

Load
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ALICE

■ Definition

Ticktime influence on the
Blacklist algorithm with all but
one fail-over

5



⁵Effects of the EPNs and FLPs on the Information Node for ALICE
(Puls, 2018, p. 23)

Experiment 2

Results

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Experiment two (2/12) using a cluster of Raspberry Pi's

Lost EPNs	1 EPN	2 EPNs	3 EPNs	4 EPNs	5 EPNs	6 EPNs	7 EPNs	8 EPNs	9 EPNs	10 EPNs	11 EPNs	Total
Ticktime												
5	2	1.92	1.96	1.92	1.92	2.08	2.63	2.92	3.21	3.71	4.67	18.92
10	2	2.36	2.6	3.2	3.08	3.04	3.08	3.72	4.04	5.08	6.68	28.88
15	2.96	2.96	2.96	3	3.58	3.58	3.96	4.38	5.25	6.38	8.54	37.54
20	2.96	3.13	3.25	3.75	4	4.29	4.67	5.46	6.29	8.04	10.38	46.67
25	3.36	3.64	3.92	4	4.56	4.96	5.44	6.32	7.4	9	12.68	55.28

Table 6.3: Cumulative lost TFs by ticktime/EPN ratio with a flat sample size for the Blacklist algorithm

Experiment two (2/12) using a cluster on Nikhef

Lost EPNs	1 EPN	2 EPNs	3 EPNs	4 EPNs	5 EPNs	6 EPNs	7 EPNs	8 EPNs	9 EPNs	10 EPNs	11 EPNs	
Ticktime												
5	1	2	2	2	2	2	2	3	3	3	3	4
10	1	2	3	3	3	3	3	3	4	4	4	5
15	1	3	3	3	3	3	4	4	4	5	5	7
20	9	3	3	3	4	4	4	5	5	6	6	8
25	11	3	4	4	4	4	5	5	6	7	9	

Table 6.4: Cumulative lost TFs by ticktime by lost EPNs (van der Heijden, 2018, p. 38)



Experiment 2

Results

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Experiment two (3/18) using a cluster of Raspberry Pi's

Lost EPNs	1 EPN	2 EPNs	3 EPNs	4 EPNs	5 EPNs	6 EPNs	7 EPNs	8 EPNs	9 EPNs	10 EPNs	11 EPNs	Total
Ticktime												
5	1.14	1.1	1.05	1.05	1.05	1.1	1.5	1	1.67	1.52	1.62	3.33
10	1.04	1.25	1.29	1.17	1.88	2.04	2	2.08	1.96	2.08	2.04	8.83
15	2	2.08	2.08	2.08	2.04	2	2.08	2.08	2.33	2.71	2.79	14.29
20	2.16	2.12	2.08	2.08	2.16	2.12	2.4	2.52	2.96	3.04	3.08	16.72
25	2.04	2.16	2.04	2.16	2.6	2.48	2.92	3.08	3.2	3.36	3.72	19.76

Table 6.8: Cumulative lost TFs by ticktime/EPN ratio with a flat sample size for the Blacklist algorithm

Experiment two (4/24) using a cluster of Raspberry Pi's

Lost EPNs	1 EPN	2 EPNs	3 EPNs	4 EPNs	5 EPNs	6 EPNs	7 EPNs	8 EPNs	9 EPNs	10 EPNs	11 EPNs	Total
Ticktime												
5	1.15	1.15	1.25	1.15	1.05	1.15	1.15	1.15	1.1	1.1	1.25	2.65
10	1.08	1.04	1.08	1.08	1.48	1.48	1.52	1.8	2.04	1.96	2.24	6.8
15	1.4	1.68	1.72	2	2.04	2.04	2.08	2	2.08	2	2.08	11.12
20	2.12	2.04	2.08	2	2.16	2.12	2.08	2.08	2.12	2.08	2.24	13.12
25	2.12	2.12	2.16	2.12	2.12	2.04	2.2	2.08	2.6	2.68	2.64	14.88

Table 6.11: Cumulative lost TFs by ticktime/EPN ratio with a flat sample size for the Blacklist algorithm



Experiments

Experiment 3

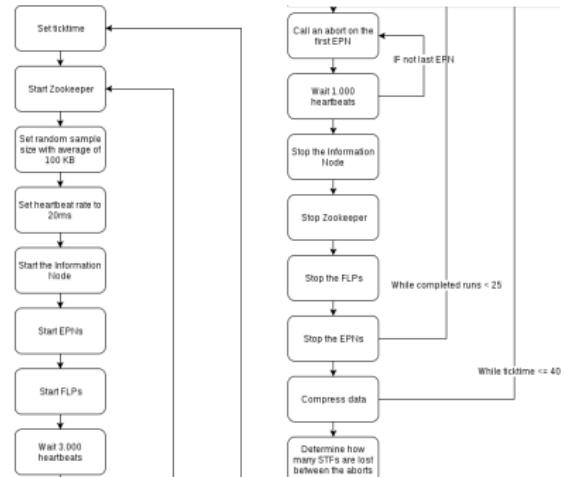
Load

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■ Definition

Ticktime influence on the Blacklist algorithm with all but one fail-over using a random sample size

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⁶Effects of the EPNs and FLPs on the Information Node for ALICE
(Puls, 2018, p. 24)



Experiment 3

Results

Load
Balancing for
ALICE

Experiment three (2/12) using a cluster of Raspberry Pi's

Lost EPNs	1 EPN	2 EPNs	3 EPNs	4 EPNs	5 EPNs	6 EPNs	7 EPNs	8 EPNs	9 EPNs	10 EPNs	11 EPNs	Total
Ticktime												
5	1.92	1.96	1.96	2.2	2.52	2.88	2.96	3.08	3.56	4.2	4.92	23.88
10	1.96	2.3	2.52	2.74	2.81	2.93	2.85	3.48	3.85	4.74	6.33	26.52
15	3	2.92	2.96	2.96	3.21	3.38	4.04	4.42	5.25	6.29	8.67	37.08
20	3	3	3.38	3.5	3.92	4.17	4.79	5.17	6.08	7.54	10.88	45.12
25	3.71	3.54	3.92	3.83	4.13	4.79	5.33	6.13	7.21	9.17	13.38	55.13

Table 6.5: Cumulative lost TFs by ticktime/EPN ratio with a random sample size for the Blacklist algorithm

Experiment three (2/12) using a cluster on Nikhef

Lost EPNs	1 EPN	2 EPNs	3 EPNs	4 EPNs	5 EPNs	6 EPNs	7 EPNs	8 EPNs	9 EPNs	10 EPNs	11 EPNs	
Ticktime												
5	1	2	2	2	2	3	3	3	3	4	4	
10	1	3	3	3	3	3	3	4	4	5	6	
15	11	3	3	3	3	3	4	4	5	6	7	
20	10	3	3	3	4	4	4	5	6	7	9	
25	13	3	4	4	4	4	5	5	7	8	10	

Table 6.6: Cumulative TF data loss across events with the Blacklist algorithm and a random sample size (van der Heijden, 2018, p. 40)



Experiment 3

Results

Load
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Experiment three (3/18) using a cluster of Raspberry Pi's

Lost EPNs	1 EPN	2 EPNs	3 EPNs	4 EPNs	5 EPNs	6 EPNs	7 EPNs	8 EPNs	9 EPNs	10 EPNs	11 EPNs	Total
Ticktime												
5	2.56	2.39	2.22	1.17	1.22	2	1.11	2.17	1.44	1.33	1.72	9.33
10	2.88	2.88	2.38	1.08	1.71	2	1.54	2.25	2.08	2	2.29	13.08
15	3.08	4	3	2.04	2.04	2.58	2.08	3.04	2.33	2.25	2.54	19
20	3.28	4.04	3.24	2.08	2.12	3.12	2.16	3.16	3	2.88	3.08	22.16
25	3.7	4.00	3.87	2.52	2.78	3.13	2.83	3.65	3.39	3.3	3.96	27.22

Table 6.9: Cumulative lost TFs by ticktime/EPN ratio with a random sample

Experiment three (4/24) using a cluster of Raspberry Pi's

Lost EPNs	1 EPN	2 EPNs	3 EPNs	4 EPNs	5 EPNs	6 EPNs	7 EPNs	8 EPNs	9 EPNs	10 EPNs	11 EPNs	Total
Ticktime												
5	1.1	2.14	1.14	1.57	1.24	2.14	1.14	2	2.1	1.48	2.05	8.1
10	1.52	1.96	1.04	1.68	1.4	2.04	1.36	1.88	2.04	2.04	2.16	9.12
15	2.08	2.04	1.04	2.16	2.16	2.4	2.12	1.92	2.12	2.08	2.28	12.4
20	2.04	2.2	1.48	2.32	2.16	2.88	2.04	2.8	2.96	2.2	2.96	16.04
25	2.13	2.54	2.08	2.33	2.33	3.13	2.13	2.96	3	2.92	3.04	18.58

Table 6.12: Cumulative lost TFs by ticktime/EPN ratio with a random sample size for the Blacklist algorithm



Experiments

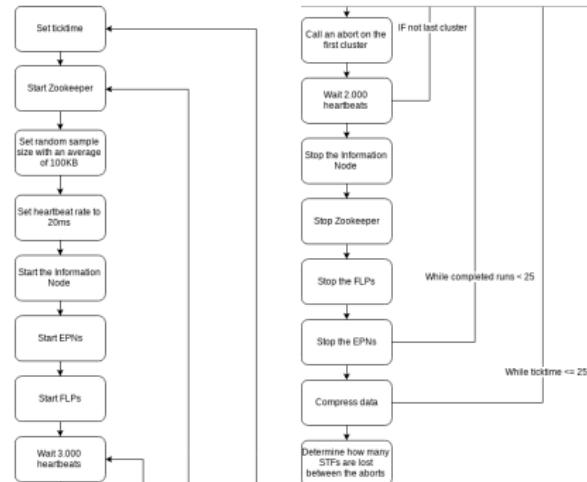
Experiment 4

Load
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■ Definition

Ticktime influence on the
Blacklist algorithm with a fixed
cluster fail-over pattern using a
random sample size

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⁷Effects of the EPNs and FLPs on the Information Node for ALICE
(Puls, 2018, p. 25)



Experiment 4

Results

Load
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Experiment four (4/24) using a cluster of Raspberry Pi's

Lost Clusters	1 Cluster	2 Clusters	3 Clusters	4 Clusters	5 Clusters	Total
Ticktime						
5	2.83	5.25	1.88	4.67	250.67	261.29
10	3.64	3.76	6.04	4.52	285.92	299.88
15	5.6	2.04	6.28	7.76	277.68	295.36
20	7.26	4.74	6.26	13.3	296.09	323.65
25	7.44	8.4	8.12	9.44	254.72	284.12

Table 6.13: Cumulative lost TFs by ticktime/EPN ratio with a random sample size for the Blacklist algorithm and a fixed cluster fail-over pattern



Experiments

Experiment 5

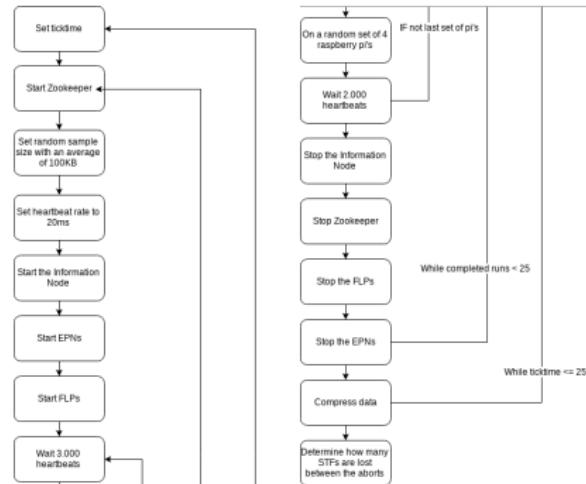
Load

Balancing for
ALICE

■ Definition

Ticktime influence on the Blacklist algorithm with a random cluster fail-over pattern using a random sample size

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⁸Effects of the EPNs and FLPs on the Information Node for ALICE
(Puls, 2018, p. 26)



Experiment 5

Results

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ALICE

Experiment five (4/24) using a cluster of Raspberry Pi's

Lost Clusters	1 Cluster	2 Clusters	3 Clusters	4 Clusters	5 Clusters	Total
Ticktime						
5	3.21	23.53	38.32	79.53	174.89	315.47
10	4.48	21.92	35.36	40.44	185.04	283.24
15	5.52	23	36.84	28.16	188.4	277.92
20	5.68	24.8	39.6	42.52	190.64	299.24
25	6.26	26.74	42.83	84.61	194.39	350.83

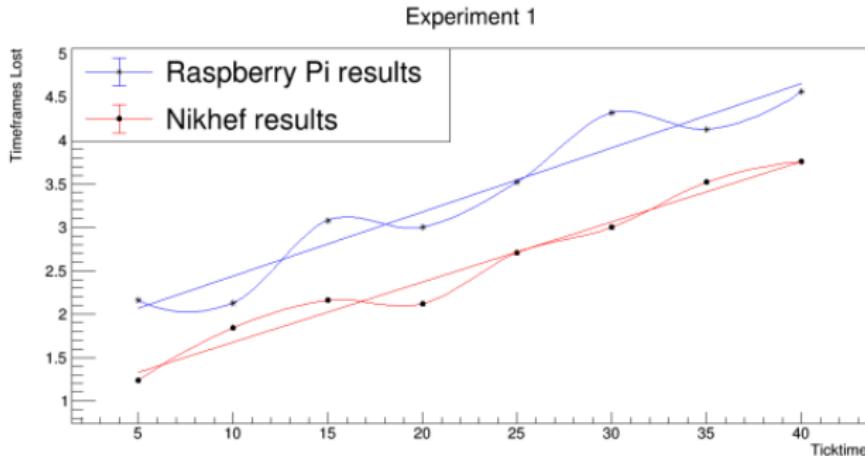
Table 6.14: Cumulative lost TFs by ticktime/EPN ratio with a random sample size for the Blacklist algorithm and a random cluster fail-over pattern



Conclusions

Compare

Load
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	Slope Pi	Intercept Pi	Slope Nikhef	Intercept Nikhef	First > 1	Next + 1
Experiment 1	0.074	1.7	0.069	0.982	64	222
Experiment 2	1.810	10.305	1.794	4.077	-	64
Experiment 3	1.622	13.216	1.783	9.072	-	6

Experiment	Pearson Correlation
1	0.95
2	0.99
3	0.99



Conclusions

Expand 2 -> 3

Load

Balancing for
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Experiment 1	2/12	3/18	Nominal difference	% difference
Ticktime				
5	2.16	1.13	1.03	-47.68
10	2.13	1	1.13	-53.05
15	3.08	1.92	1.16	-37.66
20	3	2.08	0.92	-30.67
25	3.52	2.08	1.44	-40.91
30	4.32	2.08	2.24	-51.85
35	4.13	2.52	1.61	-38.98
40	4.56	2.84	1.72	-37.72
Average			1.41	-41.82

Experiment 2	2/12	3/18	Nominal difference	% difference
Ticktime				
5	18.92	3.33	15.59	-82.4
10	28.88	8.83	20.05	-68.43
15	37.54	14.29	23.25	-61.93
20	46.67	16.72	29.95	-64.17
25	55.28	19.76	35.52	-64.25
Average			24.87	-66.4
Experiment 3	2/12	3/18	Nominal difference	% difference
Ticktime				
5	23.88	9.33	14.55	-60.93
10	26.52	13.08	13.44	-50.68
15	37.08	19	18.08	-48.76
20	45.12	22.16	22.96	-50.89
25	55.13	27.22	27.91	-50.63
Average			19.39	-51.64



Conclusions

Expand 3 -> 4

Load

Balancing for
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Experiment 1	3/18	4/24	Nominal difference	% difference
Ticktime				
5	1.13	1	0.13	-11.5
10	1	1.08	-0.08	8
15	1.92	1.76	0.16	-8.33
20	2.08	2.12	-0.04	1.92
25	2.08	2	0.08	-3.85
30	2.08	2	0.08	-3.85
35	2.52	2.16	0.36	-14.29
40	2.84	2.33	0.51	-17.96
Average			0.15	-7.67

Experiment 2	3/18	4/24	Nominal difference	% difference
Ticktime				
5	3.33	2.65	0.68	-20.42
10	8.83	6.8	2.03	-22.99
15	14.29	11.12	3.17	-22.18
20	16.72	13.12	3.6	-21.53
25	19.76	14.88	4.88	-24.7
Average			2.87	-22.82
Experiment 3	3/18	4/24	Nominal difference	% difference
Ticktime				
5	9.33	8.1	1.23	-13.18
10	13.08	9.12	3.96	-30.28
15	19.0	12.4	6.6	-34.74
20	22.16	16.04	6.12	-27.62
25	27.22	18.58	8.64	-31.74
Average			5.31	-29.24



Conclusions

Cluster fail-over

Load
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Ticktime	Experiment 4	Experiment 5	t-statistic	p-value
5	261.29	315.47		
10	299.88	283.24		
15	295.36	277.92		
20	323.65	299.24		
25	284.23	350.83		
Total			-0.75	0.474



Recommendations

- 1. Increase the unit count even further**
- 2. Do the experiment with Ansible induced fail-overs**
- 3. Use a lowest latency approach, as opposed to a round robin for the distribution**



The end

Load Balancing for ALICE
Any questions?

August 31, 2018



Hogeschool van Amsterdam