Load Balancing for ALICE

Software for Science, CERN

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Hogeschool van Amsterdam

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Introduction

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

ALICE

- CERN
- LHC
- ALICE

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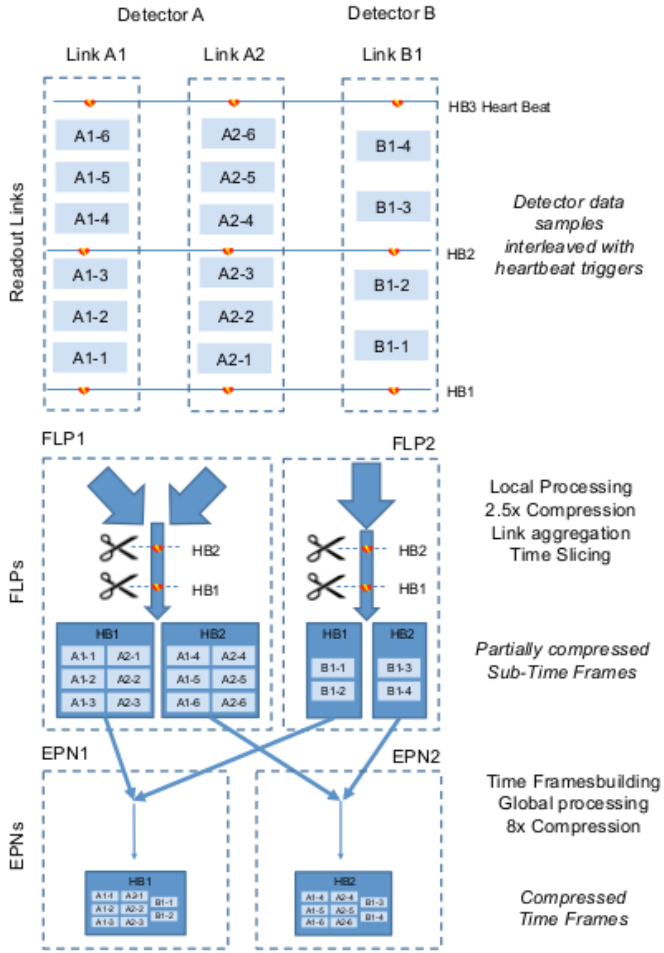
[1] http://alice-collaboration.web.cern.ch/

Load Balancing

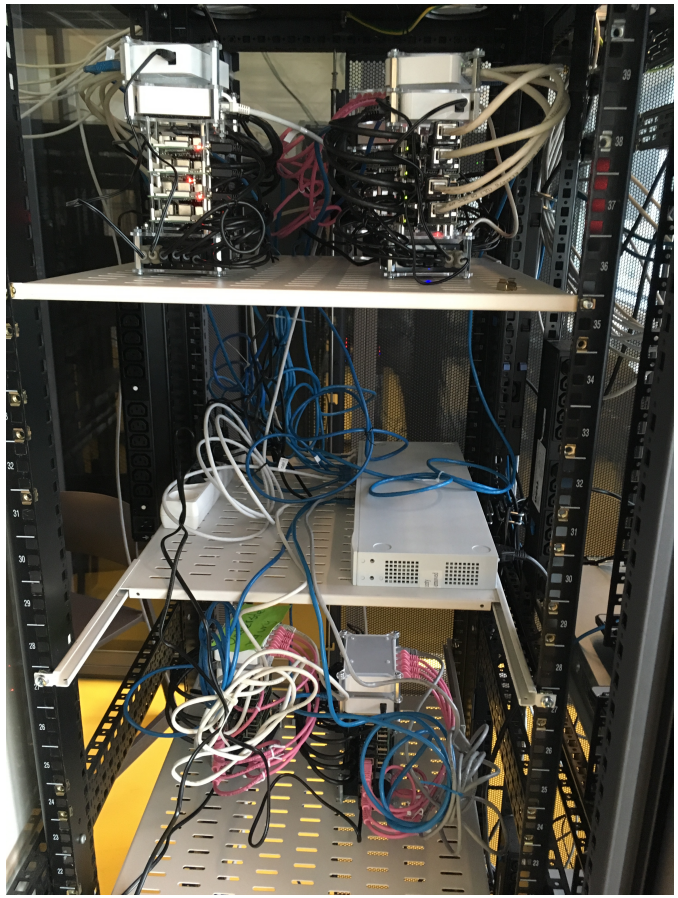
- Setup
  - First Level Processors (FLP)
  - Event Processing Nodes (EPN)
  - Information Node (IN)
- Blacklist Algorithm



[2] Technical Design Report for the Upgrade of the Online Offline Computing System, 2015, p. 34

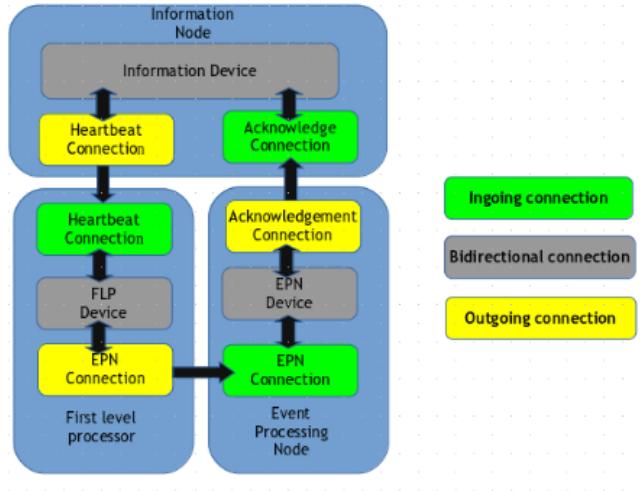
Cluster

- Raspberry Pi
- Cluster
- 2nd Ethernet Interface



Experiments

- Ratio
- Compare
- Expand



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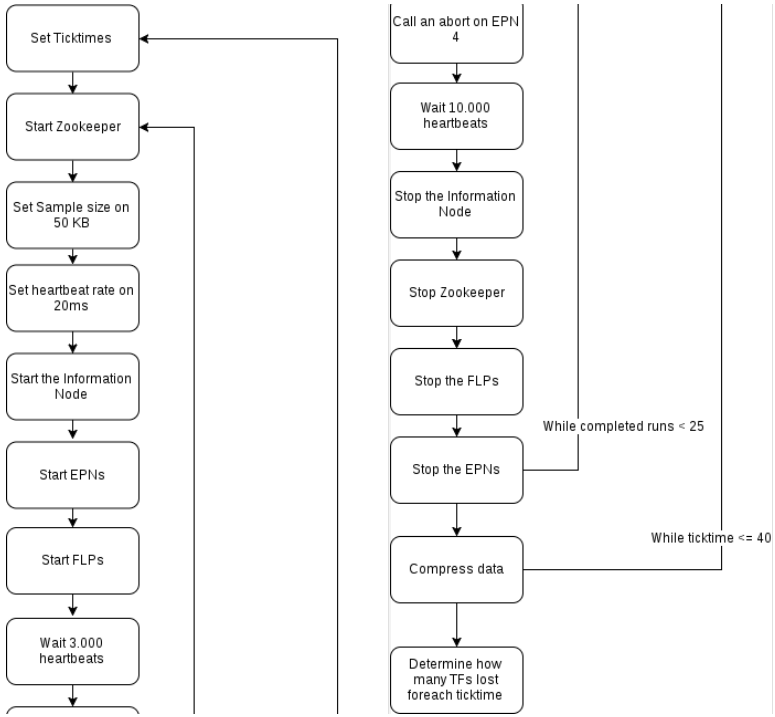
[3] Block diagram of the cluster connections (van der Heijden, 2018, p. 22)

Experiments
Experiment 1

- Definition

Ticktime influence on the Blacklist algorithm with one fail-over



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[4] Effects 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

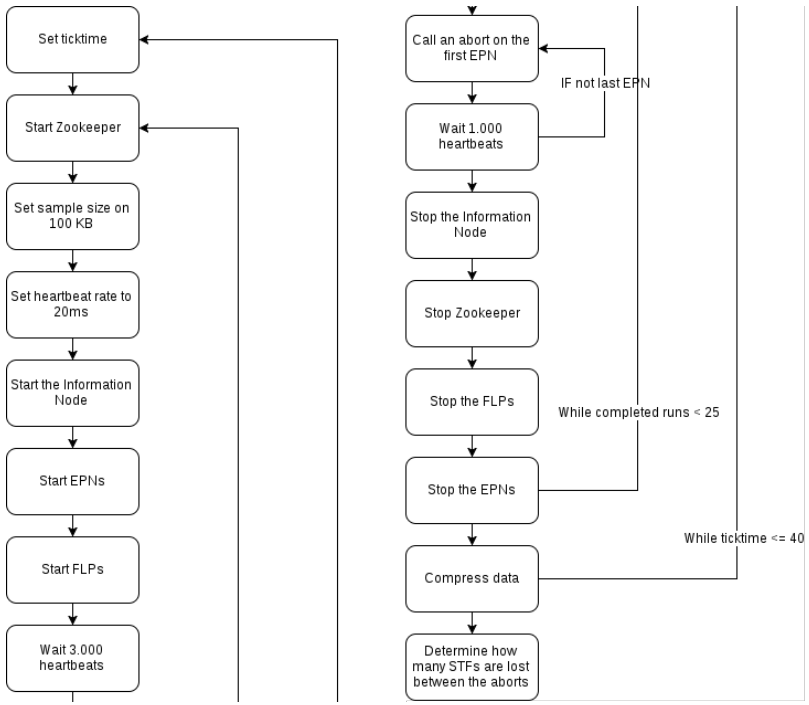
Ticktime	Mean TF loss	Standard Deviation
5	1	0
10	1.08	0.28
15	1.76	0.53
20	2.12	0.44
25	2	0
30	2	0
35	2.16	0.37
40	2.33	0.48

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

Experiments
Experiment 2

- Definition

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



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

Experiment 2
Results

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	4
10	1	2	3	3	3	3	3	3	4	4	5
15	1	3	3	3	3	3	4	4	4	5	7
20	9	3	3	3	4	4	4	5	5	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

Load Balancing for ALICE

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

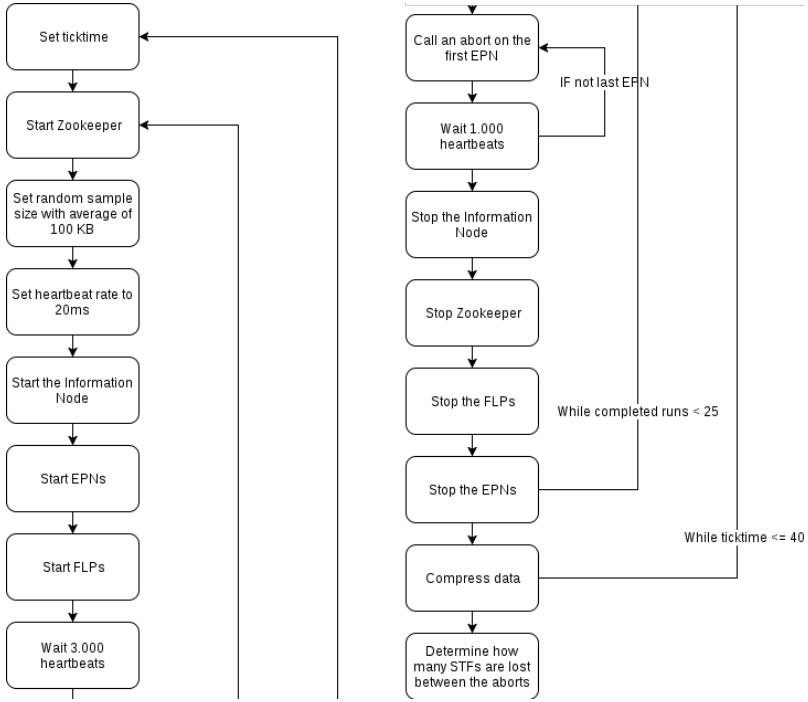
Lost EPNs	1 EPN	2 EPNs	3 EPNs	4 EPNs	5 EPNs	6 EPNs	7 EPNs	8 EPNs	9 EPNs	10 EPNs	11 EPNs	Total
Ticktime												
5	1.15	1.15	1.25	1.15	1.05	1.15	1.15	1.15	1.1	1.1	1.25	**2.65**
10	1.08	1.04	1.08	1.08	1.48	1.48	1.52	1.8	2.04	1.96	2.24	**6.8**
15	1.4	1.68	1.72	2	2.04	2.04	2.08	2	2.08	2	2.08	**11.12**
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

- Definition

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



[6] Effects 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 Balancing for ALICE

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	4.09	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

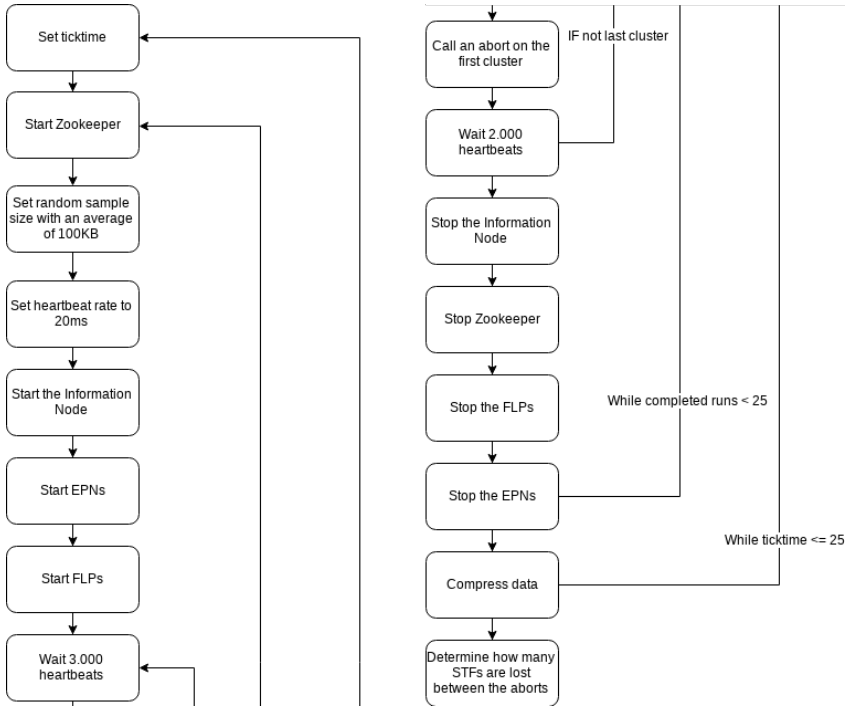
Lost EPNs	1 EPN	2 EPNs	3 EPNs	4 EPNs	5 EPNs	6 EPNs	7 EPNs	8 EPNs	9 EPNs	10 EPNs	11 EPNs	Total
Ticktime												
5	1.1	2.14	1.14	1.57	1.24	2.14	1.14	2	2.1	1.48	2.05	**8.1**
10	1.52	1.96	1.04	1.68	1.4	2.04	1.36	1.88	2.04	2.04	2.16	**9.12**
15	2.08	2.04	1.04	2.16	2.16	2.4	2.12	1.92	2.12	2.08	2.28	**12.4**
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

- Definition

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



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

Experiment 4
Results

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

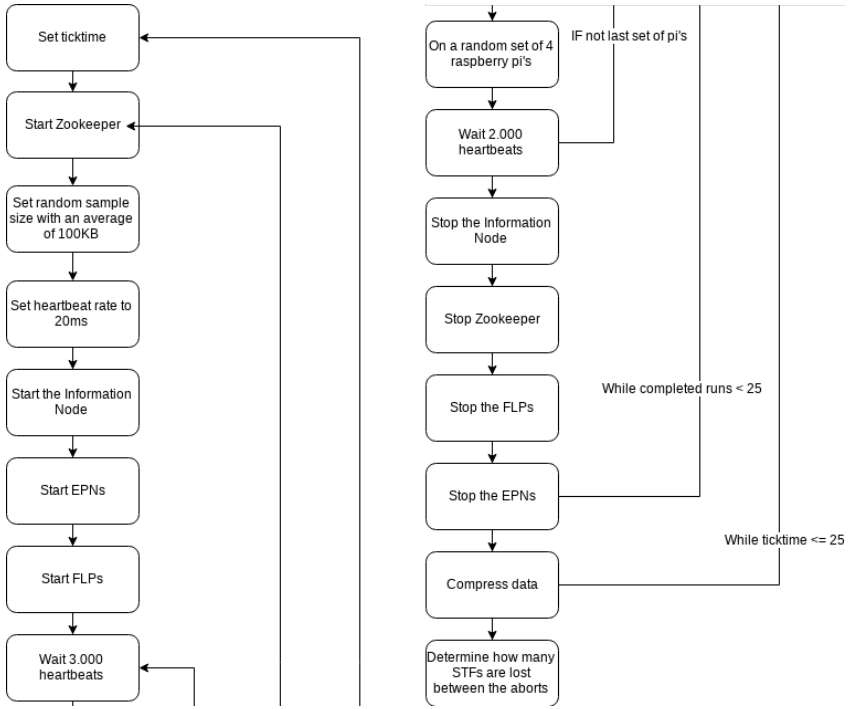
Lost Clusters	1 Cluster	2 Clusters	3 Clusters	4 Clusters	5 Clusters	Total
Ticktime						
5	2.83	5.25	1.88	4.67	250.67	**261.29**
10	3.64	3.76	6.04	4.52	285.92	**299.88**
15	5.6	2.04	6.28	7.76	277.68	**295.36**
20	7.26	4.74	6.26	13.3	296.09	**323.65**
25	7.44	8.4	8.12	9.44	254.72	**284.12**

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

- Definition

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



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

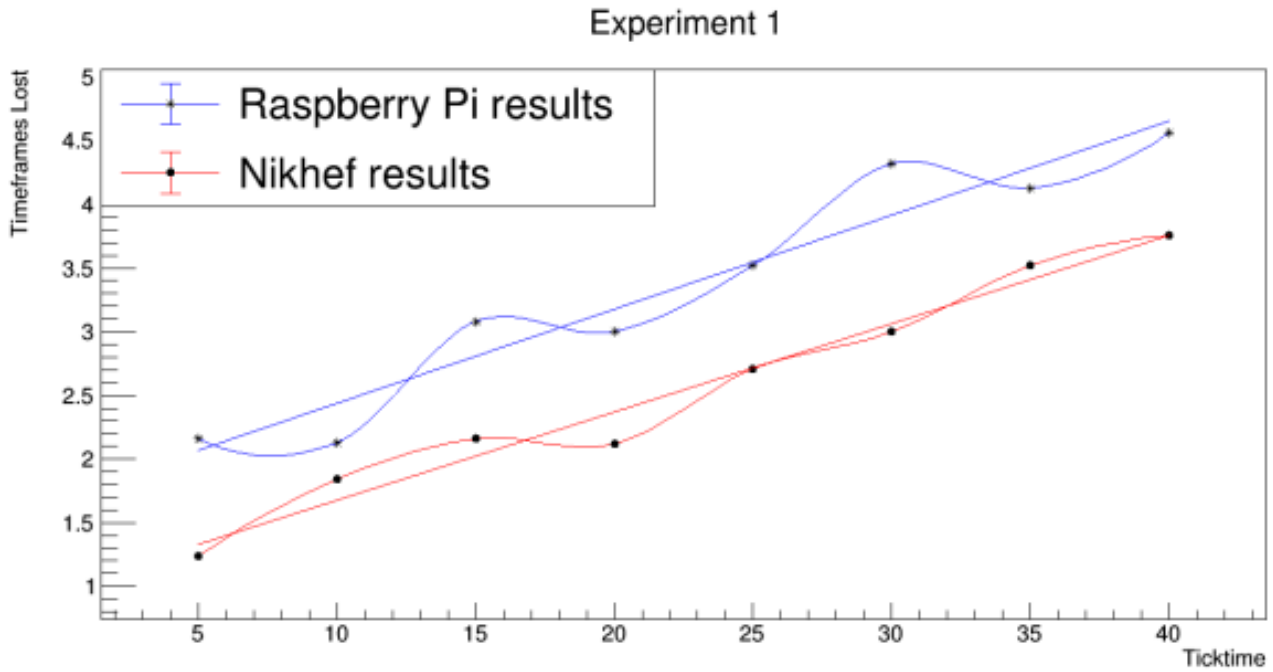
Experiment 5
Results

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



	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

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

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

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**

The end

Load Balancing for ALICE

Any questions?

August 29, 2018

Hogeschool van Amsterdam