CPU capacity forecasting & node failure scenarios

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CPU capacity

Below are the sizing scenarios (workload growth and node fail) and forecasting for headroom expiry days (# of days to reach 75% utilization).

- The current CPU utilization is at 39% clusterwide (49.92 out of 128 CPU threads total capacity)

Node Failure Scenarios

- First, let's do node failure scenarios using the sizing worksheet
  https://github.com/karlarao/sizing_worksheet

Overall Utilization:

	Total CPUs & pct% USED	Total Mem GB & pct% USED
	49.92 CPUs 39.0%	**92 GB** 9.0%

Recommended Hardware:

Equivalent compute nodes
1.6 nodes

Total Host CPUs	CPU Utilization	DB name	PGA Max (G)	SGA Max (G)	node 1	node 2	node 3	node 4
					1 instance 39% cpu used 9% mem used 22G HPages	1 instance 39% cpu used 9% mem used 22G HPages	1 instance 39% cpu used 9% mem used 22G HPages	1 instance 39% cpu used 9% mem used 22G HPages
128	39.00%	PDOIE01	3	20	P	P	P	P

- Replacing the P on the 4th node with F will fail the node. It shows 52% on the remaining three nodes. Here you can afford to lose one more node. And this is also assuming all of the nodes are well balanced in terms of CPU workload.

Overall Utilization:

	Total CPUs & pct% USED	Total Mem GB & pct% USED
	49.92 CPUs 39.0%	**69 GB** 6.7%

Recommended Hardware:

Equivalent compute nodes
1.6 nodes

Total Host CPUs	CPU Utilization	DB name	PGA Max (G)	SGA Max (G)	node 1	node 2	node 3	node 4
					1 instance 52% cpu used 9% mem used 22G HPages	1 instance 52% cpu used 9% mem used 22G HPages	1 instance 52% cpu used 9% mem used 22G HPages	0 instance 0% cpu used 0% mem used 0G HPages
128	39.00%	PDOIE01	3	20	P	P	P	F

- 2 nodes fail, it shows 78% on the remaining two nodes

Overall Utilization:

Total CPUs & pct% USED	Total Mem GB & pct% USED
49.92 CPUs 39.0%	46 GB 4.5%

Recommended Hardware:

Equivalent compute nodes
1.6 nodes

Total Host CPUs	CPU Utilization	DB name	PGA Max (G)	SGA Max (G)	node 1	node 2	node 3	node 4
					1 instance 78% cpu used 9% mem used 22G HPages	1 instance 78% cpu used 9% mem used 22G HPages	0 instance 0% cpu used 0% mem used 0G HPages	0 instance 0% cpu used 0% mem used 0G HPages
128	39.00%	PDOIE01	3	20	P	P	F	F

- With all 4 nodes running change the 39% to 75% to simulate a workload growth. Let's say the current workload continue to increase.

Overall Utilization:

Total CPUs & pct% USED	Total Mem GB & pct% USED
96 CPUs 75.0%	92 GB 9.0%

Recommended Hardware:

Equivalent compute nodes
3 nodes

Total Host CPUs	CPU Utilization	DB name	PGA Max (G)	SGA Max (G)	node 1	node 2	node 3	node 4
					1 instance 75% cpu used 9% mem used 22G HPages	1 instance 75% cpu used 9% mem used 22G HPages	1 instance 75% cpu used 9% mem used 22G HPages	1 instance 75% cpu used 9% mem used 22G HPages
128	75.00%	PDOIE01	3	20	P	P	P	P

- Then fail a node. It shows 100% on the remaining three nodes. With 75% clusterwide utilization we can't even afford to lose a node. At 75% it's already a high utilization, and at 100% everything will be very unstable.

Overall Utilization: ## Recommended Hardware:

Total CPUs & pct% USED	Total Mem GB & pct% USED		Equivalent compute nodes
96 CPUs	**69 GB**		**3 nodes**
75.0%	6.7%		

Total Host CPUs	CPU Utilization	DB name	PGA Max (G)	SGA Max (G)	node 1	node 2	node 3	node 4
					1 instance 100% cpu used 9% mem used 22G HPages	1 instance 100% cpu used 9% mem used 22G HPages	1 instance 100% cpu used 9% mem used 22G HPages	0 instance 0% cpu used 0% mem used 0G HPages
128	75.00%	PDOIE01	3	20	P	P	P	F

- 2 nodes fail, it shows 150% on the remaining two nodes

Overall Utilization: ## Recommended Hardware:

Total CPUs & pct% USED	Total Mem GB & pct% USED		Equivalent compute nodes
96 CPUs	**46 GB**		**3 nodes**
75.0%	4.5%		

Total Host CPUs	CPU Utilization	DB name	PGA Max (G)	SGA Max (G)	node 1	node 2	node 3	node 4
					1 instance 150% cpu used 9% mem used 22G HPages	1 instance 150% cpu used 9% mem used 22G HPages	0 instance 0% cpu used 0% mem used 0G HPages	0 instance 0% cpu used 0% mem used 0G HPages
128	75.00%	PDOIE01	3	20	P	P	F	F

Forecasting headroom expiry
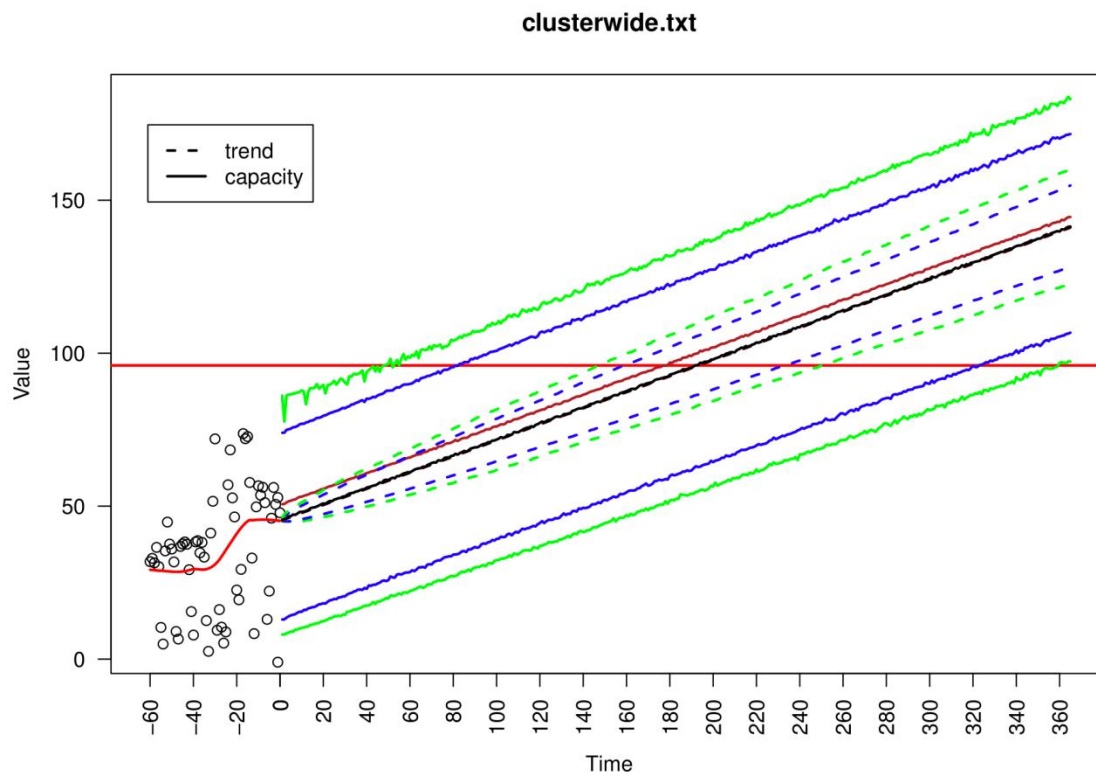
clusterwide.txt

Based on the clusterwide CPU demand forecast we will reach the 75% of the clusterwide CPU (that's 128CPUs x .75 = 96 CPUs) around the 48th day (about 1.5months) at 99% forecast quantile and 84th day (about 2.7 months) at 95% forecast quantile.

To summarize, the current 39% clusterwide CPU utilization is still acceptable given that 1 node failure can be tolerated. But there should be a remediation/tuning activity done immediately so the upward growth will be flat or decrease. If the capacity remediation/tuning is not successful or can't be done then adding one more nodes is a must.

Commands used:
```
E:\GitHub\forecast examples\monte carlo\tmp>"C:\Program Files\R\R-3.2.2\bin\Rscript.exe" analyze.R
clusterwide.txt 96 30 .99 0 365
Running Monte Carlo. Please wait
null device
          1
$mean
[1] 192

$quantiles
     quantile headroom
[1,]     0.99       48

E:\GitHub\forecast examples\monte carlo\tmp>"C:\Program Files\R\R-3.2.2\bin\Rscript.exe" analyze.R
clusterwide.txt 96 30 .95 0 365
Running Monte Carlo. Please wait
null device
          1
$mean
[1] 193

$quantiles
     quantile headroom
[1,]     0.95       84
```

Appendices

Setting up the data

The time series CPU data used here came from the top events script of run_awr tool
https://github.com/karlarao/run_awr-quickextract/blob/master/run_awr_topevents.sql

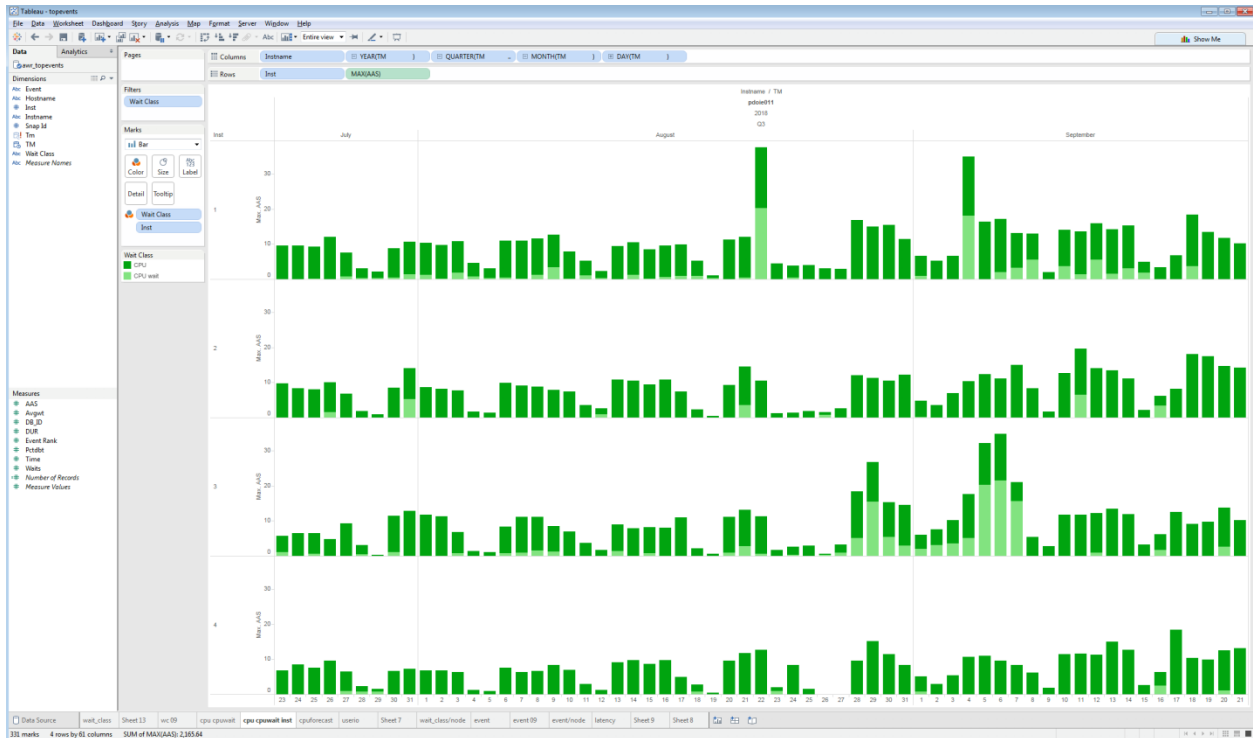The host OS CPU utilization data can also be used which can be gathered using
https://github.com/karlarao/run_awr-quickextract/blob/master/run_awr_cpuwl.sql

I use both data whenever I do sizing and forecasting exercise but for this example I'm only showing the top events.

- Visualize the clusterwide CPU utilization
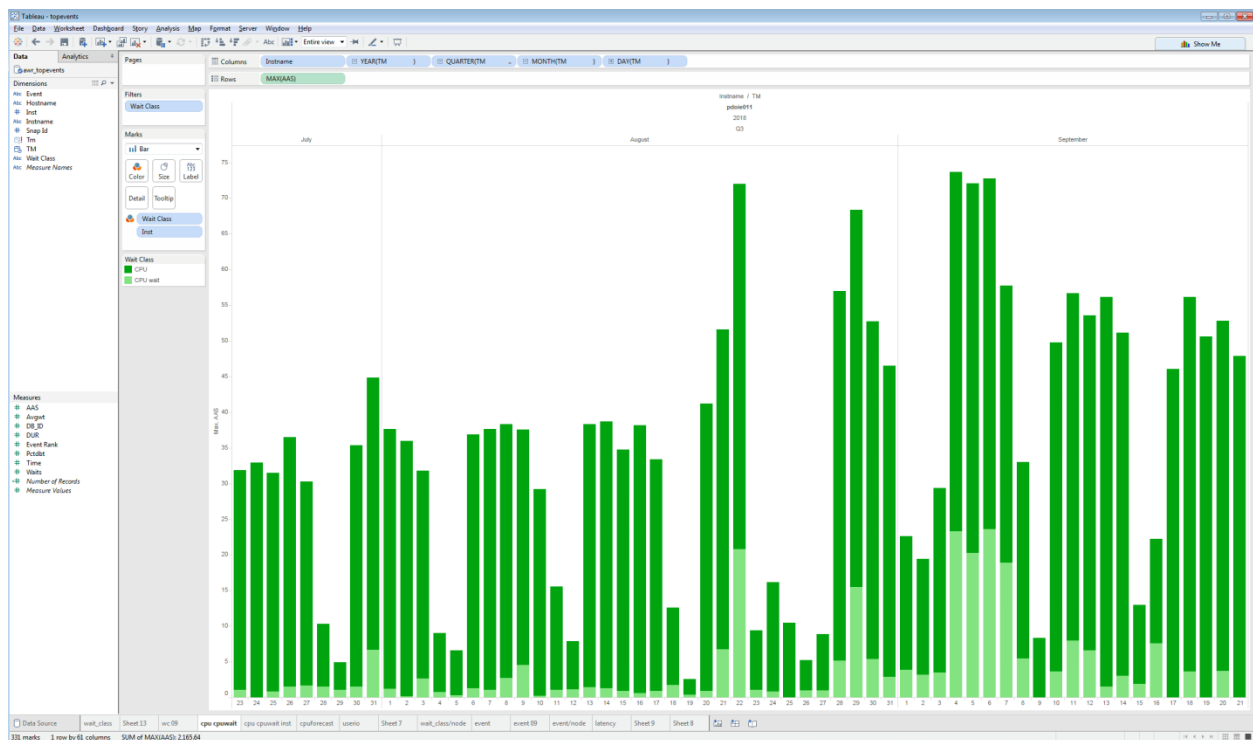
- Split the data by node and filter just the CPU and CPU wait

- Rotate the data and split it by Instance and Wait Class

- Export the data to excel. Go to "Worksheet" -> "Export" -> "Crosstab to Excel". Save the excel file and name it as data.xlsx

- The crosstab output is on the left section and on the right are the aggregate of CPU + CPU wait by node and clusterwide

- Create a text file for each node and clusterwide

clusterwide.txt

Date	CPU_AAS
23-Jul	31.89
24-Jul	32.92
25-Jul	31.48
26-Jul	36.53
27-Jul	30.25
28-Jul	10.34
29-Jul	4.96
30-Jul	35.38
31-Jul	44.82
1-Aug	37.61
2-Aug	35.98
3-Aug	31.77
4-Aug	9.02
5-Aug	6.57
6-Aug	36.85
7-Aug	37.66
8-Aug	38.30
9-Aug	37.54
10-Aug	29.24
11-Aug	15.54
12-Aug	7.86
13-Aug	38.33
14-Aug	38.70
15-Aug	34.76
16-Aug	38.15
17-Aug	33.36
18-Aug	12.60
19-Aug	2.55
20-Aug	41.21
21-Aug	51.59
22-Aug	71.98
23-Aug	9.44
24-Aug	16.19
25-Aug	10.47
26-Aug	5.26
27-Aug	8.90
28-Aug	57.00
29-Aug	68.39
30-Aug	52.74
31-Aug	46.49
1-Sep	22.58
2-Sep	19.41
3-Sep	29.36
4-Sep	73.71
5-Sep	72.06
6-Sep	72.78
7-Sep	57.73

node1.txt

Date	Value
23-Jul	9.60
24-Jul	9.65
25-Jul	9.36
26-Jul	12.09
27-Jul	7.54
28-Jul	3.14
29-Jul	2.22
30-Jul	8.77
31-Jul	10.70
1-Aug	10.38
2-Aug	9.69
3-Aug	10.85
4-Aug	4.63
5-Aug	3.12
6-Aug	10.99
7-Aug	10.98
8-Aug	11.66
9-Aug	12.75
10-Aug	7.94
11-Aug	5.33
12-Aug	2.40
13-Aug	9.41
14-Aug	10.57
15-Aug	8.54
16-Aug	9.57
17-Aug	9.96
18-Aug	5.26
19-Aug	1.06
20-Aug	11.29
21-Aug	12.01
22-Aug	37.61
23-Aug	4.55
24-Aug	3.82
25-Aug	4.01
26-Aug	3.11
27-Aug	2.96
28-Aug	16.81
29-Aug	15.06
30-Aug	15.42
31-Aug	11.39
1-Sep	6.63
2-Sep	5.33
3-Sep	6.74
4-Sep	34.99
5-Sep	16.37
6-Sep	17.14
7-Sep	13.20

node2.txt

Date	Value
23-Jul	9.75
24-Jul	8.29
25-Jul	8.01
26-Jul	10.05
27-Jul	6.85
28-Jul	1.85
29-Jul	0.87
30-Jul	8.55
31-Jul	14.02
1-Aug	8.61
2-Aug	8.24
3-Aug	7.75
4-Aug	1.65
5-Aug	1.33
6-Aug	9.89
7-Aug	9.21
8-Aug	8.87
9-Aug	7.87
10-Aug	7.46
11-Aug	3.60
12-Aug	2.60
13-Aug	10.86
14-Aug	10.56
15-Aug	9.44
16-Aug	10.85
17-Aug	7.44
18-Aug	2.30
19-Aug	0.47
20-Aug	9.26
21-Aug	14.60
22-Aug	10.47
23-Aug	1.22
24-Aug	1.40
25-Aug	1.88
26-Aug	1.47
27-Aug	2.69
28-Aug	12.01
29-Aug	11.35
30-Aug	10.54
31-Aug	12.19
1-Sep	4.75
2-Sep	3.58
3-Sep	6.91
4-Sep	10.37
5-Sep	12.42
6-Sep	11.13
7-Sep	15.08

node3.txt

Date	Value
23-Jul	5.74
24-Jul	6.45
25-Jul	6.55
26-Jul	4.85
27-Jul	9.31
28-Jul	3.09
29-Jul	0.35
30-Jul	11.46
31-Jul	12.85
1-Aug	11.81
2-Aug	11.25
3-Aug	6.89
4-Aug	1.43
5-Aug	1.15
6-Aug	8.42
7-Aug	11.10
8-Aug	11.08
9-Aug	8.50
10-Aug	6.93
11-Aug	3.72
12-Aug	1.69
13-Aug	8.94
14-Aug	7.89
15-Aug	8.17
16-Aug	8.05
17-Aug	11.01
18-Aug	2.20
19-Aug	0.55
20-Aug	11.10
21-Aug	13.16
22-Aug	11.23
23-Aug	1.64
24-Aug	2.63
25-Aug	2.95
26-Aug	0.67
27-Aug	3.25
28-Aug	18.50
29-Aug	26.86
30-Aug	15.36
31-Aug	14.54
1-Sep	6.07
2-Sep	7.60
3-Sep	10.27
4-Sep	17.67
5-Sep	32.29
6-Sep	34.85
7-Sep	21.06

node4.txt

Date	Value
23-Jul	6.81
24-Jul	8.52
25-Jul	7.57
26-Jul	9.54
27-Jul	6.55
28-Jul	2.26
29-Jul	1.52
30-Jul	6.60
31-Jul	7.25
1-Aug	6.81
2-Aug	6.80
3-Aug	6.29
4-Aug	1.31
5-Aug	0.97
6-Aug	7.55
7-Aug	6.37
8-Aug	6.70
9-Aug	8.42
10-Aug	6.91
11-Aug	2.89
12-Aug	1.18
13-Aug	9.12
14-Aug	9.69
15-Aug	8.61
16-Aug	9.68
17-Aug	4.95
18-Aug	2.85
19-Aug	0.47
20-Aug	9.56
21-Aug	11.83
22-Aug	12.67
23-Aug	2.03
24-Aug	8.34
25-Aug	1.62
26-Aug	0.01
27-Aug	0.00
28-Aug	9.67
29-Aug	15.12
30-Aug	11.43
31-Aug	8.37
1-Sep	5.13
2-Sep	2.89
3-Sep	5.44
4-Sep	10.68
5-Sep	10.99
6-Sep	9.66
7-Sep	8.39

- The working directory should have the following files

Name

- analyze.R
- functions.R
- clusterwide.txt
- node1.txt
- node2.txt
- node3.txt
- node4.txt

Running the forecast

R script HOWTO

```
How to setup:
* Setup R on your computer
* put the 'analyze.R' and 'functions.R' scripts in the same folder
* call Rscript like this:
  /usr/bin/Rscript/Rscript analyze.R cpu.txt 96 120 0.99 1 200
  * NOTE: the location of Rscript on your computer may be different if you're not using OSX. On windows
it's C:/Program Files/R/R-3.1.1/bin/Rscript.exe
  * NOTE: if the input file is not in the directory of the R script, you should use the full path like
this:
    /usr/bin/Rscript/Rscript /full/path/to/analyze.R /full/path/to/cpu.txt 96 120 0.99 1 200

INPUT:
#arg 1 is name of input file
#arg 2 is threshold value
#arg 3 is smooth window [default 120] – #days to look back
#arg 4 is quantile [default .99]
#arg 5 is capacity locked to past max (1 if true 0 if false)
#arg 6 is #days or #samples to project out [default is data length / 2]

EXAMPLE:
Rscript analyze.R cpu.txt 96 120 0.99 1 200

OUTPUT:
PDF of plot (same name as input file except with PDF extension) tab delimited file with HRE at quantile
chosen on input [see default above]

LIMITATIONS:
Right now, the program doesn't look at the date column, only the data column and assumes that the dates
are increasing one day or sample at a time. So, if this is not the case, it can give some wrong results.
This will be fixed in the future.
```

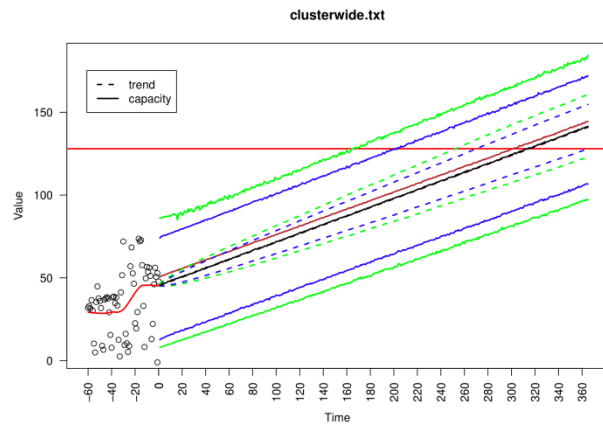# Clusterwide headroom expiry at 75% capacity
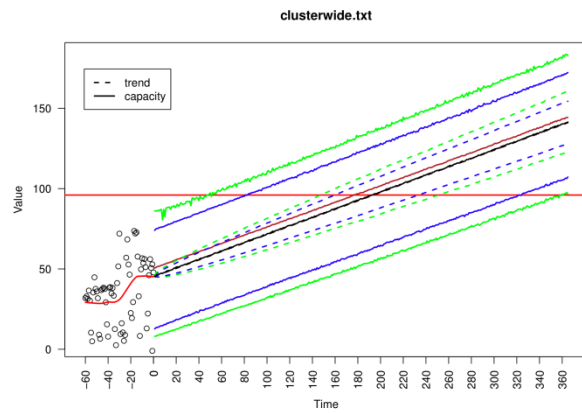
- **48 days to reach 75% utilization at 99% forecast quantile**

```
E:\GitHub\forecast examples\monte carlo\tmp>"C:\Program Files\R\R-3.2.2\bin\Rscript.exe" analyze.R
clusterwide.txt 96 30 .99 0 365
Running Monte Carlo. Please wait
null device
          1
$mean
[1] 193

$quantiles
     quantile headroom
[1,]     0.99       48
```
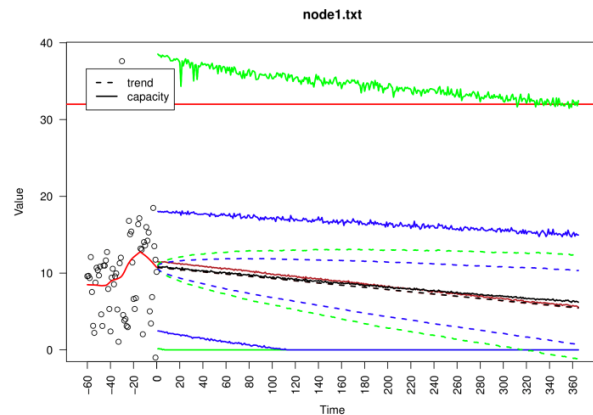
- **84 days to reach 75% utilization at 95% forecast quantile**

```
E:\GitHub\forecast examples\monte carlo\tmp>"C:\Program Files\R\R-3.2.2\bin\Rscript.exe" analyze.R
clusterwide.txt 96 30 .95 0 365
Running Monte Carlo. Please wait
null device
          1
$mean
[1] 193

$quantiles
     quantile headroom
[1,]     0.95       84
```

Clusterwide headroom expiry at 100% capacity

clusterwide.txt

- 165 days to reach 100% utilization at 99% forecast quantile

```
E:\GitHub\forecast examples\monte carlo\tmp>"C:\Program Files\R\R-3.2.2\bin\Rscript.exe" analyze.R
clusterwide.txt 128 30 .99 0 365
Running Monte Carlo. Please wait
null device
          1
$mean
[1] 314

$quantiles
     quantile headroom
[1,]     0.99      165
```

Node1 headroom expiry at 100% capacity

- **1 day to reach 100% utilization at 99% forecast quantile**

```
E:\GitHub\forecast examples\monte carlo\tmp>"C:\Program Files\R\R-3.2.2\bin\Rscript.exe" analyze.R node1.txt 32
30 .99 0 365
Running Monte Carlo. Please wait
null device
          1
$mean
[1] NA

$quantiles
     quantile headroom
[1,]     0.99        1
```
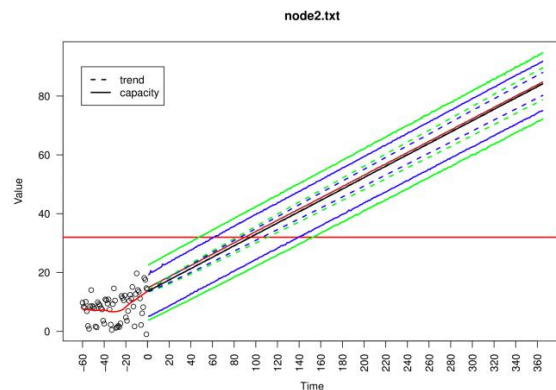
- **NA at 95% forecast quantile. This means stable and will not reach the headroom**

```
E:\GitHub\forecast examples\monte carlo\tmp>"C:\Program Files\R\R-3.2.2\bin\Rscript.exe" analyze.R node1.txt 32
30 .95 0 365
Running Monte Carlo. Please wait
null device
          1
$mean
[1] NA

$quantiles
     quantile headroom
[1,]     0.95       NA
```
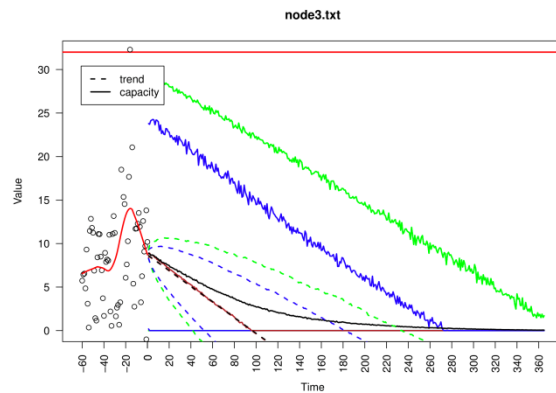
Node2 headroom expiry at 100% capacity

- **48 days to reach 100% utilization at 99% forecast quantile**

```
E:\GitHub\forecast examples\monte carlo\tmp>"C:\Program Files\R\R-3.2.2\bin\Rscript.exe" analyze.R node2.txt 32
30 .99 0 365
Running Monte Carlo. Please wait
null device
          1
$mean
[1] 95

$quantiles
     quantile headroom
[1,]     0.99       48
```
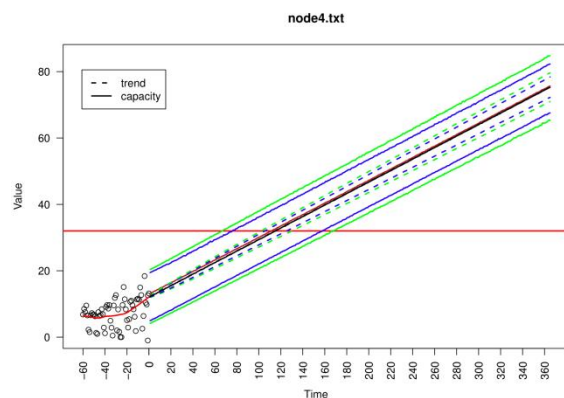
Node3 headroom expiry at 100% capacity

- NA at 99% forecast quantile. This means stable and will not reach the headroom

```
E:\GitHub\forecast examples\monte carlo\tmp>"C:\Program Files\R\R-3.2.2\bin\Rscript.exe" analyze.R node3.txt 32
30 .99 0 365
Running Monte Carlo. Please wait
null device
          1
$mean
[1] NA

$quantiles
     quantile headroom
[1,]    0.99         NA
```

Node4 headroom expiry at 100% capacity

- 67 days to reach 100% utilization at 99% forecast quantile

```
E:\GitHub\forecast examples\monte carlo\tmp>"C:\Program Files\R\R-3.2.2\bin\Rscript.exe" analyze.R node4.txt 32
30 .99 0 365
Running Monte Carlo. Please wait
null device
          1
$mean
[1] 116

$quantiles
     quantile headroom
[1,]    0.99         67
```