PEA – FINAL PROJECT

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TYPE B

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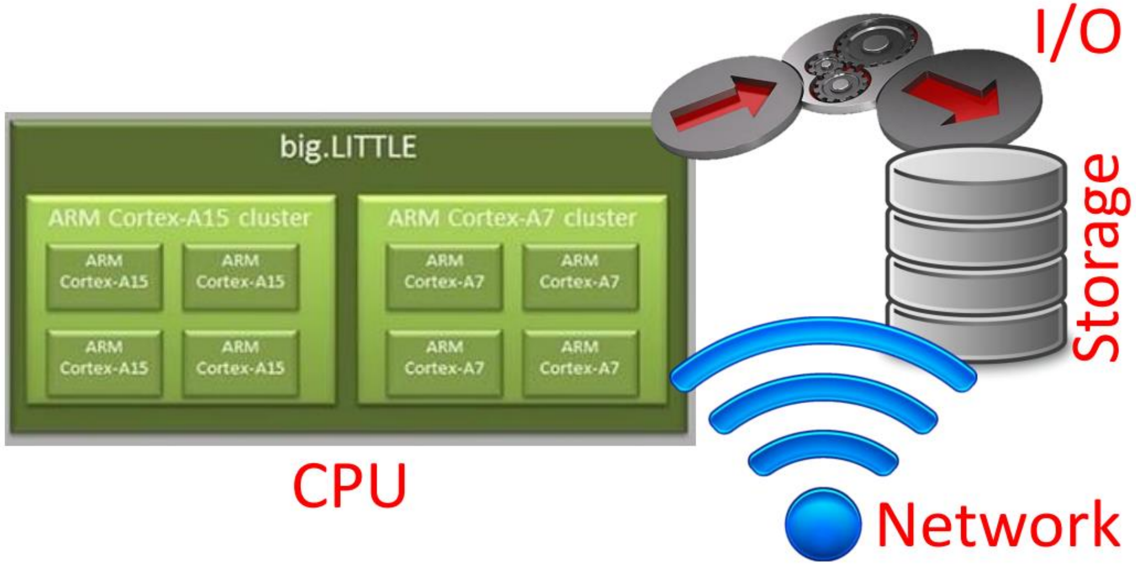
GOAL OF THE PROJECT

Performance of a Big-Little architecture

- Determine the best assignment probability distribution of tasks:
  - Test a few alternatives of probabilities of assigning a heavy computation task to an efficiency core and of assigning low computation task to a high-performance core.
- Determine the system throughput in each scenario.



CHARACTERISTICS OF THE MODEL

- A system characterized by a Big-Little architecture is characterized by **4 high performance cores**, and **8 energy efficient cores.**
- It is used by **NB = 10** heavy computation tasks, and **NL = 32** low computation tasks.
- The scheduler will mainly schedule heavy computation tasks on the high-performance cores, while low computation tasks on the energy efficient cores. However, to better use the resources, there is also a small probability that tasks will be assigned the other way round
- The execution times of the tasks on the cores are collected in the following traces (all expressed in sec):

	High Performance Cores	Energy Efficient Cores
Heavy computation tasks	`TraceB-HH.txt`	`TraceB-HE.txt`
Low computation tasks	`TraceB-LH.txt`	`TraceB-LE.txt`

All these components can be considered working in processor sharing, with an exponential service time (different per type of job), whose average is described in these tables:

	I/O	Storage	Network
Heavy computation tasks	*50 msec*	*200 msec*	*5 msec*
Low computation tasks	*150 msec*	*10 msec*	*120 msec*

OTHER COMPONENTS

FITTING

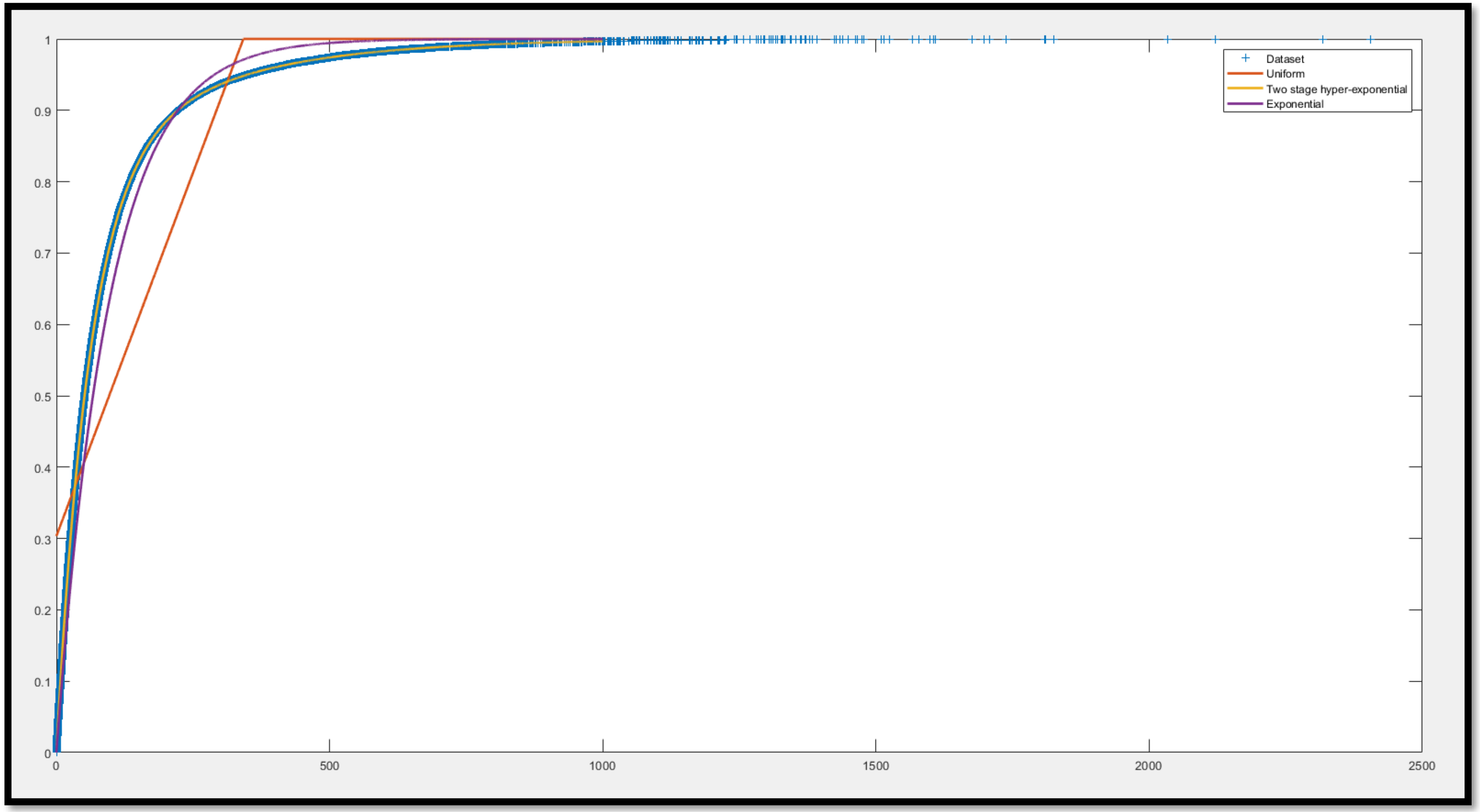
By means of MATLAB and having at disposal samples of the durations of the corresponding execution times, I was able to define the characteristics of the various departments, exploiting the method of moments and fitting the traces according to several distributions, such as Uniform, Exponential, Hyper-Exponential, Hypo-Exponential and Erlang (they were enough to fit well). Then, looking at the coefficient of variation and at the curves in the graph I chose the most appropriate rate for each of the traces

Method of moments is used to determine the best parameters producing samples with characteristics similar to the one measured in the real trace

MATLAB®

$$
\begin{aligned}
\mu_1 &\equiv \mathrm{E}[W] = g_1(\theta_1, \theta_2, \ldots, \theta_k), \\
\mu_2 &\equiv \mathrm{E}[W^2] = g_2(\theta_1, \theta_2, \ldots, \theta_k), \\
&\vdots \\
\mu_k &\equiv \mathrm{E}[W^k] = g_k(\theta_1, \theta_2, \ldots, \theta_k).
\end{aligned}
$$

FITTING 1 - HE



Heavy Computations

Energy Efficient cores

Moments:

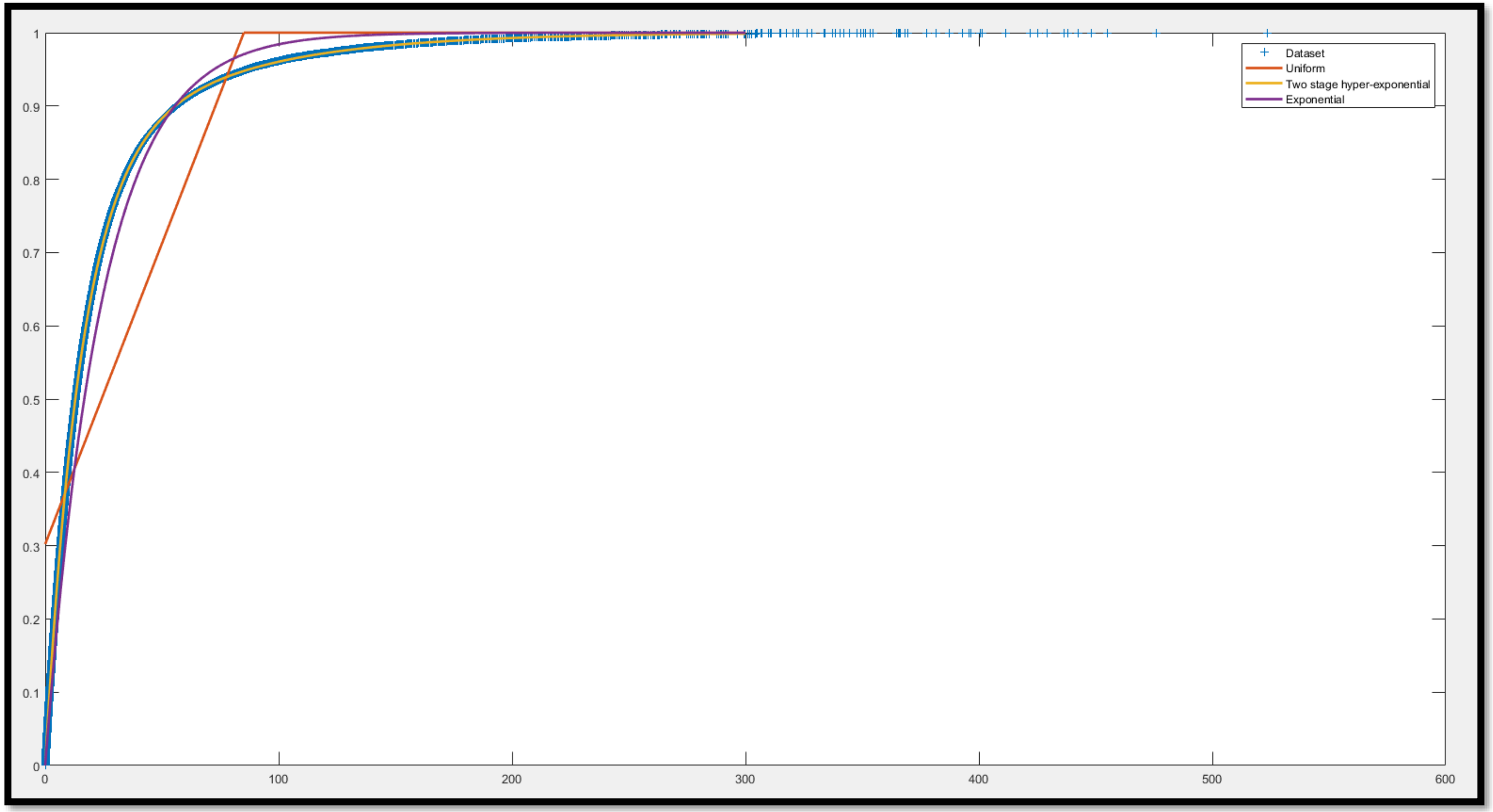
I. Moment: 96.5605
II. Moment: 29425.2
III. Moment: 1.83159e+07

CV: 1.46829

Distribution:

2 stages hyper-exponential
- p = 0.20066
- λ1 = 0.00411398
- λ2 = 0.0167277

FITTING 11 - HH



Heavy Computations

High Performance cores

<u>Moments:</u>

I. Moment: 24.1255
II. Moment: 1820.78
III. Moment: 278560

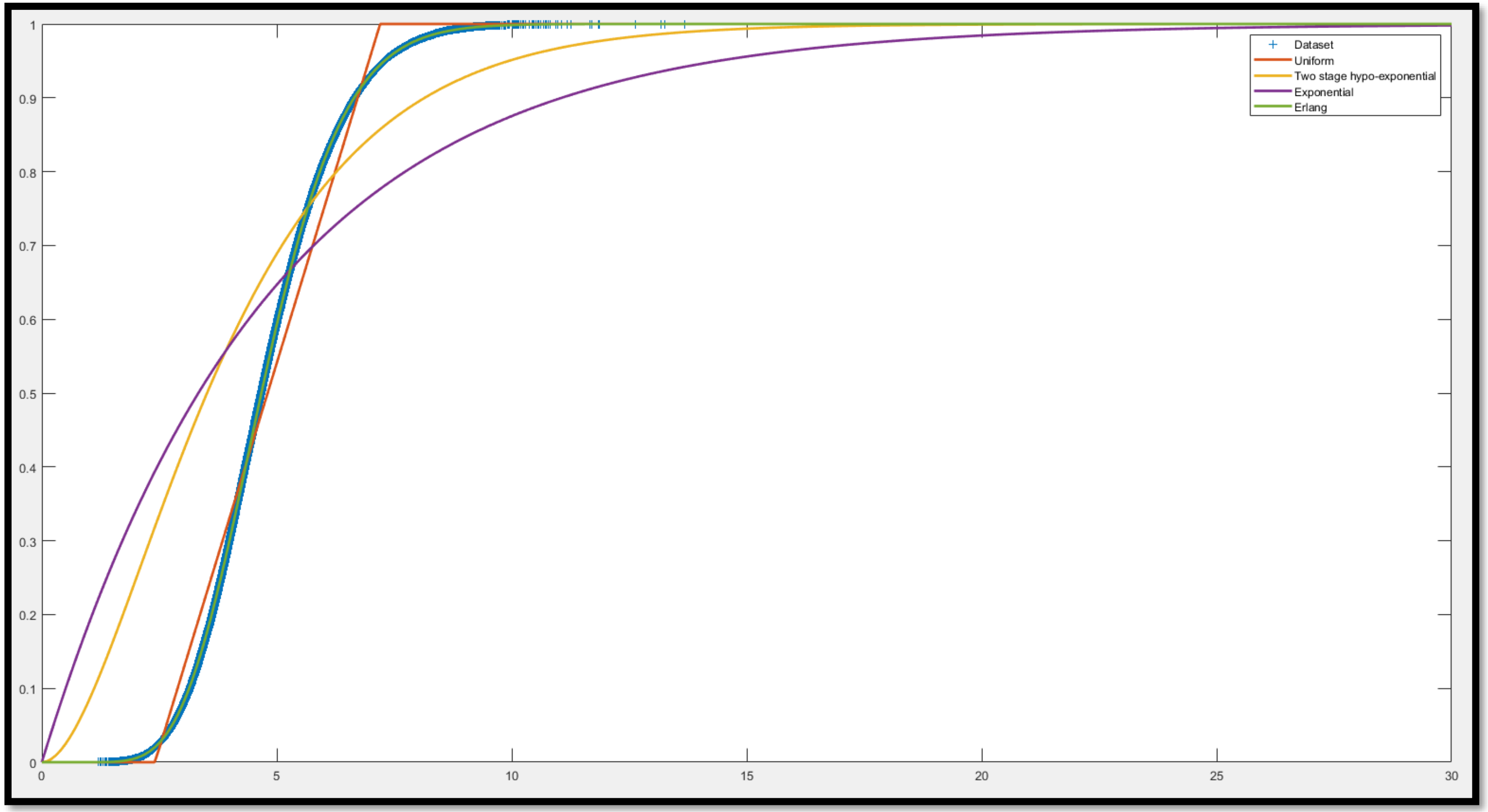
CV: 1.45886

<u>Distribution:</u>

2 stages hyper-exponential

- p = 0.206686
- λ1 = 0.0167711
- λ2 = 0.0672208

FITTING 111 - LE



Low Computations

Energy Efficient cores

Moments:

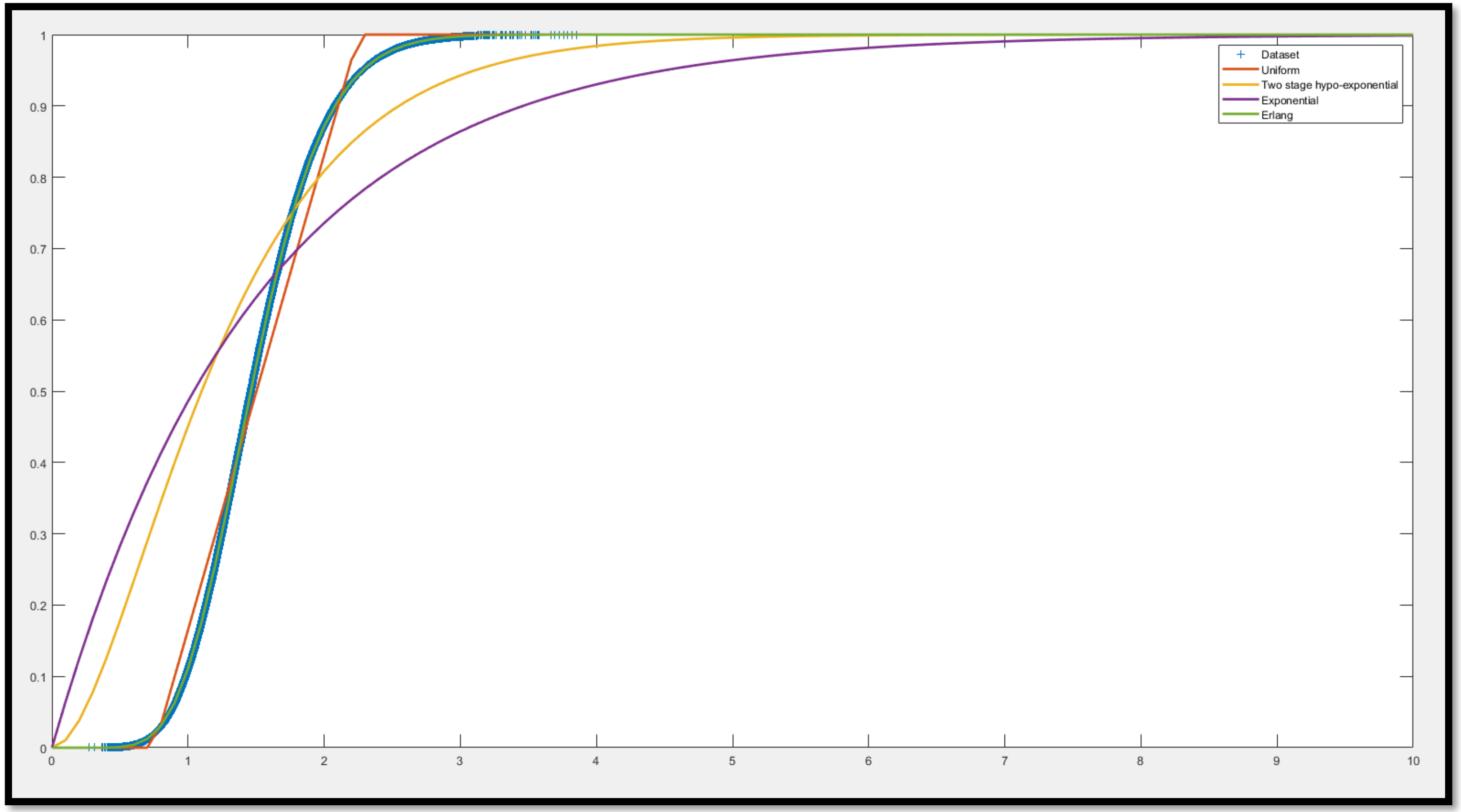
I. Moment: 4.80413
II. Moment: 24.9919
III. Moment: 139.942

- CV: 0.28784

Distribution:

- Erlang k = 12
- λ = 2.49785

FITTING IV - LH



Low Computations

High Performance cores

Moments:

I. Moment: 1.5025
II. Moment: 2.44536
III. Moment: 4.28698

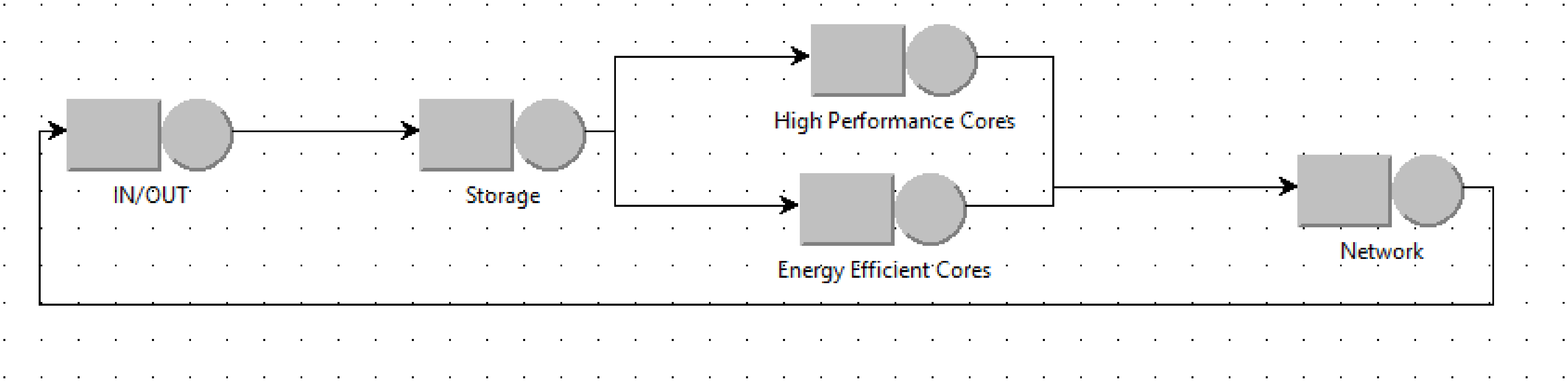
- CV: 0.288477

Distribution:

- Erlang k = 12
- λ = 7.98671

MODEL DEFINITION

- I modeled my components using JMT's JSIMgraph tool, allowing me to synthesize separable models—a system in which the order of components is irrelevant.
- All components operate under Processor Sharing with a defined Service Time. Concerning the Input/Output, Storage, and Network components, I simply expressed the parameters of the exponential distribution provided in the text. For the High Performance/Energy Efficient Cores components, I estimated the probabilistic distribution using the fitting technique, as explained in previous steps.
- As mentioned earlier, this is a closed model with precisely 10 Heavy tasks and 32 Low computation tasks, for which I created two Closed classes with their respective populations.
- The most critical aspect pertains to routing, where I evaluated various scenarios to optimize the system's Throughput (and also Response Time). In the next slides there are various scenarios studied.



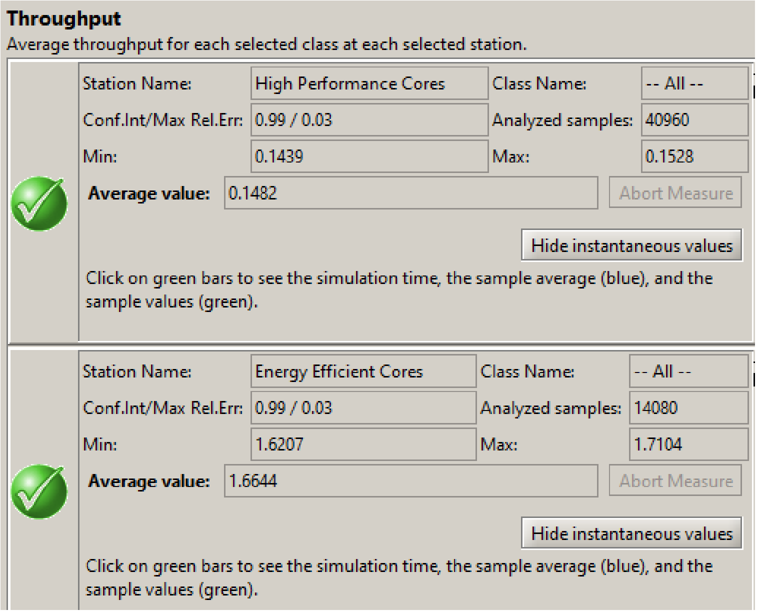
I could have added a router but it would have been superfluous since I can do the routing with any component.

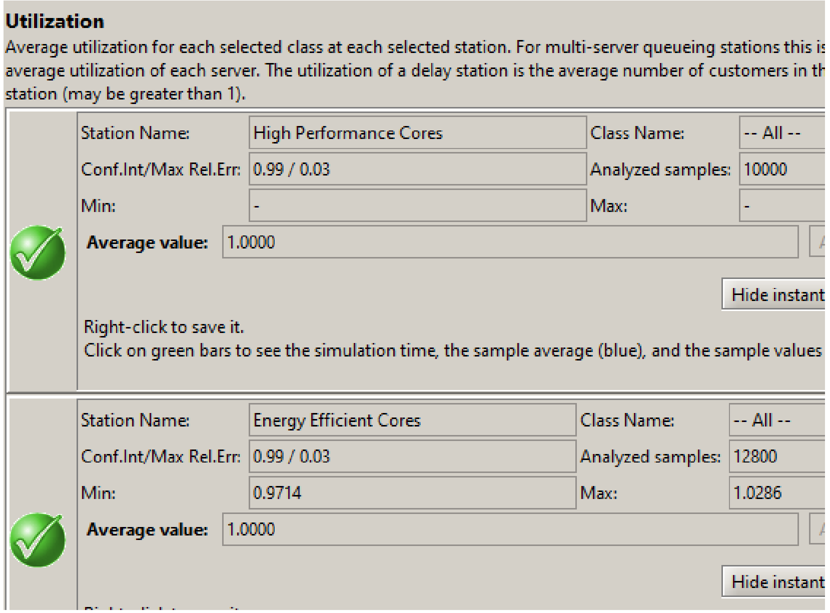
MODEL DESIGN

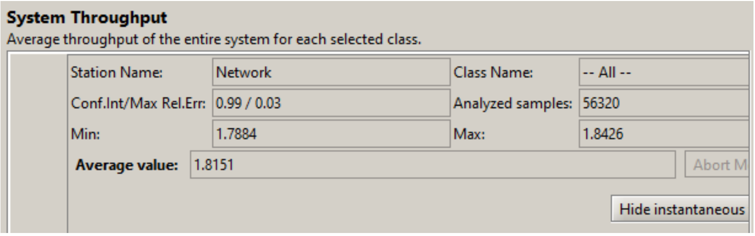
Using JMT's JSIMgraph

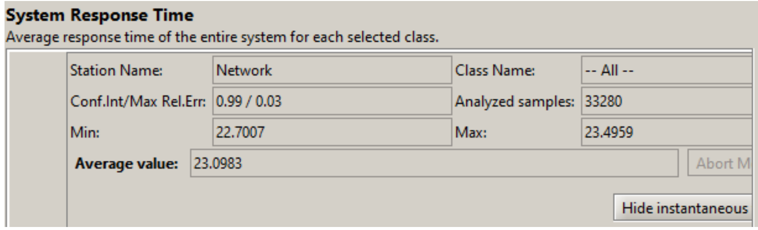
PERFORMANCE INDICES ANALYZED

<u>PROBABILITIES</u> : all Heavy Tasks on High Performance and Light Tasks on Energy Efficient





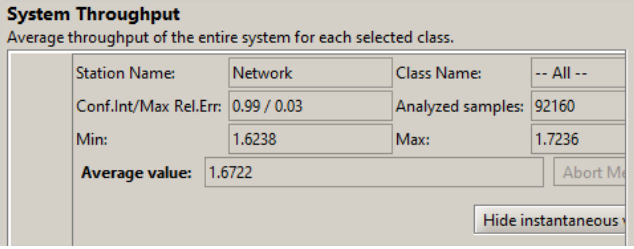




BAD ROUTING CONFIGURATION,
even it represents the main indications about routing

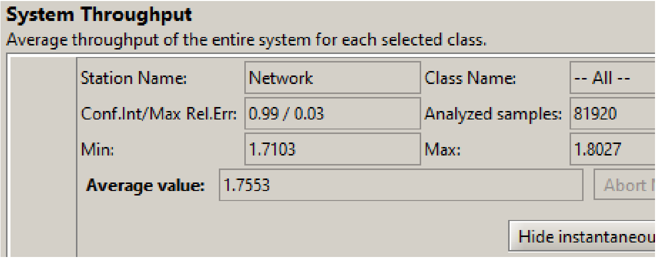
PERFORMANCE INDICES ANALYZED

<u>Different PROBABILITIES</u>

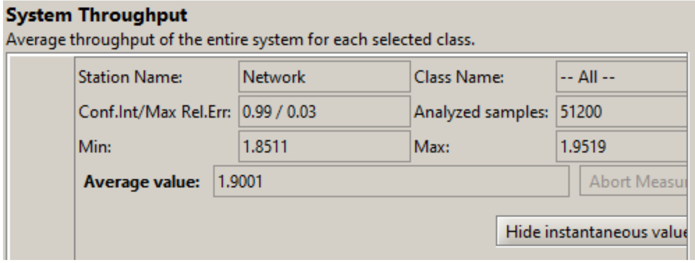


HH: 0.9
HE: 0.1
LH: 0.1
LE: 0.9

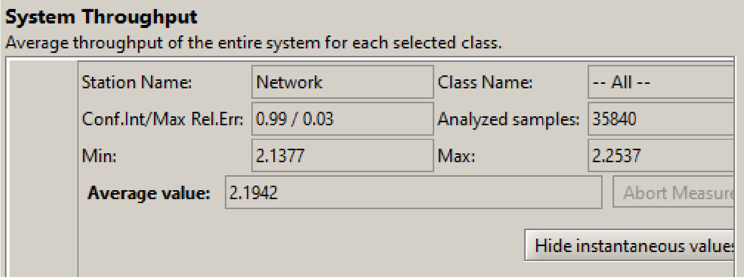
Worst combination



HH: 0.8
HE: 0.2
LH: 0.2
LE: 0.8

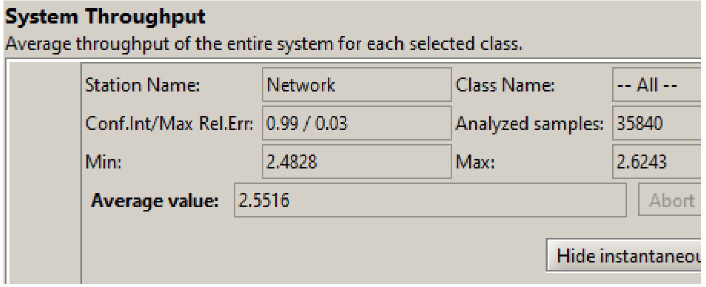


HH: 0.7
HE: 0.3
LH: 0.3
LE: 0.7



HH: 0.6
HE: 0.4
LH: 0.4
LE: 0.6

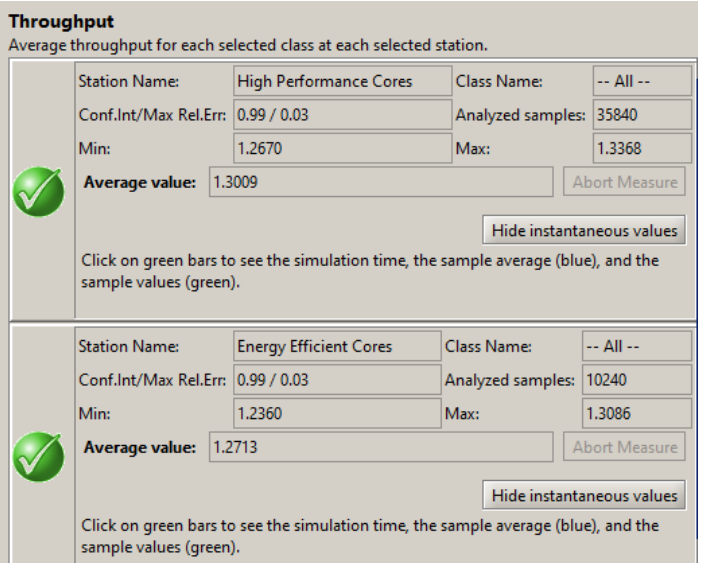
HH: 0.5
HE: 0.5
LH: 0.5
LE: 0.5

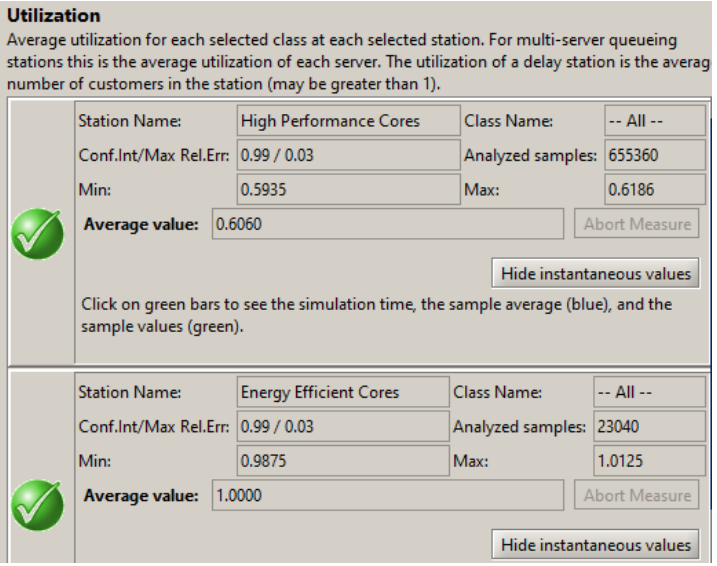


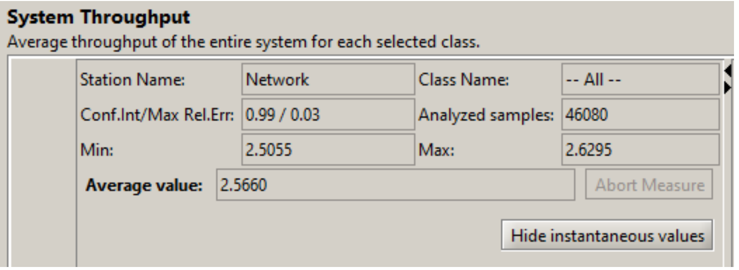
PERFORMANCE INDICES ANALYZED

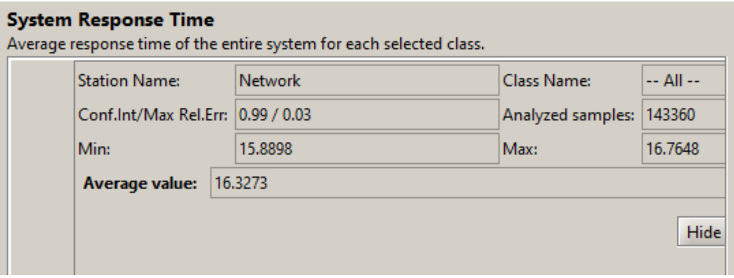
RANDOM ROUTING equals to

HH: 0.5
HE: 0.5
LH: 0.5
LE: 0.5









Still not optimized (for example Utilization)

PERFORMANCE INDICES ANALYZED

LEAST UTILIZATION

Throughput
Average throughput for each selected class at each selected station.

Station Name:	High Performance Cores	Class Name:	-- All --
Conf.Int/Max Rel.Err:	0.99 / 0.03	Analyzed samples:	143360
Min:	1.9291	Max:	2.0373
Average value:	1.9817	Abort Measure	

Hide instantaneous values

Click on green bars to see the simulation time, the sample average (blue), and the sample values (green).

Station Name:	Energy Efficient Cores	Class Name:	-- All --
Conf.Int/Max Rel.Err:	0.99 / 0.03	Analyzed samples:	35840
Min:	1.2462	Max:	1.2901
Average value:	1.2678	Abort Measure	

Hide instantaneous values

Click on green bars to see the simulation time, the sample average (blue), and the sample values (green).

Utilization
Average utilization for each selected class at each selected station. For multi-server queueing stations this is the average utilization of each server. The utilization of a delay station is the average number of customers in the station (may be greater than 1).

Station Name:	High Performance Cores	Class Name:	-- All --
Conf.Int/Max Rel.Err:	0.99 / 0.03	Analyzed samples:	40960
Min:	0.9406	Max:	0.9700
Average value:	0.9553	Abort Measure	

Hide instantaneous values

Right-click to save it.
Click on green bars to see the simulation time, the sample average (blue), and the sample values (green).

Station Name:	Energy Efficient Cores	Class Name:	-- All --
Conf.Int/Max Rel.Err:	0.99 / 0.03	Analyzed samples:	24320
Min:	0.9875	Max:	1.0125
Average value:	1.0000	Abort Measure	

Hide instantaneous values

System Throughput
Average throughput of the entire system for each selected class.

Station Name:	Network	Class Name:	-- All --
Conf.Int/Max Rel.Err:	0.99 / 0.03	Analyzed samples:	56320
Min:	3.2033	Max:	3.3753
Average value:	3.2871		

System Response Time
Average response time of the entire system for each selected class.

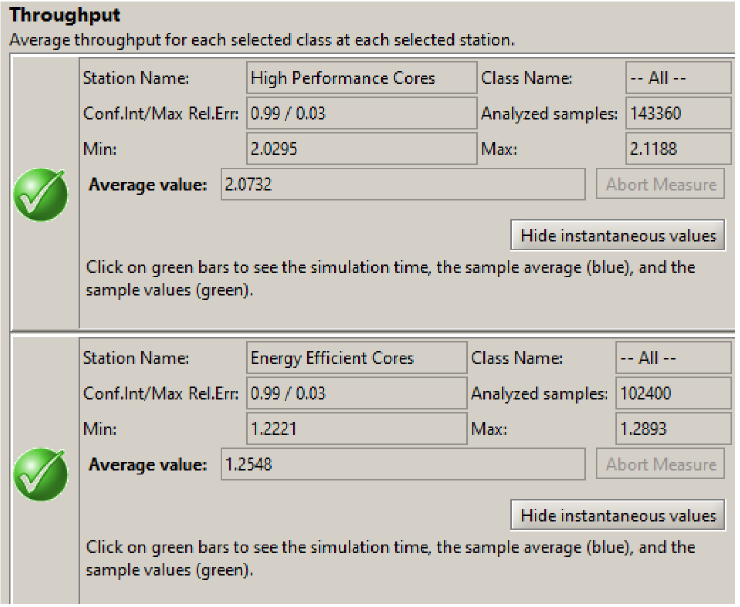
Station Name:	Network	Class Name:	-- All --
Conf.Int/Max Rel.Err:	0.99 / 0.03	Analyzed samples:	368640
Min:	12.6630	Max:	13.1715
Average value:	12.9173	Abort Measure	

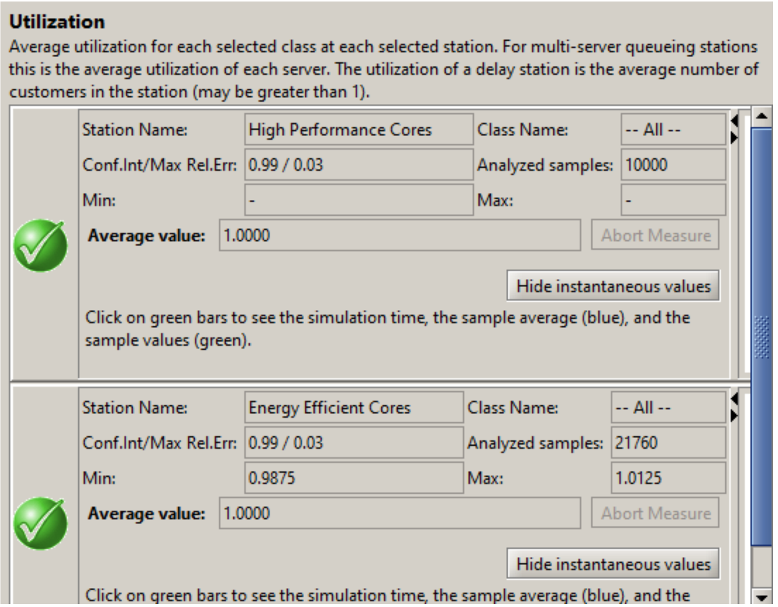
Hide instantaneous values

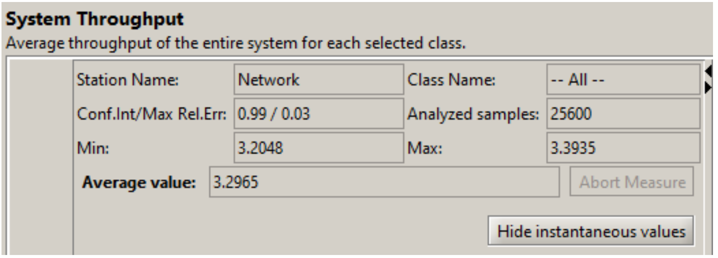
It does not comply with the routing directives but is definitely more performing

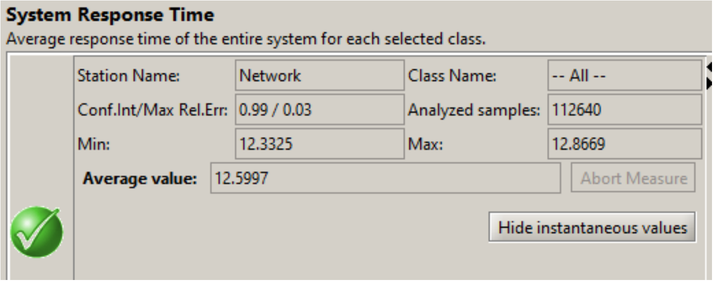
PERFORMANCE INDICES ANALYZED

JOIN THE SHORTEST QUEUE









BEST ROUTING CONFIGURATION!

Same annotations as last one but a slight improvement of performance

CONCLUSIONS

I have studied and analyzed four scenarios, all with a confidence interval of 99% and a maximum relative error of 3%. I have explored four different routing methods:

1. **Core Type-Based Routing:**
   - All heavy tasks are executed on high-performance cores, while light tasks are handled by energy-efficient cores (Configuration Requested but not well performing)
   - it would seem that the more I am routing towards reversing the tasks by changing the probabilities, the better the Throughput system performs, but it deviates completely from that small percentage of probability that it should have represented as indicated by the directives.
2. **Random Routing:**
   - This method performs significantly better than the absolute first approach but still has space for optimization. (for example for the Utilization)
3. **"Least Utilization" Approach:**
   - Jobs are routed to the station with the smallest utilization.
   - This configuration has proven to be one of the most efficient.
4. **"Join the Shortest Queue" Approach:**
   - This configuration has demonstrated to ensure the highest system Throughput and a better average response time.

In summary, after analyzing the four scenarios, the "Join the Shortest Queue" approach has emerged as the most promising, ensuring maximum system Throughput and optimal average response time, even it doesn’t comply with the routing directives

THANKS

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