Instituto Superior Técnico, Universidade de Lisboa
Large-Scale Systems Engineering

Laboratory Guide – Part III: System Analysis

Goals

The goal of this laboratory is to further study the examples in the previous laboratory and reason about the models of different service configurations.

1. Models

The Universal Scalability Model helps us reason about the behaviour of large-scale systems and predict the behaviour at scales not yet observed in practice. The model

$$X(N) = \frac{\lambda N}{1 + \sigma(N-1) + kN(N-1)}$$

is based on the following parameters:

- λ - the performance coefficient
- σ - the serial factor
- k - the coherency factor

These parameters are seldom, if ever, provided by a system designer for a specific configuration and therefore need to be determined by the system user. One method to achieve this is through linear regression. Based on a set of real observations for a specific scenario and workload, it is possible to determine the appropriate values for each parameter. There are several tools available for linear regression: Microsoft Excel, R, Python packages and Mathematica among many others.

Consider the following experimental data:

```
#size tput
1, 955.16
2, 1878.91
3, 2688.01
4, 3548.68
5, 4315.54
6, 5130.43
7, 5931.37
8, 6531.08
9, 7219.8
10, 7867.61
11, 8278.71
12, 8646.7
13, 9047.84
14, 9426.55
15, 9645.37
16, 9897.24
17, 10097.6
18, 10240.5
19, 10532.39
20, 10798.52
21, 11151.43
22, 11518.63
23, 11806
24, 12089.37
25, 12075.41
26, 12177.29
27, 12211.41
28, 12158.93
29, 12155.27
30, 12118.04
31, 12140.4
32, 12074.39
```

For our purposes, we will use a simple java command line utility to determine the parameters but students are encouraged to try other tools and compare the results.

- Download the *else-usl* tool from the course page
- Run it against the above experimental data
- Plot the original data using Gnuplot
- Plot the USL function with the obtained parameters. Recall that you can instruct Gnuplot to plot arbitrary functions, check Laboratory Guide – Part I for examples
- Given these parameters what is the maximum expected (useful) system size? What the maximum expected throughput?

2. Service configurations

Recall the last exercise of Laboratory Guide – Part II:

- Create an nginx service with one replica
- Create a siege service with one replica using the same parameters of the previous laboratory (one client, one minute run, delay of 1 second) and log the results to a logfile in a volume. To limit the CPU usage of a service you can use the *--limit-cpu* option. Wait for the service to terminate, plot and analyse the results. Are they expected?
- Repeat the above experience by first increasing the number of siege replicas to 1, 2, 3 and 4. Plot and analyse the results. What did you observe?
- Now increase the nginx service to 2,3,4 and analyse the results. Plot and analyse the results. What did you observe?

Now, compute the model parameters for the above experiments.

- How well the observations fit the observed model?
- Do the observations differ significantly between the different experiments above?
- Are the results expected?