93%

Group Number: [redacted]

4

## A) Service times

**$S_k$ WebService:**
$B_k$ / $C_k$ = 86400 / 432 000 = 12 960 / 432 000 = 0.03

**$S_k$ Authentication Server :**

1) $V_k = C_k / C$. $V_k$ here is 1.0286 and C is 432 000
   $\Leftrightarrow C_k = V_k * C = 1.0286 * 432\,000 = 444\,355$
2) $B_k = 86\,400 * 0.512 = 44\,237$
3) $S_k = B_k / C_k = 44\,237 / 444\,355 = 0.09956$

**$S_k$ Application Server:**
Using Little's law we have N = XR so X = N/R = 1.766/0.0618
Then U = X*S / c so S = c U / X = 2 *(0.5714 / 28.576) = 0.03999

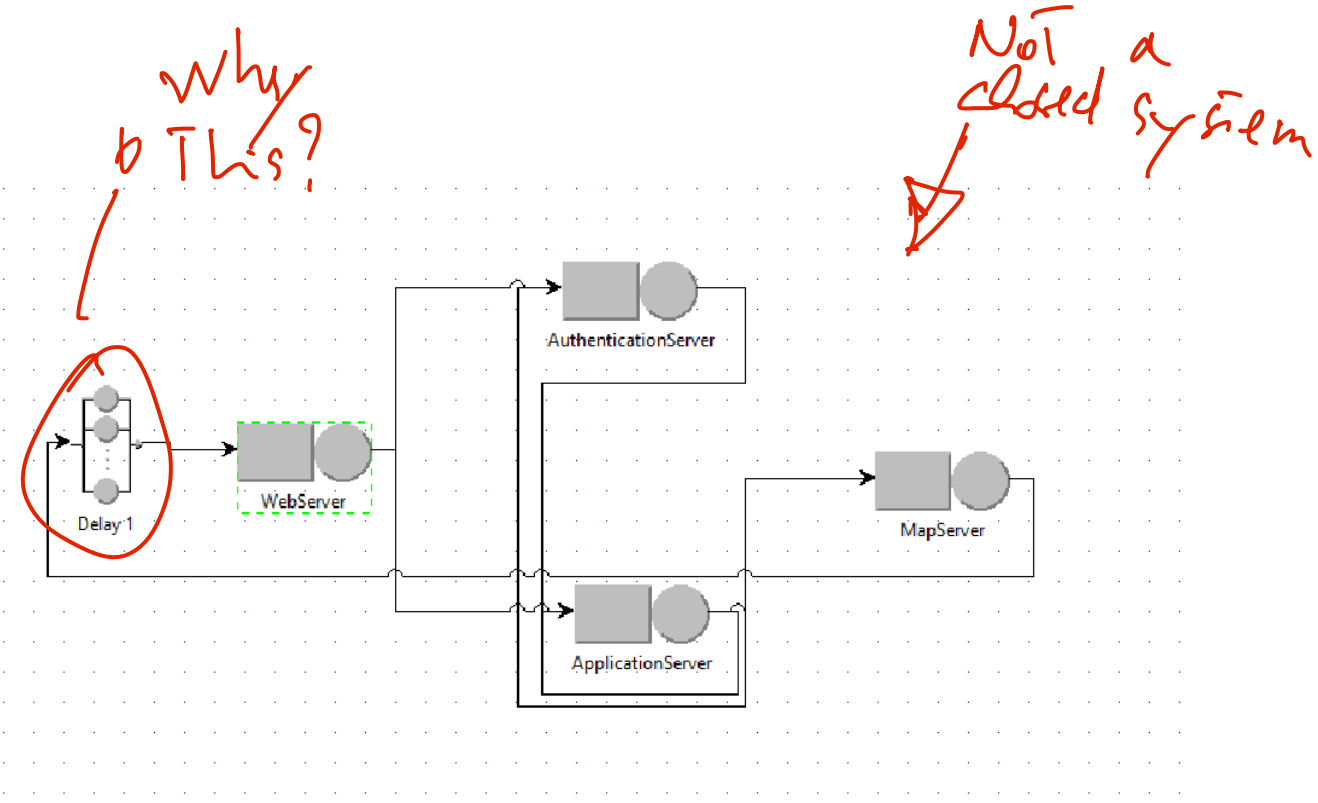
**$S_k$ Map Server**
We consider that all the requests went through the map server as it was observed that 432 000 were completed. Hence we have $C_k = C = 432\,000$
$B_k = 21\,600$
So $S_k = 21\,600 / 432\,000 = 0.05$

| Service Centre | Service Time ($S_k$) |
|---|---|
| *WebServer* | 0.03 |
| *AuthorizationServer* | 0.09956 |
| *ApplicationServer* | 0.039 |
| *MapServer* | 0.05 |

5

## B) Simulation results

*WebServer - exp(33.333)*
*AuthenticationServer - exp (10.044)*
*MapServer - exp(20)*
*ApplicationServer - exp(25.006)*




**Station Name**

Station Name: ApplicationServer

**ApplicationServer Parameters Definiton**

Queue Section | Service Section | Routing Section

**Routing Strategies**

| Class | Routing Strategy |
|---|---|
| Class2 | Probabilities |

**Description**

Jobs are routed to stations connected to the current one according to the specified probabilities. If the sum of the routing probabilities is different from 1, the values will be scaled to sum to 1.

**Routing Options**

| Destination | Probability |
|---|---|
| AuthenticationSe... | 0.075 |
| ApplicationServer | 0.75 |
| MapServer | 0.175 |

Done

Throughput | Utilization

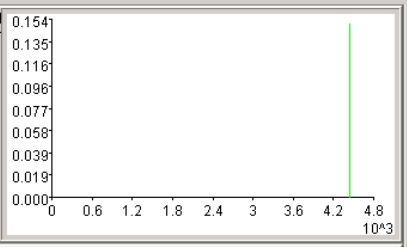
## Utilization

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: | WebServer | Class Name: | Class2 | |
| Conf.Int/Max Rel.Err: | 0.99 / 0.03 | Analyzed samples: | 40960 | |
| Min: | 0.1463 | Max: | 0.1540 | |
| **Average value:** | 0.1501 | | | Abort Measure |

Hide instantaneous values

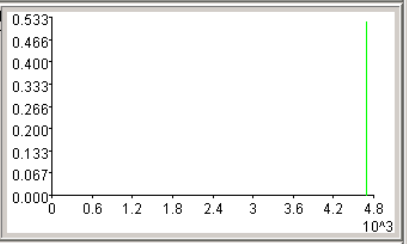
Right-click to save it.
Click on green bars to see the simulation time, the sample average (blue), and the sample values (green).




| | | | | |
|---|---|---|---|---|
| Station Name: | AuthenticationServer | Class Name: | Class2 | |
| Conf.Int/Max Rel.Err: | 0.99 / 0.03 | Analyzed samples: | 35840 | |
| Min: | 0.5076 | Max: | 0.5329 | |
| **Average value:** | 0.5202 | | | Abort Measure |

Hide instantaneous values

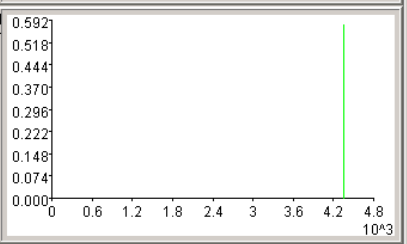
Right-click to save it.
Click on green bars to see the simulation time, the sample average (blue), and the sample values (green).




| | | | | |
|---|---|---|---|---|
| Station Name: | ApplicationServer | Class Name: | Class2 | |
| Conf.Int/Max Rel.Err: | 0.99 / 0.03 | Analyzed samples: | 143360 | |
| Min: | 0.5600 | Max: | 0.5921 | |
| **Average value:** | 0.5760 | | | Abort Measure |

Hide instantaneous values

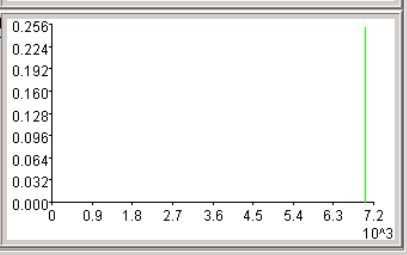
Right-click to save it.
Click on green bars to see the simulation time, the sample average (blue), and the sample values (green).



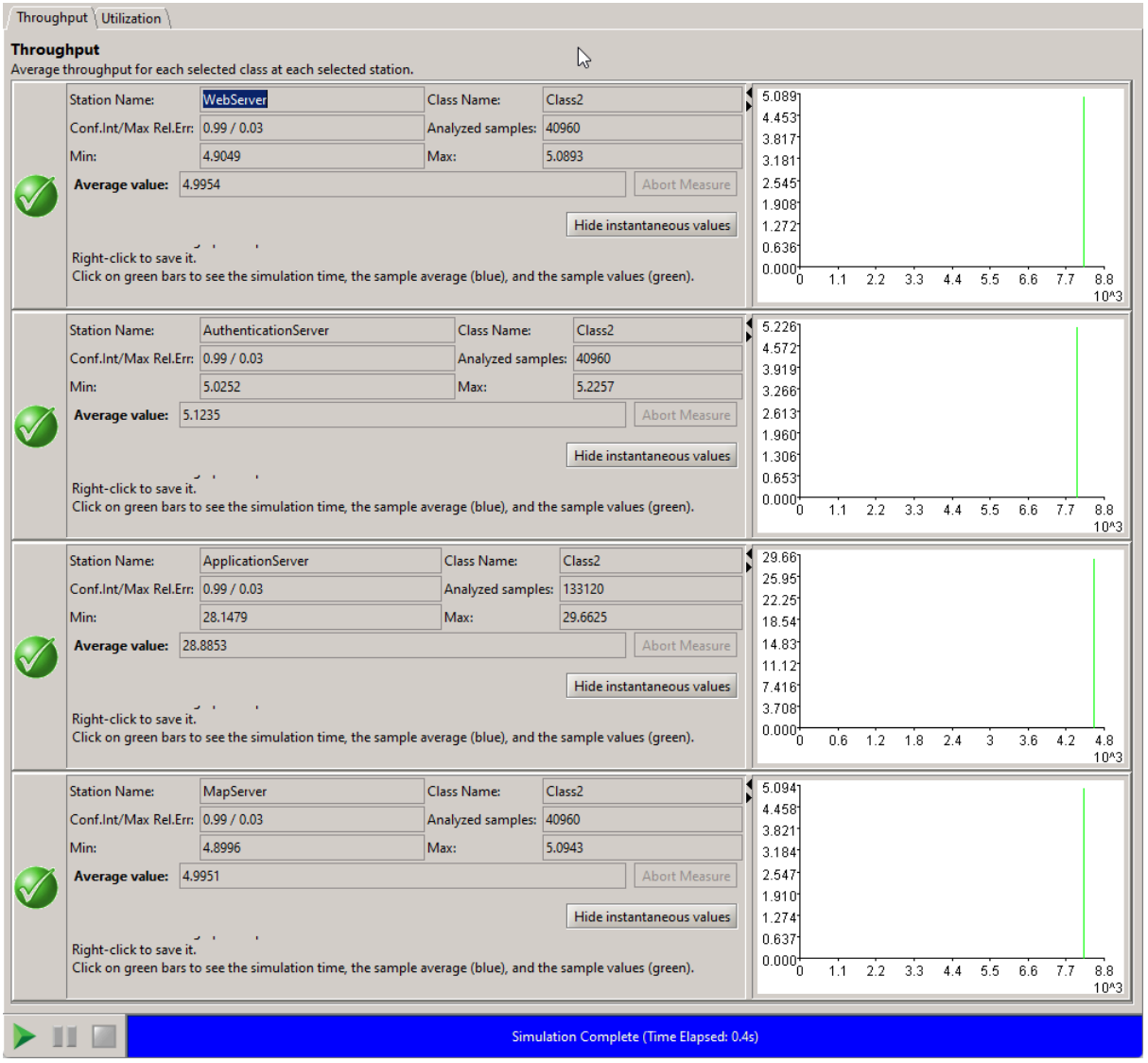

| | | | | |
|---|---|---|---|---|
| Station Name: | MapServer | Class Name: | Class2 | |
| Conf.Int/Max Rel.Err: | 0.99 / 0.03 | Analyzed samples: | 61440 | |
| Min: | 0.2457 | Max: | 0.2563 | |
| **Average value:** | 0.2510 | | | Abort Measure |

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).




Simulation Complete (Time Elapsed: 0.4s)




| Name of service center | Utilization | Throughput |
|---|---|---|
| *WebServer* | 0,1501 | 4,9954 |
| *AuthorizationServer* | 0,5202 | 5,1235 |
| *ApplicationServer* | 0,5760 | 28.8853 |
| *MapServer* | 0,2510 | 4.9951 |

Average System Response Time: **0.6505**

## C) System upgrade

**Web server**

The new throughput will be:
$X_k$: 1 296 000 / 86400 = 15
We then have the $U_k = X_k * S_k = 15 * 0.03 = 0.45$
0.45 < 1 so the web server do not need any upgrade.

**Authentication server:**

The average number of request will be: 1 296 000 * 1.0286 = 1 333 066
The new throughput will be:
$X_k$: 1 333 066 / 86400 = 15.42
We then have $U_k = (X_k * S_k) / c = 15.42 * 0.09956 = 1.54$
or $U_k < 1$ We need to divide $U_k$ by two, hence doubling the number of servers.
1.54 / 2 = 0.77. Here, $U_k = (X_k * S_k) / c$ for c = 2.
This corresponds to our findings.

**Application Server:**

We have the new average jobs which is 3*1.766 = 5.298
According to Little's law, we have N = X*R. N is 5.298 and R is 0.0618.
We have 5.298=X*0.0618 ⇔ X=5.298/0.0618 = 85.72
This corresponds to our findings.
Going further, we see that $U_k = V_k*S_k / c = (85.72*0.04) / 2$
Hence, $2U_k = 3{,}488 \Leftrightarrow U_k = 1.744$
For $U_k < 1$ We need to divide $U_k$ by two, hence doubling the number of servers, coming from 2 to 4.
Then, we would have $U_k = (85.72*0.04) / 2*2 = 0.872$.
This corresponds to our findings.

**Map Server:**

$X_k = C_k / T \rightarrow 1296000 / 86400 = 15$
$U_k = (X_k S_k) \rightarrow 15 * 0{,}05 = 0{,}75 < 1$
0.75 < 1 so the web server do not need any upgrade.

| Name of service center | Minimum number of resources | Utilization | Throughput |
|---|---|---|---|
| *WebServer* | 1 | 0.4496 | 14.9457 |
| *AuthorizationServer* | 2 | 0,7703 | 15.3760 |
| *ApplicationServer* | 4 | 0.8503 | 84.5606 |
| *MapServer* | 1 | 0,7462 | 14.9056 |

Average System Response Time (do not worry if you got the red cross  next to some result during the simulation, as long as the blue line in the graph of the chart on the right is stable): 0,9958

Throughput | Utilization | System Number of Customers | System Response Time

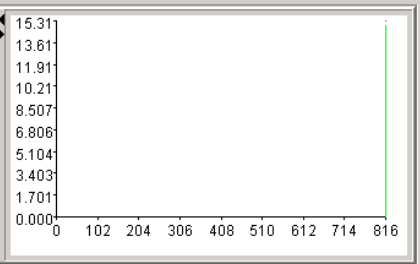
## Throughput

Average throughput for each selected class at each selected station.

| | | | |
|---|---|---|---|
| Station Name: | WebServer | Class Name: | Class2 |
| Conf.Int/Max Rel.Err: | 0.99 / 0.03 | Analyzed samples: | 11520 |
| Min: | 14.5962 | Max: | 15.3124 |
| **Average value:** | 14.9457 | | Abort Measure |

Hide instantaneous values

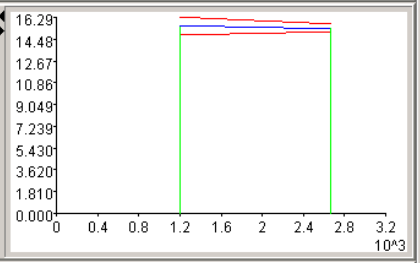
Double click on this graph to open it in a new windows.
Right-click to save it.
Click on green bars to see the simulation time, the sample average (blue), and the sample values (green).




| | | | |
|---|---|---|---|
| Station Name: | AuthenticationServer | Class Name: | Class2 |
| Conf.Int/Max Rel.Err: | 0.99 / 0.03 | Analyzed samples: | 40960 |
| Min: | 15.0356 | Max: | 15.7323 |
| **Average value:** | 15.3760 | | Abort Measure |

Hide instantaneous values

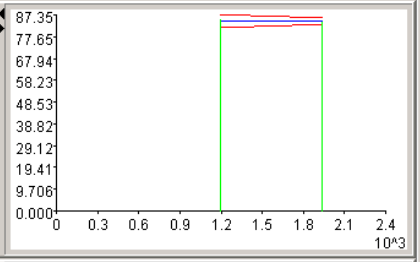
Double click on this graph to open it in a new windows.
Right-click to save it.
Click on green bars to see the simulation time, the sample average (blue), and the sample values (green).




| | | | |
|---|---|---|---|
| Station Name: | ApplicationServer | Class Name: | Class2 |
| Conf.Int/Max Rel.Err: | 0.99 / 0.03 | Analyzed samples: | 163840 |
| Min: | 82.9089 | Max: | 86.2795 |
| **Average value:** | 84.5606 | | Abort Measure |

Hide instantaneous values

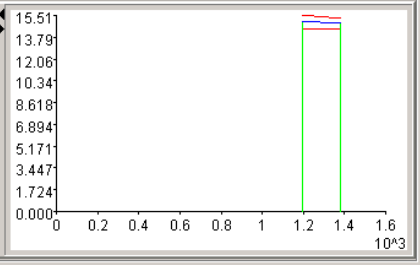
Double click on this graph to open it in a new windows.
Right-click to save it.
Click on green bars to see the simulation time, the sample average (blue), and the sample values (green).




| | | | |
|---|---|---|---|
| Station Name: | MapServer | Class Name: | Class2 |
| Conf.Int/Max Rel.Err: | 0.99 / 0.03 | Analyzed samples: | 20480 |
| Min: | 14.4816 | Max: | 15.3552 |
| **Average value:** | 14.9056 | | Abort Measure |

Hide instantaneous values

Double click on this graph to open it in a new windows.
Right-click to save it.
Click on green bars to see the simulation time, the sample average (blue), and the sample values (green).




Simulation Complete (Time Elapsed: 5.1s)

Throughput | Utilization | System Number of Customers | System Response Time

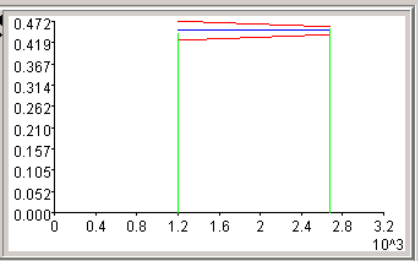
## Utilization

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: | WebServer | Class Name: | Class2 |
| Conf.Int/Max Rel.Err: | 0.99 / 0.03 | Analyzed samples: | 61440 |
| Min: | 0.4388 | Max: | 0.4603 |
| **Average value:** | 0.4496 | | Abort Measure |

Hide instantaneous values

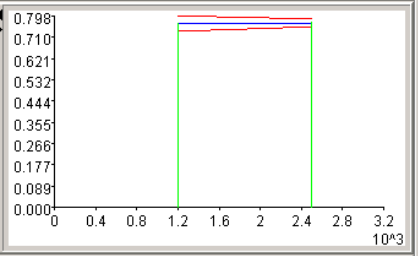
Right-click to save it.
Click on green bars to see the simulation time, the sample average (blue), and the sample values (green).




| | | | |
|---|---|---|---|
| Station Name: | AuthenticationServer | Class Name: | Class2 |
| Conf.Int/Max Rel.Err: | 0.99 / 0.03 | Analyzed samples: | 51200 |
| Min: | 0.7506 | Max: | 0.7900 |
| **Average value:** | 0.7703 | | Abort Measure |

Hide instantaneous values

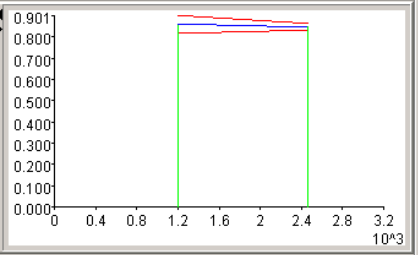
Right-click to save it.
Click on green bars to see the simulation time, the sample average (blue), and the sample values (green).




| | | | |
|---|---|---|---|
| Station Name: | ApplicationServer | Class Name: | Class2 |
| Conf.Int/Max Rel.Err: | 0.99 / 0.03 | Analyzed samples: | 204800 |
| Min: | 0.8330 | Max: | 0.8676 |
| **Average value:** | 0.8503 | | Abort Measure |

Hide instantaneous values

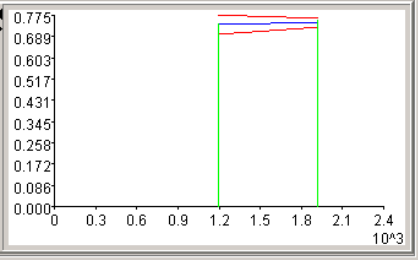
Right-click to save it.
Click on green bars to see the simulation time, the sample average (blue), and the sample values (green).




| | | | |
|---|---|---|---|
| Station Name: | MapServer | Class Name: | Class2 |
| Conf.Int/Max Rel.Err: | 0.99 / 0.03 | Analyzed samples: | 35840 |
| Min: | 0.7264 | Max: | 0.7660 |
| **Average value:** | 0.7462 | | 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).




Simulation Complete (Time Elapsed: 5.1s)