Σ 80/100


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# Modellierung & Simulation I

## Serie 05

### Problem 5.1.1

please see provided code. 15/15

### Problem 5.1.2

Because the Normal Distribution has a nonzero density function everywhere, there is always the probability of sampling a negative real number. The DES is used to model waiting line systems, but as such the service time is always positive (or equal zero). So it is inappropriate to use a Normal distribution with desired mean and variance to model service time and instead Erlang-k, Exponential or Hyperexponential distributions are used. 5/5

### Problem 5.1.3

Given the system utilization $\rho$ we set $\mathbb{E}[IAT] = \frac{1}{\rho}$ to model the system properly.
please see provided code. 10/10

### Problem 5.1.4

please see provided code. waiting Prob Batch falsch 15/20

### Problem 5.1.5

The figures in 1 show a little dependency of the autocorrelation from the system utilization. With higher values of $\rho$ the autocorrelation for all lags is going down. The plots also show, that for every value of $\rho$ and every $c_{var}$ the lag 1 has the strongest autocorrelation. For the plot generation we already set $l_{batch} = 1000$). Because the system dynamics we used this value for the remaining tasks as well.

(✓) Prinzip

Ihr ignoriert Cvar im Prinzip -5

5/10

### Problem 5.1.6

2/10

und deshalb ist $c_{var} = 1$

The plot 2 shows the mean individual and batch waiting times (and their confidence intervals for $\alpha = 0.1$) for the range of possible system utilization values. There is a striking similarity between the different values of $c_{var}$. This effect can be explained, because we used exponentially distributed service and arrival times and their mean/variance is interconnected as described in task 5.1.3. The second figure also shows, that for the waiting time the batch means method is only slightly different for estimating the waiting time. Other explanations could be the "high" value for the batch size or that the implementation is off. The next figure 3 shows the probability, that the individual mean of waiting time exceeds five times the individual mean of service time. The strong dependence from the system utilization is straight forward. If the system is very busy, the customer has to wait longer. A different picture gives plot 4. The graphs can not be right, because the probabilities are not normalized, even though we divided the counted occurrences of the event $\mathbb{E}[WT] > 5\mathbb{E}[ST]$ for the batch means counter through the batch number. Additionally the failed normalization can not be the only implementation error, because the graphs contradict the meaningful explanation for the previous plot.

die erhöht ihr aber hie

### Problem 5.1.7

The results in the following table show that the confidence intervals for the batch means method are larger. This is caused due to the aggregated means of the batches. Because the batch means have a smaller count than the individual method, causes outliers to be taken more into account and result in a shift of the convidence intervals.

10/10

| | batch means | individual |
|---|---|---|
| z(1-alpha/2) | 1.6599917491749174 | 1.6502355385538554 |
| lowerBound | 17.3696811538551 | 18.200432770783063 |
| upperBound | 19.105876747834582 | 18.27512513090809 |
| mean | 18.23777895084484 | 18.237778950845577 |
| samples | 651 | 651000 |

## Problem 5.1.8

Setting $l_{batch} = 1$ gives the following values:

mean: 10.491277777777787
samples: 828

This is caused because we set $l_{batch} = 1$ which causes the batch means method to not get used properly, due to the means only containing one value. Basically it's like taking the individual values. In comparison to an appropiate $l_{batch}$ value, we can see that the mean varies quite a bit due to the means being individual values in addition to the small sample count. FT

10/10

## Problem 5.1.9

Recalling the formulas for lower and upper bound of a convidence interval (chapter 4.4 in course script) gives:

$$
\begin{aligned}
l(n, \alpha) &= \bar{X}(n) - z_{1-\alpha/2} \cdot \sqrt{S^2(n)/n} \\
u(n, \alpha) &= \bar{X}(n) + z_{1-\alpha/2} \cdot \sqrt{S^2(n)/n} \\
\bar{X}(n) &= \frac{\sum_{i=1}^{n} x_i}{n} \\
S^2(n) &= \frac{\sum_{i=1}^{n} [x_i - \bar{X}]^2}{n-1}
\end{aligned}
$$

3/5

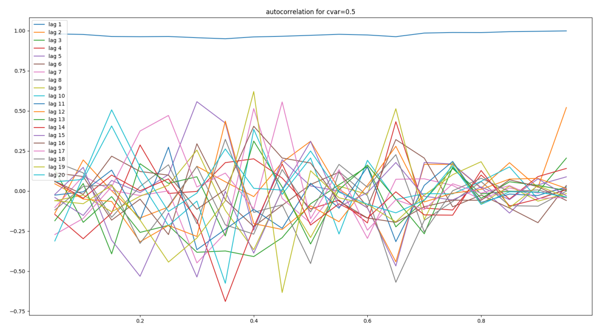
Recalling that $n = l_{batch}$ for these formulas shows that the width of the confidence interval is dependent on $l_{batch}$ for a given overall number of samples. (✓)

Und wie genau? -2

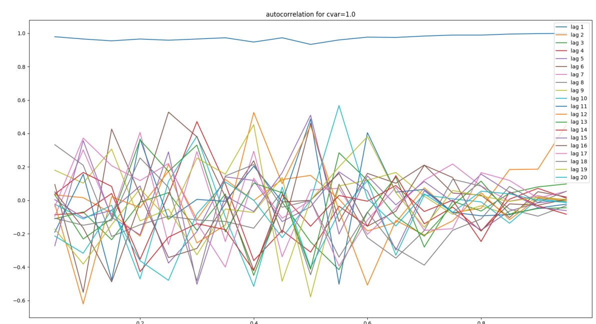
## Problem 5.1.10

Yes, there is an alternative called the "replicate/delete method". It has the drawback that there need to be multiple runs, which causes additional workload through unused transient phases. In addition, the correct determination of the end of the transient phase has a big influence on the quality of the result. ✓

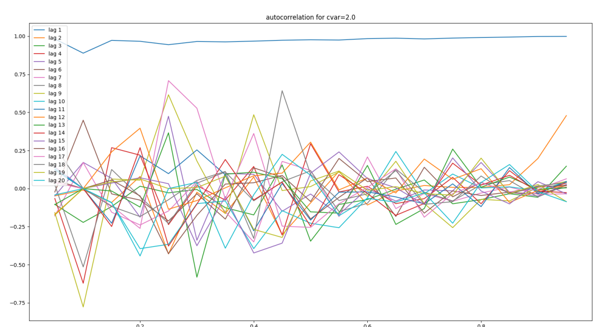
5/5




(a) $c_{var} = 0.5$




(b) $c_{var} = 1.0$




(c) $c_{var} = 2.0$

Figure 1: Plot for Problem 5.1.5

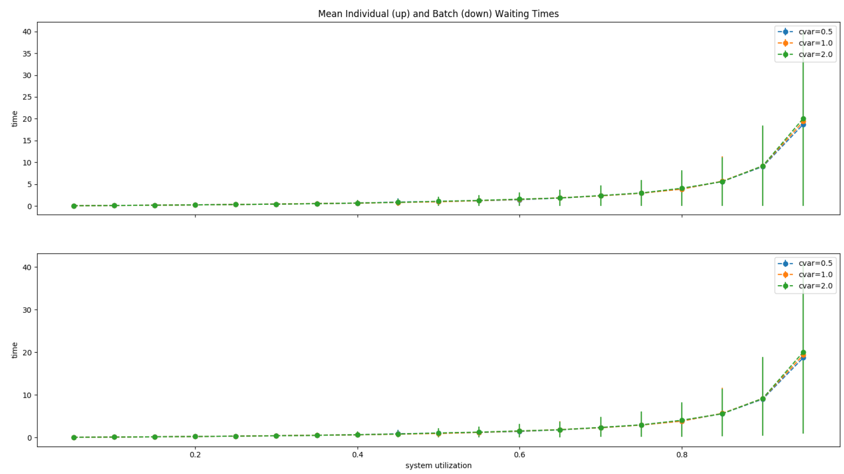



Figure 2: Plot for Problem 5.1.4/5.1.6

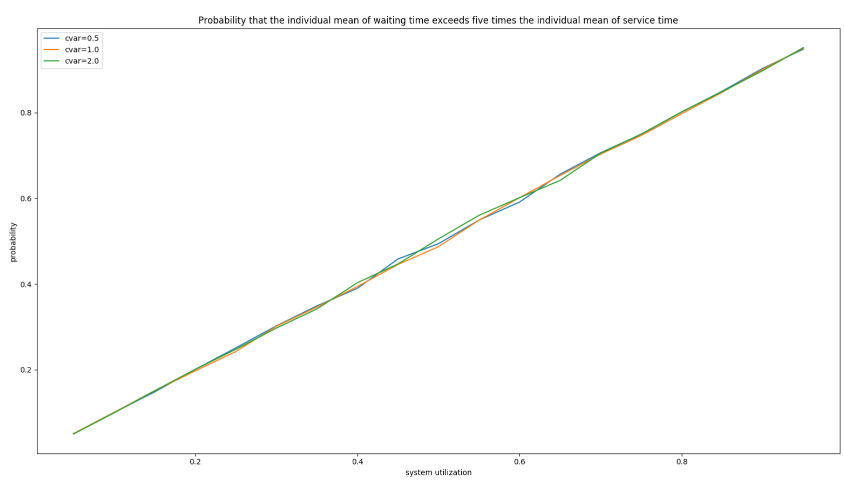



Figure 3: Plot for Problem 5.1.4/5.1.6

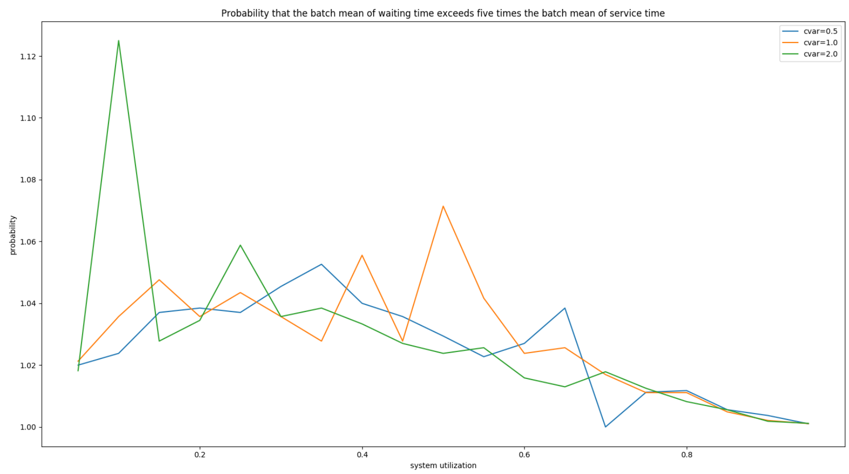



Figure 4: Plot for Problem 5.1.4/5.1.6