Distributed Real Time Systems

Question 1a:

1. Create a DNC/RTC arrival-model og the periodic external traffic source of the in-car network
2. Assume all nodes are connected to a switched 10Mbps duplex ethernet. Switch is assumed to employ FIFO scheduling on the output port.
3. Encode your model in RTC or CyNC
4. Compute mac backlogs and max waiting times for all the deterministic part of the network.
5. Select parameters for token bucket filters for the Poisson traffic sources and include these sources in the DNC/RTC model.
6. Compute mean queue lengths, mean waiting times and packet loss probabilities for the token buckets.
7. Encode the network model in OmNet.
8. Simulate to obtain estimates of the mean and max queue lengths as well as mean and max waiting times.
9. Compare simulation results with previously computed results.

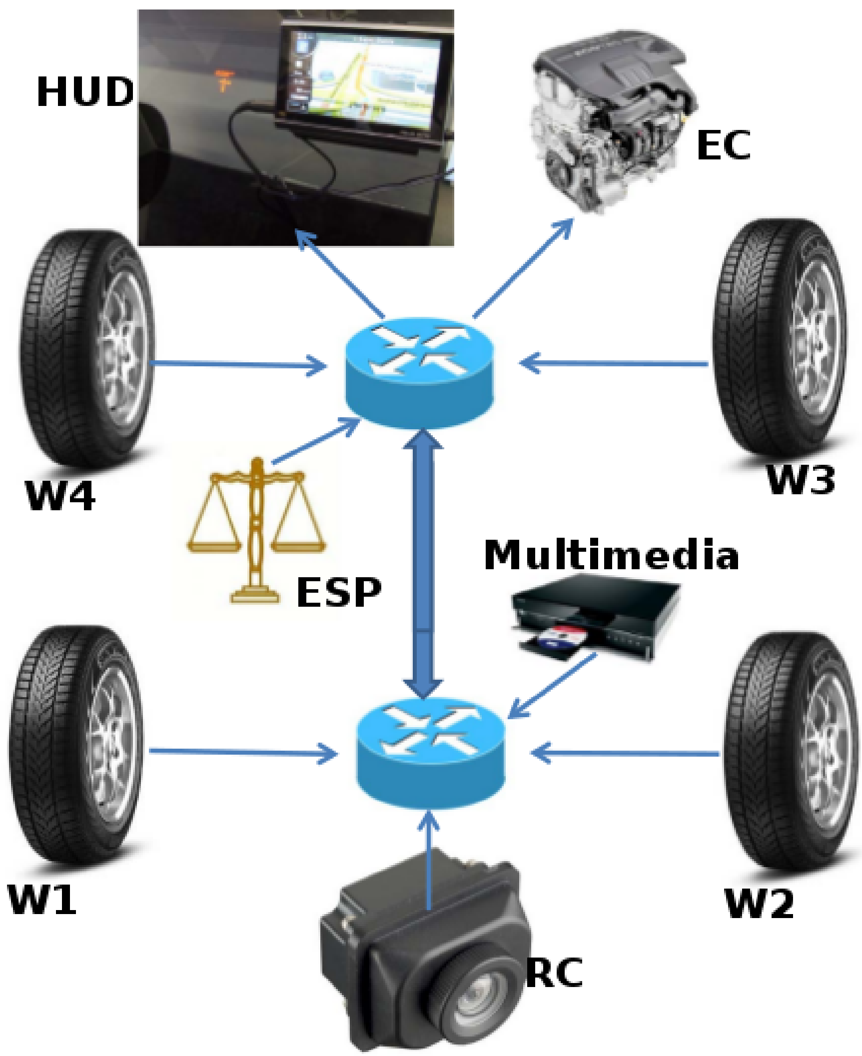
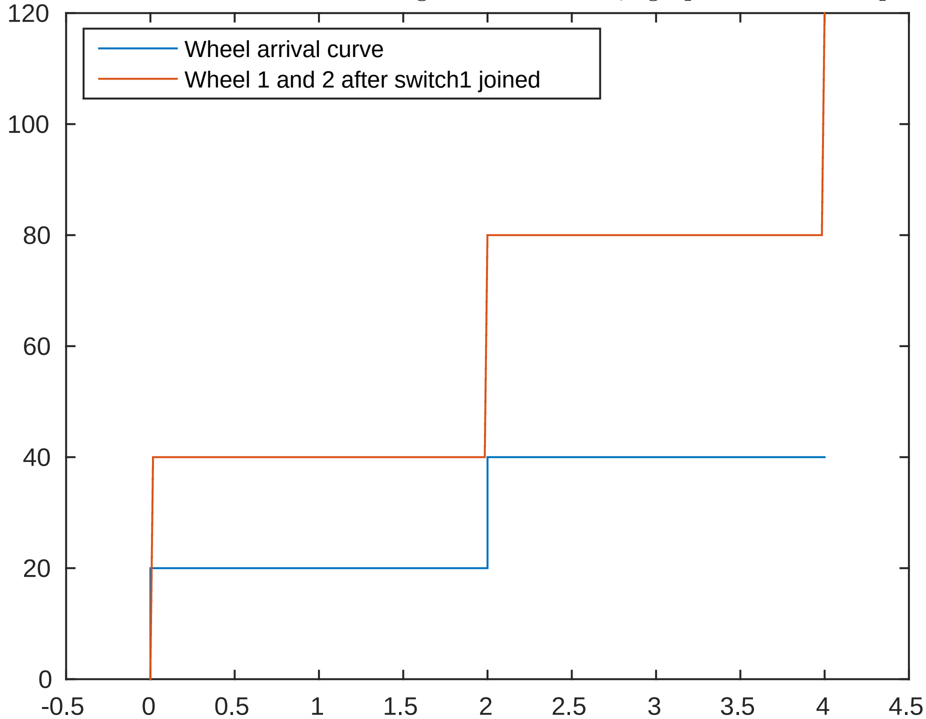


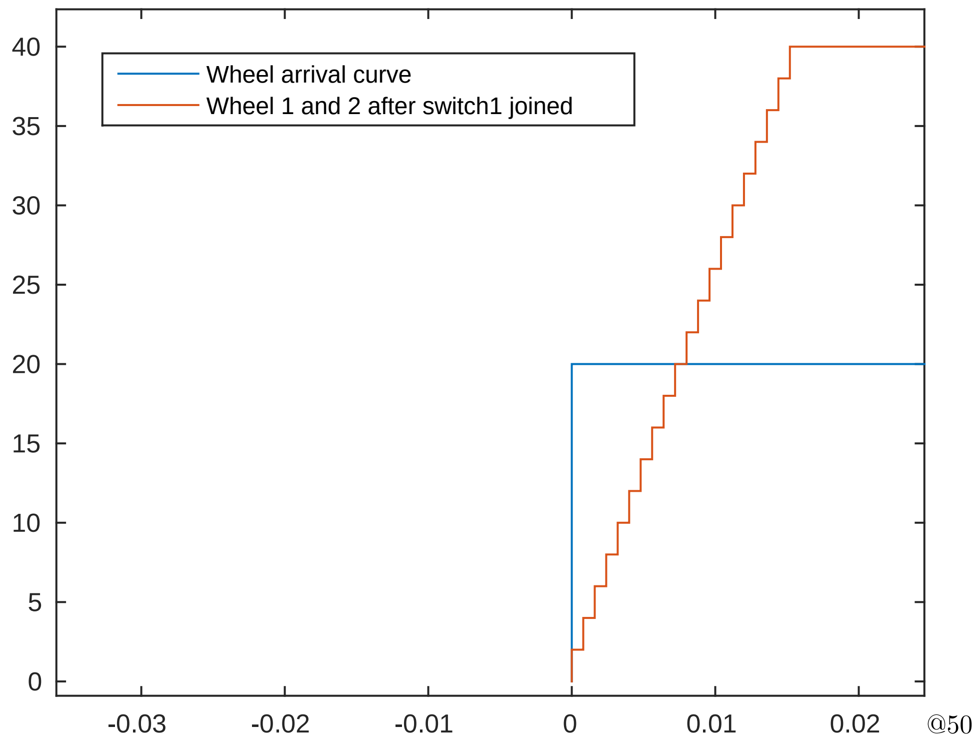
Figure 1: The model

1. Create a DNC/RTC arrival-model og the periodic external traffic source of the in-car network

This is done in MATLAB using RTC Toolbox, graph for the output:



Graph showing the output from switch of the deterministic part (wheel 1 and 2)



The same graph but zoomed in.

2. and 3. done

4. Outputs from script, - the RTC part

time:

- Wheel 1,2 -> HUD: 0.016 + 0.0168 + 0.0168 + 0.0328 = 0.0656 [ms]
- Wheel 3,4 -> HUD: 0.016 + 0.0328 = 0.0488 [ms]
- ESP -> EC : 0.0064 [ms] the only one queue.

backlog:

- Wheel 1,2 -> HUD: 40
- Wheel 3,4 -> HUD: 40
- ESP -> EC: 8

Output from MATLAB:

```
Switch 1
Wheel1: delay after 1th buf in sw1: 0.016; backlog after 1th buf in sw1: 20
Wheel2: delay after 1th buf in sw1: 0.016; backlog after 1th buf in sw1: 20
Wheel1: delay after fifo: 0.0168; backlog1 after fifo: 20
Wheel2: delay after fifo: 0.0168; backlog2 after fifo: 20
Switch 2
Wheel3: delay after 1th buf in sw2: 0.016; backlog after 1th buf in sw2: 20
Wheel4: delay after 1th buf in sw2: 0.016; backlog after 1th buf in sw2: 20
Wheel12: delay after 1th buf in sw2: 0.0168; backlog after 1th buf in sw2: 21
Wheel3: delay after fifo in switch2: 0.0328; backlog3 after fifo: 20
Wheel4: delay after fifo in switch2: 0.0328; backlog4 after fifo: 20
Wheel12: delay after fifo in switch2: 0.0328; backlog12 after fifo: 40
ESP: delay after switch: 0.0064; backlog after switch: 8
RC wait time: 21.5195; mean backlog for RC: 8.745; expected package loss: 0.79681
Multimedia wait time: 17.2156;
    mean backlog for multimedia: 8.745; expected package loss: 0.79681
```

5. Select parameters for token bucket filters for the Poisson traffic sources and include these sources in the DNC/RTC model.

RC: The values used in RTC, some other values are used for omnet. This is done because RTC gave an error if T = a floating point.

- L = 10; % queue size
- M = 5; % bucket
- T = 4; % Token period

Multimedia: * L = 10; % queue size * M = 5; % bucket * T = 5; % Token period

The time values we should have used:

RC: T = 1.9

Multimedia: T = 2.9

6. Compute mean queue lengths, mean waiting times and packet loss probabilities for the token buckets.

RC:

- Mean wait time: 21.5 ms
- Backlog: 8.745
- packet loss: 0.79

Multimedia:

- Mean wait time: 17.2 ms
- Backlog: 8.745
- packet loss: 0.79

Backlog and package loss are the same since bucket size and queue size are the same for both Multimedia and RC.

7. Encode the network model in OmNet.

done

8. Simulate to obtain estimates of the mean and max queue lengths as well as mean and max waiting times.

RC:

- Mean wait time: 1.6 μs
- Max wait time: 3.8 ms
- Mean backlog: 0
- Max backlog: 3
- Packet loss: 0%

Multimedia: * Mean wait time: 276 ms * Max wait time: 290 ms * Mean backlog: 95 * Max backlog: 100 * Packet loss: 14%

9. Compare simulation results with previously computed results.

The results vary a lot, because it is not the same Time value

RC:

T: 1.9; time: 1.6314; backlog: 3.2629; loss: 1.4301e-06

Multimedia:

T: 2.9; time: 52.1754; backlog: 96.1913; loss: 0.26256

Question 2:

1. Assume faults happen only in switches and each switch is non ageing with a failure rate of $\frac{1}{2e6}\frac{1}{hour}$
2. Assume the life time of the remaining part of the car is uniformly distributed in [5,15] years.
3. Compute the probability that a switch fails within the lifetime of a car.

Given: $\lambda = \frac{1}{2e6 \cdot hour}(failurerate)$

Assuming the failure rate follows an exponential distribution, the probability at failure before time t is:

$$F(t) = 1 - e^{-\lambda \cdot t}, \text{Where t} \sim \text{U}(5, 15)$$

The probability the switch fails within lifetime of the car is:

$$E(F(t)) = E(1 - e^{\lambda \cdot t})$$

$$= \int_{5}^{15} (1 - e^{-\lambda \cdot t}) ft \cdot dt$$

$$ft = \frac{1}{15-5} = \frac{1}{10} \xrightarrow{\text{in hours}} \frac{1}{10 \cdot 365 \cdot 24} \cdot \frac{1}{87600}$$

15 years = 131400 hours

5 years = 43800 hours

$$C(F(t)) = \frac{1}{87600} \int_{43800}^{131400} (1 - e^{\frac{-t}{2 \cdot 10^6}})dt$$

$$\approx 0.0427 = 4.3 \ \%$$

4. Compute equivalent probabilities for cases where one and two switches are duplicated.

This provides the minimal paths:

$$s_1, s_4 s_1, s_3 s_2, s_3 s_2, s_4$$

Each switch has equal fail probability:

$$p = 0.043$$

The probability a link works:

$$s_1 \cdot s_2, \text{where } s = 1 - p$$

The p teh link doesn't work:

$$1 - s_1 \cdot \cdot \cdot_2$$

the p that parallel link don't works is

$$(1 - s_1 \cdot s_4)(1 - s_1 \cdot s_3)(1 - s_2 \cdot s_3)(1 - s_2 \cdot s_4)$$

The probability for a single link failure u:

For this connection the failure probability is given by:

$$(1 - (1 - p)^2)^4$$