INFO-H420 Management of Data Science and Business Workflows
Assignment 2

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1. Exercise 1

We add information about waiting time and processing time into the diagram and show it in Figure 1.1.

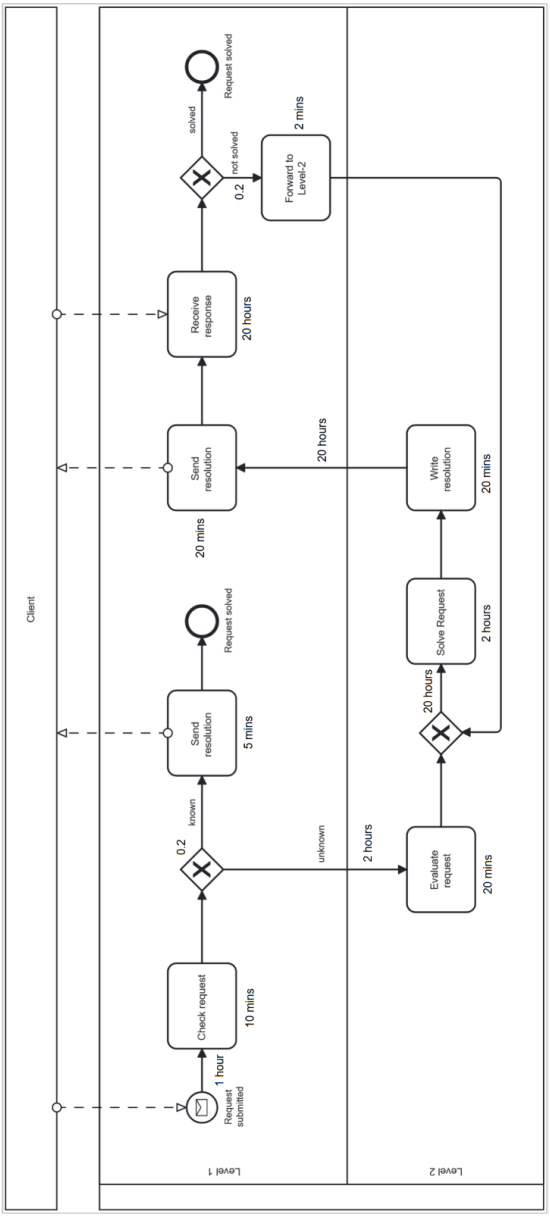

Figure 1.1. The process diagram with time annotations.

The total cycle time is:

$$T_C = 1h + 10m + 0.2 \times 5m + 0.8 \times \left(2h + 20m + \frac{20h + 2h + 20m + 20h + 20m + 20h + 0.2 \times 2m}{0.8}\right)$$
$$= 60 + 10 + 1 + 0.8 \times \left(120 + 20 + \frac{1200 + 120 + 20 + 1200 + 20 + 1200 + 0.4}{0.8}\right)$$
$$= 3943.4 \text{ minutes}$$

The total processing time is:

$$T_P = 10 + 0.2 \times 5 + 0.8\left(20 + \frac{120 + 20 + 20 + 1200 + 0.2 \times 2}{0.8}\right) = 187.4 \text{ minutes}$$

The cycle time efficiency is:

$$E_c = \frac{T_P}{T_C} = \frac{187.4}{3943.4} = 0.0475$$

The total cost is:

$$40 \times \frac{10}{60} + 0.2 \times 40 \times \frac{5}{60} + 0.8 \times \left(60 \times \frac{20}{60} + \frac{60 \times 2 + 60 \times \frac{20}{60} + 40 \times \frac{20}{60} + 0.2 \times 40 \times \frac{2}{60}}{0.8}\right)$$
$$= 176.93€$$

2. Exercise 2

The unit load of a level-2 staff is:

$$\mu_l = 20m + \frac{120 + 20}{0.8} = 195 \text{ min/instance} = 3.25 \text{ h/instance}$$

So the theoretical capacity of a level-2 staff is:

$$\mu = \frac{1}{\mu_l} = \frac{1}{3.25} = 0.3077 \text{ instance/h}$$

We are provided that the mean arrival rate is $\lambda = 1$ instance/h. The process follows a M/M/c model, where c is the number of level-2 staff. The resource utilization is:

$$\rho = \frac{\lambda}{c\mu} = \frac{1}{0.3077 \times c} = \frac{3.25}{c}$$

ρ needs to be less than 1 so that the system is stable. To this end, c needs to be larger than 3.25, so we need at least 4 level-2 staff.

From section 7.2.2 of the textbook "Fundamentals of Business Process Management", we have the following formula to calculate the mean number of instances in the queue:

$$L_q = \frac{\left(\frac{\lambda}{\mu}\right)^c \rho}{c!\,(1-\rho)^2 \left(\frac{\left(\frac{\lambda}{\mu}\right)^c}{c!\,(1-\rho)} + \sum_{n=0}^{c-1} \frac{\left(\frac{\lambda}{\mu}\right)^n}{n!} \right)}$$

From Little's law, the mean waiting time in the queue is:

$$W_q = \frac{L_q}{\lambda} = L_q$$

We try diffrent values of c (starting from 4) to find the number of level-2 staff required to make the mean waiting time less than 2 hours. The result is shown in Table 2.1.

Table 2.1. Result of finding the required number of level-2 staff

c	4	5
W_q	2.475	0.834

So the final solution to the required number of level-2 staff is 5.

3. Exercise 3

3.1. Simulation settings

The inter-arrival time is:

$$T = \frac{1}{\lambda} = \frac{1}{4} = 0.25 \text{ hour} = 15 \text{ minutes}$$

We prepare 3 scenarios for simulation with the online tool: https://bimp.cs.ut.ee/simulator. We create a resource "Client" with the cost of 0 to represent the client in the process. The settings for each scenario are shown in Table 3.1.

Table 3.1. Scenario settings.

Scenario	Resource	Quantity	Cost per hour (EUR)
1	Level 1	5	40
	Level 2	3	60
	Client	100	0
2	Level 1	10	40
	Level 2	6	60
	Client	100	0
3	Level 1	3	40
	Level 2	2	60
	Client	100	0

The settings for each activity are shown in Table 3.2.

Table 3.2. Activity settings.

Activity	Resource	Distribution	Parameters
Check request	Level 1	Exponential	Mean: 10min
Evaluate request	Level 2	Exponential	Mean: 20min
Forward to Level-2	Level 1	Fixed	2min
Receive response	Client	Fixed	20h
Send resolution	Level 1	Gaussian	Mean: 5min; Std: 2min
Send resolution	Level 1	Gaussian	Mean: 20min; Std: 5min
Solve request	Level 2	Exponential	Mean: 2h
Write resolution	Level 2	Exponential	Mean: 20min

Probability settings for two gate XOR gates follow the business description: 20% of requests are known by level-1 staff and 20% of resolutions by level-2 staff are unsuccessful.

3.2. Results

3.2.1 Scenario 1

The scenario statistics are shown in Figure 3.1. We get the mean cycle time excluding off-time table (i.e. only consider working hours from 9 a.m. to 5 p.m., Monday to Friday) of 2.3 weeks, or 2.3x5x8x60=5520 minutes. This is higher than the theoretical cycle time (3943.4 minutes) because of waiting time in the queue, which is not taken into account in our simulation. The resulted mean cost is 178.9 EUR, which is close to our computed cost (176.93 EUR). This is because the cost depends only on the processing time, so it is not affected by the waiting time.

	Minimum	Maximum	Average
Process instance cycle times including off-timetable hours	3.1 minutes	20.7 weeks	9.4 weeks
Process instance cycle times excluding off-timetable hours	3.1 minutes	4.9 weeks	2.3 weeks
Process instance costs	2.1 EUR	1085.9 EUR	178.9 EUR

Figure 3.1. Scenario 1 simulation statistics

The resource utilization is shown in Figure 3.2. It is clear that the workload of level-2 staff is much higher than their level-1 colleagues, which is reasonable considering that only 20% of issues can be solved by level-1 staff.

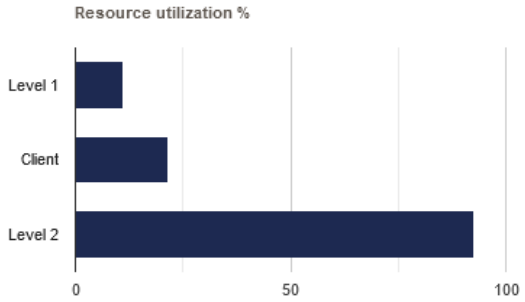

Figure 3.2. Scenario 1 resource utilization.

3.2.2 Scenario 2

In this scenario, we double the number of resources, so we expected that the cycle time would decrease. The scenario statistics are shown in Figure 3.3. We can observe that there is a great reduction in the mean cycle time to just 5.7 days, or 2736 minutes. This is due to the addition of resources, resulting in decreased waiting time. The mean cost remains nearly the same.

	Minimum	Maximum	Average
Process instance cycle times including off-timetable hours	2.8 minutes	10.3 weeks	3.4 weeks
Process instance cycle times excluding off-timetable hours	2.8 minutes	2.5 weeks	5.7 days
Process instance costs	1.9 EUR	933.2 EUR	180.3 EUR

Figure 3.3. Scenario 2 simulation statistics.

The resource utilization is shown in Figure 3.4. The level-2 staff utilization is still higher than that of level-1, but it has gone down compared to its level in scenario 1.

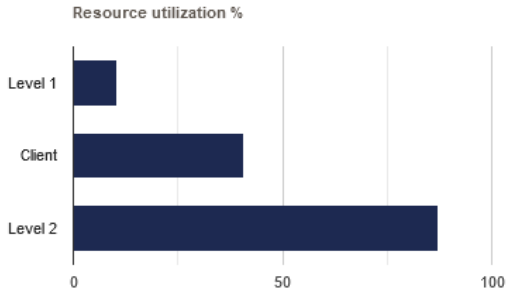

Figure 3.4. Scenario 2 resource utilization.

3.2.3 Scenario 3

In this scenario, we reduce the number of resources, so the cycle time is expected to rise. The results in Figure 3.5 agree with our intuition, as we the mean simulated cycle time goes up to 3.7 weeks, or 8880 minutes. The cost stays nearly unchanged.

	Minimum	Maximum	Average
Process instance cycle times including off-timetable hours	2.3 minutes	32.2 weeks	15.6 weeks
Process instance cycle times excluding off-timetable hours	2.3 minutes	7.7 weeks	3.7 weeks
Process instance costs	1.5 EUR	1567.8 EUR	173.6 EUR

Figure 3.5. Scenario 3 simulation statistics

In terms of resource utilization, it can be seen from Figure 3.6 that the level-2 utilization has climbed up to reach nearly 100% due to the heavy workload and reduced available resources.

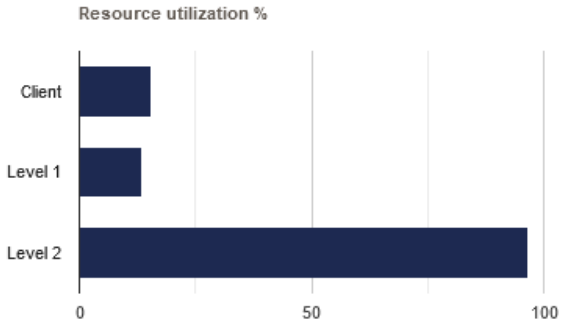

Figure 3.6. Scenario 3 resource utilization.

4. Exercise 4

4.1. Issue register

Table 4.1 shows the issue register for the current business workflow.

Table 4.1. Issue register.

Name	Explanation	Data / Hypotheses	Qualitative Impact	Quantitative Impact
Requests unnecessarily moved between staff levels	When Level-1 staff does not know the resolution, the request is forwarded to Level-2 support staff	- 2 requests are registered per hour. - In 80% of these cases, the requests are unknown and forwarded to level-2 staff. - Cycle time is 1h10min per request. - Processing time is 10min per request. - Cost for request check by level-1 is 6.67€ per request.	- Request takes longer time to be checked by 2 staff levels. - Higher delivery time to clients.	- 0.8x6.67x2=10.672€ is cost waste per hour on forwarding requests from level-1 to level-2 - In 80% of the cases, 1h of cycle time is wasted per request.
Resolutions always sent by level-1 staff.	Level-2 staff sends back resolution to level-1 staff, who then forwards the resolution to client.	- 1 resolution is forwarded to level-1 staff per hour. - Cycle time for check is 20h20min per request - Processing time for check is 20min per request. - Cost for check by level-1 is 13.33€ per request.	- Resolution takes longer time to reach client because level-1 has to wait for receiving resolution from level-2 and send it back to client.	- 13.33x1=13.33€ is cost waste per hour on forwarding resolution to client by level-1. - 20h of cycle time is wasted per request.
Unsuccessful resolutions sent back to level-2 by level-1	If the request is not fixed, level-1 sends it again to level-2.	- 2 requests are forwarded to level-2 per hour. - 20% of resolution by level-2 are unsuccessful - Processing time is 2min. - Cost for forwarding by level-1 is 1.33€ per unsuccessful resolution	- Level-1 staff perform redundant tasks. - Workflow takes longer time in case of unsuccessful resolution.	- 1.33x2x0.2=0.532€ is cost waste on request sent again by level-1 to level-2.
Requests checked twice by level-1 and level-2	In case of unknown problem, requests are checked by level-1 and again by level-2.	- 2 requests are registered per hour. - In 80% of these cases, the requests are unknown and forwarded to level-2 staff. - Cycle time for request evaluation by level-2 is 2h20min per request. - Processing time for request evaluation by level-2 is 20min per request. - Cost for request evaluation by level-2 is 20€ per request.	- Level-2 staff has to evaluate a request that's already checked by level-1 staff. - Evaluations by level-1 and level-2 staff may differ.	- 20x2x0.8=32€ is cost waste on request re-evaluation by level-2.

4.2. Proposal of changes

We propose the following changes to the process based on Redesign Heuristics.

4.2.1 Task level redesign heuristics

- Task elimination
  - Remove the task of forwarding level-2 resolutions to clients by level-1 staff. We let level-2 staff send resolutions directly to clients.
  - Remove two activities “Receive response” and “Forward response to level-2" by level-1. We let level-2 staff directly communicate with clients.
- Task composition
  - Compose two activities “Receive response” and “Forward response to level-2" into a single task.
  - Compose two activities “Solve request” and “Write resolution” into a single activity.
- Triage
  - Generalize two activities “Check request” and “Evaluate request” to “Check and evaluate” activity by level-2 staff.

4.2.2 Flow level redesign heuristics

- Re-sequencing
  - Put activity “Evaluate request” by level-2 before “Check request” by level-1 to avoid double-checking situations.
- Parallelism enhancement
  - Parallelize two activities “Check request” and “Evaluate request” to check if the issue is known and assign the priority concurrently.

4.2.3. Process-level redesign heuristics

- Process specialization
  - Assign a specialized staff in request evaluation. This can help assign tasks faster and more accurately to each level.
- Resource optimization
  - Level-2 staff can also do level-1 activities depending on their availability, because they are more experienced and can solve the issue in the first place without waiting for the check by level-1.
- Communication optimization
  - Create a page of Frequently Asked Questions (FAQ) where clients can search for common issues along with their resolution. This can help reduce the number of requests submitted to IT helpdesk.
- Automation
  - Develop a feature that can automatically detect if the issue is already known and if yes, provide the client with the resolution. This can help avoid already-known problems being sent to IT helpdesk.

5. Exercise 5

A possible to-be process model is shown in Figure 5.1.

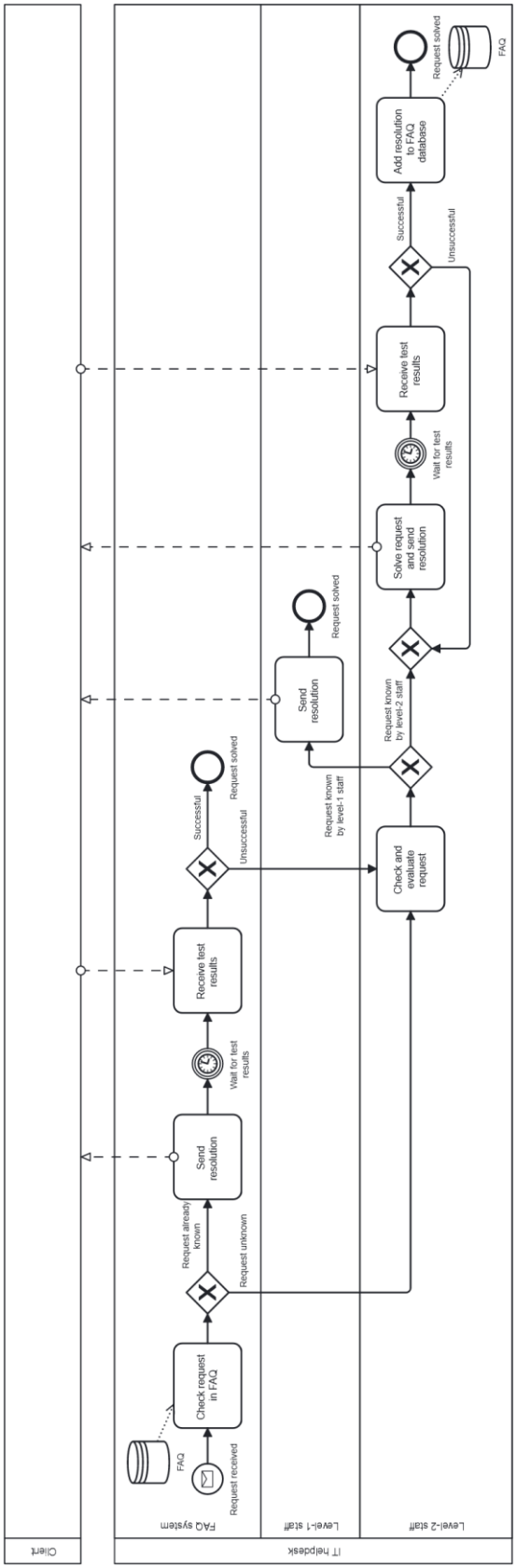

Figure 5.1. A possible to-be process model.