Institute of Computer Science, University of Bern
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Exercise 2

2.1 Pizza or pasta? (4pt)

An Italian restaurant has three employees: Alice, Bob and Carol. Alice is a waitress and Bob and Carol are cooks. The restaurant offers two dishes: pizza and pasta. Bob is responsible for making a pizza and Carol for cooking pasta. Cooks can prepare one dish at the time but there is a limit on how many orders they can have in the waiting list. Bob can have 3 pizzas and Carol 7 portions of pasta in the waiting list.

Using terminology as shown in the lecture for the *JobHandler* [CGR11, Sec. 1.4.3], implement the order-processing protocol of the Italian restaurant as shown in Figure 1. It should contain three modules (Alice, Bob, and Carol) and ensure that

- every customer will eventually get his/her order;
- no dish is delivered if it was not ordered;
- every customer gets each order exactly once.

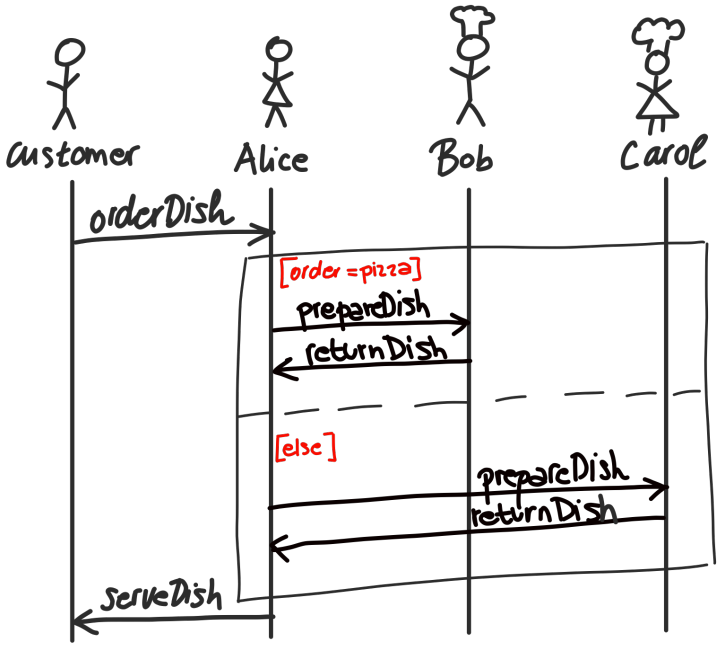

Figure 1. Overview of an order processing in an Italian restaurant.

2.2 Safety and liveness (3pt)

On the opposing sides of a canyon, there are two armies, each led by a different general. General A and General B want to attack a third army (led by General Z), which will travel through the canyon. However, the third army is quite strong, and in order to succeed, both generals need to attack at exactly the same time (both Generals have synchronized clocks available). Thus, both generals devised the following algorithm for a coordinated attack:

- General A chooses an attack time t and sends a messenger m_1 carrying t (denoted $m_1(t)$) to General B.
- General B waits for m_1. Upon the arrival of $m_1(t)$, General B sends a messenger m_2 carrying a confirmation to General A. Then it waits until time t and attacks.
- General A waits for m_2. Upon the arrival of m_2, General A waits until time t and attacks.

Which of the following properties are safety properties, which ones are liveness properties, and which ones are a mixture of the two? Explain your answers (See [CGR11, Sec. 2.1.3]).

a) If some general attacks at time t, then the other general attacks at the same time.

b) If m_2 arrives after time t, then General A will attack after General B.

c) Eventually, General B will attack.

d) If messengers m_1 and m_2 are not intercepted, then eventually both generals attack.

e) If m_1 and m_2 are not intercepted, then eventually both generals attack at time t.

2.3 Unreliable clocks (3pt)

Read more in Chapter 8 of DDIA [Kle17], specifically pp. 287–299, which address unreliable clocks.

Describe systems or protocols, where unreliable clocks as presented in DDIA may lead to safety and liveness violations. In particular, for each of the following examples, describe a property and how it is violated:

a) Find two examples, where timing issues lead to safety violations;

b) Find two examples, where timing issues lead to liveness violations.

References

[CGR11] C. Cachin, R. Guerraoui, and L. Rodrigues, *Introduction to reliable and secure distributed programming (Second Edition)*, Springer, 2011.

[Kle17] M. Kleppmann, *Designing data-intensive applications*, O'Reilly, 2017.