

CSCI3100 Software Engineering

Assignment 3

Due – 11:59:59pm, 14th Mar, 2021 (Sunday)

Please submit the homework online through Blackboard.

Late submission penalty within 24 hours: 50%; after 24 hours: 100%.

Remember to go through Veriguide for Academic Honesty Declaration.

Missing Veriguide report: 50% mark deduction.

Answer the following problems based on lecture Topics 4 notes, from which you can consider for solutions. You can use a tool called pipe2 (<http://pipe2.sourceforge.net/>) for developing and drawing Petri Nets. Or you can simply use Powerpoint to draw the diagrams and import them to Word, if you use Word document to prepare your homework solution.

1. Medical Treatment Problem (25 points)

The COVID-19 has been spreading all over the world since Dec. 2019. It is thought to spread from person to person, mainly through respiratory droplets produced when an infected person coughs or sneezes. To handle such a severe global emergency event, most countries take actions to prevent this virus from spreading too fast.

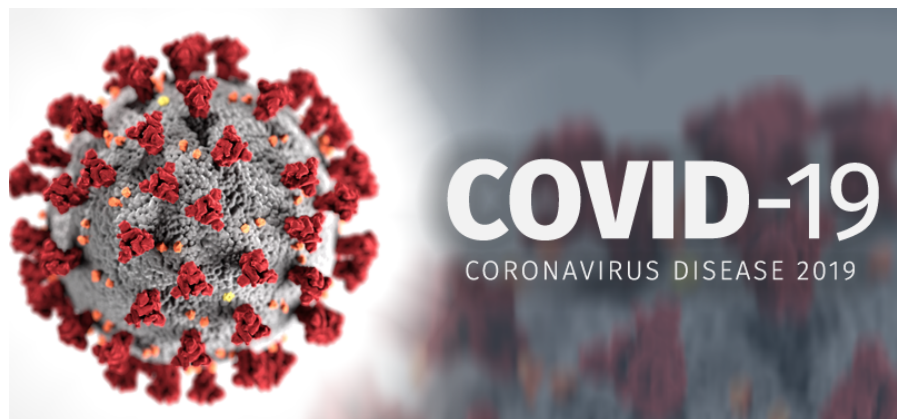


Figure 1. COVID - 19

- 1) Suppose that now CUHK employs both health code and body temperature measurement to detect infested persons. Every student from outside Hong Kong must accept this testing process before he or she can enter the campus of CUHK. The whole process is described as follows: When a student arrives at Hong Kong (“student_arrival”), he/she needs first to show his/her health code (“health_code_check”). The health code has three colors: red, yellow and green to indicate the infection risk of places the persons come from. If the color is red, then this student must go to hospital (“send_to_hospital”) and conduct a fast coronavirus test (“covid_test”). If the test result is negative, then this student can leave and go through a 14-day quarantine (“go_through_quarantine”). After this 14-day quarantine, he or she is allowed to enter the campus (“enter_campus”). If

the test result is positive, then this student must accept medical treatment (“medical_treatment”) until he or she is cured (“student_cured”). Then this student can enter the campus. If the color of health code is yellow, then this student needs to measure his/her body temperature (“measure_body_temperature”). If the body temperature is normal, then this student can leave and go through a 14-day quarantine, after which he or she can enter the campus. If the body temperature is higher than normal case, this student will be sent to hospital and accept the same process mentioned above. If the color of health code is green, then this student does not need to go through a 14-day quarantine and can enter the campus immediately.

Please design a Petri Net for this whole process and identify all possible places and transitions. Some important places are given and they must appear in your Petri Net. However, you are allowed to add more places unless they are necessary. Please also initialize the Petri Net you designed and give a possible firing sequence. Please simplify your Petri Net as much as possible.

- 2) Now let’s take a close look at the medical treatment process mentioned in the first question. Suppose that patients with abnormal body temperature are sent to the emergency center of RISE hospital. There are 2 doctors, 2 nurses and 1 director in this center. For each patient with abnormal body temperature sent into this center, firstly a nurse should accept this patient and conduct a coronavirus test for him/her. If the test result is negative, then this is just a normal fever case and the nurse should call the director to conduct a double check and endorse this case. After that the director can call a doctor to provide proper treatment for this patient. (To prepare for any emergency cases, the director does not provide medical treatment for patients.) The patient can leave after he or she is cured. If the test result is positive, then this is highly likely to be a COVID-19 case and a doctor should come to handle this patient. The doctor first checks the symptoms of this patient. If the symptoms indicate this is a quite serious case and necessary treatment is beyond the ability of this emergency center, the doctor will call the director and suggest transferring this patient to another more advanced hospital ARISE. The director needs to endorse for the judgement of this doctor and approve his/her proposal. (Suppose that the director must approve this.) After the approval, a nurse is called to send the corresponding patient to the ambulance, then the patient is transferred. If the symptoms indicate this is not a serious case, the doctor will provide a proper medical treatment. After that a nurse will send the patient to the inpatient ward, after several days the patient is cured. To guarantee the quality of treatment, the whole treatment is a blocked process, which means that a staff (doctor, nurse or director) cannot leave a patient unless another staff comes, and a staff cannot handle more than 1 patient in parallel.

Now suppose 4 patients with abnormal body temperature are sent to this RISE center. There are no other patients, and all staffs are available. Please design a Petri Net for the workflow of the patient treatments. Please identify all possible places and transitions. You need to initialize your Petri Net and simplify it as much as possible. Also give a possible firing sequence of treatments of all 4 patients.

2. Turn-based Game Problem (30 points)

Consider there are two persons playing a game card problem. This game is turn-based, which means that each player conducts actions in turn. At the beginning of this game, both players have 3 health points (HP). The game ends if HP of one player drops to zero, while HP of the other player increases to 6 at the same time.



Figure 2. A MOD in Warframe which can increase the chance of critical attack

Suppose that each player can take two actions in his/her turn: “attack” and “critical attack”. “Attack” can definitely decrease 1 HP of his/her enemy and increase 1HP of himself/herself. “Critical attack” is possible to decrease 2 HP of the enemy and get 2HP back but it is also possible that the enemy evades this attack and beat back (This action happens automatically and does not consume a turn.) to decrease 1 HP of this player and also increases 1 HP of the enemy. “Critical attack” is not allowed if the enemy’s HP is lower than 2. The workflow of one player in this game can be described as follows: When player A’s turn is ready (“A_turn_ready”), A can choose one of two actions, if A choose “attack” (“A_attack”), then B’s HP decreases and A’s HP increases. If A choose “critical attack” (“A_critical_attack”), firstly the system checks whether the enemy’s HP is lower than 2 (“check_B_HP”). If so, this action is not allowed and the status falls back to “A_turn_ready”; otherwise, this action is allowed and then there are two possible cases (“A_critical_attack_judgement”): (1) A’s attack hits B, then B’s HP decreases 2 and A’s HP increases 2 (“A_critical_attack_succeeds”). (2) A’ attack does not hit B and B beats back (“A_critical_attack_fails”), then B’s HP increases 1 and A’s HP decreases 1. When the action ends (“A_action_end”), A’s turn ends (“A_turn_wait”) and B’s turn is ready (“B_turn_ready”). The process of B’s turn is similar with that of A. When a player’s turn is ready and HP of this player is 6, the game ends and this player wins. For example, if A’s HP comes to 6 when reaches “A_turn_ready”, then the game ends and A wins (“A_wins”).

- 1) Let’s first look at only Player A. Please design a Petri Net for workflow of Player A in just one turn and do NOT consider the changes of HP. Note that you may NOT include the end condition such as “A_wins” and involve the status of HP in HP check status such as “check_B_HP” since HP is not considered at this time.

Please identify all possible places and transitions. Some important places are given and they must appear in your Petri Net. However, you are allowed to add more places if

necessary. Please also initialize the Petri Net you designed and give a possible firing sequence indicating one turn of A. Please simplify your Petri Net as much as possible.

- 2) Now let's also take Player B into consideration. Please design a Petri Net for workflow of both players in the whole game (multiple turns) and do NOT consider the changes of HP. Note that you may NOT include the end condition such as "A_wins" (which means turns will repeat infinitely in this current case) and involve the status of HP in HP check status such as "check_B_HP" since HP is not considered at this time.

Please identify all possible places and transitions. Some important places are given and they must appear in your Petri Net. However you are allowed to add more places if necessary. Please also initialize the Petri Net you designed and give a possible firing sequence indicating one turn of A and B (starting from "turn_ready" status of a player and ends with "turn_wait" status of the other player). Please simplify your Petri Net as much as possible.

- 3) Finally let's also take changes of HP into consideration for the complete solution. Please design a Petri Net for workflow of both players in the whole game (multiple turns), along with changes of HP. Note that the end condition of game such as "A_wins" MUST be included and HP check status such as "check_B_HP" MUST involve the status of HP now.

Please identify all possible places and transitions. Some important places are given and they must appear in your Petri Net. However, you are allowed to add more places if necessary. Please also initialize the Petri Net you designed and simplify your Petri Net as much as possible.

3. Entity-Relationship Diagram (20 points)

Suppose now we are developing a bank system with the following requirements:

ARISE bank has multiple branches, each branch locates on a city and has its unique name. ARISE needs to monitor the assets of each branch. Clients are identified by their ID numbers. Their names, phone numbers, family addresses are also stored. To guarantee the safety of each client's accounts, ARISE also requires clients to provide information of one contact, including name, phone, email, and relationship with this client. Bank staffs are also identified by their ID numbers. They can be managers or clerks. Each manager leads all clerks in the department. Each clerk can only work in one department. Every bank account has a clerk to be responsible for and a clerk can take charge of multiple accounts. Each branch stores the name, phone number, home address, department number and the beginning date of working of every staff. For each department, its number, name and ID number of the manager are also stored. Each department belongs to a specific branch, but a branch can have multiple departments. ARISE offers saving accounts. Each account can be owned by multiple clients and one client can have multiple accounts. Every account is identified by the account number, also its balance, open date, opening branch name are stored.

Given the information above, please identify all entities and relationships of this ARISE bank system, and design an ER diagram to describe them.

4. Logic Specification (25 points)

Please answer the described problems regarding the following logic specifications:

```
valid_layer(i, j, m, n) ≡
(j = i and ci = "N") or (n - m + 1 = 2 (j - i + 1) and
j != i and for all x (m <= x <= n and exists t implies (x -
m = 3t - 1)) implies cx = "S" and
for all y (i <= y <= j and cy != "S") implies ((cy = "B" and
for all w (2(y - i) <= w <= 3(y - i) - 1) implies cm+w = "B")
or (cy = "N" and for all k (2(y - i) <= k <= 3(y - i) - 1)
implies cm+3k = "N"))
))
```

```
valid_sequence(m, n) ≡
(m = n and cm = "B") or
(cm = "N" and
exists d implies (d >= 3 and for all c (3 <= c <= d) implies
(exists x,y,i,j (y - x + 1 = 2^(c - 3) × 3 and j - i + 1 = 2
^(c - 2) × 3 and j <= n and i = y + 1) implies
valid_layer(x,y,i,j))))
```

- 1) Considering the following input sequences. Please answer if each of them satisfies the requirement predicate of `valid_sequence(m, n)`; that is, whether it returns True or False. For all input sequence, if the predicate returns True, please also identify the value of `c` in `valid_sequence(m, n)` and the value of `x, y, i, j` each time `valid_layer(x, y, i, j)` is called by `valid_sequence(m, n)`. Suppose the sequence starts with index 1. Note c_x represents the x_{th} character in the sequence, and \leq, \geq, \neq are the same as \leq, \geq, \neq , respectively. Also the multiplication operator (\times) is omitted for clarity, and the caret (^) is used as the exponentiation operator.

- a) NBBS
- b) NNNSBNSBBS
- c) NNNSNNSNNSNNSNNSNNSNNS
- d) NNBSBBSBBS
- e) NNBSNBSBBSBNSBBSBBSBBS
- f) NNBSNNSBBSNBSBBSBBSBBSNNSBBSBBSBBSBBSBBSBBSBBS

- 2) Can you think of what predicate `valid_sequence(m, n)` will check in data structure? Explain what `valid_layer(x, y, i, j)` means when it is called by `valid_sequence(m, n)`.

4a. Logic Specification (10 bonus points – no coupon can be applied)

This is a bonus problem, it is not included in the 100 points of this assignment, however, you can get 10 extra points if you work this out.

Suppose that Bob is playing a word connection game, in which he needs to raise a word sequence, containing a number of words, and the word behind starts with the same character which the former word ends with. To add more difficulty, also the word sequence needs to contain a predefined word and the length of each word needs to be bigger than a predefined number.

Given the word sequence raised by Bob, please use logic specification for `valid_answer(m,n)` to check if this sequence satisfies the rules of the game. Suppose the input sequence of `valid_answer(m,n)` contains 3 sub-sequences, separated by "#": The first sequence is the predefined number. The second sequence is the predefined word. The last sequence is Bob's answer, there is no separate identifier between words. Please note that you first need to check if the first sequence is a number and the last two sequences are text sequences before you further check the requirements. You are given two defined predicate `valid_word(m,n)` and `valid_digit(m)` to check if a sequence is a word and if a character is a digit. You can directly call them if necessary. You are required to implement all checks in `valid_answer(m,n)`, but you are recommended to define other predicates (in Logic Specification) to help such checks. Note we do not consider the case where a word contains two same characters and one is followed by the other. For example, "necessary" has two successive "s", thus it is not considered in this problem for simplicity. You are highly recommended to add some comments for easy understanding of your specification.