Technische Universität München (I7) **Summer Semester 2020**
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Model Checking – Exercise sheet 2

Exercise 2.1

Find the *semantics* of the following formulas:

(a) $(a \wedge b) \to (c \vee d)$

(b) $(a \to b) \to (b \to c)$

Exercise 2.2

Check if the following *valuations* are a *model* fo the corresponding formula.

(a) $(a, b, c, d) = (0, 1, 1, 0) : a \to (b \vee (c \wedge d))$

(b) $(a, b, c, d) = (1, 0, 1, 1) : (a \vee b) \to (a \wedge (c \vee d))$

Exercise 2.3

Out of the following approaches to find bugs, identify which ones are *complete* and which ones are *sound*.

(a) Simulation and Testing

(b) Program Analysis

(c) Deductive Verification

(d) Model Checking

Exercise 2.4

Convert the following C program into a transition system.

```
1  #include <pthread.h>
2  typedef enum {0,1} newBool;
3
4  newBool lock = 0;
5  newBool play;
6
7  void *thread1(void *arg) {
8    while(true){
9      if(lock==0){  // a1
10       play=0; //a2
11       lock=1;   //a3
12     }
13   }
14   return 0;
15 }
16
17 void *thread2(void *arg) {
18   while(true){
19     if(lock==1){  //b1
20       play=1;  //b2
```

```
21          lock=0;   //b3
22        }
23      }
24      return 0;
25  }
26
27  int main(void) {
28
29  pthread_t t[2];
30
31  pthread_create(&t[0], 0, thread1, 0);
32  pthread_create(&t[1], 0, thread2, 0);
33  pthread_join(t[0], 0);
34  pthread_join(t[1], 0);
35
36  return 0;
37  }
```

Exercise 2.5

Convert the transition system from last question into a *Kripke Structure*.

$AP = \{p, q\}$,
$v^{-1}(p) = \{a_2\} \times \{b_1, b_2, b_3\} \times \{0, 1\} \times \{1\}$,
$v^{-1}(q) = \{a_1, a_2, a_3\} \times \{b_2\} \times \{0, 1\} \times \{0\}$

The third component corresponds to lock and fourth corresponds to play.

A puzzle: (completely unrelated to Model Checking)

The Sneaky Cat

There are five houses on a street numbered 1-5. Each night, the street cat sleeps in one of the houses. However, the cat will move to a different house next morning, either the neighboring house on the left or the neighboring one on the right. As a curious person you want to catch the cat and you are allowed to inspect 1 house each afternoon. What order do you inspect the houses in to catch the cat in least number of days without fail.

Your answer will be putting the digits together as a number. So if the strategy calls for inspecting houses 1,2,3,4,5 in that order the answer will be 12345.

Solution 2.1

(a) $\{(0, x_2, x_3, x_4)\} \cup \{(x_1, 0, x_3, x_4)\} \cup \{(x_1, x_2, 1, x_4)\} \cup \{(x_1, x_2, x_3, 1)\}$

(b) $\{(x_1, 0, x_3)\} \cup \{(x_1, x_2, 1)\}$

Solution 2.2

(a) Yes.

(b) Yes.

Solution 2.3

(a) Incomplete and Sound.

(b) Incomplete and Unsound.

(c) Complete and Unsound.

(d) Complete and Sound.

Solution 2.4

States $= \{(a_i, b_j, lock, play) \mid i, j \in \{1, 2, 3\}$ and $lock, play \in \{0, 1\}\}$
Initial states $= \{(a_1, b_1, 0, play) \mid play \in \{0, 1\}\}$
Transitions $= \{((a_1, b_1, 0, 0), (a_2, b_1, 0, 0)), \dots\}$

Solution 2.5

All states in $\{(a_2, b_i, lock, 1) \mid i \in \{1, 2, 3\}, lock \in \{0, 1\}\}$ will be annotated by $\{p\}$ and all states in $\{(a_i, b_2, lock, 0) \mid i \in \{1, 2, 3\}, lock \in \{0, 1\}\}$ will be annotated by $\{q\}$. All the remaining states will be annotated by $\{\}$.