Automated Reasoning IMC009
Practical Assignment – Part 1

Deadline: 27 October 2024

Please carefully read the pdf file containing the assignment info (which is a different pdf from this file!) before writing the report. It explains how your report will be graded.

1 Delivery

A delivery company has to deliver some pallets of apples, pears, mushrooms, saffron, and some herds of goats to a combination grocery store / petting zoo. Eight trucks are available. Each of them has a capacity of 8000 kg and can carry at most ten units of cargo. A unit of cargo is either a pallet or a herd of goats.

In total, the following has to be delivered:

- Four pallets of saffron, each of weight 700 kg.
- Eight pallets of mushrooms, each of weight 1000 kg.
- Ten herds of goats, each of weight 2500 kg.
- Twenty pallets of pears, each of weight 400 kg.
- As many pallets of apples as possible, each of weight 400 kg.

Mushrooms need to be cooled. Only three of the eight trucks have facility for cooling mushrooms.

Saffron is very valuable. To distribute the risk of loss, no two pallets of saffron may be in the same truck.

(1).
- What is the maximum number of pallets of apples that can be delivered?
- Show the distribution of all units of cargo over the eight trucks by providing a table.

(2). The company has fulfilled the order according to your specifications, but the goats have eaten all the apples! Now, the goats are banned from being in the same truck as apples. Answer the questions from part (1) with this additional constraint.

2 Chip design

An electronics manufacturing company requires a chip design containing two power components and ten regular components, satisfying the following constraints:

- Both the width and the height of the chip is 30.
- The power components have width 4 and height 3.
- The sizes of the ten regular components are 4×5, 4×6, 5×20, 6×9, 6×10, 6×11, 7×8, 7×12, 10×10, 10×20, respectively.
- All components may be turned 90°, but may not overlap.
- In order to get power, all regular components should directly be connected to a power component, that is, an edge of the component should have a part of length > 0 in common with an edge of the power component.
- Due to limits on heat production the power components should be not too close: their centres should differ at least d in either the x direction or the y direction (or both).

For $d = 16, 17, 18$ check whether a solution is possible. If so, provide a graphical presentation to show the corresponding chip design.

3 Dinner

Five couples want to organize a dinner. Each couple consists of two people living together in one house, so there are five houses in total. The dinner consists of five rounds. Each round is held in two houses at the same time, with five people in each house.

Every couple hosts two rounds in their house, for which both hosts have to be present. No participant may be in the same house with another participant for all five rounds. Between the rounds, participants may move from one house to another.

On top of these requirements, there are four desired properties:

(A) Every two people among the ten participants meet each other at least once.

(B) Every two people among the ten participants meet each other at most three times.

(C) Couples never meet outside their own houses.

(D) No person can be a guest in the same house twice.

The five couples want to create a plan for the dinner.

(1). Verify that (A)$\wedge$(C)$\wedge$(D) is unsatisfiable.

(2). Show that the following combinations are all satisfiable: for each one, provide a table to show how the people in every round should be distributed over the houses.

- (A)$\wedge$(C)
- (A)$\wedge$(D)
- (B)$\wedge$(C)$\wedge$(D)

4 Program safety

Consider the following program:

```
procedure UnsafeProgram(n)
    a ← 1
    b ← 1

    for 1 ≤ i ≤ 10 do
        if φ then
            a ← a + 2b
            b ← b + i
        else
            a ← a + i
            b ← a + b
        end if
    end for

    if b = 700 + n then
        "crash"
    end if
end procedure
```

Here, φ is an unknown condition that may be true or false. Note that the test on crash is outside the loop, so is only tested at the end.

(1). Establish for which values of $n = 1, 2, \ldots, 10$ the program can never reach "crash".

(2). Let n_{min} be the smallest $n = 1, 2, \ldots, 10$ such that the program is able to reach "crash". Provide a table to show how the program can reach $b = 700 + n_{min}$: for each iteration of the loop give the values of a, b and φ.