

# Planning and Optimization

M. Helmert, G. Röger  
 R. Christen, P. Ferber, T. Keller

University of Basel  
 Fall Semester 2022

## Exercise Sheet 9 Due: November 28, 2022

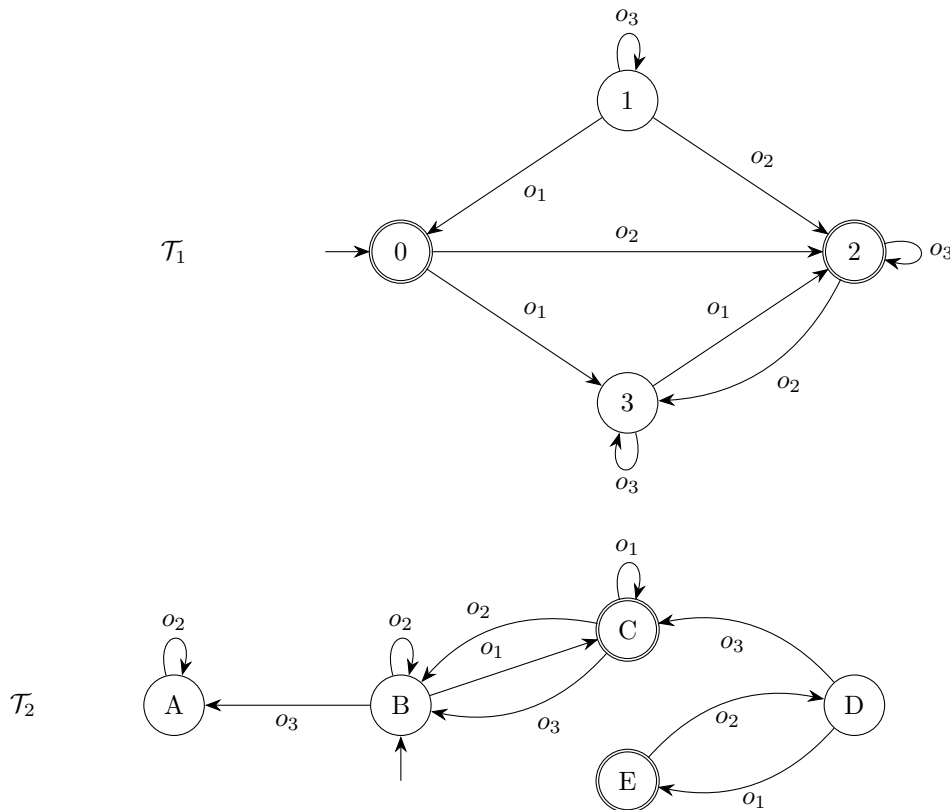
**Important:** For submission, consult the rules at the end of the exercise. Non-adherence to these rules might lead to a penalty in the form of a deduction of marks or, in the worst case, that your submission will not be corrected at all.

### Exercise 9.1 (1 mark)

Compare *pattern database* heuristics to *merge-and-shrink* heuristics by stating one advantage of each over the other (one sentence per comparison is sufficient).

### Exercise 9.2 (1+2 marks)

Consider the abstract transition systems  $\mathcal{T}_1$  and  $\mathcal{T}_2$  as depicted below. As usual, an incoming arrow indicates the initial state, and goal states are marked by a double circle.



- Graphically provide the abstract transition systems  $\mathcal{T}'_1$  and  $\mathcal{T}'_2$  that are obtained by pruning all dead states from  $\mathcal{T}_1$  and  $\mathcal{T}_2$ , respectively.
- Graphically provide the abstract transition system of the synchronized product  $\mathcal{T}'_1 \otimes \mathcal{T}'_2$  of the transition systems obtained in part (a). How much smaller is  $\mathcal{T}'_1 \otimes \mathcal{T}'_2$  in comparison to  $\mathcal{T}_1 \otimes \mathcal{T}_2$ ?

**Exercise 9.3** (2 marks)

Let  $\Pi$  be a SAS<sup>+</sup> planning task with  $V = \{a, b, c, d, e, f\}$  and  $|\text{dom}(a)| = 5$ ,  $|\text{dom}(b)| = 6$ ,  $|\text{dom}(c)| = 7$ ,  $|\text{dom}(d)| = 8$ ,  $|\text{dom}(e)| = 9$  and  $|\text{dom}(f)| = 10$ . Apply the merge & shrink algorithm with the general strategy from the lecture and

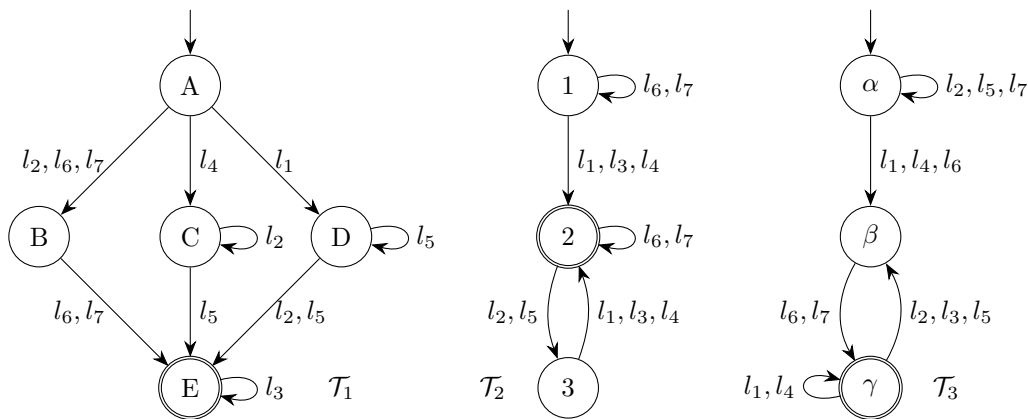
- use a size limit of  $N = 250$ ;
- use a linear merging strategy that considers all factors in lexicographically increasing order;
- if necessary, shrink the abstraction computed in the *previous* iteration just enough to make the merge possible.

In each step, provide all elements of the factored transition system along with their size and which factors are shrunk (if necessary) and merged.

*Hint: The concrete form of the transition systems is irrelevant for this exercise.*

**Exercise 9.4** (2+2 marks)

Consider the abstract transition systems  $\mathcal{T}_1$ ,  $\mathcal{T}_2$  and  $\mathcal{T}_3$  with identical label set  $L = \{l_1, \dots, l_7\}$  and cost function  $\text{cost}(l) = 1$  for all  $l \in L$  as depicted graphically below. As usual, an incoming arrow indicates the initial state, and goal states are marked by a double circle.



- (a) Provide all pairs of labels that are locally equivalent in  $\mathcal{T}_1$ ,  $\mathcal{T}_2$  and  $\mathcal{T}_3$ . Then provide a mapping  $\lambda : L \mapsto L'$  that maps all  $\mathcal{T}_1$ -combinable labels to the same (new) label and all other labels  $l$  to itself. Let  $c'$  be the cost function that allows exact label reduction with  $\langle \lambda, c' \rangle$ . Graphically provide  $\mathcal{T}_1^{\langle \lambda, c' \rangle}$ ,  $\mathcal{T}_2^{\langle \lambda, c' \rangle}$  and  $\mathcal{T}_3^{\langle \lambda, c' \rangle}$ .
- (b) Graphically provide the transition systems  $\mathcal{T}'_1$  and  $\mathcal{T}''_1$  that result from shrinking  $\mathcal{T}_1^{\langle \lambda, c' \rangle}$  with the following shrinking strategies:
- $\mathcal{T}'_1$  results from applying  $f$ -preserving shrinking, and
  - $\mathcal{T}''_1$  results from applying bisimulation-based shrinking.

**Submission rules:**

- Exercise sheets must be submitted in groups of two or three students. Please submit a single copy of the exercises per group (only one member of the group does the submission).

- Create a single PDF file (ending .pdf) for all non-programming exercises. Use a file name that does not contain any spaces or special characters other than the underscore “\_”. If you want to submit handwritten solutions, include their scans in the single PDF. Make sure it is in a reasonable resolution so that it is readable, but ensure at the same time that the PDF size is not astronomically large. Put the names of all group members on top of the first page. Either use page numbers on all pages or put your names on each page. Make sure your PDF has size A4 (fits the page size if printed on A4).
- For programming exercises, only create those code textfiles required by the exercise. Put your names in a comment on top of each file. Make sure your code compiles and test it. Code that does not compile or which we cannot successfully execute will not be graded.
- For the submission: if the exercise sheet does not include programming exercises, simply upload the single PDF. If the exercise sheet includes programming exercises, upload a ZIP file (ending .zip, .tar.gz or .tgz; *not* .rar or anything else) containing the single PDF and the code textfile(s) and nothing else. Do not use directories within the ZIP, i.e., zip the files directly. After creating your zip file and before submitting it, open the file and verify that it complies with these requirements.
- Do not upload several versions to ADAM, i.e., if you need to resubmit, use the same file name again so that the previous submission is overwritten.