Planning and Optimization

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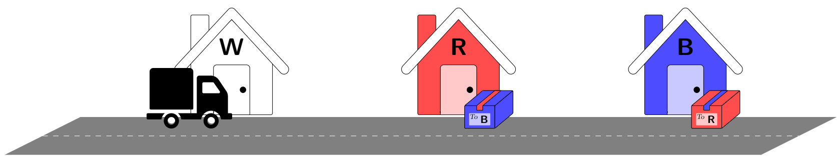
Exercise Sheet 8

Due: November 27, 2023

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 marked at all.

Exercise 8.1 (2 marks)

Consider a logistics problem similar to the running example from the lecture. A single truck needs to pick up and deliver two packages between three locations. The figure below illustrates the initial state of the problem. The color of each package indicates its destination.



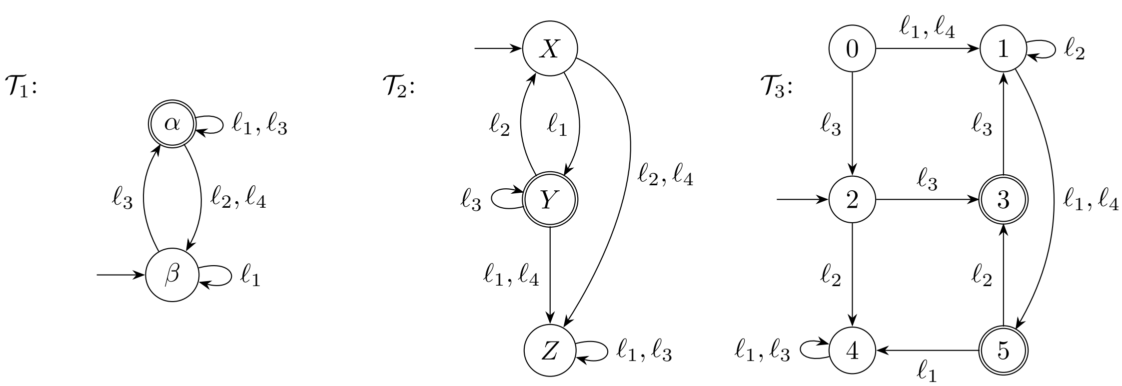
Formally, we can describe this problem as a SAS$^+$planning task $\Pi = \langle V, I, O, \gamma \rangle$ with

- $V = \{t, p_B, p_R\}$ where $dom(t) = \{W, R, B\}$ and $dom(p_B) = dom(p_R) = \{W, R, B, T\}$;
- $I = \{t \mapsto W, p_B \mapsto R, p_R \mapsto B\}$;
- $O = \{move_{o,d} \mid o, d \in \{W, R, B\}, o \neq d\} \cup \{load_{p,l} \mid p \in \{p_B, p_R\}, l \in \{W, R, B\}\} \cup \{unload_{p,l} \mid p \in \{p_B, p_R\}, l \in \{W, R, B\}\}$ where
  - $move_{o,d} = \langle t = o, t := d, 1 \rangle$,
  - $load_{p,l} = \langle t = l \land p = l, p := T, 1 \rangle$, and
  - $unload_{p,l} = \langle t = l \land p = T, p := l, 1 \rangle$; and
- $\gamma = p_B = B \land p_R = R$.

Visualize the factored transition system induced by the atomic projections of Π. Make sure to indicate initial states, goal states, and transition labels in all factors.

Exercise 8.2 (1+0.5+1+0.5+1+1 marks)

Consider the factored transition system $F = \{\mathcal{T}_1, \mathcal{T}_2, \mathcal{T}_3\}$ with label set $L = \{\ell_1, \ell_2, \ell_3, \ell_4\}$ and cost function $c(\ell_1) = 1$ and $c(\ell_2) = c(\ell_3) = c(\ell_4) = 2$. The transition systems look as follows:



(a) Graphically provide the synchronized product $\mathcal{T}_1 \otimes \mathcal{T}_2$.

(b) Which states of $\mathcal{T}_3$ are alive?

(c) We discussed the f-preserving shrinking strategy in the lecture. Now consider instead h-preserving shrinking which groups together all states with the same goal distance. Apply h-preserving shrinking to $\mathcal{T}_3$ and provide the resulting transition system $\mathcal{T}_3'$.

(d) Assume $\mathcal{T}_3$ is the product of two factors of a previous merge step. The following table represents this merge:

	$s_2 = 0$	$s_2 = 1$	$s_2 = 2$
$s_1 = 0$	0	1	3
$s_1 = 1$	2	4	5

Provide the linked list representation after applying h-preserving shrinking as done in part (c).

(e) For all transition systems $\mathcal{T} \in F$, enumerate all pairs $\ell, \ell' \in L$ such that ℓ locally subsumes ℓ' in $\mathcal{T}$.

(f) Based on your results for the previous part: Is there an exact label reduction for F? If yes, provide the functions λ and c'. If no, explain why not.

Exercise 8.3 (1+1+1 marks)

Let X and X' be collections of transition systems. Why is $h(s) = h^*_{\mathcal{T}_{X'}}(\sigma(s))$ not necessarily an admissible heuristic for $\mathcal{T}_X$ if the transformation from X to X' is not conservative? Discuss the question for each of the following reasons why a transformation with functions σ and λ may not be conservative:

(a) $c'(\lambda(\ell)) > c(\ell)$ for at least one $\ell \in L$.

(b) There is a transition $\langle s, \ell, t \rangle$ of $\mathcal{T}_X$ such that $\langle \sigma(s), \lambda(\ell), \sigma(t) \rangle$ is not a transition of $\mathcal{T}_{X'}$.

(c) There is a goal state s of $\mathcal{T}_X$ such that $\sigma(s)$ is not a goal state of $\mathcal{T}_{X'}$.

Hint: Try to come up with a counterexample for each case.

Submission rules:

- Exercise sheets must be submitted in groups of 2–3 students. Create a team on ADAM including all members of your group and submit a single copy of the exercises per group.
- 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 text file(s) 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 text file(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.