Erratum: Transitive Separation Logic

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Definition 5.4 (p. 8):

- In item 1. add: As an additional case we also consider $\square$ to be a linked structure.
- In item 2. the first two sentences should read as follows:
 a is a *forest* if a is acyclic and has maximal in-degree 1 except possibly for $\square$ nodes. Algebraically this is expressed by the dual of the formula for determinacy, namely $\forall p : |a'| \langle a' | p \leq p$, where $a' =_{df} a \cdot \neg\square$.

Definition 5.7 (p. 9) should read as follows:

For identifier i , selector name l and expression e we set

$i.l := e =_{df} \{ ((s, a), (s, (s(i) \mapsto \llbracket e \rrbracket_{(s,a)})) | a_l) : s(i) \neq \square, s(i) \leq \lceil a \rceil \}$,
where the update $| a_l$ leaves all a_k with $k \neq l$ unchanged.

Definition 6.1 (p. 9): The definition of *links* can be discarded.

Definition 6.4 (p. 9) should read as follows:

For trees a_1, a_2 we define *directed combinability* by

$$a_1 \triangleright a_2 \Leftrightarrow_{df} \lceil a_1 \cdot \overline{a_2} \rceil = 0 \wedge a_1^\top \cdot a_2^\top \leq \square \wedge a_1^\top \cdot \lceil a_2 \rceil = \text{root}(a_2) .$$

Lemma 6.5 (p. 10) should read as follows:

If a is a tree then $\square \triangleright a \Leftrightarrow \text{FALSE}$ and $a \triangleright \square \Leftrightarrow \square \leq \overline{a}$.

Lemma 6.6 (p. 10) should read as follows:

For trees a_1 and a_2 , assume $a_1 \triangleright a_2$. Then $\text{terms}(a_1 + a_2) = (\text{terms}(a_1) - \text{root}(a_2)) + \text{terms}(a_2)$ and $\text{root}(a_1 + a_2) = \text{root}(a_1)$.

In the proof of Lemma 6.6, the part concerning the formula for root should read as follows:

For root we first observe that $a_1 \neq \square$ by Lemma 6.5. Next, we calculate, symmetrically, $\text{root}(a_1 + a_2) = \lceil a_1 \cdot \neg a_1 \rceil \cdot \neg a_2 \rceil + \lceil a_2 \cdot \neg a_1 \rceil \cdot \neg a_2 \rceil$.

The first summand reduces to $\lceil a_1 \cdot \neg a_1 \rceil = \text{root}(a_1)$, since $a_1 \triangleright a_2$ implies $\lceil a_1 \cdot a_2 \rceil = 0$, i.e., $\lceil a_1 \rceil \leq \neg a_2 \rceil$. The second summand is, by definition, equal to $\text{root}(a_2) \cdot \neg a_1 \rceil$. Since $a_1 \triangleright a_2$ implies $\text{root}(a_2) \leq a_1 \rceil$, this summand reduces to 0.

Page 11 The definitions of `list` and `l_cell` should read as follows:

$$\begin{aligned} \text{list} &=_{df} \{a : a \text{ is a chain} \}, \\ \text{l_cell} &=_{df} \{a : a \text{ is a cell} \}. \end{aligned}$$

Page 11 In the proof of Lemma 7.4 the third and fourth paragraphs should read as follows:

Finally, we prove $a_2 \rceil \cdot \lceil a_3 = \text{root}(a_3)$ and hence $a_2 + a_3 \in P_2 \oplus P_3$. First, one can show that for deterministic a and arbitrary b one has $a \triangleright b \Rightarrow \text{root}(b) = \text{terms}(a)$. Set now $r_i =_{df} \text{root}(a_i)$. By $a_{12} \triangleright a_3$ we have $r_3 = a_{12} \rceil \cdot \lceil a_3 = (a_1 \rceil + a_2 \rceil) \cdot \lceil a_3 = a_1 \rceil \cdot \lceil a_3 + a_2 \rceil \cdot \lceil a_3$. Since r_3 is atomic and $a_1 \rceil \cdot a_2 \rceil = 0$ by $a_1 \triangleright a_2$, it follows that $r_3 = a_1 \rceil \cdot \lceil a_3$ or $r_3 = a_2 \rceil \cdot \lceil a_3$. Assume $r_3 = a_1 \rceil \cdot \lceil a_3$. Then $\text{terms}(a_1) = r_3$ in contradiction to $\text{terms}(a_1) = r_2$ by $a_1 \triangleright a_2$ and $\lceil a_2 \cdot \lceil a_3 = 0$. Hence we must have $r_3 = a_2 \rceil \cdot \lceil a_3$.

Moreover, $\text{terms}(a_1) = \text{root}(a_2) = \text{root}(a_1 + a_2)$ also follows from Lemma 6.6 and therefore $a \in P_1 \oplus (P_2 \oplus P_3)$. The reverse inclusion is proved analogously.

Page 11 Lemma 7.5 needs to be discarded.

Page 11 In the proof of Lemma 7.5, after the first paragraph add:

An analogous calculation shows that $a_1 + a_2$ has maximal in-degree 1.

Lemma 7.9 (p. 12) In line 4 k needs to be replaced by j .

In the proof of Lemma 7.9 the third and fourth paragraphs should read as follows:

Further, we know $\text{root}(a_1), \text{root}(a_3) \neq 0$ by definition. Assume $a_3 \neq \square$, thus $\text{root}(a_3) \leq \lceil a$ and $\text{root}(a_3) \neq \square$. Then $a_1 \oplus a_3 \Rightarrow \text{root}(a_1) \cdot \text{root}(a_3) = 0$, Lemma 6.2 and assumptions imply $(\text{root}(a_1) \mapsto \text{root}(a_3)) \rceil \cdot \lceil a_3 = \text{root}(a_3)$. Moreover, $\lceil (\text{root}(a_1) \mapsto \text{root}(a_3)) \rceil \cdot \lceil a_3 = \text{root}(a_1) \cdot \lceil a_3 \leq \lceil a_1 \cdot \lceil a_3 = 0$ and $(\text{root}(a_1) \mapsto \text{root}(a_3)) \rceil \cdot a_3 \rceil = \text{root}(a_3) \cdot a_3 \rceil \leq 0$. Finally, by Lemma 7.3 we have $(\text{root}(a_1) \mapsto \text{root}(a_3)) + a_3 \in \text{l_context}(p) \oplus R(q)$.

It remains to show $(\text{root}(a_1) \mapsto \text{root}(a_3)) \oplus a_2$ and $a_3 \oplus a_2$. The latter follows from commutativity of $\oplus$ while the former resolves to $\text{root}(a_1) \cdot \lceil a_2 = 0$ and $\text{root}(a_3) \cdot \lceil a_2 = 0$ by Lemma 6.2. Hence, $\text{root}(a_1) \cdot \lceil a_2 = 0$ by $a_1 \triangleright a_2$. Similarly, $\text{root}(a_3) \cdot \lceil a_2 \leq 0$ by assumptions.

Page 14 In line 11 the trees in question should read T_l, T_k, T_r . The correctness proof should read as follows:

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{ right_tree_context(i)  $\oplus$  (left_tree_context(i.right)  $\oplus$  tree(i.right.left))  $\wedge$ 
   $i^{\leftrightarrow} = \langle T_l, p, \langle T_k, q, T_r \rangle \rangle$  }
j := i.right;
{ right_tree_context(i)  $\oplus$  (left_tree_context(j)  $\oplus$  tree(j.left)  $\wedge$ 
   $i^{\leftrightarrow} = \langle T_l, p, \langle T_k, q, T_r \rangle \rangle \wedge j^{\leftrightarrow} = \langle T_k, q, T_r \rangle$  }
i.right :=  $\square$ ,
{ right_tree_context(i)  $\otimes$  (left_tree_context(j)  $\oplus$  tree(j.left)  $\wedge$ 
   $i^{\leftrightarrow} = \langle T_l, p, \langle \rangle \rangle \wedge j^{\leftrightarrow} = \langle T_k, q, T_r \rangle$  }
k := j.left;
{ right_tree_context(i)  $\otimes$  (left_tree_context(j)  $\oplus$  tree(k))  $\wedge$ 
   $i^{\leftrightarrow} = \langle T_l, p, \langle \rangle \rangle \wedge j^{\leftrightarrow} = \langle T_k, q, T_r \rangle \wedge k^{\leftrightarrow} = T_k$  }
j.left :=  $\square$ ;
{ right_tree_context(i)  $\otimes$  left_tree_context(j)  $\otimes$  tree(k)  $\wedge$ 
   $i^{\leftrightarrow} = \langle T_l, p, \langle \rangle \rangle \wedge j^{\leftrightarrow} = \langle \langle \rangle, q, T_r \rangle \wedge k^{\leftrightarrow} = T_k$  }
j.left := i;
{ (left_tree_context(j)  $\oplus$  right_tree_context(i))  $\otimes$  tree(k)  $\wedge$ 
   $i^{\leftrightarrow} = \langle T_l, p, \langle \rangle \rangle \wedge j^{\leftrightarrow} = \langle \langle T_l, p, \langle \rangle \rangle, q, T_r \rangle \wedge k^{\leftrightarrow} = T_k$  }
i.right := k;
{ left_tree_context(j)  $\oplus$  (right_tree_context(i)  $\oplus$  tree(k))  $\wedge$ 
   $j^{\leftrightarrow} = \langle \langle T_l, p, T_k \rangle, q, T_r \rangle \wedge i^{\leftrightarrow} = \langle T_l, p, T_k \rangle \wedge k^{\leftrightarrow} = T_k$  }

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The optimised program should read as follows:

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{  $i^{\leftrightarrow} = \langle T_l, p, \langle T_k, q, T_r \rangle \rangle$  }
j := i.right;
i.right := j.left;
j.left := i;
{  $j^{\leftrightarrow} = \langle \langle T_l, p, T_k \rangle, q, T_r \rangle$  }

```