Corrections and Commentary for

The Space and Motion of Communicating Agents

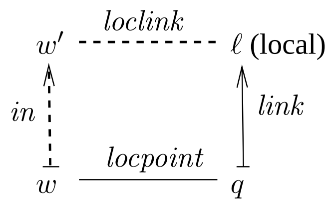
(Cambridge University Press, March 2009)

Corrections updated **24 October 2009** Commentary updated **October 2009**

Corrections

In each correction, everything except the textual changes is printed in this slanted font. Short changes are often defined by ‘ $\mapsto$ ’, which means ‘to be changed to’.

1. *Page xvi, line -1* I am convinced $\mapsto$ I believe
2. *Page 179, line 14* *remove the dangling* $\sim_{\mathrm{r}}$.
3. *Page 92, line 4* $R\bullet d \ \mapsto\ (R \otimes \mathsf{id}_Y) \circ d$ $R'\bullet\overline{\eta}(d) \ \mapsto\ (R' \otimes \mathsf{id}_Y) \circ \overline{\eta}(d)$
4. *Page 33, lines 5–6* *under* §*3.2 move the sentence* ‘If $X = \cdots\cdots \otimes /x_n$’ *to before the box* □*, forming a third short paragraph under ‘***Notation***’.*
5. *Page 134, line 4* *replace the bulleted text and the diagram by the following:*
   - Whenever a link ℓ is local then (i) all its points are local, and (see diagram) (ii) each location of any point of ℓ lies within a location of ℓ. □



6. *Page 175* *replace Solution 11.7 by the following (see also Correction 5):*

11.7 It is easy to prove that the identities satisfy the scoping discipline, that tensor product preserves it, and that composition preserves condition (i) of the discipline. It remains to show that composition also preserves condition (ii).

Let $F : I \to J$ and $G : J \to K$ satisfy the scope discipline, and define $H : I \to K \stackrel{\text{def}}{=} G \circ F$. Let X, Y, Z be the names in I, J, K respectively.

Let $(w, q) \in \mathit{locpoint}_H$, where $\mathit{link}_H(q)$ is local. We must find w' such that $w\ \mathit{in}_H\ w'$ and $(w', \mathit{link}_H(q)) \in \mathit{loclink}_H$. Since $\mathit{link}_H(q)$ is local it cannot be an edge, so there are three cases:

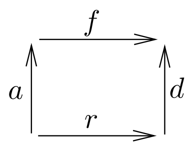
Case 1 $q \in X \uplus P_F$ and $link_H(q) = b \in B_F$. Then also $link_F(q) = b \in B_F$, and by the scope discipline for F we have $w\ in_F\ prnt_F(b)$. Now if $prnt_F(b)$ is a node v of F then also $(v, b) \in loclink_H$, so taking $w' = v$ yields what is required. Otherwise $prnt_F(b)$ is a site s of J, and taking $w' = prnt_H(b) = prnt_G(s)$ yields what is required.

Case 2 $q \in X \uplus P_F$ and $link_H(q) = \ell \in B_G \uplus Z$. Then $\ell = link_G(y)$ for some $y \in Y$, which is local by the scope discipline for G, and $y = link_F(q)$. By the scope discipline for F there must be a site s of J with $w\ in_F\ s$ and $(s, y) \in loc_J$. By the scope discipline for G again, there then exists w' with $s\ in_G\ w'$ and $(w', \ell) \in loclink_G$; but then $w\ in_H\ w'$ with $(w', \ell) \in loclink_H$, and we are done.

Case 3 $q \in P_G$ and $link_H(q) \in B_G \uplus Z$. In this case the scope discipline for G immediately yields what is required.

7. *Page 79* *replace Definition 7.10 by the following:*[1]

   Definition 7.10 (full transition system) The *full transition system* FT has all ground arrows as agents, and all arrows as labels. A label f applies to an agent a iff it is a context for a, and the transitions $a \xrightarrow{f} a'$ are all triples such that, for some reaction rule $(r, r') \in \grave{\mathcal{R}}$ and some active context d for r and r', the following diagram commutes and $a' \simeq d \circ r'$.



□

8. *Page 81, lines 6,7 in Definition 7.13* active $d : I \to J \ \mapsto$ active d
   $i \in \mathsf{width}(I) \ \mapsto \ i \in m$

9. *Page xix, Fig. 0.1* *correct four of the chapter titles:*
   2. Defining bigraphs 4. Relative and minimal bounds
   7. Reactions and transitions 12. Background, development and related work

10. *Page 18, line 10* $prnt_i \ \mapsto \ link_i$

11. *after Definition 7.2, line 1* $d \circ r \ \mapsto \ c \circ r$

12. *Page 76, lines -4,-3 twice* $\mathbf{C} \mapsto \grave{\mathbf{C}}$

13. *Page 79, line 11* a bigraphical context $\mapsto$ a context

14. *Page 89, line 4* at $i \in m \ \mapsto \ i \in m$

[1] A wrong mention of 'bigraph' is removed, and only FT is defined (rather than a more general notion of 'full', which the book does not need). Thanks to Vashti Galpin for this and several following corrections.

15. *Page 99, line 5* $\mathbf{C} \longmapsto$ BG$(\Sigma,\mathcal{R})$

16. *Page 118, lines -13,-12* $\underline{\text{PE}}_{\mathsf{m}}$ is faithful to $\underline{\text{PE}}$ $\longmapsto$ $\underline{\text{PE}}_{\mathsf{m}}$ is faithful to PE_{m}
PE_{m} is faithful to PE $\longmapsto$ $\underline{\text{PE}}$ is faithful to PE

Commentary

These comments are in response to discussion among people interested in bigraphs, including those advancing their theory and those putting them into practice. Sometimes a comment explains one of the corrections.

1 Scope discipline for bound names

Definition 11.19 mistakenly formulates a scope discipline for binding bigraphs that only works for a previous treatment of local names, in which each name in an interface has at most a single location. The correct discipline for multiply located names is formulated in Correction 5. This error was due to the author's confusion in a final stage of editing.

The more generous treatment of binding allows a name to have many locations. It is technically just as simple as the discipline for singly-located names, but allows a much wider range of application. It is a conservative extension of the previous discipline, because the two disciplines actually coincide for singly-located names.

[March 2009]

2 Names in reaction rules

Let (R, R', η) be a parametric reaction rule, defined in Definition 8.5. In Correction 3, the form of a ground redex generated by this rule is changed from $R.d$ to $(R \otimes \mathsf{id}_Y) \circ d$; thus the names of a parameter $d{:}\langle m, Y\rangle$ are made distinct from the outer names of R. This new form is used later in the book. It imposes no practical constraint, since the context D of a reaction can always equate names of R with names in d by invoking a substitution.

Definition 8.5 also requires a parametric redex to take the form $R : m \to J$, implying that it may have no inner names. This is not a necessary constraint. It should be seen in connection with Definition 8.12, which defines a *simple* redex to be one in which (among other things) every link is open. Later results are mostly about BRSs whose parametric redexes are simple.

The connection is that, whenever the inner names of R are all open, i.e. linked to an outer name, then there is another rule (S, S', η) with no inner names that yields exactly the same reactions. Thus the constraint 'no inner names' affects reaction only when some rule has a closed inner name. It is a nice exercise to prove this.

Now, suppose R has closed inner names X. In binding bigraphs they may even be bound. It is natural for each $x \in X$ to bind several points in a parameter d; thus we cannot expect every parameter d to be discrete. But it is natural to generalise the notion of discreteness; we say that $d{:}\langle m, X \uplus Y\rangle$ is *discrete for* Y if every link Y contains exactly one point. It is then easy to prove that, in generating the reactions from R, it is enough to consider only parameters $d{:}\langle m, X \uplus Y\rangle$ that are discrete for Y.

These comments should help in applications where it is natural for a redex to have closed inner names. Although the theory of *nice* BRSs in the book cannot be directly applied, a modified version can be applied. For example, Jensen [7] has successfully treated the π-calculus, whose redex indeed binds names in parameters.

[June 2009]

3 Sortings

The sortings of Chapter 6 are of two kinds: place-sorting and link-sorting. It was clear to the author that a more general notion should be sought, subsuming both. If it should consist of some decioration and constraint upon bigraphs and their interfaces, then it was not clear what form this enrichment should take.

However Birkedal, Debois and Hildebrandt [2] have proposed an elegant definition that allows the domain F of a sorting functor $\mathcal{F} : F \to \text{BG}(\Sigma)$ to be any spm category; they simply require that the functor be surjective on interfaces and faithful(= injective for each homset). Further conditions on $\mathcal{F}$ can be imposed, to ensure that the relevant theory (such as the existence of relative pushouts) of BG(Σ) can be lifted to F. Debois, in his PhD dissertation [5], explores such further conditions in detail.

The importance of this approach is to admit further models, to which the theory of bigraphs can be lifted by a sorting functors. One such model is binding bigraphs; see Comment 4.

[June 2009]

4 Binding bigraphs

Section 11.3 introduces binding bigraphs, which employ the concept of locality of names. In an interface, a name may be *local* (located at one or more sites) or *non-local* (located nowhere). The approach in Section 11.3 is to define a *binding* as a new entity, a hybrid between as place and a link. It is pointed out that this generalises the original approach to binding in bigraphs by Jensen and Milner [6], where a name could be located in at most one place. This was sufficient for Jensen in his dissertation [7] to embed the π-calculus faithfully in bigraphs.

It now appears that, if we denote by BBG(Σ) the category of these enriched bigraphs, there is indeed a functor $\mathcal{F} : \text{BBG}(\Sigma) \to \text{BG}(\Sigma)$, with the nice properties required for the theory of binding bigraphs. (The functor represents each binding by an atomic control with arity 1.) Thus binding bigraphs fit easily as a sorting functor in the sense of Debois [5]; see Comment 3.

[June 2009]

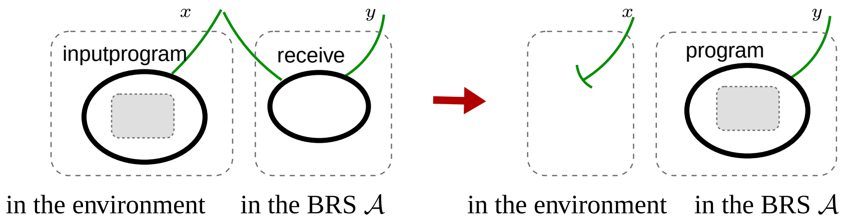
5 Interacting with a BRS

The book gives no standard way for a system modelled as a BRS $\mathcal{A}$ to interact externally, i.e. with its environment (including humans).

If this environment is already modelled as a BRS, then the interaction can be achieved by reaction rules that use controls shared between the signatures of the two

BRSs. This idea has been explored by Birkedal *et al* [1] in connection with context-aware systems. Even if the environment is not modelled as a BRS, such a shared reaction rule can be understood as describing what transactions may occur between it and the BRS $\mathcal{A}$.

For example, $\mathcal{A}$ might share with its fellow systems the control 'switchon' with an activator that switches on a light, or 'temperature' in order to record a reading from a sensor, or 'inputprogram' to receive a program as input. In the last case, this shared signature allows the BRS to contain a reaction rule such as the following:



The right hand region is within $\mathcal{A}$, and the left-hand one would be in the external agent–human or artifact–if it were modelled by a bigraph. If not, such rules can be understood as describing informally how to interact with $\mathcal{A}$.

A third possibility is that the descriptions may be formal, but represented in a logic rather than bigraphically. Such a logic may be one specially attuned to bigraphs, just as logics exist attuned to known process calculi. Work has already been done towards such a logic, by Vladi Sassone *et al* [3, 4]. It may not only describe hypothetical contributions by an environment, but also may formulate desired properties of the subsequent behaviour of $\mathcal{A}$ itself. A natural goal is that such properties may be verified (or falsified) by model-checking.

[July 2009]

References

[1] Birkedal, L., Debois, S., Elsborg, E., Hildebrandt, T. and Niss, H. (2006), Bigraphical models of context-aware systems. In: *Proc. 9th International Conference on Foundations of Software Science and Computation Structure*, Lecture Notes in Computer Science 3921, pp187–201.

[2] Birkedal, L., Debois, S. and Hildebrandt, T. (2008), On the construction of sorted reactive systems. In: *Proc. 19th International Conference on Concurrency Theory (CONCUR)*, Lecture Notes in Computer Science 5201, pp218–232.

[3] Conforti, G., Macedonio, D. and Sassone, V. (2005), Spatial logics for bigraphs. In: *International Conference on Automata, Languages and Programming*, Lecture Notes in Computer Science 3580, Springer-Verlag, pp766–778.

[4] Conforti, G., Macedonio, D. and Sassone, V. (2007), Static BiLog: a unifying langauage for spatial structures. Fundamatica Informaticae 80, pp91-110.

[5] Debois, S. (2008), Sortings & Bigraphs. PhD Dissertation, Programming, Logic and Semantics group, IT University of Copenhagen.

[6] Jensen, O.H. and Milner, R. (2004), Bigraphs and mobile processes (revised). Technical Report UCAM-CL-TR-580, University of Cambridge Computer Laboratory.

[7] O-H Jensen (2006), *Mobile Processes in Bigraphs*. Monograph available at `http://www.cl.cam.ac.uk/~rm135/Jensen-monograph.html`.