Strong Bisimilarity on Nets Revisited
(Extended Abstract)

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Abstract

In [Old89b], Olderog proposed a new notion of bisimulation between Petri nets. His proposal considers bisimulations between places of nets rather than between markings. Unfortunately, his definition leads to several problems that have not been noticed. It turns out that the situation is more complicated than in classical bisimulation theory over transition systems.

We propose a new definition which solves the problems and which is much more general. We investigate the consequences of the new definition: many results of classical bisimulation theory can be recovered modulo some adaptation. This indicates that our definition is "correct" and productive.

1 Introduction

Bisimulation, introduced in [Par81], is a fundamental concept in the theory of concurrency (see [BK89] for a review). Informally, two systems are bisimilar if their possible behaviors have the same branching structure, i.e. any behavior of one system can be reproduced by the other system, in a way that preserves the places where the non-deterministic choices have been made.

Classical bisimulation theory deals with transition systems (non-deterministic automata where transitions are labeled by actions.) It is possible to adapt the basic notion to systems with a richer structure, e.g. (Petri) nets. A simple way to do this is to view a net as a transition system, by considering the graph of its global states [Pom85, vGV87]. But this does not take the richer structure into account. Several recent proposals (e.g. [Pom85, vGV87, RT88, BDKP90, Dev90]) took (part of) the structure of nets into account and defined bisimulations between markings (the global states) that preserve (part of) the structure of transition sequences.

Recently, Olderog proposed a new notion of bisimulation between nets [Old89b, Old89a]. He considered bisimulations between places of nets rather than between markings. The relation is then lifted from places to markings. One advantage is that a relation between places is easier to visualize (it can easily be drawn on the graphical representation of a net) and to understand.
This new semantic equivalence preserves more information. Bisimilar markings must be consistent at the lower structural level of the net: e.g. they must carry the same number of tokens. This yields a stronger and richer equivalence. It really is a new concept in the semantics of nets and fully deserves further exploration.

Unfortunately, the definition in [Old89b] leads to several subtle problems that have not been noticed (as far as we know). The most striking one is that it does not give an equivalence relation! In fact, the situation is more complicated than it appears at first sight and the whole subject is rather treacherous.

In this paper, we propose a new definition that starts from Olderog's seminal idea of a bisimulation between places of nets. This new definition solves the problems of the previous one, and is more general. We compare its discriminating power with classical bisimulations on nets.

In order to gain some confidence that it is a "correct definition", we consider a few properties, inspired from the classical case, that any bisimulation should satisfy. Specifically, these requirements for a bisimulation are:

1. a bisimulation must be an equivalence relation,
2. there should exist largest bisimulations,
3. there should exist canonical representatives of equivalence classes of bisimilar nets,
4. nets having isomorphic unfoldings into acyclic nets should be bisimilar.

As an example, [Old89b] proves that his definition of bisimulation identifies isomorphic nets and preserves concurrent computations. These are subsumed by point 4 in our list. Nevertheless, the definition in [Old89b] fails on all four points.

In this paper, we prove that the first three properties of our list are indeed satisfied (possibly with some adaptation) by our definition. Section 5 explains why unfolding is not consistent with the idea of bisimulation between places. These results give a somewhat deeper understanding of the new notion and we show precisely where and when some restrictive hypothesis is required. Furthermore, useless restrictions can cripple a theory: for example we show (see Remark 2 in section 7 and developments in [ABS91]) that it is unwise to restrict oneself to safe nets.

The paper is organized as follows: We recall the general theoretical background in section 2. Then section 3 presents Olderog's seminal idea and our proposal, before we discuss Olderog's original definition in section 4. Then section 5 gives several examples aiming at explaining our definition. We investigate largest bisimulations in section 6 and canonical representatives in section 7. Section 8 mentions a few variants of our definition and explains why we discarded them. We conclude in section 9 by assessing the potential applications of the theory, and by listing several research directions that should be investigated in future work.

Some easy proofs have been omitted and some long proofs have been sketched. As a rule, complete proofs appear in the full version of this paper [ABS91].

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1We did not include congruence properties as this paper is not concerned with compositions of nets.