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On the Unification of Process Semantics: Equational Semantics

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Abstract

The complexity of parallel systems has produced a large collection of semantics for processes, a classification of which is provided by Van Glabbeek's linear time-branching time spectrum; however, no suitable unified definitions were available. We have discovered the way to unify them, both in an observational framework and by means of a quite small set of parameterized (in)equations that provide a sound and complete axiomatization of the preorders that define them. In more detail, we have proved that we only need a generic simulation axiom (*NS*), which defines the family of constrained simulation semantics, thus covering the class of branching time semantics, and a generic axiom (*ND*) for reducing the non-determinism of processes, by means of which we introduce the additional identifications induced by each of the linear time semantics.

Keywords: processes, linear time-branching time spectrum, equational semantics, uniform presentation.

1 Introduction

In order to study the behavior of concurrent processes, many different semantics have been proposed. Most of them are defined starting from the interleaving model, where the essence of concurrent computation collapses into that of non-deterministic processes, modeled by means of labeled transition systems. Most of the popular semantics in that category appear in Van Glabbeek's linear time-branching time spectrum [13]. They were introduced by different authors, using different semantic frameworks; see Figure 1.

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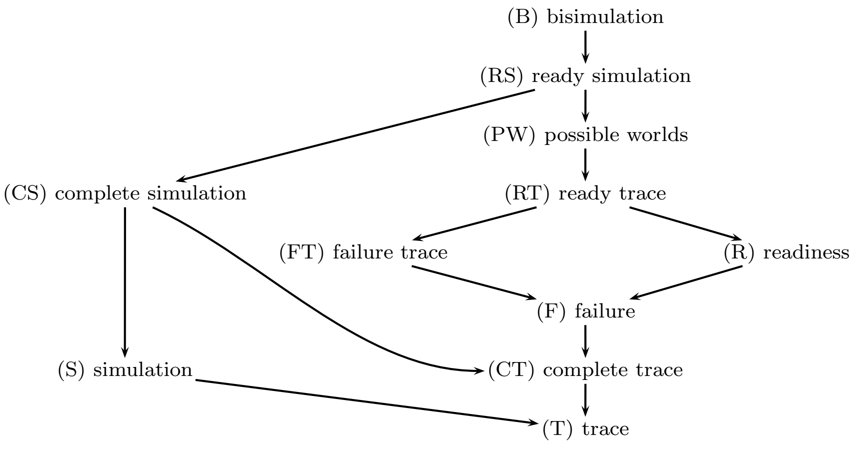

Fig. 1. Semantics in the linear time-branching time spectrum.

In his paper, Van Glabbeek aims for a uniform presentation of all these semantics by using three different approaches (the observational or testing framework, the logical one, and the algebraic characterization of the semantics) which provide sufficiently general frameworks to present them. Once in a uniform setting, it is much easier to compare the discriminating power of the different semantics, as is done in the lattice representation of the spectrum. All of these frameworks can be used to characterize not only the equivalences induced by the semantics but also the corresponding natural preorders, that in the logical presentation correspond to the "satisfy more formulas than" relation.

Even under a common framework, the semantics in the spectrum appear to be haphazardly defined and distributed in it. In this paper we aim to show that this is not the case: every process semantics can be understood as the combination of two "design decisions" that define what we have called the *dynamic* and the *static* behavior of processes.

By means of our unification we expect to cover the following three main goals:

- a new presentation of the spectrum of the process semantics justifying the special interest of some of these semantics and clarifying the relations among them;
- a uniform presentation of the semantics that allows to prove results simultaneously for all of them;
- finally, we complete the picture with some "lost" semantics which, either were proposed by other authors after the publication of Van Glabbeek's spectrum, or are introduced for the first time in this paper (as far as we know).

Our unification process has its roots in our coinductive characterizations [3,5] of the semantics in the spectrum by means of (bi)simulations up-to, that characterize both the equivalences and the preorders that define them. In particular, the dynamic component is closely related with simulations. In [6] we were able to unify the definitions of different simulation semantics, by means of *constrained* simulations, and to describe a generic axiom that characterizes all of them.

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