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A Hierarchy of SOS Rule Formats

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Abstract

In 1981 Structural Operational Semantics (SOS) was introduced as a systematic way to define operational semantics of programming languages by a set of rules of a certain shape [62]. Subsequently, the format of SOS rules became the object of study. Using so-called Transition System Specifications (TSS's) several authors syntactically restricted the format of rules and showed several useful properties about the semantics induced by any TSS adhering to the format. This has resulted in a line of research proposing several syntactical rule formats and associated meta-theorems. Properties that are guaranteed by such rule formats range from well-definedness of the operational semantics and compositionality of behavioral equivalences to security- and probability-related issues. In this paper, we provide an initial hierarchy of SOS rules formats and meta-theorems formulated around them.

Keywords: Formal Semantics, Structural Operational Semantics, Rule Formats, Framework.

1 Introduction

Structural Operational Semantics has become the common way to define operational semantics. Operational semantics defines the possible *transitions* that a piece of syntax can make during its "execution". Each transition may be *labelled* by a message to be communicated to the outside world. Transitions of a composed piece of syntax can usually be defined in a generic way, in terms of the transitions of its constituting parts. This forms the central idea behind Structural Operational Semantics (SOS).

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Transition System Specifications (TSS's), as introduced by Groote and Vaandrager in [36], are a formalization of SOS. By imposing syntactic restrictions on TSS's one can deduce several interesting properties about their induced operational semantics. These properties range from well-definedness of the operational semantics [35,15,32] to security- [70,71] and probability-related issues [10,41]. The syntactic restrictions imposed by these meta-theorems usually suggest particular forms of deduction rules to be safe for a particular purpose and hence these meta-theorems usually define what is called a *rule format*.

The excellent overview [3] provides existing rule formats to its date of publication (2001). Since then, even more formats have been proposed and we felt that in order to keep track, this field of formats requires some structure. Therefore, we attempt to present an overview of all SOS rule formats defined in the literature, together with the meta-theorems formulated around them. All the results are put in a lattice to easily locate the most suited format for a certain application. To do this, we define the concept of a TSS, in a far more general setting than [36], including the concepts of multi-sorted signatures and variable binding, inspired by the definition of [24]. This general definition of TSS serves as a unifying framework and paves the way for studying semantic meta-theorems for SOS and comparing their underlying frameworks.

The rest of this paper is organized as follows. In Section 2 the hierarchy of formats is given. In Section 3, we list different syntactic features that an SOS rules can have. In Section 4, we review semantic meta-theorems about different SOS frameworks.

Disclaimer. This paper is a step towards a complete survey. This means that although most formats and results are mentioned in the remainder of this paper, some rule formats and meta-result can still be missing. We will be very thankful if notified of such omissions.

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2 A hierarchy of operational formats

Since the first formats have been defined for TSS rules, many have been added. In order to keep track of them we made an overview of the existing rule formats in Figure 1. The lattice presented there has SOS frameworks as nodes, ordered by syntactic inclusion (mainly based on the syntactic features). The most general format can be found at the top and more specific formats at lower positions. The arrows indicate syntactical inclusion. The one inclusion that is not syntactic but possibly require some translation of syntactic constructs