Main Concepts of Networks of Transformation Units with Interlinking Semantics*

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Abstract. The aim of this paper is to introduce a modelling concept and structuring principle for rule-based systems the semantics of which is not restricted to a sequential behavior, but can be applied to various types of parallelism and concurrency. The central syntactic notion is that of a transformation unit that encapsulates a set of rules, imports other transformation units, and regulates the use and interaction of both by means of a control condition. The semantics is given by interlinking the applications of rules with the semantics of the imported units using a given collection of semantic operations. As the main result, the interlinking semantics turns out to be the least fixed point of the interlinking operator. The interlinking semantics generalizes the earlier introduced interleaving semantics of rule-based transformation units, which is obtained by the sequential composition of binary relations as only semantic operation.

1 Introduction

In this paper, we introduce networks of transformation units with interlinking semantics as a modelling concept and structuring principle for rule-based systems the semantics of which may be non-sequential. The key concept is a transformation unit encapsulating a set of local rules and importing other transformation units. Moreover, each transformation unit has a control condition that regulates

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the application of the local rules and the interaction with the imported components. If a set of transformation units is closed under import, its import structure forms a network. In this way, large sets of rules can be organized and structured in such a way that each local unit may contain only a small set of rules while the effects of other units can be used by importing them.

In [4–7] transformation units have been introduced for graphs as well as for more general configurations as underlying data structures and provided with a purely sequential semantics. It is obtained by interleaving rule applications and the semantics of the imported components in such a way that the control condition is obeyed. In this paper, we generalize the framework of transformation units such that also non-sequential systems can be specified. For this purpose, we replace the underlying domain of binary relations on configurations by a domain of more general semantic entities and the sequential composition of binary relations by a set of arbitrary operations on semantic entities. But to be able to use set-theoretic operations and their properties, we assume that the domain of semantic entities is the power set of a set of semantics items.

The operations on semantic entities may be chosen as sequential, parallel or concurrent compositions or as any other operations one wants to use to model the type of semantics one is interested in. We show that the new framework covers nicely elementary net systems with their non-sequential processes as well as rule-based systems with sequential and parallel derivations, covering Chomsky grammars and various types of graph grammars in particular. This means that not only these approaches can be seen in a unified framework, but are also provided with a common structuring principle as a novel feature.

The paper is organized in the following way. In the next section, the basic notions and notations of transformation units with interlinking semantics are introduced. Networks of transformation units and their iterated interlinking semantics are studied in Section 3. Finally, the main result of this paper is formulated in Section 4. It states that the iterated interlinking semantics is the least fixed point of the interlinking operator if the used semantic operations and the control conditions are continuous. As running examples, we discuss elementary net systems and binary relations as semantic entities of grammatical systems of various kinds. Because of lack of space, the proofs are omitted.

2 Transformation Units with Interlinking Semantics

In this section, we introduce the notion of transformation units with interlinking semantics, which generalizes the formerly defined interleaving semantics.

The basis is the notion of a semantic domain (2.1) consisting of a set of semantic items together with operations on semantic entities being sets of semantic items. Typical semantic items are derivations, computations, and processes; typical operations are sequential and parallel compositions of derivations, computations, and processes or their embedding into larger context. To be able to deal with semantic entities, a semantic domain is first equipped with rules yielding a rule base (2.2) where a rule is some abstract syntactic feature that specifies