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Encoding Bigraphical Reactive Systems into Graph Transformation Systems

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Abstract

In this paper, we present a solution for executing bigraphical reactive systems based on an investigation on graph transformation systems. For this, we encode a bigraph into a ranked graph. This encoding is ensured, formally, by defining a faithful functor that allows to move from bigraph category to ranked graph category. Then, we show that reaction rules can be simulated with graph rules.

Keywords: Bigraphs, BRS, Graphs, Matching.

1 Introduction

The theory of Bigraphical Reactive Systems (BRSs) has been developed by Milner [5] as a formalism for describing and analyzing mobile computation and pervasive systems. A BRS is a graphical model in which bigraphs can be reconfigured using reaction rules. It is very important to have an implementation of the dynamic of a BRS to enable experimentations. The main challenge of this implementation is the matching problem. In fact, it is a computational task that determines for a given bigraph B and a reaction rule R whether and how the reaction rule can be applied to rewrite the bigraph B.

The theory of BRS is closely related to graph transformation system (GTS) [3,2]. Considering the exhaustiveness of studies on graph transformations, it is natural to ask whether we could apply graph matching algorithms on Bigraphs. As an alternative to implementing matching for bigraphs, we could try to formalize BRSs as GTSs. By this way, we can benefit from existing

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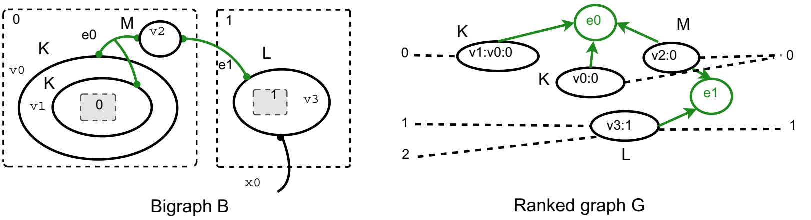

Fig. 1. Encoding a bigraph into a ranked graph

tools and techniques developed for graph transformations. Consequentially, we have initiated an investigation of how to simulate a BRS with a GTS.

In this paper, we propose a formal basis allowing such simulation. Indeed, we encode a bigraph into a graph by defining a function named F_{sim} that allows to move from bigraph category to graph category. We demonstrate that F_{sim} is a well defined and faithful functor. Then, we rely on the work of Ehrig [1] to show that reaction rules can be simulated with graph rules. As a result, we ensure the validity of simulating a BRS by a GTS.

2 Encoding a Bigraph into a Ranked Graph

In order to understand our contribution, the reader should understand bigraphs [5] and ranked graphs [4].

The main difference between bigraphs and graphs lies in the nesting and the linking structure of bigraphs. Hence, we define the nesting structure of bigraphs through the node identifiers of graphs. For instance, in Fig. 1, v_0 is nested in 0 (the parent of v_0 is 0). Its image in the graph G is a node having the identifier $v_0 : 0$. So, we encode the parent of a node through its identifier.

Furthermore, the linking structure of bigraphs is represented in graphs by defining two types of nodes: *place nodes* that represent bigraph places, and *link nodes* that represent bigraph hyperedges. For example, the hyperedge e_1 in the bigraph of Fig. 1, connecting v_2 and v_3, is represented in the graph with the green node e_1 to which are connected $v_2 : 0$ and $v_3 : 1$.

Categorically, bigraphs and their morphisms form a category $\mathcal{BG}$ which has as objects inner and outer interfaces, and as arrows bigraphs. Similar to bigraphs, ranked graphs are presented as morphisms between two interfaces i and j, forming a category denoted $\mathcal{DG}$.

Our main objective is to ensure the validity of encoding bigraphs into ranked graphs, preserving their structure. We shall achieve this by defining a functor [5] which allows to move from one category to another.

Hence, we define a functor, named $F_{sim} : \mathcal{BG} \to \mathcal{DG}$, which allows to move from $\mathcal{BG}$ to $\mathcal{DG}$. This functor associates to each morphism (Bigraph) $B : I \to J$ from $\mathcal{BG}$, a morphism (Graph) $G : i \to j$ from $\mathcal{DG}$.