Chapter 2. Cooperating Distributed Grammar Systems

Deterministic Cooperating Distributed Grammar Systems

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Abstract. Subclasses of grammar systems that can facilitate parser construction appear to be of interest. In this paper, some syntactical conditions considered for strict deterministic grammars are extended to cooperating distributed grammar systems, restricted to the terminal derivation mode. Two variants are considered according to the level to which the conditions address. The local variant, which introduces strict deterministic restrictions for each component of the system apart, results in local unambiguity of the derivations. The total variant, which extends the strict deterministic constraints at the level of the entire system, results in some cases in global unambiguity of the derivations.

1. Introduction

Cooperating distributed (CD, for short) grammar systems have been introduced in [3]. A similar generating device was considered in [11], while a particular variant of it appears in [1]. Most of the results known in this area until the middle of 1992 can be found in [4], while newer results are surveyed in [7].

However, there are still lots of classical topics in formal languages theory or in related areas which have not been studied so far in the grammar systems set-up. Constructing parsers is such a topic, which is not only of theoretical interest, but it will make grammar systems more appealing to researchers in applied computer science as well, since it will open the possibility of using grammar systems in domains where just Chomsky-like grammars are currently used (for instance, in natural language processing, or in compiler construction). This will clearly bring to the user all the advantages of having a model which can cope with such phenomena as cooperation and distribution of the work carried out by several processors.

Of interest to this aim are the results of [2] and [6]. Thus, [2] approaches CD grammar systems from the accepting point of view, comparing their accepting capacity to their own generating capacity, or to that of other classes of grammars in the regulated rewriting area. [6] considers pushdown automata systems, with the scope of

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characterizing the languages generated by grammar systems in terms of recognizers; but their model turns out to be much more powerful from the point of view of the recognized languages class.

We believe that a more involved study of the derivations in a CD grammar system would be very useful to a possible parser constructor for the languages generated by grammar systems. This is the aim of the present paper: we address subclasses of CD grammar systems which can facilitate a parser construction, due to some unambiguity properties of the derivations in such systems.

More precisely, the present paper studies the effect on CD grammar systems of syntactical constraints similar to those considered for strict deterministic context-free grammars. It is known that the family of languages generated by strict deterministic context-free grammars is the same as the family of languages generated by \( LR(0) \) grammars (see Theorem 11.5.5 in [8] and Theorem 10.12 in [9]), which are ones of the most useful class of grammars for parsing. Therefore, our intention was to see what happens if the conditions for strict deterministic grammars are extended to CD grammar systems. To our surprise, we obtained that the unambiguity of the derivations holds for some classes of grammar systems as well.

When introducing the restrictions for strict determinism in CD grammar systems, two variants should be taken into consideration, depending on the level, local/global, to which the restrictions address. In the local level case, the generative capacity of the systems remains the same, but the behaviour of each component is unambiguous. The generative power decreases when global level is considered, whereas for some more restrictive classes the derivation is totally unambiguous.

2. Definitions and Examples

We assume the reader accustomed to the basic facts in formal language theory [9]. For details concerning the grammar systems we refer to [4].

For an alphabet \( V \), we denote by \( V^* \) the set of all words over \( V \) and by \( \lambda \) the empty word; moreover, \( V^+ = V^* - \{\lambda\} \), while \( |V| \) stands for the cardinality of \( V \). For a string \( x \), denote by \( |x| \) the length of \( x \) and by \( \text{Pref}_k(x) \) the prefix of length \( k \) of \( x \), \( |x| \geq k \).

If \( \pi \) is a partition of \( V \), then we write \( a \sim^\pi b \) iff there exists \( M \in \pi \) such that \( \{a, b\} \subseteq M \).

A cooperating distributed grammar system is a construct

\[ \Gamma = (N, T, S, P_1, P_2, \ldots, P_n), \]

where \( N, T \) are disjoint alphabets, \( S \in N \), and \( P_i, 1 \leq i \leq n \), are finite sets of context-free rules over \( N \cup T \).

The sets \( P_i \) are called the components of \( \Gamma \). (If we want to point out grammars as components, then we can consider grammars without axioms, of the form \( G_i = (N, T, P_i), 1 \leq i \leq n. \))

For a component \( P_i \) of a grammar system \( \Gamma \) as above, we denote \( \text{dom}(P_i) = \{A \in N \mid A \rightarrow x \in P_i\} \), and \( T_i = (N \cup T) - \text{dom}(P_i) \).

Let \( \Gamma = (N, T, S, P_1, P_2, \ldots, P_n) \) be a CD grammar system as above and let \( \pi_i \) be a partition of \( N \cup T \), for any \( 1 \leq i \leq n \). The partition \( \pi_i \) is a local strict partition if