

# Grammars with Context Conditions and Their Applications

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*Talk Duration:* 50 minutes.

*Abstract:* In the classical formal language theory, we can divide grammatical productions into context-dependent and context-independent productions, and based on this division, we can naturally distinct context-dependent grammars, such as phrase-structure grammars, from context-independent grammars, such as context-free grammars. Making a derivation step according to context-dependent productions depends on rather strict conditions satisfied by the context surrounding the rewritten symbol while making a step according to context-independent productions does not, so from this point of view, we obviously always prefer using context-independent grammars to the others. Unfortunately, compared to context-dependent grammars, context-independent grammars are significantly less powerful; in fact, most of them are incapable to grasp some aspects of quite common programming languages. On the other hand, most context-dependent grammars are equivalent to the Turing machines, and this remarkable power represents their indisputable advantage. These pros and cons inspired the modern language theory to introducing some new grammars that simultaneously satisfy these properties—(1) they are based on context-independent productions, (2) their context conditions are significantly simpler than the strict conditions of classical context-dependent productions, and (3) they are as powerful as classical context-dependent grammars.

In the present talk, we overview the most essential types of these grammars, whose alternative context conditions can be classical into these three categories—(A) context conditions placed on derivation domains, (B) context conditions placed on the use of productions, (C) context conditions placed on the neighborhood of the rewritten symbols. As already pointed out, we want the context conditions as small as possible. Therefore, we concentrate the investigation on the reduction of context conditions. Specifically, it reduces the number of some of their components, such as nonterminals or productions. It studies how to achieve this reduction without any decrease in this generative power, which coincides with the power of the Turing machines. By achieving this reduction, it actually makes the partially parallel rewriting more succinct and economical, and this economization is obviously highly appreciated both from a practical and theoretical standpoint. Regarding each of the discussed grammars, we introduce and study their parallel and sequential versions, which represent two basic approaches to grammatical rewriting in today's formal language theory. That is, during a sequential derivation step, a grammar rewrites a single symbol in the current sentential form while during a parallel derivation step, a grammar rewrites all symbols. As context-free and EOL grammars represent perhaps the most fundamental sequential and parallel grammars, respectively, we usually base the discussion of sequential and parallel rewriting upon them.

In the conclusion of this talk, we illustrate the applications of grammars with context conditions by several biologically oriented examples.

The talk is based upon the author's latest book [Handbook of Mathematical Models for Languages and Computation](#) (written along with his PhD students Petr Horáček and Martin Tomko), The Institution of Engineering and Technology, 2020.

*Keywords:* formal grammars; context conditions; basic properties; language families; reduction; simplification; descriptive complexity; applications; perspectives.

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