

How Can We Define Languages in Computer Science?

Several scientific methods have been developed to precisely define the syntactic rules of languages.

Backus-Naur Form (BNF):

A **meta-language** used to describe the syntax of languages.

<name>	meta-symbol
::=	definition
	alternative
{expression}	repetition (minimum and maximum repetitions can be specified using subscripts)
GOTO	terminal symbol (in quotes for clarity, can also use apostrophes instead)

1. Example: Syntax of License Plates

Let's start with a few typical examples and try to generalize:

ABC-1234, GHT-234, HSD-333, AI-BB-654

Syntax definition: $\$ \$ \langle \text{license_plate} \rangle ::= \langle \text{newType} \rangle \mid \langle \text{oldType} \rangle \ \backslash \backslash \langle \text{oldType} \rangle ::= \{ \langle \text{letter} \rangle \}_3^3 - \{ \langle \text{number} \rangle \}_3^3 \ \backslash \backslash \langle \text{newType} \rangle ::= \{ \langle \text{letter} \rangle \}_2^2 - \{ \langle \text{letter} \rangle \}_2^2 - \{ \langle \text{number} \rangle \}_3^3 \ \backslash \backslash \langle \text{letter} \rangle ::= A|B|C\dots|Z \ \backslash \backslash \langle \text{number} \rangle ::= 0|1|2|3|4|5|6|7|8|9 \ \backslash \backslash \$ \$$

2. Example: Syntax of Phone Calls in Hungary

Let's list a few examples and try to generalize:

062012345, +36301234567, 0680460046

Syntax definition: $\$ \$ \langle \text{phone call} \rangle ::= \{ \langle \text{prefix} \rangle \}_0^1 \langle \text{city} \rangle \langle \text{customer} \rangle \ \backslash \backslash \langle \text{prefix} \rangle ::= \{ + \}_0^1 36|06 \ \backslash \backslash \langle \text{city} \rangle ::= \{ \langle \text{number} \rangle \}_1^2 \ \backslash \backslash \langle \text{customer} \rangle ::= \{ \langle \text{number} \rangle \}_6^7 \ \backslash \backslash \langle \text{number} \rangle ::= 0|1|2|3|4|5|6|7|8|9 \ \backslash \backslash \$ \$$

Here is the translation using MathJax syntax:

3. Example**: How can we describe the BNF formula using itself?

$\langle \text{BN formula} \rangle ::= \langle \text{rule} \rangle \ \backslash \backslash \langle \text{rule} \rangle ::= \langle \text{identifier} \rangle \ \backslash \backslash \langle \text{expression} \rangle \ \backslash \backslash \langle \text{identifier} \rangle ::= \langle \text{letter} \rangle \ \backslash \backslash \langle \text{letter} \rangle \ \backslash \backslash \langle \text{digit} \rangle \ \backslash \backslash \langle \text{expression} \rangle ::= \langle \text{term} \rangle \ \backslash \backslash \langle \text{term} \rangle \ \backslash \backslash \langle \text{term} \rangle ::= \langle \text{factor} \rangle \ \backslash \backslash \langle \text{factor} \rangle \ \backslash \backslash \langle \text{factor} \rangle ::= \langle \text{identifier} \rangle \ \backslash \backslash \langle \text{terminal_symbol} \rangle \ \backslash \backslash \langle \text{terminal_symbol} \rangle ::= \langle \text{character} \rangle$

$$\begin{aligned} \text{letter} & ::= \text{uppercase} \mid \text{lowercase} \\ \text{uppercase} & ::= A \mid B \mid C \mid \dots \mid Z \\ \text{lowercase} & ::= a \mid b \mid c \mid \dots \mid z \\ \text{digit} & ::= 0 \mid 1 \mid 2 \mid 3 \mid 4 \mid 5 \mid 6 \mid 7 \mid 8 \mid 9 \end{aligned}$$

This format uses MathJax for a more formal representation of the BNF description in a mathematical context.

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