# Lecture 11 - Oct. 20

## Syntactic Analysis

***CFG: Formulation***
***From RE or DFA to CFG***
***Ambiguity, Dangling else***

## Announcements

- **Programming Test**
  - + 2:00pm to 3:20pm on Saturday, October 29
  - + Venue to be confirmed (LAS building)
- **Project** teammates (gather at the end of the class)

# CFG: Formal Definition

Design the CFG for strings of properly-nested parentheses.

e.g., `()`, `() ()`, `( ( () () ) ) ()`, *etc.*

Present your answer in a formal manner.

$S \to (S) \mid SS \mid \varepsilon$

A ***context-free grammar (CFG)*** is a 4-tuple $(V, \Sigma, R, S)$:

- $V$ is a finite set of **variables**/non-terminals
- $\Sigma$ is a finite set of ***terminals***.
- $R$ is a finite set of ***rules*** s.t.

$$R \subseteq \{v \to s \mid v \in V \wedge s \in (V \cup \Sigma)^*\}$$

- $S \in V$ is is the **start variable**.

Rules.

$S \to (S)$ $\quad$ mix of t. and n.t.

$S \to SS$ $\quad$ variables

Given strings $u, v, w \in (V \cup \Sigma)^*$, variable $A \in V$, a rule $A \to w$:

- $uAv \Rightarrow uwv$ menas that $uAv$ ***yields*** $uwv$.
- $u \overset{*}{\Rightarrow} v$ means that $u$ ***derives*** $v$, if:
  - $u = v$; or
  - $u \Rightarrow u_1 \Rightarrow u_2 \Rightarrow \cdots \Rightarrow u_k \Rightarrow v$ [ a ***yield sequence*** ]

Given a CFG $G = (V, \Sigma, R, S)$, the language of $G$

$$L(G) = \{w \in \Sigma^* \mid S \overset{*}{\Rightarrow} w\}$$

no non-terminals.

# Context-Free Grammar (CFG): Example Version 3

| | | |
|---|---|---|
| Expr | → | Expr + Term |
| | \| | Term |
| Term | → | Term * Factor |
| | \| | Factor |
| Factor | → | ( Expr ) |
| | \| | a |

**Example**: a * a + a

↳ Exercise: draw PT.

different precedences.

Expr → [Expr] + Term

↓

Term

↓

Term * Factor → higher precedence

# Context-Free Grammar (CFG): from RE (1)

| RE | CFG |
| --- | --- |
| $L(\epsilon)$ | $S \to \varepsilon$ |
| $L(a)$ $a \in \Sigma$ | $S \to a$ |
| $L(E+F)$ | $S \to cfg(E) \mid cfg(F)$ |
| $L(EF)$ | $S \to cfg(E)\, cfg(F)$ |
| $L(E^*)$ | $S \to \varepsilon \mid S\, cfg(E)$ |
| $L((E))$ | $S \to (\, cfg(E)\,)$ |

# Context-Free Grammar (CFG): from RE (2)

$(0 + 1)^* 1 (0+1)$ — T U V

$S \to TUV$

$T \to \varepsilon \mid T T_2$

$T_2 \to 0 \mid 1$

$U \to 1$

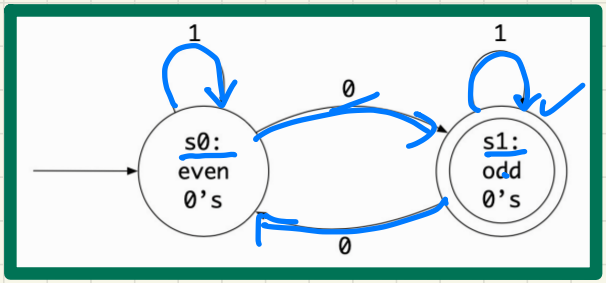
$V \to 0 \mid 1$

CNF ↳ Chomsky Normal Form

$(00 + 1)^* + (11 + 0)^*$

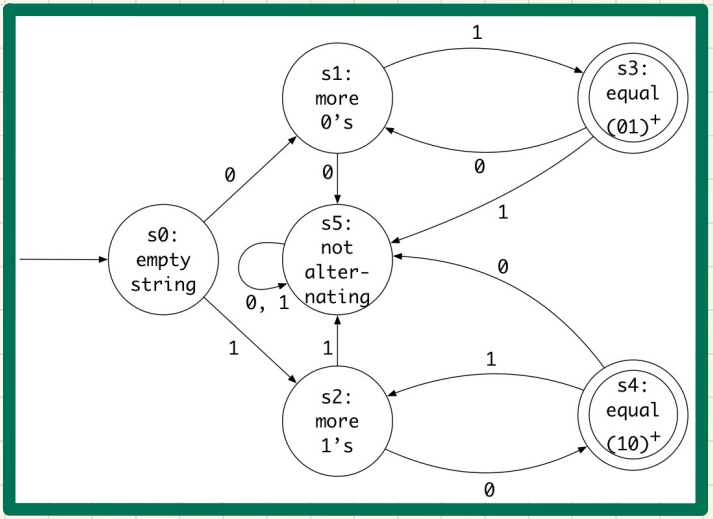
Exercise.

# Context-Free Grammar (CFG): from DFA




$S_0 \to 0S_1 \mid 1S_0$

$S_1 \to \varepsilon \mid 1S_1 \mid 0S_0$




Exercise.