Conversões entre gramáticas e autômatos finitos

- Se $G = (V, \Sigma, P, S)$ é uma gramática regular, então o NFA $N = \langle \Sigma, Q, q_0, \delta, F \rangle$, definido como segue, é tal que $\mathcal{L}(N) = \mathcal{L}(G)$:

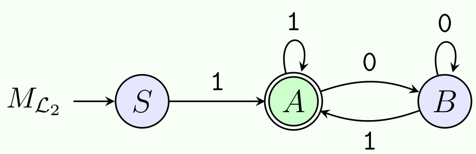
$$
\begin{aligned}
Q &= \begin{cases} V \cup \{Z\}, & \text{se } (A \to a) \in P, \text{ onde } Z \notin V; \\ V, & \text{caso contrário;} \end{cases} \\
q_0 &= S; \\
\delta(A, a) &= B, \text{ sempre que } A \to aB \in P; \\
\delta(A, a) &= Z, \text{ sempre que } A \to a \in P; \\
F &= \begin{cases} \{A \mid A \to \varepsilon \in P\} \cup \{Z\}, & \text{se } Z \in Q; \\ \{A \mid A \to \varepsilon \in P\}, & \text{caso contrário.} \end{cases}
\end{aligned}
$$

- Se $N = \langle \Sigma, Q, q_0, \delta, F \rangle$ é um NFA, então a gramática $G = (V, \Sigma, P, S) = (Q, \Sigma, \{q_i \to aq_j \mid \delta(q_i, a) = q_j\} \cup \{q_i \to \varepsilon \mid q_i \in F\}, q_0)$ é tal que $\mathcal{L}(G) = \mathcal{L}(N)$.

$\mathcal{L}_1 = \{w \in \Sigma^* = \{0,1\}^* \mid |w|_{01} > 0$ ou $|w|_{10} > 0\}$

$\mathcal{L}_2 = \{w \in \Sigma^* = \{0,1\}^* \mid w$ representa um número binário ímpar (sem zeros à esquerda)$\}$

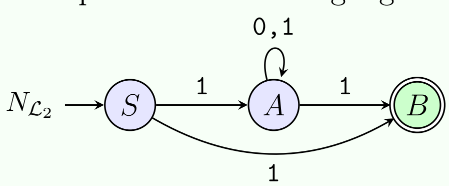
- DFA mínimo que reconhece as cadeias de $\mathcal{L}_2$



- Gramática G_1 que gera as cadeias de $\mathcal{L}_2$:

$$
G_1 = (V, \Sigma, P, S) = (\{A, B, S\}, \{0, 1\}, P, S), \text{ com:}
$$
$$
P = \left\{ \begin{array}{l} S \to 1A, \\ A \to 0B \mid 1A \mid \varepsilon, \\ B \to 0B \mid 1A \end{array} \right\}.
$$

- NFA que reconhece a linguagem $\mathcal{L}_2$:



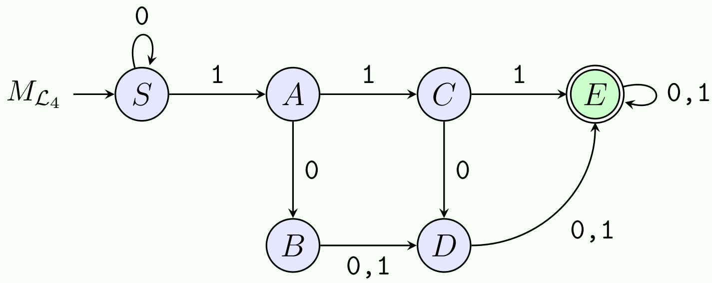
- Gramática G_2 que gera as cadeias de $\mathcal{L}_2$:

$$
G_2 = (V, \Sigma, P, S) = (\{A, B, S\}, \{0, 1\}, P, S), \text{ com:}
$$
$$
P = \left\{ \begin{array}{l} S \to 1A \mid 1B, \\ A \to 0A \mid 1A \mid 1B, \\ B \to \varepsilon \end{array} \right\}.
$$

$\mathcal{L}_3 = \{w \in \Sigma^* = \{0,1\}^* \mid w$ representa um número binário e $w \pmod 3 = 1\}$

$\mathcal{L}_4 = \{w \in \Sigma^* = \{0,1\}^* \mid w$ representa um número binário e $w \geqslant 7\}$

- DFA mínimo que reconhece as cadeias de $\mathcal{L}_4$

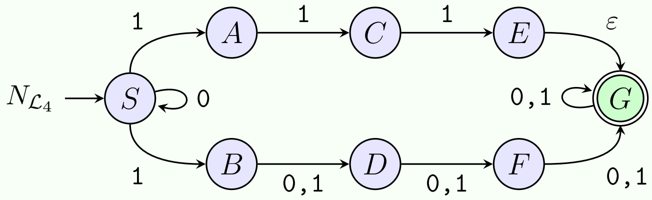


- Gramática G_1 que gera as cadeias de $\mathcal{L}_4$:

$$G_1 = (V, \Sigma, P, S) = (\{A, B, C, D, E, S\}, \{0,1\}, P, S), \text{ com:}$$

$$P = \left\{ \begin{array}{l|l} S \to 0S \mid 1A, & C \to 0D \mid 1E, \\ A \to 0B \mid 1C, & D \to 0E \mid 1E, \\ B \to 0D \mid 1D, & E \to 0E \mid 1E \mid \varepsilon \end{array} \right\}.$$

- NFA que reconhece a linguagem $\mathcal{L}_4$:



- Gramática G_2 que gera as cadeias de $\mathcal{L}_4$:

$$G_2 = (V, \Sigma, P, S) = (\{A, B, C, D, E, F, G, S\}, \{0,1\}, P, S), \text{ com:}$$

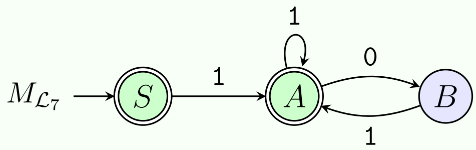
$$P = \left\{ \begin{array}{l|l|l} S \to 0S \mid 1A \mid 1B, & C \to 1E, & F \to 0G \mid 1G, \\ A \to 1C, & D \to 0F \mid 1F, & G \to 0G \mid 1G \mid \varepsilon \\ B \to 0D \mid 1D, & E \to G, & \end{array} \right\}.$$

$\mathcal{L}_5 = \{w \in \Sigma^* = \{0,1\}^* \mid w$ contém 001 ou 110$\}$

$\mathcal{L}_6 = \{w \in \Sigma^* = \{0,1\}^* \mid w$ não contém 001 ou não contém 110$\}$

$\mathcal{L}_7 = \{w \in \Sigma^* = \{0,1\}^* \mid$ todo 0 em w é adjacente à esquerda e à direita a um 1$\}$

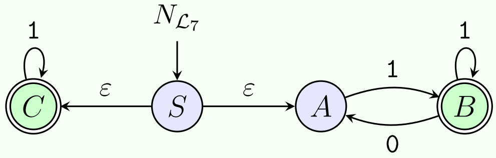
- DFA mínimo que reconhece as cadeias de $\mathcal{L}_7$



- Gramática G_1 que gera as cadeias de $\mathcal{L}_7$:

$$G_1 = (V, \Sigma, P, S) = (\{A, B, S\}, \{0, 1\}, P, S), \text{ com:}$$
$$P = \left\{ \begin{array}{l} S \to 1A \mid \varepsilon, \\ A \to 0B \mid 1A \mid \varepsilon, \\ B \to 1A \end{array} \right\}.$$

- NFA que reconhece a linguagem $\mathcal{L}_7$:



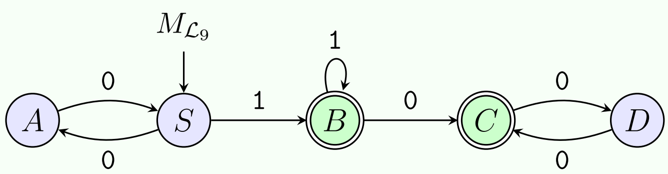
- Gramática G_2 que gera as cadeias de $\mathcal{L}_7$:

$$G_2 = (V, \Sigma, P, S) = (\{A, B, C, S\}, \{0, 1\}, P, S), \text{ com:}$$
$$P = \left\{ \begin{array}{l|l} S \to A \mid C, & B \to 0A \mid 1B \mid \varepsilon \\ A \to 1B, & C \to 1C \mid \varepsilon \end{array} \right\}.$$

$\mathcal{L}_8 = \{w \in \Sigma^* = \{0,1\}^* \mid w$ contém as subcadeias 01 e $10\}$

$\mathcal{L}_9 = \{w \in \Sigma^* = \{0,1\}^* \mid w = xyz,$ com $x \in \{0\}^*, |x| = 2k, y \in \{1\}^+$ e $z \in \{0\}^*, |z| = 0$ ou $|z| = 2k' + 1;\ k, k' \in \mathbb{N}\}$

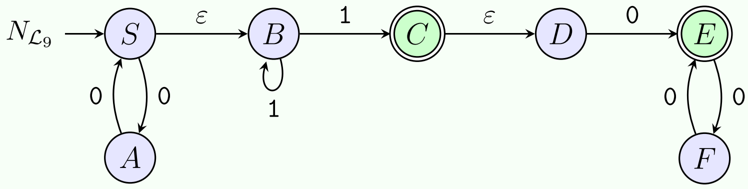
- DFA mínimo que reconhece as cadeias de $\mathcal{L}_9$



- Gramática G_1 que gera as cadeias de $\mathcal{L}_9$:

$$G_1 = (V, \Sigma, P, S) = (\{A, B, C, D, S\}, \{0, 1\}, P, S), \text{ com:}$$
$$P = \left\{ \begin{array}{l|l} S \to 0A \mid 1B, & C \to 0D \mid \varepsilon, \\ A \to 0S, & D \to 0C \\ B \to 0C \mid 1B \mid \varepsilon, & \end{array} \right\}.$$

- NFA que reconhece a linguagem $\mathcal{L}_9$:



- Gramática G_2 que gera as cadeias de $\mathcal{L}_9$:

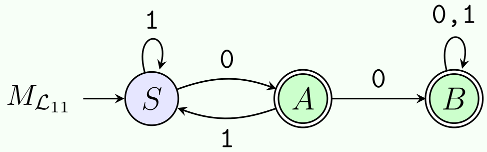
$$G_2 = (V, \Sigma, P, S) = (\{A, B, C, D, S\}, \{0, 1\}, P, S), \text{ com:}$$

$$P = \left\{ \begin{array}{l|l|l} S \to 0A \mid B, & C \to D \mid \varepsilon, & E \to 0F \mid \varepsilon, \\ A \to 0S, & D \to 0E, & F \to 0E \\ B \to 1B \mid 1C, & & \end{array} \right\}.$$

$\mathcal{L}_{10} = \{w \in \Sigma^* = \{0,1\}^* \mid w = x0y0z$ com $|y| = 2k$ ou $w = x1y1z$ com $|y| = 2k' + 1;\ x, y, z \in \Sigma^*;\ k, k' \in \mathbb{N}\}$

$\mathcal{L}_{11} = \{w \in \Sigma^* = \{0,1\}^* \mid$ pelo menos um 0 em w não é seguido de $1\}$

- DFA mínimo que reconhece as cadeias de $\mathcal{L}_{11}$

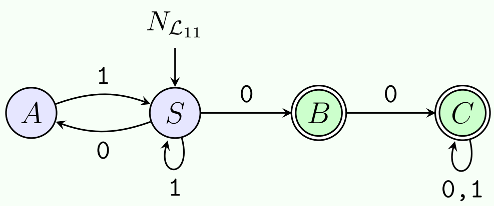


- Gramática G_1 que gera as cadeias de $\mathcal{L}_{11}$:

$$G_1 = (V, \Sigma, P, S) = (\{A, B, S\}, \{0, 1\}, P, S), \text{ com:}$$

$$P = \left\{ \begin{array}{l} S \to 0A \mid 1S, \\ A \to 0B \mid 1S \mid \varepsilon, \\ B \to 0B \mid 1B \mid \varepsilon \end{array} \right\}.$$

- NFA que reconhece a linguagem $\mathcal{L}_{11}$:



- Gramática G_2 que gera as cadeias de $\mathcal{L}_{11}$:

$$G_2 = (V, \Sigma, P, S) = (\{A, B, C, S\}, \{0, 1\}, P, S), \text{ com:}$$

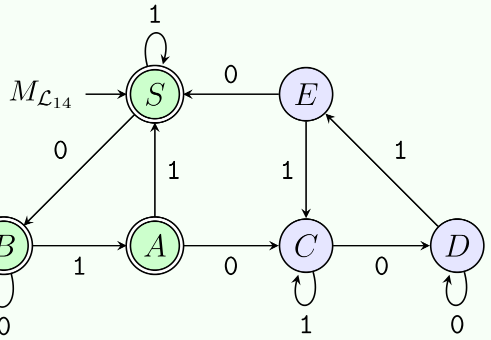
$$P = \left\{ \begin{array}{l|l} S \to 0A \mid 0B \mid 1S, & B \to 0C \mid \varepsilon, \\ A \to 1S, & C \to 0C \mid 1C \mid \varepsilon \end{array} \right\}.$$

$\mathcal{L}_{12} = \{w \in \Sigma^* = \{0,1\}^* \mid w$ não contém 101 e termina com $1\}$

$\mathcal{L}_{13} = \{w \in \Sigma^* = \{0,1\}^* \mid |w| \geqslant 3$ e o terceiro e o penúltimo símbolos de w não são $1\}$

$\mathcal{L}_{14} = \{w \in \Sigma^* = \{0,1\}^* \mid w$ contém uma quantidade par da subcadeia $010\}$

- $\mathcal{ER} = (1 \cup 0^+11)^*(0^+10(1 \cup 0^+11)^*0^+10(1 \cup 0^+11)^*)^*(0^*1^*)$.
- $\mathcal{ER} = (1 \cup 0^+11 \cup 0^+10(1 \cup 0^+11)^*0^+10))^*(\varepsilon \cup 0^+ \cup 0^+1)$.
- DFA mínimo que reconhece as cadeias de $\mathcal{L}_{14}$

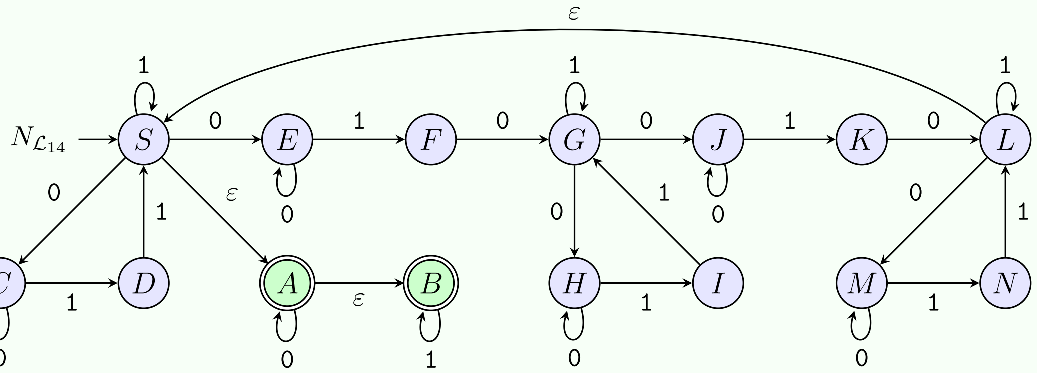


- Gramática G_1 que gera as cadeias de $\mathcal{L}_{14}$:

$$G_1 = (V, \Sigma, P, S) = (\{A, B, C, D, E, S\}, \{0,1\}, P, S), \text{ com:}$$

$$P = \left\{ \begin{array}{ll} S \to 0B \mid 1S \mid \varepsilon, & C \to 0D \mid 1C, \\ A \to 0C \mid 1S \mid \varepsilon, & D \to 0D \mid 1E, \\ B \to 0B \mid 1A \mid \varepsilon, & E \to 0S \mid 1C \end{array} \right\}.$$

- NFA que reconhece a linguagem $\mathcal{L}_{14}$:



- Gramática G_2 que gera as cadeias de $\mathcal{L}_{14}$:

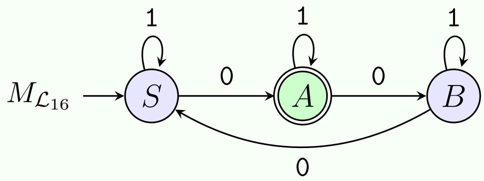
$$G_2 = (V, \Sigma, P, S) = (\{A, B, C, D, E, F, G, H, I, J, K, L, M, N, S\}, \{0,1\}, P, S), \text{ com:}$$

$$P = \left\{ \begin{array}{l|l|l} S \to A \mid 0C \mid 0E \mid 1S, & E \to 0E \mid 1F, & J \to 0J \mid 1K, \\ A \to B \mid 0A \mid \varepsilon, & F \to 0G, & K \to 0L, \\ B \to 1B \mid \varepsilon, & G \to 0H \mid 0J \mid 1G, & L \to S \mid 0M \mid 1L, \\ C \to 0C \mid 1D, & H \to 0H \mid 1I, & M \to 0M \mid 1N, \\ D \to 1S, & I \to 1G, & N \to 1L \end{array} \right\}.$$

$\mathcal{L}_{15} = \{w \in \Sigma^* = \{0,1\}^* \mid w$ contém uma quantidade par da subcadeia $000\}$

$\mathcal{L}_{16} = \{w \in \Sigma^* = \{0,1\}^* \mid |w|_0 \pmod 3 = 1\}$

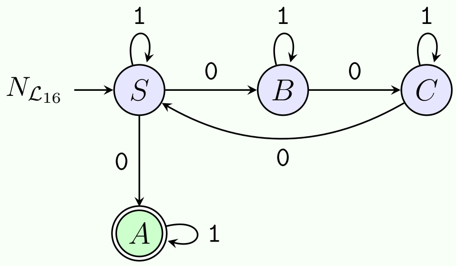
- DFA mínimo que reconhece as cadeias de $\mathcal{L}_{16}$



- Gramática G_1 que gera as cadeias de $\mathcal{L}_{16}$:

$$G_1 = (V, \Sigma, P, S) = (\{A, B, S\}, \{0,1\}, P, S),\ \text{com:}$$
$$P = \left\{ \begin{array}{l} S \to 0A \mid 1S, \\ A \to 0B \mid 1A \mid \varepsilon, \\ B \to 0S \mid 1B \end{array} \right\}.$$

- NFA que reconhece a linguagem $\mathcal{L}_{16}$:



- Gramática G_2 que gera as cadeias de $\mathcal{L}_{16}$:

$$G_2 = (V, \Sigma, P, S) = (\{A, B, C, S\}, \{0,1\}, P, S),\ \text{com:}$$
$$P = \left\{ \begin{array}{l|l} S \to 0A \mid 0B \mid 1S, & B \to 0C \mid 1B \\ A \to 1A \mid \varepsilon, & C \to 0S \mid 1C \end{array} \right\}.$$

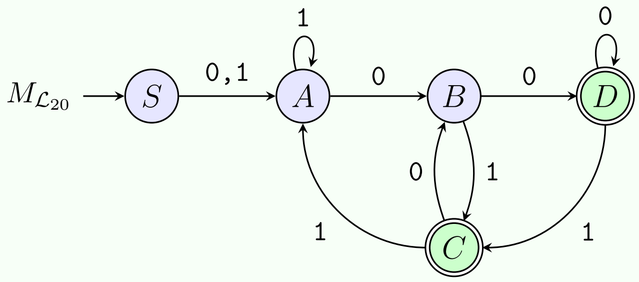
$\mathcal{L}_{17} = \{w \in \Sigma^* = \{0,1\}^* \mid |w|_0 \geqslant 3$ e $|w|_1 \leqslant 2\}$

$\mathcal{L}_{18} = \{w \in \Sigma^* = \{0,1\}^* \mid |w|_0 \geqslant 3$ ou $|w|_1 = 2,$ e w não contém $11\}$

$\mathcal{L}_{19} = \{w \in \Sigma^* = \{0,1\}^* \mid w$ contém exatamente uma ocorrência de 00 ou de $11\}$

$\mathcal{L}_{20} = \{w \in \Sigma^* = \{0,1\}^* \mid |w| \geqslant 3$ e o penúltimo símbolo é $0\}$

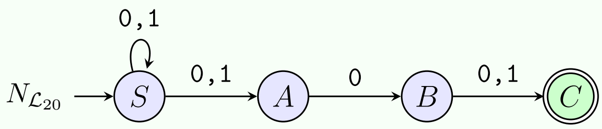
- DFA mínimo que reconhece as cadeias de $\mathcal{L}_{20}$



- Gramática G_1 que gera as cadeias de $\mathcal{L}_{20}$:

$$G_1 = (V, \Sigma, P, S) = (\{A, B, C, D, S\}, \{0, 1\}, P, S), \text{ com:}$$
$$P = \left\{ \begin{array}{l|l} S \to 0A \mid 1A, & C \to 0B \mid 1A \mid \varepsilon, \\ A \to 0B \mid 1A, & D \to 0D \mid 1C \mid \varepsilon \\ B \to 0D \mid 1C, & \end{array} \right\}.$$

- NFA que reconhece a linguagem $\mathcal{L}_{20}$:

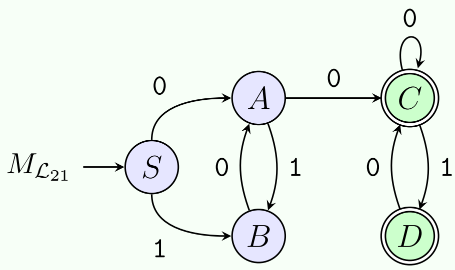


- Gramática G_2 que gera as cadeias de $\mathcal{L}_{20}$:

$$G_2 = (V, \Sigma, P, S) = (\{A, B, C, S\}, \{0, 1\}, P, S), \text{ com:}$$
$$P = \left\{ \begin{array}{l|l} S \to 0A \mid 0S \mid 1A \mid 1S, & B \to 0C \mid 1C, \\ A \to 0B, & C \to \varepsilon \end{array} \right\}.$$

$\mathcal{L}_{21} = \{w \in \Sigma^* = \{0,1\}^* \mid |w|_{00} \geqslant 1 \text{ e } |w|_{11} = 0\}$

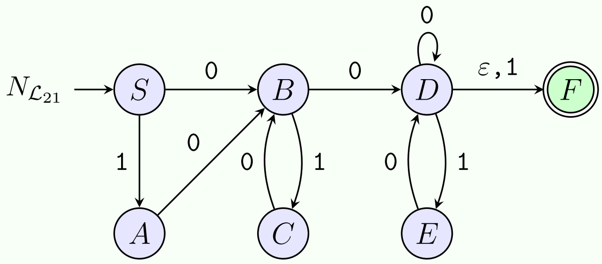
- DFA mínimo que reconhece as cadeias de $\mathcal{L}_{21}$



- Gramática G_1 que gera as cadeias de $\mathcal{L}_{21}$:

$$G_1 = (V, \Sigma, P, S) = (\{A, B, C, D, S\}, \{0, 1\}, P, S), \text{ com:}$$
$$P = \left\{ \begin{array}{l|l} S \to 0A \mid 1B, & C \to 0C \mid 1D \mid \varepsilon, \\ A \to 0C \mid 1B, & D \to 0C \mid \varepsilon \\ B \to 0A, & \end{array} \right\}.$$

- NFA que reconhece a linguagem $\mathcal{L}_{21}$:



- Gramática G_2 que gera as cadeias de $\mathcal{L}_{21}$:

$$G_2 = (V, \Sigma, P, S) = (\{A, B, C, D, E, F, S\}, \{0, 1\}, P, S), \text{ com:}$$

$$P = \left\{ \begin{array}{l|l} S \to 0B \mid 1A, & D \to 0D \mid 1E \mid 1F \mid F, \\ A \to 0B, & E \to 0D, \\ B \to 0D \mid 1C, & F \to \varepsilon \\ C \to 0B, & \end{array} \right\}.$$

$\mathcal{L}_{22} = \{w \in \Sigma^* = \{0,1\}^* \mid |w| \geqslant 2$ e os dois primeiros símbolos de w são iguais aos dois últimos$\}$

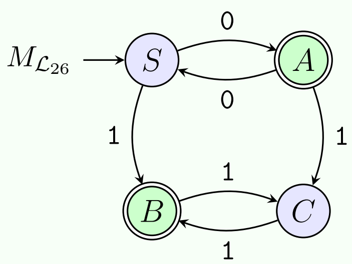
$\mathcal{L}_{23} = \{w \in \Sigma^* = \{0,1\}^* \mid w$ não começa com 10, mas termina com $10\}$

$\mathcal{L}_{24} = \{w \in \Sigma^* = \{0,1\}^* \mid w$ contém pelo menos um 0 e pelo menos dois 1's$\}$

$\mathcal{L}_{25} = \{w \in \Sigma^* = \{0,1\}^* \mid w = 0u$ e $|w|$ é par ou $w = 1u'$ e $|u'|$ é par, com $u, u' \in \Sigma^*\}$

$\mathcal{L}_{26} = \{w \in \Sigma^* = \{0,1\}^* \mid |w|_0 + |w|_1 = 2k + 1,\ k \in \mathbb{N}$ e w não contém $10\}$

- DFA mínimo que reconhece as cadeias de $\mathcal{L}_{26}$

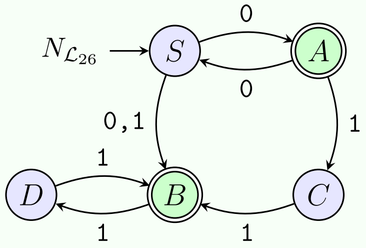


- Gramática G_1 que gera as cadeias de $\mathcal{L}_{26}$:

$$G_1 = (V, \Sigma, P, S) = (\{A, B, C, S\}, \{0, 1\}, P, S), \text{ com:}$$

$$P = \left\{ \begin{array}{l|l} S \to 0A \mid 1B, & B \to 1C \mid \varepsilon, \\ A \to 0S \mid 1C \mid \varepsilon, & C \to 1B \end{array} \right\}.$$

- NFA que reconhece a linguagem $\mathcal{L}_{26}$:

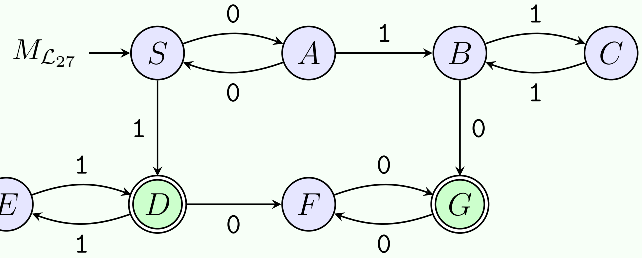


- Gramática G_2 que gera as cadeias de $\mathcal{L}_{26}$:

$$G_2 = (V, \Sigma, P, S) = (\{A, B, C, D\}, \{0, 1\}, P, S),\ \text{com:}$$
$$P = \left\{ \begin{array}{l|l} S \to 0A \mid 0B \mid 1B, & C \to 1B, \\ A \to 0S \mid 1C \mid \varepsilon, & D \to 1B \\ B \to 1D \mid \varepsilon, & \end{array} \right\}.$$

$\mathcal{L}_{27} = \{w \in \Sigma^* = \{0,1\}^* \mid w = xyz,\ x, z \in \{0\}^*,\ y \in \{1\}^+;\ |x|_0 + |z|_0 = 2k,\ |y|_1 = 2k' + 1,\ k, k' \in \mathbb{N}\}$

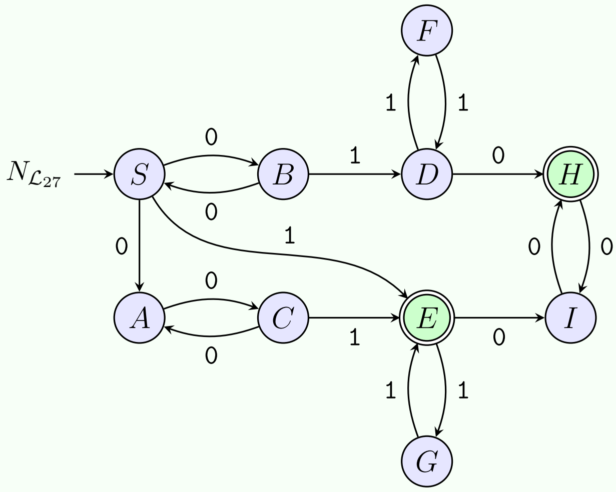
- DFA mínimo que reconhece as cadeias de $\mathcal{L}_{27}$



- Gramática G_1 que gera as cadeias de $\mathcal{L}_{27}$:

$$G_1 = (V, \Sigma, P, S) = (\{A, B, C, D, E, F, G, S\}, \{0, 1\}, P, S),\ \text{com:}$$
$$P = \left\{ \begin{array}{l|l} S \to 0A \mid 1D, & D \to 0F \mid 1E \mid \varepsilon, \\ A \to 0S \mid 1B, & E \to 1D, \\ B \to 0G \mid 1C, & F \to 0G, \\ C \to 1B, & G \to 0F \mid \varepsilon \end{array} \right\}.$$

- NFA que reconhece a linguagem $\mathcal{L}_{27}$:



- Gramática G_2 que gera as cadeias de $\mathcal{L}_{27}$:

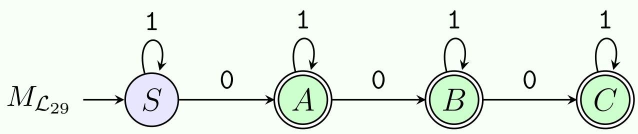
$$G_1 = (V, \Sigma, P, S) = (\{A, B, C, D, E, F, G, H, I, S\}, \{0, 1\}, P, S), \text{ com:}$$

$$P = \left\{ \begin{array}{l|l|l} S \to 0A \mid 0B \mid 1E, & D \to 0H \mid 1F, & H \to 0I \mid \varepsilon \\ A \to 0C, & E \to 0I \mid 1G \mid \varepsilon, & I \to 0H \\ B \to 0S \mid 1D, & F \to 1D, & \\ C \to 0A \mid 1E, & G \to 1E, & \end{array} \right\}.$$

$\mathcal{L}_{28} = \{w \in \Sigma^* = \{0,1\}^* \mid w = xcycz,\ c \in \Sigma,\ x, y, z \in \Sigma^*;\ |x| = 2k+1,\ |z| = 2k',\ k, k' \in \mathbb{N};\ |y| = 2\}$

$\mathcal{L}_{29} = \{w \in \Sigma^* = \{0,1\}^* \mid w$ contém uma, duas ou três ocorrências do símbolo $0\}$

- DFA mínimo que reconhece as cadeias de $\mathcal{L}_{29}$

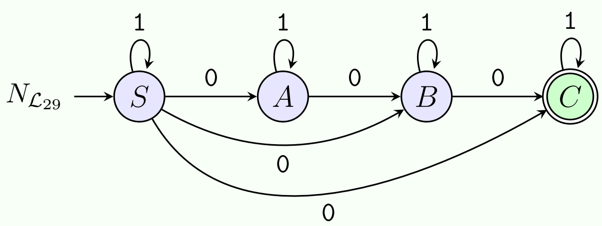


- Gramática G_1 que gera as cadeias de $\mathcal{L}_{29}$:

$$G_1 = (V, \Sigma, P, S) = (\{A, B, C, S\}, \{0, 1\}, P, S), \text{ com:}$$

$$P = \left\{ \begin{array}{l|l} S \to 0A \mid 1S, & B \to 0C \mid 1B \mid \varepsilon, \\ A \to 0B \mid 1A \mid \varepsilon, & C \to 1C \mid \varepsilon \end{array} \right\}.$$

- NFA que reconhece a linguagem $\mathcal{L}_{29}$:



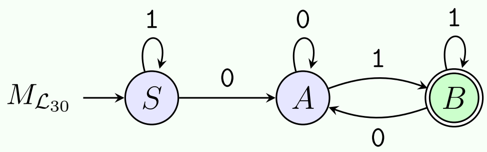
- Gramática G_2 que gera as cadeias de $\mathcal{L}_{29}$:

$$G_2 = (V, \Sigma, P, S) = (\{A, B, C, S\}, \{0, 1\}, P, S), \text{ com:}$$

$$P = \left\{ \begin{array}{l|l} S \to 0A \mid 0B \mid 0C \mid 1S, & B \to 0C \mid 1B, \\ A \to 0B \mid 1A, & C \to 1C \mid \varepsilon \end{array} \right\}.$$

$\mathcal{L}_{30} = \{w \in \Sigma^* = \{0, 1\}^* \mid w = u01^n,\ u \in \Sigma^*,\ n \in \mathbb{N}^+\}$

- DFA mínimo que reconhece as cadeias de $\mathcal{L}_{30}$

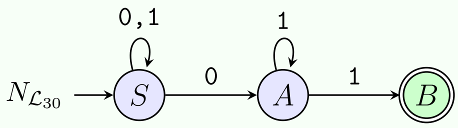


- Gramática G_1 que gera as cadeias de $\mathcal{L}_{30}$:

$$G_1 = (V, \Sigma, P, S) = (\{A, B, S\}, \{0, 1\}, P, S), \text{ com:}$$

$$P = \left\{ \begin{array}{l} S \to 0A \mid 1S, \\ A \to 0A \mid 1B, \\ B \to 0A \mid 1B \mid \varepsilon \end{array} \right\}.$$

- NFA que reconhece a linguagem $\mathcal{L}_{30}$:



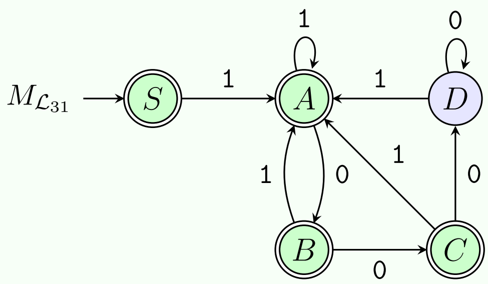
- Gramática G_2 que gera as cadeias de $\mathcal{L}_{30}$:

$$G_2 = (V, \Sigma, P, S) = (\{A, B, S\}, \{0, 1\}, P, S), \text{ com:}$$

$$P = \left\{ \begin{array}{l} S \to 0A \mid 0S \mid 1S, \\ A \to 1A \mid 1B, \\ B \to \varepsilon \end{array} \right\}.$$

$\mathcal{L}_{31} = \{w \in \Sigma^* = \{0, 1\}^* \mid w$ **não começa com** 0 **e não termina com** $000\}$

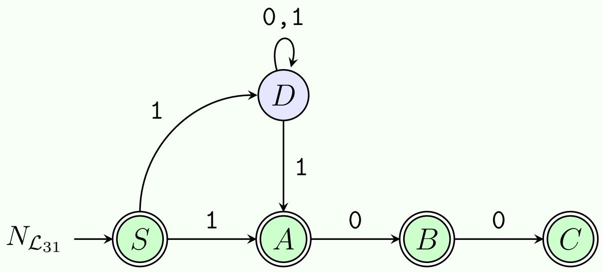
- DFA mínimo que reconhece as cadeias de $\mathcal{L}_{31}$



- Gramática G_1 que gera as cadeias de $\mathcal{L}_{31}$:

$$G_1 = (V, \Sigma, P, S) = (\{A, B, C, D, S\}, \{0, 1\}, P, S), \text{ com:}$$
$$P = \left\{ \begin{array}{l|l} S \to 1A \mid \varepsilon, & C \to 0D \mid 1A \mid \varepsilon, \\ A \to 0B \mid 1A \mid \varepsilon, & D \to 0D \mid 1A, \\ B \to 0C \mid 1A \mid \varepsilon, & \end{array} \right\}.$$

- NFA que reconhece a linguagem $\mathcal{L}_{31}$:



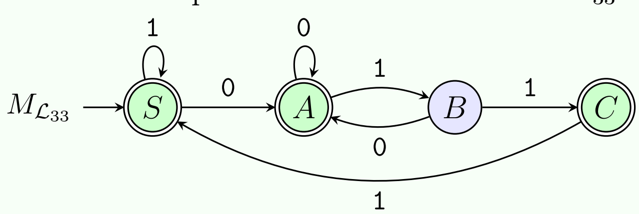
- Gramática G_2 que gera as cadeias de $\mathcal{L}_{31}$:

$$G_2 = (V, \Sigma, P, S) = (\{A, B, C, D, S\}, \{0, 1\}, P, S), \text{ com:}$$
$$P = \left\{ \begin{array}{l|l} S \to 1A \mid 1D \mid \varepsilon, & C \to \varepsilon, \\ A \to 0B \mid \varepsilon, & D \to 0D \mid 1A \mid 1D \\ B \to 0C \mid \varepsilon, & \end{array} \right\}.$$

$\mathcal{L}_{32} = \{w \in \Sigma^* = \{0, 1\}^* \mid w = uc,\ u \in \Sigma^*,\ c \in \Sigma,\ |u|_c \leqslant 2\}$

$\mathcal{L}_{33} = \{w \in \Sigma^* = \{0, 1\}^* \mid w$ não contém 0110 e não termina com 01$\}$

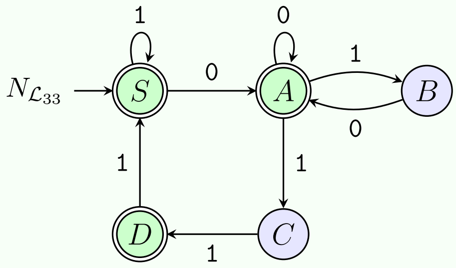
- DFA mínimo que reconhece as cadeias de $\mathcal{L}_{33}$



- Gramática G_1 que gera as cadeias de $\mathcal{L}_{33}$:

$$G_1 = (V, \Sigma, P, S) = (\{A, B, C, S\}, \{0, 1\}, P, S), \text{ com:}$$
$$P = \left\{ \begin{array}{l|l} S \to 0A \mid 1S \mid \varepsilon, & B \to 0A \mid 1C, \\ A \to 0A \mid 1B \mid \varepsilon, & C \to 1S \mid \varepsilon \end{array} \right\}.$$

- NFA que reconhece a linguagem $\mathcal{L}_{33}$:



- Gramática G_2 que gera as cadeias de $\mathcal{L}_{33}$:

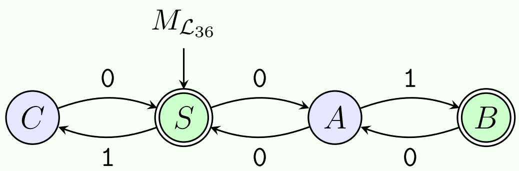
$$G_2 = (V, \Sigma, P, S) = (\{A, B, C, D, S\}, \{0, 1\}, P, S), \text{ com:}$$
$$P = \left\{ \begin{array}{l|l} S \to 0A \mid 1S \mid \varepsilon, & C \to 1D, \\ A \to 0A \mid 1B \mid 1C \mid \varepsilon, & D \to 1S \mid \varepsilon, \\ B \to 0A, & \end{array} \right\}.$$

$\mathcal{L}_{34} = \{w \in \Sigma^* = \{0, 1\}^* \mid |w| \geqslant 4$, começa com 0 e contém pelo menos um 1 do terceiro ao penúltimo símbolo$\}$

$\mathcal{L}_{35} = \{w \in \Sigma^* = \{0, 1\}^* \mid |w| = 2k + 1,\ k \in \mathbb{N},\ w$ termina com 1 e contém pelo menos mais um 1$\}$

$\mathcal{L}_{36} = \{w \in \Sigma^* = \{0, 1\}^* \mid |w| = 2k,\ k \in \mathbb{N},\ w$ não contém 11$\}$

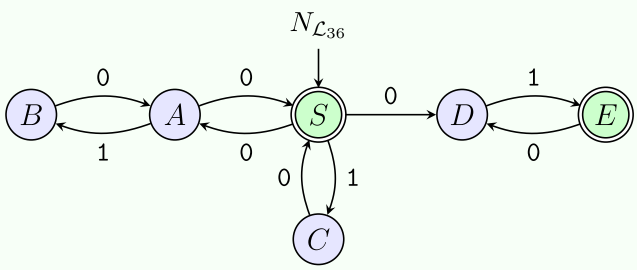
- DFA mínimo que reconhece as cadeias de $\mathcal{L}_{36}$



- Gramática G_1 que gera as cadeias de $\mathcal{L}_{36}$:

$$G_1 = (V, \Sigma, P, S) = (\{A, B, S\}, \{0, 1\}, P, S), \text{ com:}$$
$$P = \left\{ \begin{array}{l|l} S \to 0A \mid 1C \mid \varepsilon, & B \to 0A \mid \varepsilon \\ A \to 0S \mid 1B, & C \to 0S \end{array} \right\}.$$

- NFA que reconhece a linguagem $\mathcal{L}_{36}$:

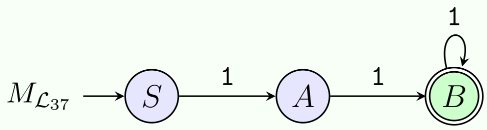


- Gramática G_2 que gera as cadeias de $\mathcal{L}_{36}$:

$$G_2 = (V, \Sigma, P, S) = (\{A, B, C, D, E, S\}, \{0, 1\}, P, S), \text{ com:}$$
$$P = \left\{ \begin{array}{l|l} S \to 0A \mid 0D \mid 1C \mid \varepsilon, & C \to 0S, \\ A \to 0S \mid 1B, & D \to 1E, \\ B \to 0A, & E \to 0D \mid \varepsilon \end{array} \right\}.$$

$\mathcal{L}_{37} = \{w \in \Sigma^* = \{0,1\}^* \mid w = u11,\ u \in \Sigma^*$ e todo 0 em u é seguido de um par de símbolos distintos$\}$

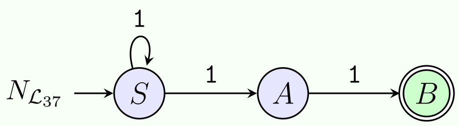
- DFA mínimo que reconhece as cadeias de $\mathcal{L}_{37}$



- Gramática G_1 que gera as cadeias de $\mathcal{L}_{37}$:

$$G_1 = (V, \Sigma, P, S) = (\{A, B, S\}, \{0, 1\}, P, S), \text{ com:}$$
$$P = \left\{ \begin{array}{l} S \to 1A, \\ A \to 1B, \\ B \to 1B \mid \varepsilon \end{array} \right\}.$$

- NFA que reconhece a linguagem $\mathcal{L}_{37}$:



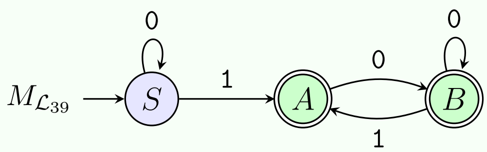
- Gramática G_2 que gera as cadeias de $\mathcal{L}_{37}$:

$$G_2 = (V, \Sigma, P, S) = (\{A, B, S\}, \{0, 1\}, P, S), \text{ com:}$$
$$P = \left\{ \begin{array}{l} S \to 1A \mid 1S, \\ A \to 1B, \\ B \to \varepsilon \end{array} \right\}.$$

$\mathcal{L}_{38} = \{w \in \Sigma^* = \{0,1\}^* \mid w$ contém os símbolos 0 e 1, mas não contém $00\}$

$\mathcal{L}_{39} = \{w \in \Sigma^* = \{0,1\}^* \mid w$ contém pelo menos um 1, mas não contém $11\}$

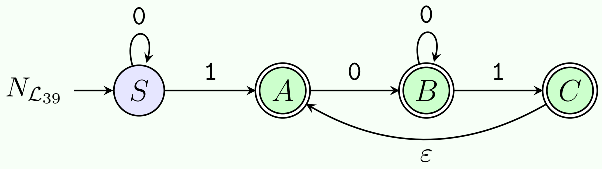
- DFA mínimo que reconhece as cadeias de $\mathcal{L}_{39}$



- Gramática G_1 que gera as cadeias de $\mathcal{L}_{39}$:

$$G_1 = (V, \Sigma, P, S) = (\{A, B, S\}, \{0, 1\}, P, S), \text{ com:}$$
$$P = \left\{ \begin{array}{l} S \to 0S \mid 1A, \\ A \to 0B \mid \varepsilon, \\ B \to 0B \mid 1A \mid \varepsilon \end{array} \right\}.$$

- NFA que reconhece a linguagem $\mathcal{L}_{39}$:

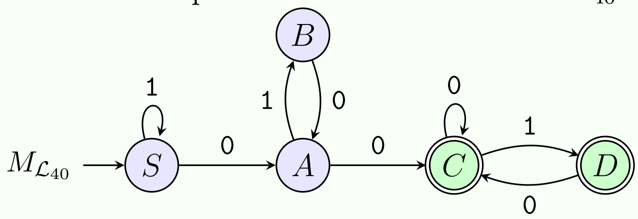


- Gramática G_2 que gera as cadeias de $\mathcal{L}_{39}$:

$$G_2 = (V, \Sigma, P, S) = (\{A, B, C, S\}, \{0, 1\}, P, S), \text{ com:}$$
$$P = \left\{ \begin{array}{l|l} S \to 0S \mid 1A, & B \to 0B \mid 1C \mid \varepsilon \\ A \to 0B \mid \varepsilon, & C \to A \mid \varepsilon \end{array} \right\}.$$

$\mathcal{L}_{40} = \{w \in \Sigma^* = \{0, 1\}^* \mid w$ contém 00, mas não contém 011$\}$

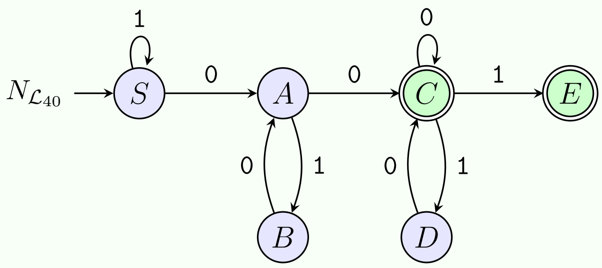
- DFA mínimo que reconhece as cadeias de $\mathcal{L}_{40}$



- Gramática G_1 que gera as cadeias de $\mathcal{L}_{40}$:

$$G_1 = (V, \Sigma, P, S) = (\{A, B, C, D, S\}, \{0, 1\}, P, S), \text{ com:}$$
$$P = \left\{ \begin{array}{l|l} S \to 0A \mid 1S, & C \to 0C \mid 1D \mid \varepsilon \\ A \to 0C \mid 1B, & D \to 0C \mid \varepsilon \\ B \to 0A, & \end{array} \right\}.$$

- NFA que reconhece a linguagem $\mathcal{L}_{40}$:



- Gramática G_2 que gera as cadeias de $\mathcal{L}_{40}$:

$$G_2 = (V, \Sigma, P, S) = (\{A, B, C, D, E, S\}, \{0, 1\}, P, S), \text{ com:}$$

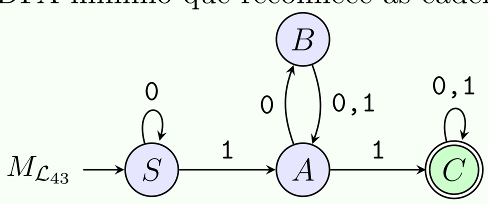
$$P = \left\{ \begin{array}{l|l} S \to 0A \mid 1S, & C \to 0C \mid 1D \mid 1E \mid \varepsilon \\ A \to 0C \mid 1B, & D \to 0C, \\ B \to 0A, & E \to \varepsilon \end{array} \right\}.$$

$\mathcal{L}_{41} = \{w \in \Sigma^* = \{0, 1\}^* \mid w$ contém pelo menos um 00, mas não contém $11\}$

$\mathcal{L}_{42} = \{w \in \Sigma^* = \{0, 1\}^* \mid w$ começa com 0 e contém 010 ou w começa com 1 e contém $101\}$

$\mathcal{L}_{43} = \{w \in \Sigma^* = \{0, 1\}^* \mid w$ contém dois 1's separados por uma quantidade par de símbolos$\}$

- DFA mínimo que reconhece as cadeias de $\mathcal{L}_{43}$

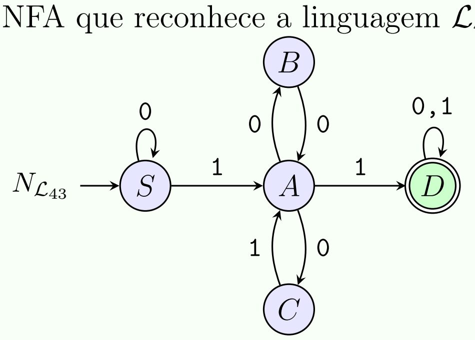


- Gramática G_1 que gera as cadeias de $\mathcal{L}_{43}$:

$$G_1 = (V, \Sigma, P, S) = (\{A, B, C, S\}, \{0, 1\}, P, S), \text{ com:}$$

$$P = \left\{ \begin{array}{l|l} S \to 0S \mid 1A, & B \to 0A \mid 1A, \\ A \to 0B \mid 1C, & C \to 0C \mid 1C \mid \varepsilon \end{array} \right\}.$$

- NFA que reconhece a linguagem $\mathcal{L}_{43}$:



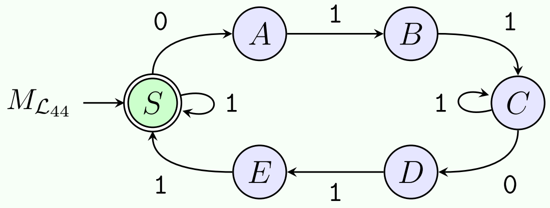
- Gramática G_2 que gera as cadeias de $\mathcal{L}_{43}$:

$$G_2 = (V, \Sigma, P, S) = (\{A, B, C, D, S\}, \{0, 1\}, P, S), \text{ com:}$$

$$P = \left\{ \begin{array}{l|l} S \to 0S \mid 1A, & C \to 1A, \\ A \to 0B \mid 0C \mid 1D, & D \to 0D \mid 1D \mid \varepsilon \\ B \to 0A, & \end{array} \right\}.$$

$\mathcal{L}_{44} = \{w \in \Sigma^* = \{0,1\}^* \mid |w|_0 = 2k,\ k \in \mathbb{N},$ e cada 0 é seguido de pelo menos dois 1's consecutivos$\}$

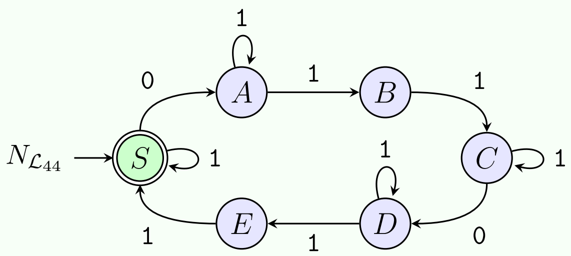
- DFA mínimo que reconhece as cadeias de $\mathcal{L}_{44}$



- Gramática G_1 que gera as cadeias de $\mathcal{L}_{44}$:

$$G_1 = (V, \Sigma, P, S) = (\{A, B, C, D, E, S\}, \{0,1\}, P, S),\ \text{com:}$$
$$P = \left\{ \begin{array}{l|l} S \to 0A \mid 1S \mid \varepsilon, & C \to 0D \mid 1C, \\ A \to 1B, & D \to 1E, \\ B \to 1C, & E \to 1S \end{array} \right\}.$$

- NFA que reconhece a linguagem $\mathcal{L}_{44}$:

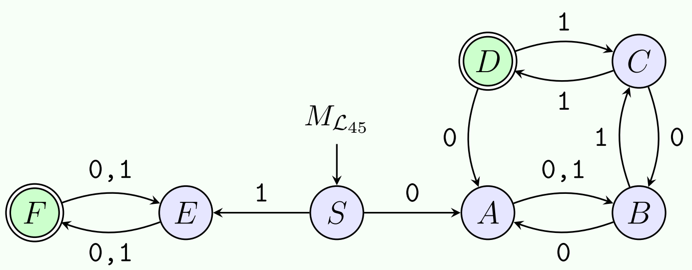


- Gramática G_2 que gera as cadeias de $\mathcal{L}_{44}$:

$$G_2 = (V, \Sigma, P, S) = (\{A, B, C, D, E, S\}, \{0,1\}, P, S),\ \text{com:}$$
$$P = \left\{ \begin{array}{l|l} S \to 0A \mid 1S \mid \varepsilon, & C \to 0D \mid 1C, \\ A \to 1A \mid 1B, & D \to 1D \mid 1E, \\ B \to 1C, & E \to 1S \end{array} \right\}.$$

$\mathcal{L}_{45} = \{w \in \Sigma^* = \{0,1\}^* \mid |w| = 2k,\ k \in \mathbb{N},$ e w começa com 1 ou termina com 11$\}$

- DFA mínimo que reconhece as cadeias de $\mathcal{L}_{45}$

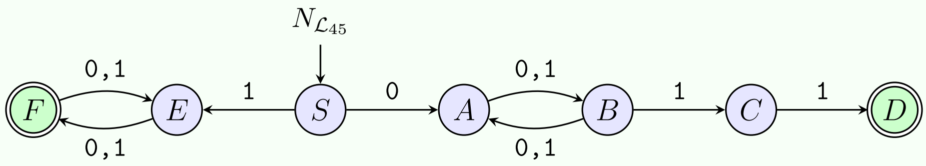


- Gramática G_1 que gera as cadeias de $\mathcal{L}_{45}$:

$$G_1 = (V, \Sigma, P, S) = (\{A, B, C, D, E, F, S\}, \{0, 1\}, P, S), \text{ com:}$$

$$P = \left\{ \begin{array}{l|l|l} S \to 0A \mid 1E, & C \to 0B \mid 1D, & E \to 0F \mid 1F \\ A \to 0B \mid 1B, & D \to 0A \mid 1C \mid \varepsilon, & F \to 0E \mid 1E \mid \varepsilon \\ B \to 0A \mid 1C, & & \end{array} \right\}.$$

- NFA que reconhece a linguagem $\mathcal{L}_{45}$:



- Gramática G_2 que gera as cadeias de $\mathcal{L}_{45}$:

$$G_2 = (V, \Sigma, P, S) = (\{A, B, C, D, E, F, S\}, \{0, 1\}, P, S), \text{ com:}$$

$$P = \left\{ \begin{array}{l|l|l} S \to 0A \mid 1E, & C \to 1D, & E \to 0F \mid 1F \\ A \to 0B \mid 1B, & D \to \varepsilon, & F \to 0E \mid 1E \mid \varepsilon \\ B \to 0A \mid 1A \mid 1C, & & \end{array} \right\}.$$

$\mathcal{L}_{46} = \{w \in \Sigma^* = \{0, 1\}^* \mid w$ é diferente de 0, 00, 1, 11 e $010\}$

$\mathcal{L}_{47} = \{w \in \Sigma^* = \{0, 1\}^* \mid |w|_0 = 2k$ e $|w|_1 = 3k',\ k, k' \in \mathbb{N}\}$