NFA to DFA Conversions:

Simulate NFA moves with DFA here.

① DFA Start State == NFA Start State

② Each DFA state is a subset of set of NFA states.

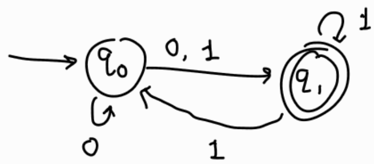
③ New DFA states, Calculate the states reachable through each $t \in \Sigma$.

④ Final DFA state, contain any NFA final state.

* No. of DFA states can be exponential as compared to NFA.
for Q states, there can be 2^Q subsets.

e.g. Convert

$M = \{ \{q_0, q_1\}, \{0,1\}, q_0, \delta, \{q_1\} \}$



M

Let $M_{DFA} = \{Q', \Sigma', \delta, q_0', F'\}$

Step 1: Q'

	0	1
$\rightarrow q_0$	$q_0 q_1$	q_1
$* q_0 q_1$	$q_0 q_1$	$q_0 q_1$
$* q_1$	ϕ	$q_0 q_1$

Step 2: q_0'

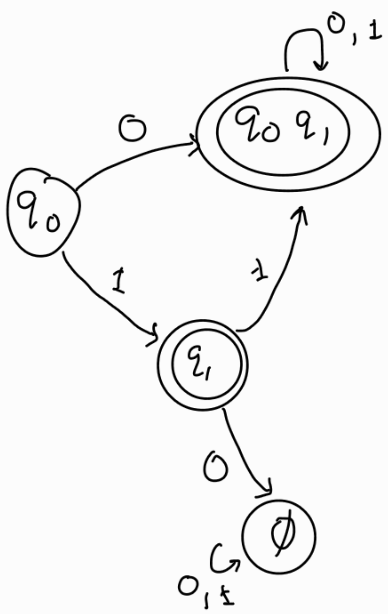
NFA $\Rightarrow q_0$ DFA $\Rightarrow q_0$

Step 3: F'

Containing F of M

$F' = \{ q_1, q_0q_1 \}$

Step 4: $\hat{\delta}$



RE Algebra:

$a = a$

$a = b, \; b = a$

$a = b, \; b = c$ then $a = c$

$L + M = M + L$

$(L+M)+N = L+(M+N)$

$(LM)N = L(MN)$ Note $LM \neq ML$

CFG Simplification:

③ Useless Symbols. ⟶ ① Non Generating ② Non Reachable

① ε-productions ⟶ ① ε-prods ② Useless symbol (again)

② Unit Productions

* Sequence ε → Unit P → Useless Symbols

① $S \to XYX$

$X \to 0X \mid \varepsilon$

$Y \to 1Y \mid \varepsilon$

Nullable = $\{S, X, Y\}$

$S \to XYX \mid YX \mid XY \mid X \mid Y \mid XX$

$X \to 0X \mid 0$

$Y \to 1Y \mid 1$

② $S \to AB$

$A \to aAA \mid \epsilon$

$B \to bBB \mid \epsilon$

Nullable = $\{A, B, S\}$

$A \to aAA \mid aA \mid a$

$B \to bBB \mid bB \mid b$

$S \to AB \mid A \mid B$

③ $S \to a \mid aA \mid B \mid C$

$A \to aB \mid \epsilon$

$B \to aA$

$C \to aCD$

$D \to ddd$

Step 1:)

ε-productions = $\{A\}$

$S \to a \mid aA \mid B \mid C$

$A \to aB$

$B \to aA \mid a$

$C \to aCD$

$D \to ddd$

Step 2:

i) Non generating: C

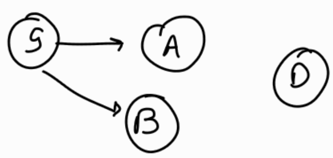
$S \to a \mid aA \mid B$

$A \to aB$

$B \to aA \mid a$

$D \to ddd$

ii) Non rechable



$S \to a \mid aA \mid B$

$A \to aB$

$B \to aA \mid a$

$S \to Aa \mid B$

$A \to a \mid bc \mid B$

$B \to A \mid bb$

unit $\to$ $S \to B$

$A \to B$

$S \to Aa \mid bb \mid a \mid bc \mid B$

$A \to a \mid bc \mid bb \mid B$

$B \to bb \mid a \mid bc \mid B$

Simply :

G_1: $S \to a \mid aA \mid B \mid C$

$A \to aB \mid \varepsilon$

$B \to aA$

$C \to cCD$

$D \to ddd$

Step 1: Episilon prods.

Nullable $\to$ $\{A\}$

<u>P1</u>:

$S \to a \mid aA \mid B \mid C$

$A \to aB$

$B \to aA \mid a$

$C \to cCD$

$D \to ddd$

Step : <u>Unit prods</u> :

$S \to B$

$S \to C$

After removal

$S \to a \mid aA \mid cCD$

$A \to aB$

$B \to aA \mid a$

$C \to cCD$

$D \to ddd$

Step 3: Useless

1. <u>Non generating :</u>

$\{C\}$

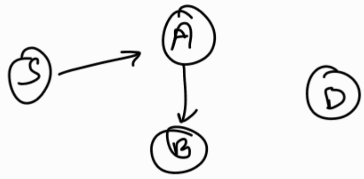
$S \to a \mid aA$

$A \to aB$

$B \to aA \mid a$

$D \to ddd$

(1) Non reachable



<u>P4</u>:

$S \to a \mid aA$

$A \to aB$

$B \to aA \mid a$

$G = \{ \{S, A, B\}, \{a\}, P4, S \}$

$S \to Aa \mid B$
$B \to a \mid bC$
$C \to a \mid \varepsilon$

① ε-prods
$\{C\}$

P1] $C \to a$
$B \to a \mid bC \mid b$

$S \to Aa \mid B$

② Unit Productions:
$S \to B$
$S \to Aa \mid a \mid bC \mid b$
$C \to a$

③ Useless Symbols:
$\{\}$

Non reachable : $\{\}$

$\therefore G = \{\{S, C\}, \{a, b\}, \{S \to Aa \mid a \mid bC \mid b, C \to a\}, S\}$

CNF :

what we're allowed

$A \to BC$ or $A \to a$

Step 1: eliminate useless, ϵ, unit

Step 2: a) Elimination of terminals from RHS.

b) if '$B \to aX$' is present, add $A \to a$ to Variable of Grammer, replace '$B \to AX$'.

c) Consider Production: $W \to X_1 X_2 X_3 X_4 .. X_n$ where $n \geq 3$ and all X's are variables. introduce new productions :

$W \to X_1 C_1$
$C_1 \to X_2 C_2$
$C_2 \to X_3 C_3$
$C_n \to X_{n-1} X_n$

to Productions of Grammar.

---

e.g. $S \to ASA \mid aB$
$A \to B \mid S$
$B \to b \mid \varepsilon$

step 1) a) ε prods: $\{B, A\}$

$S \to ASA \mid aB \mid a \mid AS \mid SA \mid S$
$A \to B \mid S$
$B \to b$

ⓑ Unit Productions:
$S \to S$
$A \to B$
$A \to S$

P1) $S \to ASA \mid aB \mid a \mid AS \mid SA$

$A \to b \mid ASA \mid aB \mid a \mid AS \mid SA$
$B \to b$

ⓒ useless symbols.
i) Non Generating. $= \{\}$
ii) Non Reachable $= \{\}$

P1

Step 2: a) $S \to ASA \mid DB \mid a \mid AS \mid SA$

$A \to b \mid ASA \mid CB \mid a \mid AS$

$B \to b$

$C \to a$

b) two or more Variables :

$S \to ASA$

$A \to ASA$

$S \to AC_1$

$C_1 \to SA$

$\therefore$ P_2 :

$S \to AC_1 \mid DB \mid a \mid AS \mid SA$

$A \to b \mid AC_1 \mid DB \mid a \mid AS \mid SA$

$C_1 \to SA$

$B \to b$

$C \to a$

$S \to AbA$

$A \to Aa \mid \varepsilon$

1 a) $\varepsilon = \{A\}$

P1) $S \to AbA \mid Ab \mid bA \mid b$

$A \to Aa \mid a$

b) Unit prods $= \{\}$

c) Useless $= \{\}$

2

P2) i) RHS terminals

$S \to ABA \mid AB \mid BA \mid b$

$A \to AC_a \mid a$

$C_a \to a$

$B \to b$

ii) $S \to ABA$

$S \to AC_1$

$C_1 \to BA$

Pf

$S \to AC_1 \mid AB \mid BA \mid b$

$A \to AC_a \mid a$

$C_a \to a$

$B \to b$

$C_1 \to BA$

PDA :

- Recognize CFL
- FA with stack.

operations:

push

pop

skip

7-tuple $(Q, \Sigma, \Gamma, \delta, q_0, Z_0, F)$

- $(P, a, t) \rightarrow (Q, u)$

Skip:

if $t = u$

$(P, a, t) \rightarrow (Q, t)$ ... skip operation

Pop:

$(P, a, t) \rightarrow (Q, \epsilon)$

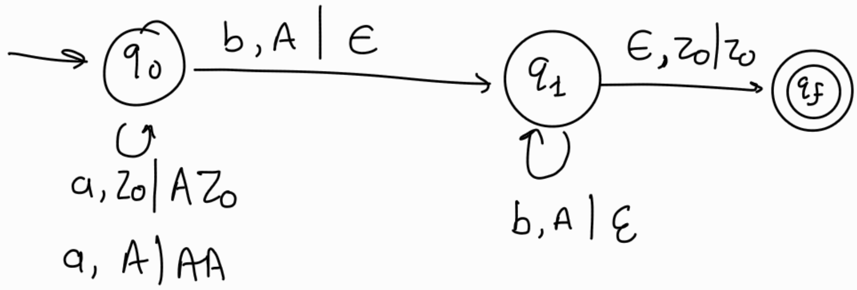
Push

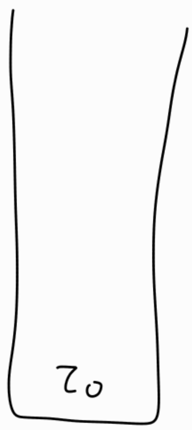
$(P, a, t) \rightarrow (Q, wx)$

t replaced with x

w is pushed.

$a^n b^n$





$w = (n_a = n_b)$

$(q_0, aaabbb, Z_0)$

$(q_0, aabbb, AZ_0)$

$(q_0, abbb, AAZ_0)$

$(q_0, bbb, AAAZ_0)$

(q_1, bb, AAZ_0)

(q_1, b, AZ_0)

(q_1, ε, Z_0)

(q_2, ϵ, Z_0)