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NFA

Non-deterministic-Finite Automata

Rules 1) there can be multiple transition for one symbol.

2) can change state without consuming any symbol. **ε-transition**

3) Only important transitions are needed.

Every DFA is a NFA

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Formal Definition – NFA

1. Q → finite set of state
2. Σ → finite alphabet
3. $\delta : Q \times \Sigma_\epsilon \to P(Q)$ transition function
4. q_0 → start state
5. F → set of final states.

1. $Q = \{q_1, q_2, q_3, q_4\}$
2. $\Sigma = \{0, 1\}$
3. δ

	0	1	ϵ
q_1	$\{q_1\}$	$\{q_1, q_2\}$	$\emptyset$
q_2	$\{q_3\}$	$\emptyset$	$\{q_3\}$
q_3	$\emptyset$	$\{q_4\}$	$\emptyset$
q_4	$\{q_4\}$	$\{q_4\}$	$\emptyset$

4. q_4 is the start state
5. $F = \{q_4\}$

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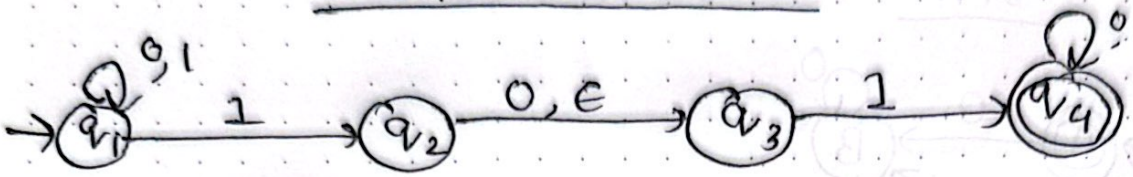
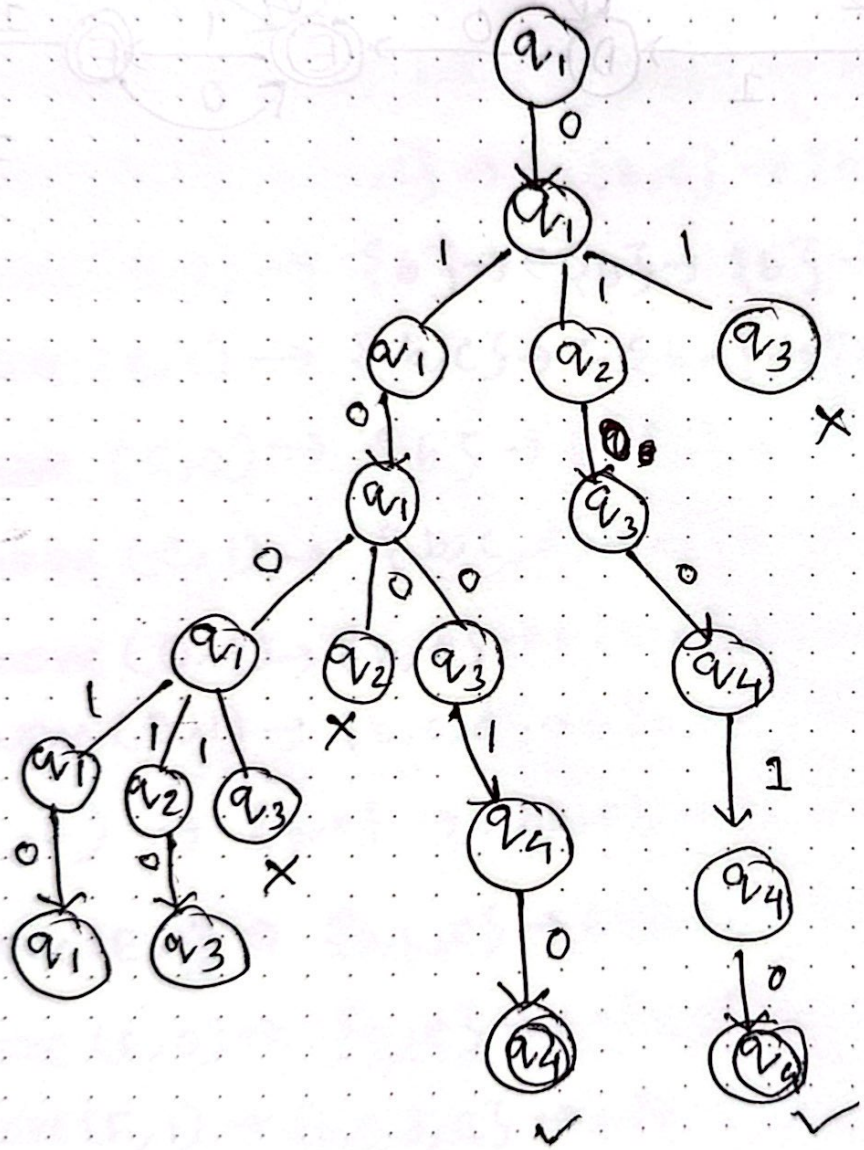
Nondeterminism



read 0 1 0 1 1 0



two accepting routes.

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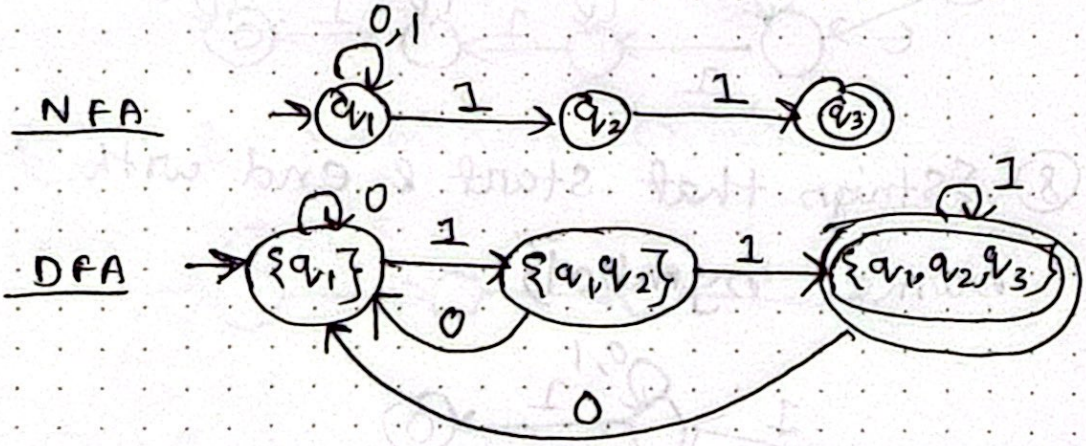
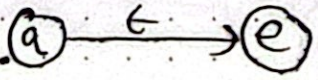
NFA to DFA

Subset construction

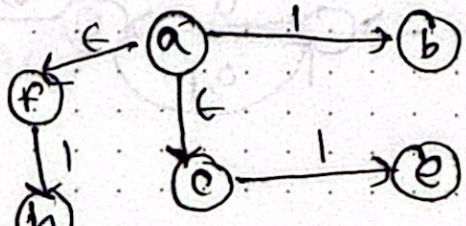
- remove ϵ-transition ✗
- remove multiple transition ✗
- include transition for every symbol.



ϵ-closure



means staying at 'a' state & both 'e' state since reading no symbol.



ϵ-closure of (a) = {a and every state it can go using ϵ}

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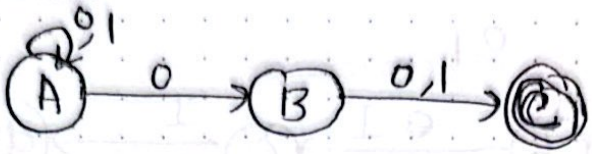
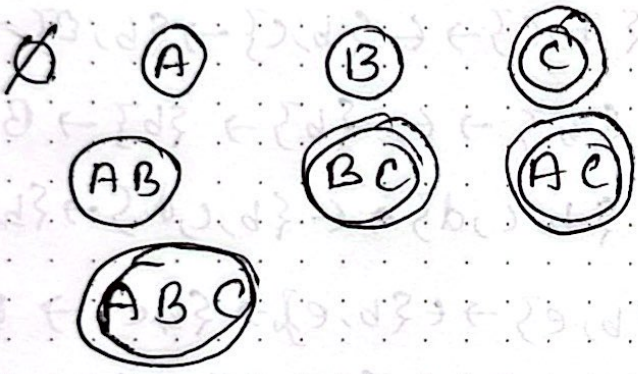
NFA



NFA - n states

DFA - 2^n (at mak states)

In DFA there can be any combination of state net.



accepting states are states that has ϵ state.

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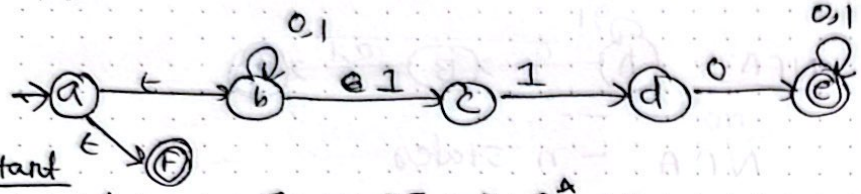

Start

ε-of (a) → {a, b, f} → A* →

move (A, 0) → {b} → ε{b} → {b} → B

move (A, 1) → {b, c} → ε-{b, c} → {b, c} → C

move (B, 0) → {b} → ε{b} → {b} → B

move (B, 1) → {b, c} → ε-{b, c} → {b, e} → C

move (C, 0) → {b} → ε-{b} → {b} → B

move (C, 1) → {b, c, d} → ε{b, c, d} → {b, c, d} → D

move (D, 0) → {b, e} → ε{b, e} → {b, e} → E*

move (D, 1) → {b, c, d} → ε{b, c, d} → {b, c, d} → D

move (E, 0) → {b, e} → ε{b, e} → {b, e} → E

move (E, 1) → {b, c, e} → ε{b, c, e} → {b, c, e} → F*

move (F, 0) → {b, e} → ε-{b, e} → {b, e} → E

move (F, 1) → {b, c, d, e} → ε{b, c, d, e} → G*

move (G, 0) → {b, e} → ε{b, e} → E

move (G, 1) → {b, c, d, e} → ε{b, c, d, e} → G

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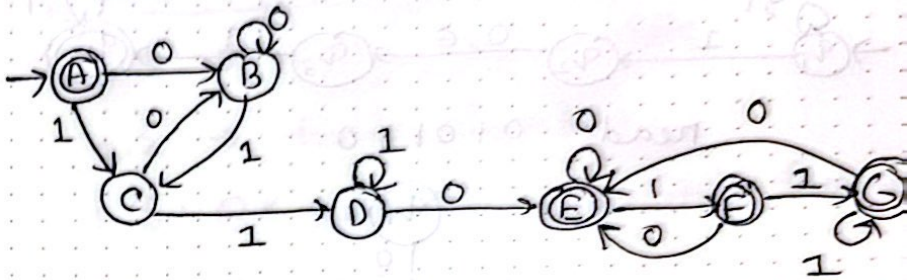
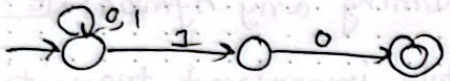
DFA



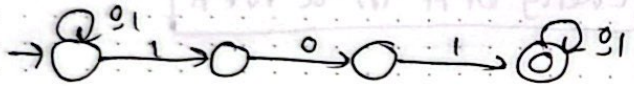
NFA Examples

(1) L = {starts with 10}

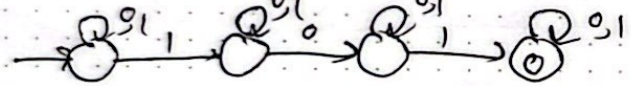
(2) L = {ends with 10}



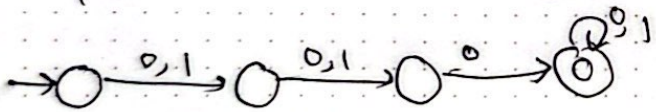
(3) L = {strings contain 101}



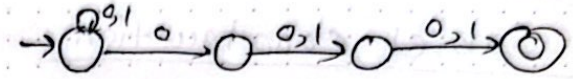
(4) L={String contains 101 as subsequence}



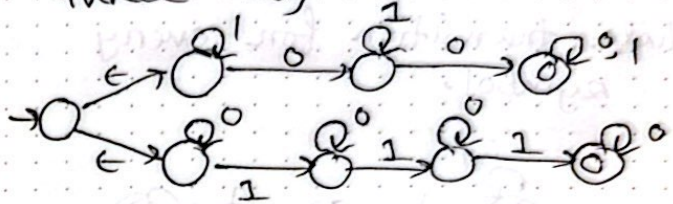
(5) L={0 at third position}



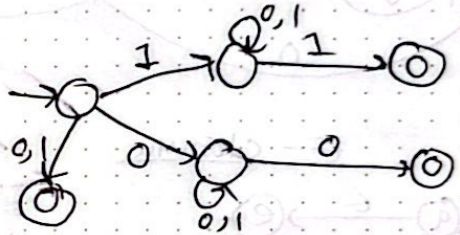
6) 0 at third last position



(7) {at least two 0's or exactly three 1's}



(8) {Strings that start & end with same symbol}



(9) {zeros at odd position}

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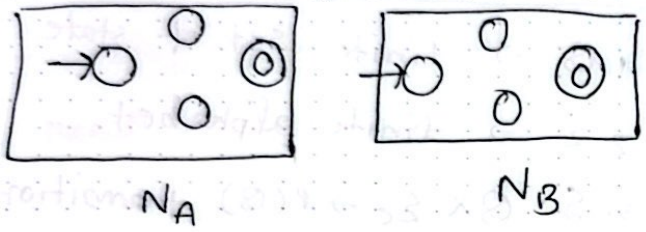
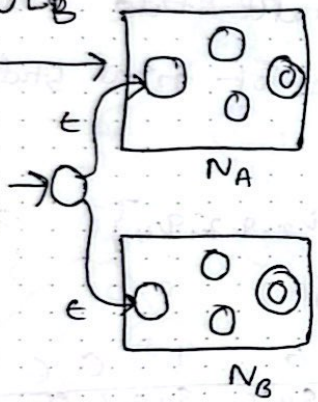
Regular Operations



$L = L_A \cup L_B$



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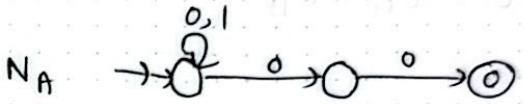
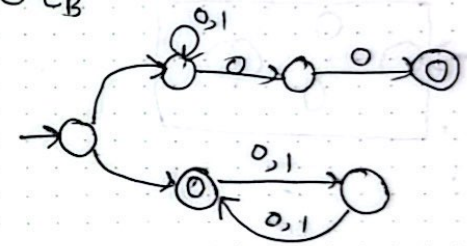
Example L_A = { ends with "00" }

L_B = { length of w is even }



$L_B = L_A \cup L_B$

N =



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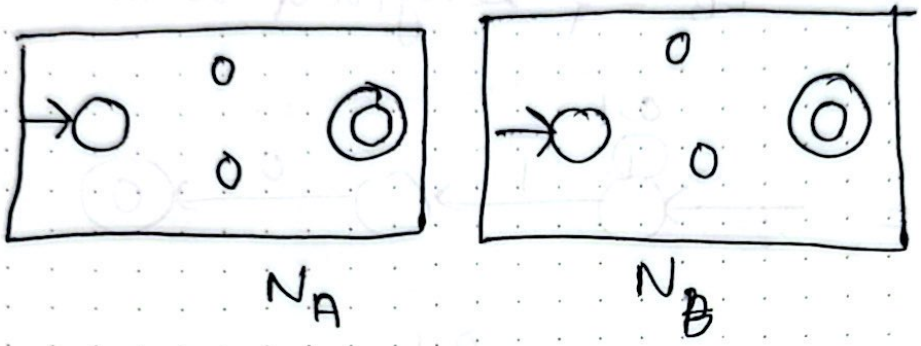
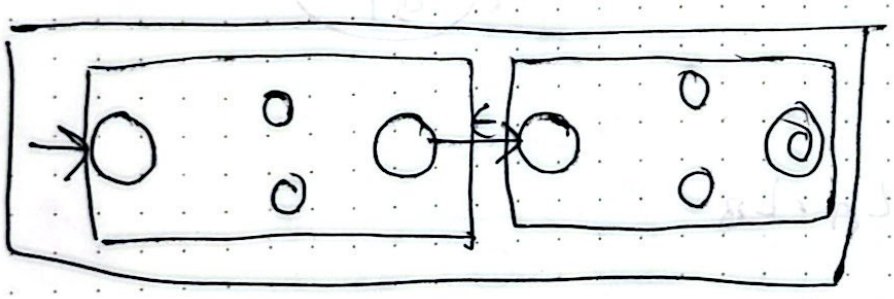
Concatenation

$$L = L_A \cdot L_B$$



N_A N_B



N

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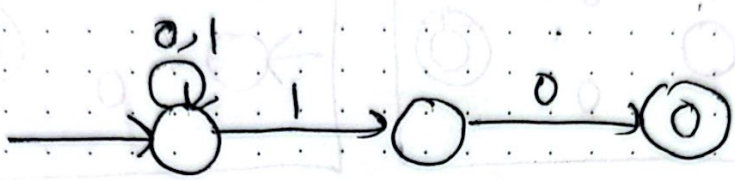
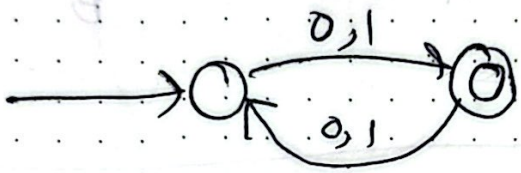
Example: $L_A = \{$ ends with $10\}$

$L_B = \{$ length of w is odd$\}$

$N_A =$

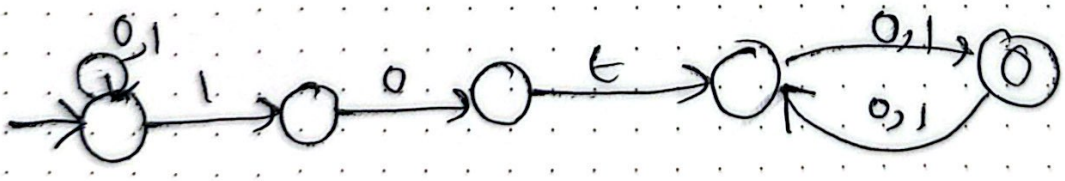


$N_B =$



$L_1 = L_A \cdot L_B$

$N = N_A \cdot N_B$



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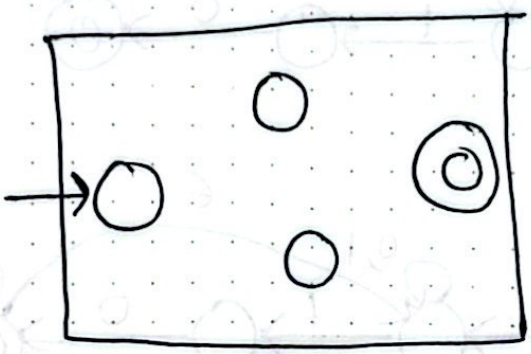
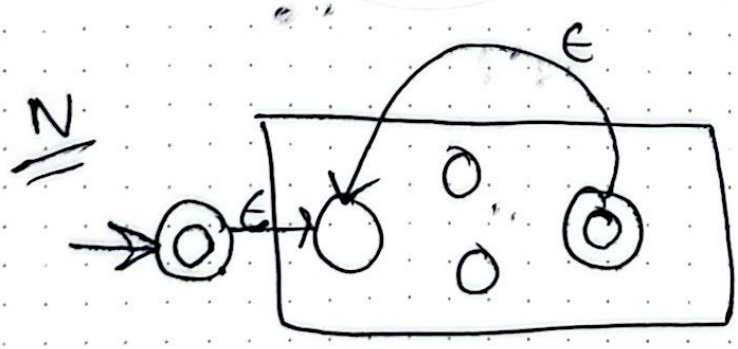
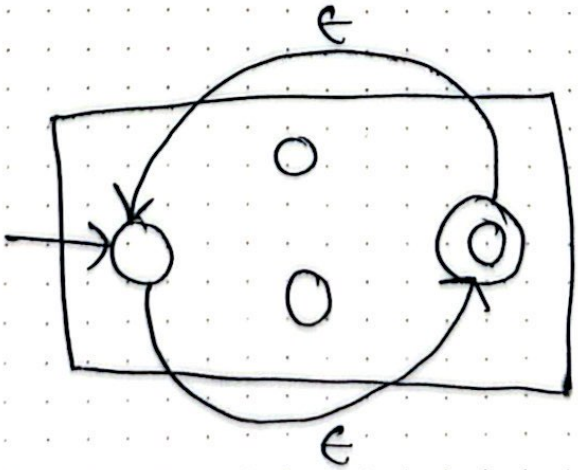
$$L = L_A^*$$



N_A



Or,



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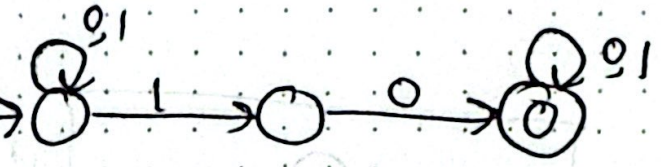
Example

$L_A = \{ w \text{ contains } 10 \}$

$N_A \Rightarrow$



$L = L_A^*$

$N_A^* \rightarrow$