Theory of Computation (CS F351)

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Non-deterministic Finite Automata (Sec. 2.2 of T1)

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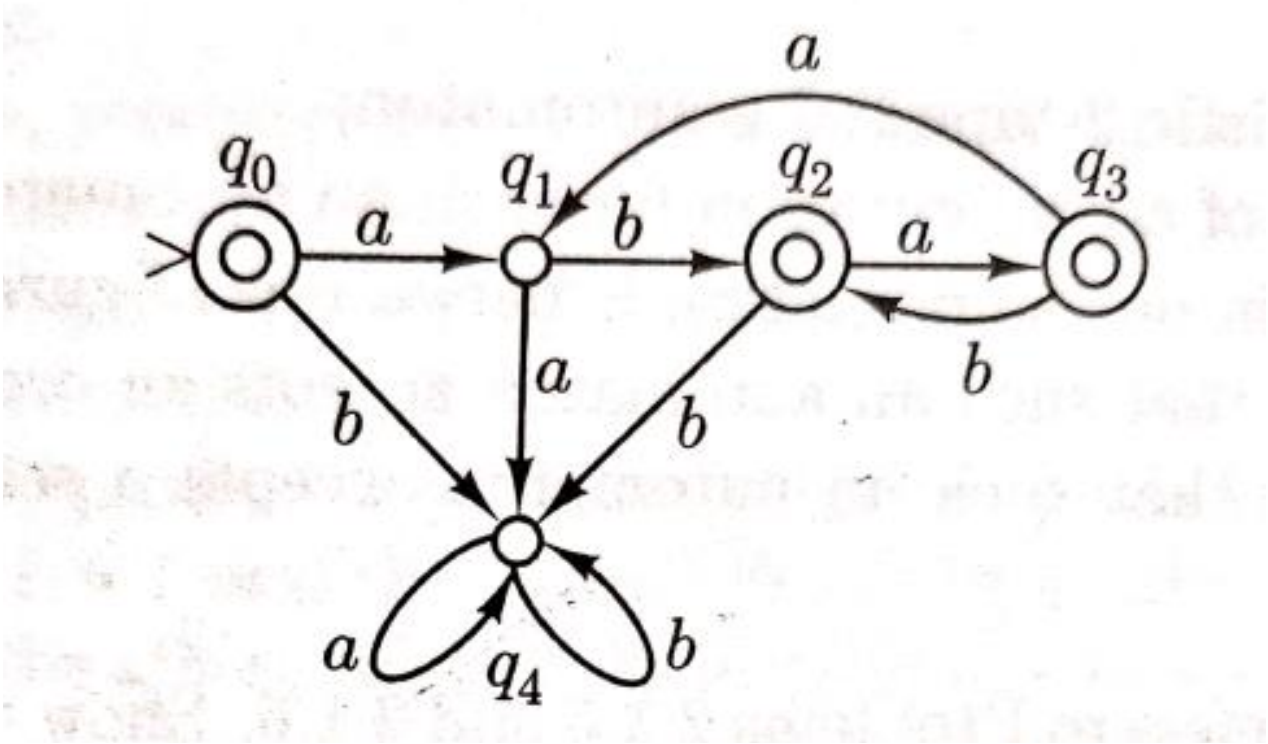
What is non-determinism in FA?

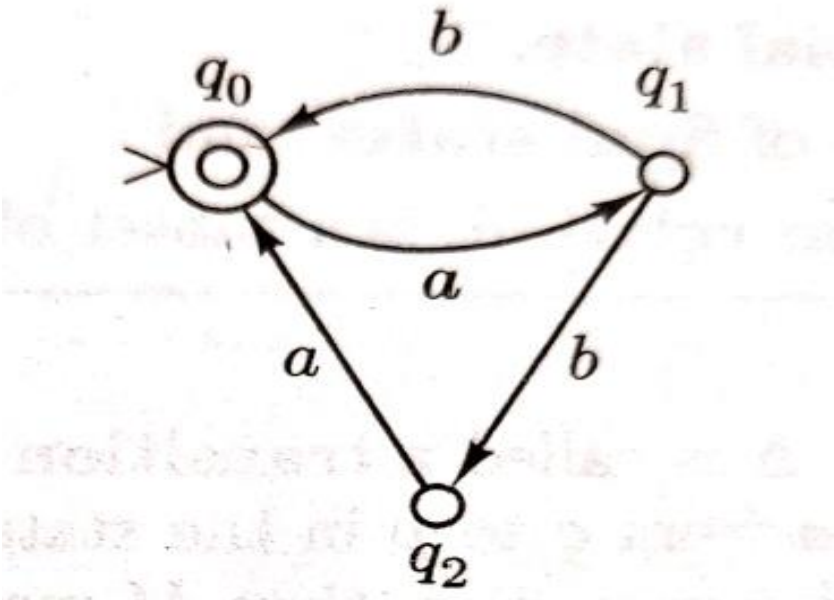
It is a powerful feature.

What is this nondeterminism?

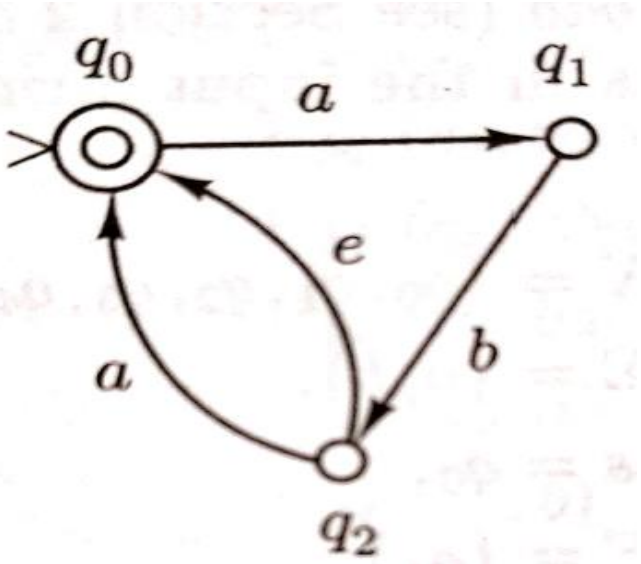
A Deterministic Finite Automaton (DFA)



A Non-deterministic Finite Automaton (NDFA) for the same language



NDFA for the same language with null transition



Description of an NDFA

Definition 2.2.1: A **nondeterministic finite automaton** is a quintuple $M = (K, \Sigma, \Delta, s, F)$, where

K is a finite set of **states**,

Σ is an **alphabet**,

$s \in K$ is the **initial state**,

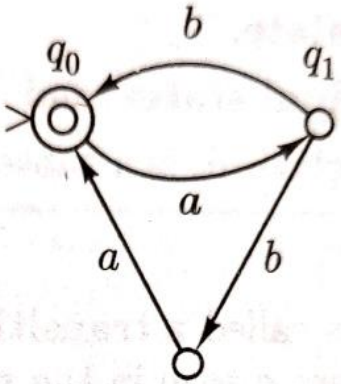
$F \subseteq K$ is the set of **final states**, and

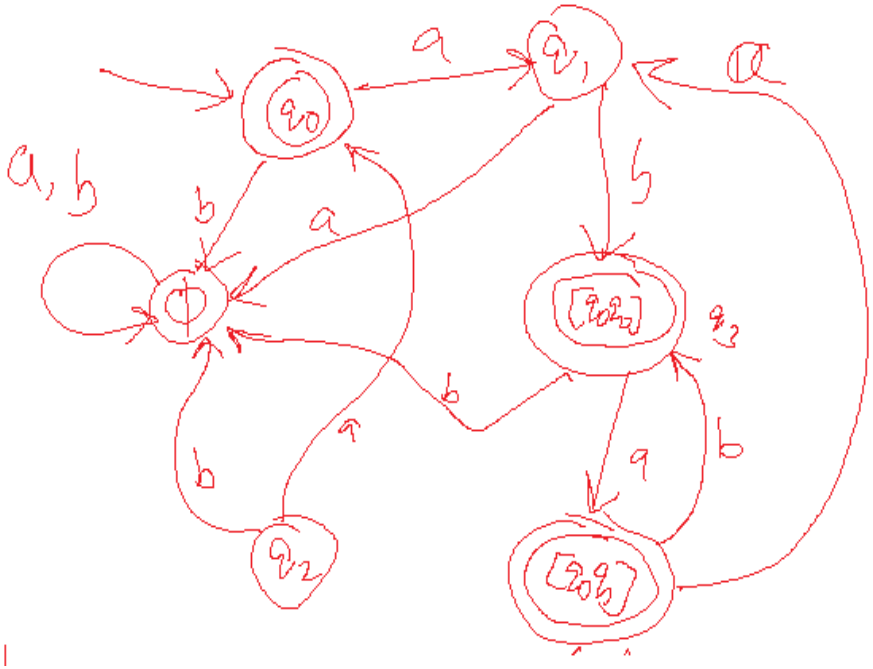
Δ, the **transition relation**, is a subset of $K \times (\Sigma \cup \{e\}) \times K$.

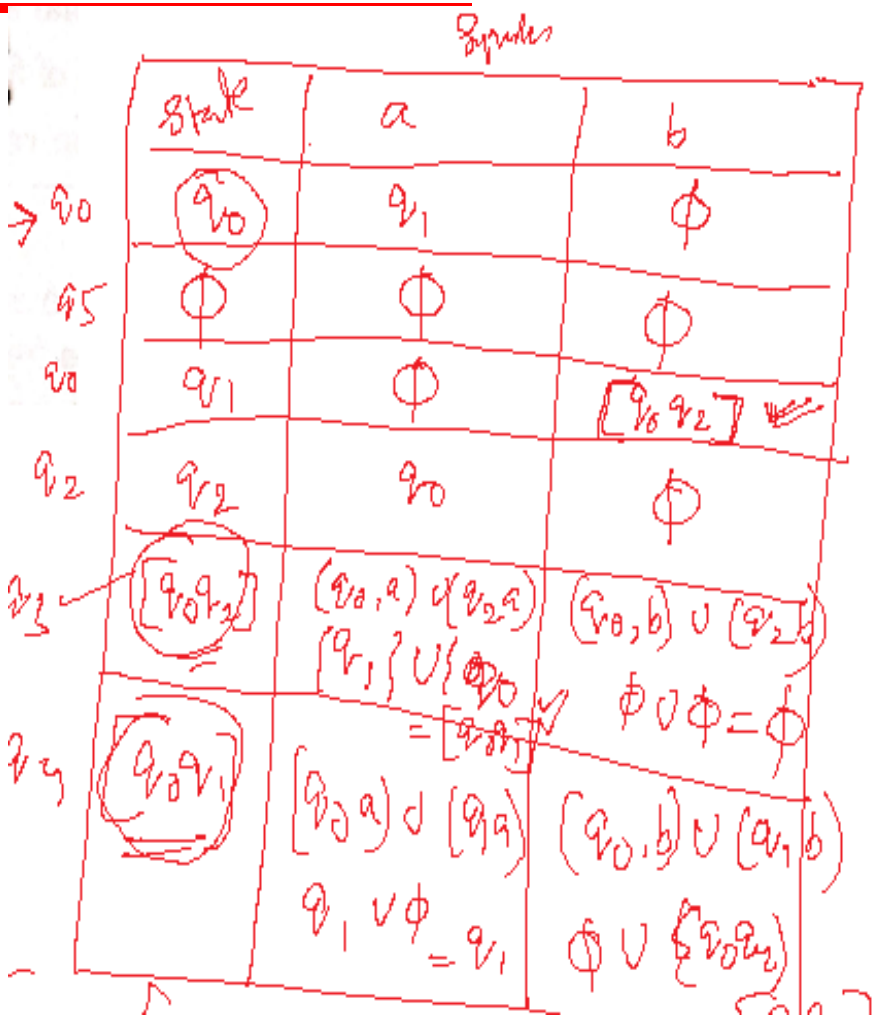
About NDFA

- NDFA are not meant as realistic models for computers.
- They simply notational generalization of FA, as they simplify the description of these FA.
- Meaning that we can draw a FA for a language with ease (less number of states and edges)
- Further, non-determinism is a non-essential feature of FA.
- Ever NDFA can be converted to equivalent DFA.
- We have algorithms that can convert NDFA to its equivalent DFA.

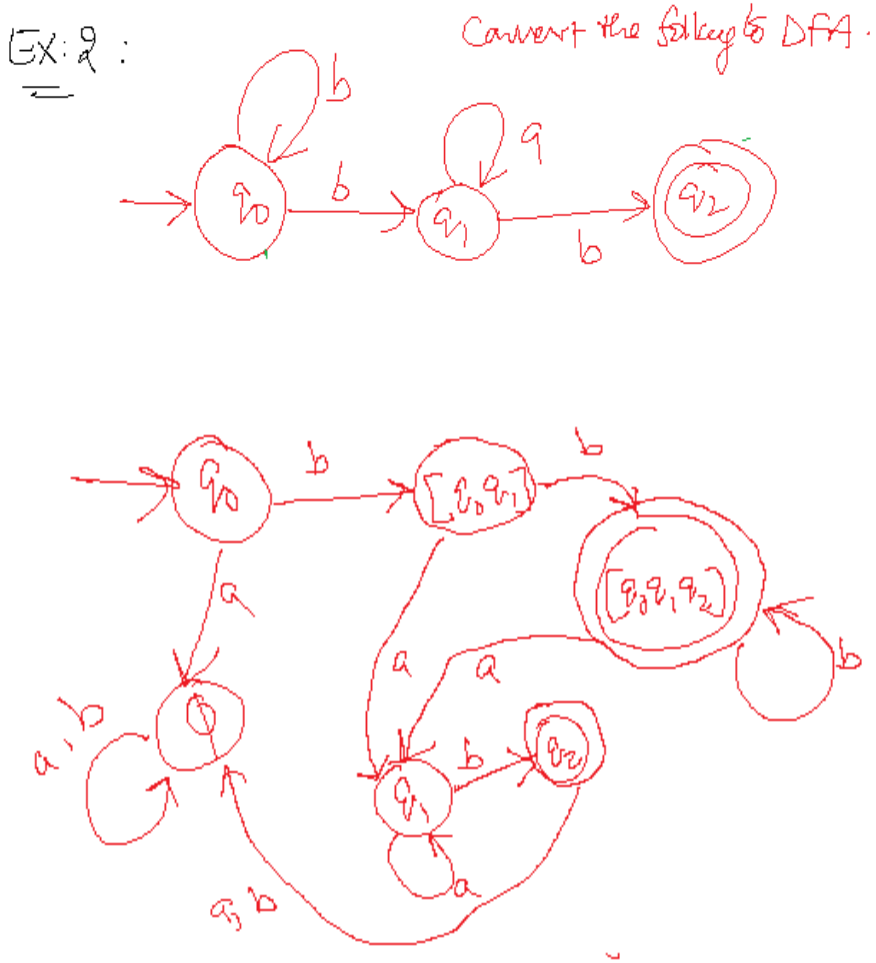
Converting a NDFA without null moves, to equivalent DFA







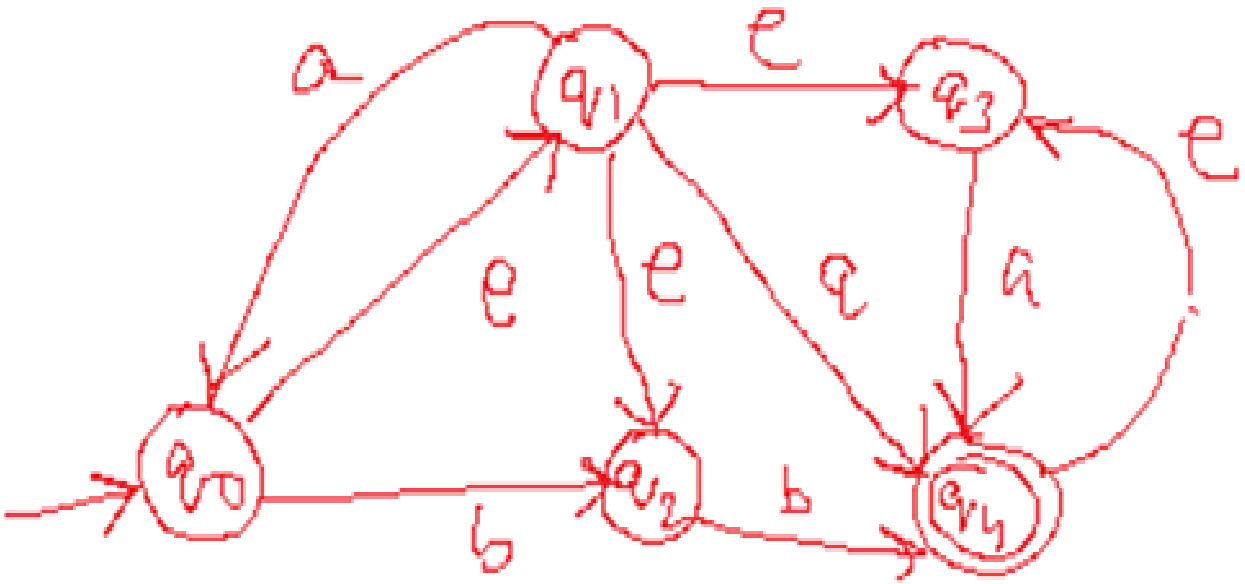
Converting a NDFA without null moves, to equivalent DFA



State	a	b
ϕ	ϕ	ϕ
$\rightarrow q_0$ (A)	ϕ	$[q_0, q_1]$ ✓
q_1 (B)	q_1	q_2
q_2 (C)	ϕ	ϕ
$[q_0 q_1]$ (D)	q_1	$[q_0 q_1 q_2]$ ✓
$[q_0 q_1 q_2]$ (E)	$\phi \cup q_1 \cup \phi = \{q_1\}$	$q_0, q_1 \cup [q_2] \cup = [q_0 q_1 q_2]$

Converting a NDFA with null moves, to equivalent DFA

Ex.1



Computing E(q) for each q∈K

$E(q_0) = \{q_0, q_1, q_2, q_3\}$

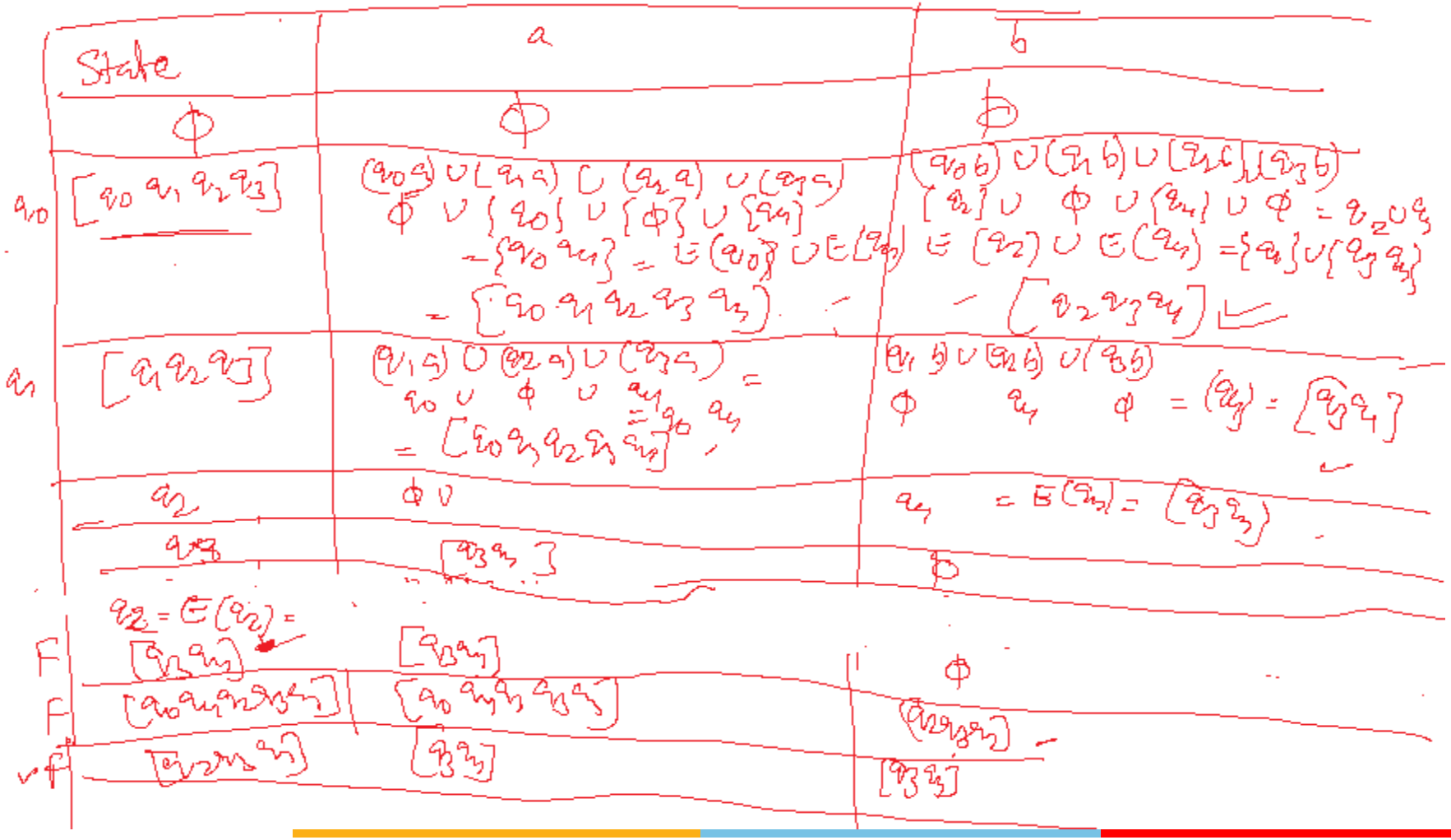
$E(q_1) = \{q_1, q_2, q_3\}$

$E(q_2) = \{q_2\}$

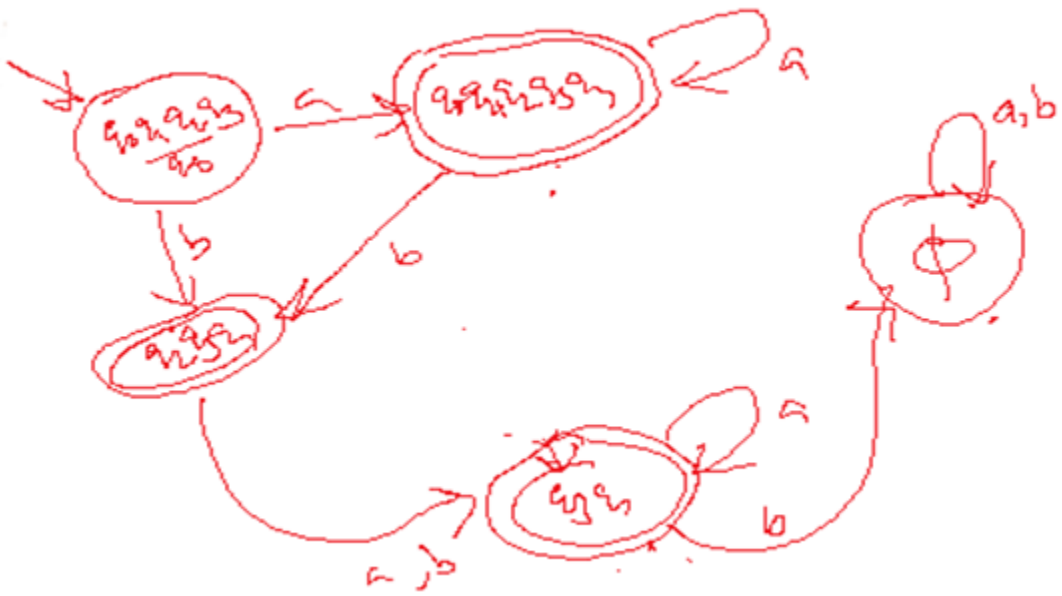
$E(q_3) = \{q_3\}$

$E(q_4) = \{q_3, q_4\}$

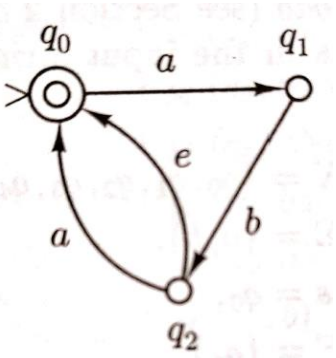
Defining the transitions of DFA



Final equivalent DFA



Converting a NDFA with null moves, to equivalent DFA



$E(q_0) = \{q_0\}$

$E(q_1) = \{q_1\}$

$E(q_2) = \{q_0, q_2\}$

State	a	b
ϕ	ϕ	ϕ
$q_0 = E(q_0) = q_0$	q_1	ϕ
$q_1 = E(q_1) = q_1$	ϕ	$q_2 = E(q_2) = [q_0 q_2]$
F $q_2 = E(q_2) = [q_0 q_2]$	$(q_0, q) \cup (q_2, q)$ $q_1 \cup q_0$ $= [q_0 q_1]$	$(q_0, b) \cup (q_2, b)$ $\phi \cup \phi$ $= \phi$
F $[q_0 q_1]$	$(q_0, q) \cup (q_1, q)$ $q_1 \cup \phi$ $= q_1$	$(q_0, b) \cup (q_1, b)$ $\phi \cup q_2 = [q_2]$ $= E(q_2) = [q_0 q_2]$