

# NFA to DFA Conversion

October 19, 2012

# Converting an NFA to a DFA

## Given:

A non-deterministic finite state machine (NFA)

## Goal:

Convert to an equivalent deterministic finite state machine (DFA)

## Why?

Faster recognizer!

## Approach:

Consider simulating a NFA.

Work with sets of states.

**IDEA:** Each state in the DFA will correspond to a set of NFA states.

## Worst-case:

There can be an exponential number  $\mathbf{O}(2^N)$  of sets of states.

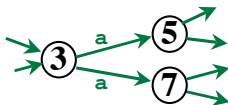
The DFA can have exponentially many more states than the NFA  
... but this is rare.

## NFA to DFA

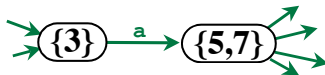
Input: A NFA      $S = \text{States} = \{s_0, s_1, \dots, s_N\} = S_{\text{NFA}}$   
                          $\delta = \text{Move function} = \text{Move}_{\text{NFA}}$   
                          $\text{Move}'(S, a) \rightarrow \text{Set of states}$

Output: A DFA      $S = \text{States} = \{?, ?, \dots, ?\} = S_{\text{DFA}}$   
                          $\delta = \text{Move function} = \text{Move}_{\text{DFA}}$   
                          $\text{Move}(s, a) \rightarrow \text{Single state from } S_{\text{DFA}}$

Main Idea:     Each state in  $S_{\text{DFA}}$  will be a set of states from the NFA  
 $S_{\text{DFA}} = \{ \{ \dots \}, \{ \dots \}, \dots, \{ \dots \} \}$

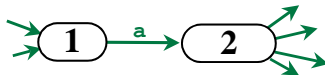


NFA



DFA

*(The names of the states is arbitrary and can be changed later, if desired.)*



## Algorithm: Convert NFA to DFA

### We'll use...

$\text{Move}_{\text{NFA}}(\mathbf{S}, \mathbf{a})$  the transition function from NFA  
 $\epsilon\text{-Closure}(\mathbf{s})$  where  $\mathbf{s}$  is a single state from NFA  
 $\epsilon\text{-Closure}(\mathbf{S})$  where  $\mathbf{S}$  is a set of states from NFA

### We'll construct...

$\mathbf{S}_{\text{DFA}}$  the set of states in the DFA  
Initially, we'll set  $\mathbf{S}_{\text{DFA}}$  to  $\{\}$

Add  $\mathbf{X}$  to  $\mathbf{S}_{\text{DFA}}$  where  $\mathbf{X}$  is some *set of* NFA states

Example: “Add  $\{\mathbf{3}, \mathbf{5}, \mathbf{7}\}$  to  $\mathbf{S}_{\text{DFA}}$ ”

We'll “mark” some of the states in the DFA.

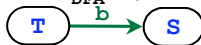
**Marked** = “We’ve done this one” (✓)

**Unmarked** = “Still need to do this one”

$\text{Move}_{\text{DFA}}(\mathbf{T}, \mathbf{b})$  The transition function from DFA

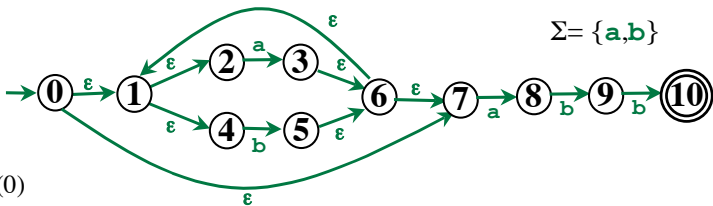
To add an edge to the growing DFA...

Set  $\text{Move}_{\text{DFA}}(\mathbf{T}, \mathbf{b})$  to  $\mathbf{S}$



...where  $\mathbf{S}$  and  $\mathbf{T}$  are sets of NFA states

## Example

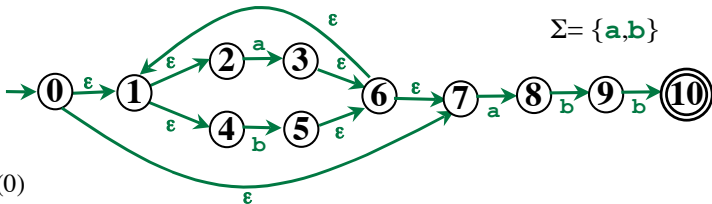


Start state:

$\epsilon$ -Closure (0)

=

## Example

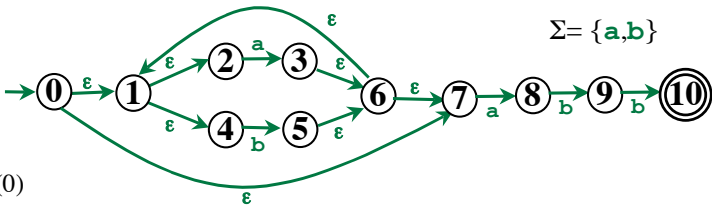


Start state:

$\epsilon$ -Closure (0)

$= \{0, 1, 2, 4, 7\}$

## Example

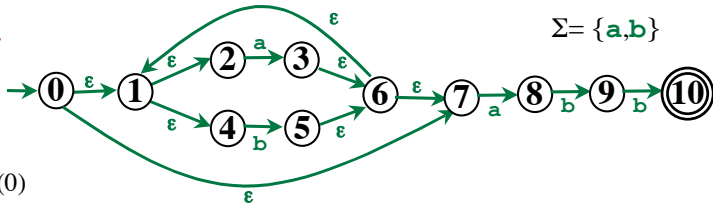


Start state:

$\epsilon$ -Closure (0)

$= \{0, 1, 2, 4, 7\} = A$

## Example



Start state:

$\epsilon$ -Closure (0)

$= \{0, 1, 2, 4, 7\} = A$

$\text{Move}_{\text{DFA}}(A, a)$

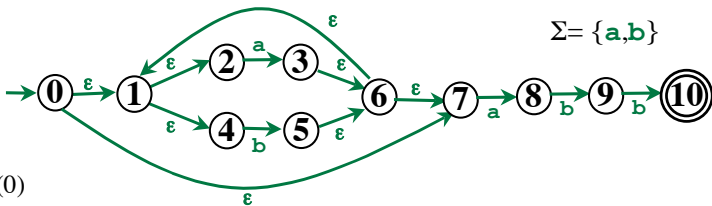
$=$

$\text{Move}_{\text{DFA}}(A, b)$

$=$



## Example



Start state:

$\epsilon$ -Closure (0)

$= \{0, 1, 2, 4, 7\} = A$

$\text{Move}_{\text{DFA}}(A, a)$

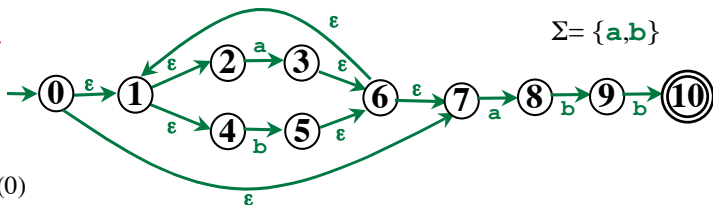
$= \epsilon\text{-Closure}(\text{Move}_{\text{NFA}}(A, a))$

$=$

$\text{Move}_{\text{DFA}}(A, b)$

$=$

## Example



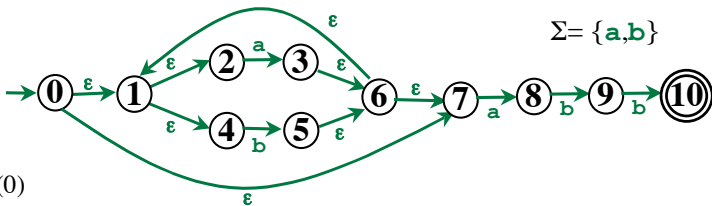
Start state:

$$\begin{aligned} &\epsilon\text{-Closure}(0) \\ &= \{0, 1, 2, 4, 7\} = A \end{aligned}$$

$$\begin{aligned} &\text{Move}_{\text{DFA}}(A, a) \\ &= \epsilon\text{-Closure}(\text{Move}_{\text{NFA}}(A, a)) \\ &= \epsilon\text{-Closure}(\{3, 8\}) \\ &= \end{aligned}$$

$$\begin{aligned} &\text{Move}_{\text{DFA}}(A, b) \\ &= \end{aligned}$$

## Example



Start state:

$\epsilon$ -Closure (0)

$= \{0, 1, 2, 4, 7\} = A$

$\text{Move}_{\text{DFA}}(A, a)$

$= \epsilon\text{-Closure}(\text{Move}_{\text{NFA}}(A, a))$

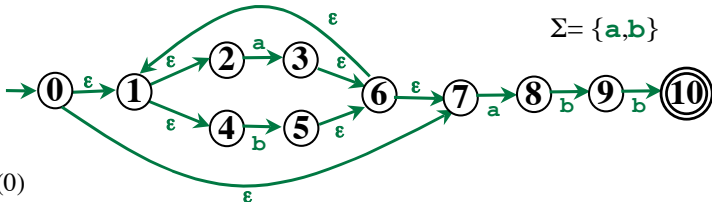
$= \epsilon\text{-Closure}(\{3, 8\})$

$= \{1, 2, 3, 4, 6, 7, 8\}$

$\text{Move}_{\text{DFA}}(A, b)$

$=$

## Example



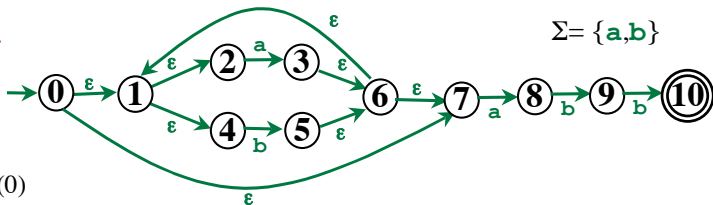
Start state:

$$\begin{aligned} &\epsilon\text{-Closure}(0) \\ &= \{0, 1, 2, 4, 7\} = A \end{aligned}$$

$$\begin{aligned} &\text{Move}_{\text{DFA}}(A, a) \\ &= \epsilon\text{-Closure}(\text{Move}_{\text{NFA}}(A, a)) \\ &= \epsilon\text{-Closure}(\{3, 8\}) \\ &= \{1, 2, 3, 4, 6, 7, 8\} = B \end{aligned}$$

$$\begin{aligned} &\text{Move}_{\text{DFA}}(A, b) \\ &= \end{aligned}$$

## Example



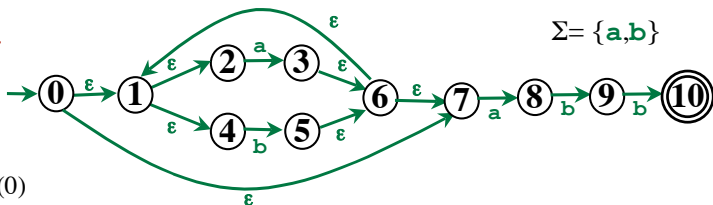
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$$\begin{aligned} &\text{Move}_{\text{DFA}}(A, b) \\ &= \epsilon\text{-Closure}(\text{Move}_{\text{NFA}}(A, b)) \\ &= \end{aligned}$$

## Example



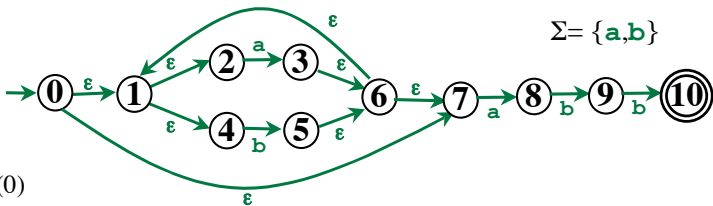
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$$\begin{aligned} &\text{Move}_{\text{DFA}}(A, b) \\ &= \epsilon\text{-Closure}(\text{Move}_{\text{NFA}}(A, b)) \\ &= \epsilon\text{-Closure}(\{5\}) \\ &= \end{aligned}$$

## Example



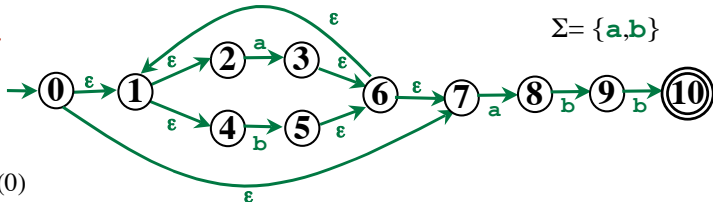
Start state:

$$\begin{aligned} &\epsilon\text{-Closure}(0) \\ &= \{0, 1, 2, 4, 7\} = A \end{aligned}$$

$$\begin{aligned} &\text{Move}_{\text{DFA}}(A, a) \\ &= \epsilon\text{-Closure}(\text{Move}_{\text{NFA}}(A, a)) \\ &= \epsilon\text{-Closure}(\{3, 8\}) \\ &= \{1, 2, 3, 4, 6, 7, 8\} = B \end{aligned}$$

$$\begin{aligned} &\text{Move}_{\text{DFA}}(A, b) \\ &= \epsilon\text{-Closure}(\text{Move}_{\text{NFA}}(A, b)) \\ &= \epsilon\text{-Closure}(\{5\}) \\ &= \{1, 2, 4, 5, 6, 7\} = C \end{aligned}$$

## Example

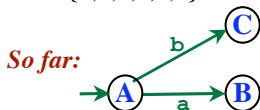


Start state:

$$\begin{aligned} &\epsilon\text{-Closure}(0) \\ &= \{0, 1, 2, 4, 7\} = A \end{aligned}$$

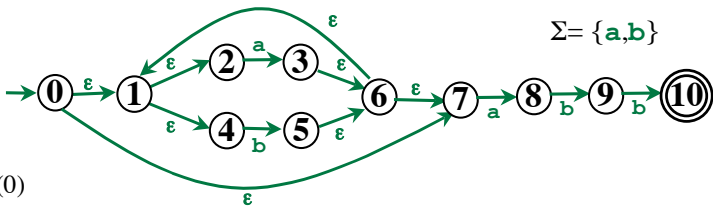
$$\begin{aligned} &\text{Move}_{\text{DFA}}(A, a) \\ &= \epsilon\text{-Closure}(\text{Move}_{\text{NFA}}(A, a)) \\ &= \epsilon\text{-Closure}(\{3, 8\}) \\ &= \{1, 2, 3, 4, 6, 7, 8\} = B \end{aligned}$$

$$\begin{aligned} &\text{Move}_{\text{DFA}}(A, b) \\ &= \epsilon\text{-Closure}(\text{Move}_{\text{NFA}}(A, b)) \\ &= \epsilon\text{-Closure}(\{5\}) \\ &= \{1, 2, 4, 5, 6, 7\} = C \end{aligned}$$





## Example

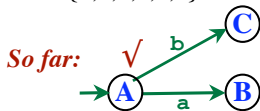


Start state:

$\epsilon$ -Closure (0)  
 $= \{0, 1, 2, 4, 7\} = A$

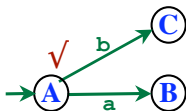
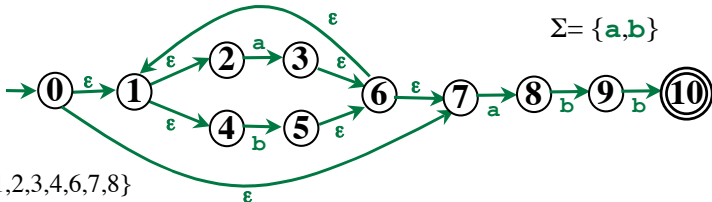
$\text{Move}_{\text{DFA}}(A, a)$   
 $= \epsilon\text{-Closure}(\text{Move}_{\text{NFA}}(A, a))$   
 $= \epsilon\text{-Closure}(\{3, 8\})$   
 $= \{1, 2, 3, 4, 6, 7, 8\} = B$

$\text{Move}_{\text{DFA}}(A, b)$   
 $= \epsilon\text{-Closure}(\text{Move}_{\text{NFA}}(A, b))$   
 $= \epsilon\text{-Closure}(\{5\})$   
 $= \{1, 2, 4, 5, 6, 7\} = C$

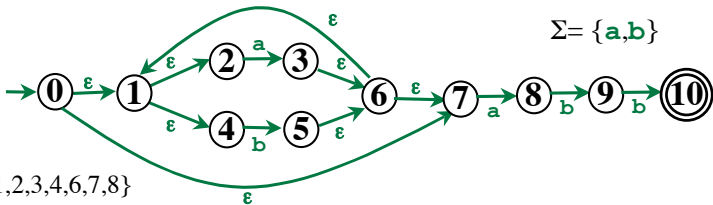


A is now done; mark it!  
B and C are unmarked.  
Let's do B next...

## Example



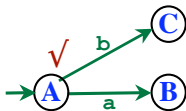
## Example



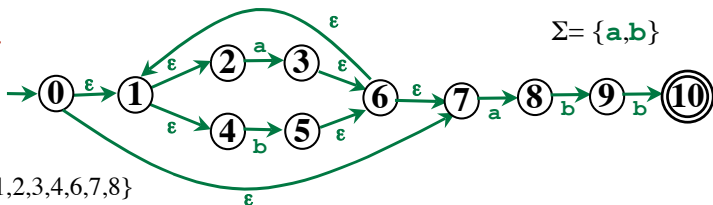
Process  $B = \{1, 2, 3, 4, 6, 7, 8\}$

$\text{Move}_{\text{DFA}}(B, a)$

=

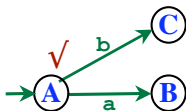


## Example

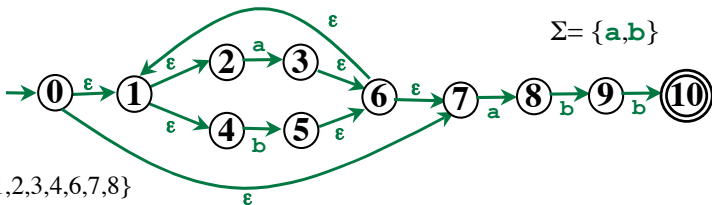


Process  $B = \{1, 2, 3, 4, 6, 7, 8\}$

$\text{Move}_{\text{DFA}}(B, a)$   
 $= \epsilon\text{-Closure}(\text{Move}_{\text{NFA}}(B, a))$   
 $=$

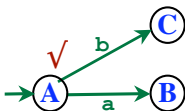


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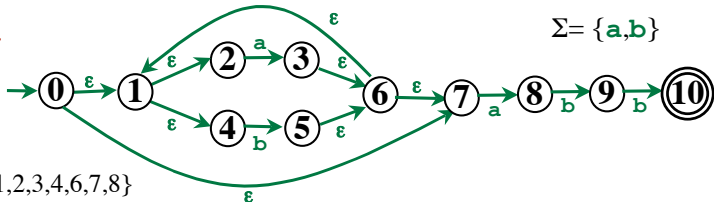


Process  $B = \{1, 2, 3, 4, 6, 7, 8\}$

$\text{Move}_{\text{DFA}}(B, a)$   
 $= \epsilon\text{-Closure}(\text{Move}_{\text{NFA}}(B, a))$   
 $= \epsilon\text{-Closure}(\{3, 8\})$   
 $=$



## Example



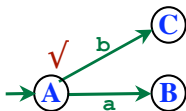
Process  $B = \{1, 2, 3, 4, 6, 7, 8\}$

$\text{Move}_{\text{DFA}}(B, a)$

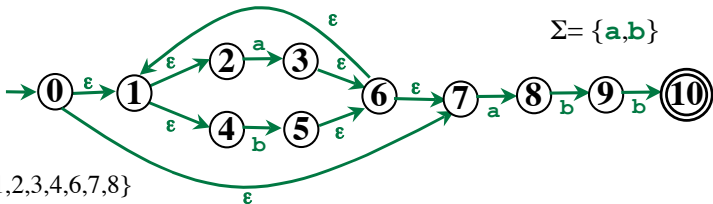
$= \varepsilon\text{-Closure}(\text{Move}_{\text{NFA}}(B, a))$

$= \varepsilon\text{-Closure}(\{3, 8\})$

$= \{1, 2, 3, 4, 6, 7, 8\} = B$

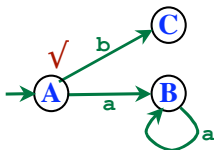


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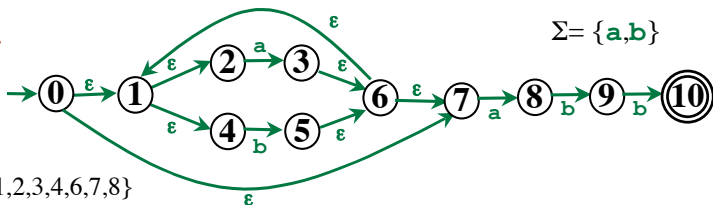


Process  $B = \{1, 2, 3, 4, 6, 7, 8\}$

$\text{Move}_{\text{DFA}}(B, a)$   
=  $\epsilon\text{-Closure}(\text{Move}_{\text{NFA}}(B, a))$   
=  $\epsilon\text{-Closure}(\{3, 8\})$   
=  $\{1, 2, 3, 4, 6, 7, 8\} = B$



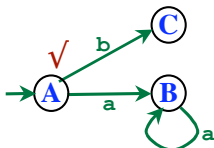
## Example



Process  $B = \{1, 2, 3, 4, 6, 7, 8\}$

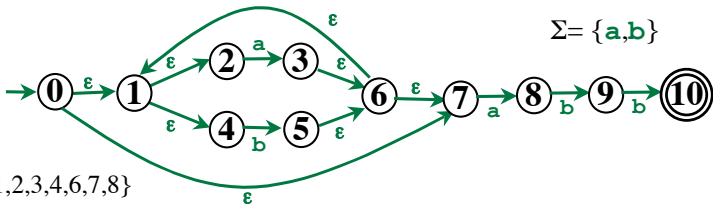
$\text{Move}_{\text{DFA}}(B, a)$   
 $= \varepsilon\text{-Closure}(\text{Move}_{\text{NFA}}(B, a))$   
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 $= \{1, 2, 3, 4, 6, 7, 8\} = B$

$\text{Move}_{\text{DFA}}(B, b)$   
 $=$





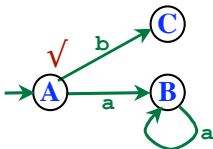
## Example



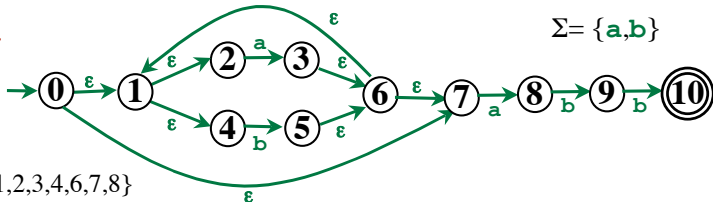
Process  $B = \{1, 2, 3, 4, 6, 7, 8\}$

$\text{Move}_{\text{DFA}}(B, a)$   
=  $\epsilon\text{-Closure}(\text{Move}_{\text{NFA}}(B, a))$   
=  $\epsilon\text{-Closure}(\{3, 8\})$   
=  $\{1, 2, 3, 4, 6, 7, 8\} = B$

$\text{Move}_{\text{DFA}}(B, b)$   
=  $\epsilon\text{-Closure}(\text{Move}_{\text{NFA}}(B, b))$   
=



## Example



Process  $B = \{1, 2, 3, 4, 6, 7, 8\}$

$\text{Move}_{\text{DFA}}(B, a)$

$= \epsilon\text{-Closure}(\text{Move}_{\text{NFA}}(B, a))$

$= \epsilon\text{-Closure}(\{3, 8\})$

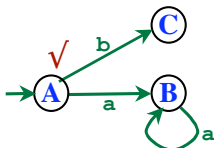
$= \{1, 2, 3, 4, 6, 7, 8\} = B$

$\text{Move}_{\text{DFA}}(B, b)$

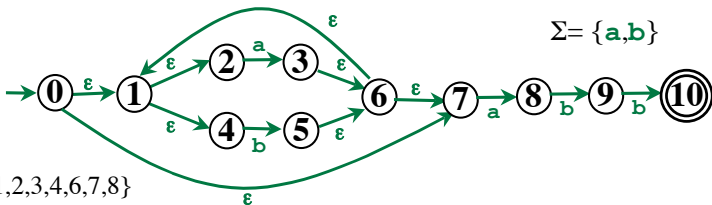
$= \epsilon\text{-Closure}(\text{Move}_{\text{NFA}}(B, b))$

$= \epsilon\text{-Closure}(\{5, 9\})$

$=$



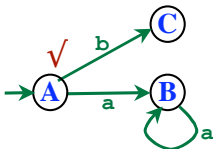
## Example



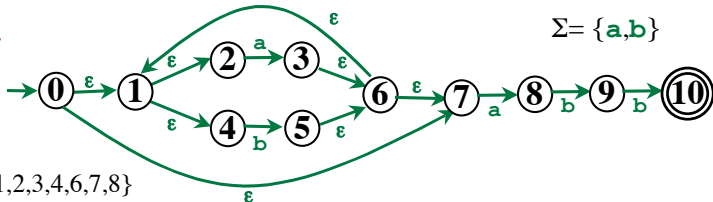
Process  $B = \{1, 2, 3, 4, 6, 7, 8\}$

$\text{Move}_{\text{DFA}}(B, a)$   
=  $\epsilon\text{-Closure}(\text{Move}_{\text{NFA}}(B, a))$   
=  $\epsilon\text{-Closure}(\{3, 8\})$   
=  $\{1, 2, 3, 4, 6, 7, 8\} = B$

$\text{Move}_{\text{DFA}}(B, b)$   
=  $\epsilon\text{-Closure}(\text{Move}_{\text{NFA}}(B, b))$   
=  $\epsilon\text{-Closure}(\{5, 9\})$   
=  $\{1, 2, 4, 5, 6, 7, 9\} = D$



## Example



Process  $B = \{1, 2, 3, 4, 6, 7, 8\}$

$\text{Move}_{\text{DFA}}(B, a)$

$= \epsilon\text{-Closure}(\text{Move}_{\text{NFA}}(B, a))$

$= \epsilon\text{-Closure}(\{3, 8\})$

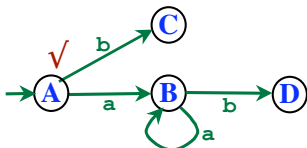
$= \{1, 2, 3, 4, 6, 7, 8\} = B$

$\text{Move}_{\text{DFA}}(B, b)$

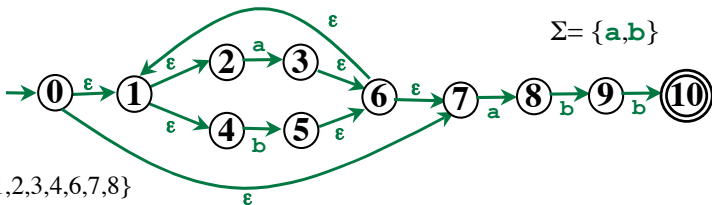
$= \epsilon\text{-Closure}(\text{Move}_{\text{NFA}}(B, b))$

$= \epsilon\text{-Closure}(\{5, 9\})$

$= \{1, 2, 4, 5, 6, 7, 9\} = D$



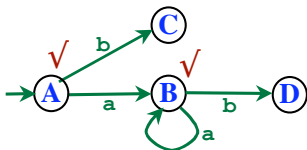
## Example



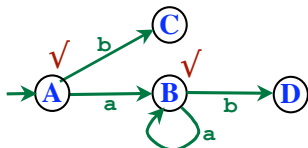
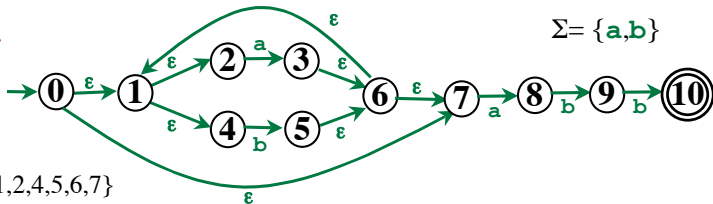
Process  $B = \{1, 2, 3, 4, 6, 7, 8\}$

$\text{Move}_{\text{DFA}}(B, a)$   
=  $\epsilon\text{-Closure}(\text{Move}_{\text{NFA}}(B, a))$   
=  $\epsilon\text{-Closure}(\{3, 8\})$   
=  $\{1, 2, 3, 4, 6, 7, 8\} = B$

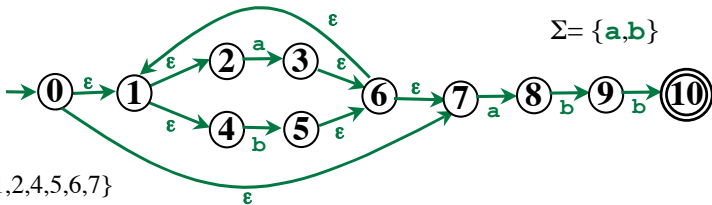
$\text{Move}_{\text{DFA}}(B, b)$   
=  $\epsilon\text{-Closure}(\text{Move}_{\text{NFA}}(B, b))$   
=  $\epsilon\text{-Closure}(\{5, 9\})$   
=  $\{1, 2, 4, 5, 6, 7, 9\} = D$



## Example



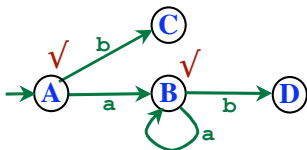
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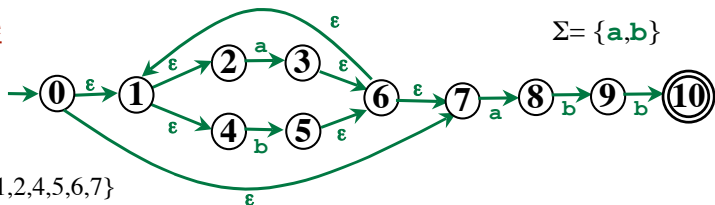
Process  $C = \{1, 2, 4, 5, 6, 7\}$

$\text{Move}_{\text{DFA}}(C, a) =$

$\text{Move}_{\text{DFA}}(C, b) =$



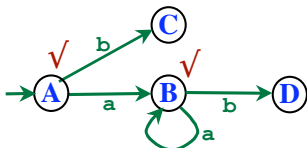
## Example



Process  $C = \{1, 2, 4, 5, 6, 7\}$

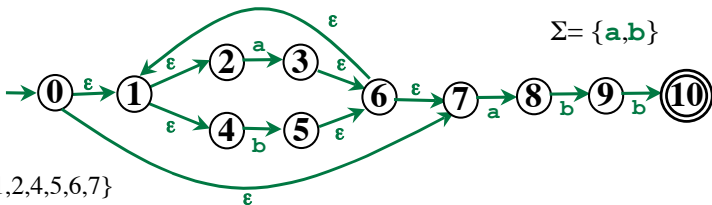
$\text{Move}_{\text{DFA}}(C, a) = \{1, 2, 3, 4, 6, 7, 8\} = B$

$\text{Move}_{\text{DFA}}(C, b) =$





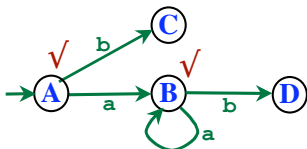
## Example



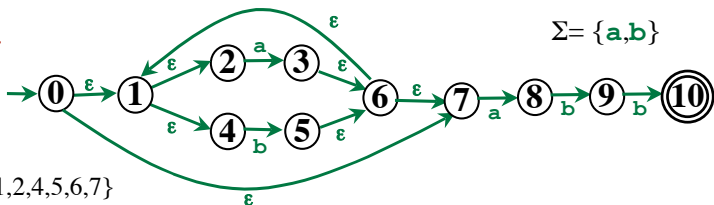
Process  $C = \{1, 2, 4, 5, 6, 7\}$

$\text{Move}_{\text{DFA}}(C, a) = \{1, 2, 3, 4, 6, 7, 8\} = B$

$\text{Move}_{\text{DFA}}(C, b) = \{1, 2, 4, 5, 6, 7\} = C$



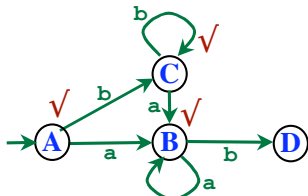
## Example



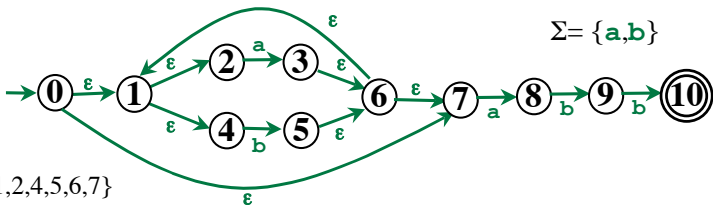
Process  $C = \{1, 2, 4, 5, 6, 7\}$

$\text{Move}_{\text{DFA}}(C, a) = \{1, 2, 3, 4, 6, 7, 8\} = B$

$\text{Move}_{\text{DFA}}(C, b) = \{1, 2, 4, 5, 6, 7\} = C$



## Example



Process  $C = \{1, 2, 4, 5, 6, 7\}$

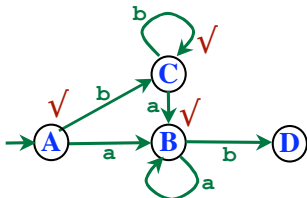
$$\text{Move}_{\text{DFA}}(C, a) = \{1, 2, 3, 4, 6, 7, 8\} = B$$

$$\text{Move}_{\text{DFA}}(C, b) = \{1, 2, 4, 5, 6, 7\} = C$$

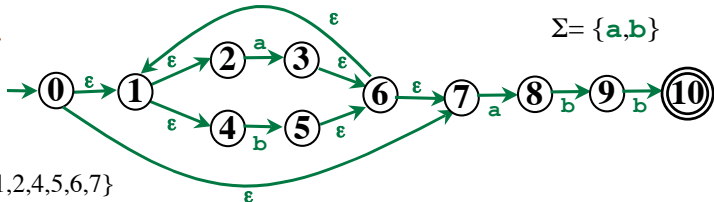
Process  $D = \{1, 2, 4, 5, 6, 7, 9\}$

$$\text{Move}_{\text{DFA}}(D, a) =$$

$$\text{Move}_{\text{DFA}}(D, b) =$$



## Example



Process  $C = \{1, 2, 4, 5, 6, 7\}$

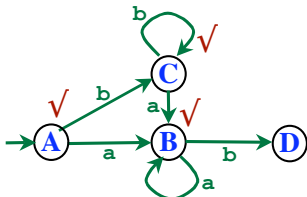
$$\text{Move}_{\text{DFA}}(C, a) = \{1, 2, 3, 4, 6, 7, 8\} = B$$

$$\text{Move}_{\text{DFA}}(C, b) = \{1, 2, 4, 5, 6, 7\} = C$$

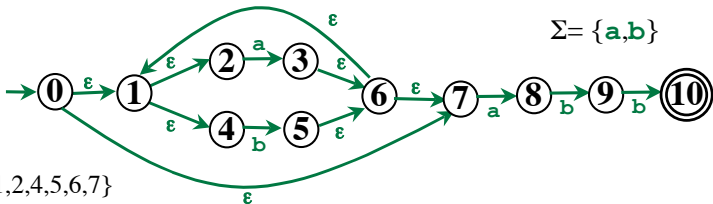
Process  $D = \{1, 2, 4, 5, 6, 7, 9\}$

$$\text{Move}_{\text{DFA}}(D, a) = \{1, 2, 3, 4, 6, 7, 8\} = B$$

$$\text{Move}_{\text{DFA}}(D, b) =$$



## Example



Process  $C = \{1, 2, 4, 5, 6, 7\}$

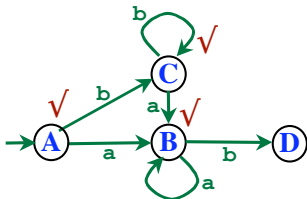
$\text{Move}_{\text{DFA}}(C, a) = \{1, 2, 3, 4, 6, 7, 8\} = B$

$\text{Move}_{\text{DFA}}(C, b) = \{1, 2, 4, 5, 6, 7\} = C$

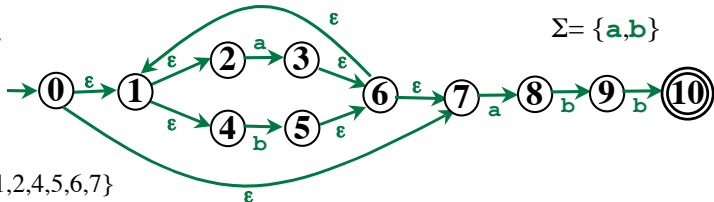
Process  $D = \{1, 2, 4, 5, 6, 7, 9\}$

$\text{Move}_{\text{DFA}}(D, a) = \{1, 2, 3, 4, 6, 7, 8\} = B$

$\text{Move}_{\text{DFA}}(D, b) = \{1, 2, 4, 5, 6, 7, 10\} = E$



## Example



Process  $C = \{1, 2, 4, 5, 6, 7\}$

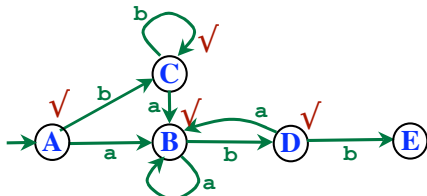
$\text{Move}_{\text{DFA}}(C, a) = \{1, 2, 3, 4, 6, 7, 8\} = B$

$\text{Move}_{\text{DFA}}(C, b) = \{1, 2, 4, 5, 6, 7\} = C$

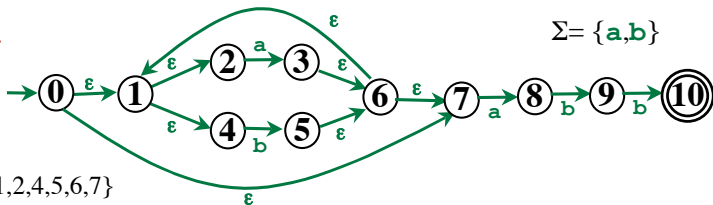
Process  $D = \{1, 2, 4, 5, 6, 7, 9\}$

$\text{Move}_{\text{DFA}}(D, a) = \{1, 2, 3, 4, 6, 7, 8\} = B$

$\text{Move}_{\text{DFA}}(D, b) = \{1, 2, 4, 5, 6, 7, 10\} = E$



## Example



Process  $C = \{1, 2, 4, 5, 6, 7\}$

$\text{Move}_{\text{DFA}}(C, a) = \{1, 2, 3, 4, 6, 7, 8\} = B$

$\text{Move}_{\text{DFA}}(C, b) = \{1, 2, 4, 5, 6, 7\} = C$

Process  $D = \{1, 2, 4, 5, 6, 7, 9\}$

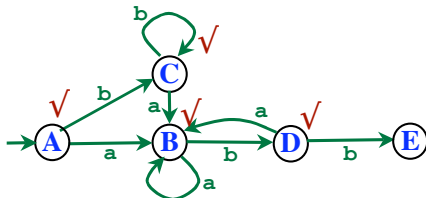
$\text{Move}_{\text{DFA}}(D, a) = \{1, 2, 3, 4, 6, 7, 8\} = B$

$\text{Move}_{\text{DFA}}(D, b) = \{1, 2, 4, 5, 6, 7, 10\} = E$

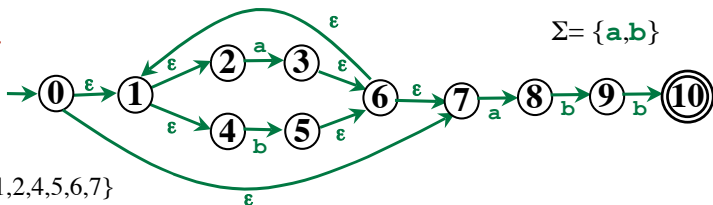
Process  $E = \{1, 2, 4, 5, 6, 7, 10\}$

$\text{Move}_{\text{DFA}}(E, a) =$

$\text{Move}_{\text{DFA}}(E, b) =$



## Example



Process  $C = \{1, 2, 4, 5, 6, 7\}$

$\text{Move}_{\text{DFA}}(C, a) = \{1, 2, 3, 4, 6, 7, 8\} = B$

$\text{Move}_{\text{DFA}}(C, b) = \{1, 2, 4, 5, 6, 7\} = C$

Process  $D = \{1, 2, 4, 5, 6, 7, 9\}$

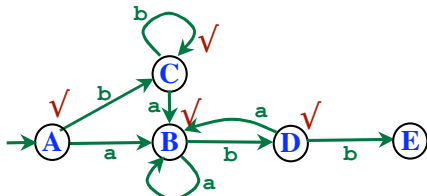
$\text{Move}_{\text{DFA}}(D, a) = \{1, 2, 3, 4, 6, 7, 8\} = B$

$\text{Move}_{\text{DFA}}(D, b) = \{1, 2, 4, 5, 6, 7, 10\} = E$

Process  $E = \{1, 2, 4, 5, 6, 7, 10\}$

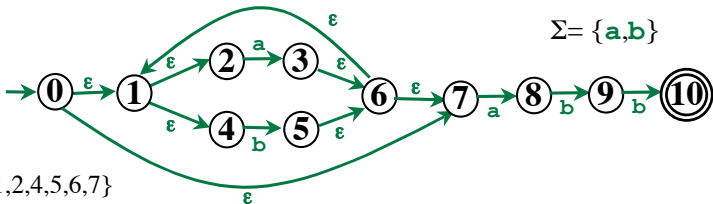
$\text{Move}_{\text{DFA}}(E, a) = \{1, 2, 3, 4, 6, 7, 8\} = B$

$\text{Move}_{\text{DFA}}(E, b) =$





## Example



Process  $C = \{1, 2, 4, 5, 6, 7\}$

$\text{Move}_{\text{DFA}}(C, a) = \{1, 2, 3, 4, 6, 7, 8\} = B$

$\text{Move}_{\text{DFA}}(C, b) = \{1, 2, 4, 5, 6, 7\} = C$

Process  $D = \{1, 2, 4, 5, 6, 7, 9\}$

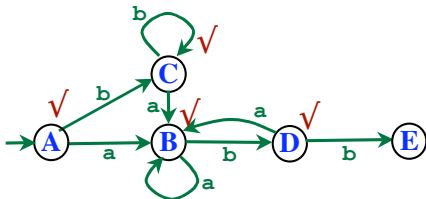
$\text{Move}_{\text{DFA}}(D, a) = \{1, 2, 3, 4, 6, 7, 8\} = B$

$\text{Move}_{\text{DFA}}(D, b) = \{1, 2, 4, 5, 6, 7, 10\} = E$

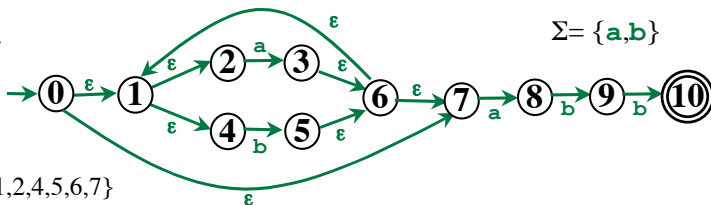
Process  $E = \{1, 2, 4, 5, 6, 7, 10\}$

$\text{Move}_{\text{DFA}}(E, a) = \{1, 2, 3, 4, 6, 7, 8\} = B$

$\text{Move}_{\text{DFA}}(E, b) = \{1, 2, 4, 5, 6, 7\} = C$



## Example



Process  $C = \{1, 2, 4, 5, 6, 7\}$

$\text{Move}_{\text{DFA}}(C, a) = \{1, 2, 3, 4, 6, 7, 8\} = B$

$\text{Move}_{\text{DFA}}(C, b) = \{1, 2, 4, 5, 6, 7\} = C$

Process  $D = \{1, 2, 4, 5, 6, 7, 9\}$

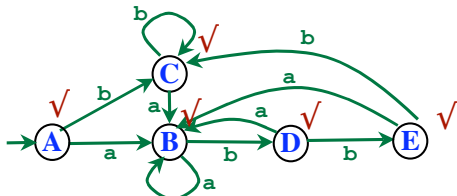
$\text{Move}_{\text{DFA}}(D, a) = \{1, 2, 3, 4, 6, 7, 8\} = B$

$\text{Move}_{\text{DFA}}(D, b) = \{1, 2, 4, 5, 6, 7, 10\} = E$

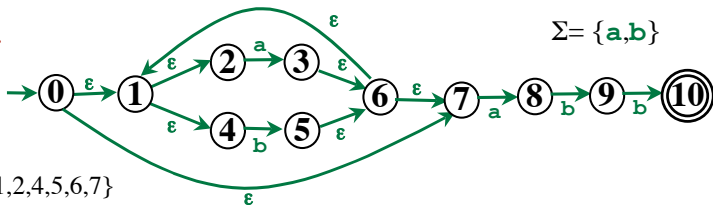
Process  $E = \{1, 2, 4, 5, 6, 7, 10\}$

$\text{Move}_{\text{DFA}}(E, a) = \{1, 2, 3, 4, 6, 7, 8\} = B$

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## Example



Process  $C = \{1, 2, 4, 5, 6, 7\}$

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Process  $D = \{1, 2, 4, 5, 6, 7, 9\}$

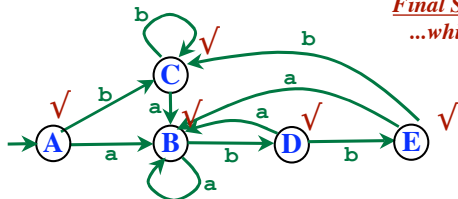
$\text{Move}_{\text{DFA}}(D, a) = \{1, 2, 3, 4, 6, 7, 8\} = B$

$\text{Move}_{\text{DFA}}(D, b) = \{1, 2, 4, 5, 6, 7, 10\} = E$

Process  $E = \{1, 2, 4, 5, 6, 7, 10\}$

$\text{Move}_{\text{DFA}}(E, a) = \{1, 2, 3, 4, 6, 7, 8\} = B$

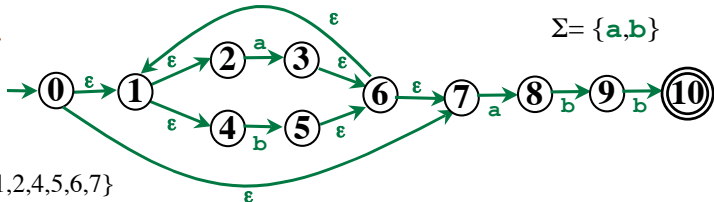
$\text{Move}_{\text{DFA}}(E, b) = \{1, 2, 4, 5, 6, 7\} = C$



Final States in DFA?

*...which state(s) contain 10?*

## Example



Process  $C = \{1, 2, 4, 5, 6, 7\}$

$\text{Move}_{\text{DFA}}(C, a) = \{1, 2, 3, 4, 6, 7, 8\} = B$

$\text{Move}_{\text{DFA}}(C, b) = \{1, 2, 4, 5, 6, 7\} = C$

Process  $D = \{1, 2, 4, 5, 6, 7, 9\}$

$\text{Move}_{\text{DFA}}(D, a) = \{1, 2, 3, 4, 6, 7, 8\} = B$

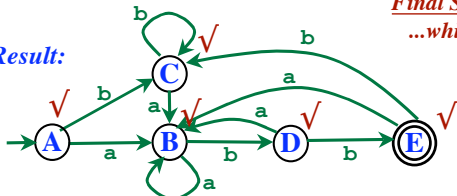
$\text{Move}_{\text{DFA}}(D, b) = \{1, 2, 4, 5, 6, 7, 10\} = E$

Process  $E = \{1, 2, 4, 5, 6, 7, 10\}$

$\text{Move}_{\text{DFA}}(E, a) = \{1, 2, 3, 4, 6, 7, 8\} = B$

$\text{Move}_{\text{DFA}}(E, b) = \{1, 2, 4, 5, 6, 7\} = C$

**Final Result:**



Final States in DFA?

...which state(s) contain 10?

## Algorithm: Convert NFA to DFA

$S_{DFA} = \{\}$

Add  $\epsilon$ -Closure( $s_0$ ) to  $S_{DFA}$  as the start state

Set the only state in  $S_{DFA}$  to "unmarked"

while  $S_{DFA}$  contains an unmarked state do

Let **T** be that unmarked state

*A set of NFA states*

Mark **T**

for each **a** in  $\Sigma$  do

**S** =  $\epsilon$ -Closure(Move<sub>NFA</sub>(**T**, **a**))

*Everywhere you could possibly get to on an **a***

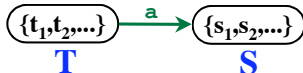
if **S** is not in  $S_{DFA}$  already then

Add **S** to  $S_{DFA}$  (as an "unmarked" state)

endIf

Set Move<sub>DFA</sub>(**T**, **a**) to **S**

*i.e., add an edge to the DFA...*



endFor

endWhile

for each **S** in  $S_{DFA}$  do

if any  $s \in S$  is a final state in the NFA then

Mark **S** as a final state in the DFA

endIf

endFor