

Nondeterministic Finite Automaton (NFA)

Definition: An NFA is a TG with a unique start state and a property of having single letter as label of transitions. An NFA is a collection of three things

- 1) Finite many states with one initial and some final states
- 2) Finite set of input letters, say, $\Sigma = \{a, b, c\}$
- 3) Finite set of transitions, showing where to move if a letter is input at certain state (λ is not a valid transition), there may be more than one transition for certain letters and there may not be any transition for certain letters.

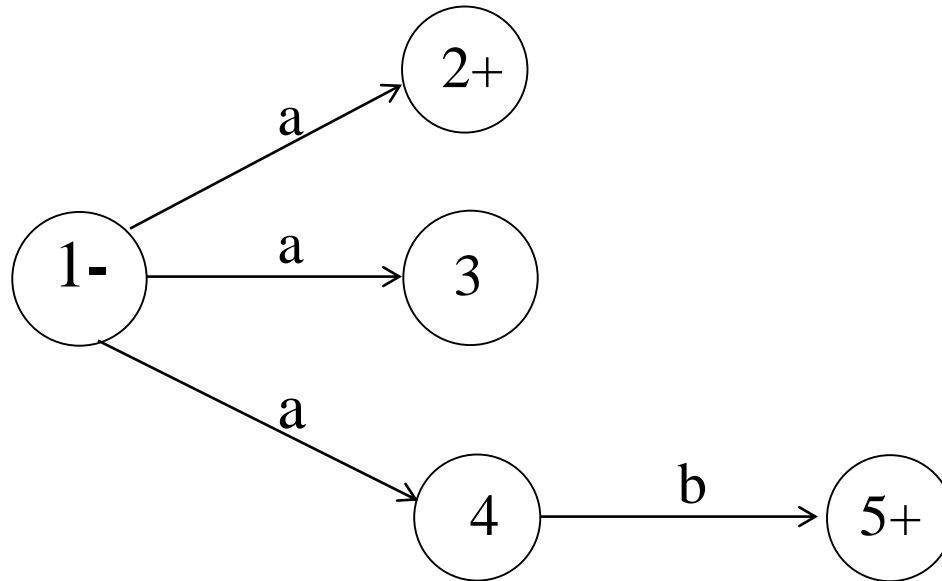
Observations

It may be observed, from the definition of NFA, that the string is supposed to be accepted, if there exists at least one successful path, otherwise rejected.

It is to be noted that an NFA can be considered to be an intermediate structure between FA and TG.

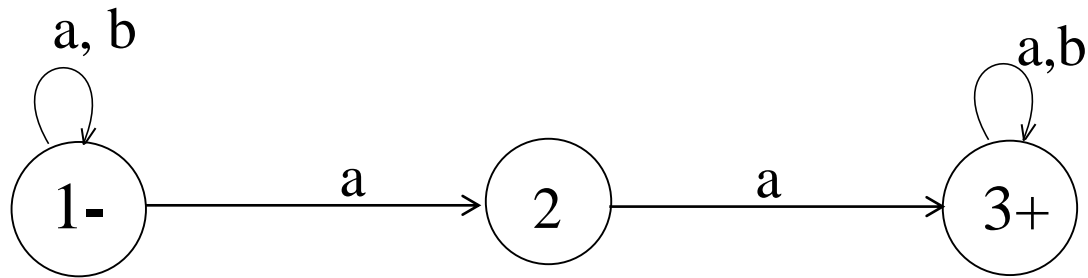
The examples of NFAs can be found in the following

Example



It is to be noted that the above NFA accepts the language consisting of a and ab .

Example



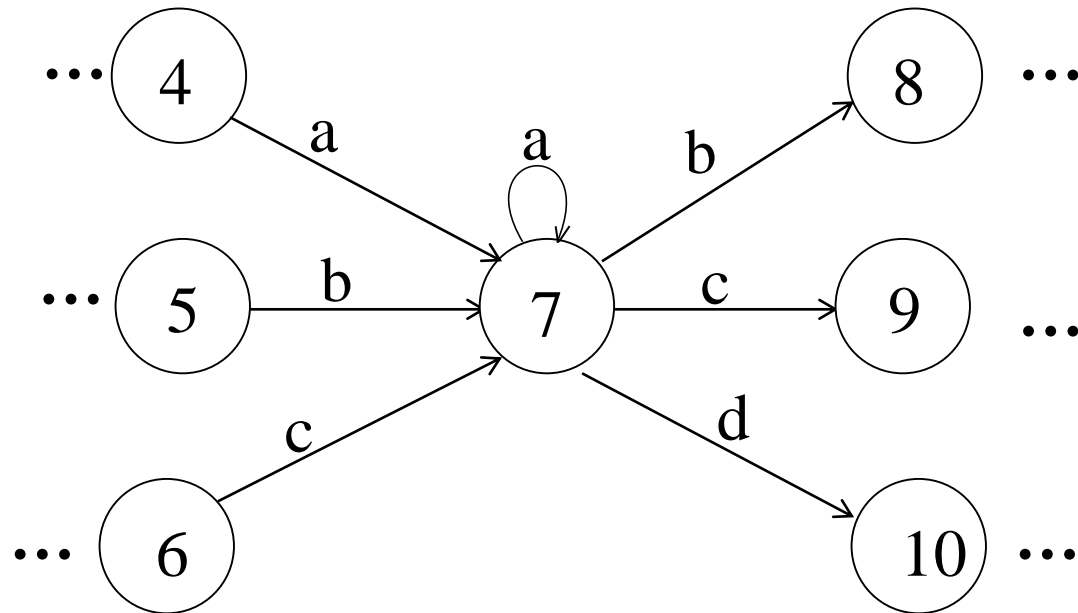
It is to be noted that the above NFA accepts the language of strings, defined over $\Sigma = \{a, b\}$, containing aa .

Note

- It is to be noted that NFA helps to eliminate a loop at certain state of an FA. This process is done converting the loop into a circuit. But during this process the FA remains no longer FA and is converted to a corresponding NFA, which is shown in the following example.

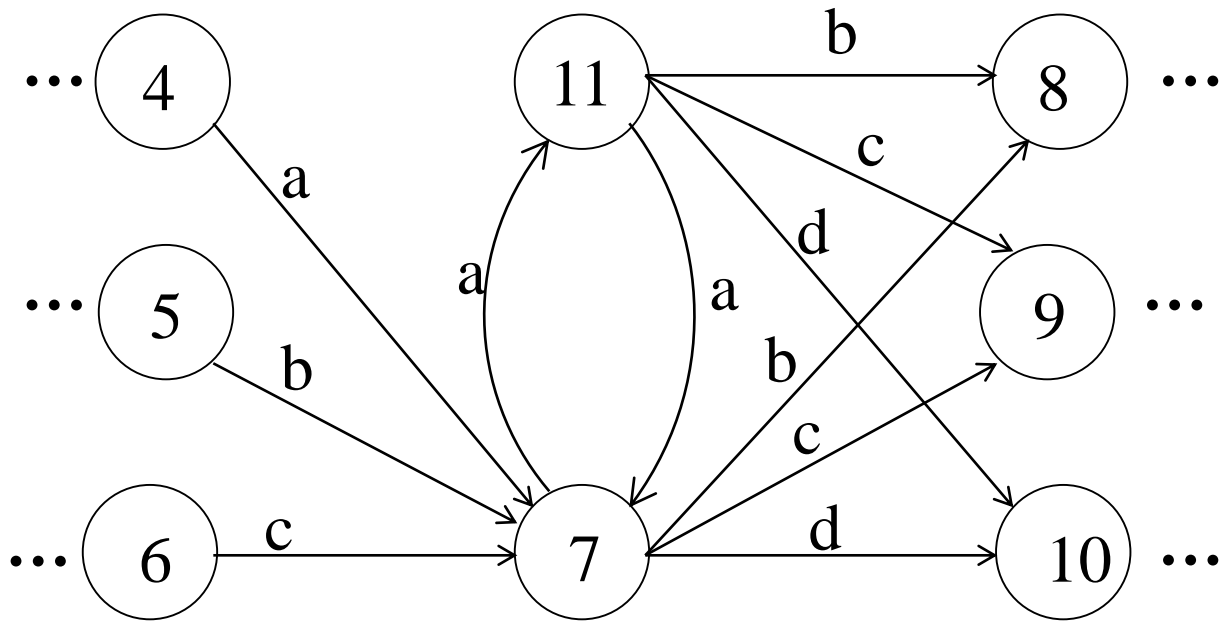
Example

- Consider a part of the following FA with an alphabet $\Sigma = \{a, b, c, d\}$



To eliminate the loop at state 7, the corresponding NFA may be as follows

Example continued ...



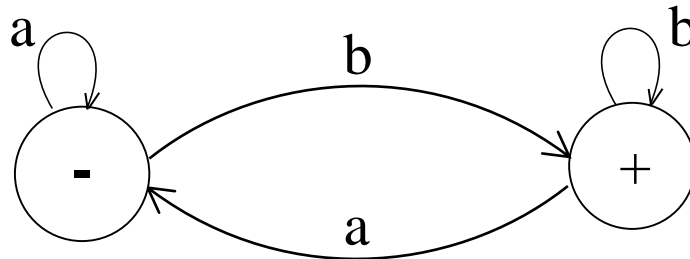
Converting an FA to an equivalent NFA

- It is to be noted that according to the Kleene's theorem, if a language can be accepted by an FA, then there exists a TG accepting that language. Since, an NFA is a TG as well, therefore there exists an NFA accepting the language accepted by the given FA. In this case these FA and NFA are said to be equivalent to each others.

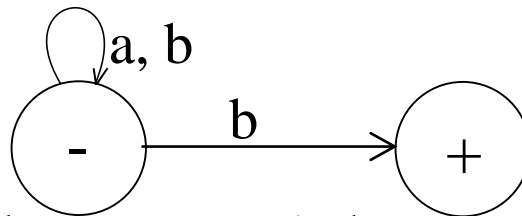
Following are the examples of FAs to be converted to the equivalent NFAs

Example

- Consider the following FA corresponding to $(a+b)^*b$



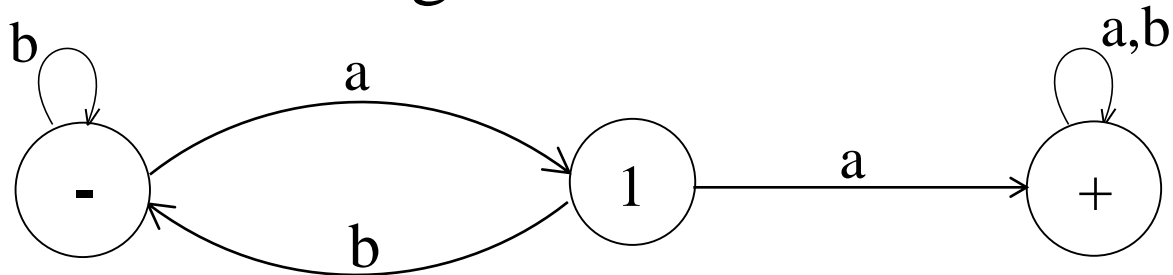
- The above FA may be equivalent to the following NFA



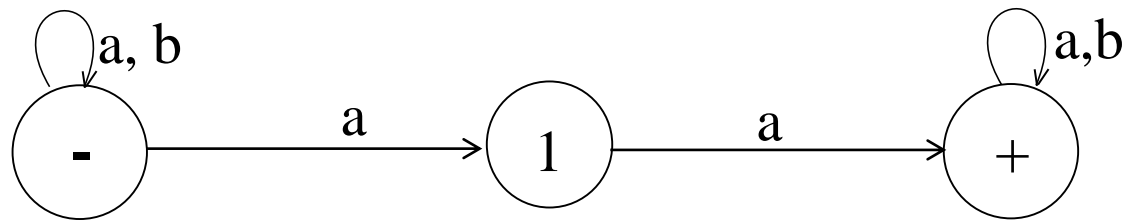
Can the structure of above NFA be compared with the corresponding RE ?

Example

- Consider the following FA



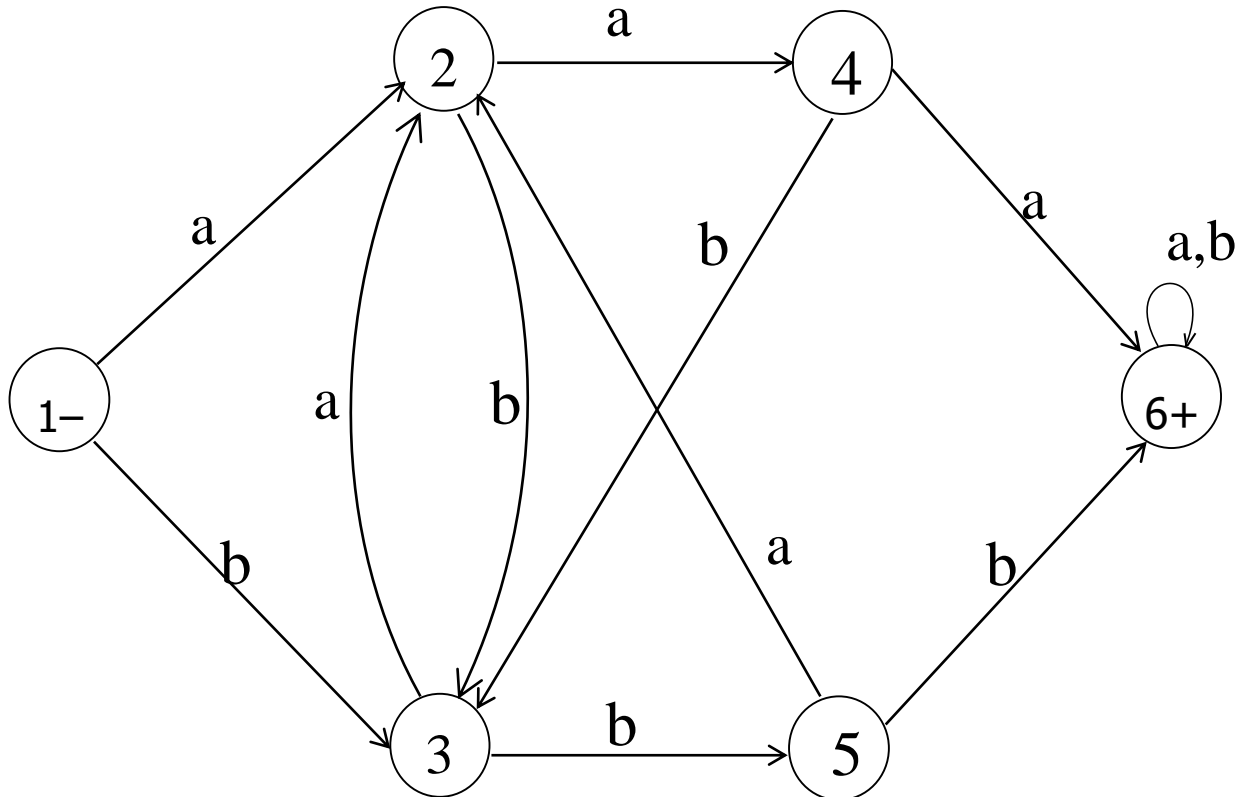
- The above FA may be equivalent to the following NFA



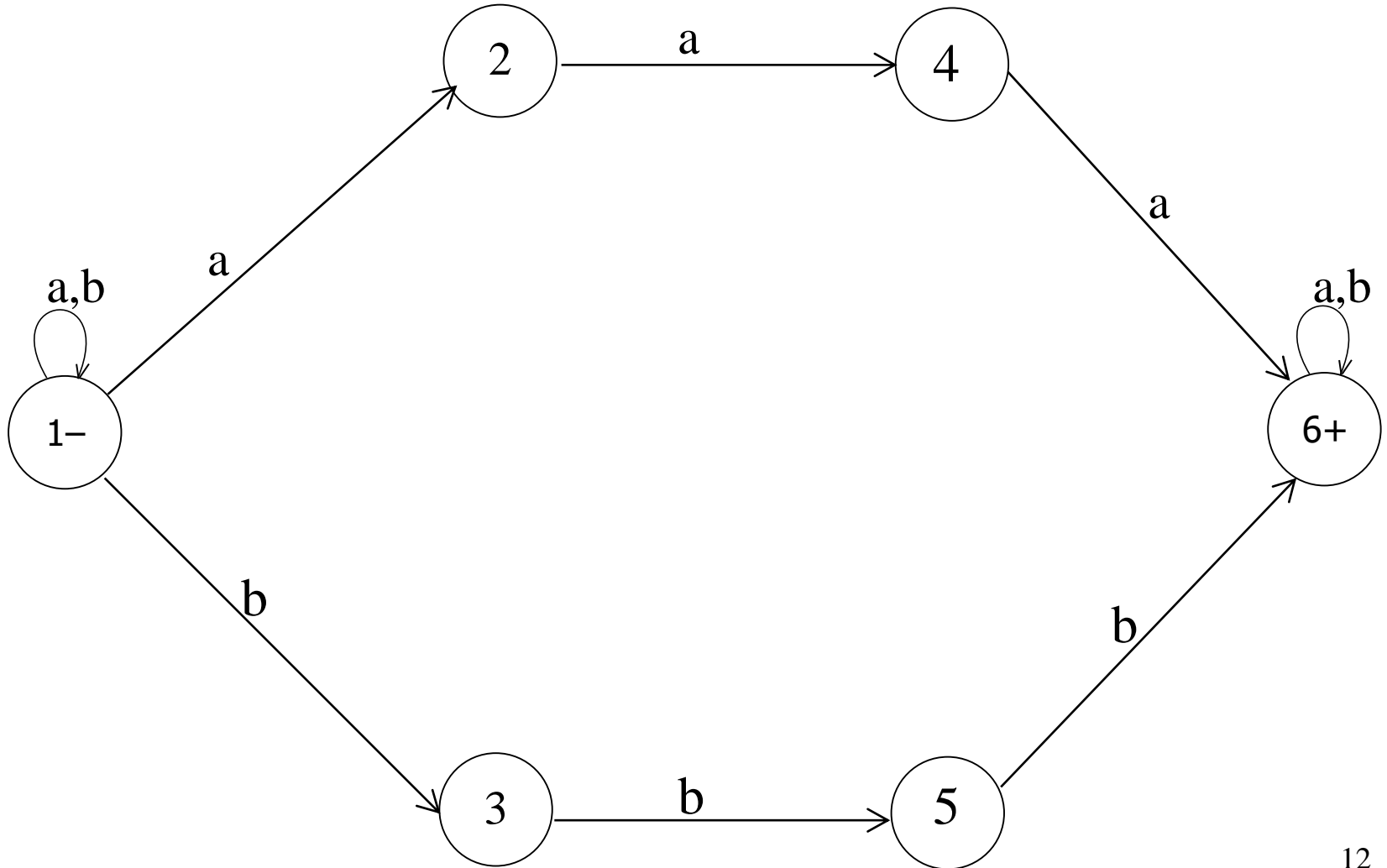
- Can the structure of above NFA be compared with the corresponding RE ?

Task

Build an NFA equivalent to the following FA



Solution of the Task



Application of an NFA

- There is an important application of an NFA in artificial intelligence, which is discussed in the following example of a maze

-	1	2	3
4	L	5	O
6	M	7	P
8	N	9	+

Summing Up

- Examples of Kleene's theorem part III (method 3), NFA, examples, avoiding loop using NFA, example, converting FA to NFA, examples, applying an NFA on an example of maze