LEX4: Regexps as Automata

Lexical Analysis

CMPT 379: Compilers

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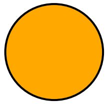
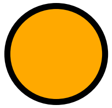
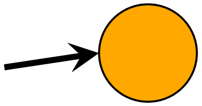
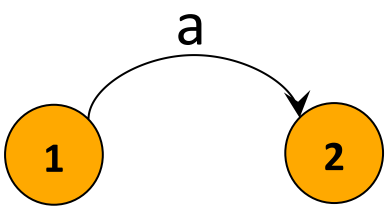
anoopsarkar.github.io/compilers-class

Regular Expressions

- To describe all lexemes that form a token as a *pattern*
- Need decision procedure: $s \in L(R)$ whether the given sequence of characters belongs to L(R) ?
  - Finite State Automata
  - Can be deterministic (DFA) or non-deterministic (NFA)

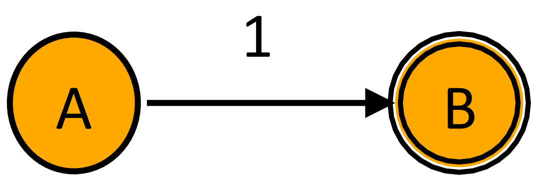
Finite State Automata

- An alphabet ∑ of input symbols
- A finite set of states S 
  - One start state q_0 
  - zero or more final (accepting) states F 
- A transition function:
  - δ: S x $\Sigma \Rightarrow$ S 
- Example: $\delta(1, a) = 2$



FA: Example

- A finite automaton that accepts only ‘1’

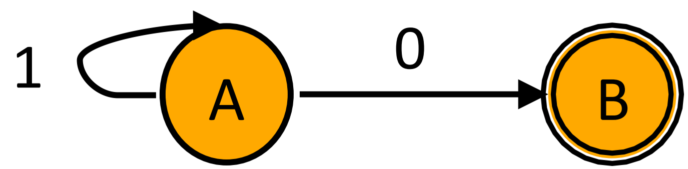


Language of a FA: set of accepted strings

state	input	
A	1	
B	1	Accept
A	0	Reject
A	1 0	
B	1 0	Reject

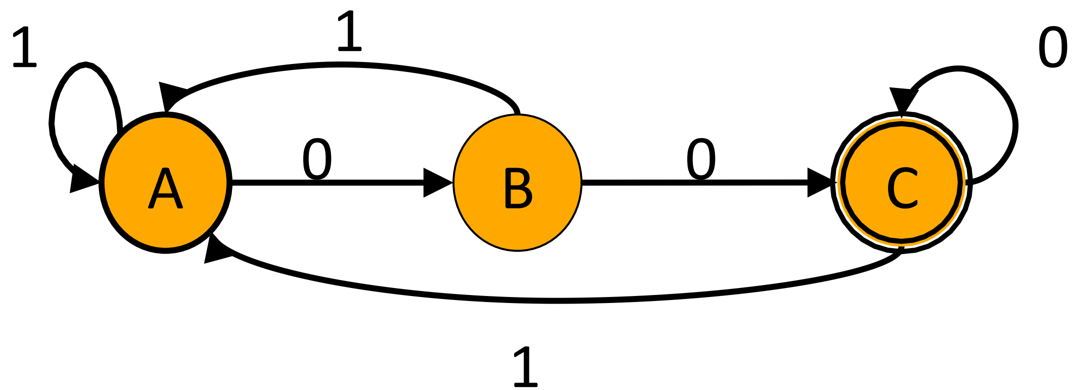
FA: Example

- A finite automaton accepting any number of 1's followed by a single 0



FA: Example

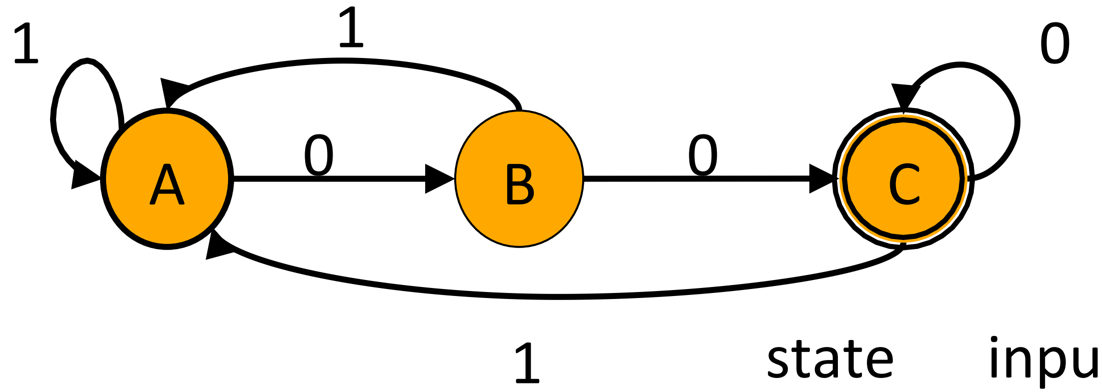
- What regular expression does this automaton accept?



A: start state
C: final state

Answer: (0|1)*00

FA simulation



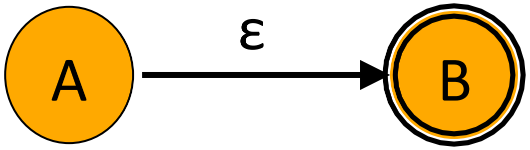
Input string: 00100

state	input
A	00100
B	00100
C	00100
A	00100
B	00100
C	00100

Accept

ε-move

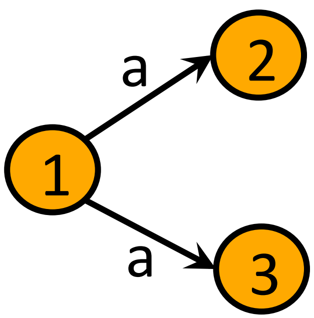
- Another kind of transition: ε-moves



state	input
A	$x_1 x_2 x_3$
B	$x_1 x_2 x_3$

Deterministic Finite Automata (DFA)

- One transition per input per state

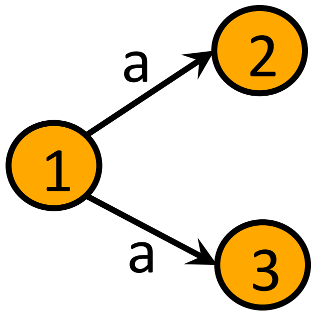


Invalid

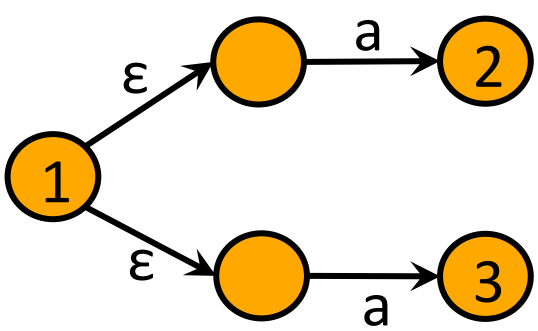
- No ε-moves

Nondeterministic Finite State Automata (NFA)

- Can have multiple transitions for one input in a given state

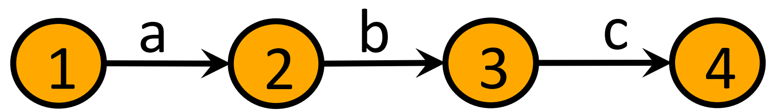


- Can have ε-moves

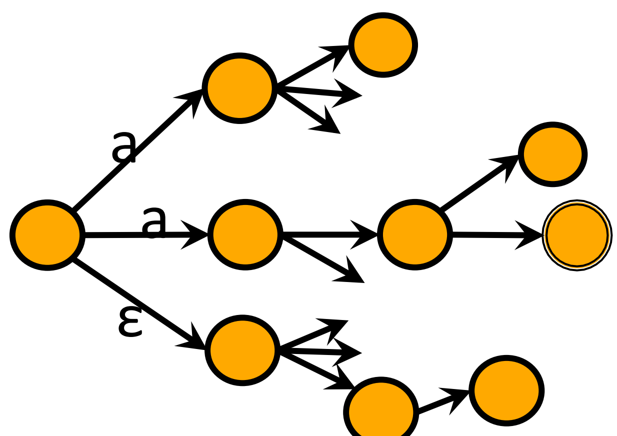


Nondeterministic Finite State Automata (NFA)

- A DFA takes only one path through the state graph (per input)

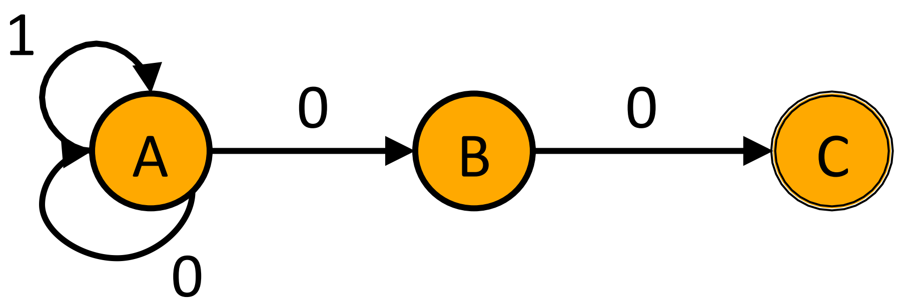


- NFA can choose!
  - An NFA accepts if some choices lead to a final state



Nondeterministic Finite State Automata (NFA)

- An NFA can get into multiple states



state	input
{A}	100
{A}	100
{A,B}	100
{A,B,**C**}	100

NFAs vs DFAs

- NFAs and DFAs recognize the same set of languages
  - Regular expressions
- DFAs are faster to execute
  - There are no choices to consider
- DFAs are usually smaller than NFAs
- But in a worst case analysis, DFAs can be larger than NFAs
  - Exponentially larger