CS 160 Compilers

Lecture 7: Revisiting DFA & NFA

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Fall 2021

Outline

- Today: Revisiting RE & NFA & DFA
- High-level story: RegEx -> NFA -> DFA -> Table

Finite automata

- Regular Expressions ⇔ Specification
- Finite Automata ⇔ Implementation
- A finite automata formally consists of:
    - An input alphabet Σ
    - A set of states S
    - A start state n
    - A set of accepting states $F \subseteq S$
    - A set of transitions state $\rightarrow^{\text{input}}$ state

Finite automata

- Transition $S_1 \rightarrow^{\alpha} S_2$
- This means: In state S_1 and input character α, go to state S_2
- If end of input and in accepting state $\Rightarrow$ accept
- Otherwise $\Rightarrow$ reject

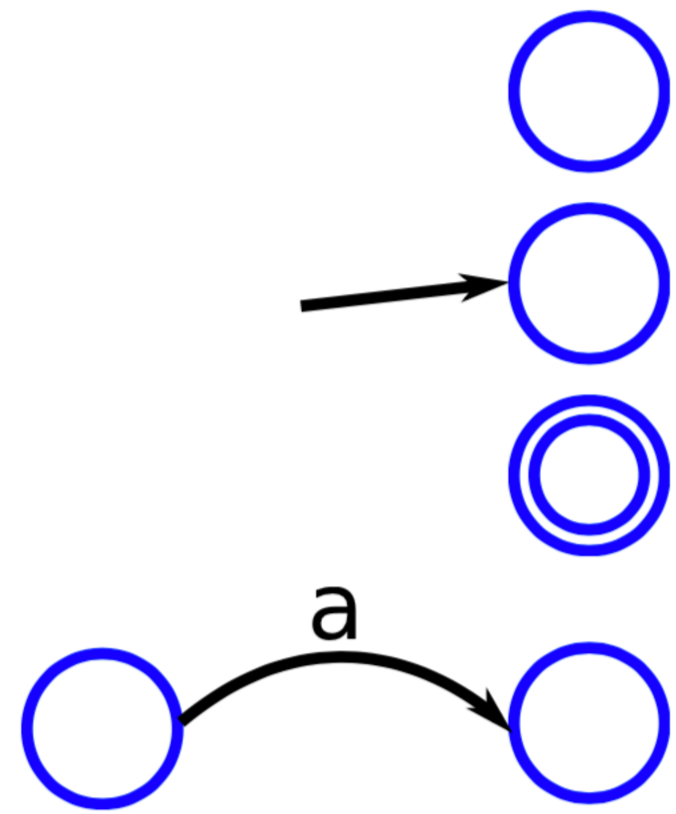
Finite Automata as State Graphs

A state:

The start state:

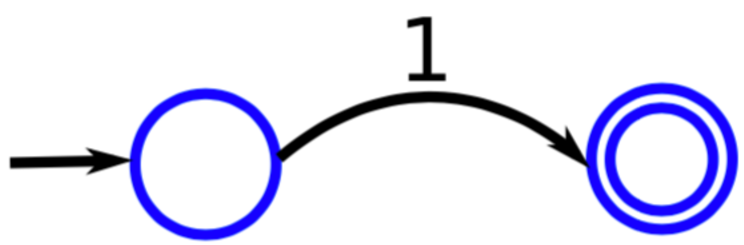
An accepting state:

A transition:



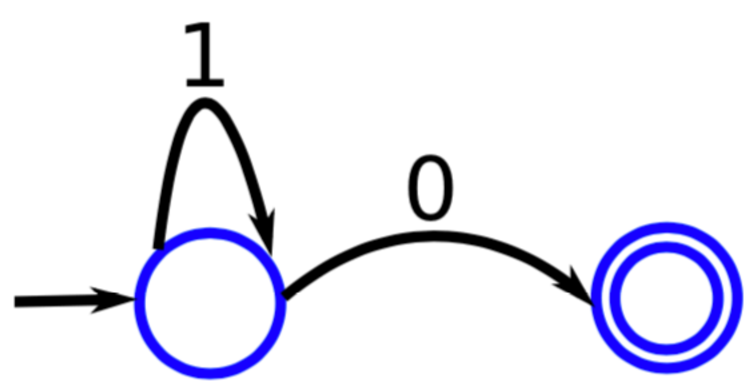
A simple example

- Here is an automaton that only accepts the string ”1”:



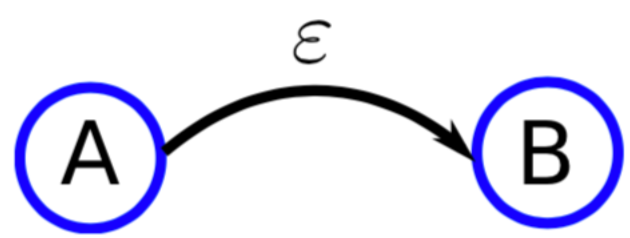
Another simple example

- A finite automaton accepting any number of 1’s followed by a single 0
- Alphabet: {0,1}



Epsilon transitions

- A special kind of transition: ε-transitions
- Machine can move from state A to B without reading any input



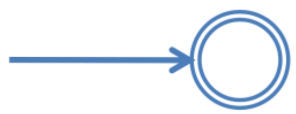
Deterministic and Nondeterministic Automata

- Deterministic Finite Automata (DFA)
  - At most one transition per input on any state
  - No ε moves
- Nondeterministic Finite Automate (NFA)
  - Can have multiple transitions for one input in a given state
  - Can have ε-moves

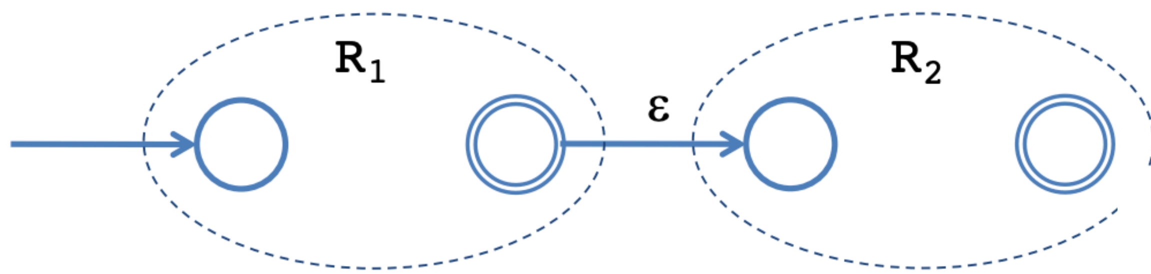
RE to NFA

'a'

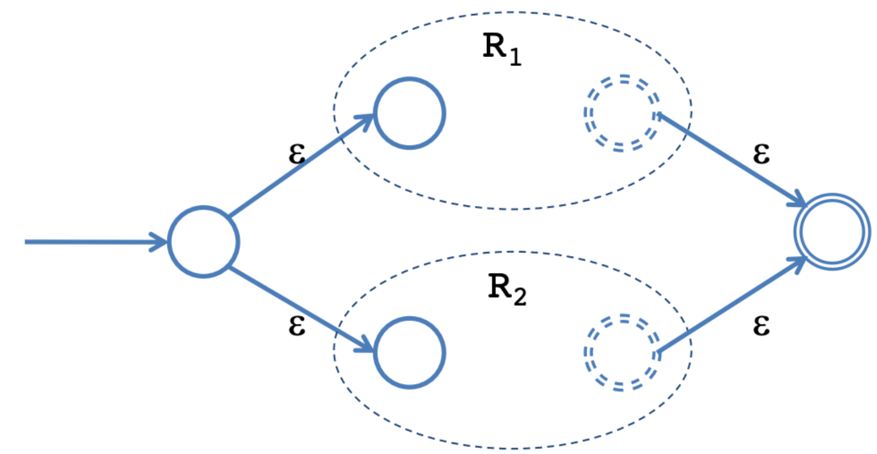
ε



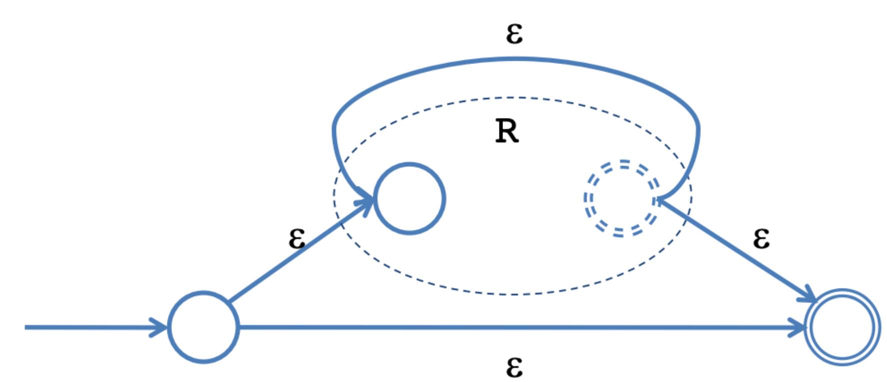
R_1R_2



$R_1 | R_2$



R*

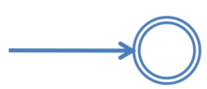


In-class exercise

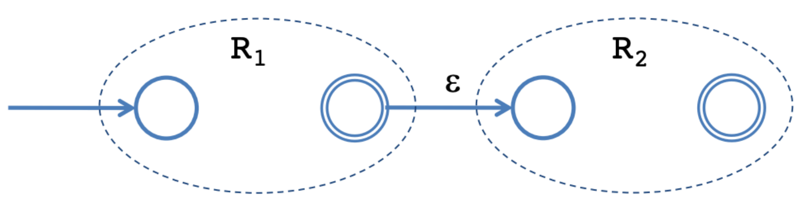
- Please draw the NFA for: a (b | c)*

'a'

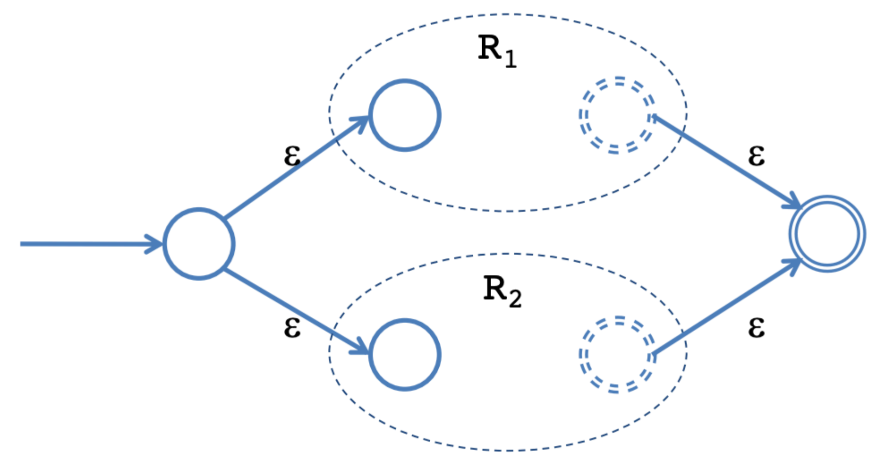
ε



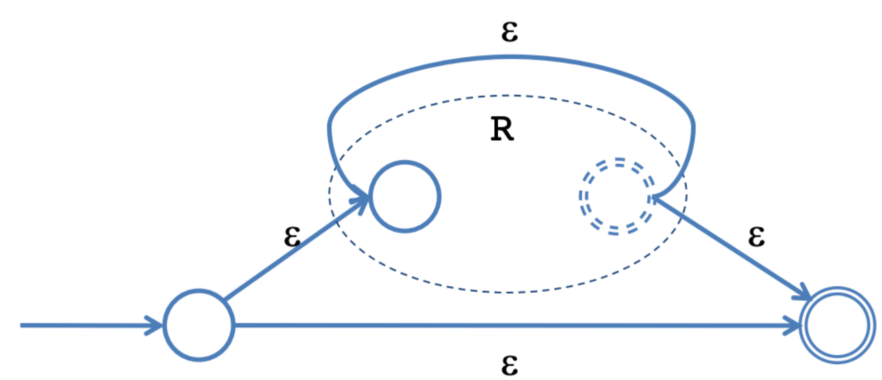
R_1R_2



$R_1|R_2$



R*

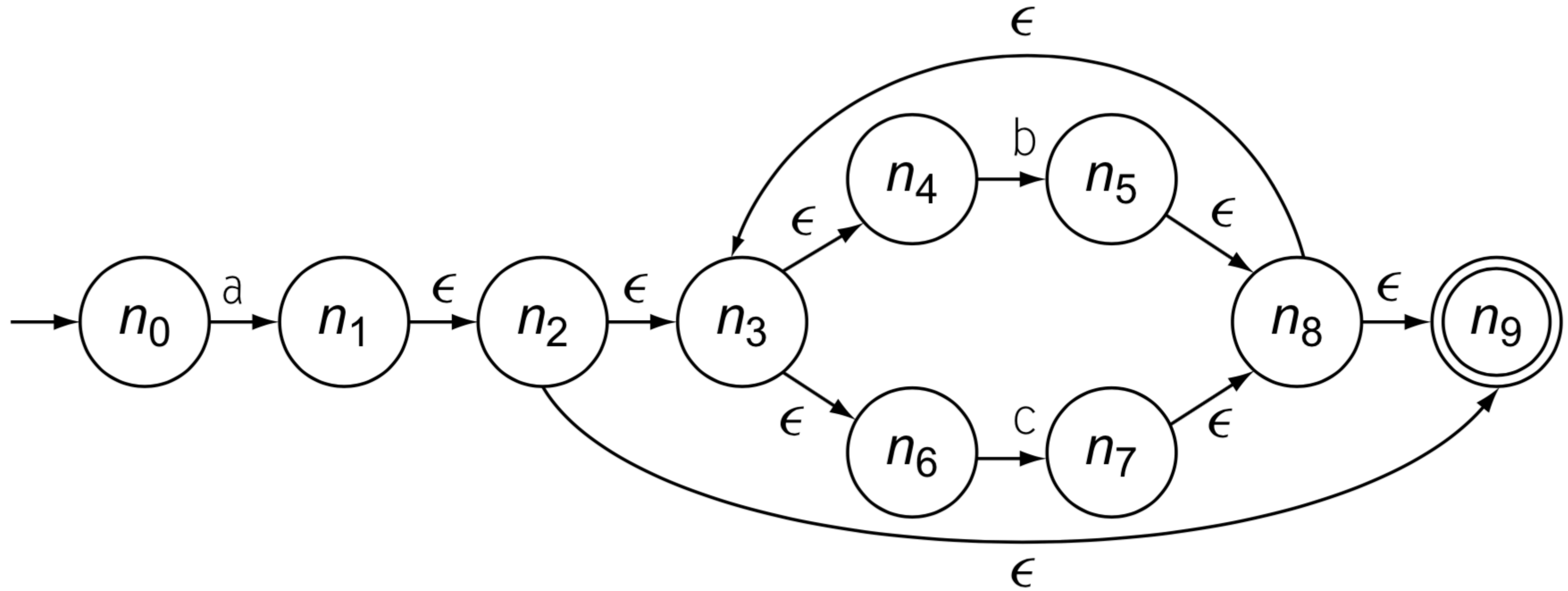


NFA to DFA: The Algorithm

```
q0 ← ε-closure({n0});
Q ← q0;
WorkList ← {q0};

while (WorkList ≠ Ø ) do
    remove q from WorkList;
    for each character c ∈ Σ do
        t ← ε-closure(Delta(q,c));
        T[q,c] ← t;
        if t ∉ Q then
            add t to Q and to WorkList;
    end;
end;
```

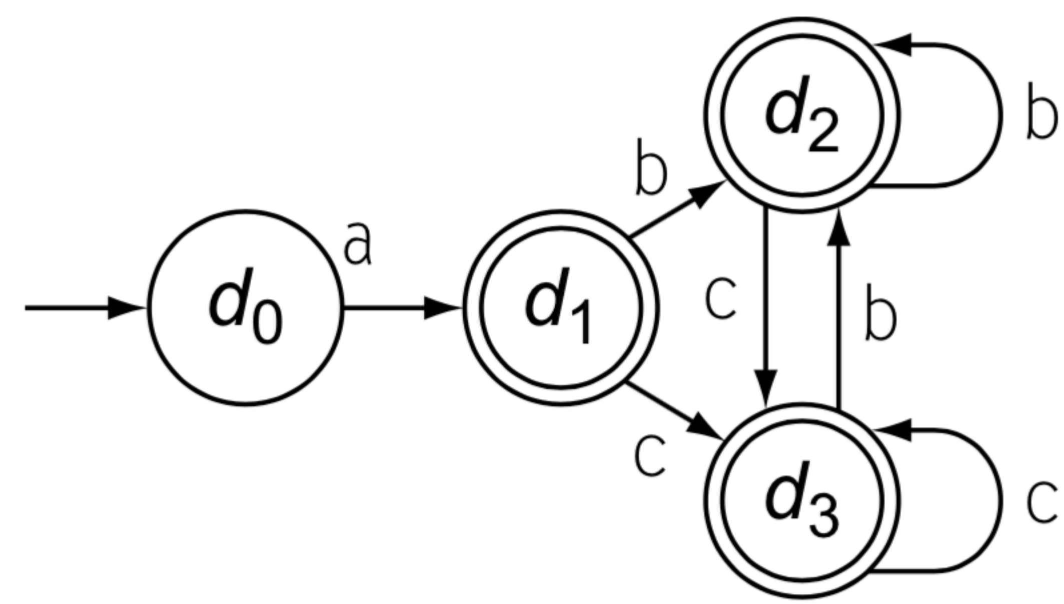
Apply NFA's transition function to each element of q



(a) NFA for "$a(b \mid c)^*$" (With States Renumbered)

Set Name	DFA States	NFA States	ϵ-closure(Delta(***q***,*)) a	b	c
q_0	d_0	n_0	$\{n_1, n_2, n_3, n_4, n_6, n_9\}$	– none –	– none –
q_1	d_1	$\{n_1, n_2, n_3, n_4, n_6, n_9\}$	– none –	$\{n_5, n_8, n_9, n_3, n_4, n_6\}$	$\{n_7, n_8, n_9, n_3, n_4, n_6\}$
q_2	d_2	$\{n_5, n_8, n_9, n_3, n_4, n_6\}$	– none –	q_2	q_3
q_3	d_3	$\{n_7, n_8, n_9, n_3, n_4, n_6\}$	– none –	q_2	q_3

(b) Iterations of the Subset Construction



(a) Resulting DFA

Engineering a compiler, C2.4

TODOs by next lecture

- Hw2 will be out. Get familiar with the Patina language
- Come to the discussion session if you have questions