Can every grammar be unambiguous?

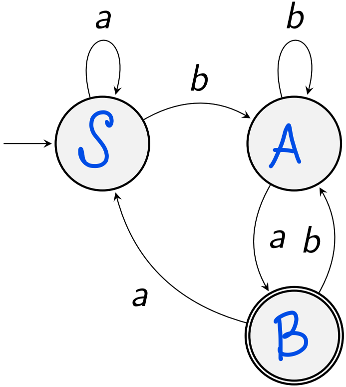
- Consider $L = \{a^i b^j c^k \mid i == j \text{ or } j == k\}$
- Can we make unambiguous grammar?

$a^0 b^0 c^0$

$S \rightarrow S_1 \mid S_2$

All regular languages are Context Free

Idea: given a DFA, **construct** equivalent CFG



$$S \to aS \mid bA$$
$$A \to aB \mid bA$$
$$B \to \varepsilon \mid aS \mid bA$$

One more exercise

w reversed.
(same w as prefix)

This exercise is from Lewis/Papadimitriou 3.1.3(a)
Give a CFG for $\{wcw^R : w \in \{a, b\}^*\}$

$S \to c \mid aSa \mid bSb$

CompSci 162
Spring 2023 Lecture 9:
Introducing Push-Down Automata

Push-Down Automata Notation

$$p \xrightarrow{a, s; w} q$$

w can be multiple symbols

- In order to follow this transition:
  - Be in state p
  - Consume 'a' from front of input tape.
  - See 's' on top of stack (empty? 's' is $)
- If you follow this transition:
  - Pop 's' from stack.
  - Push 'w' to stack
  - Move state: $p \rightarrow q$

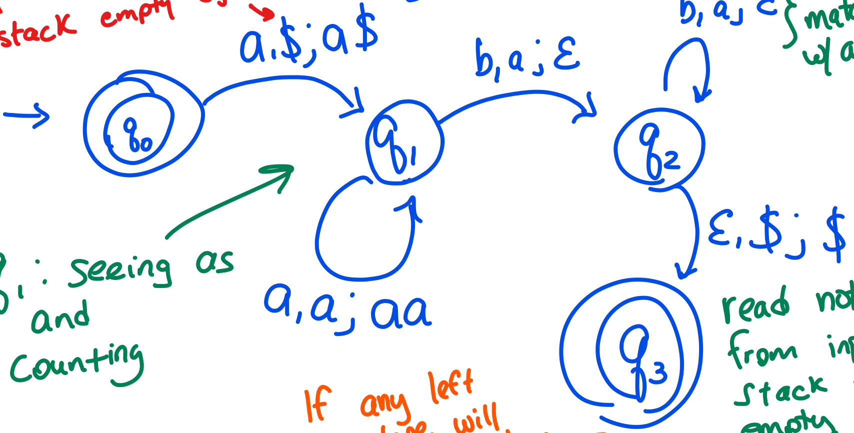
The Language $a^n b^n$

Stack "counts" as seen so far.

Give a PDA for this language.

$ is a phantom "stack empty" symbol

push $ then push a



b is matched w/ an a

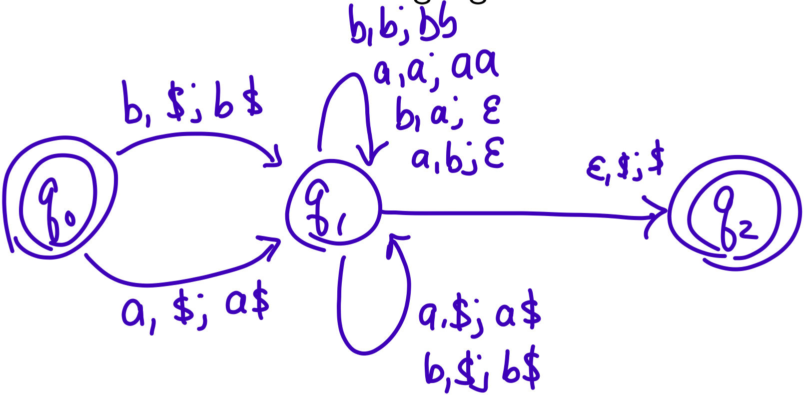
q_1 : seeing as and counting

read nothing from input. stack is empty

If any left on tape, will trap from here.

Equal # *a* and *b*

Give a PDA for this language.



Formal Definition of PDA

A **pushdown automata** is $M = (K, \Sigma, \Gamma, \Delta, s, F)$ where

- K is a finite set of states
- Σ is an alphabet (**input symbols**)
- Γ is an alphabet (the **stack symbols**)
- $s \in K$ is the initial state
- $F \subseteq K$ is the set of final states
- Δ is the **transition relation**, a finite subset of $(K \times \underbrace{(\Sigma \cup \{\varepsilon\})}_{\text{read from tape}} \times \Gamma^*) \times \underbrace{(K \times \Gamma^*)}_{\text{state to move and push symbol(s)}}$

we are here

pop symbols(s)

Deterministic PDA

- Cannot be multiple transitions with same initial triple

- Cannot any ε out of a state that pop same as non-ε out of the same

- Which PDA earlier is deterministic?

- Which is not?

Another language

$$\{a^i b^j c^k \ : \ i, j, k \geq 0 \text{ and } i == j \text{ OR } i == k\}$$

Discussion: try before

One more

$$\{ww^R \ : \ w \in \{a, b\}^*\}$$

try before

discussion