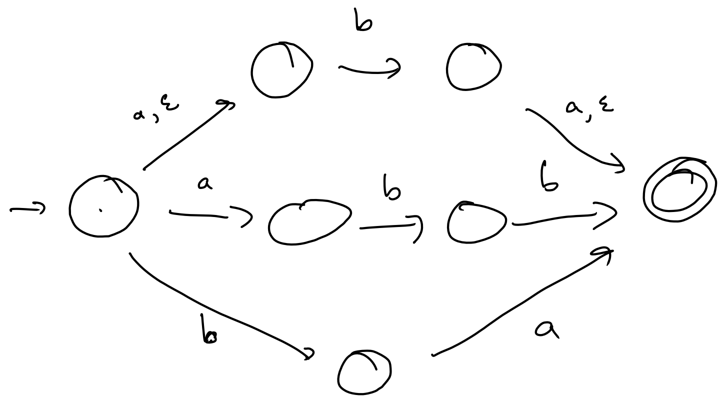
Last time: regex $\to$ NFA

Can we do NFA $\to$ regex?

Yes!

Make this into regex:



What are the paths from start to accepting?

write each path as regex, combine with +.

bottom: ba

middle: abb

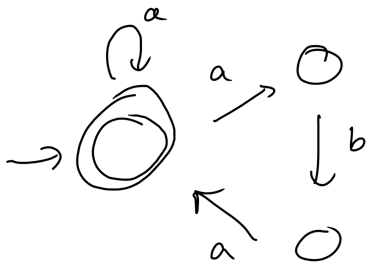
top: $aba + ab + ba + b$

$(a+\varepsilon)b(a+\varepsilon)$

The NFA is equivalent to

$(a+\varepsilon)b(a+\varepsilon) + abb + ba$

When there are loops, we must use *



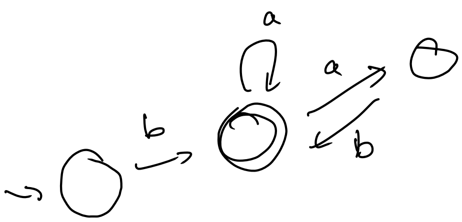
which loops can we do?

The a loop would be a^*

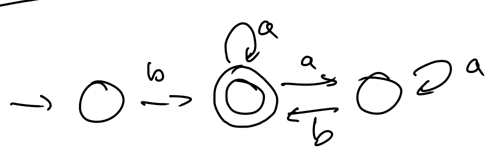
the other would be $(aba)^*$

$$\boxed{(a+aba)^*}$$

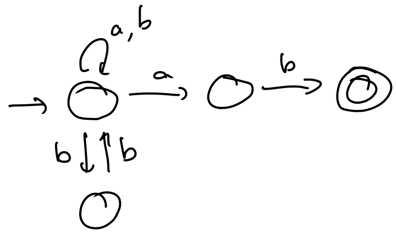
" sum the loops inside a * "



$$b(a + ab)^*$$



$$b(a + aa^*b)^*$$



$$\boxed{((a+b)+bb)^*ab}$$

$(a+b+bb)^*ab$

$(a+b)^*ab$

Any NFA can be converted to a regex.

We can go back & forth

regex $\longleftrightarrow$ NFA

Thm Kleene's Theorem

L is a regular language iff

L can be generated by regex.

There are non-regular languages,

$\{a^n b^n \mid n \in \mathbb{N}\}$ is not regular

A general method to show a language is non-regular.

Involves the derivative!

The Brzozowski Derivative

(not in our book)

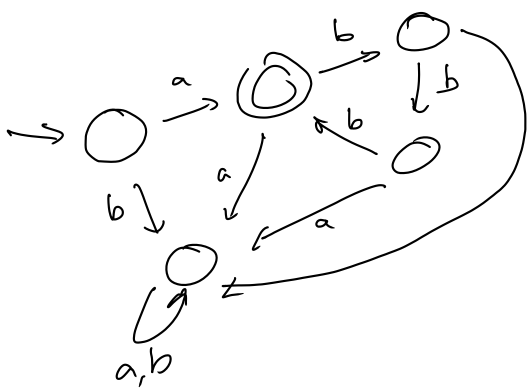
book uses The Pumping Lemma

The derivative is related this question:

What happens to the language of a NFA if I move the starting state?

Ex

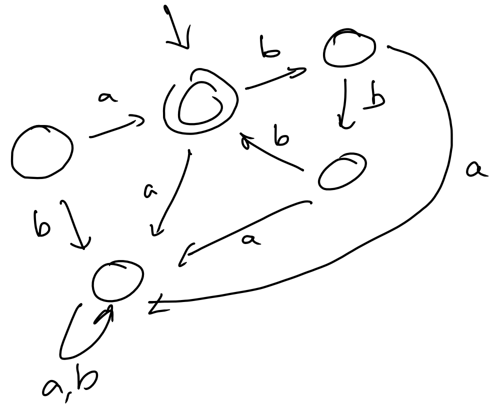
M:



Here, $L(M) = \{ a(b^3)^n \mid n \in \mathbb{N} \}$

What if we move the start state thru the a edge?

N:

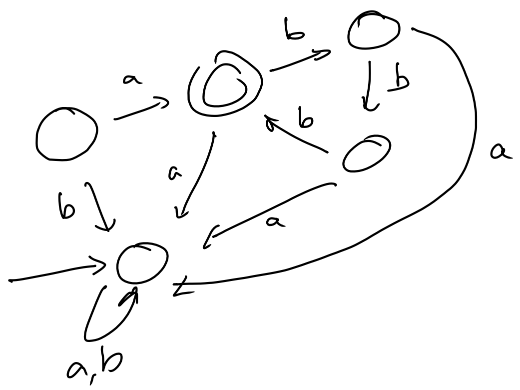


$L(N) = \{ (b^3)^n \mid n \in \mathbb{N} \}$

Moving the start state thru the $\underline{a}$ edge deletes $\underline{a}$ from the start of all our strings.

Move it the other way:

$\underline{P}$:



$L(P) = \emptyset$

We are skipping over any initial b's.

but $L(M) = \{ a (b^3)^n \}$ has $\underline{\text{no}}$ initial b's, so we end up with nothing.

What we're doing by "skipping initial a's" is really:

$$\{ x \mid ax \in L \}$$

This is the B. derivative of L with respect to a.

<u>Def</u> $\frac{d}{da} L = \{ x \mid ax \in L \}$

For $L = \{ a(b^3)^n \}$,

$\frac{d}{da} L = \{ (b^3)^n \}$

$\frac{d}{db} L = \emptyset$

If L was the set of all English words,

what does $\frac{d}{da} L$ look like?

it contains strings like: llow since allow $\in L$

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