CPSC 421/501, Sept 28, 2021

September 30:
National Day for Truth and Reconcilliation.
(concerning Canada's residential school system and related abuses)
also known as
Orange Shirt Day

UBC STEM (Science, Coding, and Engineering) invites you to their:

Intergenerational March to commemorate Orange Shirt Day, Sept 30, 11:45am - 2pm

- It is not easy for survivors of the Indian Residential School System to talk about their past trauma.
- Survivors and their families tire from giving repeated explanations
- Children are not responsible for the mistakes of their parents, but have the obligation to learn about these mistakes
- One of my favourite suggestions "Learn for yourself"

I have learned.

We have learned.

We are learned.

Start Chapter 1:

1.1 DFA's & Regular Languages

1.2 Regular Languages are closed under $\circ$, $*$

e.g.

$\{a^4, a^5\}^*$ is regluar

How do we know? NFA's

1.3 Regular Expressions ← string search

~~1.4 Skip~~, but handout of Myhill-Nerode thm

Def: A DFA, i.e. a (deterministic) finite automaton, (or finite automaton), is a 5-tuple $(Q, \Sigma, \delta, q_0, F)$ s.t. Q, Σ are finite sets, $\delta : Q \times \Sigma \to Q$ is a function, $q_0 \in Q$, and $F \subset Q$.

? ? ?

Start with examples...

Old school!

① – Regular languages (subset)

② – Context-free " (subset)
Current

Later
- Languages decided by Turing machines (subset)

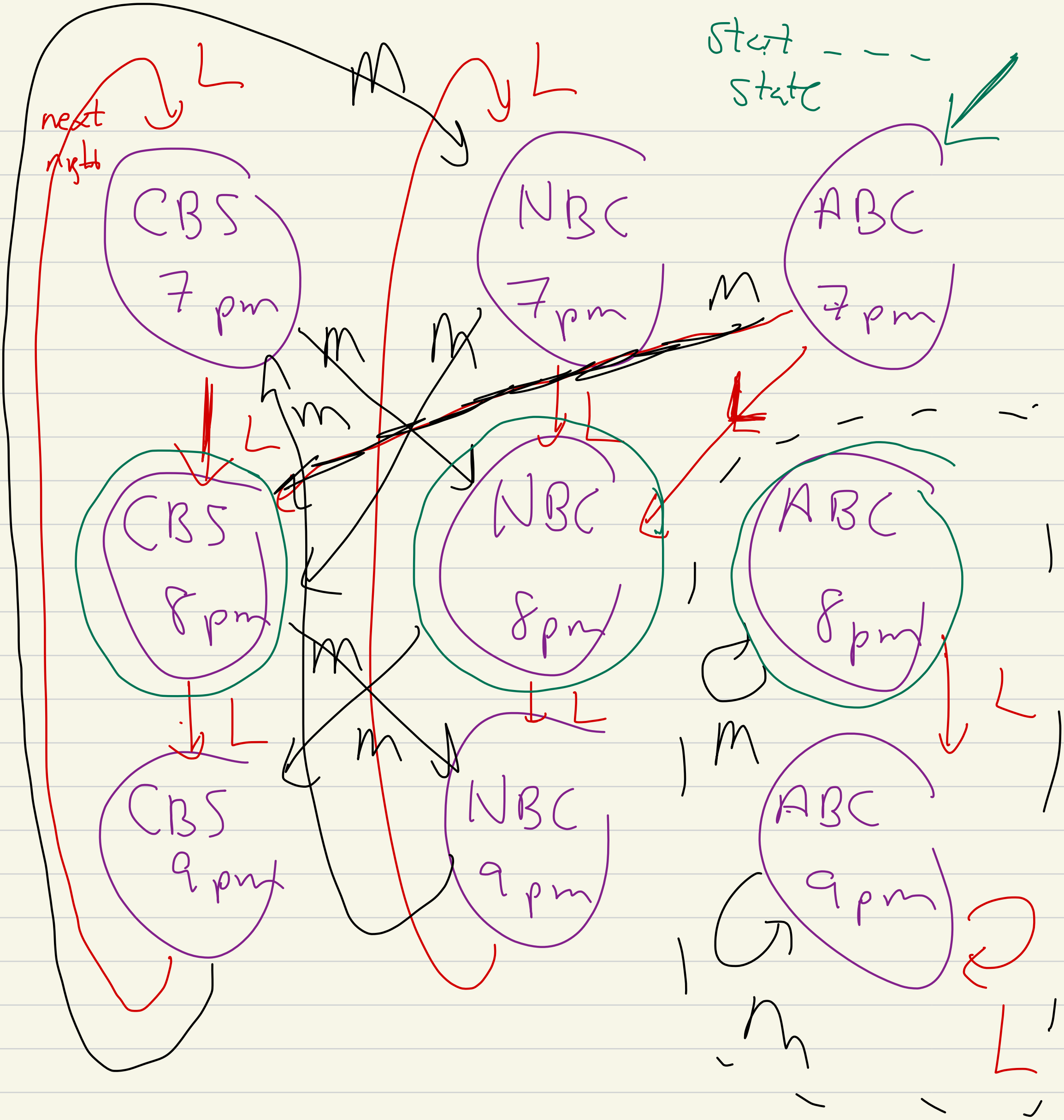
- Languages recognized by Turing machines

Simple TV Watching of mid 1970's :

3 major networks, WGN, PBS

ABC, CBS, NBC

Typical weeknight :



$\Sigma = \{ L, M \}$

liked / love → L

meh → M

A DFA is $(Q, \Sigma, \delta, q_0, F)$

① Q = {set of states} of the DFA

here { CBS 7pm, CBS 8pm, ... }

② Σ = alphabet of the DFA

③ δ : $Q \times \Sigma \longrightarrow Q$

transition function; idea

$\delta(q, \sigma)$ = the state you transition to when in state q

and you {read / get} σ

(4) $q_0 \in Q$ designed as the initial state

(5) $F \subset Q$ called the {accepting / final} states

Idea!

given q_0 initial state

$\longrightarrow \bigcirc$ and a {word / string} over the alphabet Σ,

take you to a state,

if you land in $F \subset Q$

then you state $\begin{cases} \text{yes (accepted)} \\ \text{no (rejected)} \end{cases}$

F : 

=

Each DFA recognizes a language $L \subset \Sigma^*$.

Goal: End of Ch 1 — find min # of states of a DFA that recognizes a given language

$$\{DFA\} \times \left\{\begin{matrix}\text{inputs} \\ = \Sigma^*\end{matrix}\right\} \to \left\{\begin{matrix}\text{yes} \\ \text{no}\end{matrix}\right\}$$

M = machine

$$\text{Language}(DFA) \stackrel{!}{=} \{w \in \Sigma^* \mid w \text{ is accepted by } M\}$$

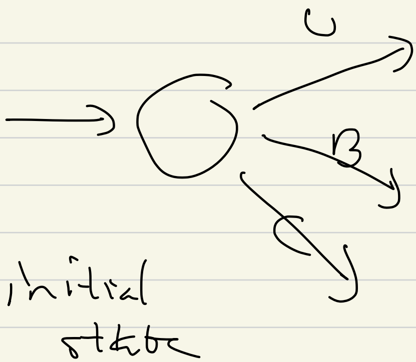
break for 5 minutes

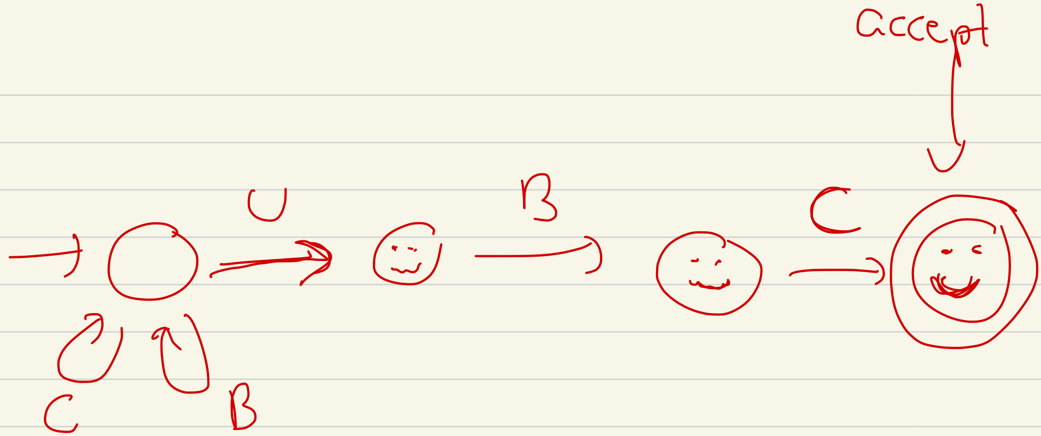
10:11 – 10:16

① You want to find UBC in a string over $\Sigma = \{B, C, U\}$

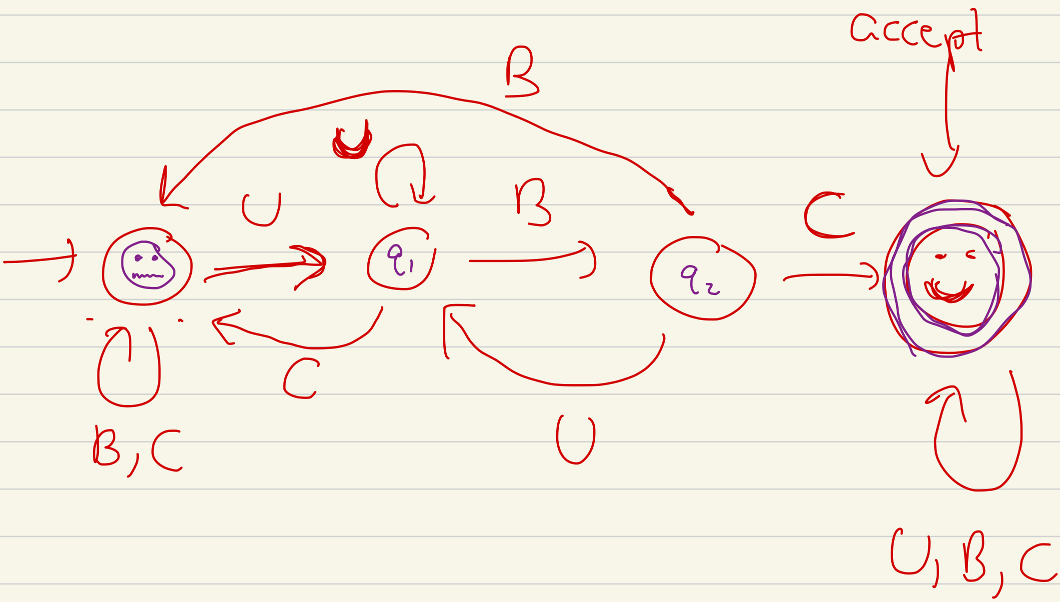
given UUBBCCCCC 

given UUUUUUU<u>UBC</u>CCC 





usually



$$Q = \{ ☹, q_1, q_2, ☺ \}$$

$$\Sigma = \{ B, C, U \}$$

$$\delta : Q \times \Sigma \to Q$$

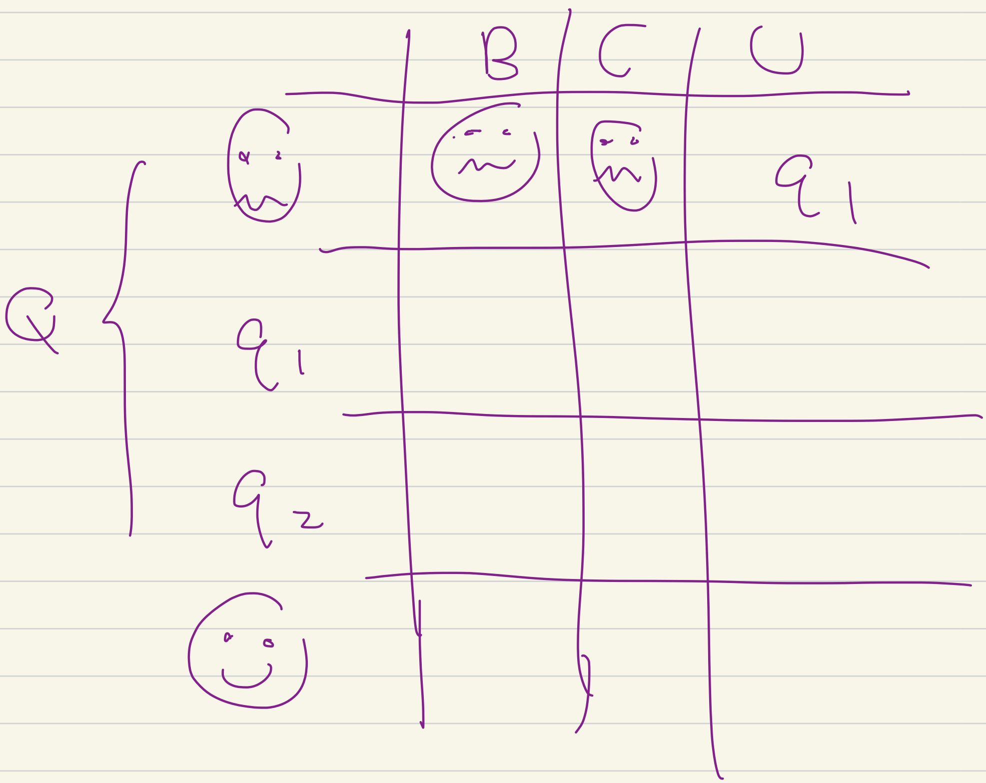
$$\delta(☹, U) = q_1$$

$$\delta(☹, B) = ☹$$

$$\delta(☹, C) = ☹$$

$$\vdots$$

$$\delta : Q \times \Sigma \to Q$$



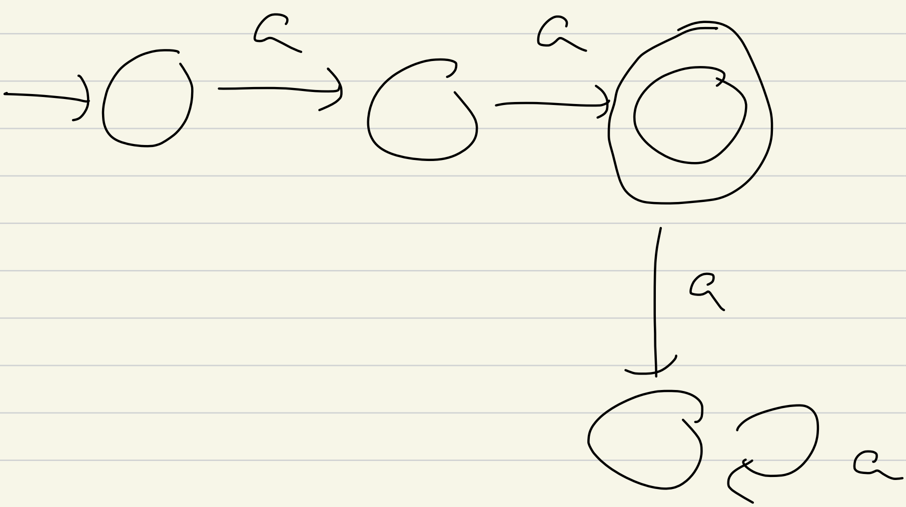
$q_0 =$  $\in Q$

$F = \{$  $\}$

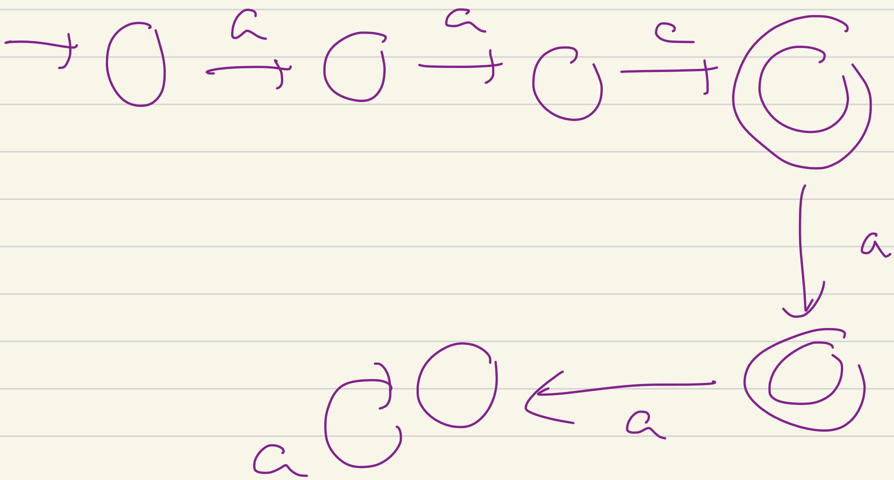
Another example:

$$\Sigma = \{a\}$$

$$L = \{a^2\} = \{aa\}$$



$L = \{a^3, a^4\}$ $\Sigma = \{a\}$



Thm: If $L \subset \Sigma^*$ is recognized by a DFA, M, i.e. for some M

we have

$$L = \left\{ w \in \Sigma^* \;\middle|\; \begin{array}{l} \text{on input } w, \\ \text{the DFA, } M, \\ \left\{\begin{array}{l}\text{accept} \\ \text{~~Yes~~}\end{array}\right\} \; w \end{array} \right\}$$

then there is a DFA, M', that recognizes

$$L^* \stackrel{\text{def}}{=} \left\{ \begin{array}{l} \text{all strings that are} \\ \text{concatenations of} \\ \text{elements of } L \end{array} \right\}$$

$$= \left\{ w_1 \ldots w_k \;\middle|\; w_1, \ldots, w_k \in L \right\}$$

We view

$$L \subset \Sigma^*$$

as a "problem" to solve,

i.e. we want a DFA

$$M = (Q, \Sigma, \delta, q_0, F)$$

s.t.

$$L = \left\{ w \in \Sigma^* \;\middle|\; \begin{array}{c} M \text{ accepts} \\ w \end{array} \right\}$$

<u>Def</u> $L \subset \Sigma^*$ is <u>regular</u>

if there is a DFA that

recognizes L.

Regular Languages include

$\{$strings, w, over U, B, C s.t. some substring of w equals UBC$\}$ → $\Sigma = \{U, B, C\}$

$\{a^2\} \subset \Sigma^*$, $\Sigma = \{a\}$

$\{a^3, a^4\} = \{aaa, aaaa\}$
$\subset \Sigma^*$, $\Sigma = \{a\}$

are all regular.

Non-regular languages $\begin{cases} 1.4 \text{ [S;p]} \\ \text{Myhill-Nerode} \end{cases}$

e.g. $\Sigma = \{a\}$

$$\{ w = a^n \mid n \text{ is prime} \}$$

$=$

$$\{ a^2, a^3, a^5, a^7, a^{11}, \ldots \}$$

is not regular, or non-regular