8.2
What is a Turing machine

Turing machine

finite-state control

head

X_1 X_2 $\cdots$ X_n
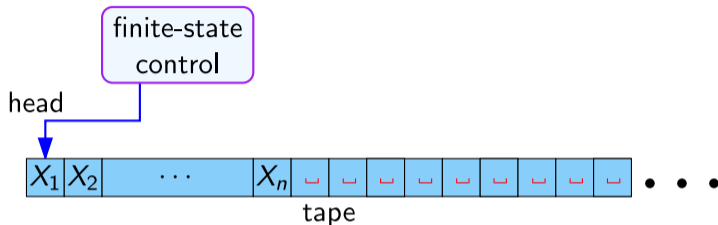
tape

1. Input written on (infinite) one sided tape.

2. Special blank characters.

3. Finite state control (similar to DFA).

4. Ever step: Read character under head, write character out, move the head right or left (or stay).

High level goals

1. Church-Turing thesis: TMs are the most general computing devices. So far no counter example.
2. Every TM can be represented as a string.
3. Existence of Universal Turing Machine which is the model/inspiration for stored program computing. UTM can simulate any TM
4. Implications for what can be computed and what cannot be computed

Turing machine: Formal definition

A **Turing machine** is a 7-tuple

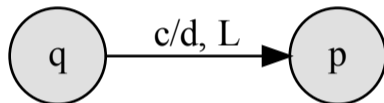$$(Q, \Sigma, \Gamma, \delta, q_0, q_{\text{acc}}, q_{\text{rej}})$$

- Q: finite set of states.
- Σ: finite input alphabet.
- Γ: finite tape alphabet.
- $\delta : Q \times \Gamma \to Q \times \Gamma \times \{\text{L}, \text{R}, \text{S}\}$: Transition function.
- $q_0 \in Q$ is the initial state.
- $q_{\text{acc}} \in Q$ is the **accepting**/**final** state.
- $q_{\text{rej}} \in Q$ is the **rejecting** state.
- $\sqcup$ or ␣: Special blank symbol on the tape.

Turing machine: Transition function

$$\delta : Q \times \Gamma \to Q \times \Gamma \times \{\mathtt{L}, \mathtt{R}, \mathtt{S}\}$$

As such, the transition

$$\delta(q, c) = (p, d, \mathtt{L})$$

1. q: current state.
2. c: character under tape head.
3. p: new state.
4. d: character to write under tape head
5. $\mathtt{L}$: Move tape head left.

Missing transitions lead to hell state.
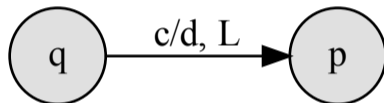"Blue screen of death."
"Machine crashes."

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THE END

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(for now)