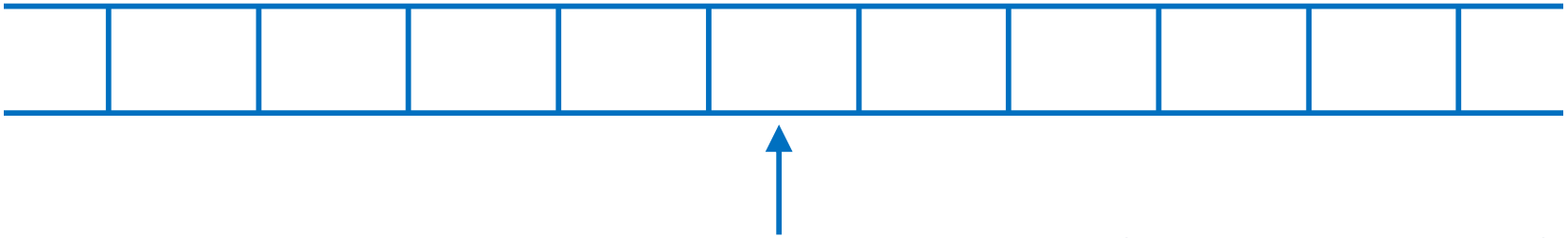
Variations of the Turing Machine

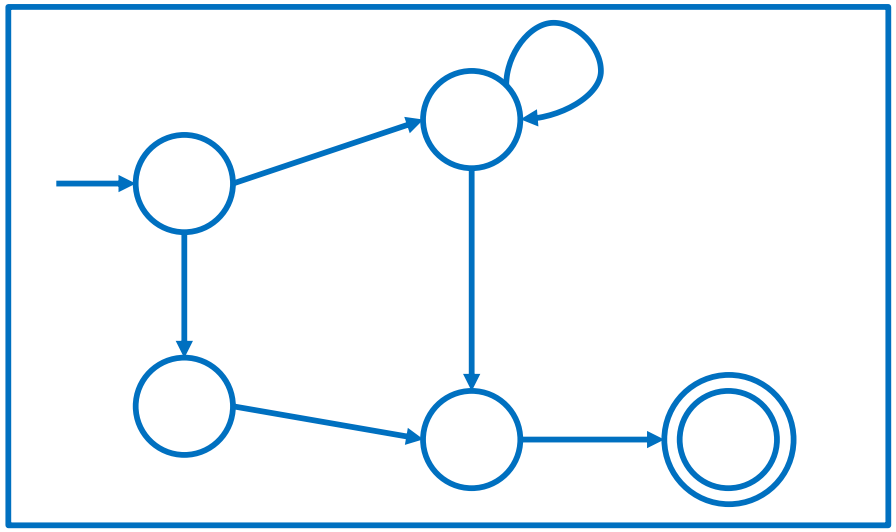
A Standard Turing Machine

Tape



Read-Write head (Left or Right)

Control Unit



Deterministic

Variations of the Standard Model

- Turing machines with:
  - Stay-Option
  - Semi-Infinite Tape
  - Off-Line
  - Multitape
  - Multidimensional
  - Nondeterministic

Variations of the Standard Model

- The variations form different **Turing Machine Classes**

BUT

- Each class has the **same power** with the **Standard Model**

Variations of the Standard Model

- Same power of two classes means:

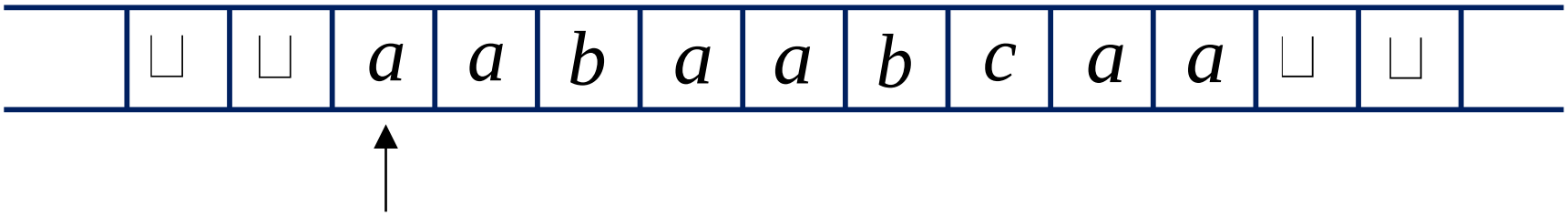
  For any machine M_1 of first class, there is a machine M_2 such that

  $$L(M_1) = L(M_2)$$

  and vice versa.

Stay-Option

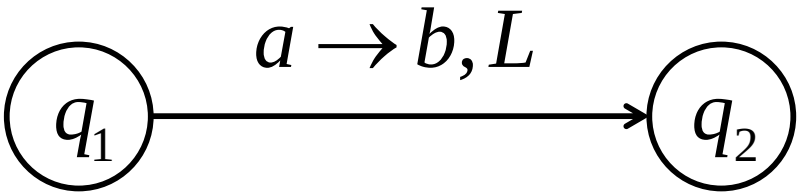
The head can stay in the same position

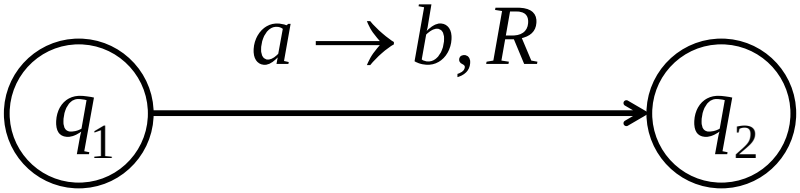


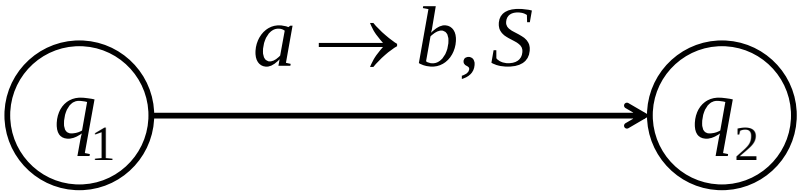
Left, Right, Stay

L,R,S: moves

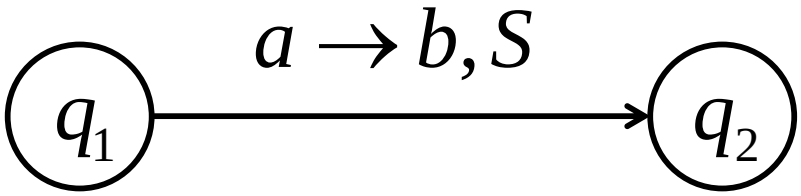
Stay-Option

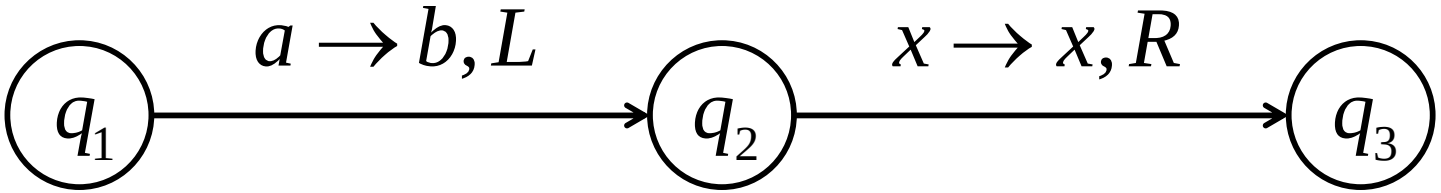






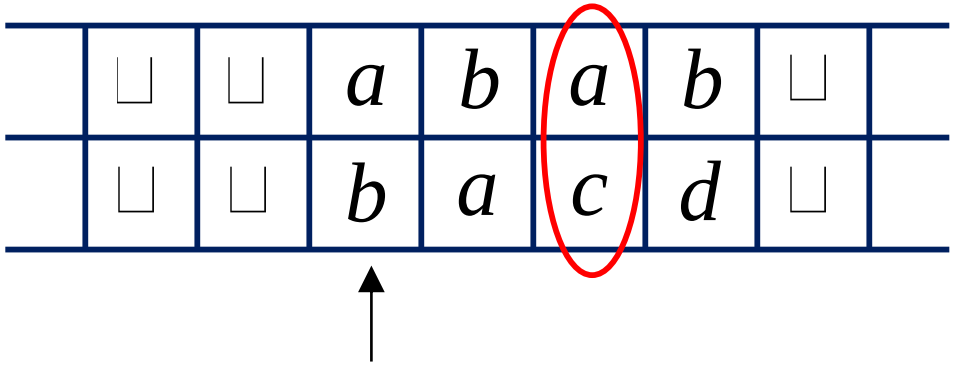
Stay-Option



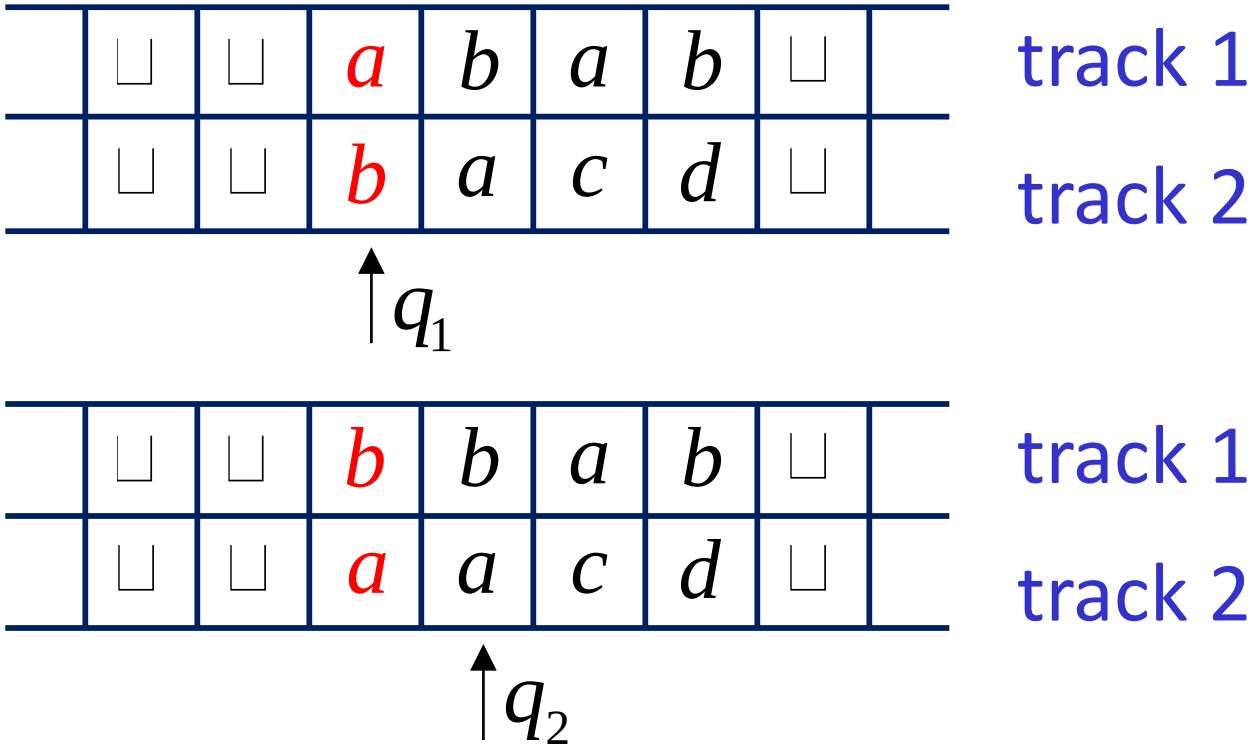


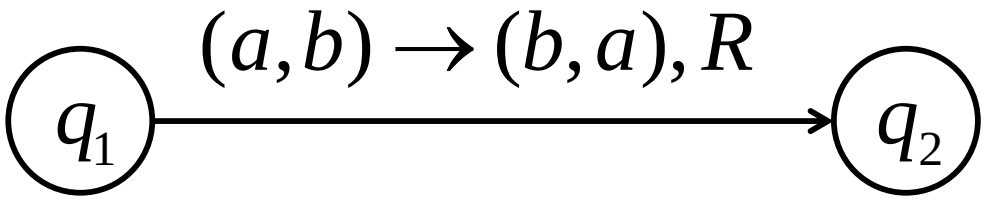
For every symbol $x \in \Sigma$

Multiple Track Tape

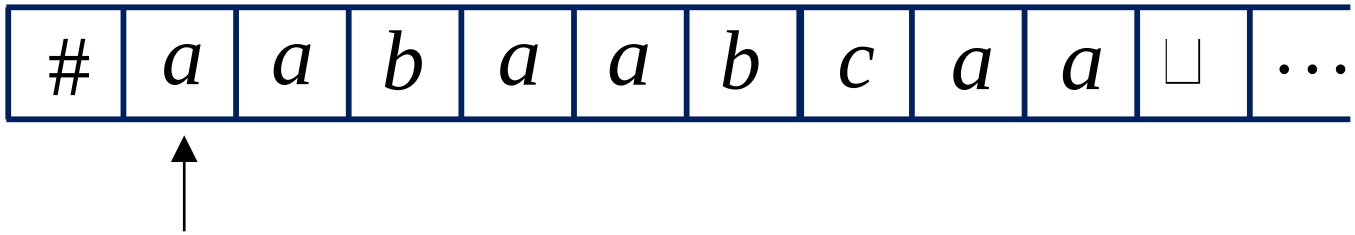


Multiple Track Tape

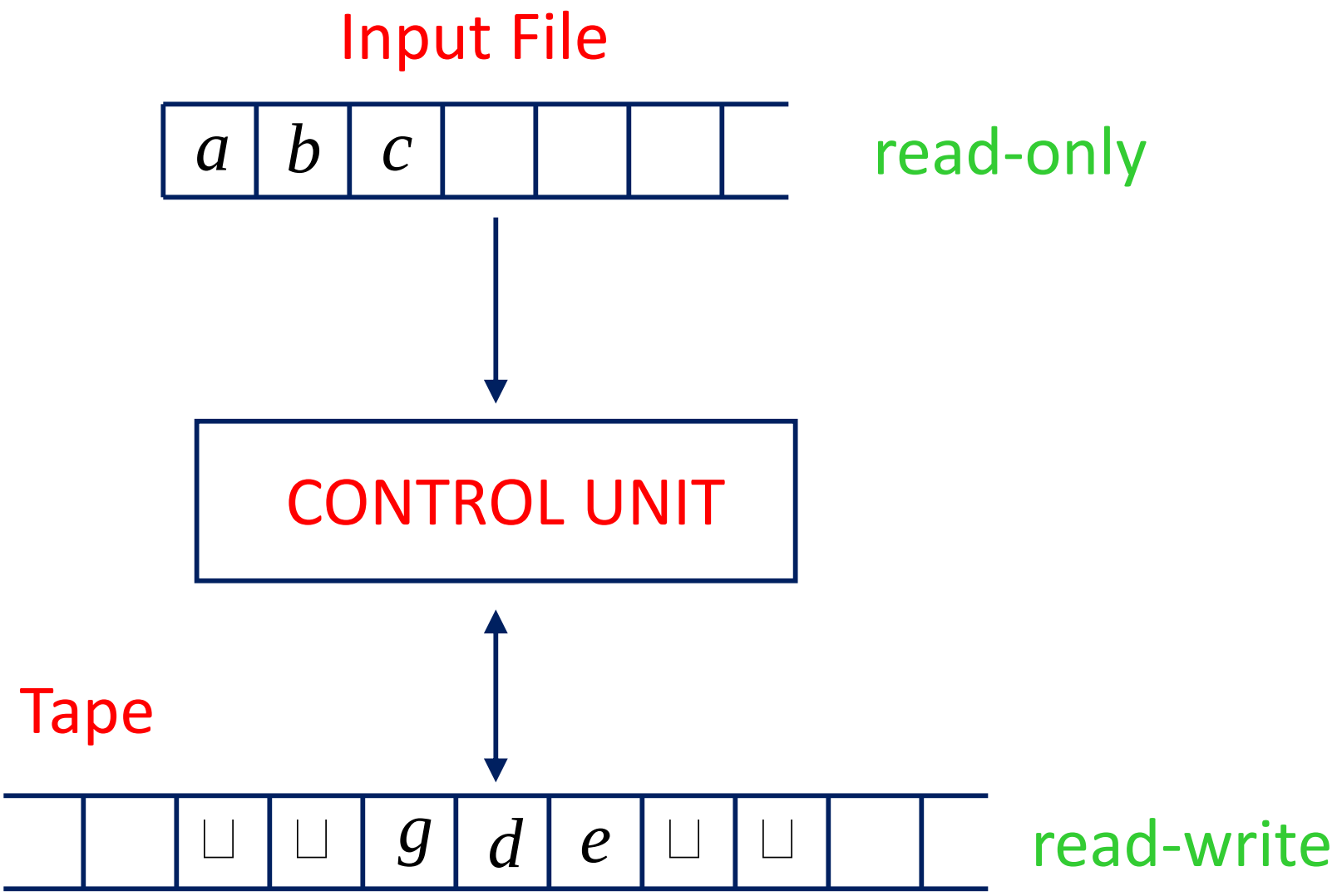




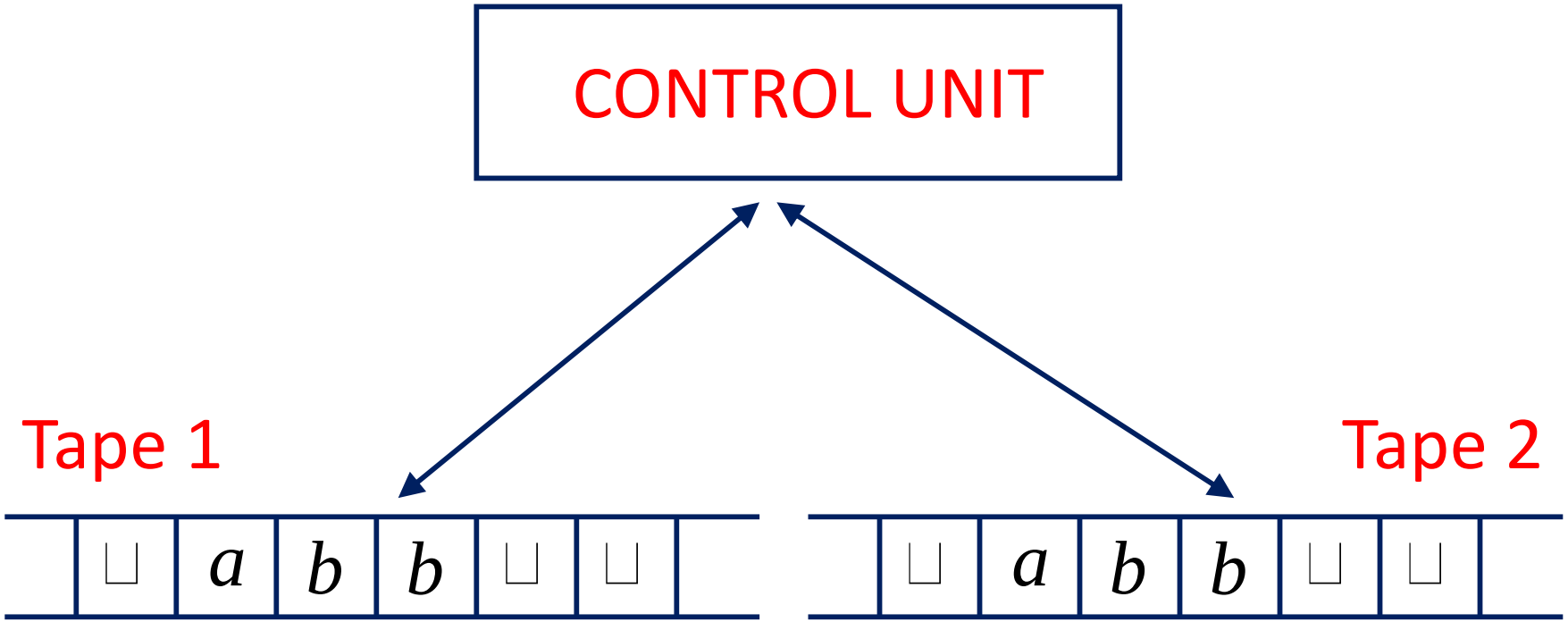
Semi-Infinite Tape



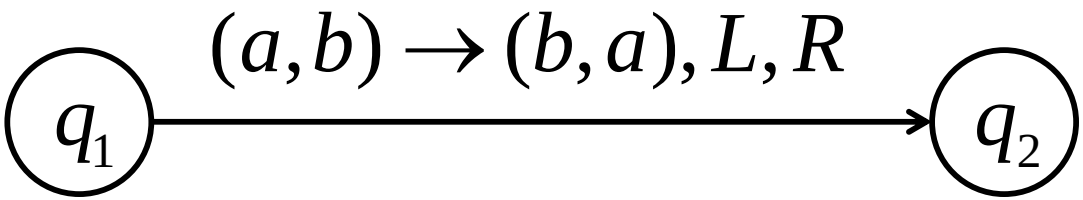
The Off-Line Machine



Multitape Turing Machines



Input



Multitape Turing Machines

Same power doesn't imply same speed:

$$L = \{a^n b^n\}$$

	Acceptance Time
Standard machine	n^2
Two-tape machine	n

Multitape Turing Machines

Standard machine:

Go back and forth n^2 times

Two-tape machine:

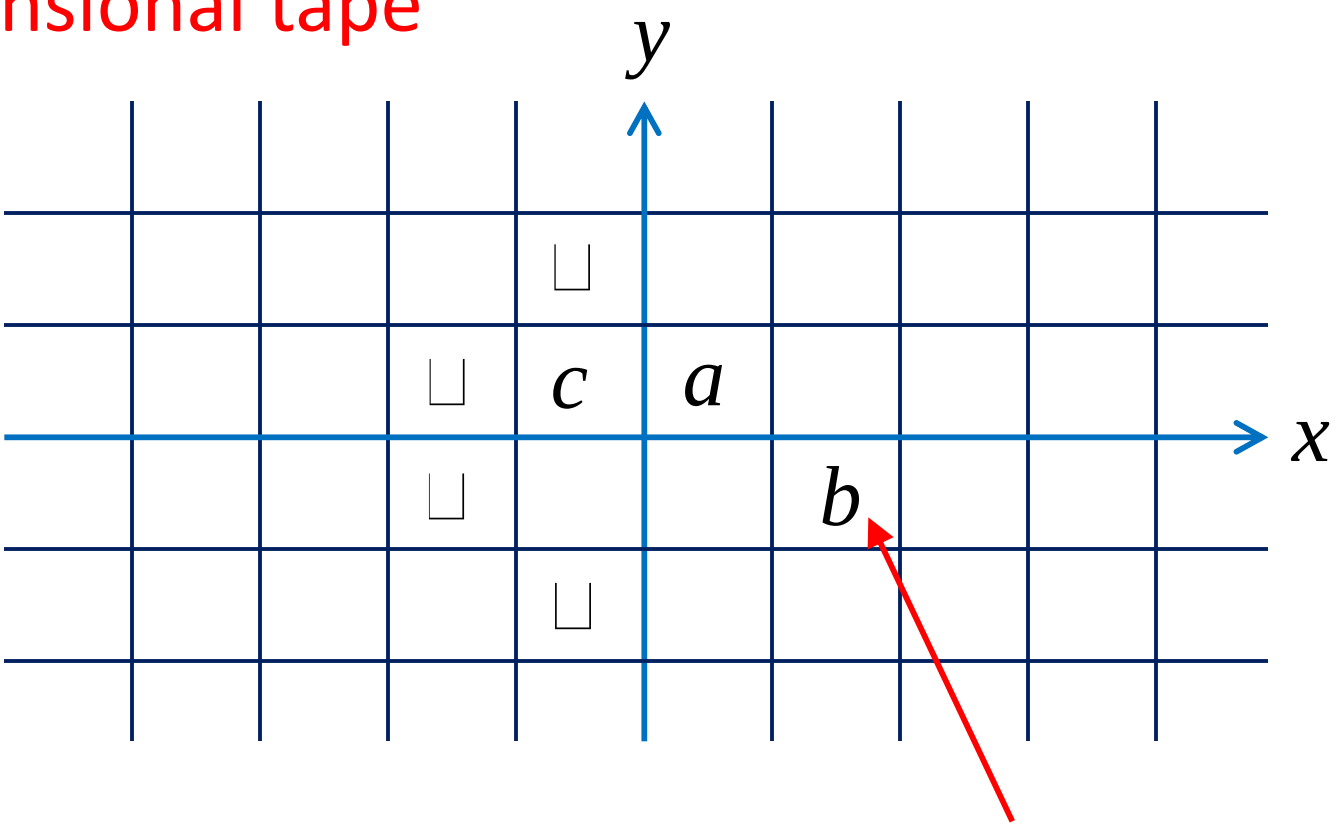
Copy b^n to tape 2 (n steps)

Leave a^n on tape 1 (n steps)

Compare tape 1 and tape 2 (n steps)

Multi-Dimensional Turing Machines

Two-dimensional tape



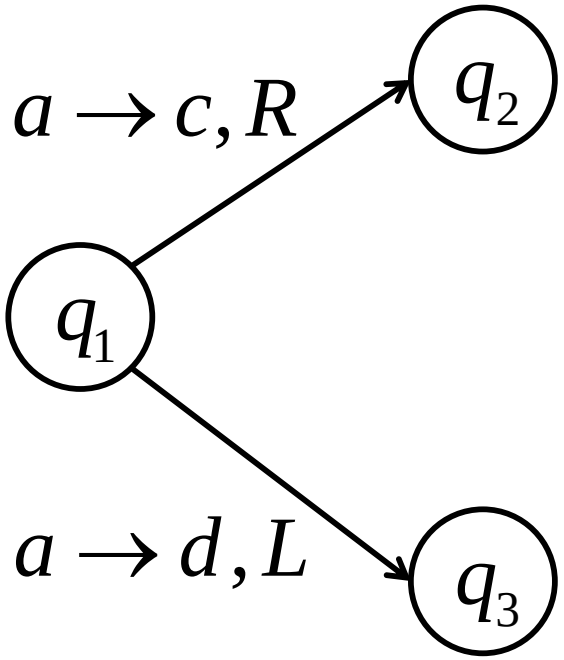
MOVES: L,R,U,D

U: up D: down

HEAD

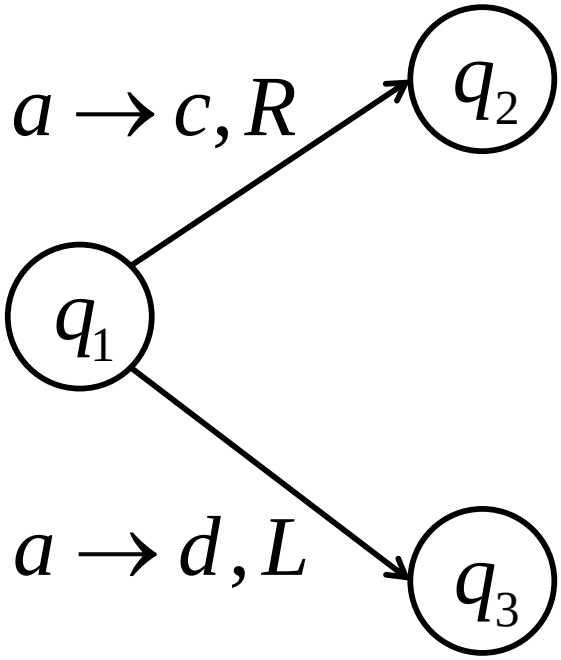
Position: (+2,-1)

Non-deterministic Turing Machines

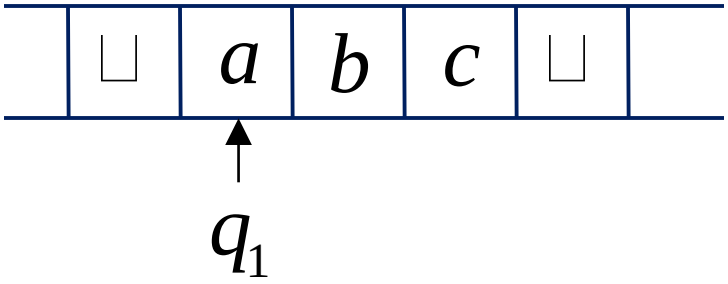


Non-deterministic Choice

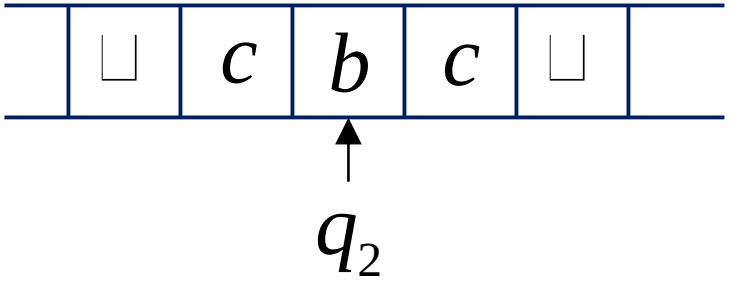
Non-deterministic Turing Machines



Time 0

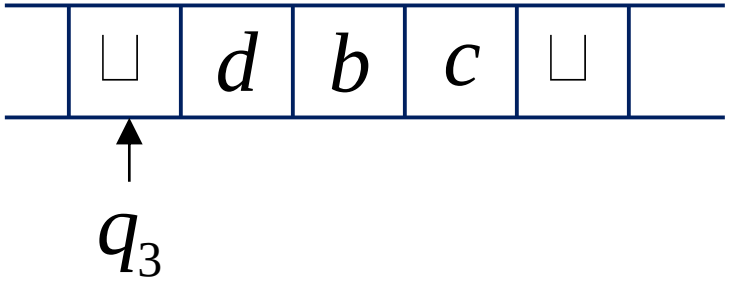


Choice 1

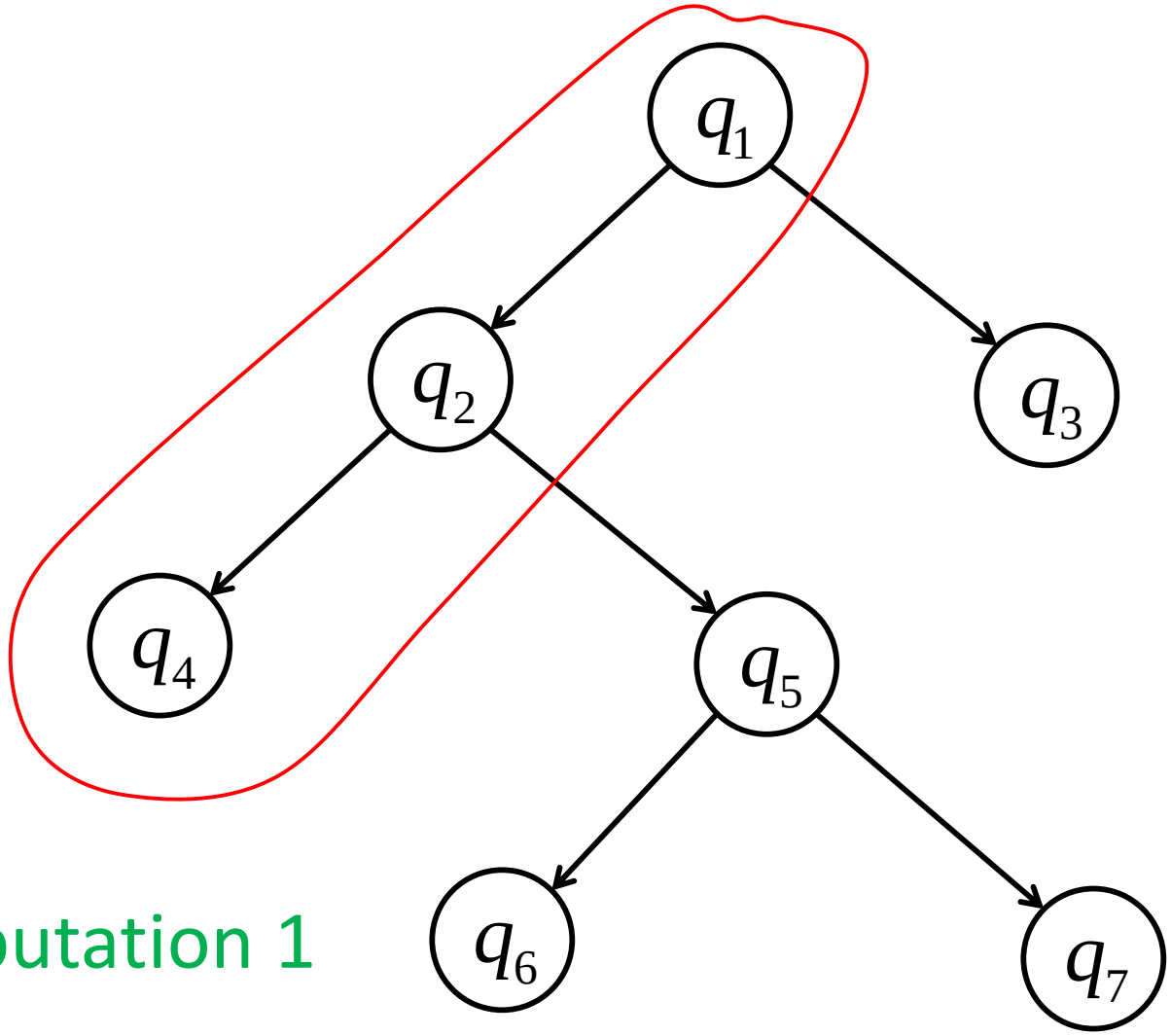


Time 1

Choice 2

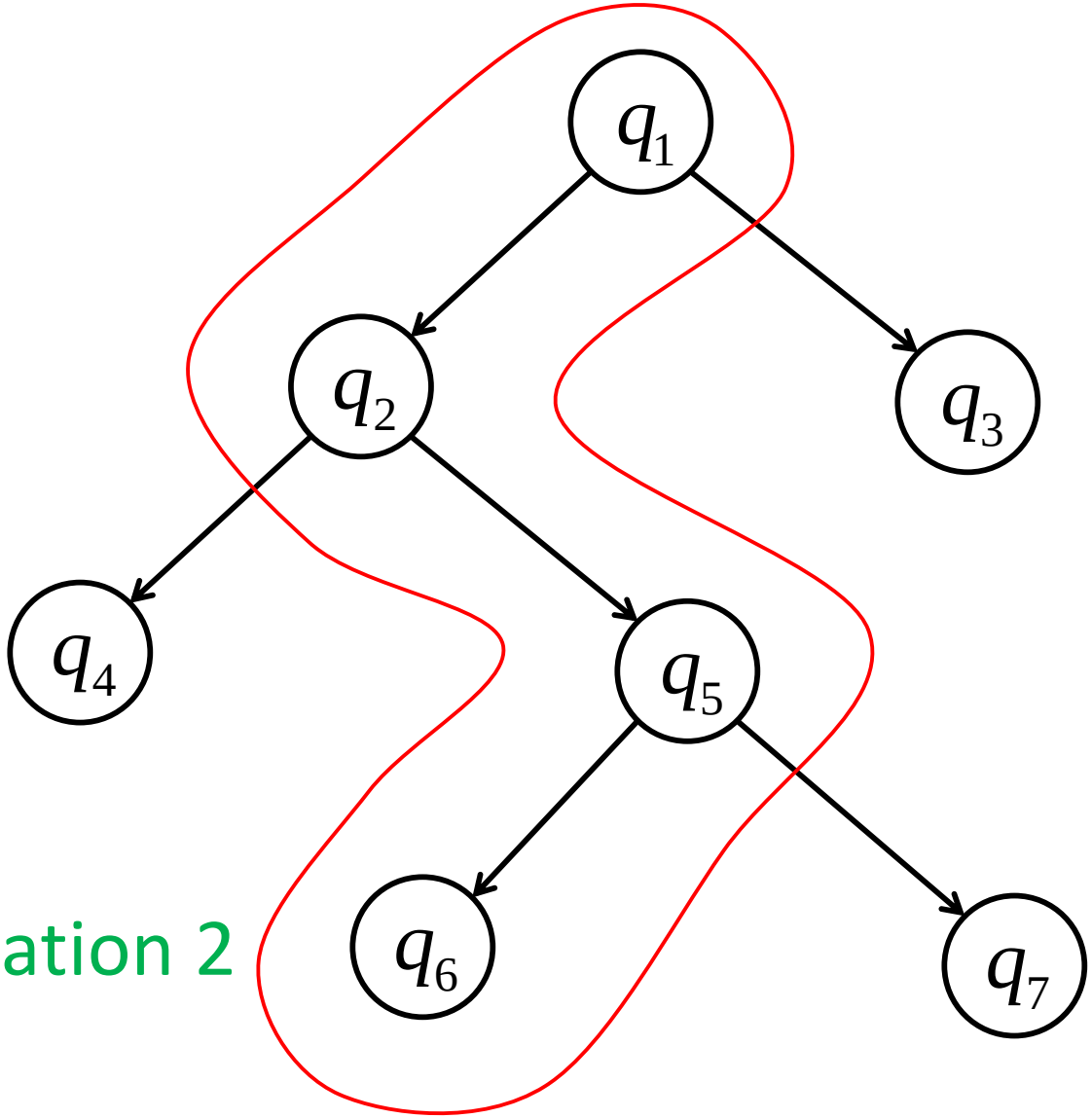


Non-deterministic Turing Machines



Computation 1

Non-deterministic Turing Machines



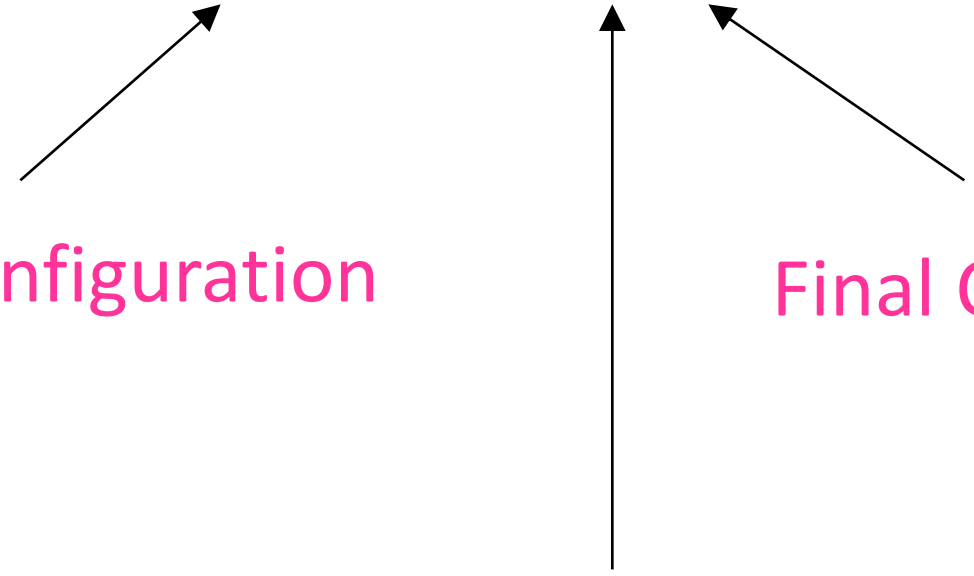
Computation 2

Non-deterministic Turing Machines

Input string w is accepted if

this a possible computation

$$q_0 w \succ^* x\, q_f\, y$$



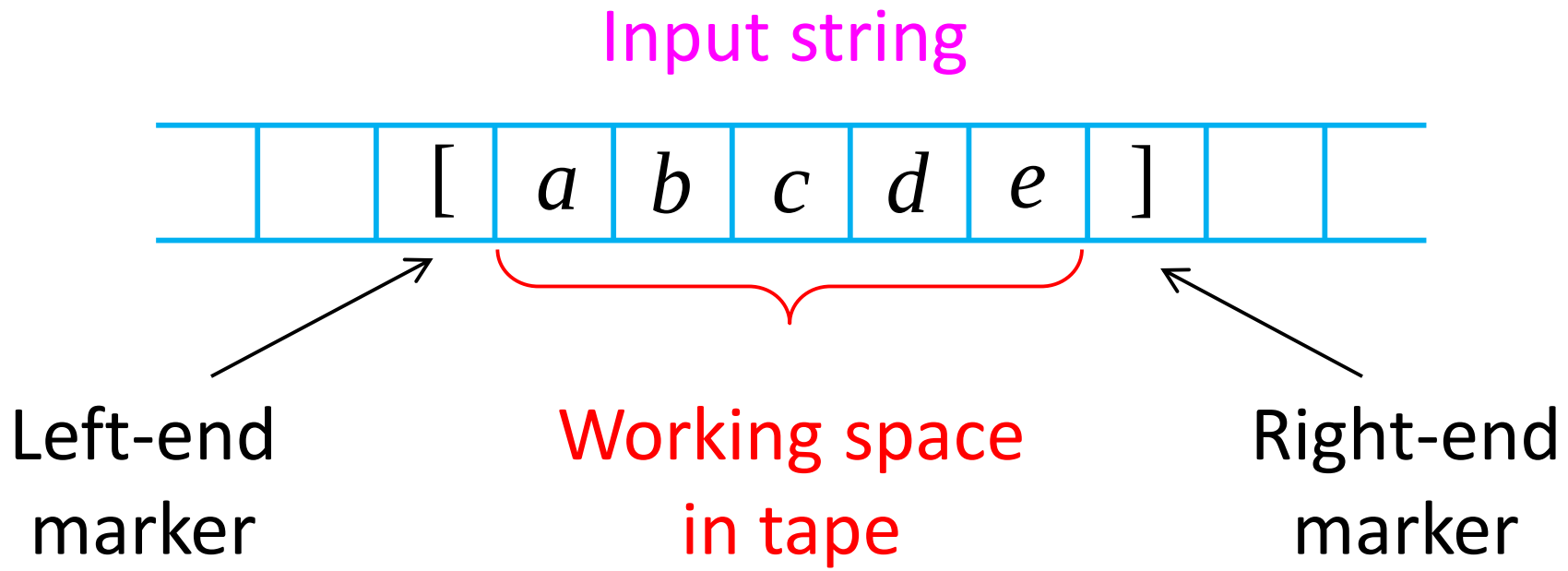
Initial configuration

Final state

Final Configuration

Linear Bounded Automata

- **Linear Bounded Automata (LBAs)** are the same as Turing Machines with one difference: the input string tape space is the only tape space allowed to use.



Linear Bounded Automata

- Example languages accepted by LBAs:

$$L = \{a^n b^n c^n\} \qquad L = \{a^{n!}\}$$

- LBA have less power than Turing Machines