



# Theory of Machines and Languages

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# Other Models of Turing Machines

## □ Multitape Turing Machines

### ➤ Example

- Consider the language  $\{a^n b^n\}$
- Using a two-tape machine:
  - Assume that the initial string is written on tape 1
  - We then read all the  $a$ 's, copying them onto tape 2
  - When we reach the end of the  $a$ 's, we match the  $b$ 's on tape 1 against the copied  $a$ 's on tape 2

$$\delta(q_0, a, B) = (q_1, a, a, R, R)$$

$$\delta(q_1, a, B) = (q_1, a, a, R, R)$$

$$\delta(q_1, b, B) = (q_2, b, B, S, L)$$

$$\delta(q_2, b, a) = (q_2, b, a, R, L)$$

$$\delta(q_2, B, B) = (q_f, B, B, L, R)$$

### ➤ Exercise

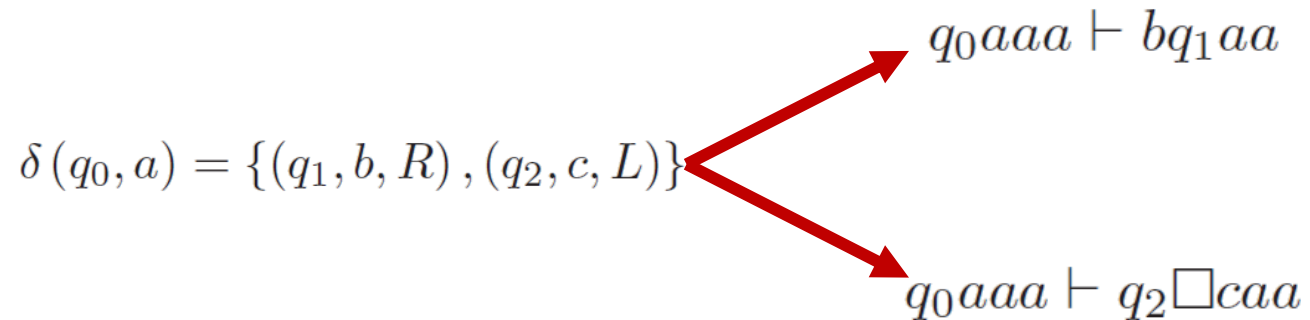
- $L = \{a^n b^n c^n\}, n \geq 1$

# Other Models of Turing Machines

## □ Nondeterministic Turing Machines

$$\delta : Q \times \Gamma \rightarrow 2^{Q \times \Gamma \times \{L, R\}}$$

### ➤ Example



- The class of deterministic Turing machines and the class of nondeterministic Turing machines are equivalent.

# Turing Machines

## Exercise

- Design a Turing machine that accepts the following language  
 $L = \{ww : w \in \{0, 1\}^+\}$

