Turing Machines

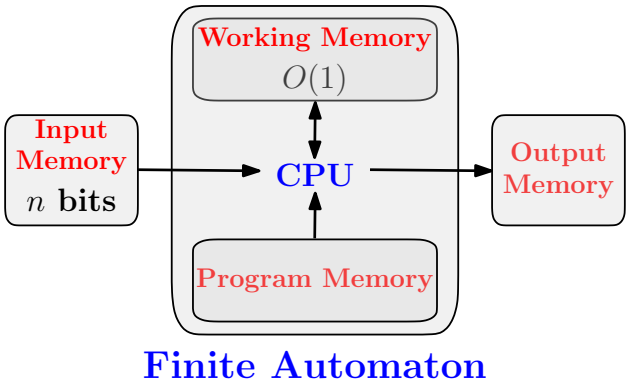
- Turing Machine: Model of Computation
- Turing Machine: Anatomy and Working
- Turing Machine: Formal Definition and Rules of Computation
- Recognizable and Decidable Languages
- Turing Machine: Levels of Abstraction
- Varaints of Turing Machine and The Church-Turing Thesis
- Non-Deterministic Turing Machine

Imdad ullah Khan

Anatomy and Simulation of a Turing Machine

Anatomy of DFA

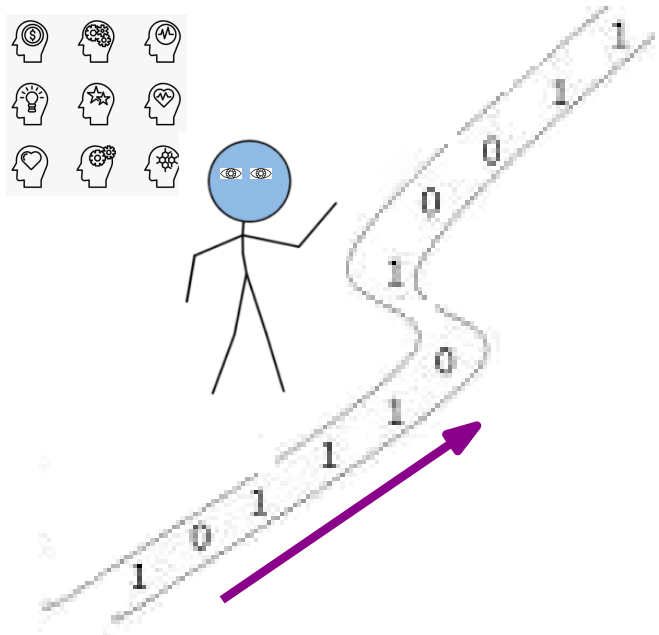
A Deterministic Finite Automata has constant working memory



Finite Automaton

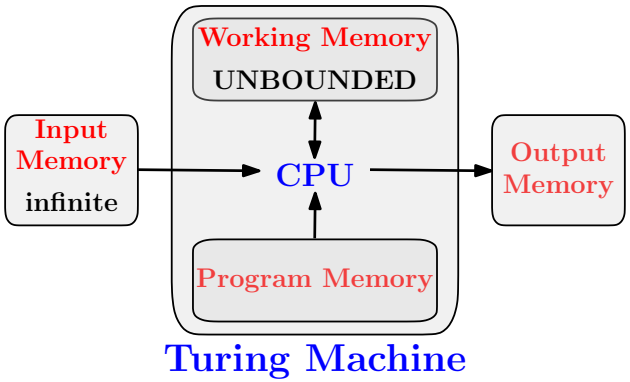
A deterministic finite automata or finite state machine is a little creature

- it has tiny eyes sees one symbol
- changes its state of mind according to the symbol it sees
- only remember its current state of mind



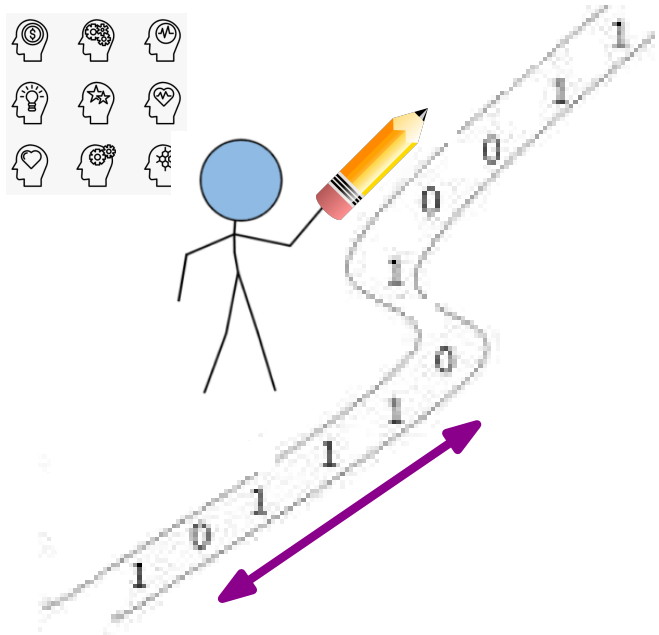
Anatomy of Turing Machine

A Turing Machine has unbounded working memory

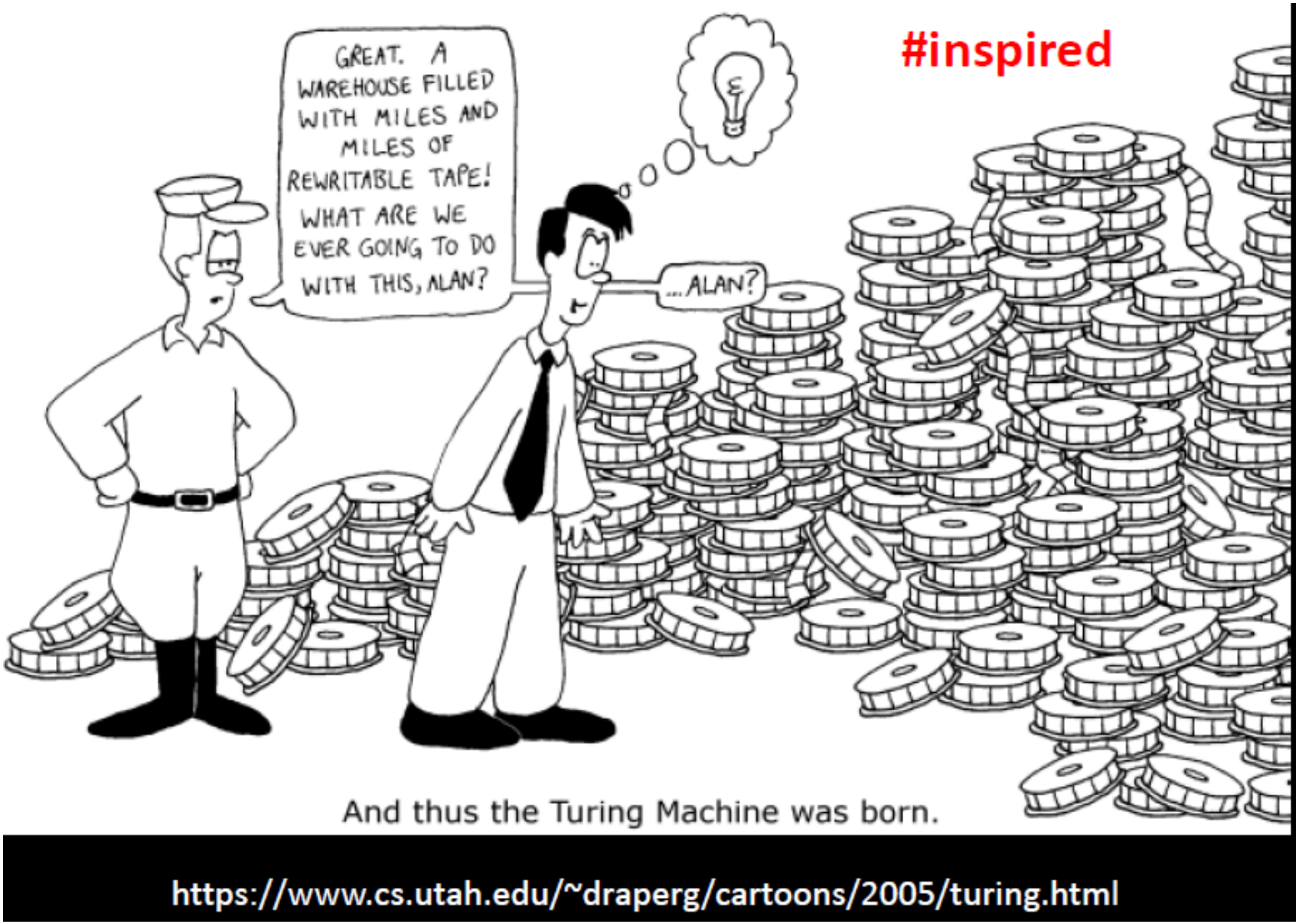


A Turing machine is a ~~little~~ creature

- it has tiny eyes sees one symbol
- changes its state of mind according to the symbol it sees on the infinite tape
- can move on the tape left/right (or not)
- can write on tape (has pencil with eraser)



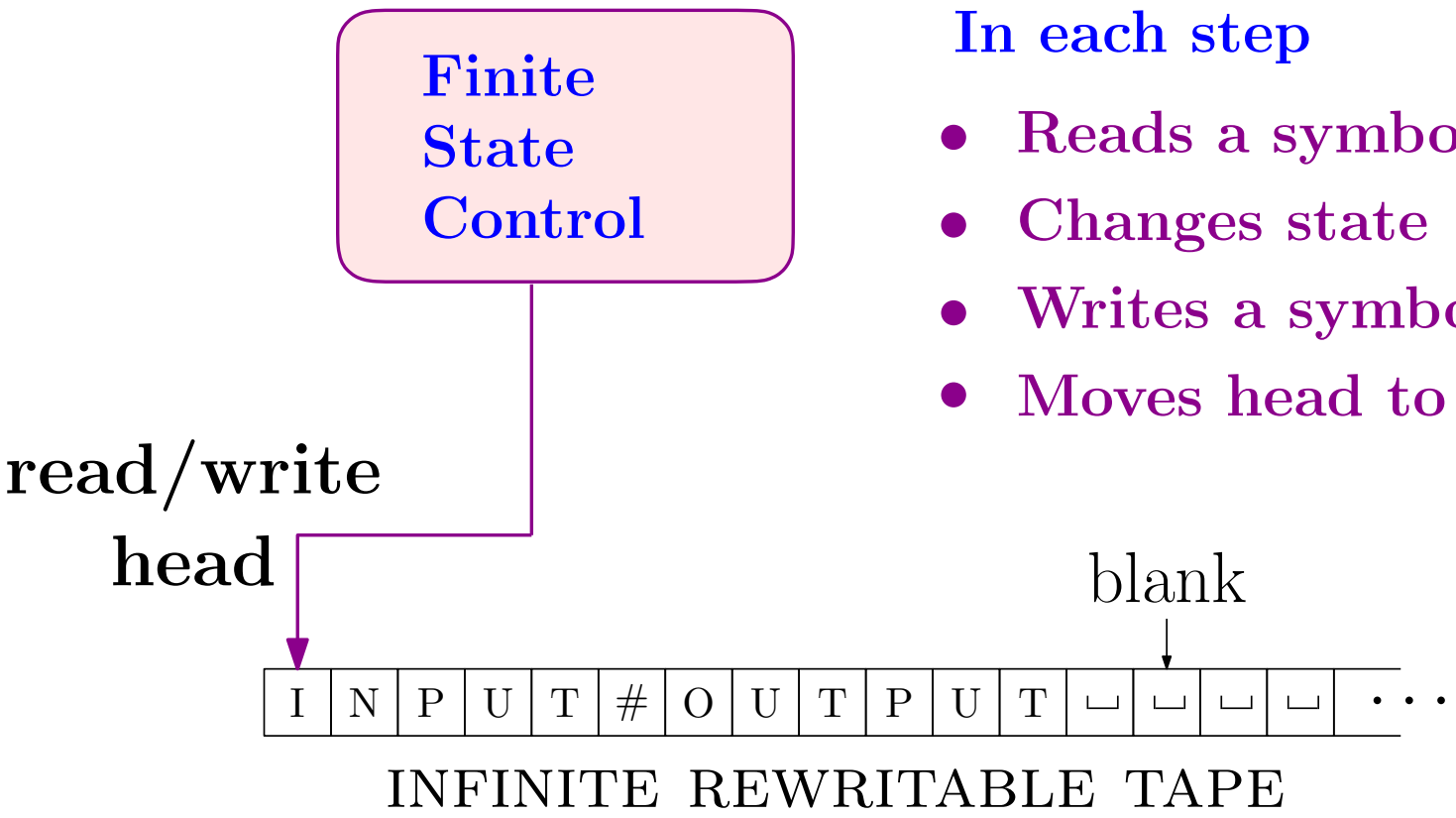
What can Turing Machines do?



DFAs versus Turing Machine

- The input is written on an infinite tape with $\sqcup$ after the input
- The tape head can move left and right
- TM can both read from and write to the tape
- TM can write symbols that are not part of the input
- The entire input does not have to be read for accept/reject decision
- TMs can loop forever, computation can continue further after all input is read
- Accept and Reject take immediate effect (computation halts as soon as TM goes into accept or reject state)

How Turing Machines Work



In each step

- **Reads a symbol at the head**
- **Changes state**
- **Writes a symbol at the head**
- **Moves head to left or right**

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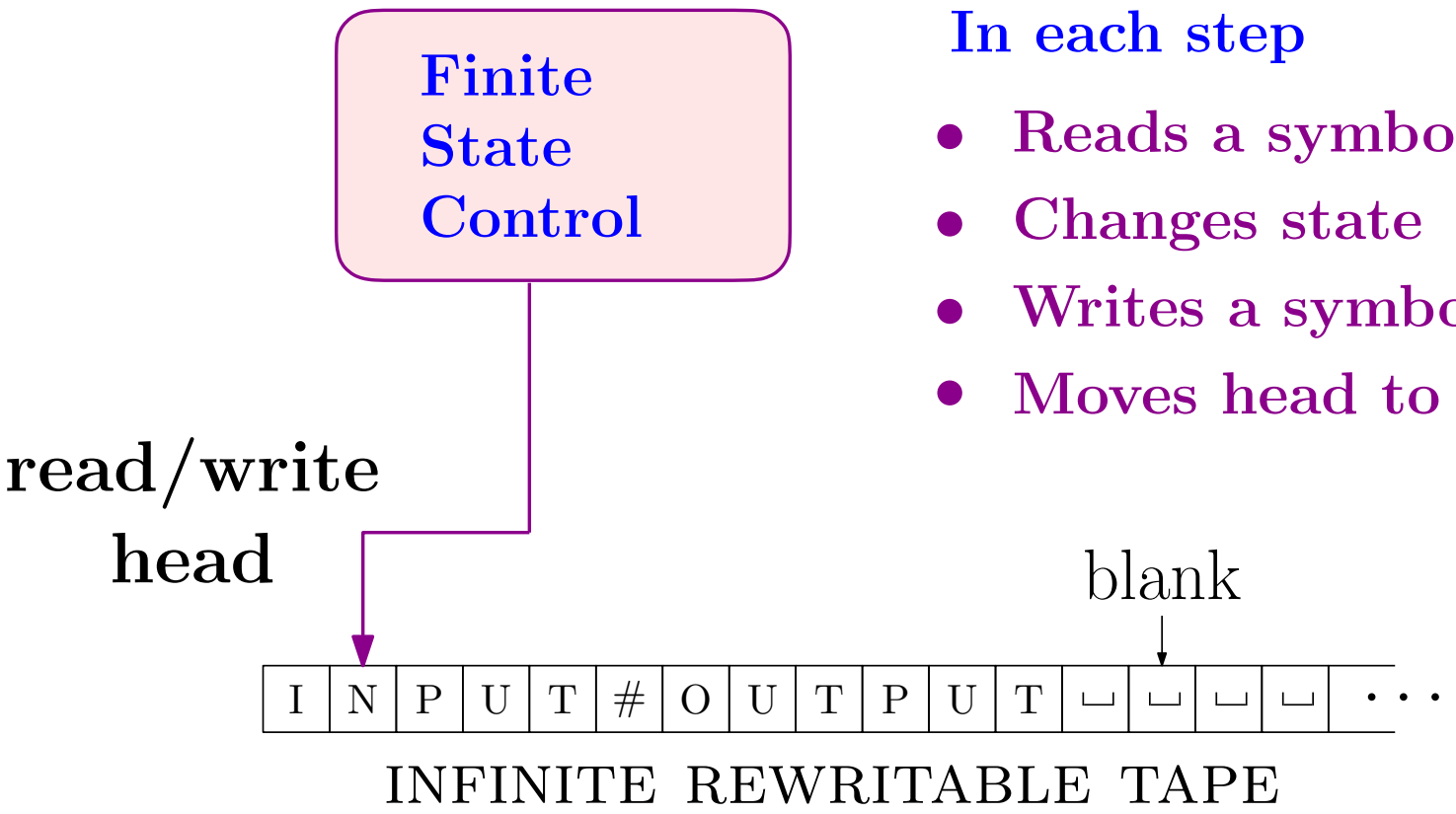

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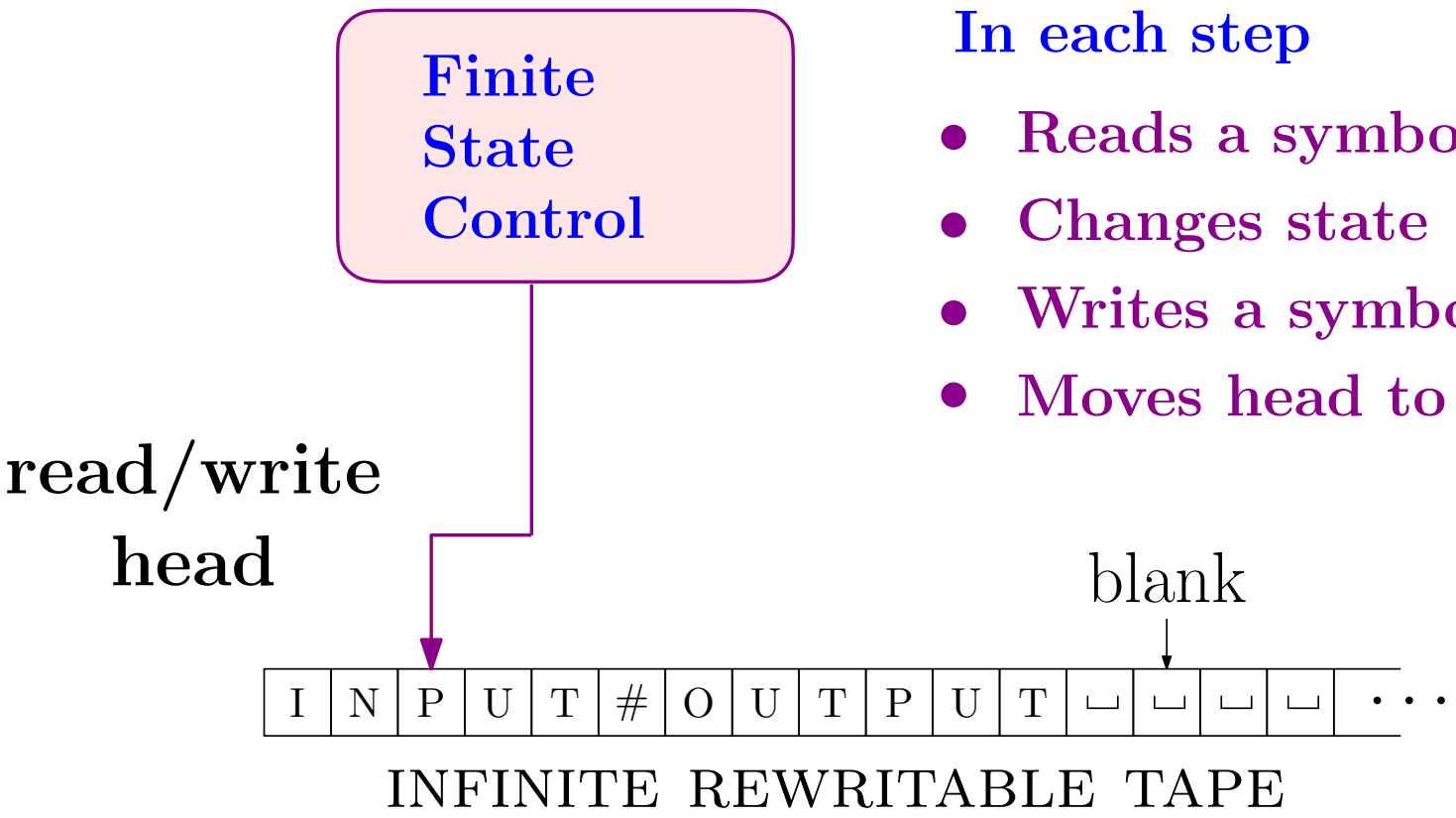

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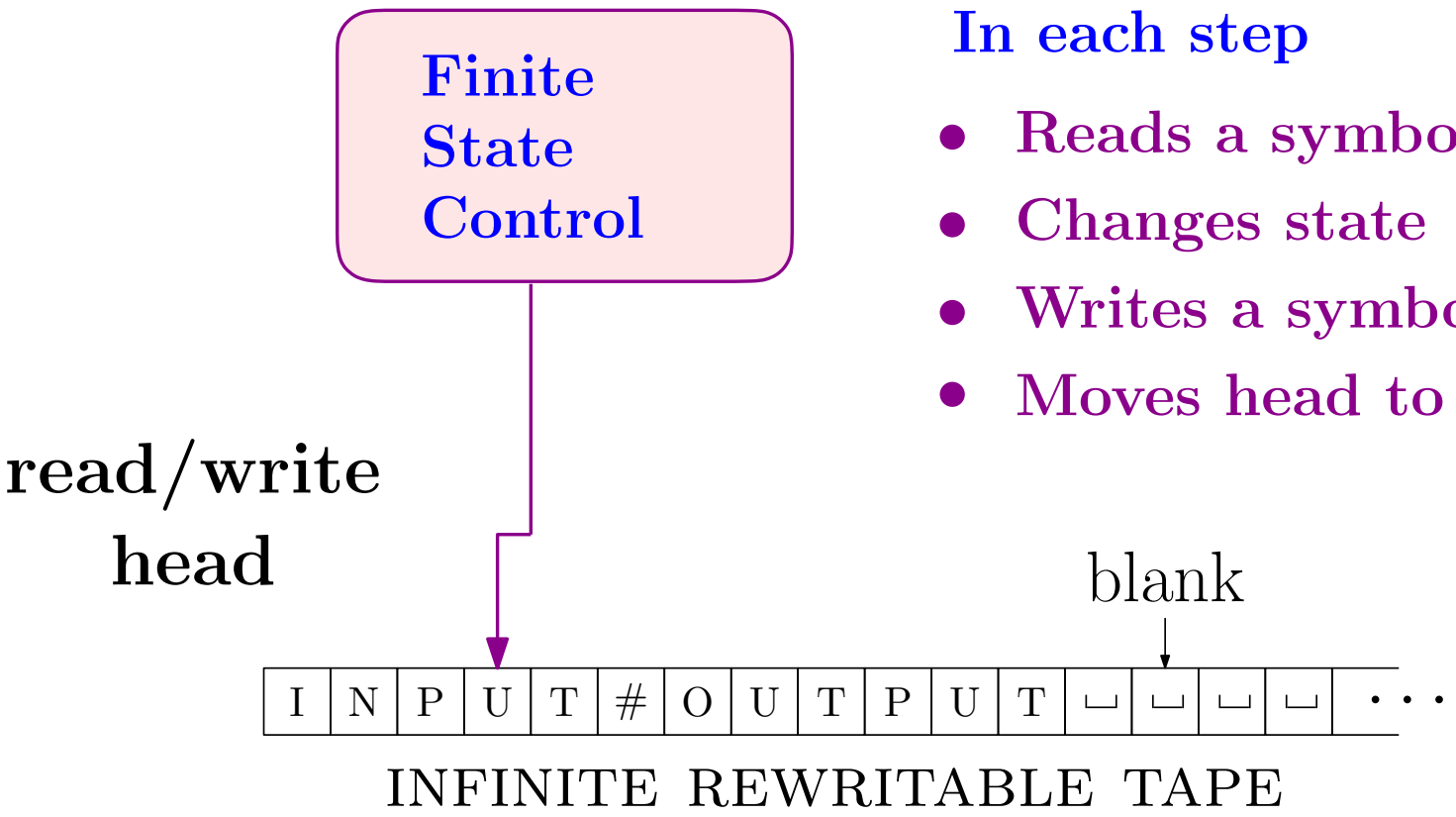

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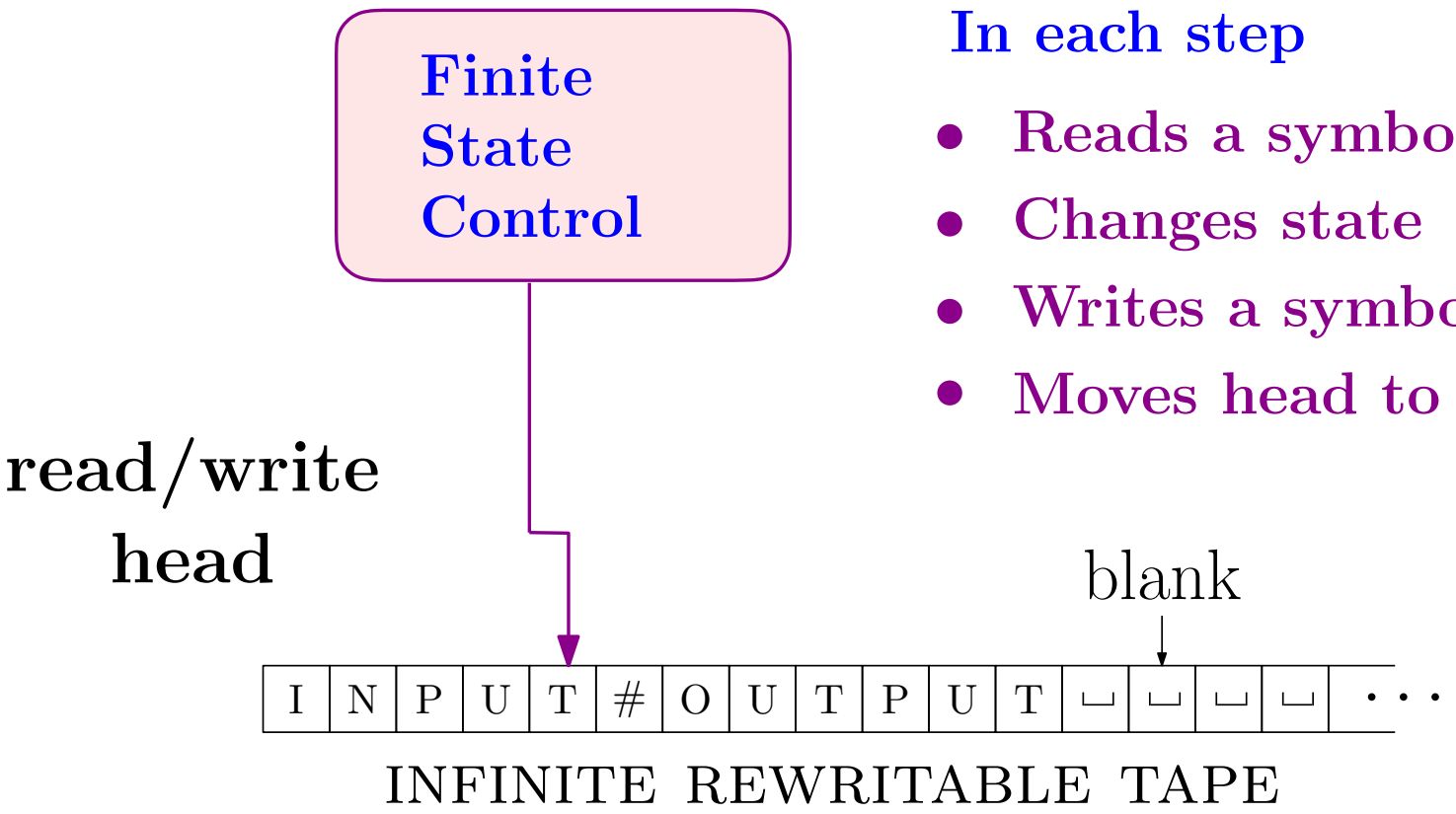

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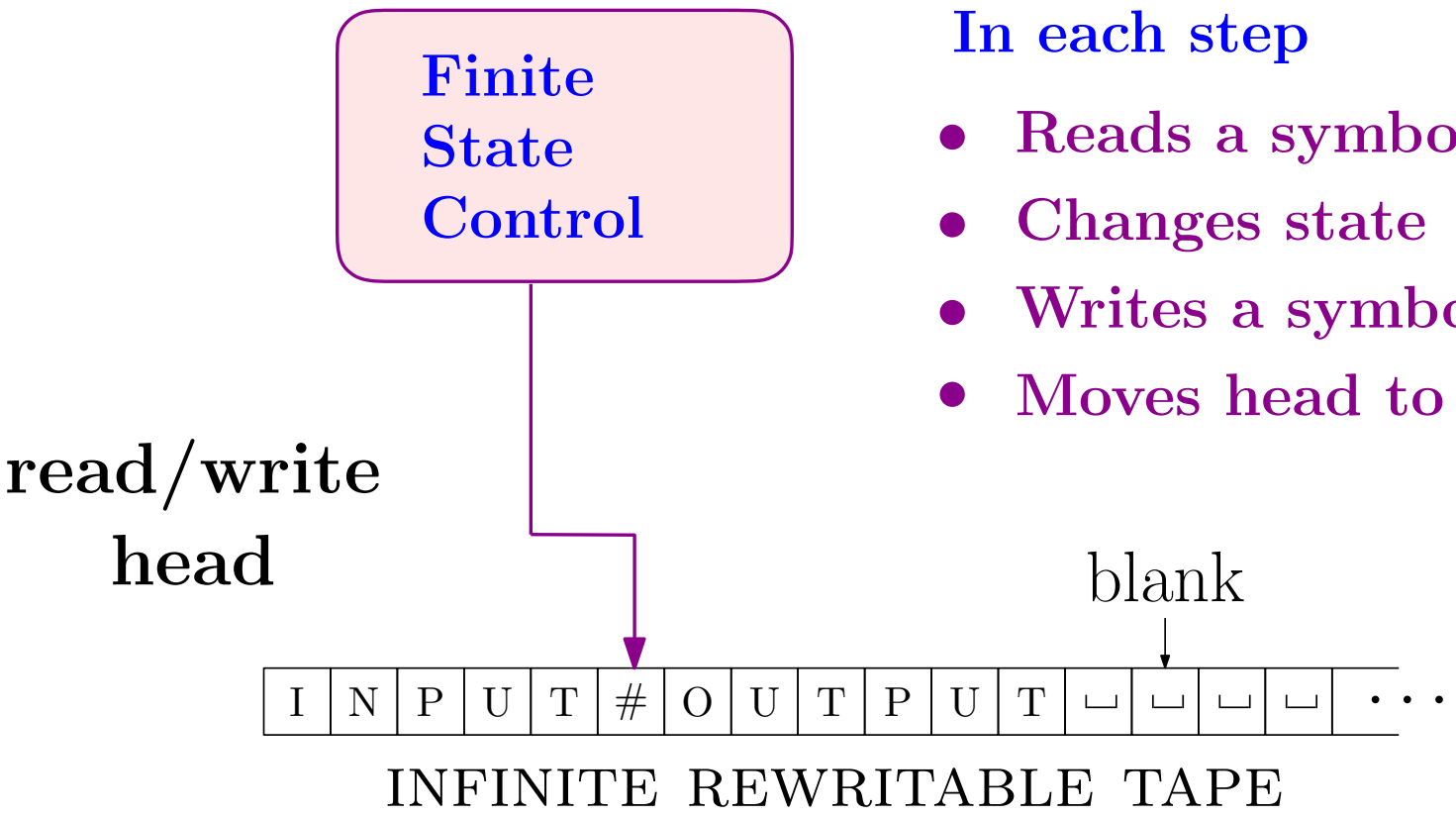

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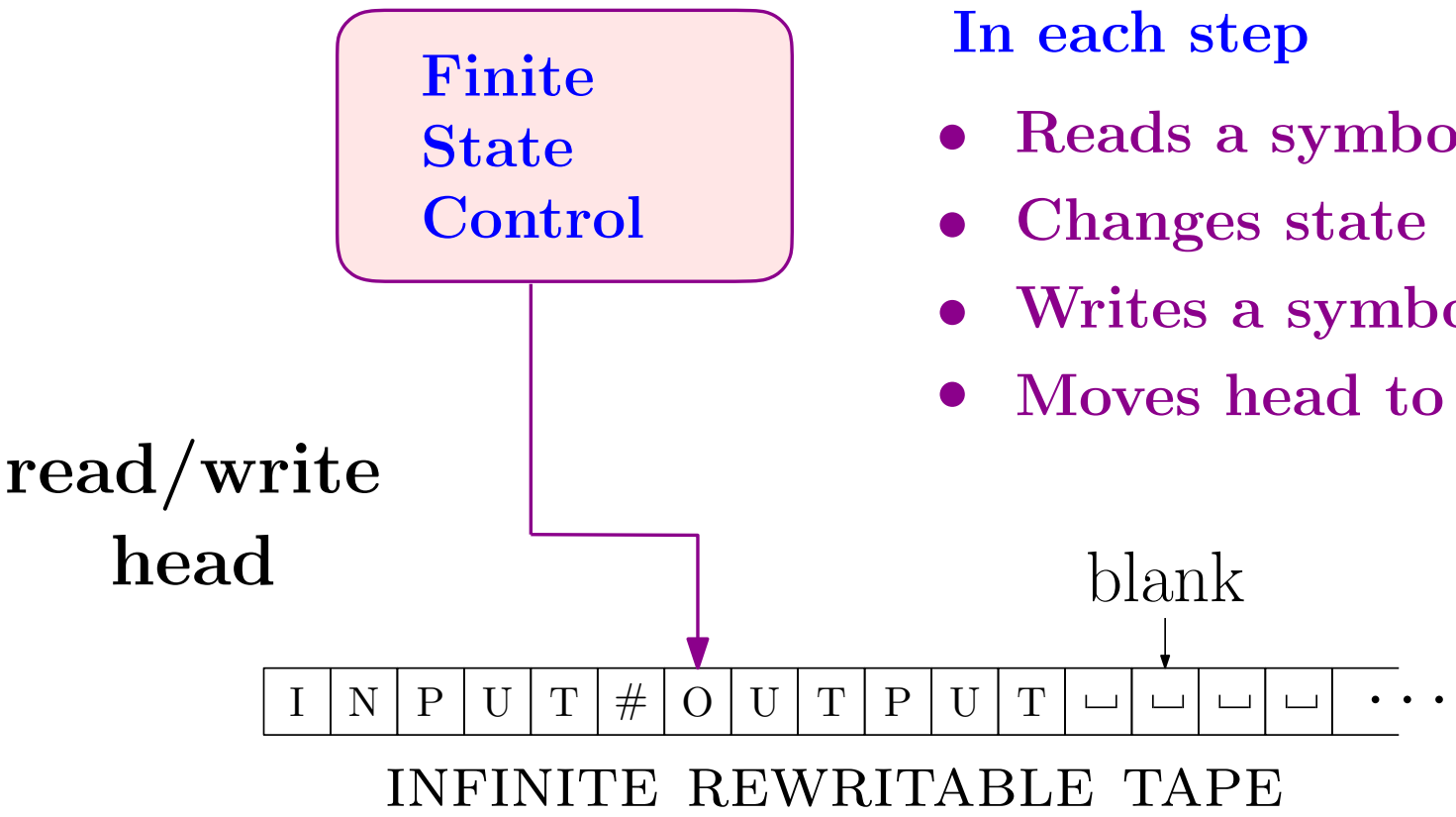

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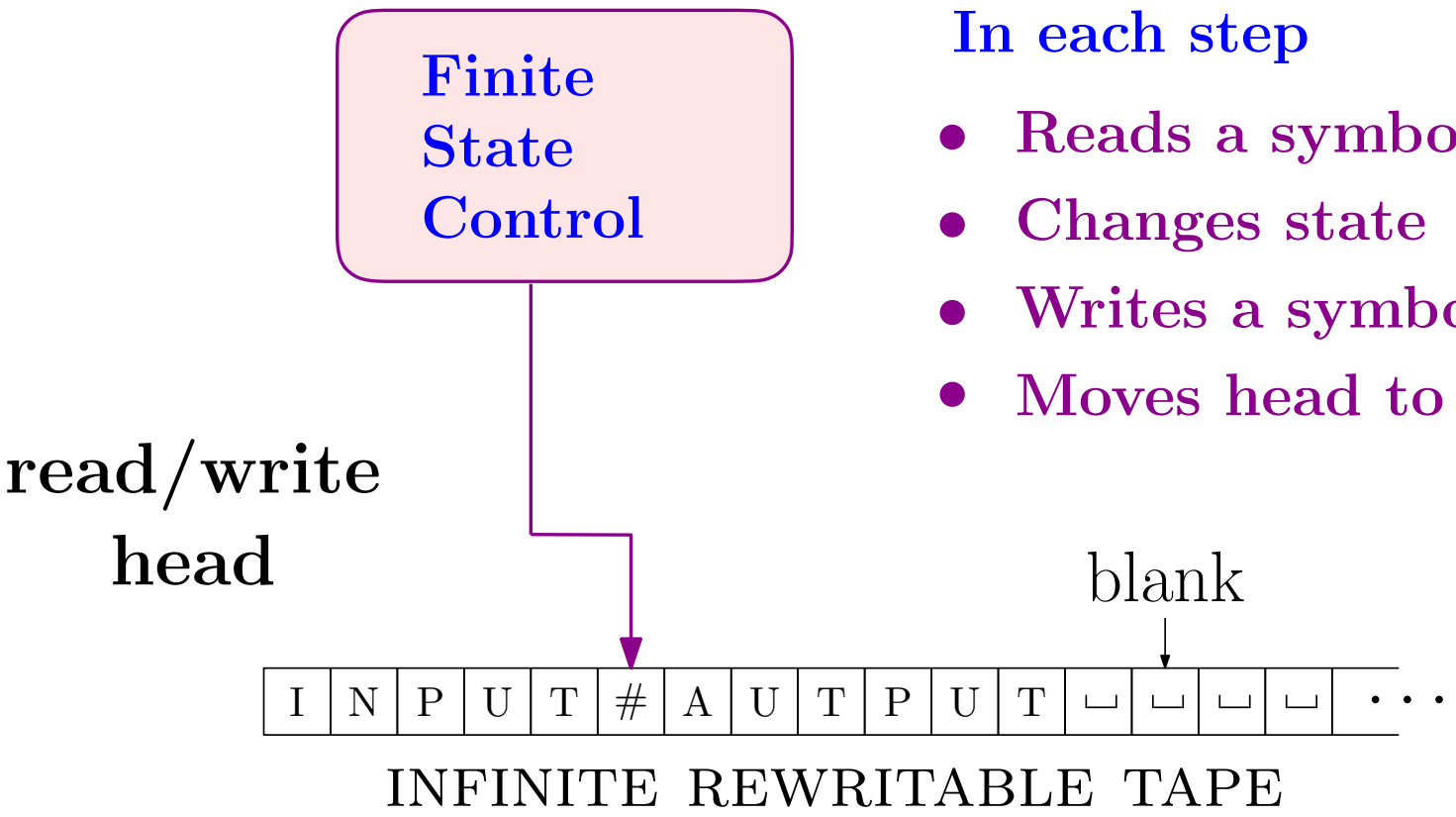

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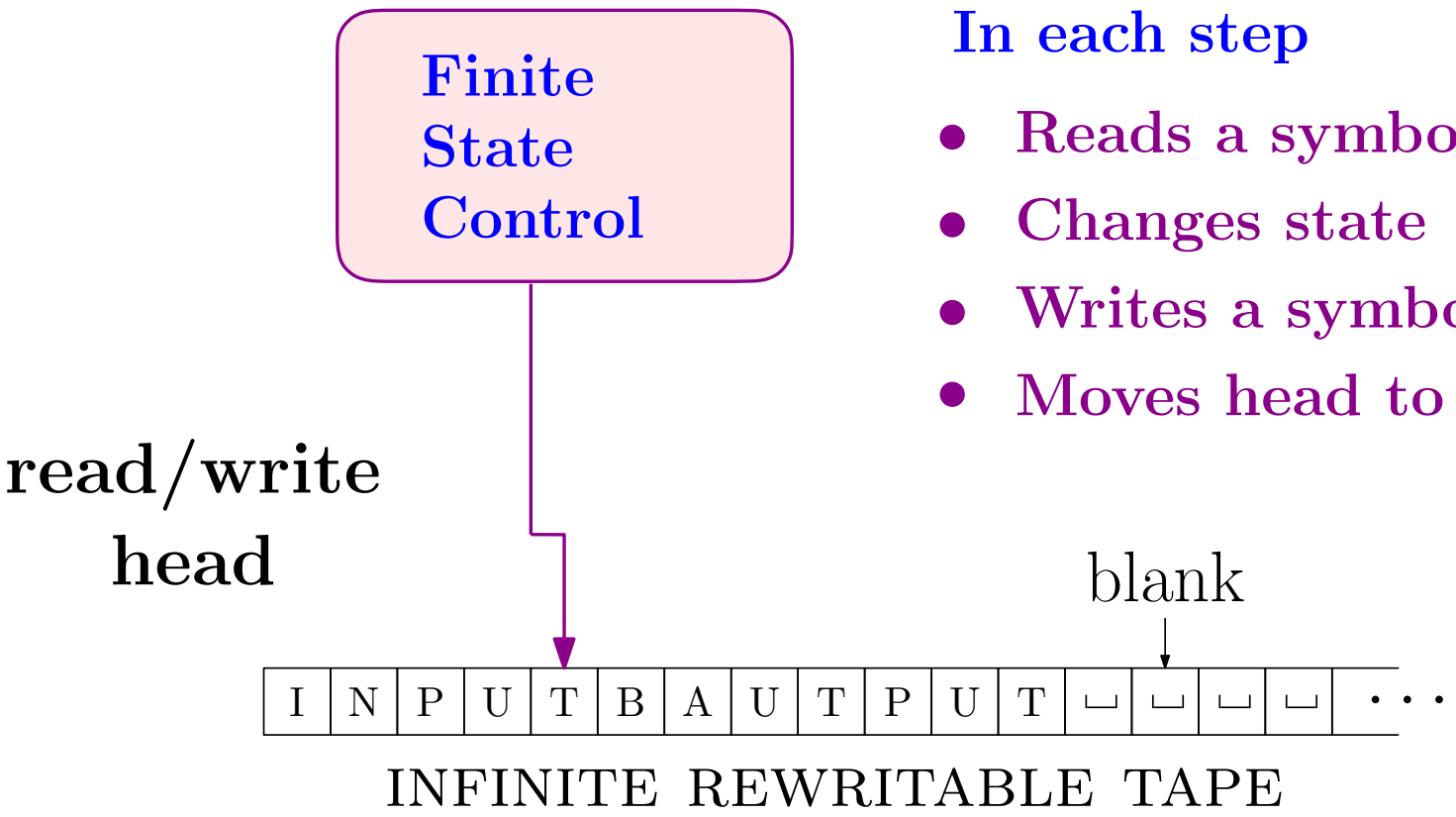

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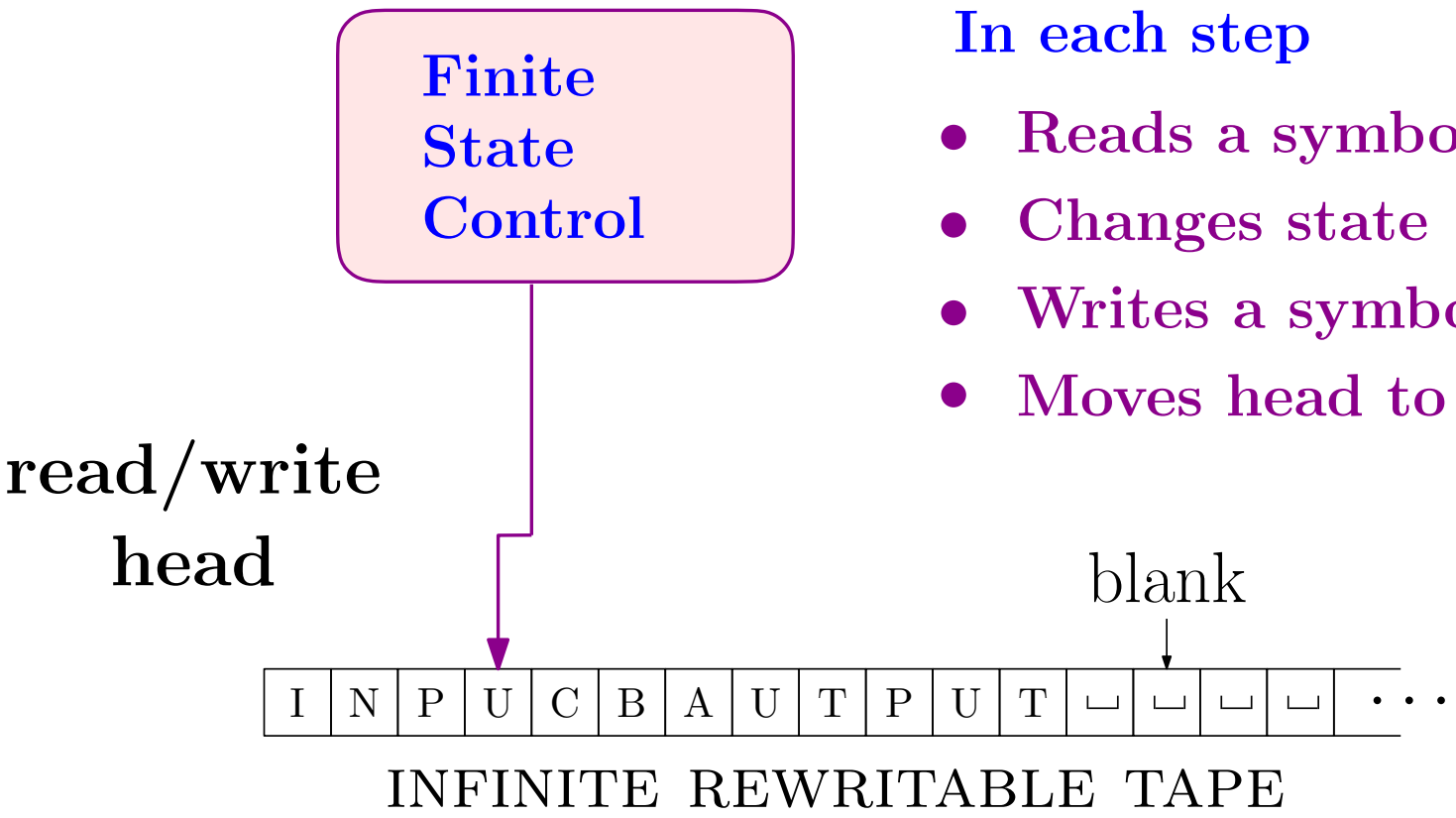

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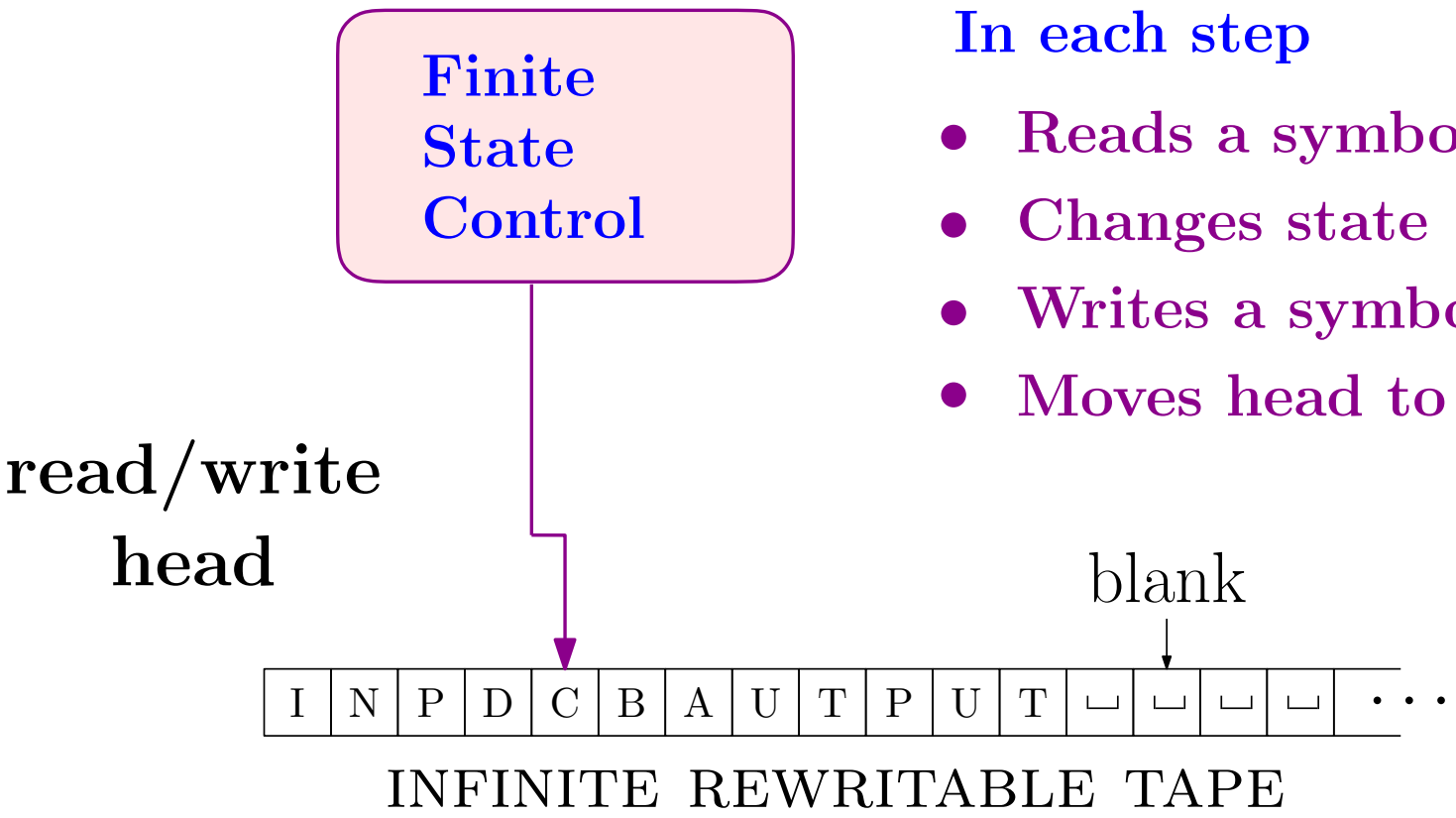

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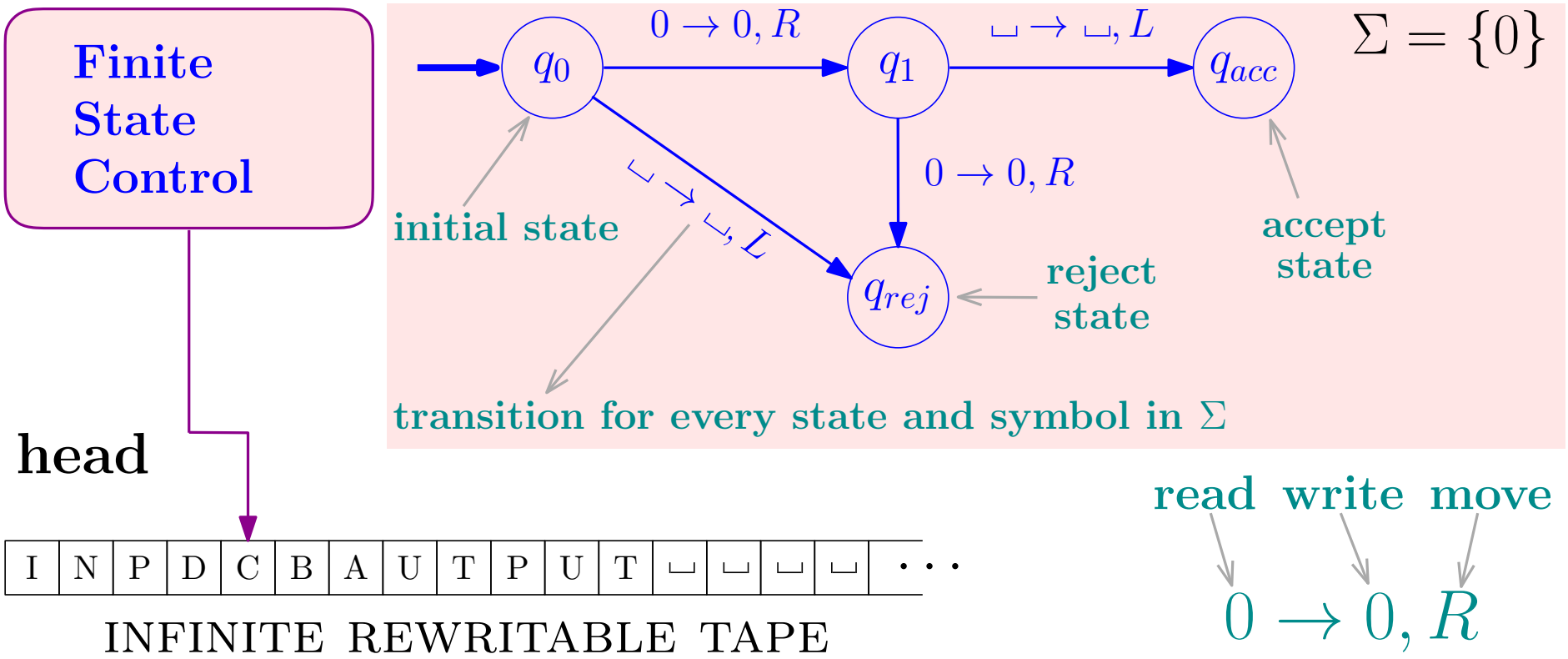
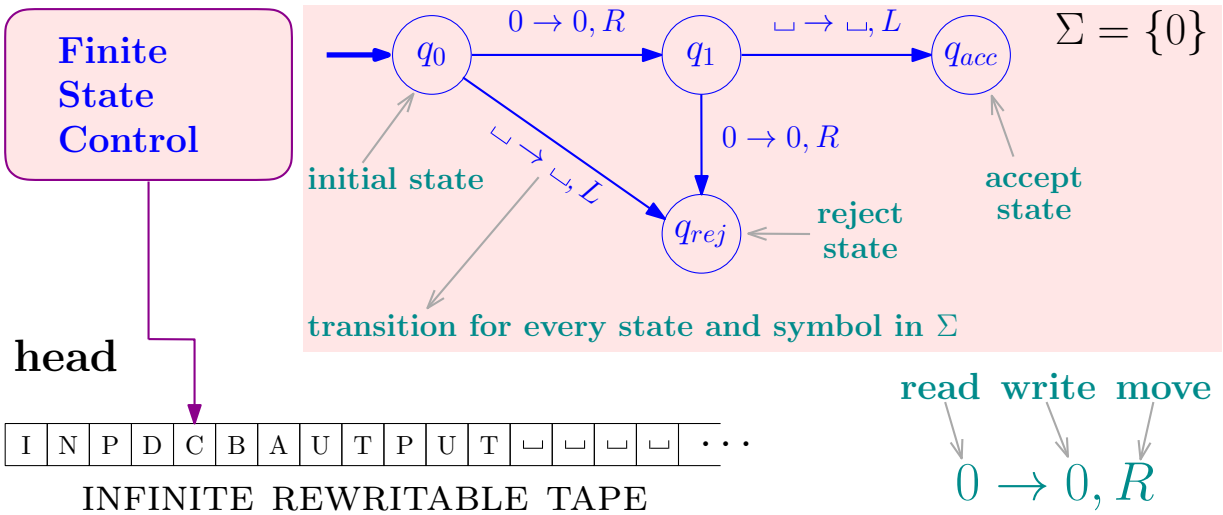
Anatomy of Turing Machines



Turing Machine: Simulation



TM starts in the initial state and reads the first symbol

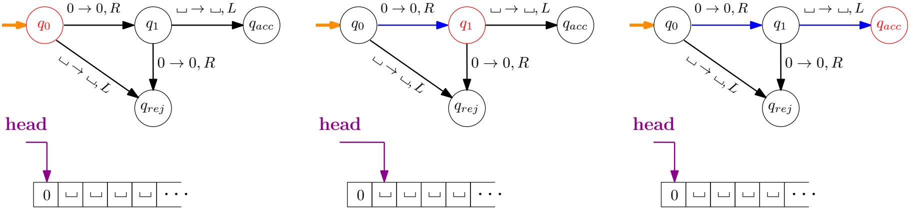
It changes state according to the transition function (possibly writing a symbol at current head position and moves the head left/right)

The transition function determine moving to an accept or reject state ▷
TM can move to an accept or reject state without reading the whole input

Accept and **Reject** take immediate effect

Turing Machine: Simulation

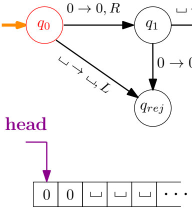
$\Sigma = \{0\}$

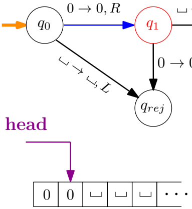


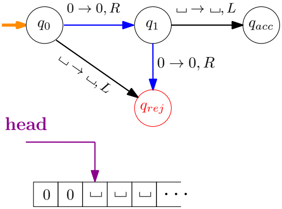
The TM accepts the string 0

Turing Machine: Simulation

$\Sigma = \{0\}$







The TM accepts the string 0

The TM rejects the string 00

Turing Machine: Simulation

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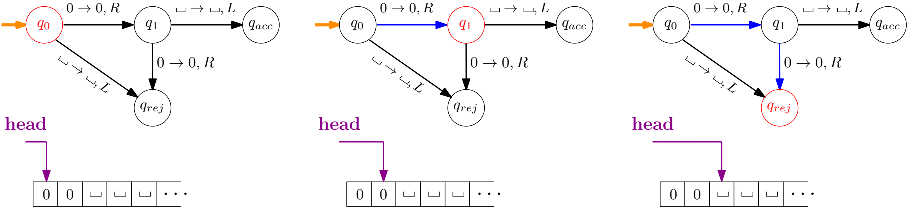

The TM accepts the string 0

The TM rejects the string 00

Can we say the language of TM is $\{0\}$? Not really?

Turing Machine: Simulation

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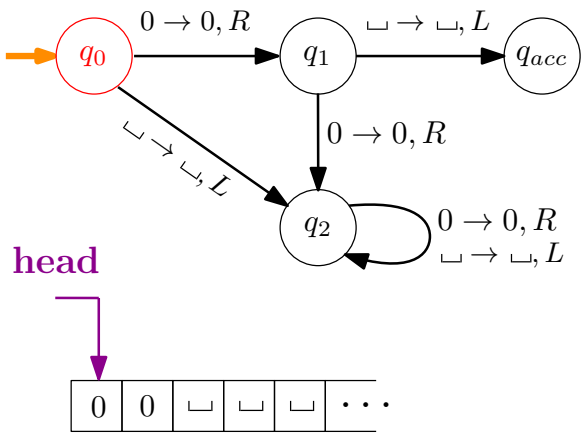

The TM accepts the string 0

The TM does not accept any other string

Can we say the language of TM is $\{0\}$? Not really?

On any other string the TM loops forever