

Turing Machines

Alan Turing

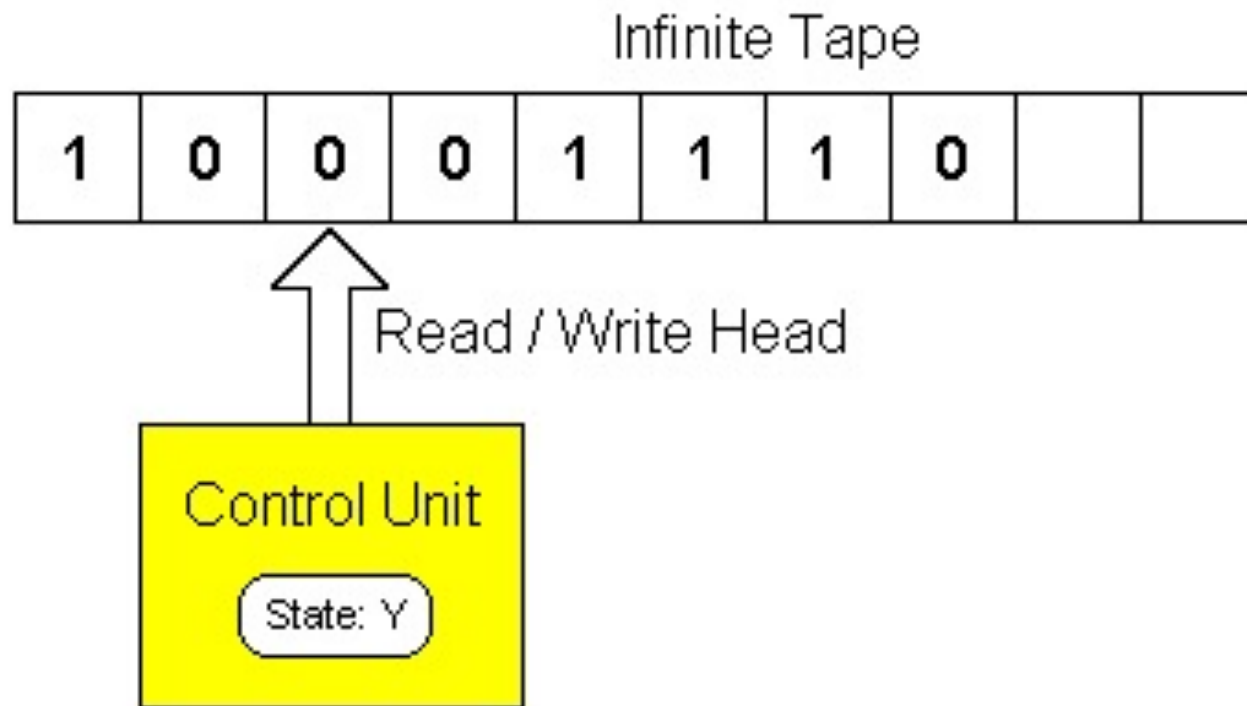
- Enigma (criptography)
- Turing test
- Turing machine (1937)



Turing Machine

- Mathematical model for computation
- Abstract machine
- Can simulate any algorithm

Turing Machine



- Input band (infinite)
- Reading head
- Control Unit: states
- Transitions / moves

Turing machine – definition

7-tuple $M = (Q, \Gamma, b, \Sigma, \delta, q_0, F)$ where:

- Q – finite set of states
- Γ - alphabet (finite set of band symbols)
- $b \in \Gamma$ - blank (symbol)
- $\Sigma \subseteq \Gamma \setminus \{b\}$ – input alphabet
- $\delta : (Q \setminus F) \times \Gamma \rightarrow Q \times \Gamma \times \{L, R\}$ – transition function
- $q_0 \in Q$ – initial state
- $F \subseteq Q$ – set of final states

L = left
R = right

Example – palindrome over $\{0,1\}$

- 001100, 00100, 101101 a.s.o. accepted
- 00110, 1011 a.s.o. not accepted

001100

Example – palindrome over $\{0,1\}$

	0	1	b
q_0	(p_1, b, R)	(p_2, b, R)	(q_f, b, R)
p_1	$(p_1, 0, R)$	$(p_1, 1, R)$	(q_1, b, L)
p_2	$(p_2, 0, R)$	$(p_2, 1, R)$	(q_2, b, L)
q_1	(q_r, b, L)		(q_f, b, R)
q_2		(q_r, b, L)	(q_f, b, R)
q_r	$(q_r, 0, L)$	$(q_r, 1, L)$	(q_0, b, R)
q_f			

Delete 0 in left side;
search 0 in right side

Delete 1 in left side;
search 1 in right side

On right is 0 or 1?

Shift right

q_1 and q_2 – process 0 and
1 on the right

q_f – final state

0110

0	1	1	0	
	1	1	0	
	1	1	0	
	1	1	0	
	1	1	0	
	1	1	0	
	1	1	0	
	1	1		

	1	1		
	1	1		
	1	1		
	1	1		
	1	1		
		1		

...

$(q_0, \underline{0}11\underline{0}) \mid - (p_1, \underline{1}1\underline{0}) \mid - (p_1, 1\underline{1}\underline{0})$

$\mid - (p_1, 11\underline{0}) \mid - (p_1, 110\underline{b}) \mid - (q_1, 11\underline{0})$

$\mid - (q_r, 1\underline{1}) \mid - (q_r, \underline{1}1) \mid - (q_r, \underline{b}11)$

$\mid - (q_0, \underline{1}1) \mid - \dots$

	0	1	b
q_0	(p_1, b, R)	(p_2, b, R)	(q_f, b, R)
p_1	$(p_1, 0, R)$	$(p_1, 1, R)$	(q_1, b, L)
p_2	$(p_2, 0, R)$	$(p_2, 1, R)$	(q_2, b, L)
q_1	(q_r, b, L)		(q_f, b, R)
q_2		(q_r, b, L)	(q_f, b, R)
q_r	$(q_r, 0, L)$	$(q_r, 1, L)$	(q_0, b, R)
q_f			

<https://turingmachinesimulator.com>