CMSC 141 Automata and Language Theory

Turing Machines

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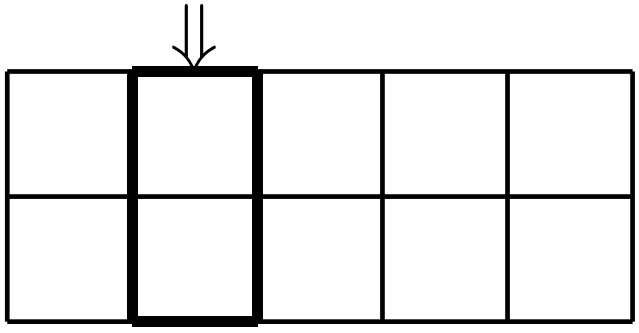
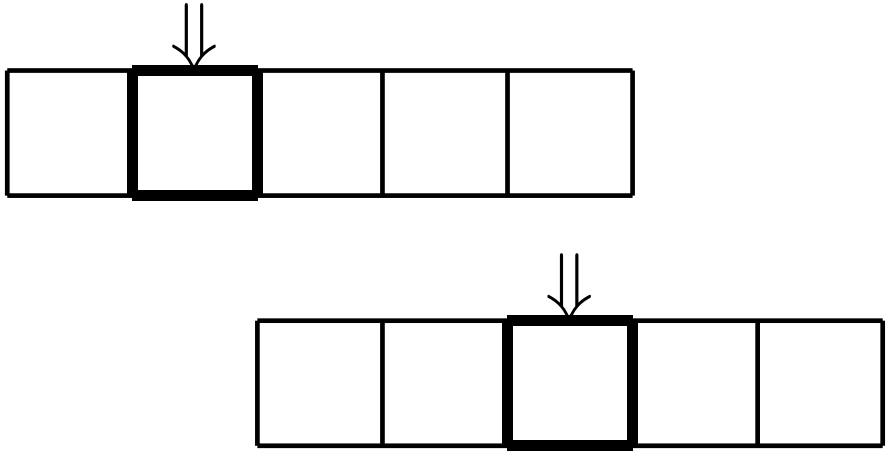
Turing Machine Variants

- Multiple tracks/tapes

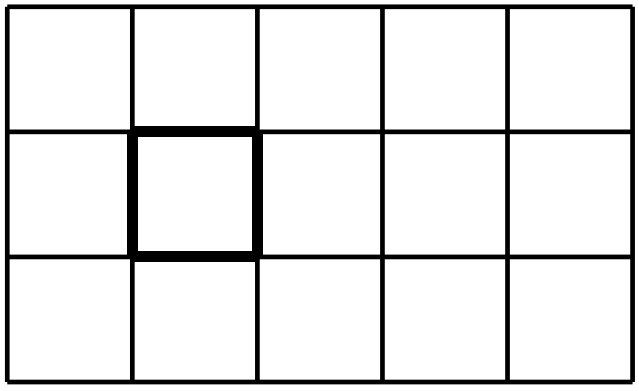


- Multiple tapes with multiple independent heads



Turing Machine Variants

- 2-dimensional "tape"



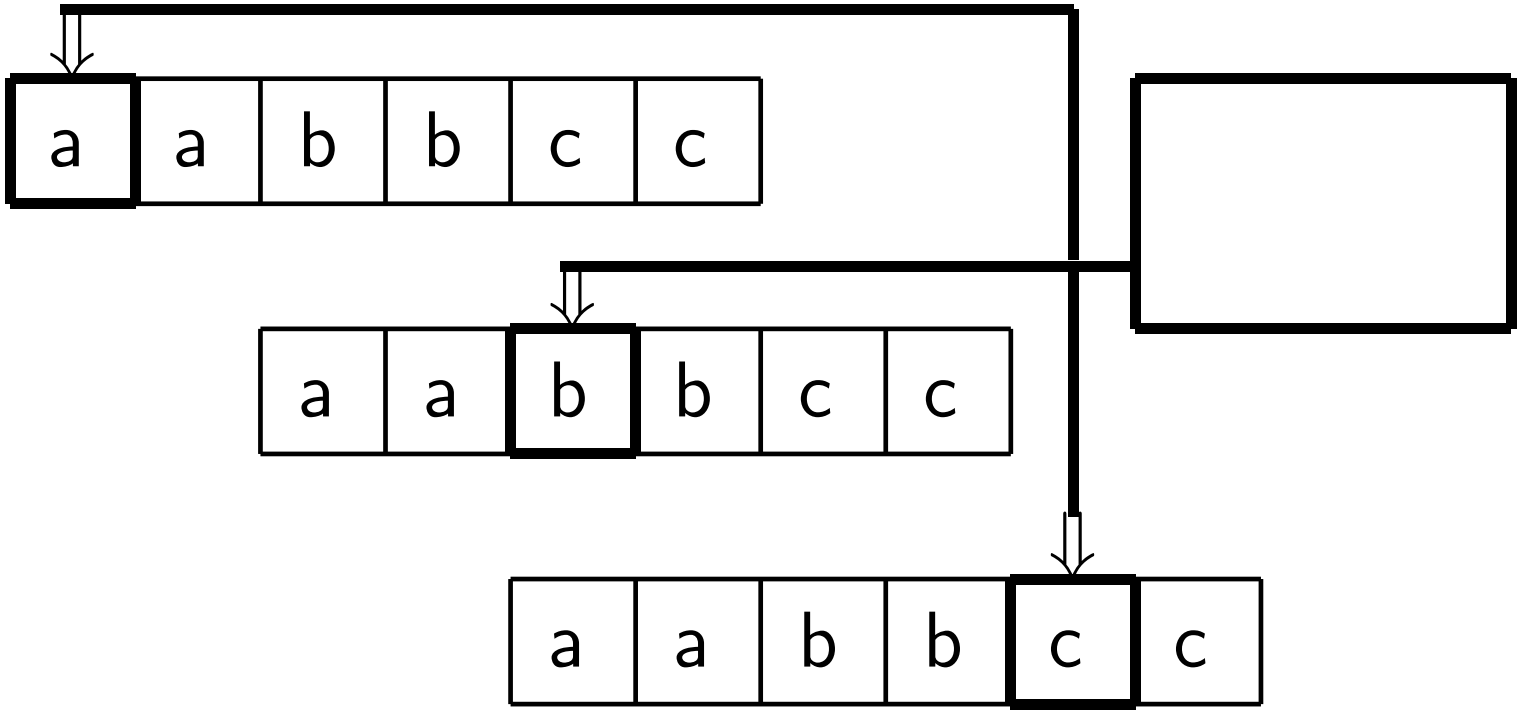
- Of course we can mix and match these variants

Changes to transition function

- Basic Model
  - $\delta : Q \times \Sigma \to Q \times \Sigma \times \{L, R\}$
- With Stay Option
  - $\delta : Q \times \Sigma \to Q \times \Sigma \times \{L, S, R\}$
- k-Tracks
  - $\delta : Q \times \Sigma^k \to Q \times \Sigma^k \times \{L, R\}$
- p-Tapes with Independent Heads
  - $\delta : Q \times \Sigma^p \to Q \times (\Sigma \times \{L, R\})^p$
- 2-dimensional Tape
  - $\delta : Q \times \Sigma \to Q \times \Sigma \times \{L, S, R, U, D\}$

Turing Machine for Languages

How can we now recognize the non-CFL
$L = \{a^n b^n c^n : n > 0\}$



How about using only one tape?

Universal Turing Machine

- The example Turing machines discussed seem to solve very specific problems
- However, it is possible to define a Turing Machine that can simulate any TM on any input
- This makes Turing machines as general-purpose problem solvers

Universal Turing Machine

- UTMs can be considered as the origin of the stored-program computer
- UTMs are programmable to simulate any other TM; think of compilers and interpreters
- Kara has an example of a UTM that is actually quite big
- There is also a UTM with only 7 states and 4 symbols (Minsky 1962)
- Another with only 2 states and 5 symbols (Wolfram 1985)

References

- Previous slides on CMSC 141
- M. Sipser. Introduction to the Theory of Computation. Thomson, 2007.
- J.E. Hopcroft, R. Motwani and J.D. Ullman. Introduction to Automata Theory, Languages and Computation. 2nd ed, Addison-Wesley, 2001.
- E.A. Albacea. Automata, Formal Languages and Computations, UPLB Foundation, Inc. 2005
- JFLAP, www.jflap.org
- Various online LaTeX and Beamer tutorials