

Solution to Homework Problem 20

Homework Problem 20. As we discuss in class, a Turing machine can be described as a finite automata with two stacks:

- the right stack contains, on top, the symbol to which the head points; below is the next symbol to the right, then the next to next symbol to the right, etc.;
- the left stack contains, on top, the symbol directly to the left of the head (if there is a one), under it is the next symbol to the left, etc.

On the example a Turing machine that computes $n - 1$ for a binary number $n = 2$, show, step-by-step:

- how each state of the corresponding Turing machine can be represented in terms of two stacks, and
- how each transition from one state to another can be implemented by push and pop operations.

Solution. The rules of this Turing machine are as follows:

start, $- \rightarrow$ moving, R

moving, $0 \rightarrow 1$, R

moving, $1 \rightarrow 0$, L, back

back, $0 \rightarrow$ L

back, $1 \rightarrow$ L

back, $- \rightarrow$ halt

1. At first, we have the following configuration:

-	0	1	-	-	-	...	start
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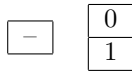
Here, the left stack is empty, and the right stack has the form

-
0
1

2. Then, the configuration changes to:

-	<u>0</u>	1	-	-	-	...	moving
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Here, the two stacks have the following form:



To get to this configuration, we pop the symbol - (meaning black space) from the right stack and push it into the left stack.

3. Then, the configuration changes to:



Here, the left stack has the following form:



and the right stack has the following form:



To get to this configuration, we pop 1 from the right stack, change it to 0, and push it into the left stack.

4. Then, the configuration changes to:



Here, the left stack has the following form:



and the right stack has the following form:



To get to this configuration, we replace 1 with 0, pop 0 from the right stack and push it into the left stack.

5. Then, the configuration changes to:

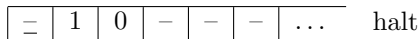


Here, the left stack is empty, and the right stack has the following form:



To get to this configuration, we pop blank from the left stack and push it into the right stack.

6. Then, the configuration changes to:



Here, we did not change anything on the tape, and we did not change the location of the head, so the stacks remain the same.