

Normal NTM :  $\delta : Q \times \Gamma \rightarrow Q \times \Gamma \times \{L, R\}$

Don't Write TM :  $\delta : Q \times \Gamma \rightarrow Q \times (\Gamma \cup \perp) \times \{L, R\}$   
bottom  
a character or not  
ie don't write

$\rightarrow \bigcirc \xrightarrow{a \rightarrow R} \bigcirc \xrightarrow{a \rightarrow b, L}$

compile : DWTM  $\rightarrow$  NTM ; only  $\delta$  changes

input :  $\delta_{DW}$       output :  $\delta_N$

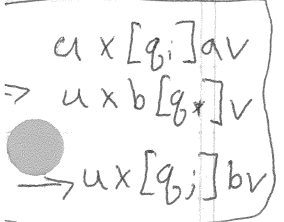
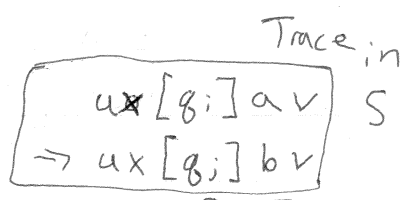
If  $\delta_{DW}(q_i, a) = (q_j, \perp, dir)$   
 then  $\delta_N(q_i, a) = (q_j, a, dir)$

Stay-TM :  $\delta : Q \times \Gamma \rightarrow Q \times \Gamma \times \{L, R, S\}$

$\rightarrow$  don't move or stay

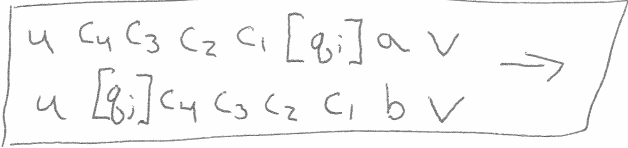
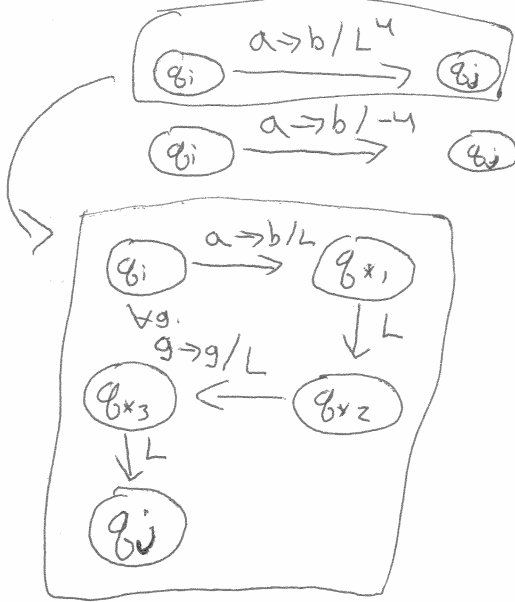
compile : STM  $\rightarrow$  NTM

input :  $\delta_S$       output :  $\delta_N$   
 $Q_S$        $Q_N$



If  $\delta_S(q_i, a) = (q_j, b, S)$   
 then [option 1]  $\delta_N(q_i, a) = \delta_N(q_j, b)$  // fails on loops  
 [option 2]  $\delta_N(q_i, a) = (q_*, b, R)$   
 $\forall q \in \Gamma \quad \delta_N(q_*, q) = (q_j, q, L)$   
 Add  $q_*$  to  $Q_N$

Many Move TM :  $\delta : Q \times \Gamma \rightarrow Q \times \Gamma \times \{L, R\} \times \mathbb{N}$   
 $\times \mathbb{Z} \leftarrow \text{int} \quad \text{nat}$   
 $\delta(q_i, a) = (q_j, b, L, k)$  then we move  $k$  spots left



M/M trace

$u c_4 c_3 c_2 [q_{x1}] c_1 b v$   
 $u c_4 c_3 [q_{x2}] c_2 c_1 b v$   
 $u c_4 [q_{x3}] c_3 c_2 c_1 b v$   
 $u [q_j] c_4 c_3 c_2 c_1 b v$

Many Tape TM  
 $k$ -TM



$$\delta : Q \times \Gamma^k \rightarrow Q \times (\Gamma \times \{L, R\})^k$$

$k$ -configuration :  $u_1 a_1 \left[ \begin{matrix} b_1 v_1 \\ \vdots \\ q_i \\ \vdots \\ b_k v_k \end{matrix} \right]$

$2$ -configuration :  $u_1 a_1 \left[ \begin{matrix} b_1 v_1 \\ q_i \\ b_2 v_2 \end{matrix} \right]$

$$\delta(q_i, b_1, b_2) = (q_j, (c_1, L), (c_2, R))$$

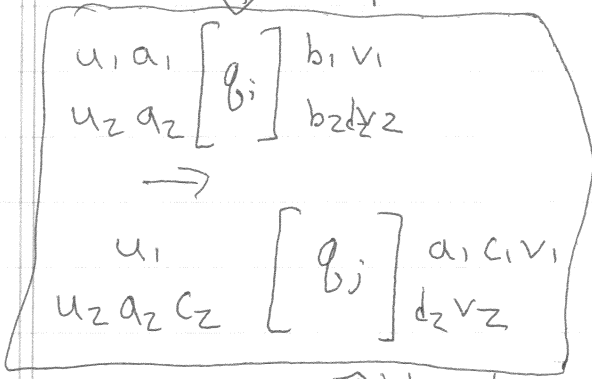
$$u_1 a_1 \left[ \begin{matrix} b_1 v_1 \\ \vdots \\ q_i \\ \vdots \\ b_2 v_2 \end{matrix} \right] \rightarrow u_1 \left[ \begin{matrix} a_1 c_1 v_1 \\ q_i \\ a_2 c_2 v_2 \end{matrix} \right]$$

$u_1 a_1 b_1 v_1 \# u_2 a_2 b_2 v_2$  X

1-config

$[q_i] u_1 a_1 \hat{b}_1 v_1 \# u_2 a_2 \hat{b}_2 v_2$  ✓

interpret



2-config

$u, v \in \Sigma^*$   
 $a, c, b, d \in \Gamma$

many  
many  
many  
step

interpret

$[q_i] u_1 \hat{a}_1 c_1 v_1 \# u_2 a_2 c_2 \hat{d}_2 v_2$

1. find head 1, remember the char
2. find head 2,
3. change tape 2
4. seek head 1
5. change tape 1
6. go all the way left

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