$M = (\Gamma, Q, \delta)$, $|\Gamma| > 4$ $\rightsquigarrow$ $M' = (\{q_1, \square, \triangleright\}, Q', \delta')$

Idea: encode $\sigma \in \Gamma$ with $\log|\Gamma|$ bits

M: ▷ A B C
▷ B B

M': ▷ 1 0 1 0 | 1 0 1 1 | 1 1 1 0 1 0
▷ 1 0 1 1 | 1 0 1 1

$\delta(q_1, (A, B)) = (q', 2, (r, \ell))$

3) movement $\log|\Gamma|$

$|\Gamma| > 4$

1) $q_\varepsilon^\varepsilon$ $(1,1)$ q_1^1 1 $(R, \sim)$
q_1^1 $(0,0)$ q_{10}^{10} 0 $(\sim, \sim)$ read $\log|\Gamma|$
q_{101}^{101} $(\sim, 1)$ q'_{0010} (S, S)

2) q'_{0010} $\perp$ q'_{001} $(1,1)$ update $\log|\Gamma|$
q'_{001} $-$ q'_{00} $(1,1)$
$\vdots$ $\vdots$

TM computing pal (3 tapes)

state	k symbols	new state	k-1 symbols	movements
start	▷, ▷, ▷	copy	▷, ▷	(r, r, r)
copy	0/1, □, □	copy	0/1 □	(r, r, s)
	□, □, □	left	□, □	(l, s, s)
left	▷, —	left	—	(l, s, s)
		compare	—	(r, s, s)
compare	0, 0, □	compare	—	(r, l, s)
	1, 1, □	"	"	(r, l, s)
	□, ▷, □	"	"	"
	—	halt	▷, 1	—
		halt	▷, 0	

TM for palindromes

linear time

Universal TM

M given by α , 1 input, 1 work, 1 output tape

$\Gamma = \{0, 1, \square, \triangle\}$

→ quadratic slowdown

U

$M \rightarrow$ input x

$M \rightarrow$ work

$\boxed{\alpha}$ — description of M

$[q$ state of M

$M \rightarrow$ output

multiple tape ⟶ single tape