BITS Pilani
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Theory of Computation
CS F351

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Lecture: 29

Formal Definition

Definition. A Turing machine is a 5-tuple $(K, \Sigma, \delta, s, H)$, where:

- K is a finite set of states

- Σ is a set of symbols (the alphabet). It contains the blank symbol ($\sqcup$), and the left end symbol ($\triangleright$). It does not contain $\leftarrow$ and $\rightarrow$

State	Σ	$\delta(q,\sigma)$

- $s \in K$ is the initial state.

- H is a subset of K, and is the set of halting states.

- δ, the transition function, is a function from
  $(K-H) \times \Sigma$ to $K \times (\Sigma \cup \{\rightarrow, \leftarrow\})$, such that,
  - For all $q \in K-H$, if $\delta(q, \triangleright) = (p, b)$, then $b = \rightarrow$
  - For all $q \in K-H$ and $a \in \Sigma$, if $\delta(q, a) = (p, b)$ then $b \neq \triangleright$

Basic Machines :-

① Symbol writing machine :-

For each $a \in \Sigma \cup \{\rightarrow, \leftarrow\} - \{\triangleright\}$,

TM $M_a = (\{s, h\}, \Sigma, \delta, s, \{h\})$ where

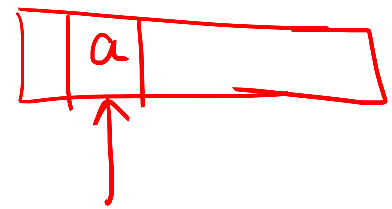
for each $b \in \Sigma - \{\triangleright\}$, $\delta(s, b) = (h, a)$

$\therefore$ $a \rightarrow$ writing M/C

$L \Rightarrow$ Move head left

$R \Rightarrow$ Move head Right.

$(K, \Sigma, \delta, s, h)$



$a \in \Sigma$

State	Symbol	δ
q_0	b	(h, a)

$\sqcup \rightarrow$ Symbol for Blank.

- a $\Rightarrow$ Write "a" onto tape & halt.
- L $\Rightarrow$ Move Left
- R $\Rightarrow$ Move Right.
- $R_\sqcup \Rightarrow$ Move Right until a blank is found.
- $L_\sqcup \Rightarrow$

$\triangleright \sqcup \omega \underline{\sqcup}$

$> R$

Two Types

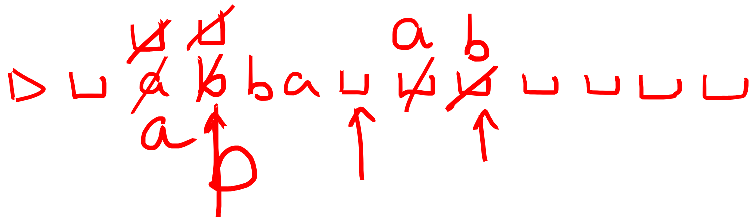
1. When no computation is required, and only decision is required.

2. When some computation is required.

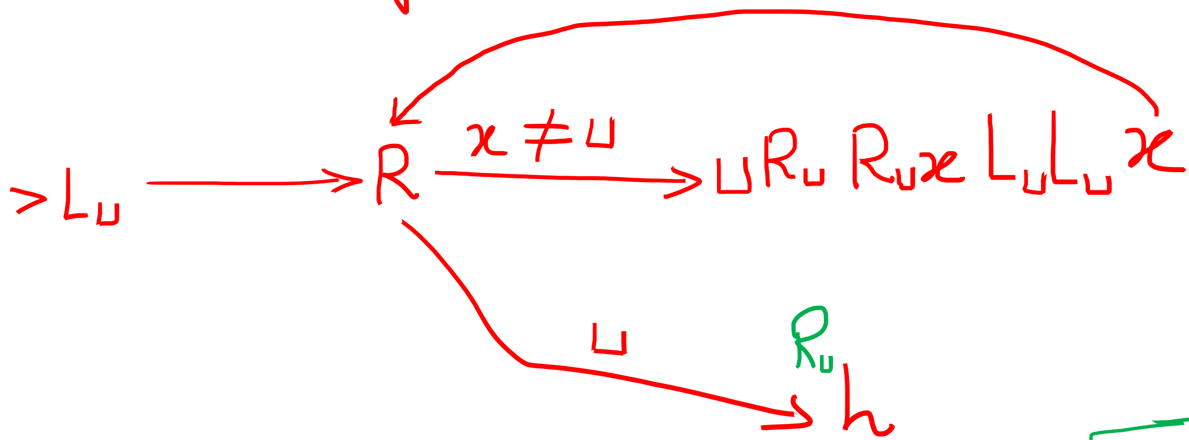
   a. TM which add's two binary no's.

   b. Input is $\triangleright \underline{\sqcup} \omega$

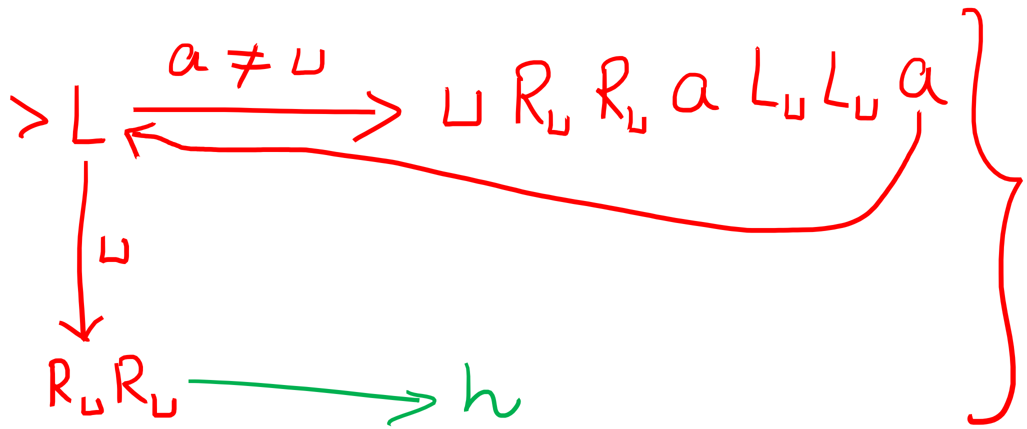
      O/p should be :- $\triangleright \underline{\sqcup} \omega \sqcup \omega \sqcup$



1) TM which transforms $\triangleright \sqcup w \underline{\sqcup}$ To $\triangleright \sqcup w \sqcup w \underline{\sqcup}$



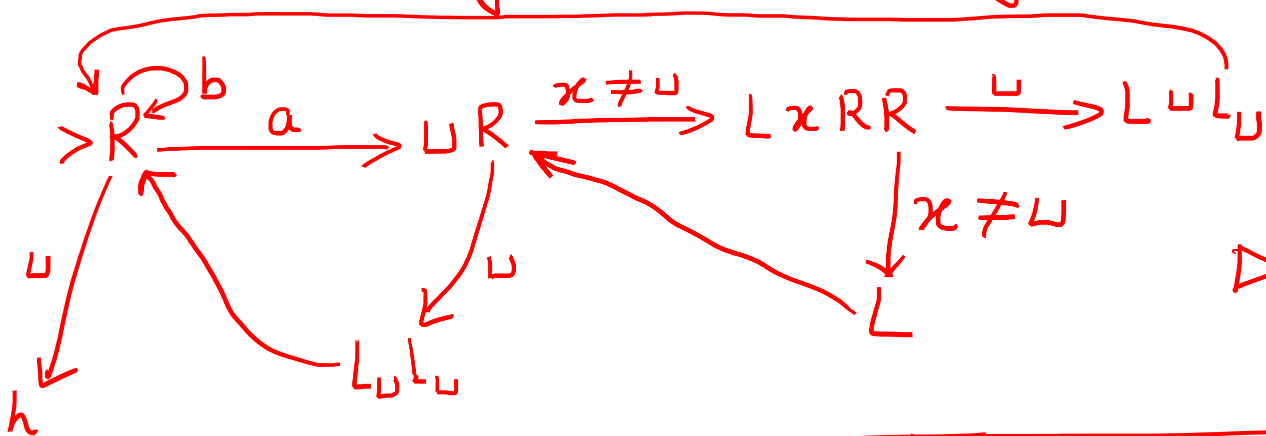
2)



$\boxed{\triangleright \sqcup w \underline{\sqcup}}$

$\triangleright \sqcup w \sqcup w^R \underline{\sqcup}$

$w \in (a+b)^*$, TM which erases all a's & compacts the word w so that all b's occur together without any blank.

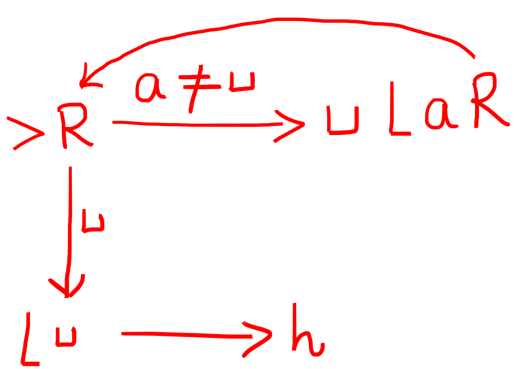


$\triangleright \underline{\sqcup} w$

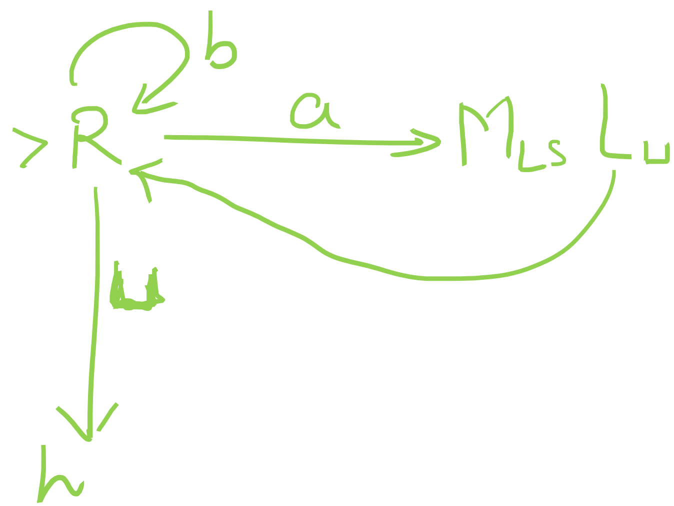
$\triangleright \underline{\sqcup}\, b\, \cancel{a}\, \sqcup$

Initial :- $\triangleright \sqcup w_1 \underline{a} w_2$

Final :- $\triangleright \sqcup w_1 w_2 \underline{\sqcup}$



M_{LS}



$\rightarrow \quad L = \{ a^n b^n \mid n > 0 \}$

$\triangleright \ \underline{\sqcup} \ \overset{X}{\cancel{a}} \overset{X}{\cancel{a}} \overset{X}{\cancel{a}} \overset{X}{\cancel{a}} \overset{X}{\cancel{b}} \overset{X}{\cancel{b}} \overset{X}{\cancel{b}} \overset{X}{\cancel{b}} \ \sqcup$

$\rightarrow \quad \{$