Theory of Computation
CS F351

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Agenda

- Is Turing Machine a Hardware or a Software ??

Conventions

- TM state is represented as {q}{0, 1}*
- Tape symbol is represented as {a}{0, 1}*

- Let M = (K, ∑, δ, s, H) be a TM. Let i and j be smallest integers such that:

$$2^i \geq |K| \quad \text{and} \quad 2^j \geq |\Sigma| + 2$$

- Now each state of TM is represented by symbol **"q"** followed by a binary string of length i; and each a ∈ ∑ by symbol **"a"** followed by binary string of length j.

Conventions

- Fix the representation of special symbols as:

Symbol	Representation
blank	$a0^j$
Left end marker	$a0^{j-1}1$
←	$a0^{j-2}10$
→	$a0^{j-2}11$
Start state	$q0^i$

- Encoding of TM M (denoted as "M") is the sequence of strings of the form **(q, a, p, b)**, with **q** and **p** representing states and **a** and **b** representing tape symbols.

Conventions

- Observe that we have not represented any halting state.
- Set of halting states will be determined indirectly; that is by the absence of halting states as a first component in any quadruple.

Example

- Show the encoding of the following Turing Machine $M_{example}$:

State	Symbol	Transition
s	⊔	(q1, →)
q1	a	(q1, →)
q1	b	(q1, →)
q1	⊔	(q2, ←)
q2	a	(q3, ←)
q3	a	(q4, ←)
q4	a	(h, ←)

- $|K| = 6$, therefore $i = 3$.
- $|\sum| = 4$ (i.e. a, b, ⊔, and ▶). Therefore, $j = 3$

- So, now what is the encoding of TM $M_{example}$??

Universal TM

- Now, we want a universal TM U to have following property: **U halts in input "M""w" iff M halts in input w**.
- What is the design of such Universal TM ??

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Thank You