

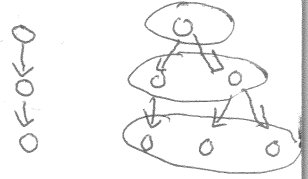
Non-deterministic TM

DFA

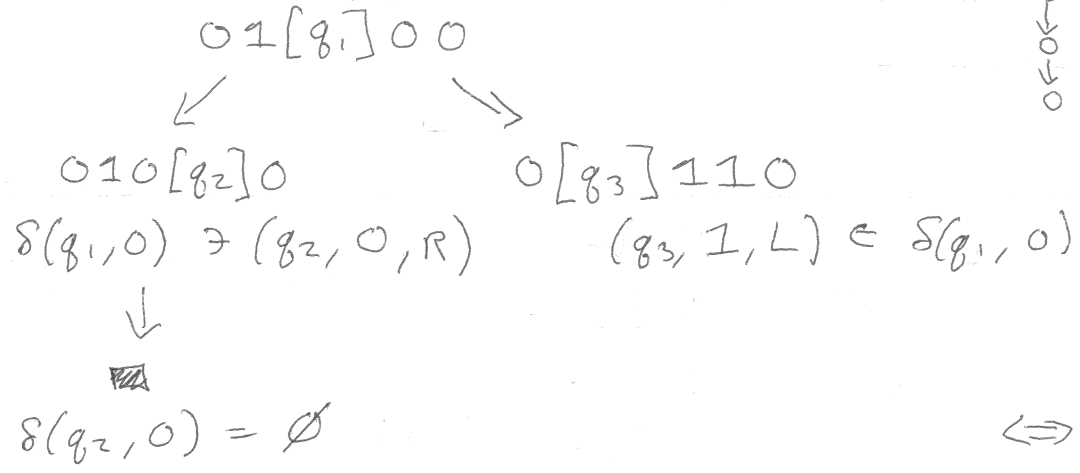
$Q \times \Sigma \rightarrow Q$

NFA

$Q \times \Sigma \rightarrow P(Q)$



$Q \times \Gamma \rightarrow P(Q \times \Gamma \times \{L, R\})$



$x \in S$

$\Leftrightarrow S \ni x$

Intuition

Semantics

Compilation

NFA

- 1) Parallelism
- 2) Back-tracking
- 3) See the future

A set of rules for determining if a run is valid for the NFA

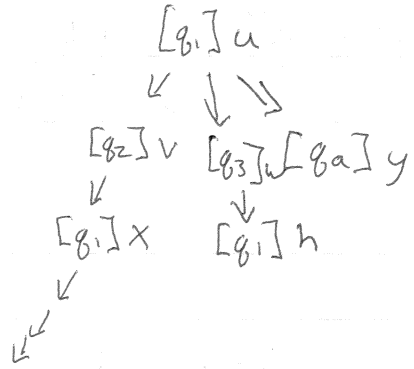
→ DFA where $Q_{DFA} = P(Q_{NFA})$
(one state = range of the tree)

NTM

- 1) Parallelism
- ~~2) Back-tracking~~
- 3) See the future
- 1) Breadth-first

same idea as an NFA

~~n choices =~~
~~if $|S| > 1, n =$~~
n steps =
every $\delta, n =$



config graph is potentially infinite

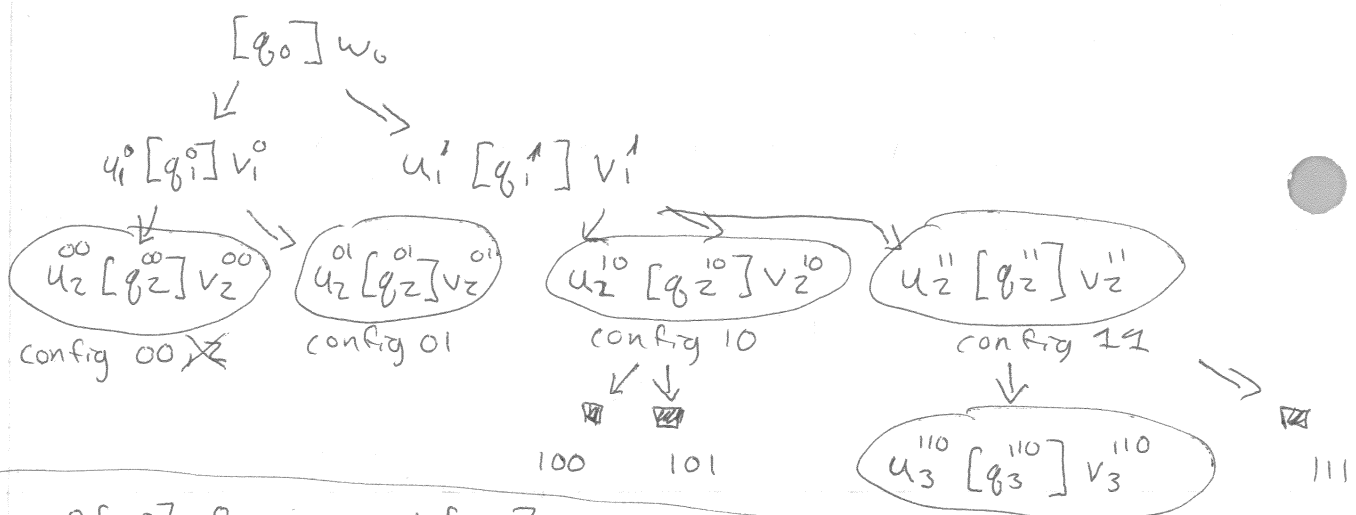
Maze: config \Leftrightarrow block

$\delta(\text{block}) = \emptyset \Leftrightarrow$ deadend

$\delta(\text{block}) = q_a \Leftrightarrow$ exit

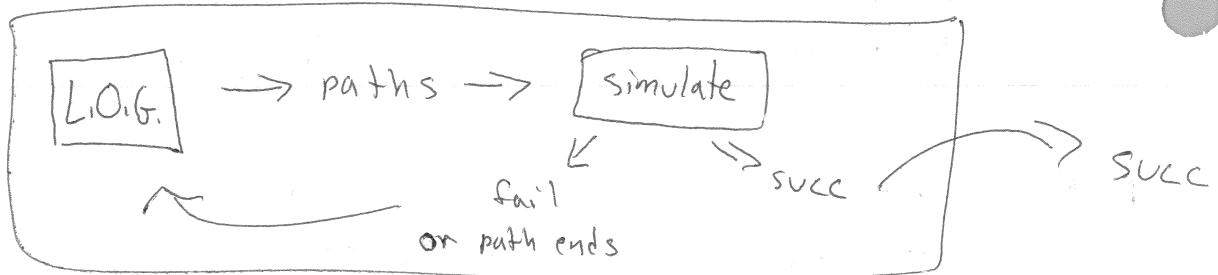
$\delta(b1) = \{q_i\} \Leftrightarrow$ hallway

$\delta(b1) = \{q_i, q_j\} \Leftrightarrow$ fork in road



$c0 \quad u^0 [q^0] v^0 := ab [q_7] c$
 $c00 \Rightarrow u^{00} [q^{00}] v^{00} \Rightarrow a [q_8] b d \quad (q_8, d, L) \in \delta(q_7, c)$
 $u^0 = ab \quad q^0 = q_7 \quad v^0 = c$
 $u^{00} = a \quad q^{00} = q_8 \quad v^{00} = bd$

BFS: $\epsilon, 0, 1, 00, 01, 10, 11, 000, 001, 010, 011, 100, 101, 110, 111, \dots$ The lexicographic ordering of $\Sigma_0 B^*$



Accepter (Σ_1)
 Decider (Σ_0) — add a flag that says "Progress Made" when $k \uparrow$, if flag is true, continue o.w. Reject

3-Tape Machine:

- Tape 1: Original input, w
- Tape 2: current path
- Tape 3: simulate tape of the current execution

Fork-TM

$$\delta: Q \times \Gamma \rightarrow (Q \times \Gamma \times \{L, R\}) + (Q, \alpha)$$

↓ hallway

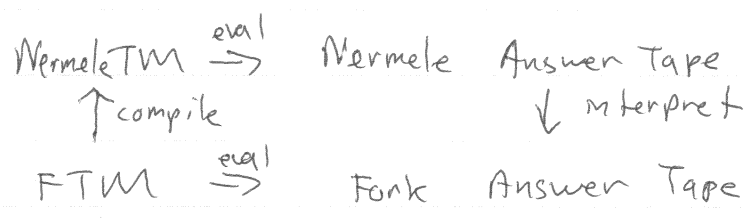
↓ fork

fork-config = set of normal config

$$S \Rightarrow S'$$

$$S \cup \{u a [q_i] b v\} \Rightarrow S \cup \{u a c [q_j] v\} \\ \text{iff } \delta(q_i, b) = (q_j, c, L)$$

$$S \cup \{u a [q_i] b v\} \Rightarrow S \cup \left\{ \begin{array}{l} u a [q_i] b v, \\ u a [q_k] b v \end{array} \right\} \\ \text{iff } \delta(q_i, b) = (q_i, q_k)$$



$$\text{fork-config } \{ u [q_i] a v, x [q_j] b y, \alpha [q_k] c B \}$$

$$\text{Nermele-config } [start] u [q_i] a v, x [q_j] b y, \alpha [q_k] c B$$

$$[start] u \heartsuit q_i \heartsuit a v \star x \heartsuit q_j \heartsuit b y \star \alpha \heartsuit q_k \heartsuit c B$$

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