Theory of Computation – Construction of Regular Expressions from Deterministic Finite Automata

We know that for every regular expression there exist a deterministic finite automaton. So we can say that regular languages, regular expressions and finite automata are all different representation of the same thing. Earlier we learnt how to convert a regular expression into a finite automaton; in this tutorial we will learn how to convert a given finite automaton to a regular expression. For that we must first learn about Arden's Theorem.

Arden's Theorem

Let P and Q be two regular expressions over alphabet Σ. If P does not contain null string, then

R = Q + RP

has a unique solution that is R = QP*

Proof:

Put the value of R in the R.H.S.

$R = Q + (Q + RP)P = Q + QP + RP^2$

When we put the value of R again and again we get the following equation

$R = Q + QP + QP^2 + QP^3$.....

$R = Q(1 + P + P^2 + P^3 + ...$

$R = Q(\epsilon + P + P^2 + P^3 + ...$

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The second part of the product on the L.H.S can be replaced with the kleen closure. So the equation becomes
R = QP*

Using Arden's Theorem to find Regular Expression of a Deterministic Finite automata

1. For getting the regular expression for the automata we first create equations of the given form for all the states
   $q_1 = q_1w_{11} + q_2w_{21} + \ldots + q_nw_{n1} + \epsilon$ (q_1 is the initial state)
   $q_2 = q_1w_{12} + q_2w_{22} + \ldots + q_nw_{n2}$
   . .
   . .
   . .
   $q_n = q_1w_{1n} + q_2w_{2n} + \ldots + q_nw_{nn}$
   w_{ij} is the regular expression representing the set of labels of edges from q_i to q_j
   Note: for parallel edges there will be that many expressions for that state in the expression.
2. Then we solve these equations to get the equation for q_i in terms of w_{ij} and that expression is the required solution, where q_i is a final state.

Assumptions made while forming the regular expression

1. The transition diagram should not have ϵ – transitions
2. It must have only a single initial state

Let us see an example to demonstrate this method

Example: Draw a FA that accepts strings containing exactly 1 over alphabet {0, 1} and write a regular expression for the same.
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Note: We need not consider a trap state in our equations as it does not contribute to the regular expression

Given below are few questions for you to practice.

Question1: Construct a regular expression corresponding to the automata given below

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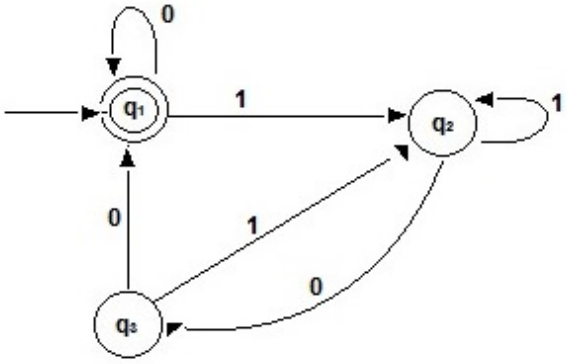

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Question 2: Derive a regular expression for the language containing strings ending in 1 but not containing substring 00.

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Theory of Computation – Transition Graph and Transition Table For a Finite Automata

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Best Reference Books – Integer Programming: Theory and Computations

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