Software Developer Co-op - Technical Assignment

Please complete the assignment below in the language of your choice, organize your code at a production level and make sure your code is well tested. Please refer to the provided rubric we use to evaluate responses to this assignment.

Objective

Consider a string of ones and zeros representing an unsigned binary integer. Design and implement a solution that will compute the remainder when the represented value is divided by three.

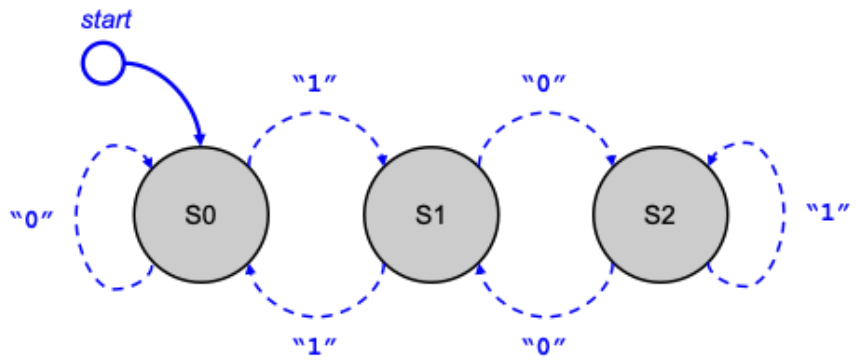
For example:

Input: '1101' Output: 1
Input: '1110' Output: 2
Input: '1111' Output: 0

One way to implement this would be to convert the input string to a number type and use the modulus operator (%). While that approach will produce the correct answer, for this exercise we suggest you use a more interesting method derived from the world of computer hardware: Finite State Machine (FSM).

What is Finite State Machine (FSM)?

Let us build an FSM to solve this mod-three problem. It takes the input characters, one at a time, MOST significant bit first and transitions between three states: S0, S1, S2.



The value returned from our function will depend on the state selected after the character sequence is exhausted. The final state will be converted to a remainder value as specified in the following table:

Final State	Remainder
S0	0
S1	1
S2	2

For input string `"110"`, the machine will operate as follows:

1. Initial state = S0, Input = 1, result state = S1
2. Current state = S1, Input = 1, result state = S0
3. Current state = S0, Input = 0, result state = S0
4. No more input – return the remainder value corresponding to the final state S0.

For input string `"1010"` the machine will operate as follows:

1. Initial state = S0, Input = 1, result state = S1
2. Current state = S1, Input = 0, result state = S2
3. Current state = S2, Input = 1, result state = S2
4. Current state = S2, Input = 0, result state = S1
5. No more input - return the remainder value corresponding to the final state S1.

FSM Implementation

The FSM described above is an instance of finite state automata. With object-oriented design (OOD) and the abstraction provided below, create a software module for generating an FSM. The API of your library should be designed for use by other developers. Implement the 'mod-three' procedure as an example.

Finite Automation

A finite automaton (FA) is a 5-tuple (Q, Σ, q0, F, δ), where

Q is a finite set of states;

Σ is a finite input alphabet;

$q0 \in Q$ is the initial state;

$F \subseteq Q$ is the set of accepting/final states; and

$\delta: Q \times \Sigma \rightarrow Q$ is the transition function.

For any element q of Q and any symbol $\sigma \in \Sigma$, we interpret $\delta(q, \sigma)$ as the state to which the FA moves, if it is in state q and receives the input σ.

Mod-Three FA

Based on the notation from the definition, the modulo three FSM would be configured as follows:

$Q = (S0, S1, S2)$

$\Sigma = (0, 1)$

$q0 = S0$

$F = (S0, S1, S2)$

$\delta(S0,0) = S0$; $\delta(S0,1) = S1$; $\delta(S1,0) = S2$; $\delta(S1,1) = S0$; $\delta(S2,0) = S1$; $\delta(S2,1) = S2$