

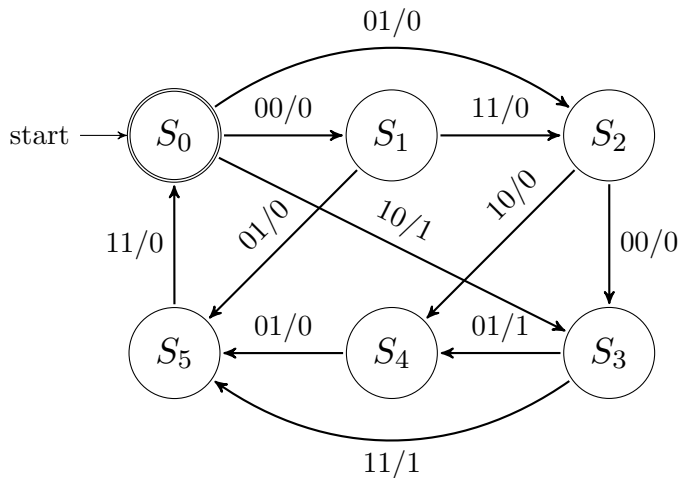
Watermarking-based Intellectual Property Core Protection Scheme

Li-Wei Chen, Shan-Yuan Zheng, Guan-Yu Chen
Supervised by C.M. Li

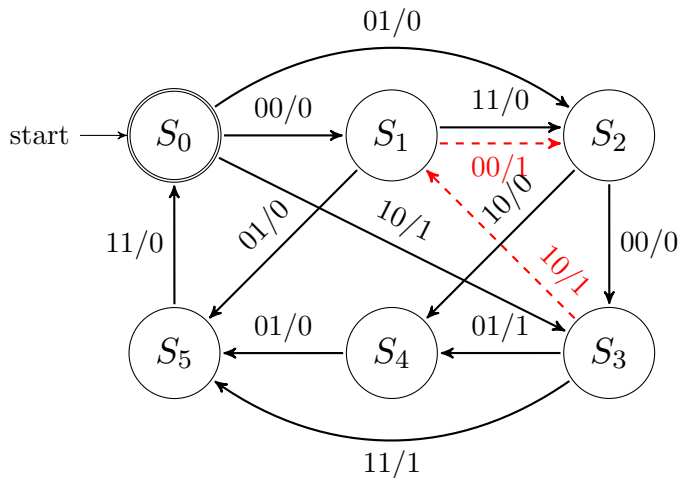
National Taiwan University

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Project Description



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Algorithm

Given the input/output bit string $b_1b_2 \cdots b_n$, where b_i is the i^{th} input/output pair and a the FSM $(\Sigma, S, s_0, \delta, F)$, we first compute the maximum length one may go from each $s \in S$ with the input and output relation specified by $b_ib_{i+1} \cdots b_n$.

The unspecified transition will not be taken into consideration, and the maximum length is recorded if there is no path to satisfy the input bit string. We also add a constraint, if the one candidate stops at b_j , the terminate state for the it must have a unspecified transition for b_{j+1} to be the maximum length path, expect for when the last input is b_n .

Algorithm

If there are multiple states that hold the same length, we choose one randomly.

Then we use a greedy strategy, starting from b_0 , we first choose the maximum length state as the first state, then if the maximum path stops at b_i , we then choose the maximum length state for b_{i+2} as the second state. Using b_j as the augmented transition from the first state to the second state.

Algorithm

A new state is inserted if all the states has zero maximum length and the required input is already specified for all states. Suppose the next input/output pair is b_i , then we use b_i as transition to the new state, and b_{i+1} as the new input/output pair(transition) and continue the algorithm.

Once a new transition or state is add to the graph, they have no difference from the predefined ones. That is, the algorithm will also take them into consideration.

Algorithm

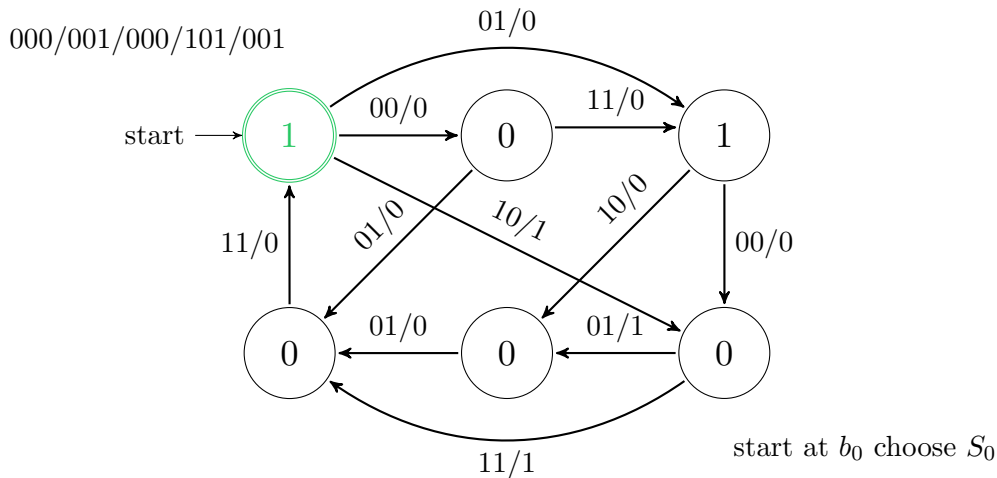
If the algorithm leads to a dead end, which is, all transitions of the give input b_j^i is occupied, we push a new state into the graph and restart the algorithm.

Although this will slow our algorithm a lot for the worst case, the contest input is constraint to be 128 bits, thus it has no influence to the time complexity.

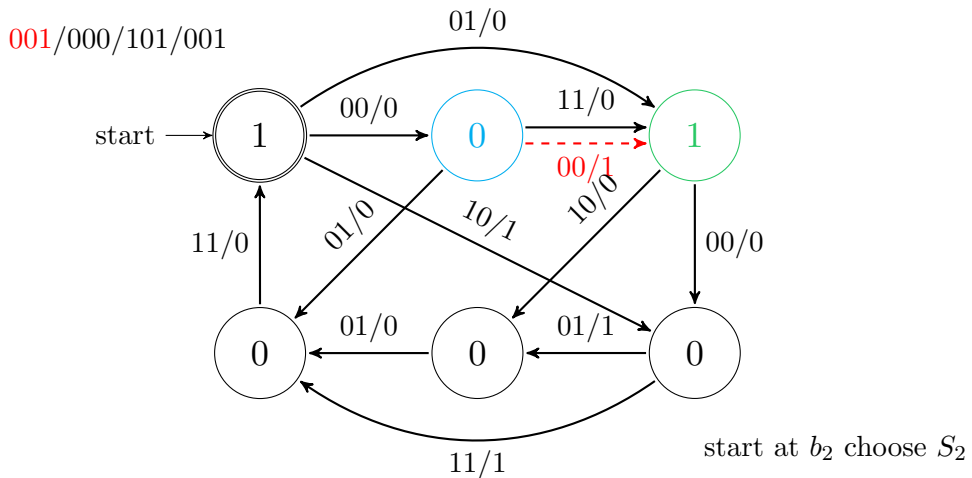
CSFSM Detection

The detection of CSFSM is after the data is loaded and the graph is constructed, we run over each state the check if the out transitions span the whole possible inputs. If yes, the program will report that a CSFSM is detected.

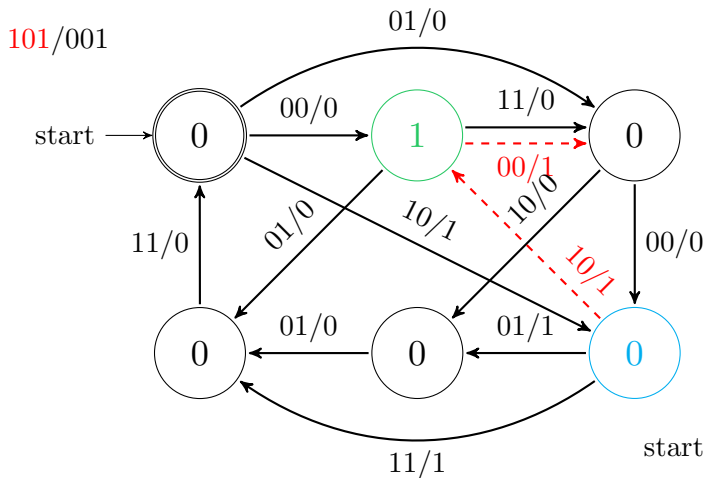
Situation—New Transition



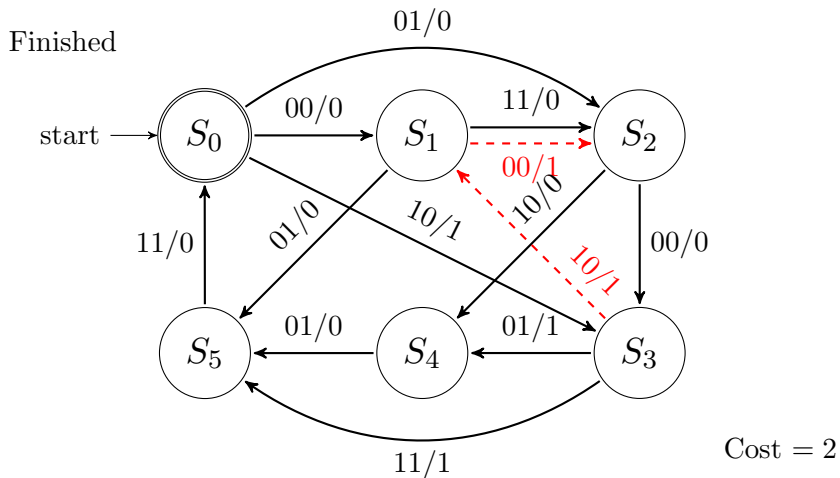
Situation—New Transition



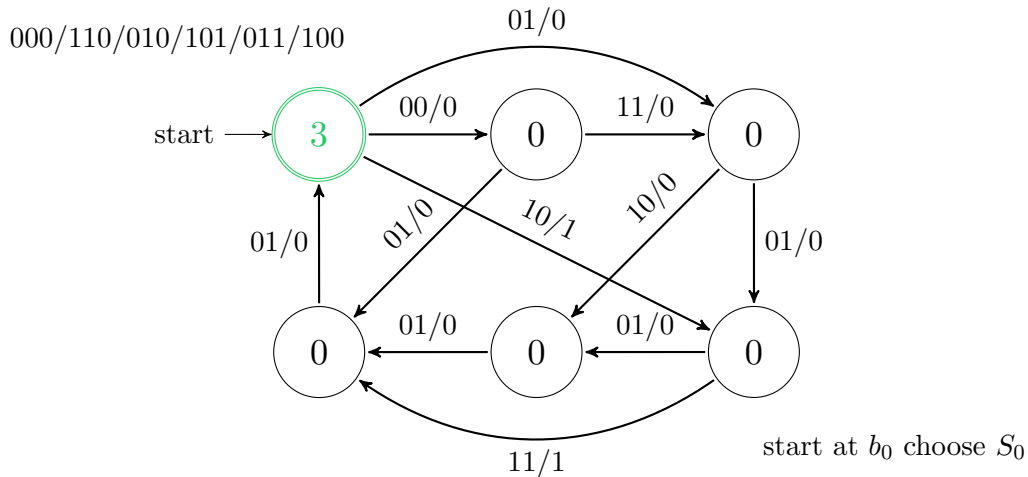
Situation—New Transition



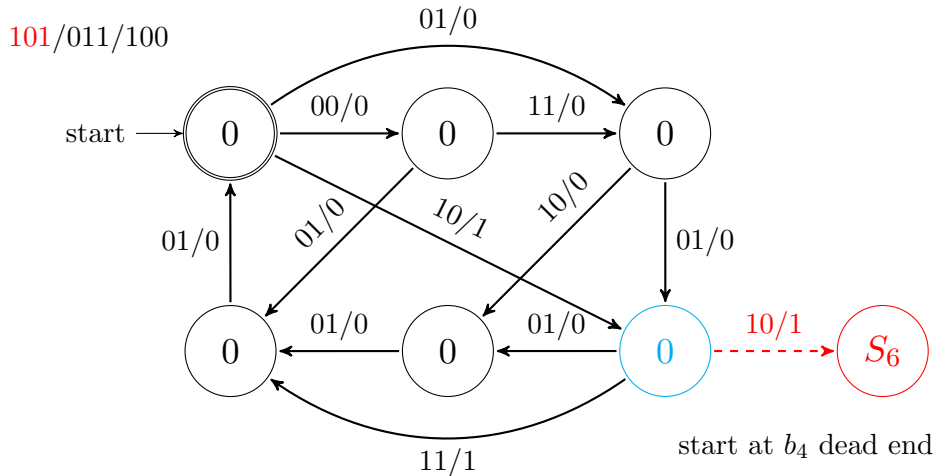
Situation—New Transition



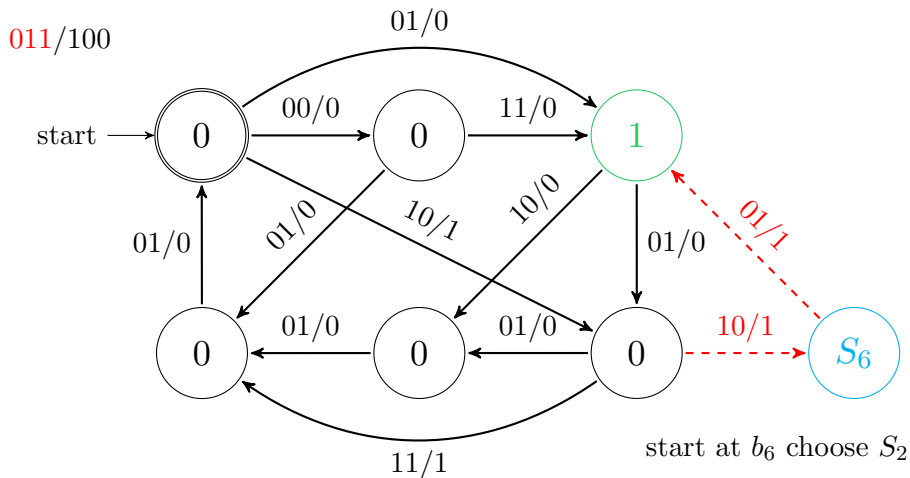
Situation—New State



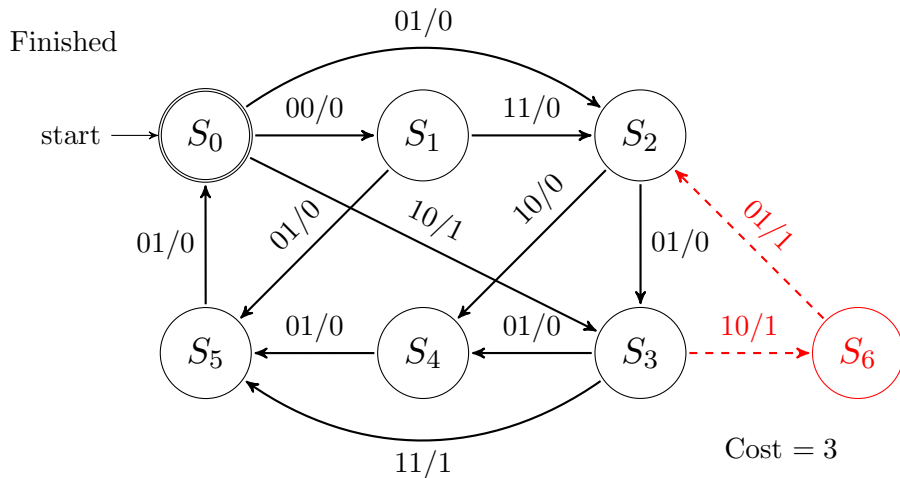
Situation—New State



Situation—New State



Situation—New State



Pseudocode

Algorithm 1 Watermark Part 1

```

1:  $G$ : Input FSM,  $(\Sigma, S, s_0, \delta, F)$ 
2:  $b^i$ : Input bit string
3:  $b^o$ : Output bit string
4:  $j = 0, maxlen = 0, start = null, dest = null$ 
5: while  $j \neq b^i.length - 1$  do
6:   for each  $s$  in  $G.S$  do
7:      $m, d, j = \text{FindMaxLength}(s, b^i, b^o, j)$ 
8:     if  $m \geq maxlen$  and  $d \neq null$  then
9:        $maxlen = m$ 
10:       $dest = d$ 
11:    end if
12:  end for
  
```

Algorithm 2 Watermark Part 2

```

13: if  $dest \neq null$  then
14:    $\text{AddTransition}(start, dest, b_j^i, b_j^o)$ 
15: else  $dest = \text{SearchFreeTransition}(G, b_j^i)$ 
16:   if  $dest \neq null$  then
17:      $\text{AddNewState}(dest, b_j^i, G)$ 
18:   else
19:      $\text{RandomAddState}(G)$ 
20:   break
21:   end if
22: end if
23:  $j = j + 1$ 
24: end while
25: if  $j \neq b^i.length - 1$  then
26:    $\text{Watermark}(G, b^i, b^o)$ 
27: end if
28: return  $G$ 
  
```

Pseudocode

Algorithm 3 SearchFreeTransition

```

1:  $G$ : Input FSM
2:  $b_j^i$ : Input bit string
3:  $dest = null$ 
4: for each  $s$  in  $G.S$  do
5:   if  $b_j^i \notin s.outedges$  then
6:      $dest = s$ 
7:     break
8:   end if
9: end for
10: return  $dest$ 
  
```

Algorithm 4 FindMaxLength

```

1:  $s$ : Input start state
2:  $b^i$ : Input bit string
3:  $b^o$ : Output bit string
4:  $j$ : Current position of the bit string
5:  $tmp = j, d = null$ 
6: while  $s.next(b_j^i) \neq null$  and  $j \neq b^i.length - 1$  do
7:    $s', o = s.next(b_j^i)$ 
8:   if  $o = b_j^o$  then
9:      $s = s'$ 
10:     $d = s'$ 
11:     $j = j + 1$ 
12:   end if
13: end while
14: if  $b_{j+1}^i \notin s'.freetransitions$  then
15:   return 0,  $null, tmp$ 
16: end if
17: return  $j - tmp, d, tmp$ 
  
```

Progress and Difficulties

We are still building the parser, dealing with the kiss format and loading into the C++ class to construct the graph. Some teammates start to implement the algorithm. The difficulties are that it's hard to work parallelly, one working on the algorithm needs to tell what data structure he needs to the one works with the parser, and the situation changes dynamically.

We think we need a universal coding structure first, we should define all the functions and data structures we need to implement the algorithm, including the return and input types. Then, filling up the whole will be much more efficient for multiple workers.