CS303T Theory of Computation

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Outline

- Recap
  - Language
  - Problem
  - Language vs Problem
  - Deterministic Finite Automata (DFA)
  - DFA-Examples
- Today
  - More Examples for DFA
  - Language to Transition Diagram
  - Transition Diagram to Language
  - Non-deterministic Finite Automata (NFA)

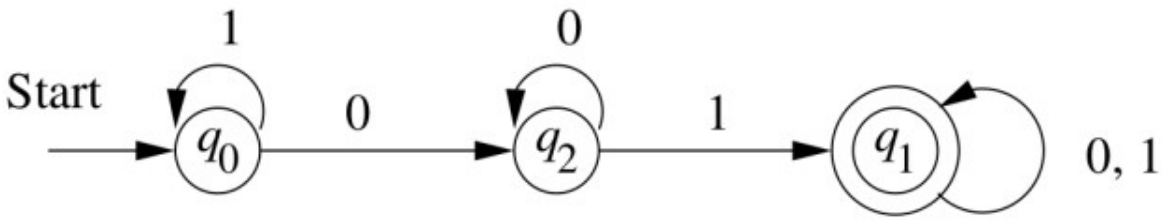
Deterministic Finite Automata (DFA)

DFA is a five tuple $(Q, \Sigma, \delta, q_0, F)$,

- A finite set of states, Q
- A finite set of input symbols, Σ
- A transition function (denoted δ) that takes as arguments a state and an input symbol and returns a state. i.e., $\delta : Q \times \Sigma \rightarrow Q$
- A start state $q_0 \in Q$
- A set of final or accepting states $F \subseteq Q$

DFA Representation

- Transition Diagram



- Transition Table

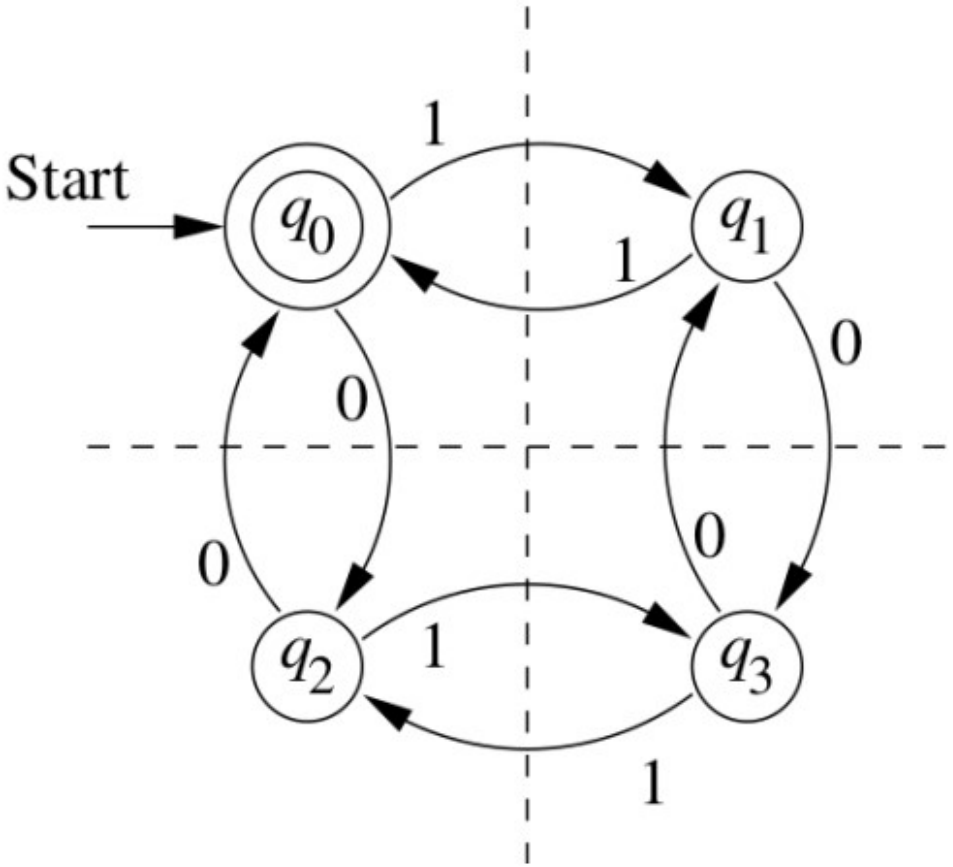
	0	1
$\rightarrow q_0$	q_2	q_0
$*q_1$	q_1	q_1
q_2	q_2	q_1

Language to Transition Diagram - Example

- Qn. Can you construct a transition diagram from the given language?
- Design a DFA to accept the language $L = \{w | w$ has both an even number of 0's and an even number of 1's $\}$
- Steps:
  - Determine the role of each state - to count the number of 0's and 1's modulo 2
  - q_0 - Both the number of 0's seen so far and the number of 1's seen so far are even
  - q_1 - The number of 0's seen so far is even but the number of 1's seen so far is odd
  - q_2 - The number of 0's seen so far is even but the number of 1's seen so far is odd
  - q_0 - Both the number of 0's seen so far and the number of 1's seen so far are odd

Continue...

- Transition Diagram for the given language



Transition Diagram To Language Examples

- Qn. Can you determine the language from the transition diagram?

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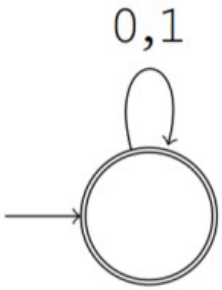

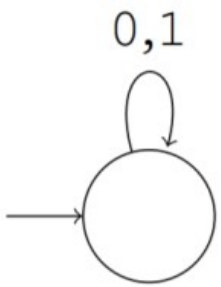

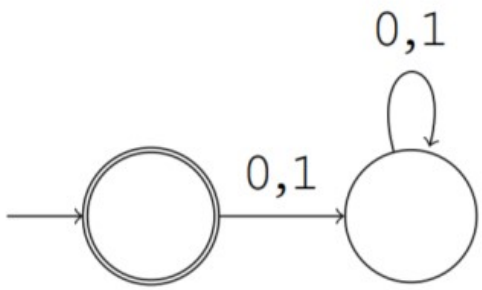

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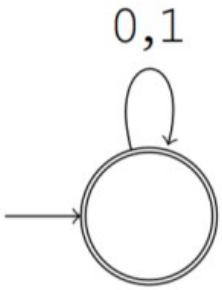

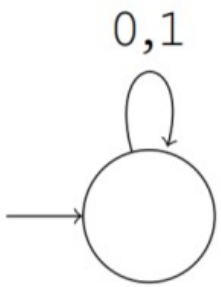

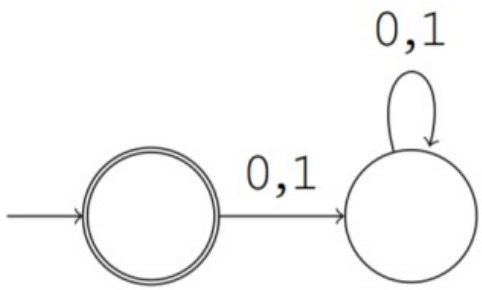

- DFA's for languages

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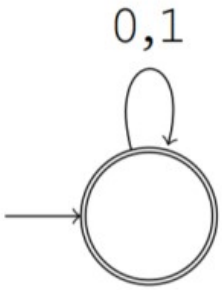
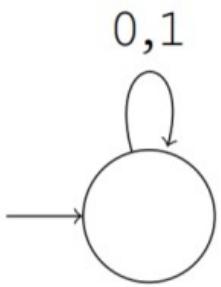
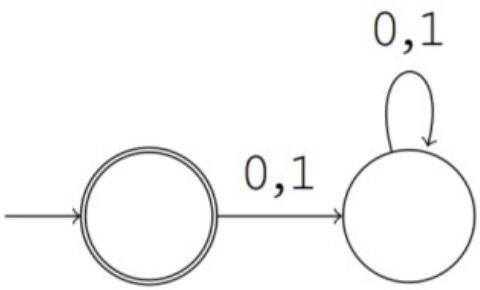


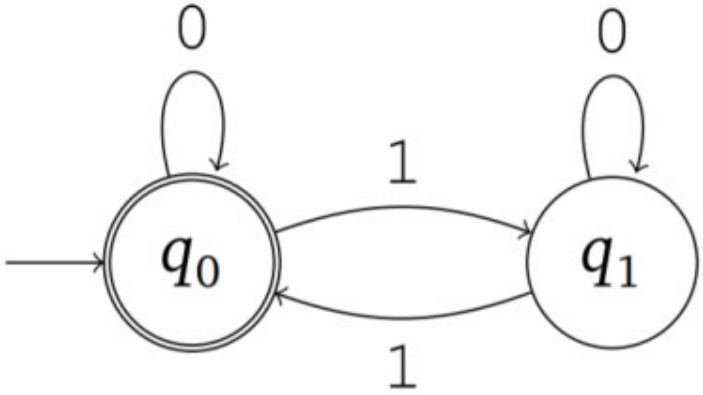




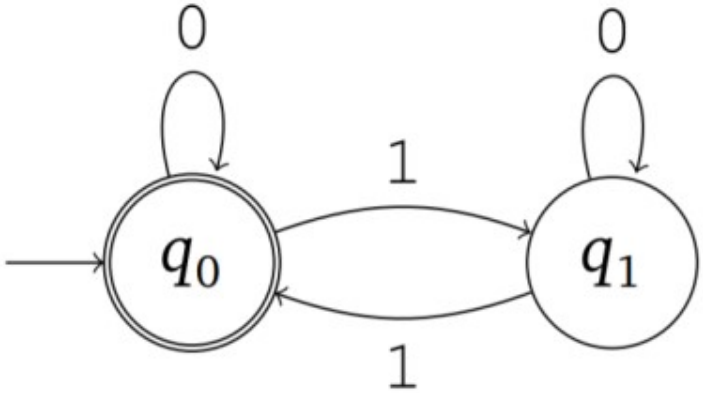
- DFA's for languages

Σ $\emptyset$ $\{\epsilon\}$

DFA-Example

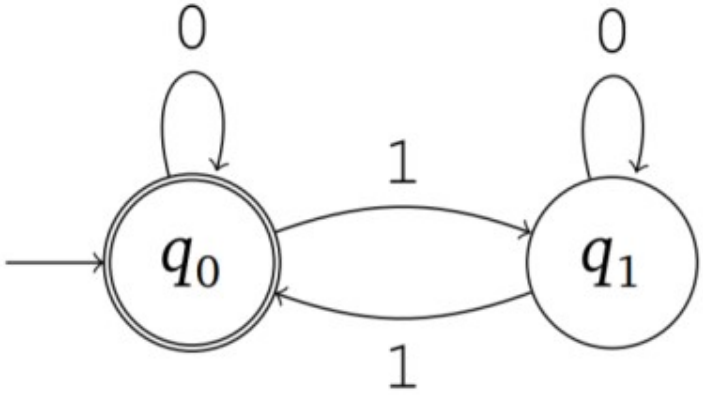


DFA-Example



- A DFA for the language of strings that contain a number of 1's that is a multiple of 2

DFA-Example



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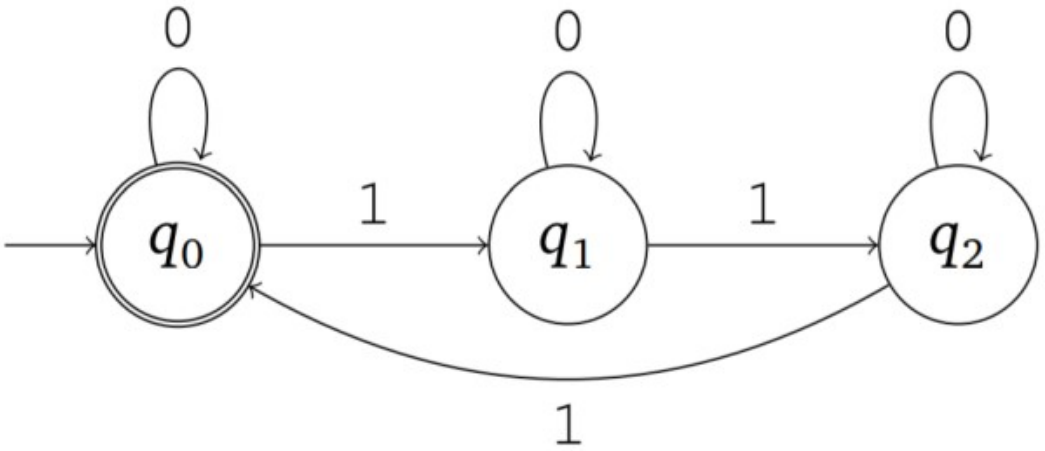

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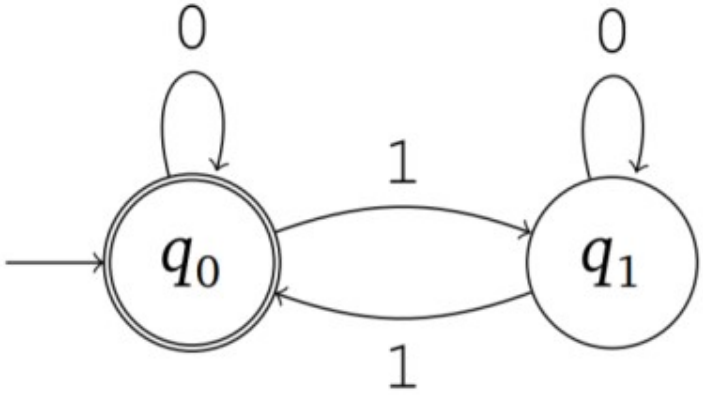
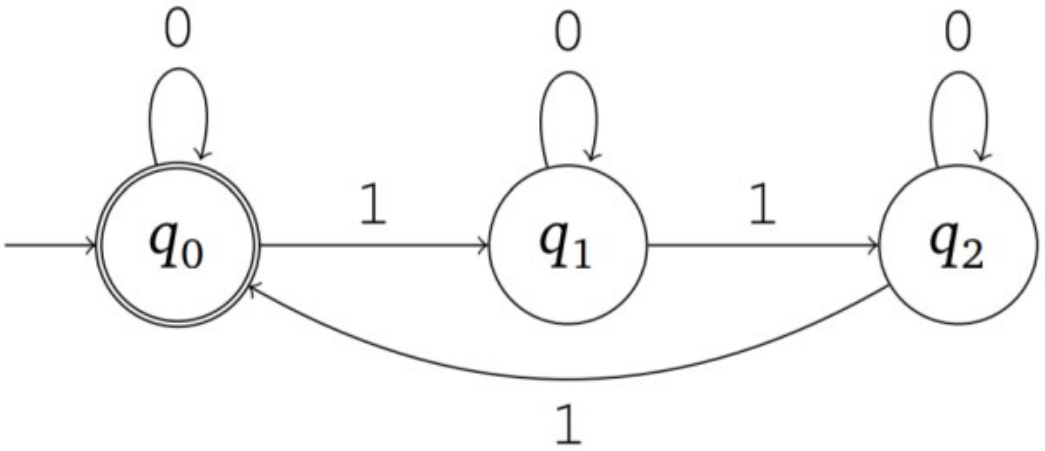
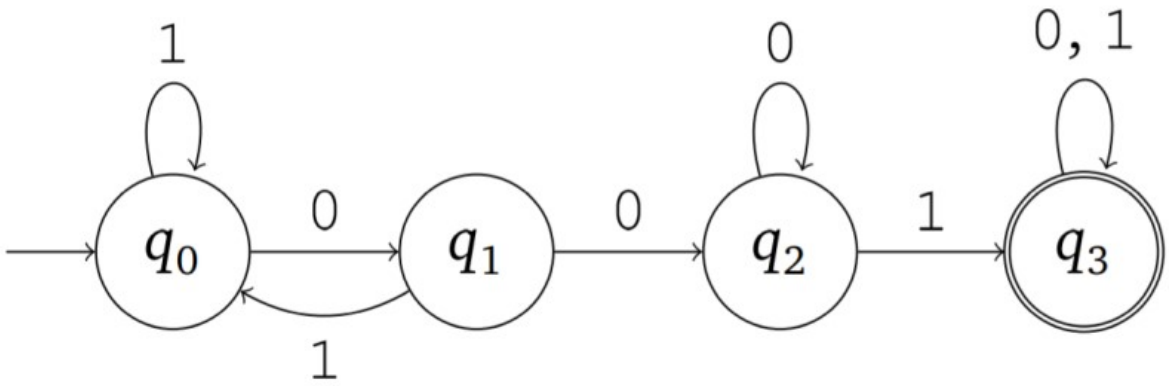


- A DFA for the language of strings that contain a number of 1's that is a multiple of 2

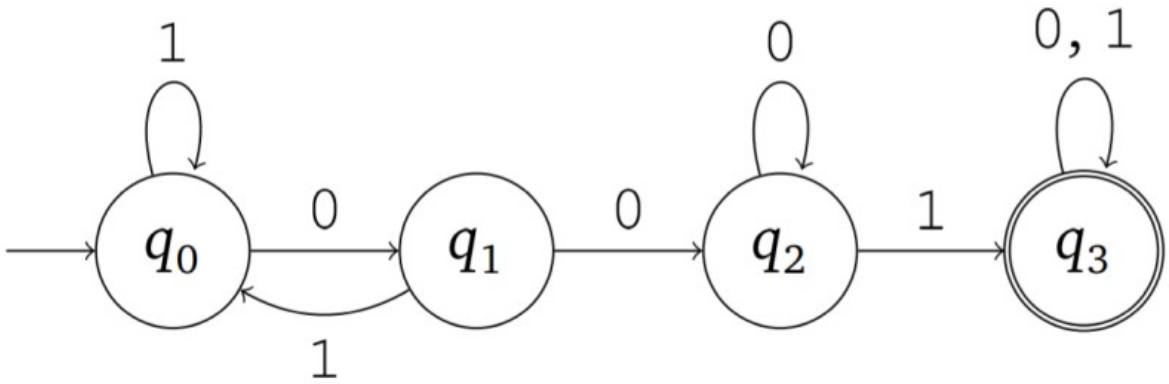


- A DFA for the language of strings that contain a number of 1's that is a multiple of 3

DFA Example

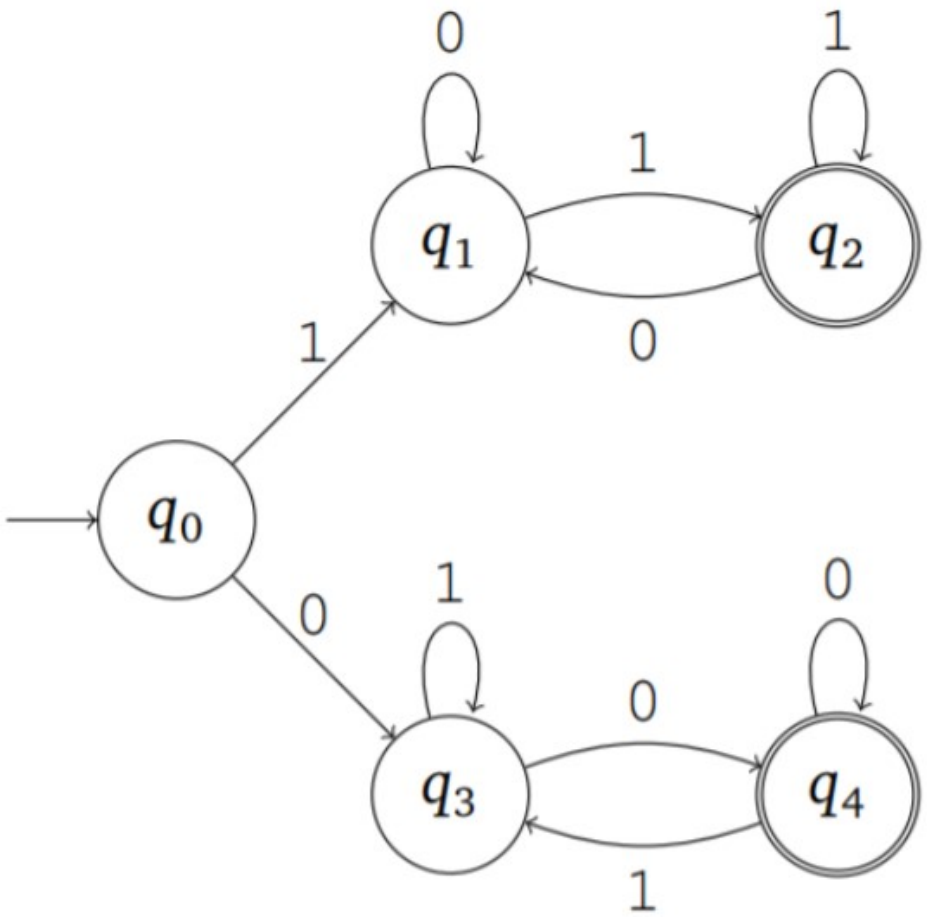


DFA Example

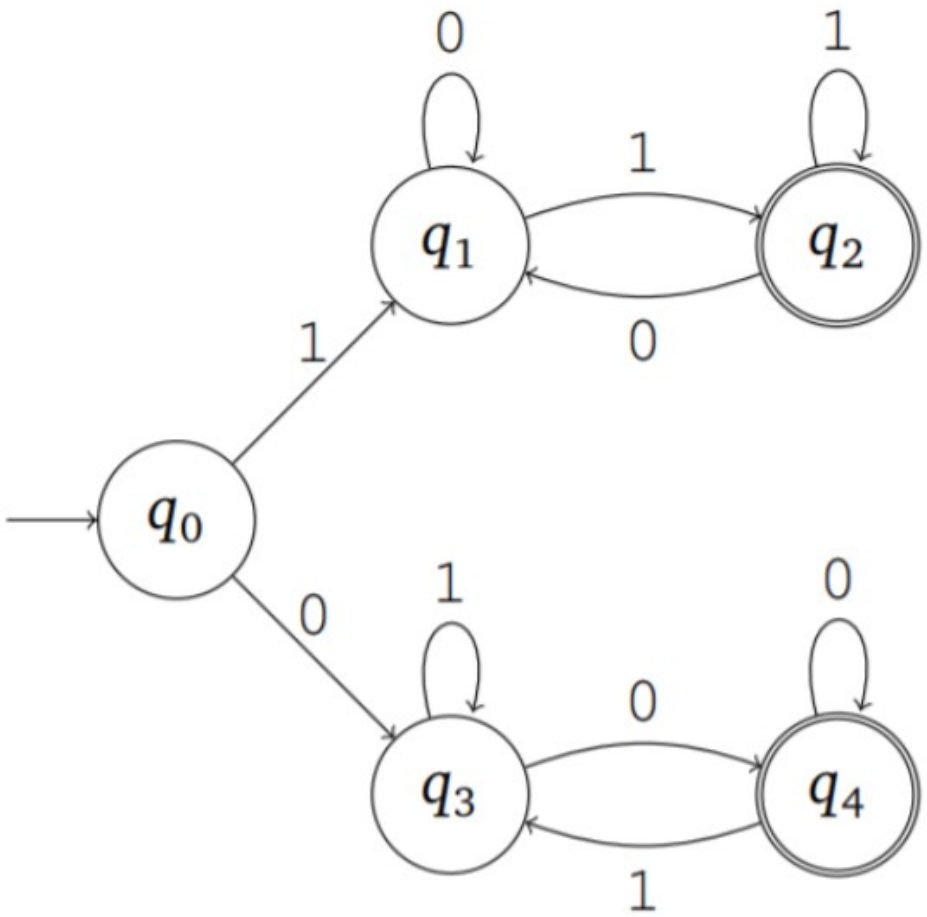


- A DFA for the language of strings that contain the substring 001

DFA Example

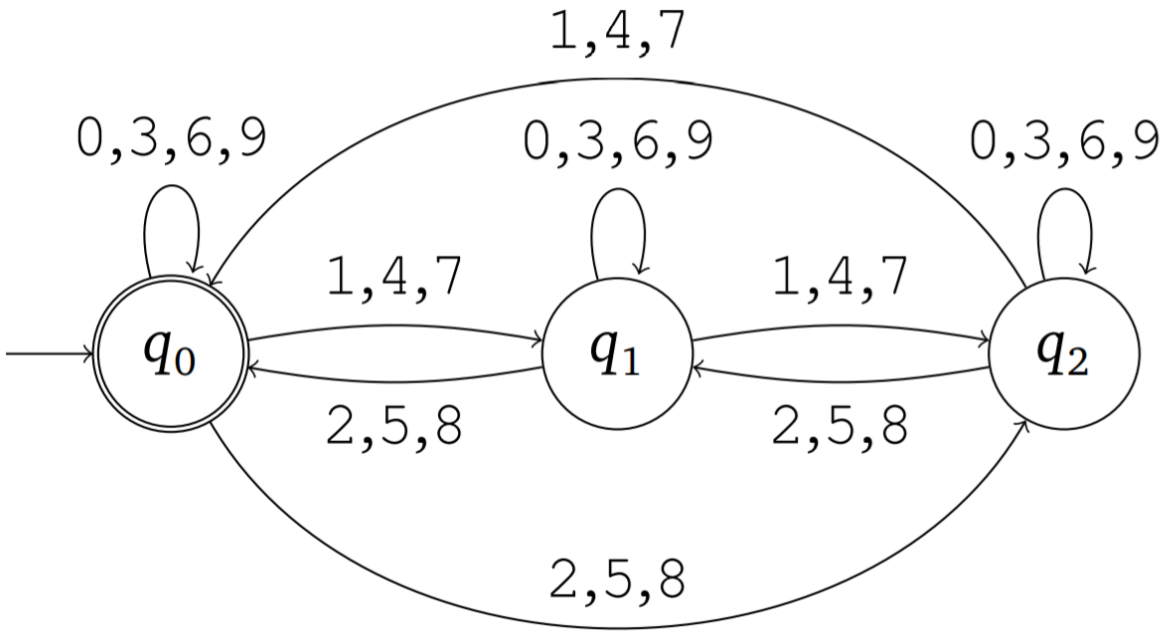


DFA Example

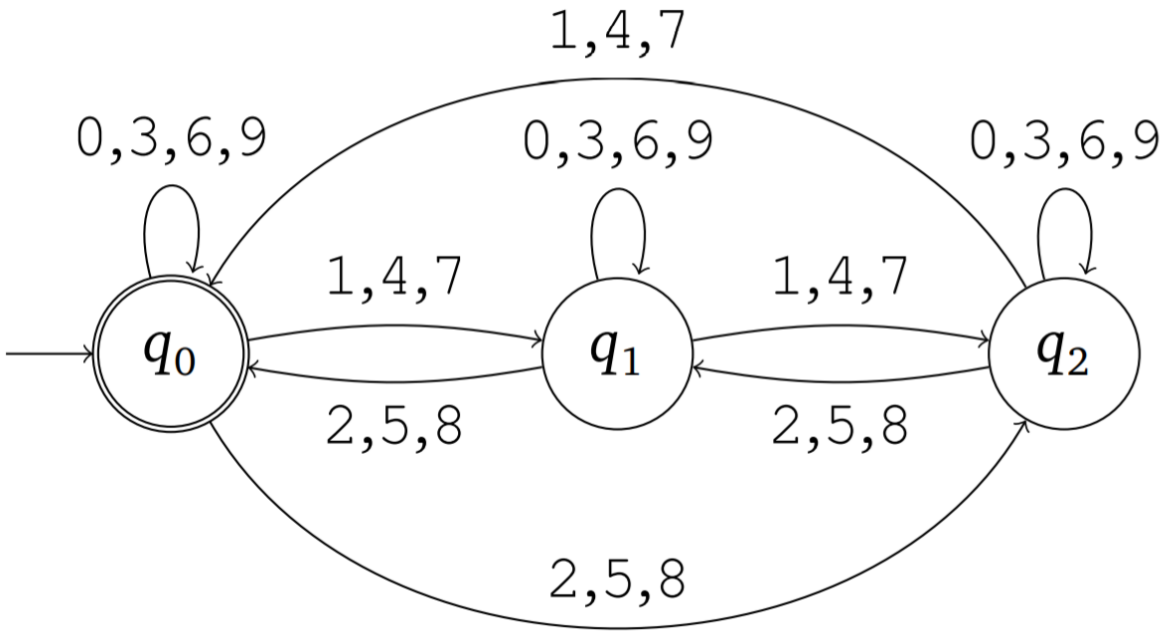


- A DFA for the language of strings of length at least two that begin and end with the same symbol

DFA Example

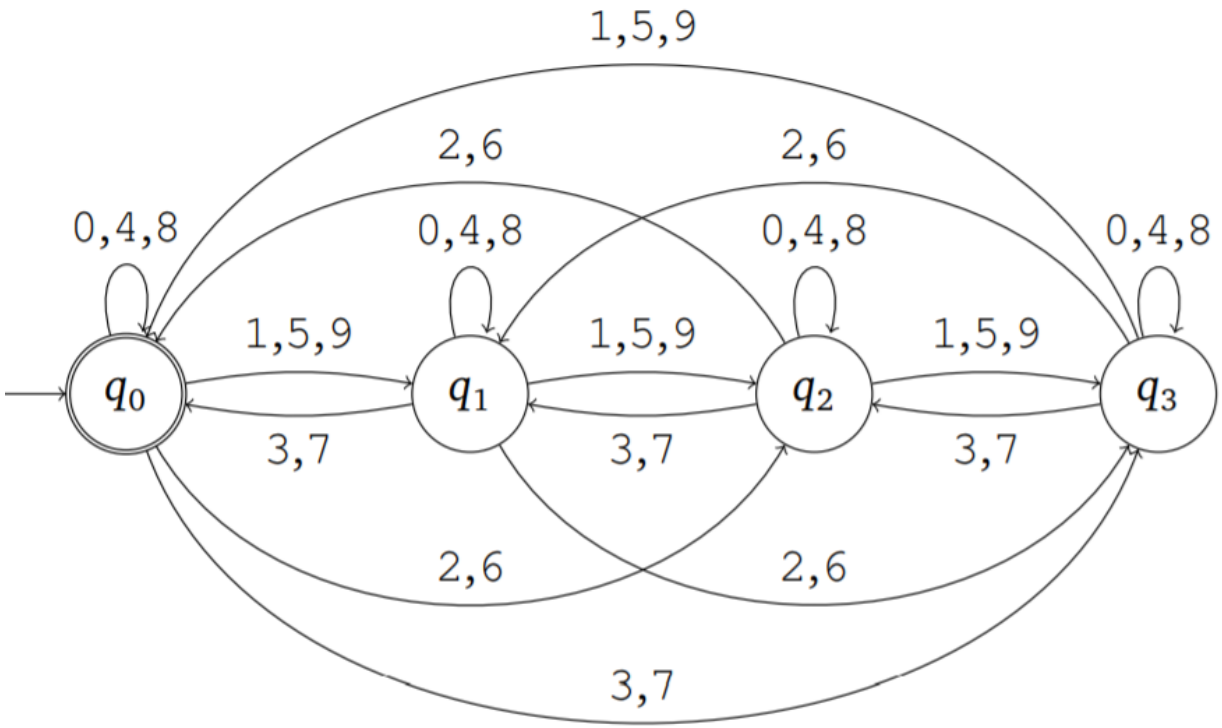


DFA Example



- A DFA for the language of strings whose digits add to a multiple of 3

DFA Example



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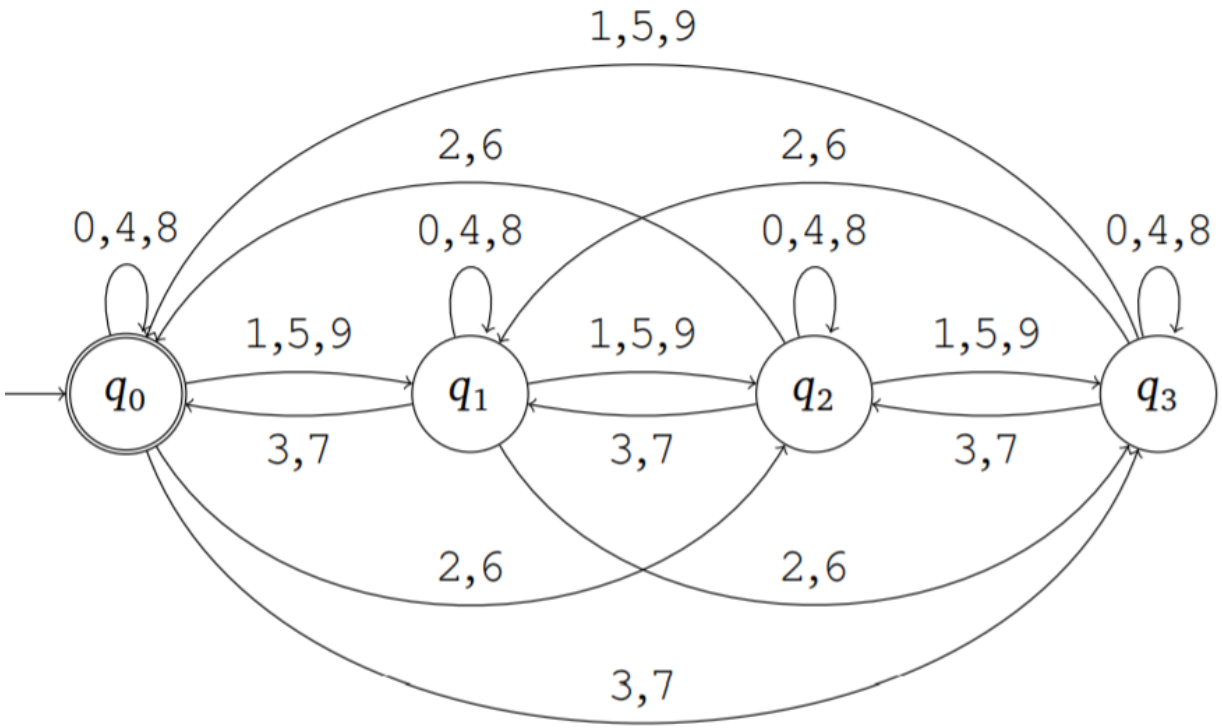

- A DFA for the language of strings whose digits add to a multiple of 4

Questions

Give DFA's for the following languages, where $\Sigma = \{0, 1\}$.

1. The language of strings that contain at least one 1
2. The language of strings that contain exactly one 1
3. The language of strings that contain at least two 1's
4. The language of strings that contain less than two 1's
5. The language of strings of length at least two whose first two symbols are the same
6. The language of strings of length at least two whose last two symbols are the same
7. The language of strings of length at least two that have a 1 in the second-to-last position

Questions

1. The language of strings of length at least two that begin with 0 and end in 1
2. The language of strings of length at least two that have a 1 as their second symbol
3. The language of strings that contain the string 001 as a substring
4. The language of strings that contain the string 001 as a subsequence
5. The language of strings that do not contain the string 001 as a subsequence
6. The language of strings that have even length and begin with the string 01