

```
from graphviz import Digraph, Source
```

Store tendering

Transitions:

- Customer pays (*pay*)
- Present payment information to bank (*transmit*)
- Recieve funds from back (*deposit*)
- Ship goods to customer (*ship*)

```
store = Source('''
    digraph {

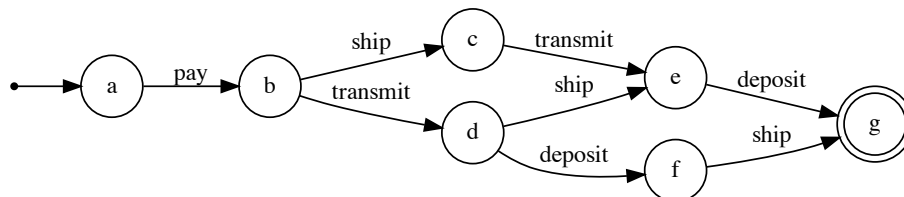
        rankdir=LR;

        node [shape=point]; start;
        node [shape=doublecircle]; g;
        node [shape=circle];

        start -> a
        a -> b [label="pay"];
        b -> c [label="ship"];
        b -> d [label="transmit"];
        c -> e [label="transmit"];
        d -> e [label="ship"];
        d -> f [label="deposit"];
        f -> g [label="ship"];
        e -> g [label="deposit"];

    }
    ''')
```

store



DFA for

$L = \{w \mid w \text{ contains the string } 01\}$

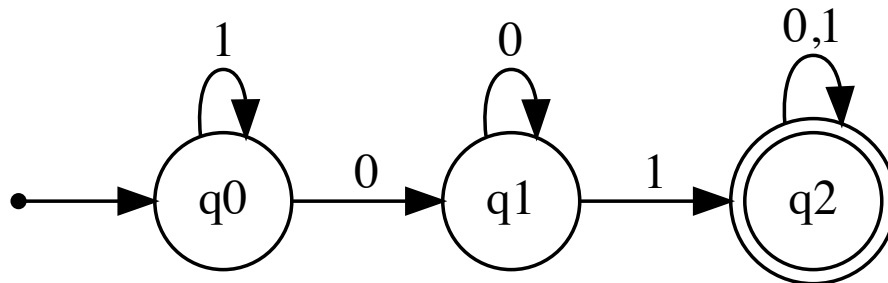
Hopcroft 2.4

```
zeroone = Source(''
    digraph {
        rankdir=LR;

        node [shape=point]; start;
        node [shape=doublecircle]; q2;
        node [shape=circle];

        start -> q0;
        q0 -> q0 [label="1"]
        q0 -> q1 [label="0"]
        q1 -> q1 [label="0"]
        q1 -> q2 [label="1"]
        q2 -> q2 [label="0,1"]
    }
'')
```

zeroone



$M = (Q, \Sigma, \delta, q_1, F)$ Where

1. $Q = \{q_0, q_1, q_2\}$
2. $\Sigma = \{0, 1\}$
3. δ is described by $|\delta|0|1| \quad |:-|:-| \quad | *q_0 \mid q_1 \mid q_0 \mid \mid q_1 \mid q_1 \mid q_2 \mid \mid \rightarrow q_2 \mid q_2 \mid$
 $q_2 \mid$
4. q_0 is the start state
5. $F = \{q_2\}$

DFA for

$L = \{w \mid w \text{ is of even length and begins with } 01\}$

Hopcroft 2.6

```
evenodd = Source(''')
    digraph {

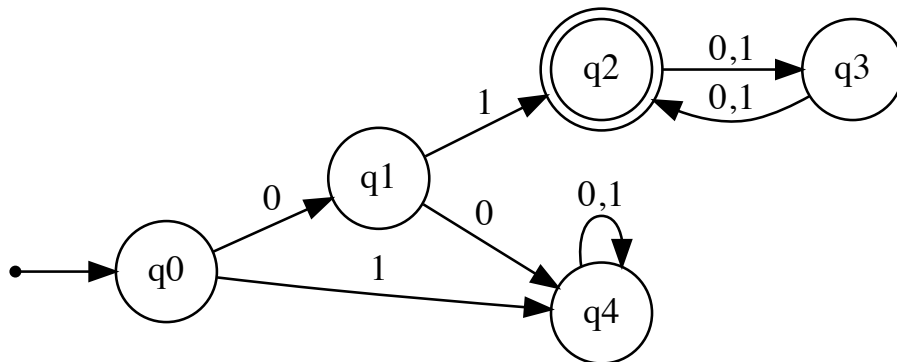
        rankdir=LR;

        node [shape=point]; start;
        node [shape=doublecircle]; q2;
        node [shape=circle];

        start -> q0;
        q0 -> q1 [label="0"];
        q0 -> q4 [label="1"];
        q4 -> q4 [label="0,1"];
        q1 -> q4 [label="0"];
        q1 -> q2 [label="1"];
        q2 -> q3 [label="0,1"];
        q3 -> q2 [label="0,1"];

    }
''')
```

evenodd



$M = (Q, \Sigma, \delta, q_1, F)$ Where

1. $Q = \{q_0, q_1, q_2, q_3\}$
2. $\Sigma = \{0, 1\}$
3. δ is described by $|\delta|0|1| \mid |:-|:-| \mid *q_0 \mid q_1 \mid q_4 \mid \mid q_1 \mid q_4 \mid q_2 \mid \mid \rightarrow q_2 \mid q_3 \mid q_3 \mid \mid q_3 \mid q_2 \mid q_2 \mid \mid q_4 \mid q_4 \mid q_4 \mid$
4. q_1 is the start state

5. $F = \{q2\}$

NFA to DFA Conversion

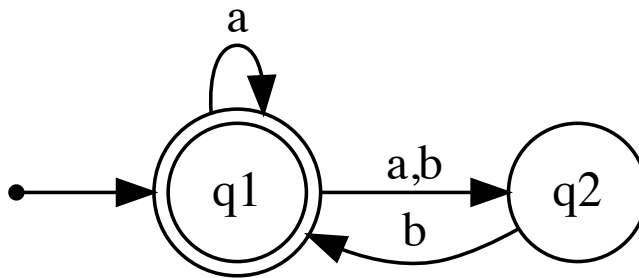
Sipser problem 1.16(a)

```
p116nfa = Source(''
    digraph {
        rankdir=LR;

        node [shape=point]; start;
        node [shape=doublecircle]; q1;
        node [shape=circle]; q2;

        start -> q1;
        q1 -> q2 [label="a,b"];
        q2 -> q1 [label="b"];
        q1 -> q1 [label="a"];
    }
'')
```

p116nfa



1. $Q = \{\emptyset, q1, q2, \{q1, q2\}\}$
2. $\Sigma = \{a, b\}$
3. $q0 = \{q1\}$
4. $F = \{q1, \{q1, q2\}\}$
5. δ is described by

δ	a	b
\emptyset	\emptyset	\emptyset
q1	$\{q1, q2\}$	q2

δ	a	b
q2	\emptyset	q1
{q1,q2}	{q1,q2}	q2

```
p116dfa = Source('''
digraph {

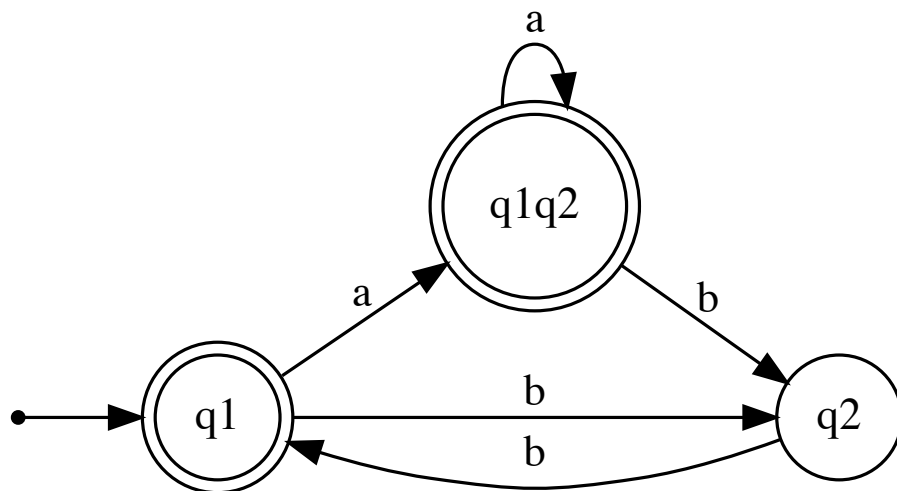
    rankdir=LR;

    node [shape=point]; start;
    node [shape=doublecircle]; q1, q1q2;
    node [shape=circle];

    start -> q1;
    q1 -> q1q2 [label="a"];
    q1 -> q2 [label="b"];
    q2 -> q1 [label="b"];
    q1q2 -> q1q2 [label="a"];
    q1q2 -> q2 [label="b"];

}
''')
```

p116dfa



Strings that are either:

- Empty
- Contain one or more instances of *bb*

NFA to DFA Conversion with

Sipser example 1.41 (pg 56)

```
e141nfa = Source('''
    digraph {

        rankdir=LR;

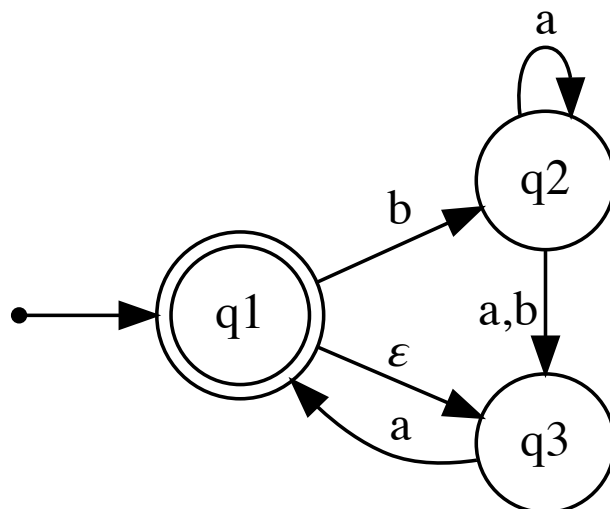
        node [shape=point]; start;
        node [shape=doublecircle]; q1;
        node [shape=circle];

        start -> q1;
        q1 -> q2 [label="b"];
        q1 -> q3 [label=" "];
        q2 -> q2 [label="a"];
        q2 -> q3 [label="a,b"];
        q3 -> q1 [label="a"];

        {rank=same; q2, q3}

    }
    ''')

e141nfa
```



1. $Q = \{\emptyset, q1, q2, q3, q1q2, q1q3, q2q3, q1q2q3, \}$
2. $\Sigma = \{a, b\}$
3. δ is described by

δ	a	b	
\emptyset	\emptyset	\emptyset	
q1	\emptyset	q2	*
q2	q2q3	q3	
q3	q1q3	\emptyset	
q1q2	q2q3	q2q3	*
q1q3	q1q3	q2	
q2q3	q1q2q3	q3	
q1q2q3	q1q2q3	q2q3	

1. $q0 = q1q3$
2. $F = \{q1, q1q2, q1q3, q1q2q3\}$

Notice states q1 and q1q2 are never transitioned into do they can be eliminated yielding:

1. $Q = \{\emptyset, q2, q3, q1q3, q2q3, q1q2q3, \}$
2. $\Sigma = \{a, b\}$
3. δ is described by

δ	a	b
\emptyset	\emptyset	\emptyset
q2	q2q3	q3
q3	q1q3	\emptyset
q1q3	q1q3	q2
q2q3	q1q2q3	q3
q1q2q3	q1q2q3	q2q3

1. $q0 = q1q3$
2. $F = \{q1q3, q1q2q3\}$

```
p116dfa = Source('')
digraph {
    rankdir=LR;

    { node [shape=point]; start; }
    { node [peripheries=2]; q1q3, q1q2q3; }

    start -> q1q3;
    -> [label="a,b"];
}
```

```

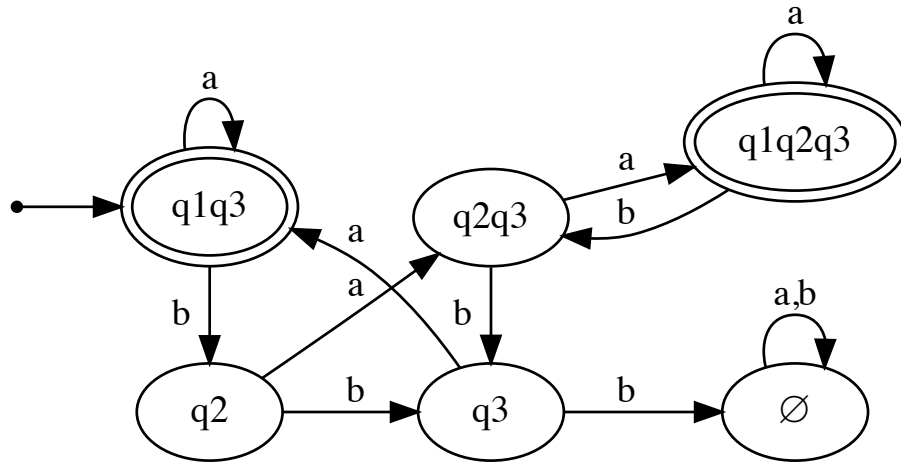
q3 -> q1q3 [label="a"];
q3 -> [label="b"];
q2q3 -> q1q2q3 [label="a"];
q2q3 -> q3 [label="b"];
q1q2q3 -> q1q2q3 [label="a"];
q1q2q3 -> q2q3 [label="b"];
q2 -> q2q3 [label="a"];
q2 -> q3 [label="b"];
q1q3 -> q1q3 [label="a"];
q1q3 -> q2 [label="b"];

{rank=same; q1q3, q2}
{rank=same; q3, q2q3}
{rank=same; , q1q2q3}

}
'''

```

p116dfa



Strings that are either:

- Empty
- Contain one or more instances of *bb*