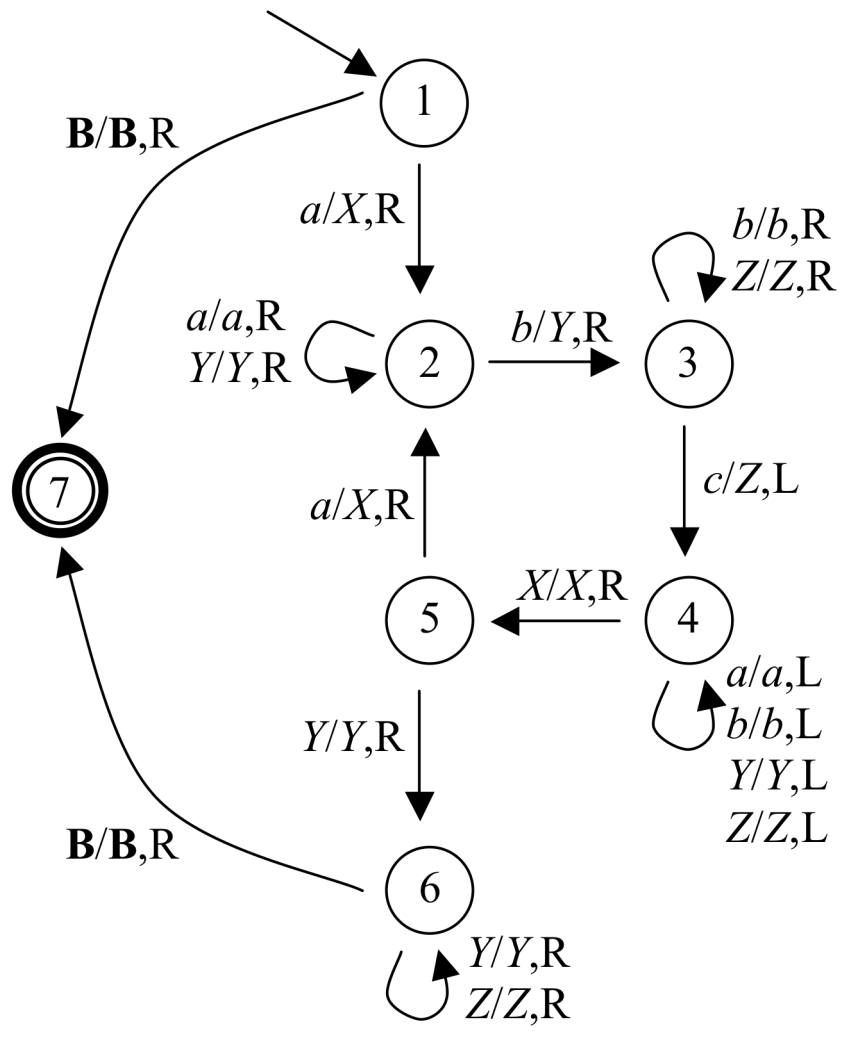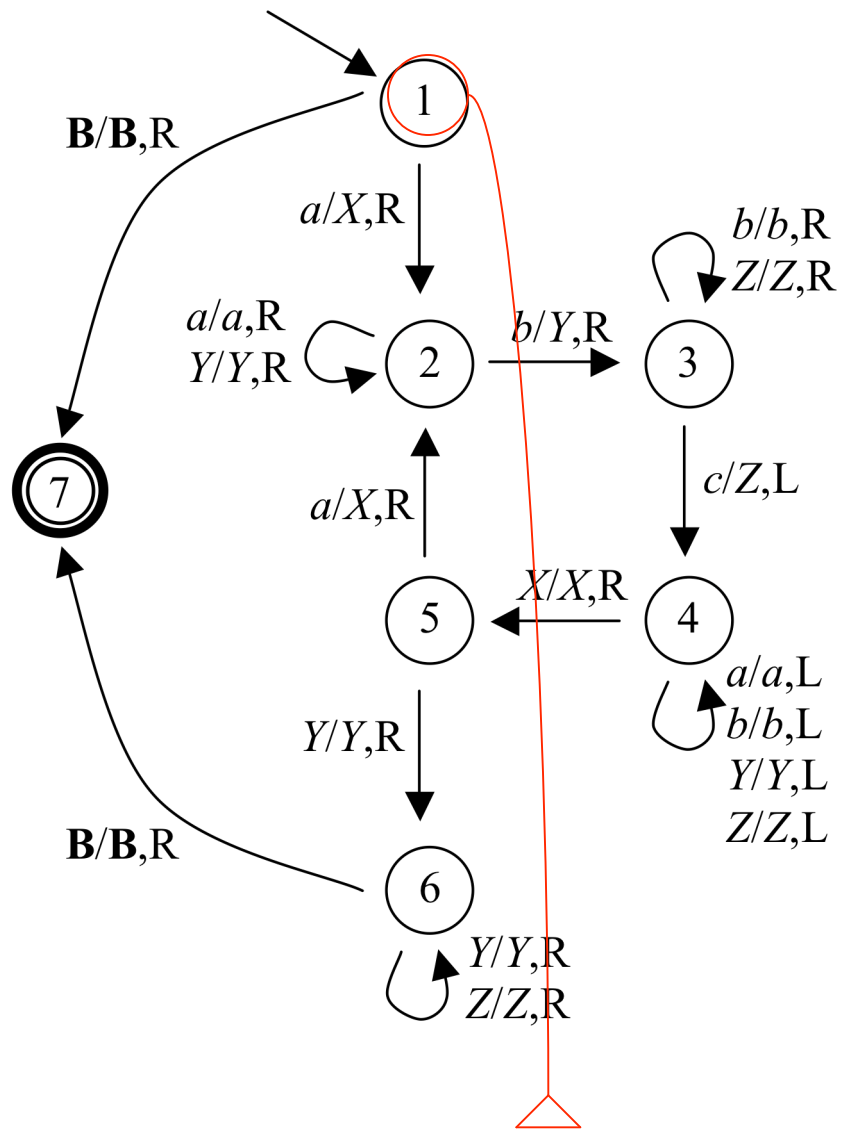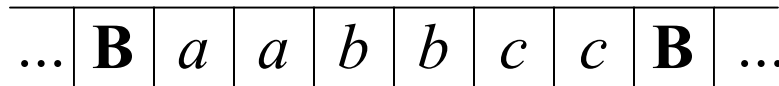# Strategy For $\{a^n b^n c^n\}$
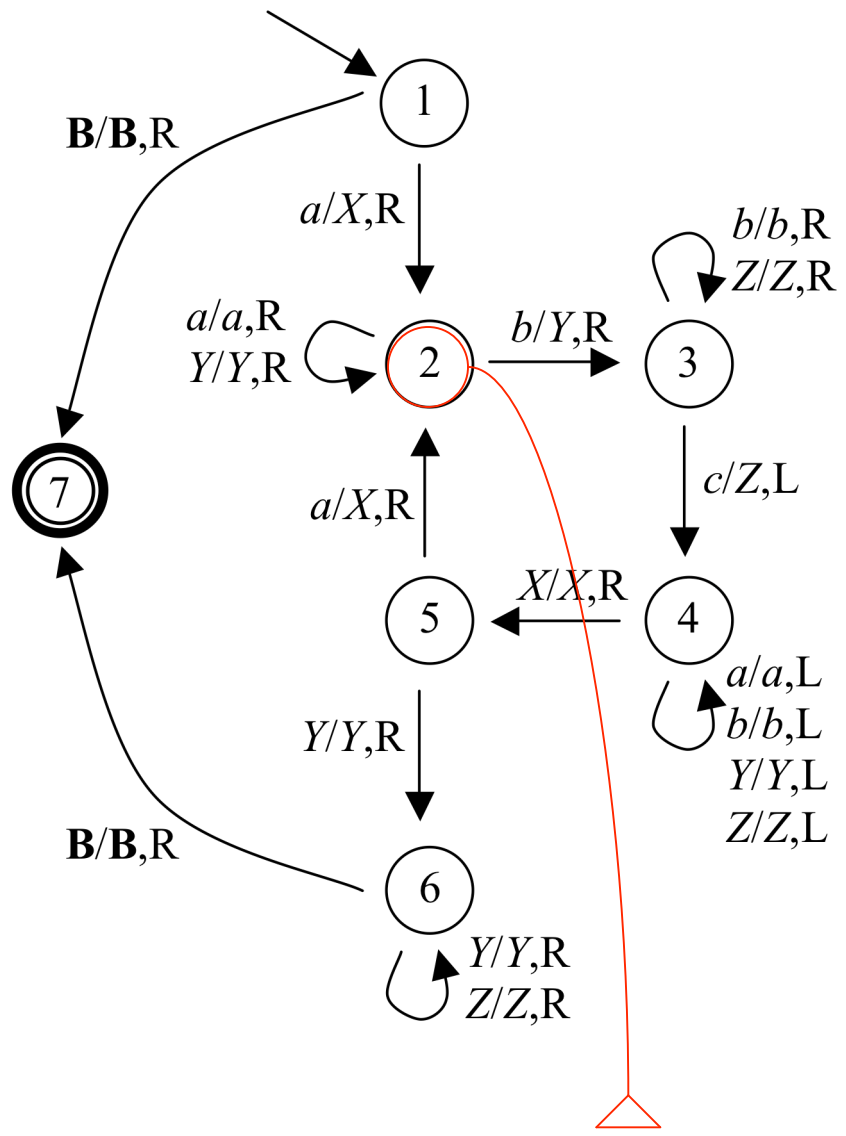
1. If the current symbol is **B**, go to step 7. If the current symbol is a, write an X over it and go to step 2.

2. Move right past any as and Ys. At the first b, write Y over it and go to step 3.

3. Move right past any bs and Zs. At the first c, write Z over it and go to step 4.

4. Move left past any as, bs, Zs, and Ys. At the first X, move right 1 symbol and go to step 5.

5. If the current symbol is a, write X and go to step 2. If the current symbol is Y go to step 6.

6. Move right past any Ys and Zs. At the first **B**, go to step 7.

7. Accept.

B/B,R

a/X,R

a/a,R
Y/Y,R

b/Y,R

b/b,R
Z/Z,R

c/Z,L

a/X,R

X/X,R
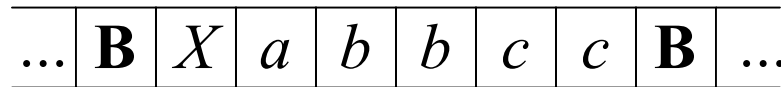
a/a,L
b/b,L
Y/Y,L
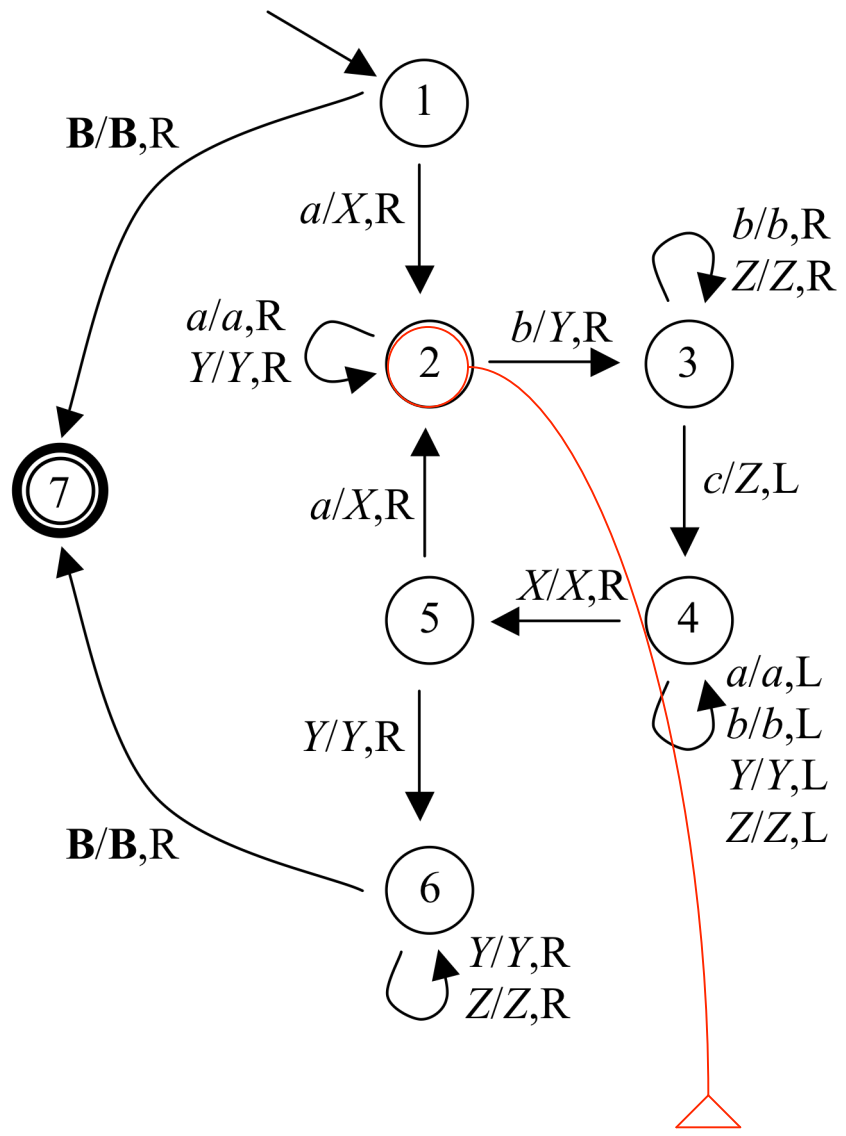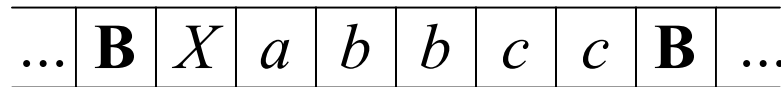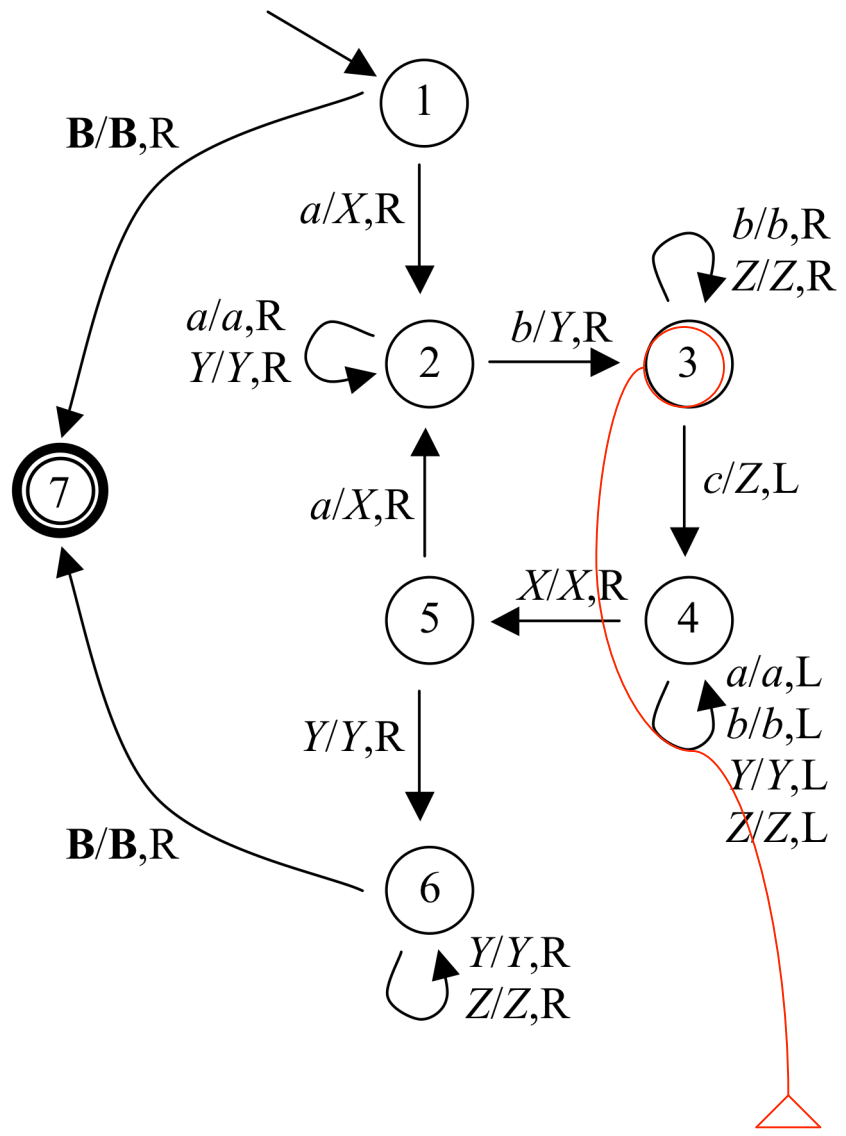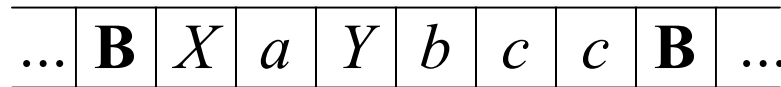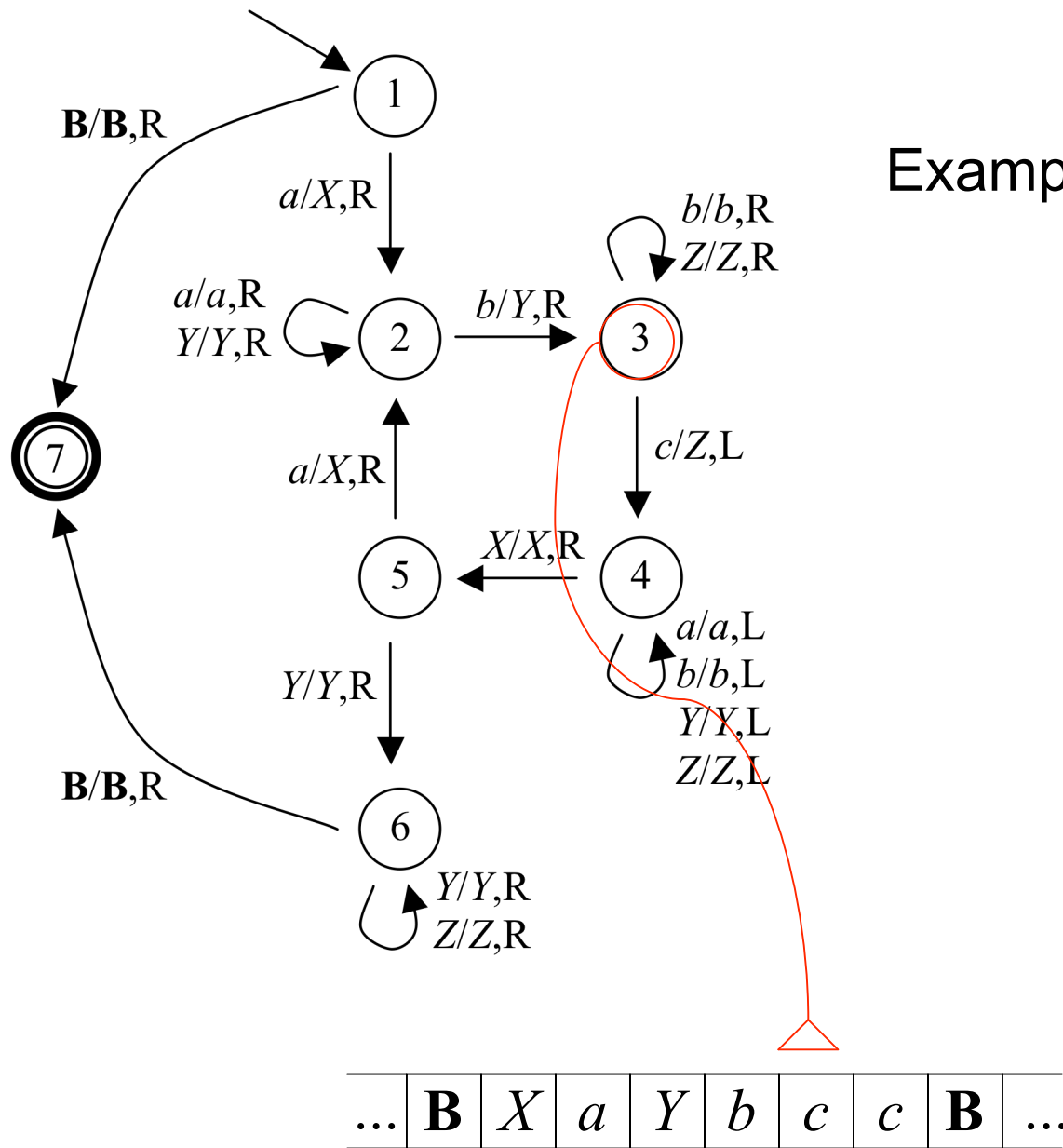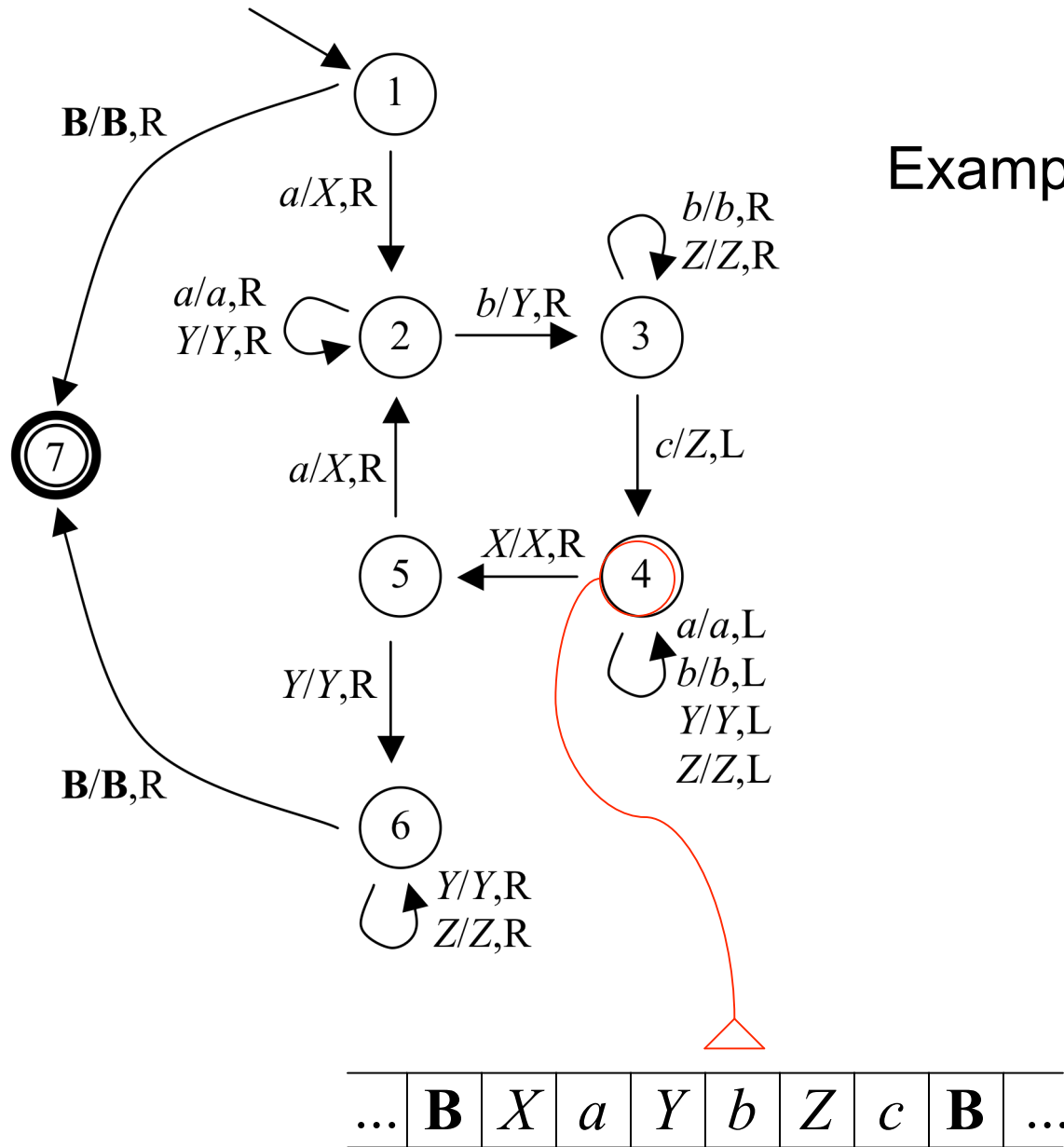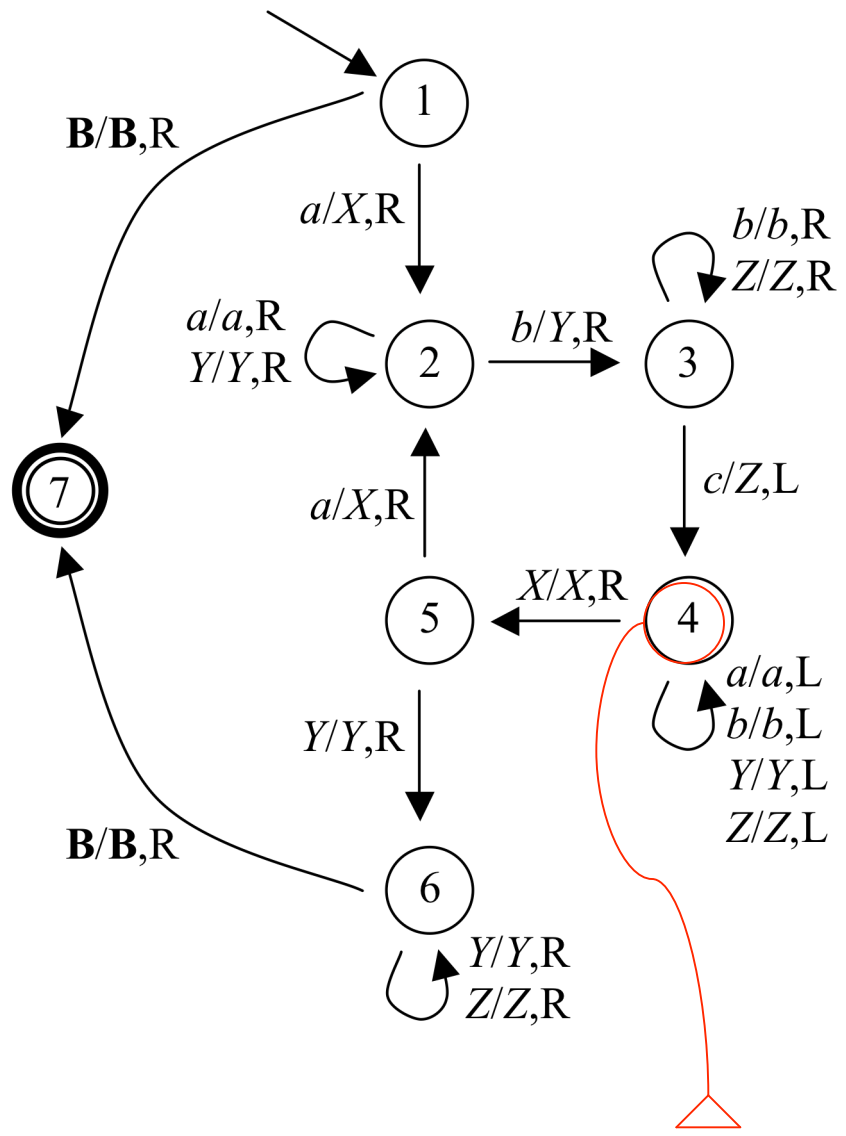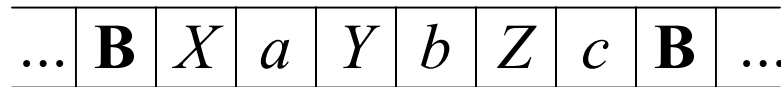*Z/Z*,L

Y/Y,R
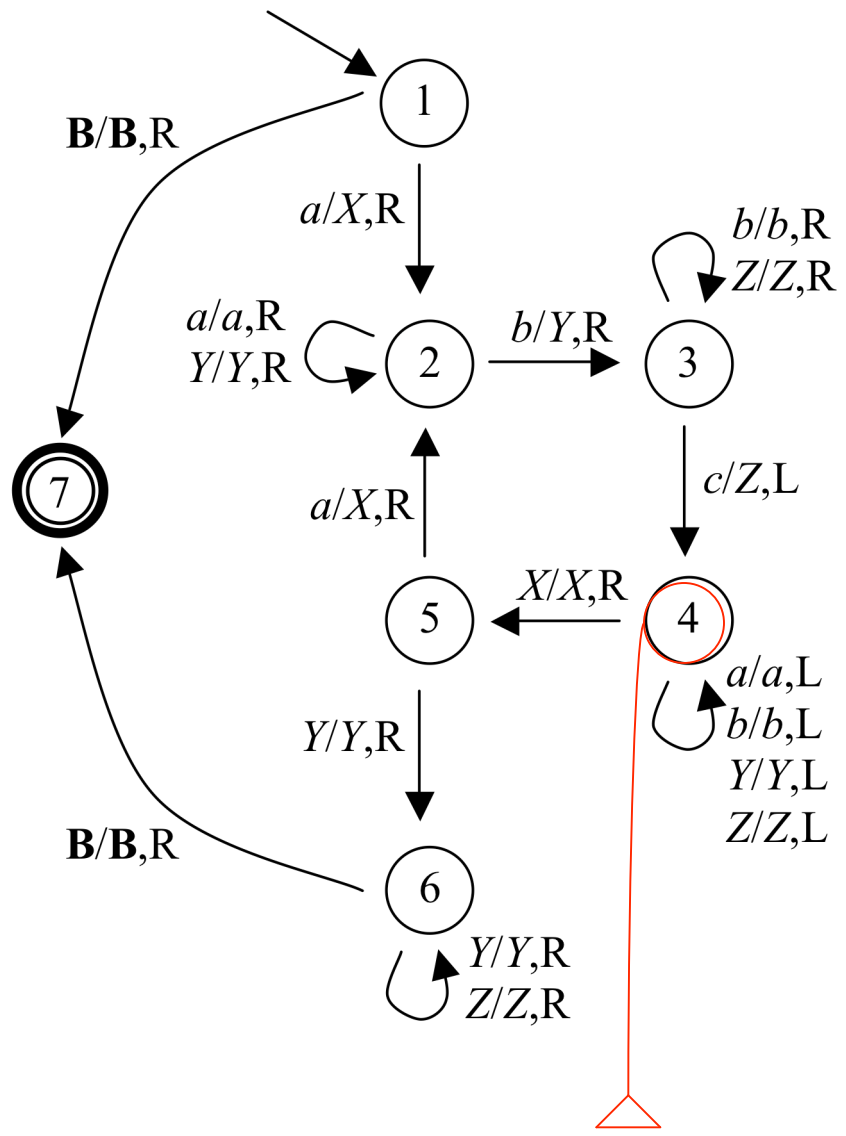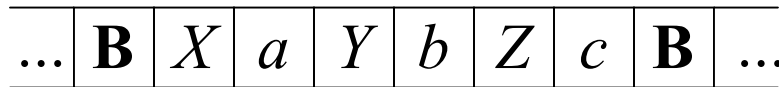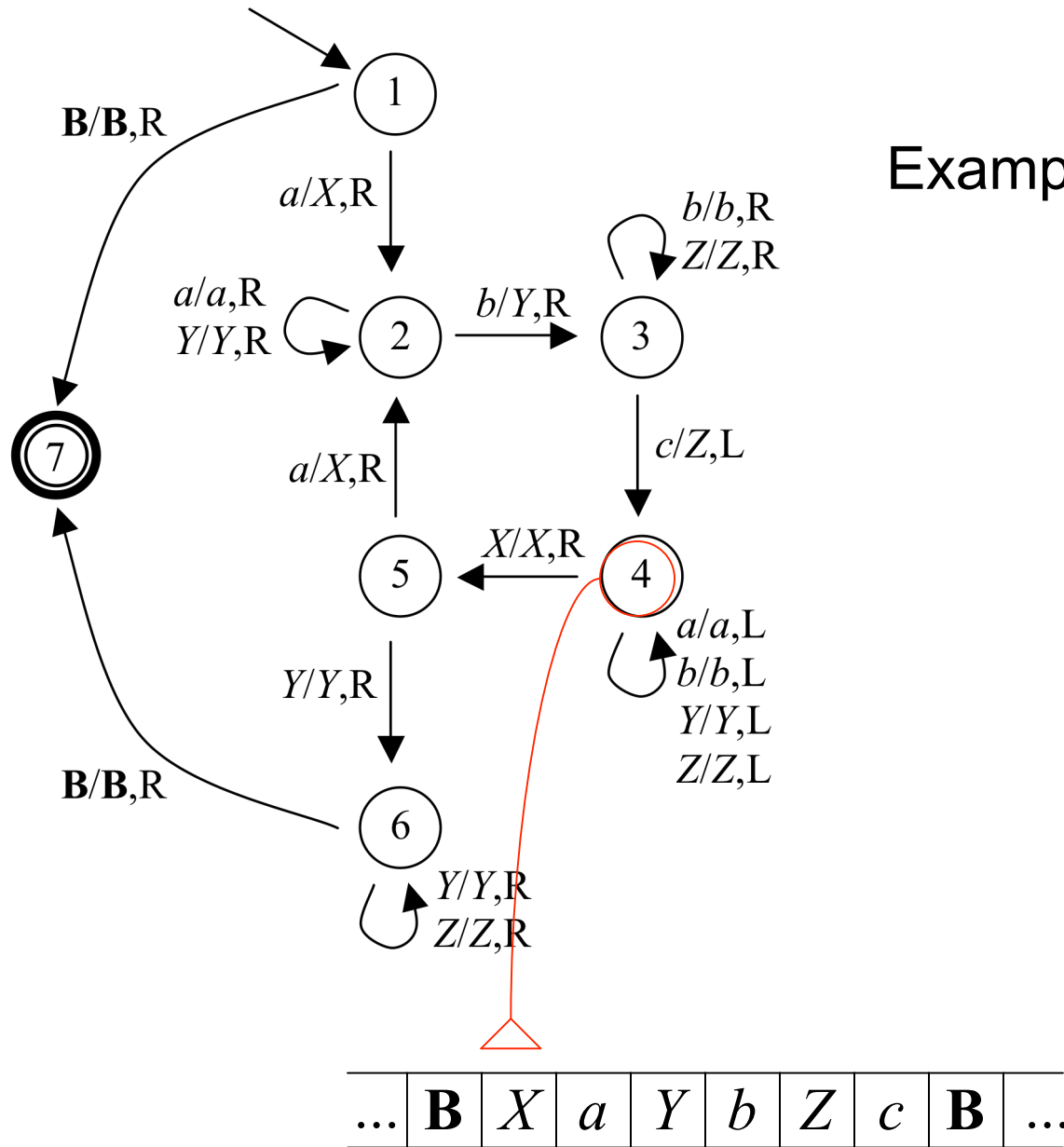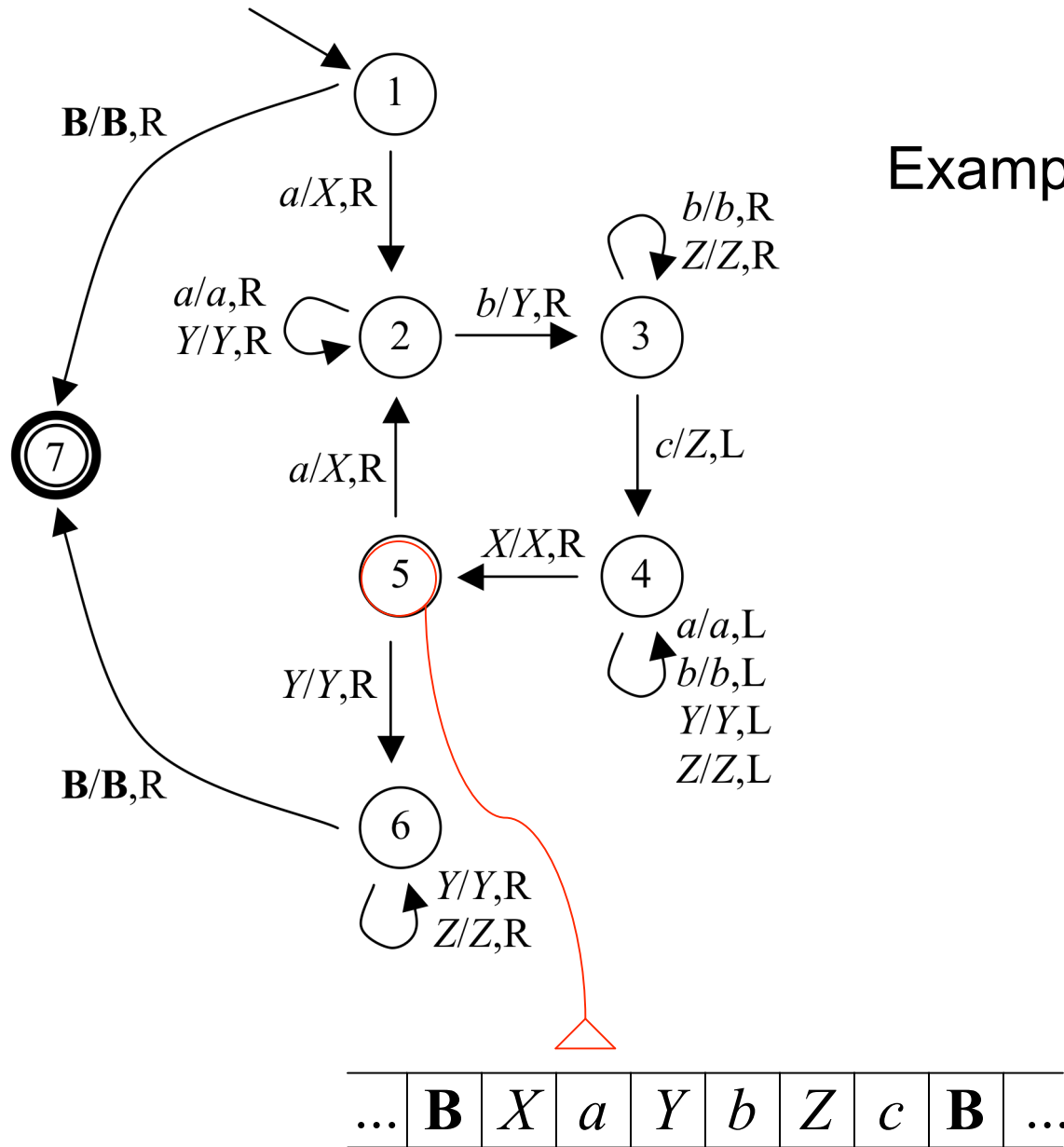
B/B,R

Y/Y,R
Z/Z,R

1

2

3

4

5

6

7

Example: *aabbcc*

Example: *aabbcc*

Example: *aabbcc*

Example: *aabbcc*

Example: *aabbcc*

B/B,R

a/X,R

a/a,R
Y/Y,R

b/Y,R

b/b,R
Z/Z,R

c/Z,L

a/X,R

X/X,R

a/a,L
b/b,L
Y/Y,L
Z/Z,L

Y/Y,R

B/B,R

Y/Y,R
Z/Z,R

... | **B** | X | a | Y | b | c | c | **B** | ...

Example: *aabbcc*

Example: *aabbcc*

B/B,R

(1)

a/X,R

a/a,R
Y/Y,R

(2)

b/Y,R

(3)

b/b,R
Z/Z,R

c/Z,L

(7)

a/X,R

X/X,R

(5)

(4)

a/a,L
b/b,L
Y/Y,L
Z/Z,L

Y/Y,R

B/B,R

(6)

Y/Y,R
Z/Z,R

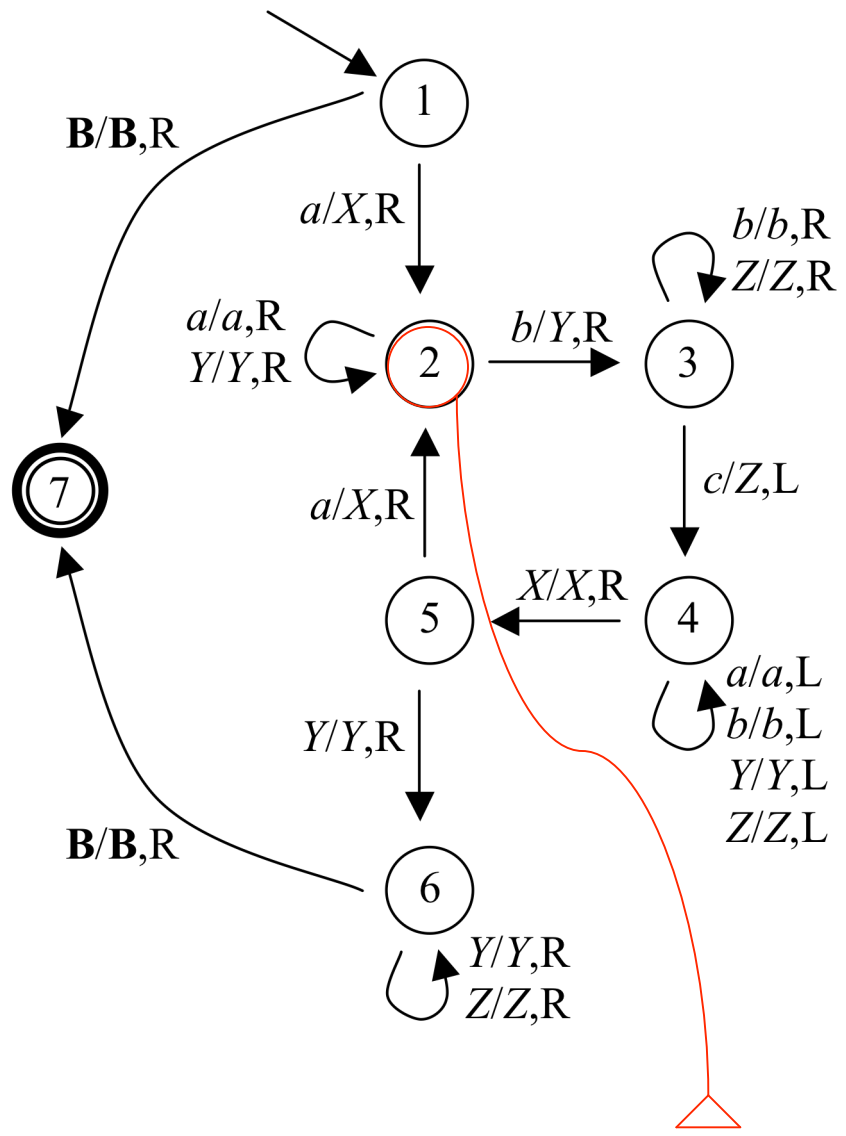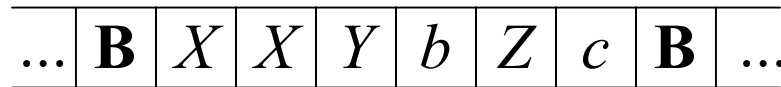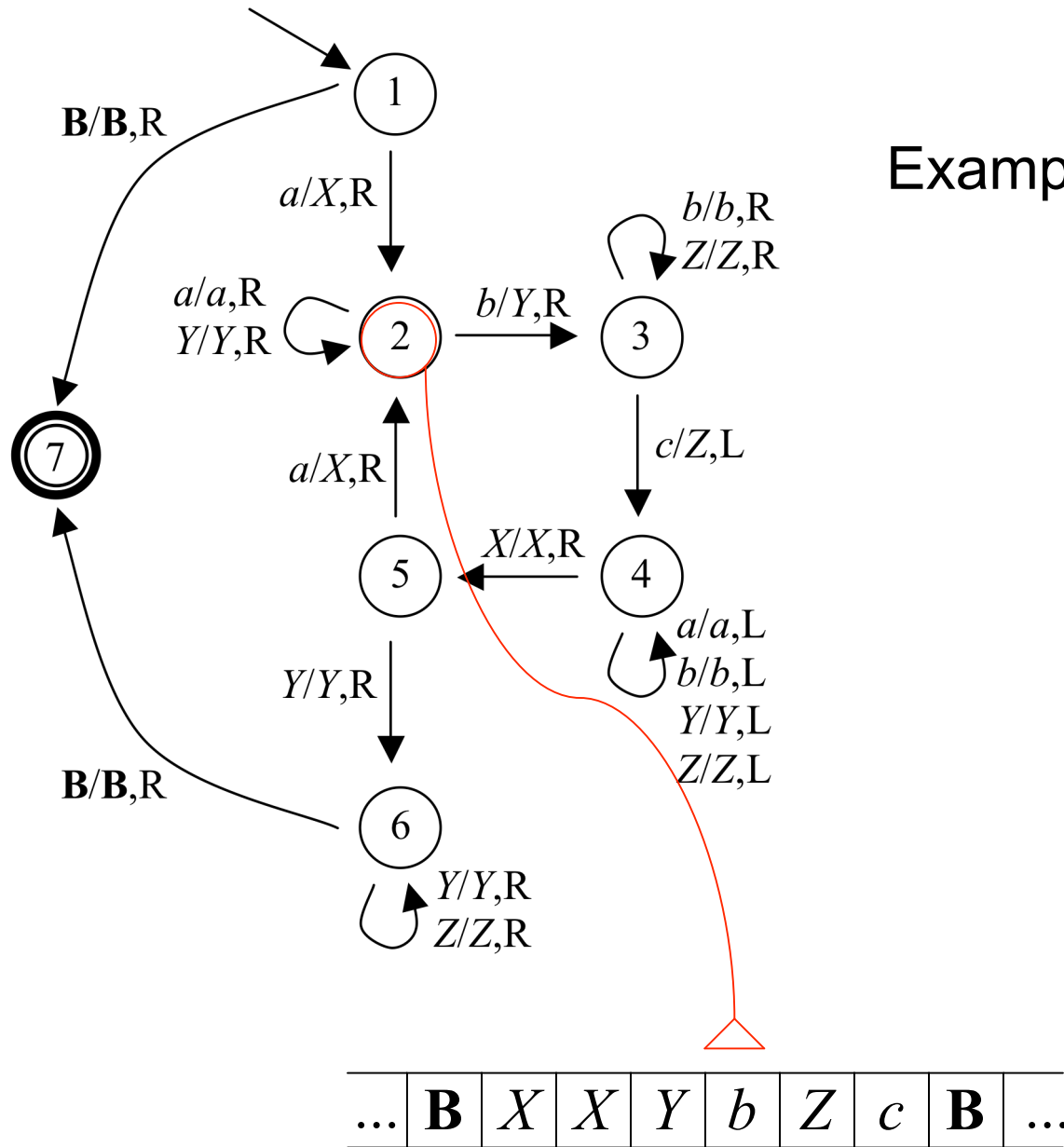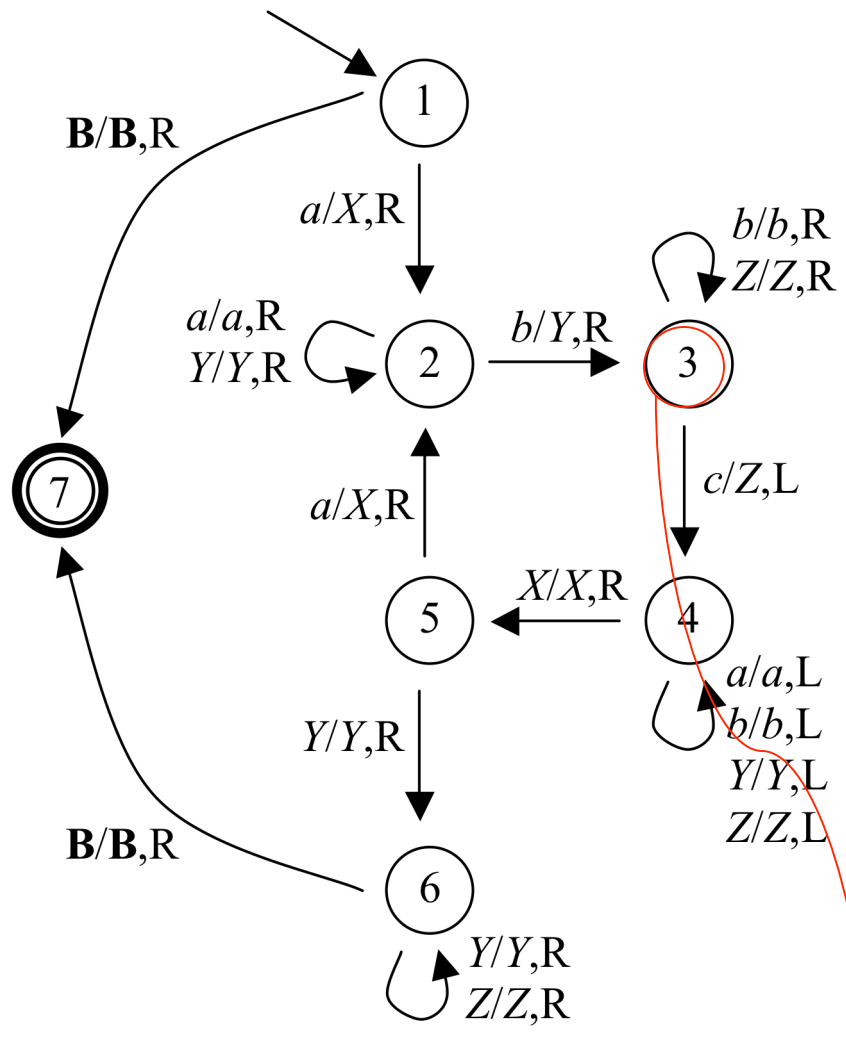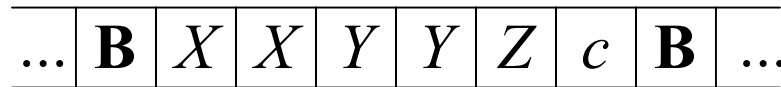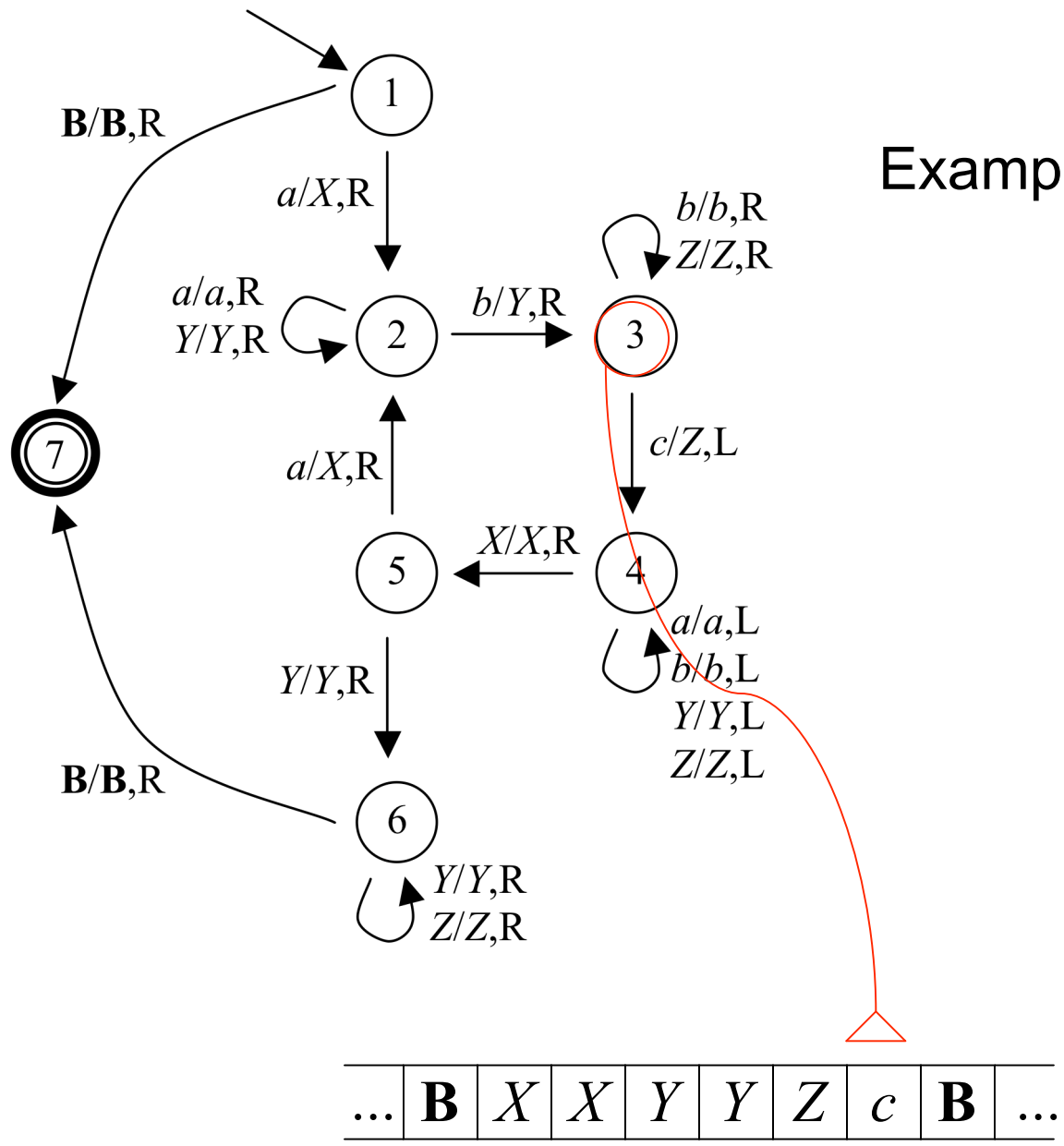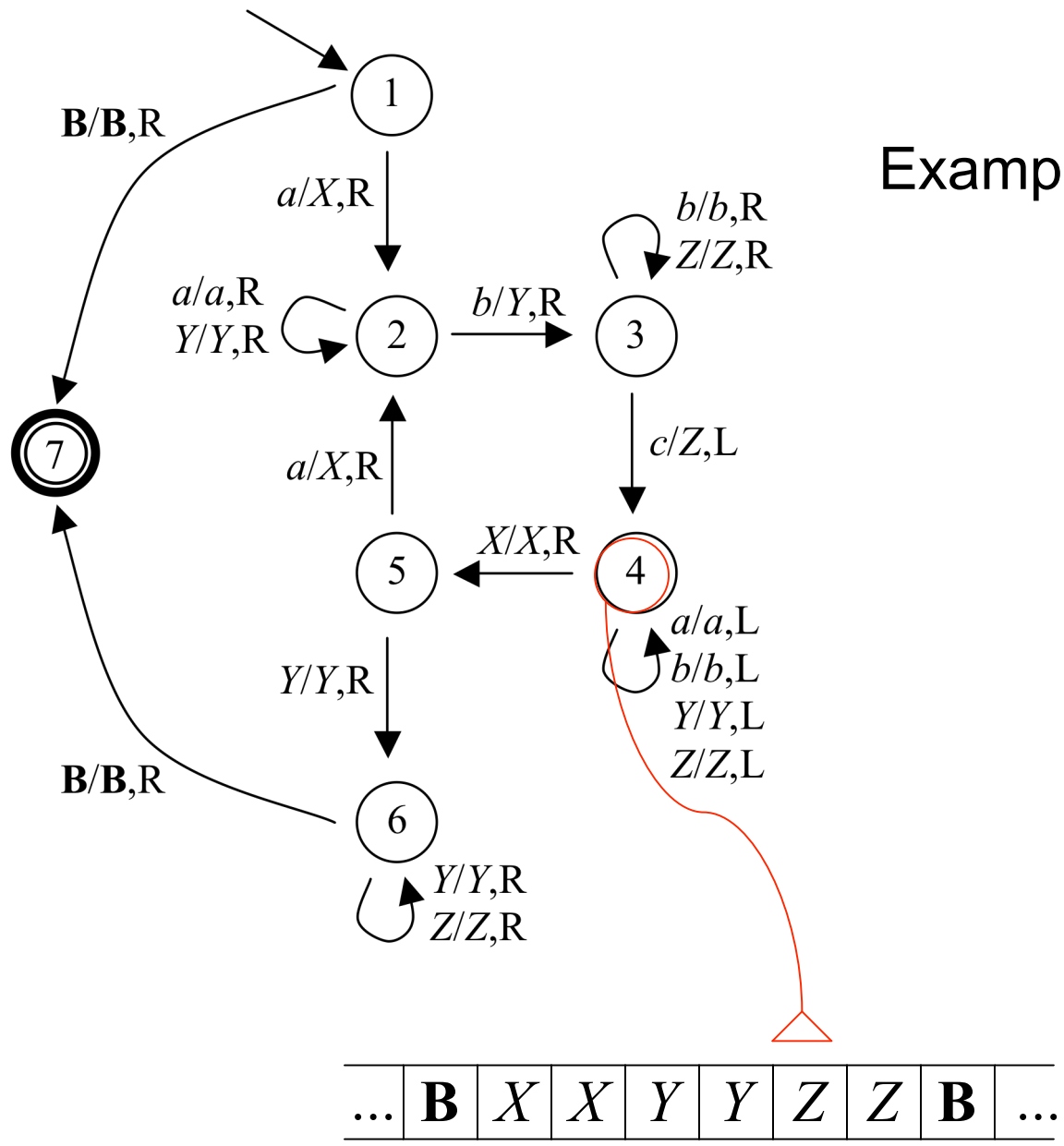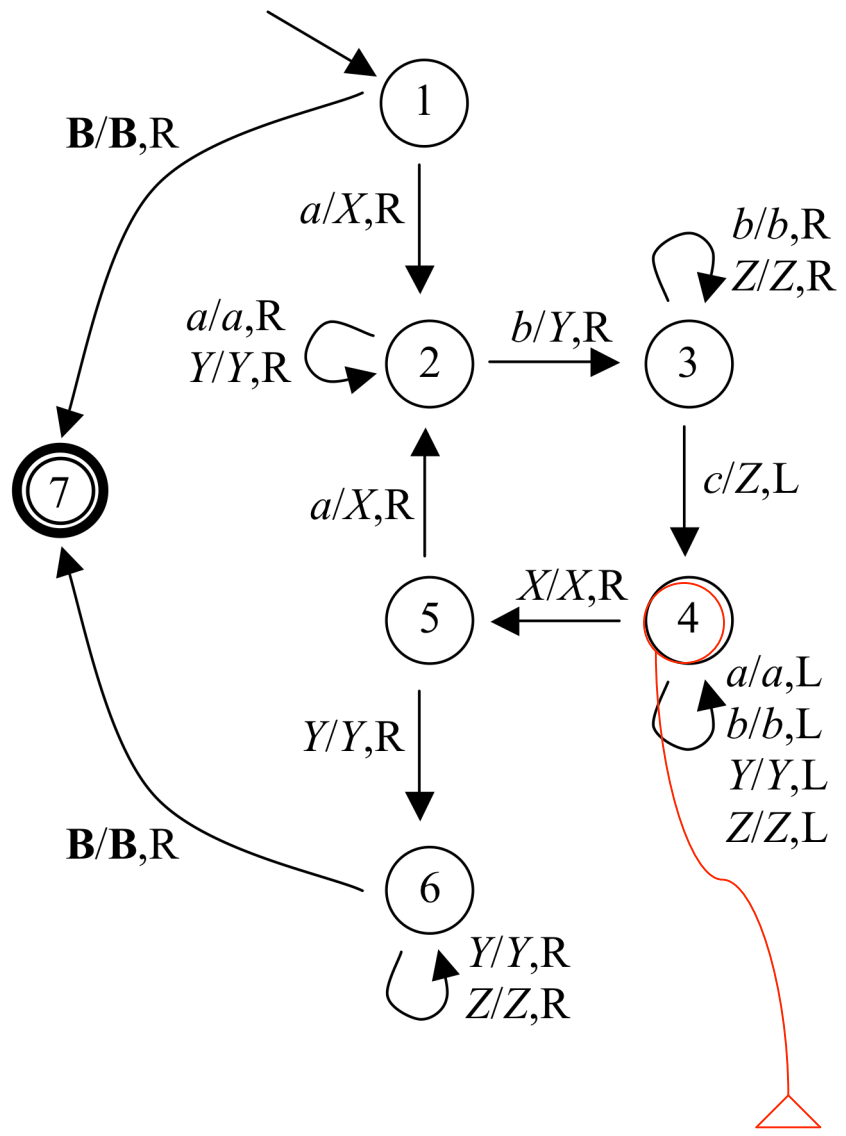| ... | **B** | *X* | *a* | *Y* | *b* | *Z* | *c* | **B** | ... |

Example: *aabbcc*

Example: *aabbcc*

Example: *aabbcc*

Example: *aabbcc*

Example: *aabbcc*

Example: *aabbcc*

Example: *aabbcc*

Example: *aabbcc*

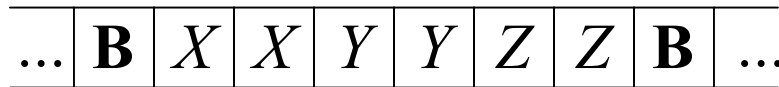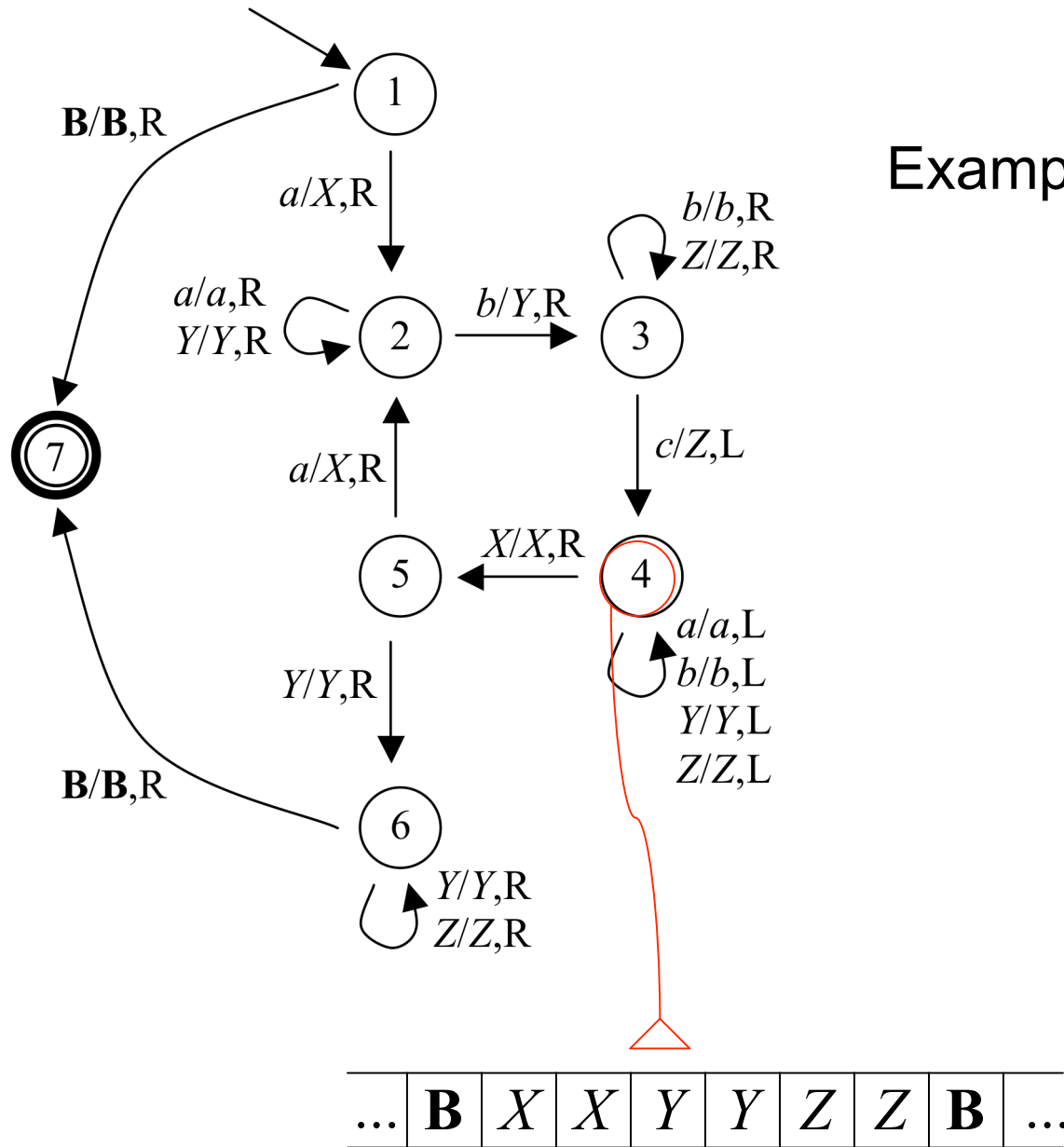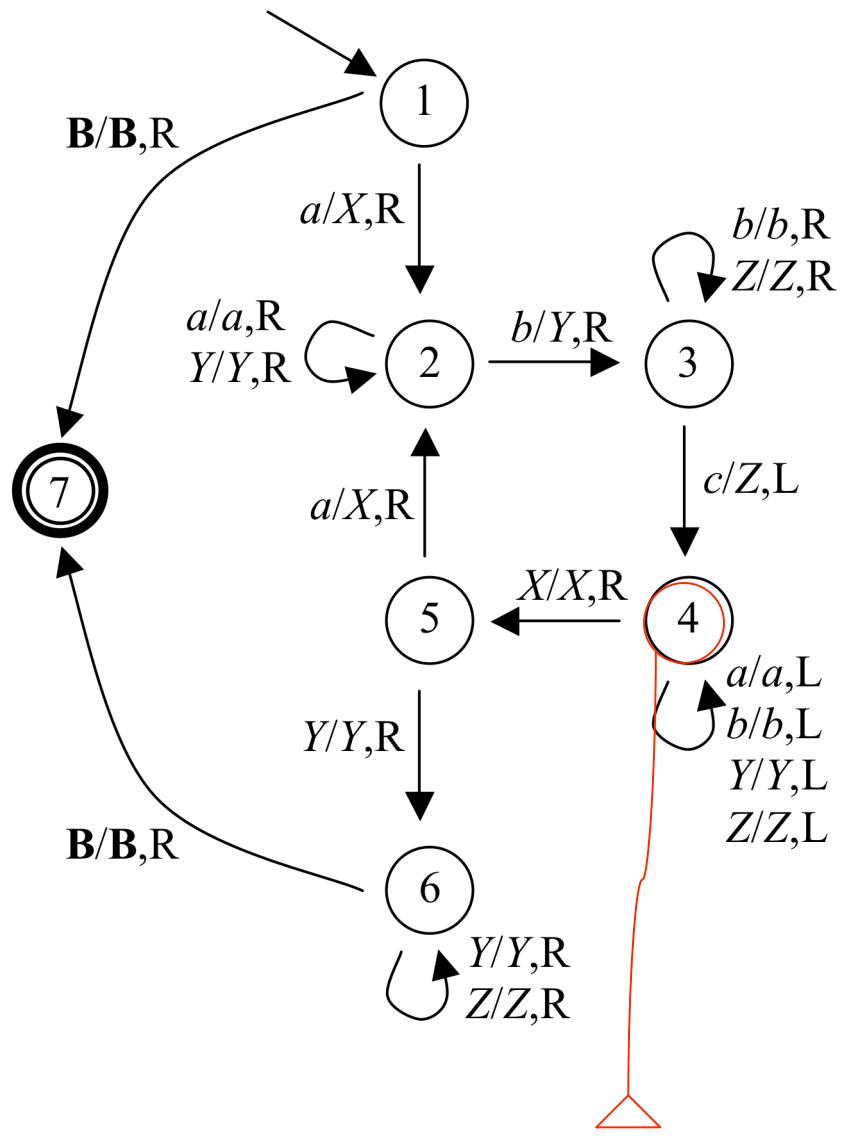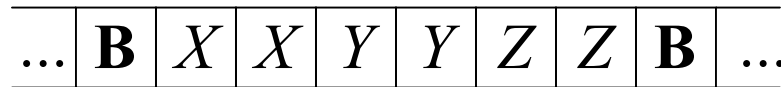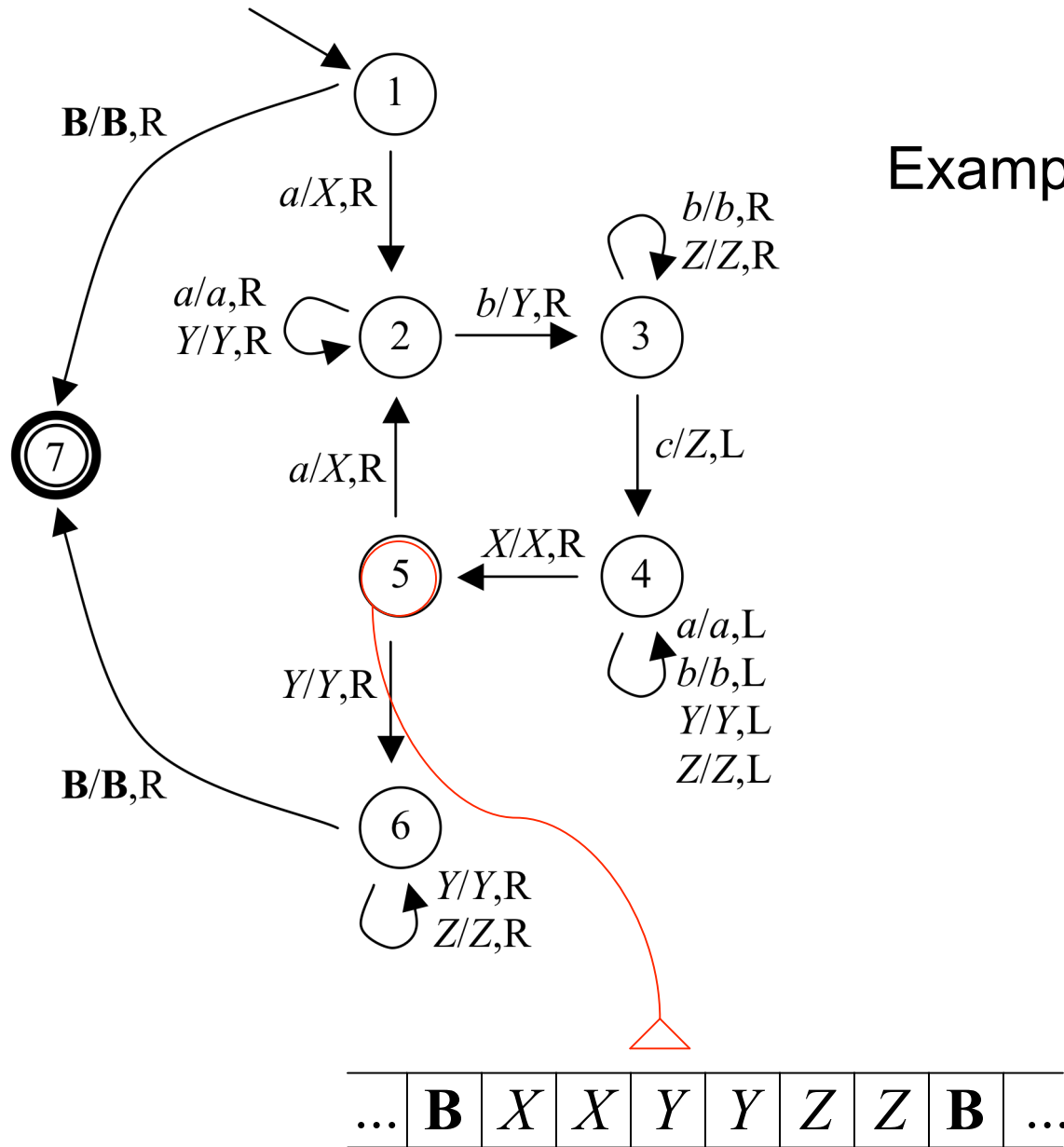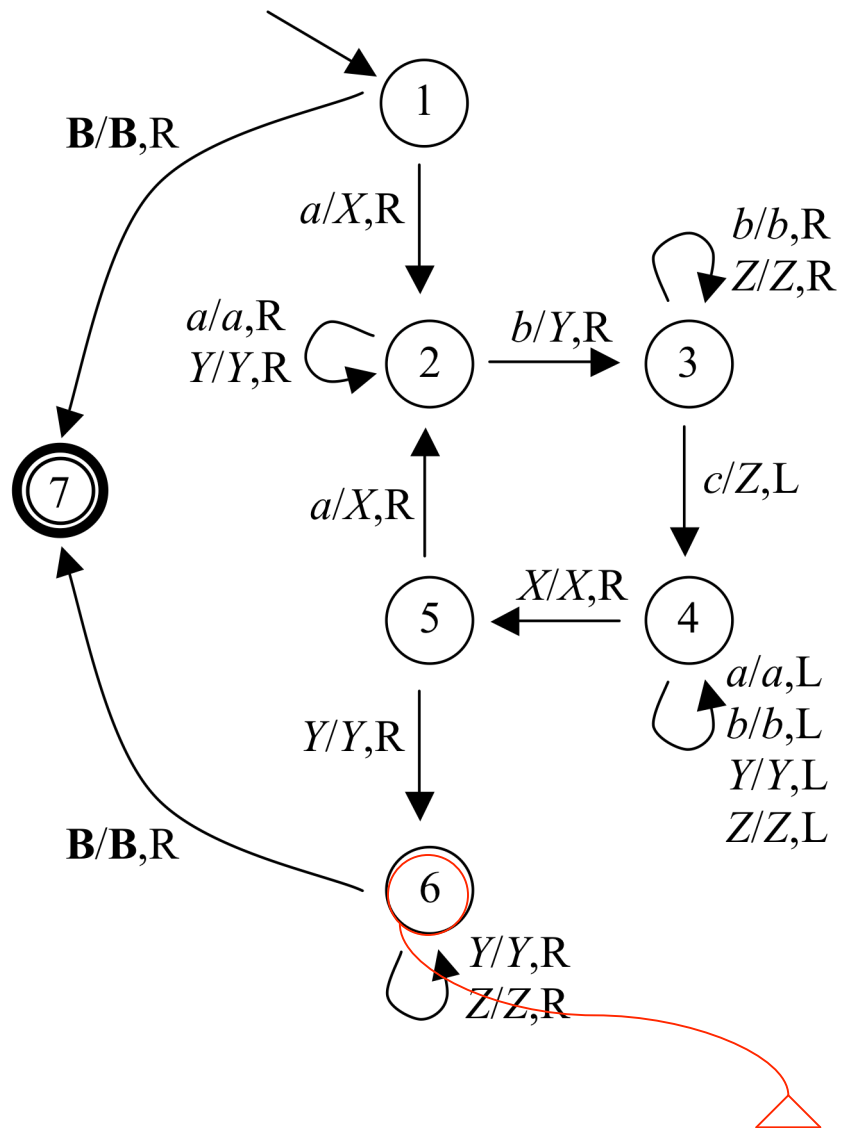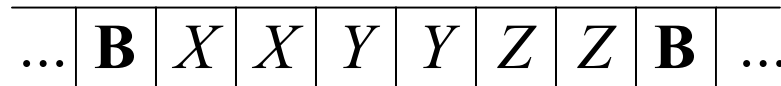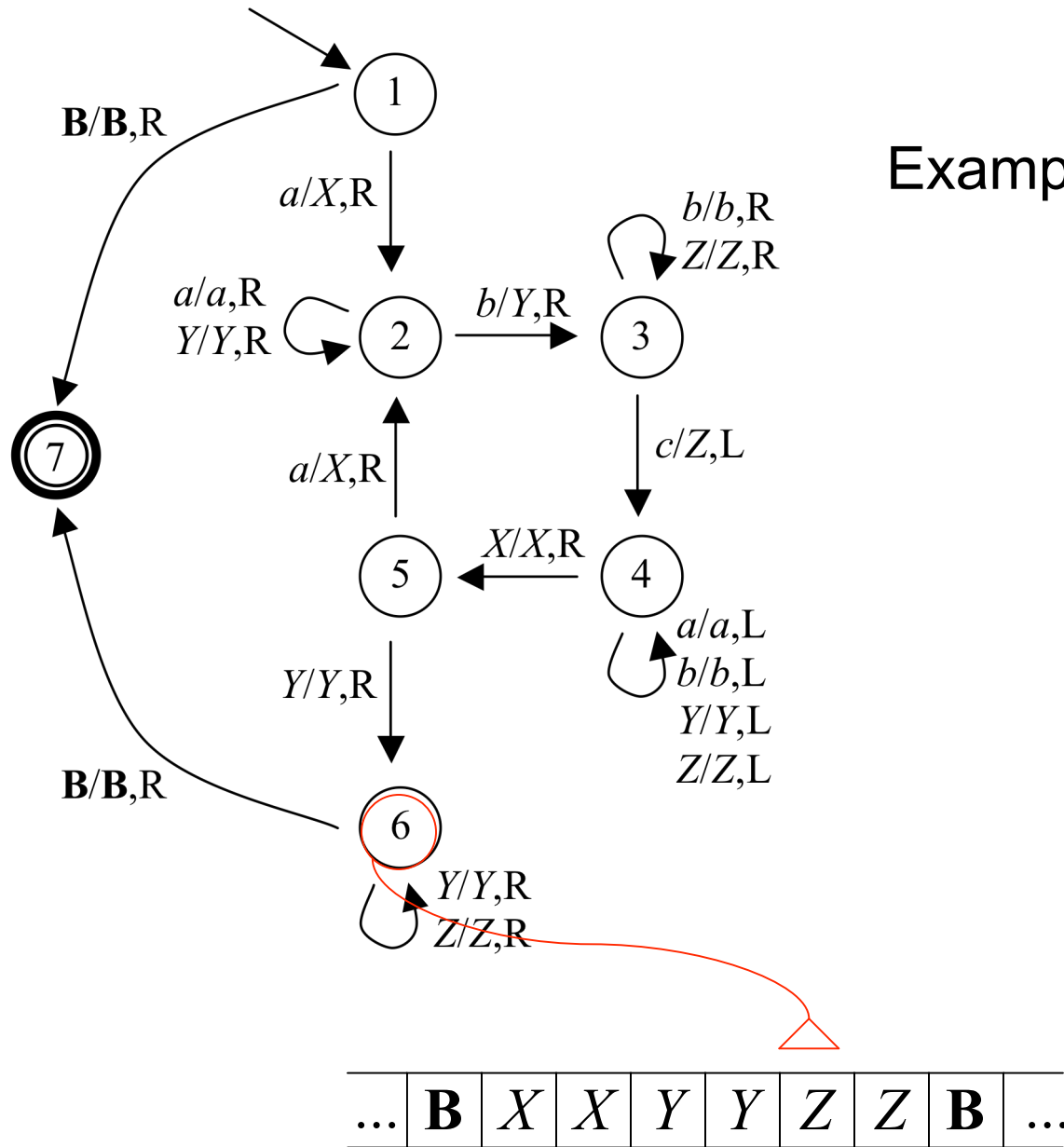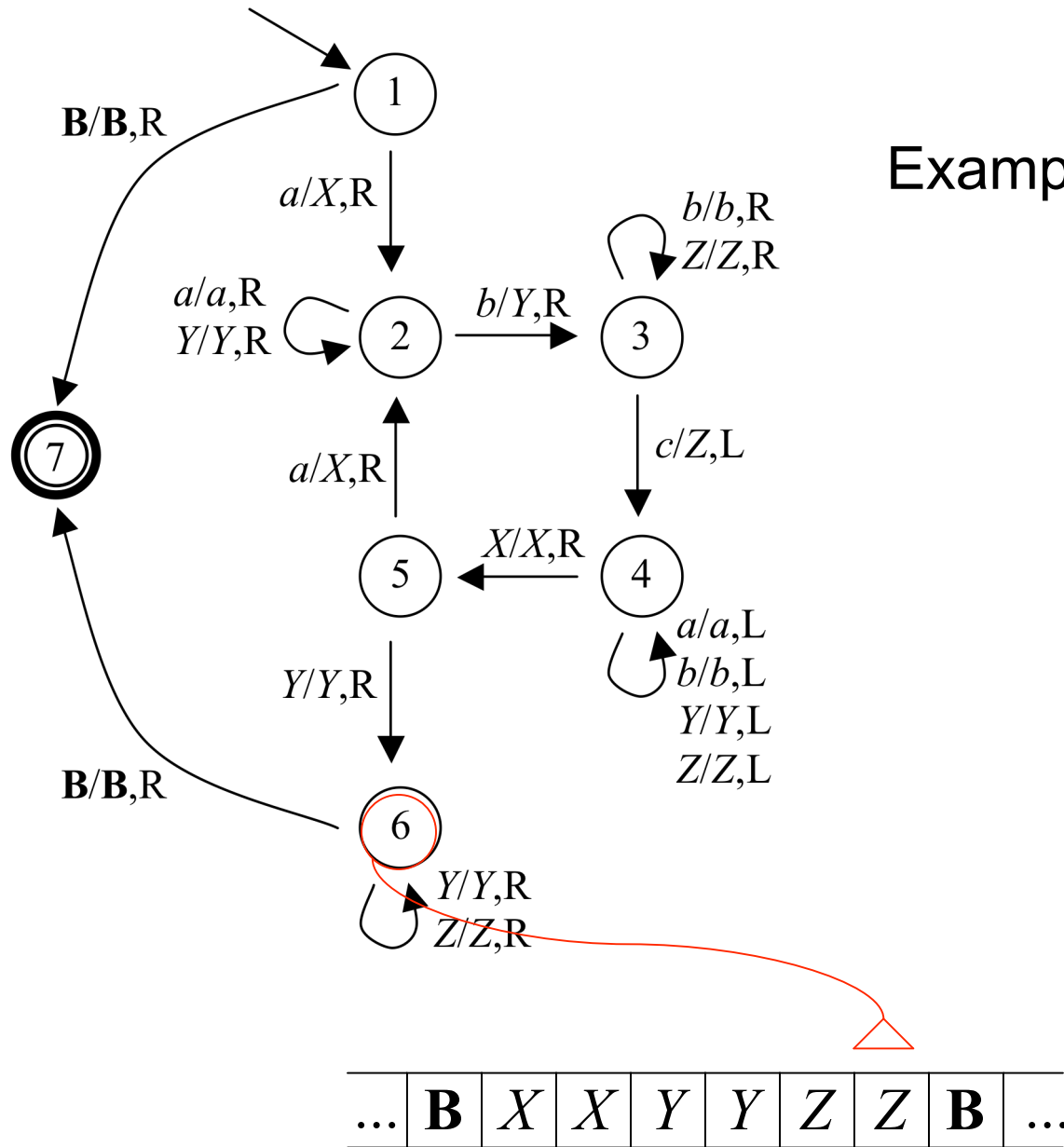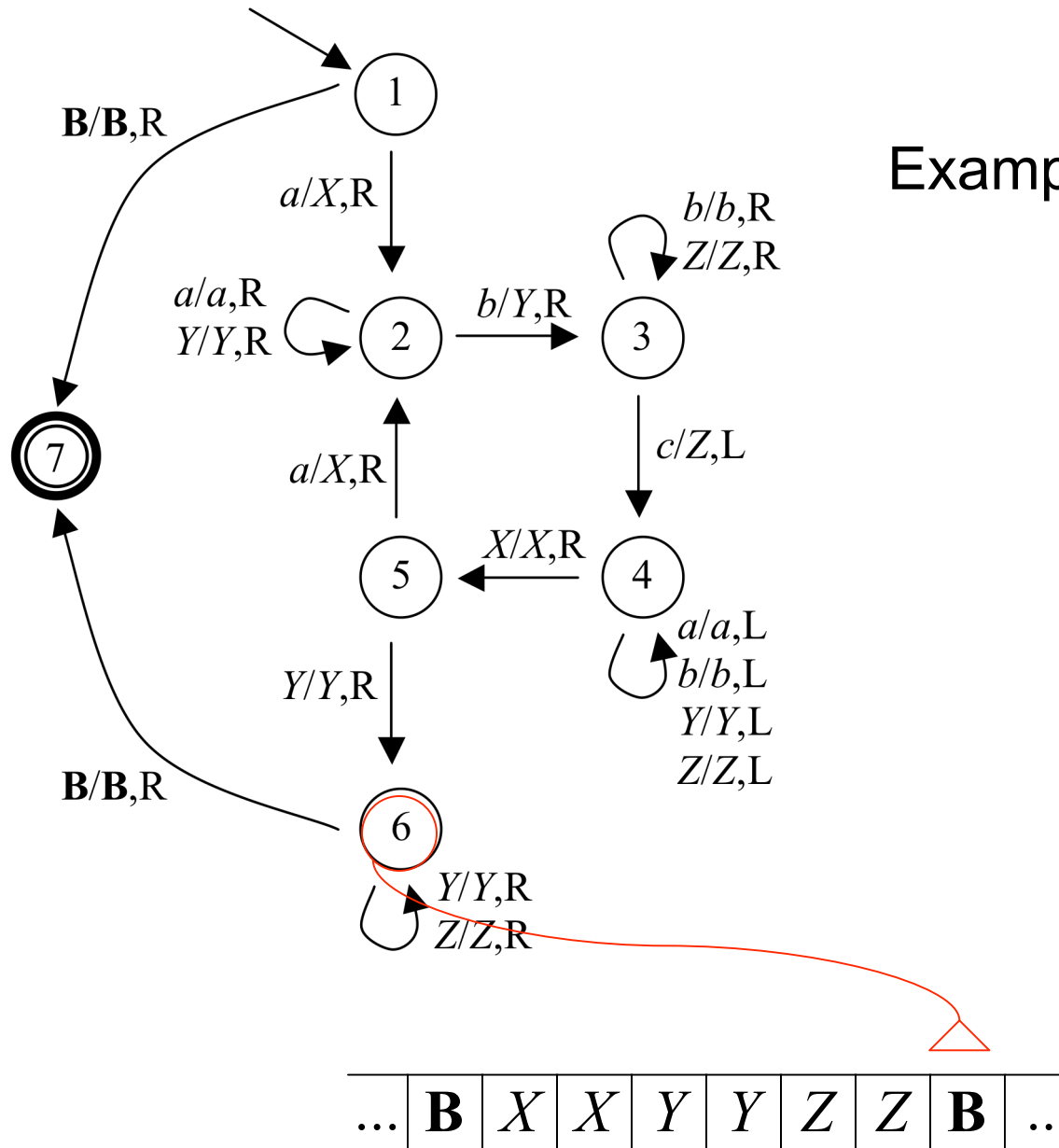Example: *aabbcc*

Example: *aabbcc*

Example: *aabbcc*

Example: *aabbcc*
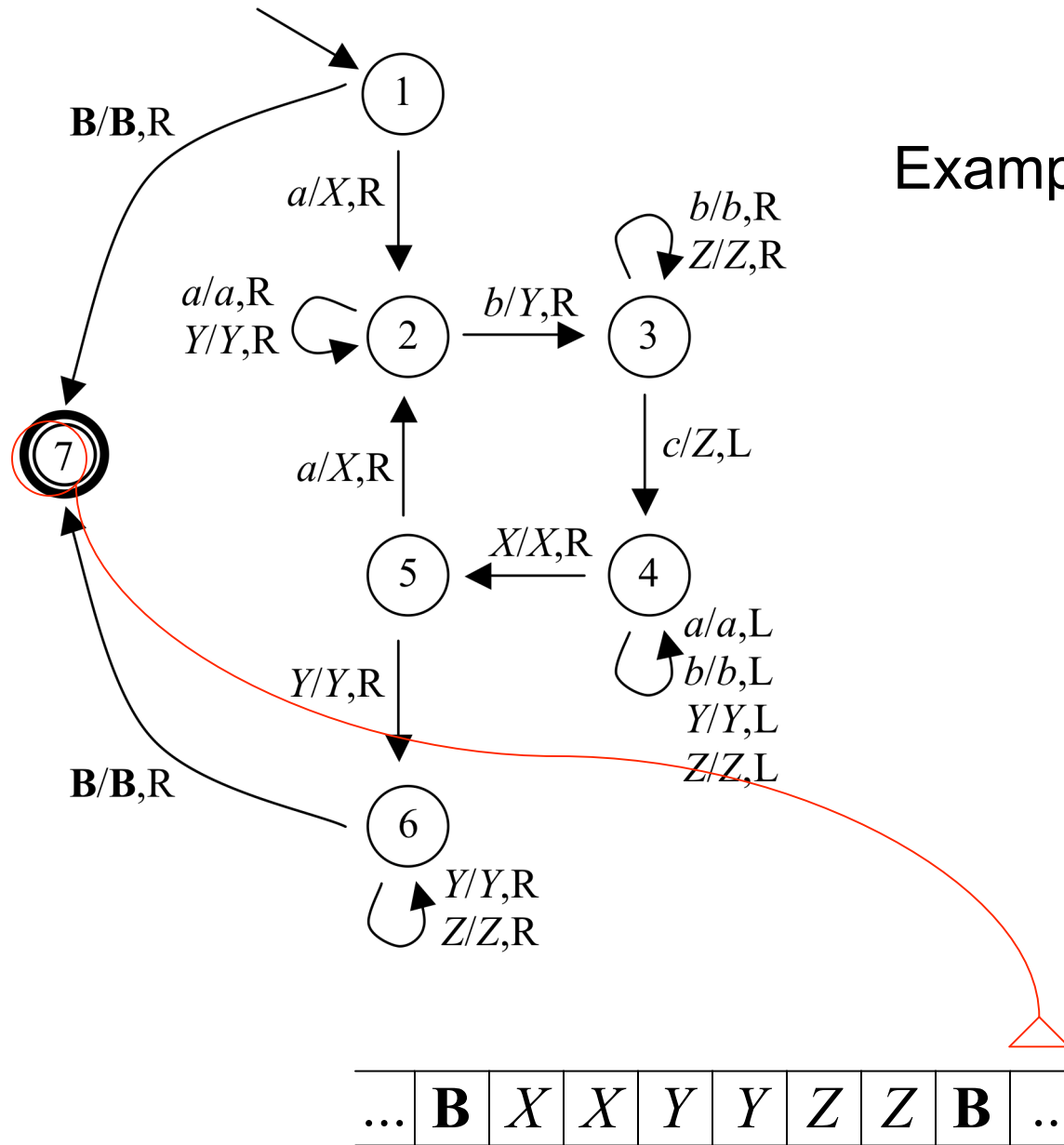
Example: *aabbcc*
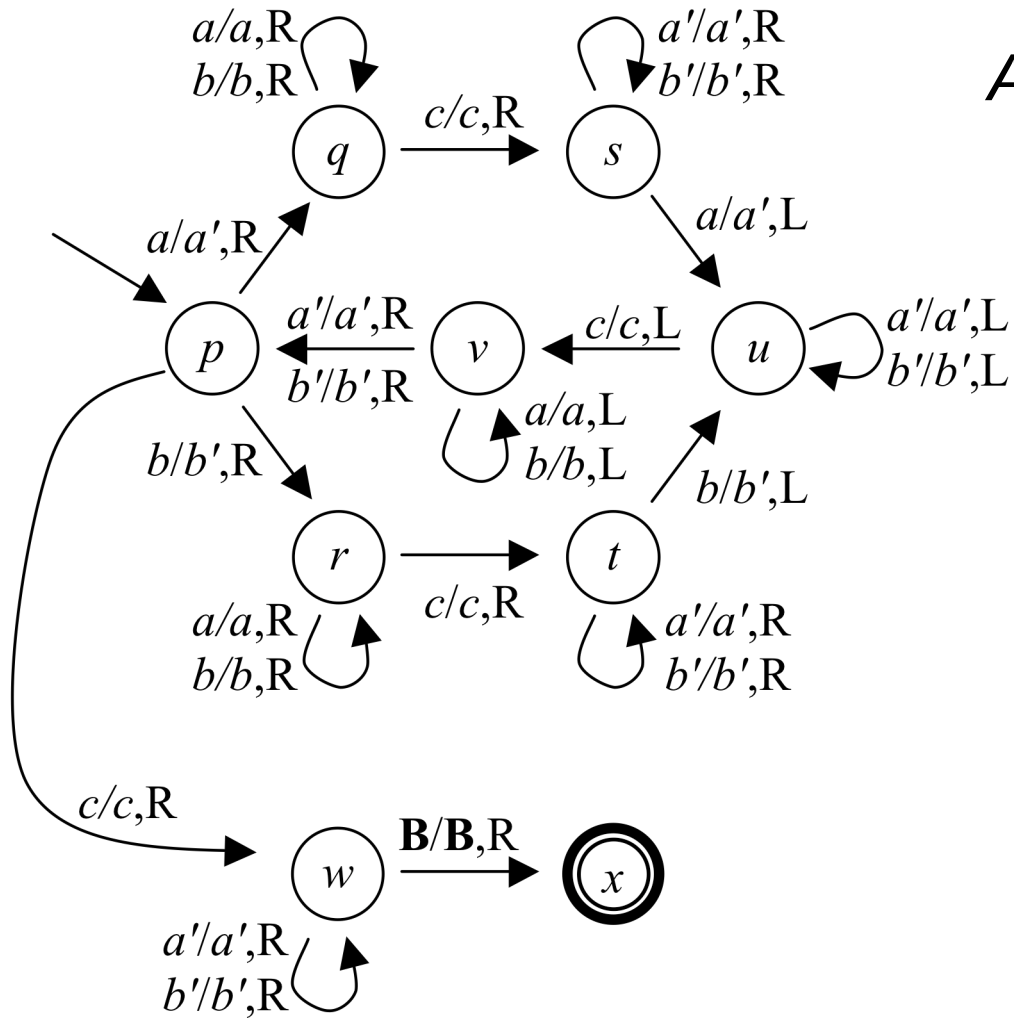
Example: *aabbcc*

Example: *aabbcc*

Example: *aabbcc*

Example: *aabbcc*

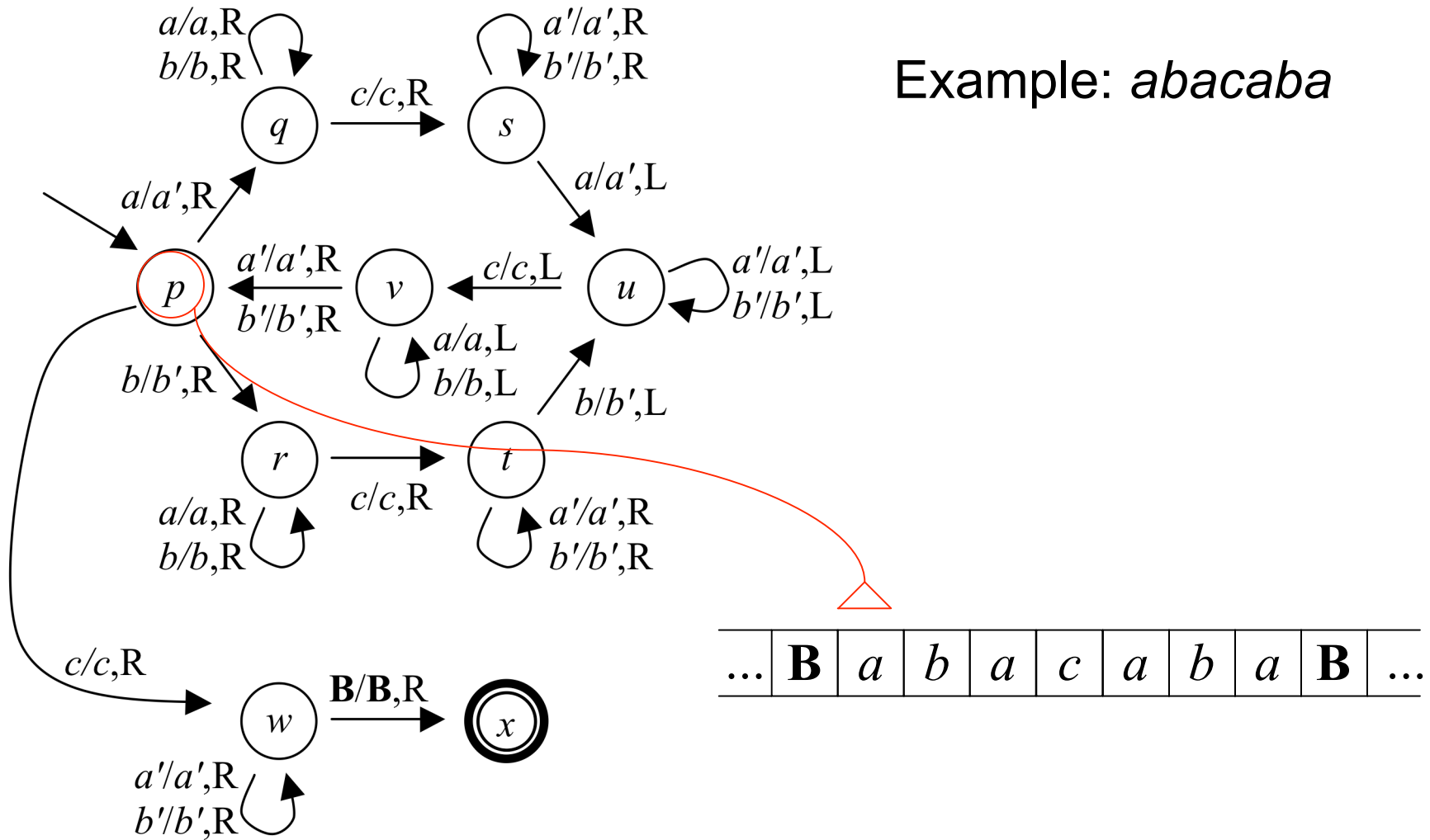# $\{xcx \mid x \in \{a,b\}^*\}$

- Not context-free, as we've seen
- A TM for this language can work by checking each symbol in the first x against the corresponding symbol in the second x
- To keep track of where it is, it will *mark* those symbols that have already been checked
- That is, it will overwrite them with marked versions of the same symbols, for instance by overwriting a with a'
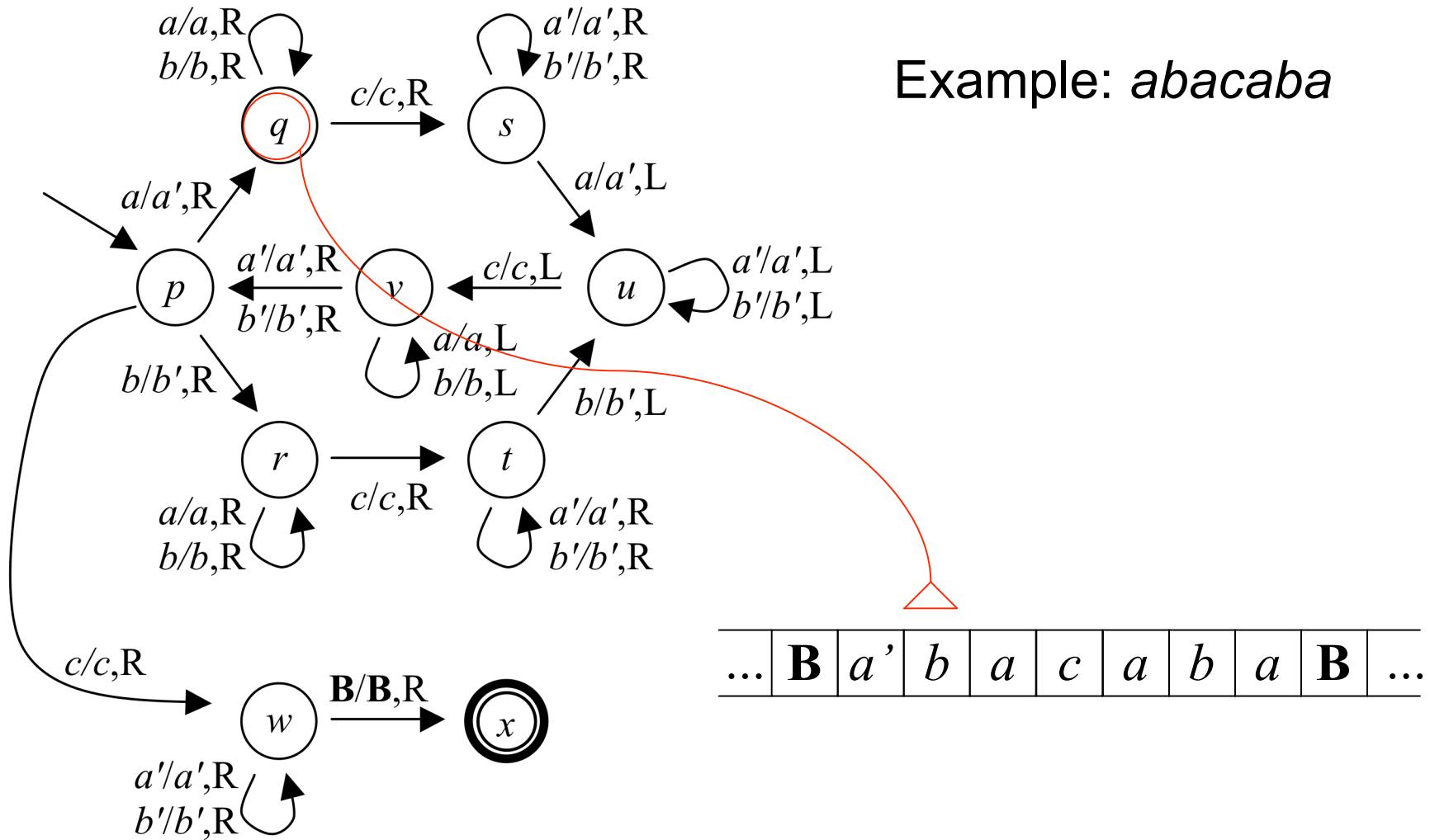
A TM For {xcx | x ∈ {a,b}*}

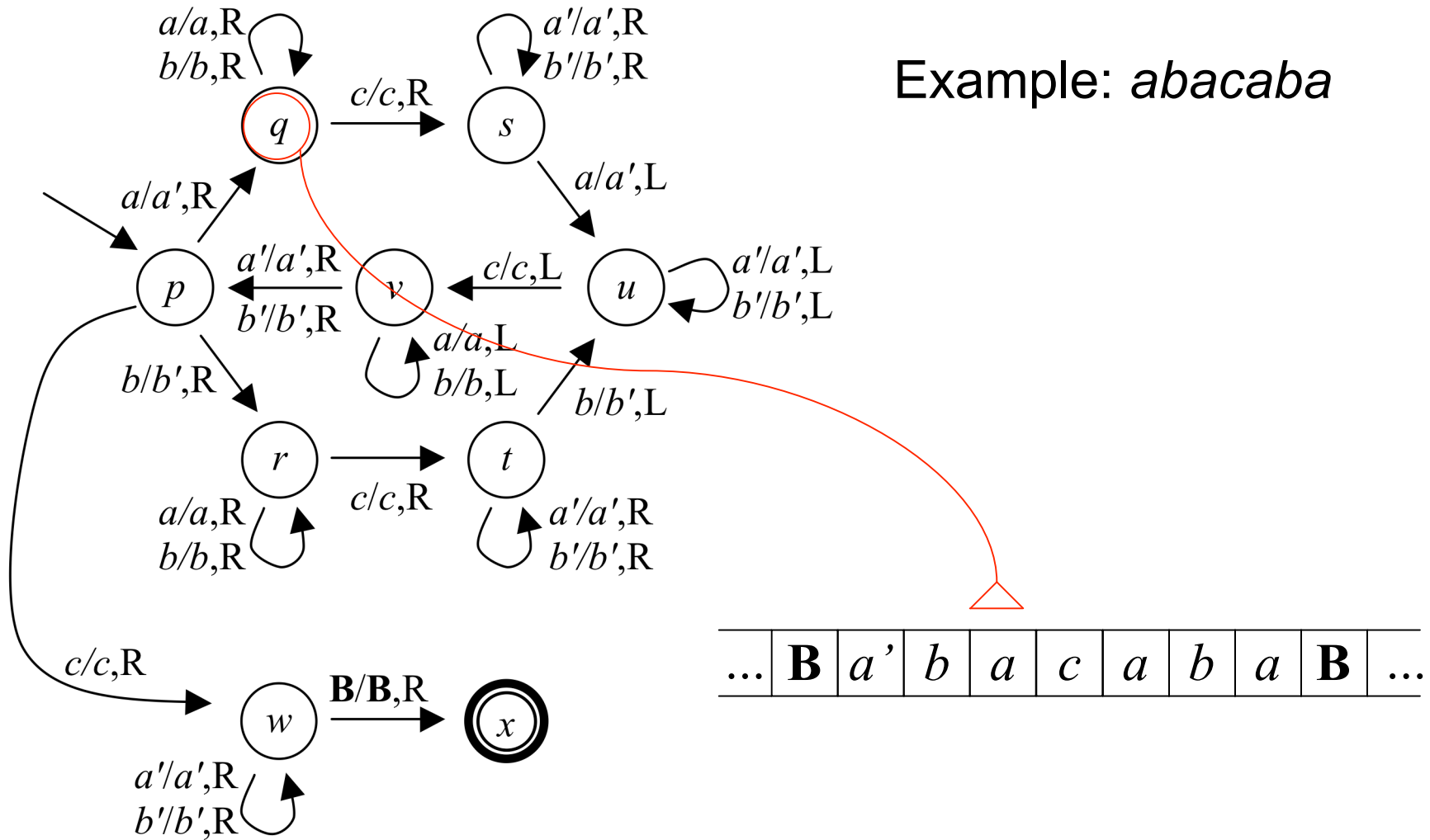Example: *abacaba*

Example: *abacaba*

Example: *abacaba*

Example: *abacaba*

Example: *abacaba*

Example: *abacaba*

a/a,R
b/b,R

a'/a',R
b'/b',R

q

c/c,R

s

a/a',R

a/a',L

p

a'/a',R
b'/b',R

v

c/c,L

u

a'/a',L
b'/b',L

a/a,L
b/b,L

b/b',R

b/b',L

r

c/c,R

t

a/a,R
b/b,R

a'/a',R
b'/b',R

c/c,R

w

$\mathbf{B}/\mathbf{B}$,R

x

a'/a',R
b'/b',R
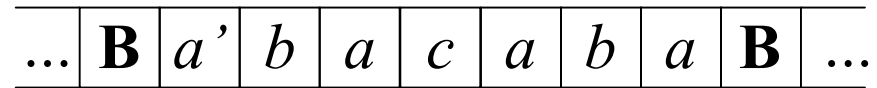
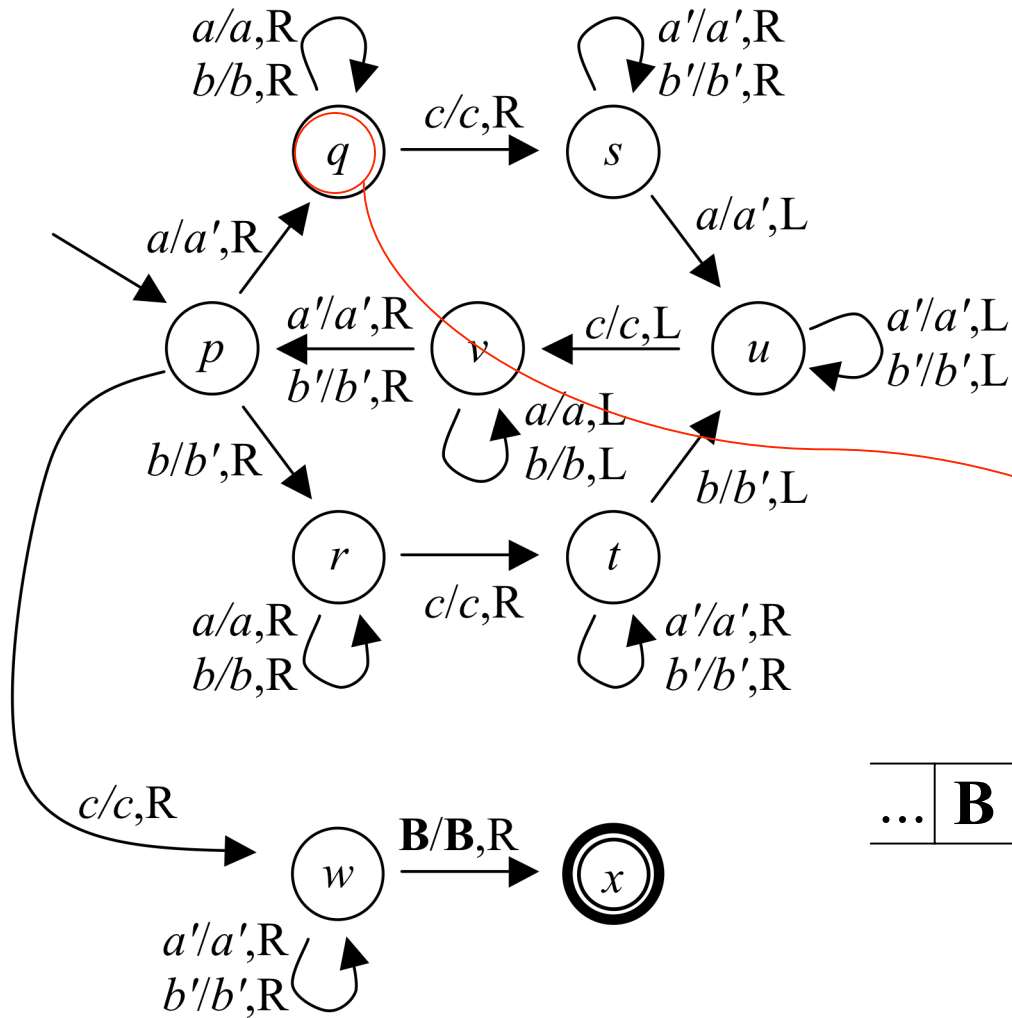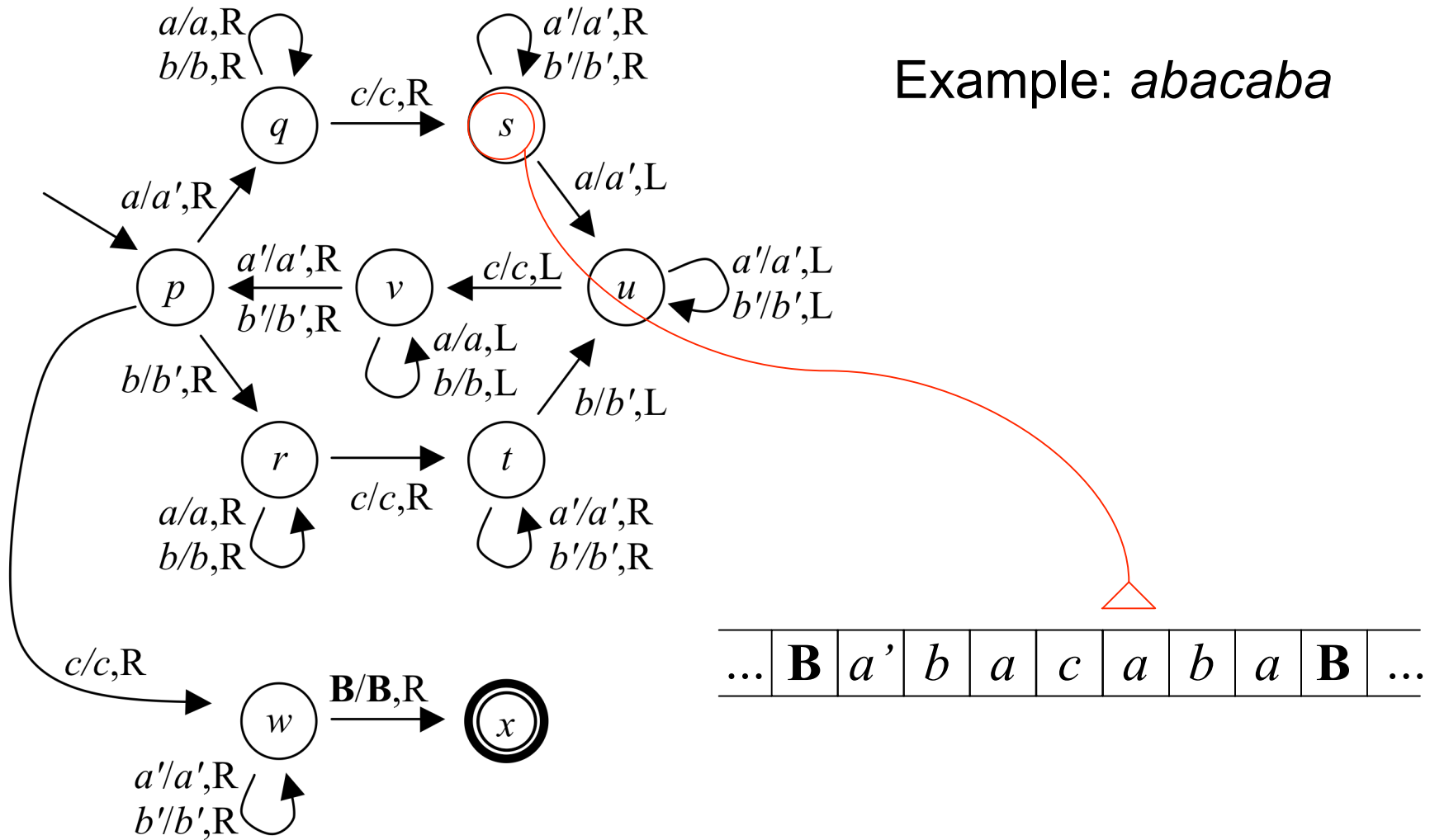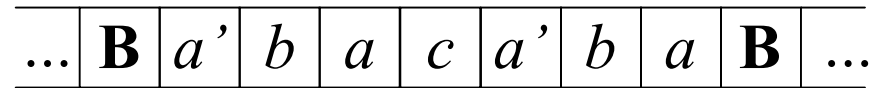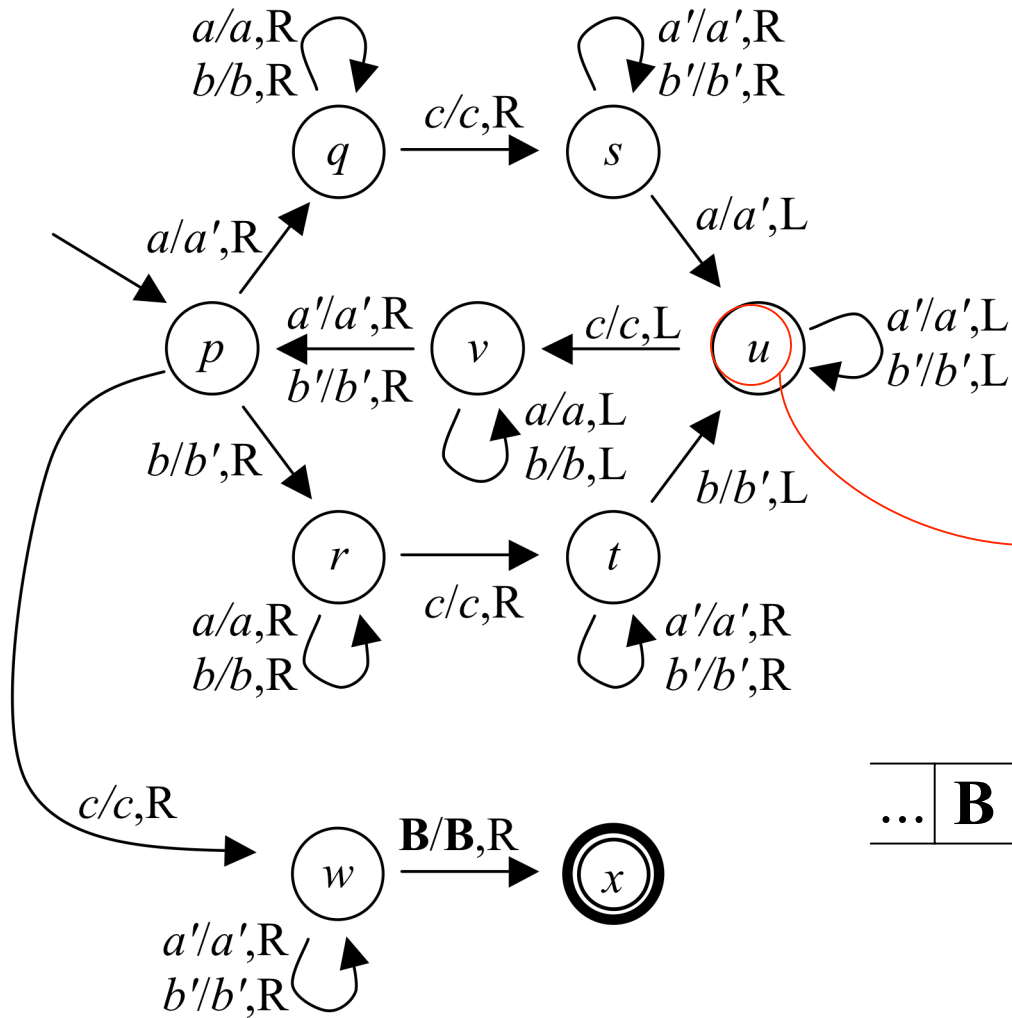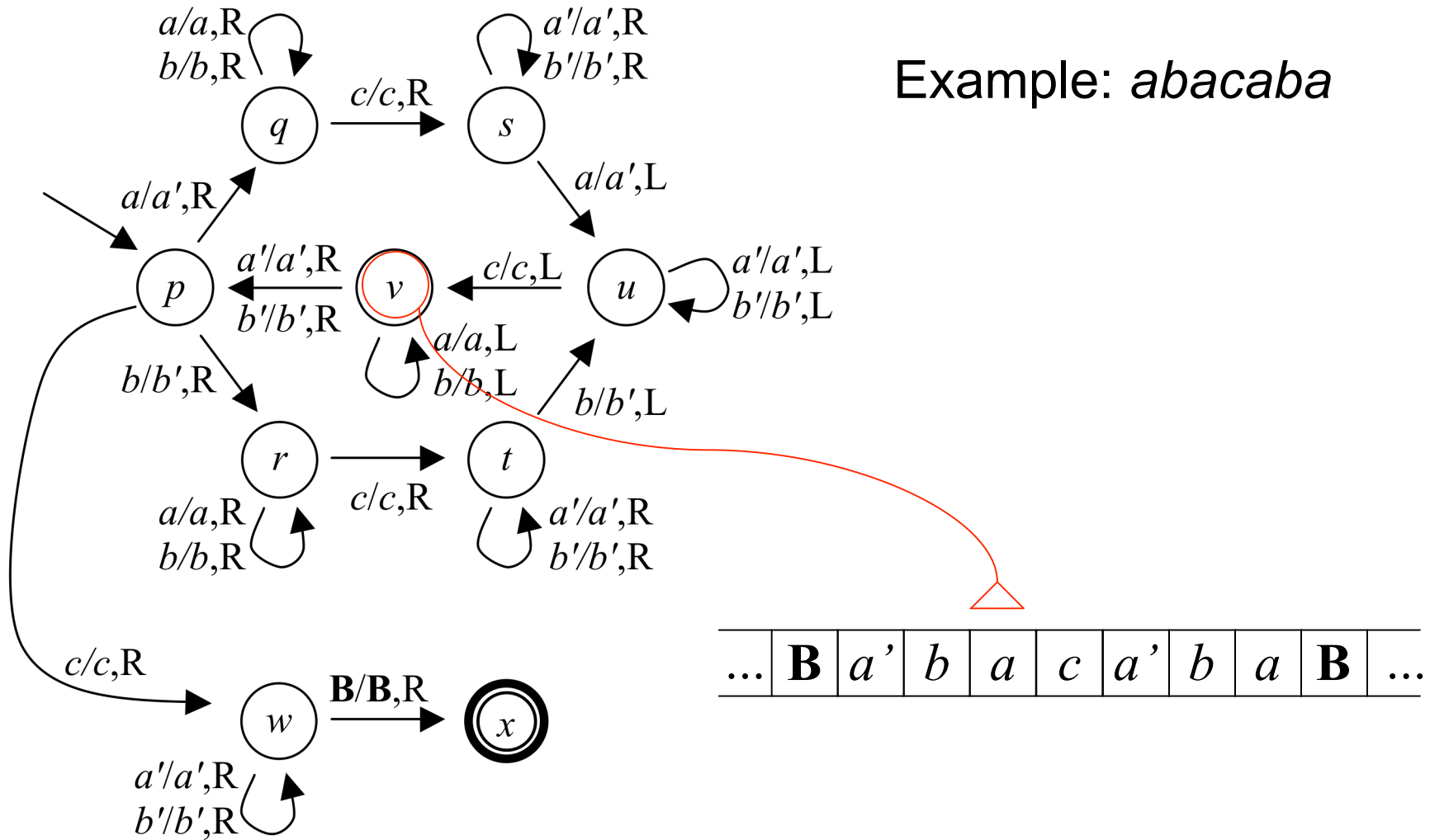| ... | $\mathbf{B}$ | a' | b | a | c | a' | b | a | $\mathbf{B}$ | ... |

Example: *abacaba*

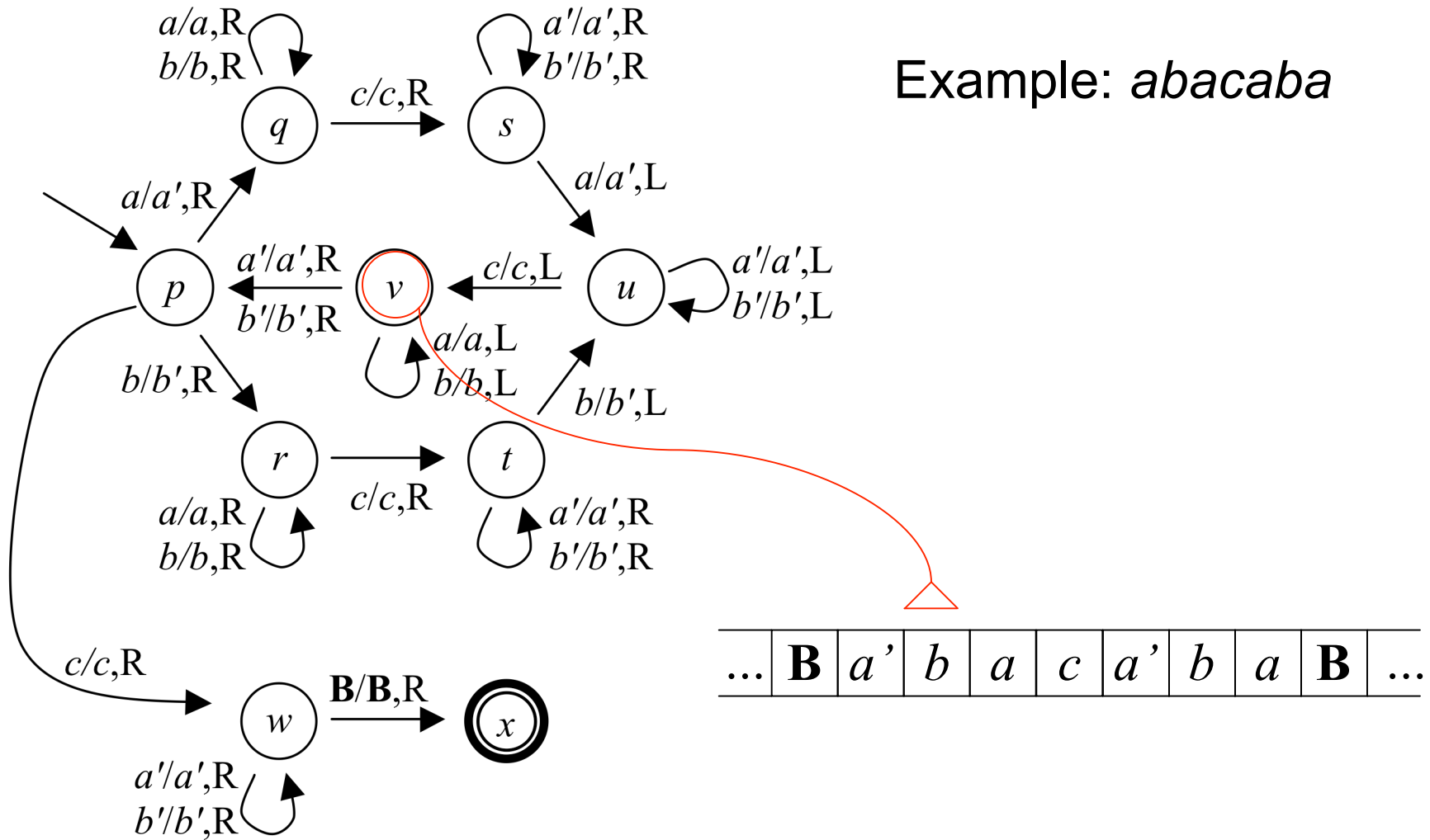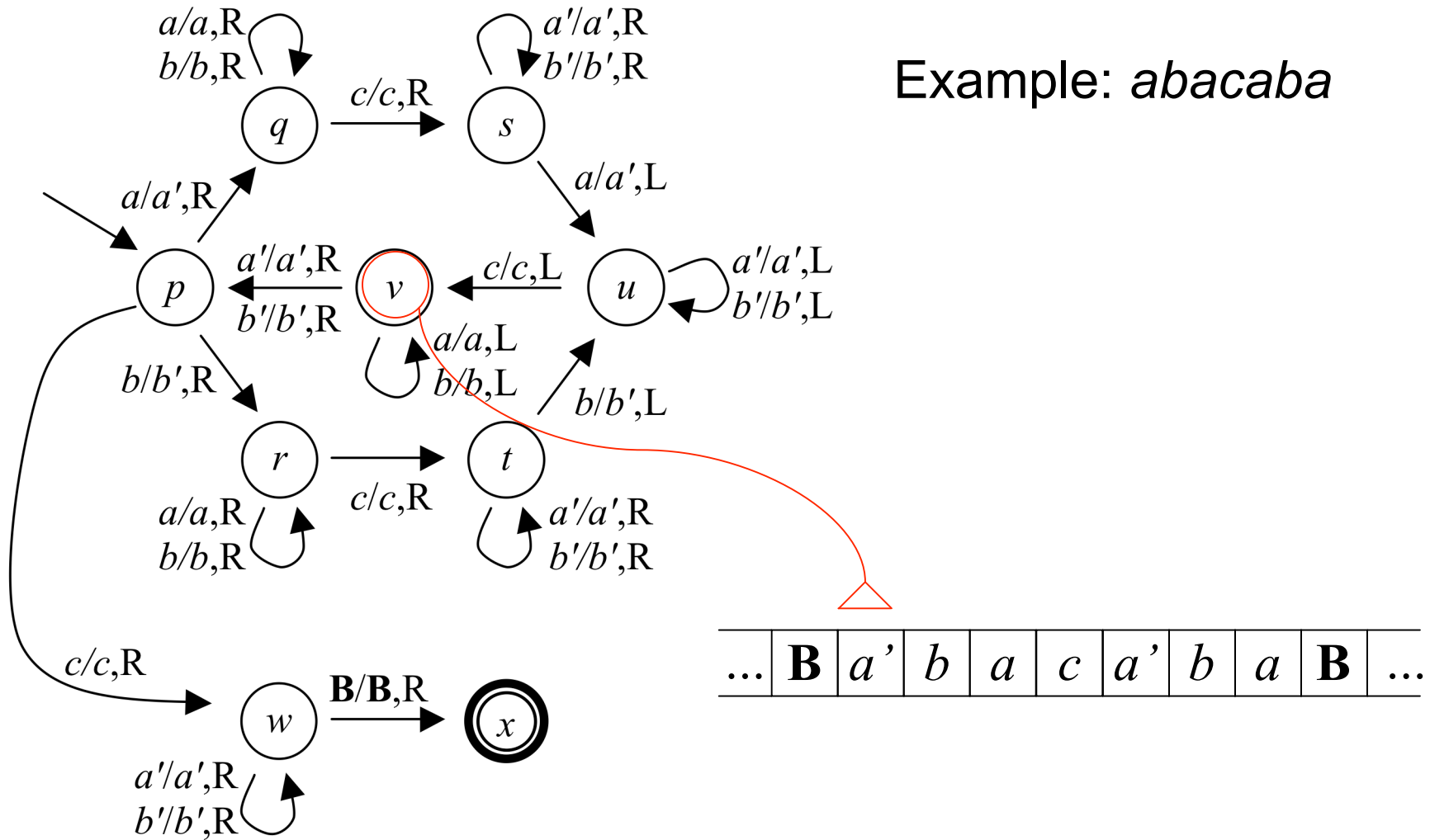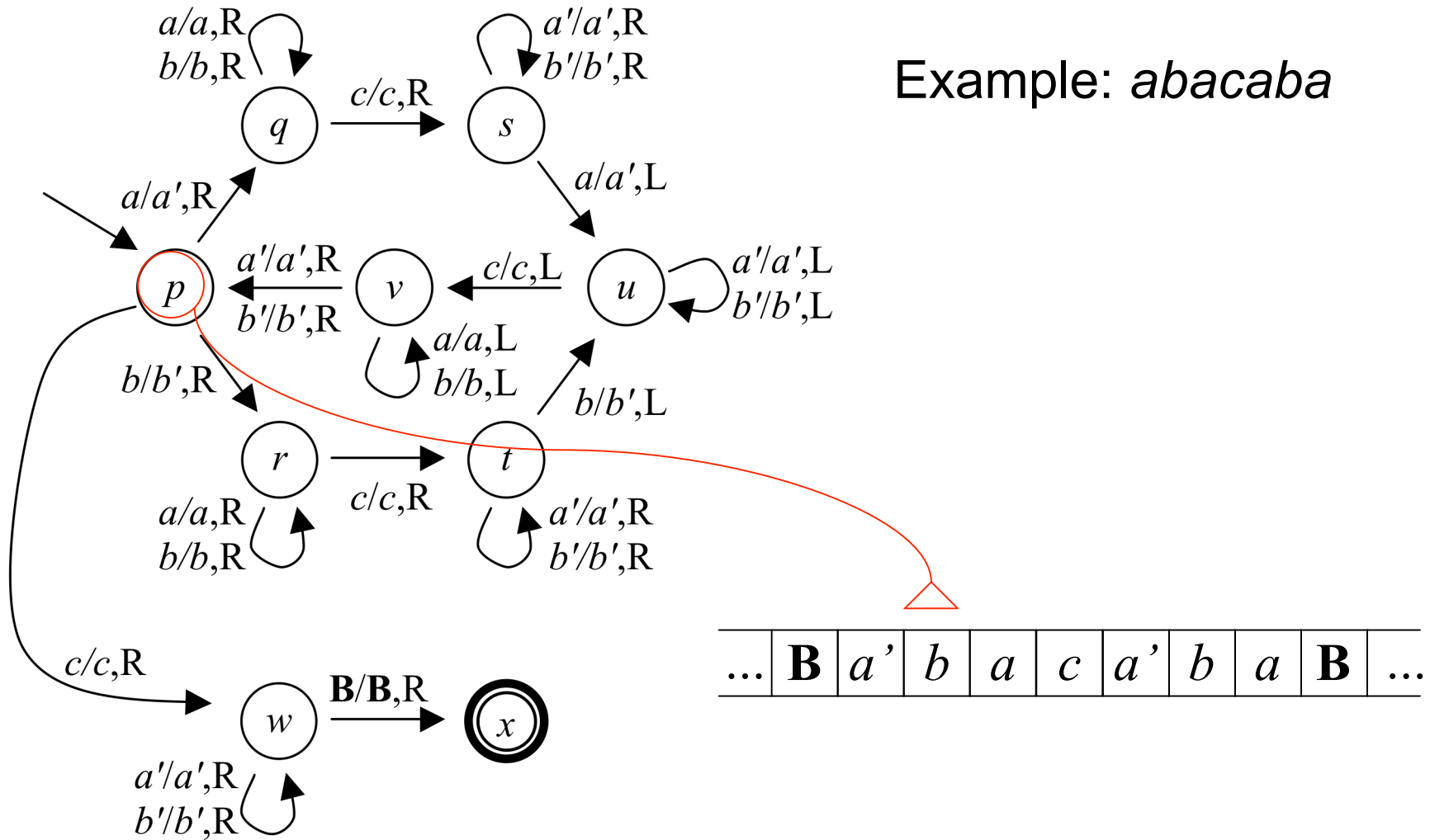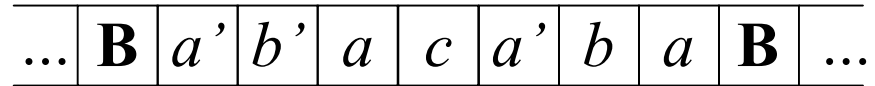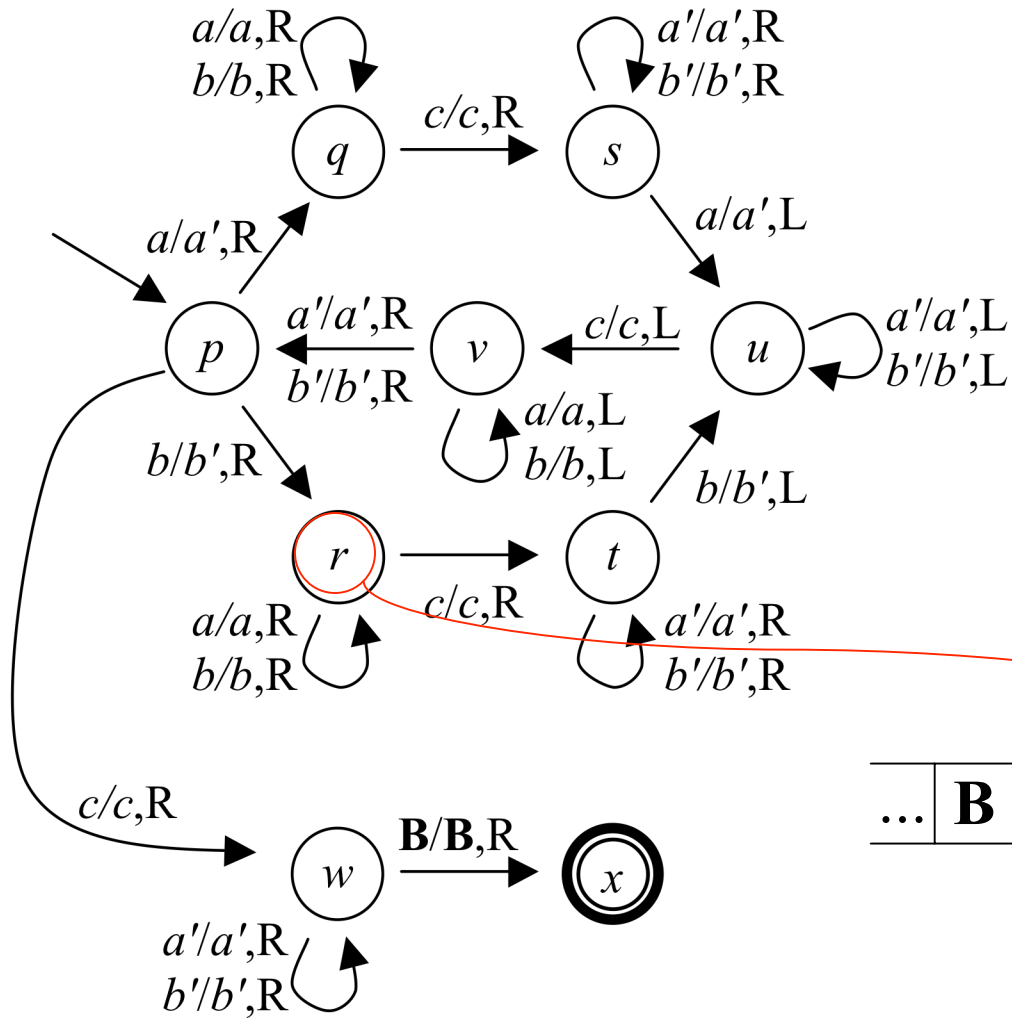Example: *abacaba*

Example: *abacaba*

Example: *abacaba*

Example: *abacaba*

Example: *abacaba*

Example: *abacaba*

Example: *abacaba*

a/a,R
b/b,R

a'/a',R
b'/b',R

q

c/c,R

s

a/a',R

a/a',L

p

a'/a',R
b'/b',R

v

c/c,L

u

a'/a',L
b'/b',L

a/a,L
b/b,L

b/b',R

r

b/b',L

t

a/a,R
b/b,R

c/c,R

a'/a',R
b'/b',R

c/c,R

w

B/B,R

x

a'/a',R
b'/b',R

... | **B** | a' | b' | a | c | a' | b | a | **B** | ...

Example: *abacaba*

a/a,R
b/b,R

q

c/c,R

a'/a',R
b'/b',R

s

a/a',L

a/a',R

p

a'/a',R
b'/b',R

v

c/c,L

u

a'/a',L
b'/b',L

b/b',R

a/a,L
b/b,L

b/b',L

r

c/c,R

t

a'/a',R
b'/b',R

a/a,R
b/b,R

c/c,R

w

B/B,R

x
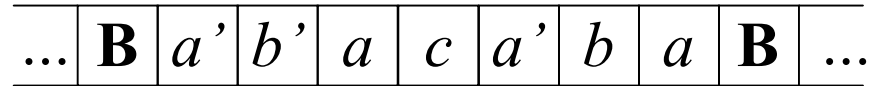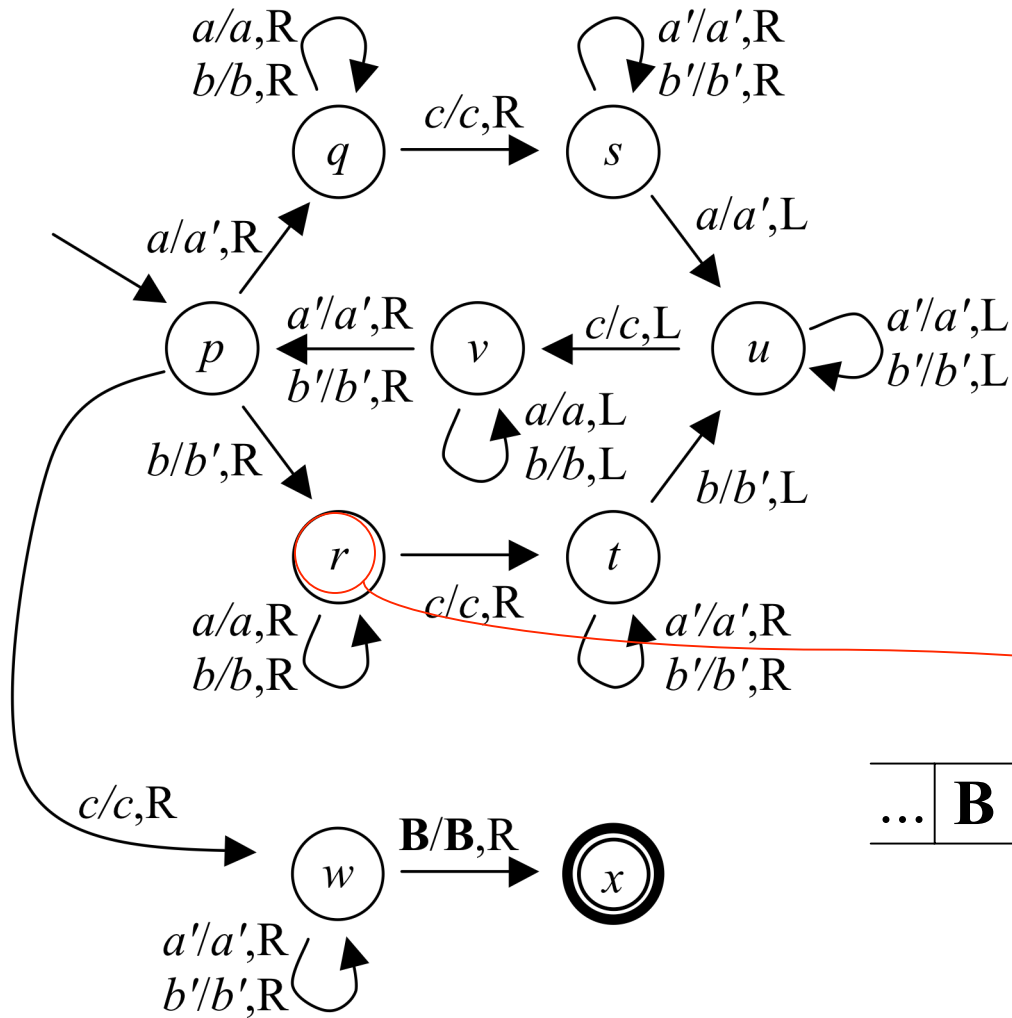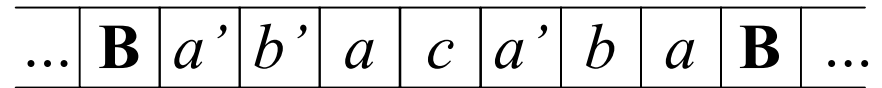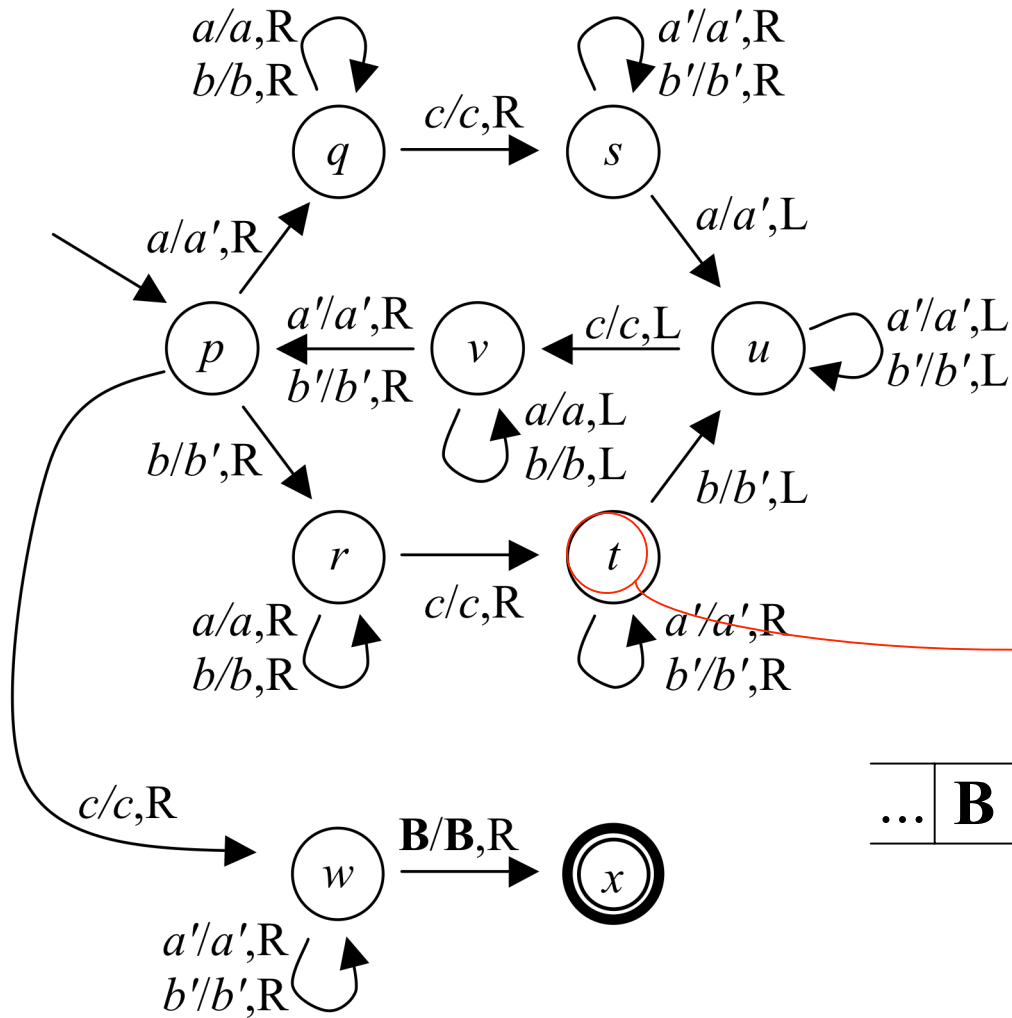
a'/a',R
b'/b',R

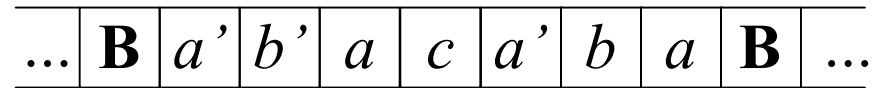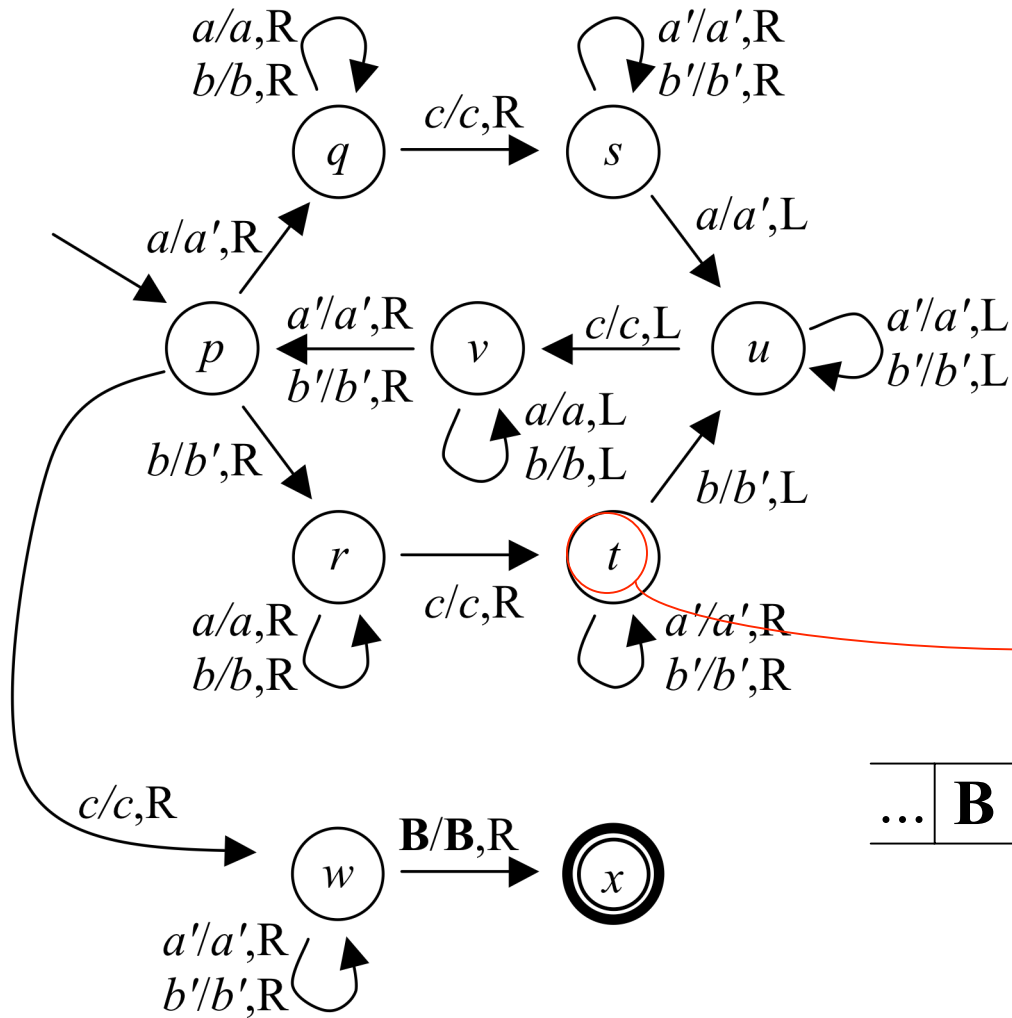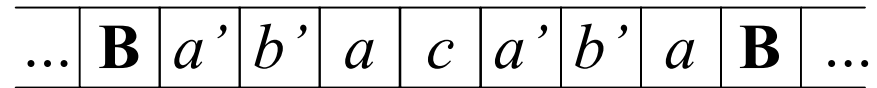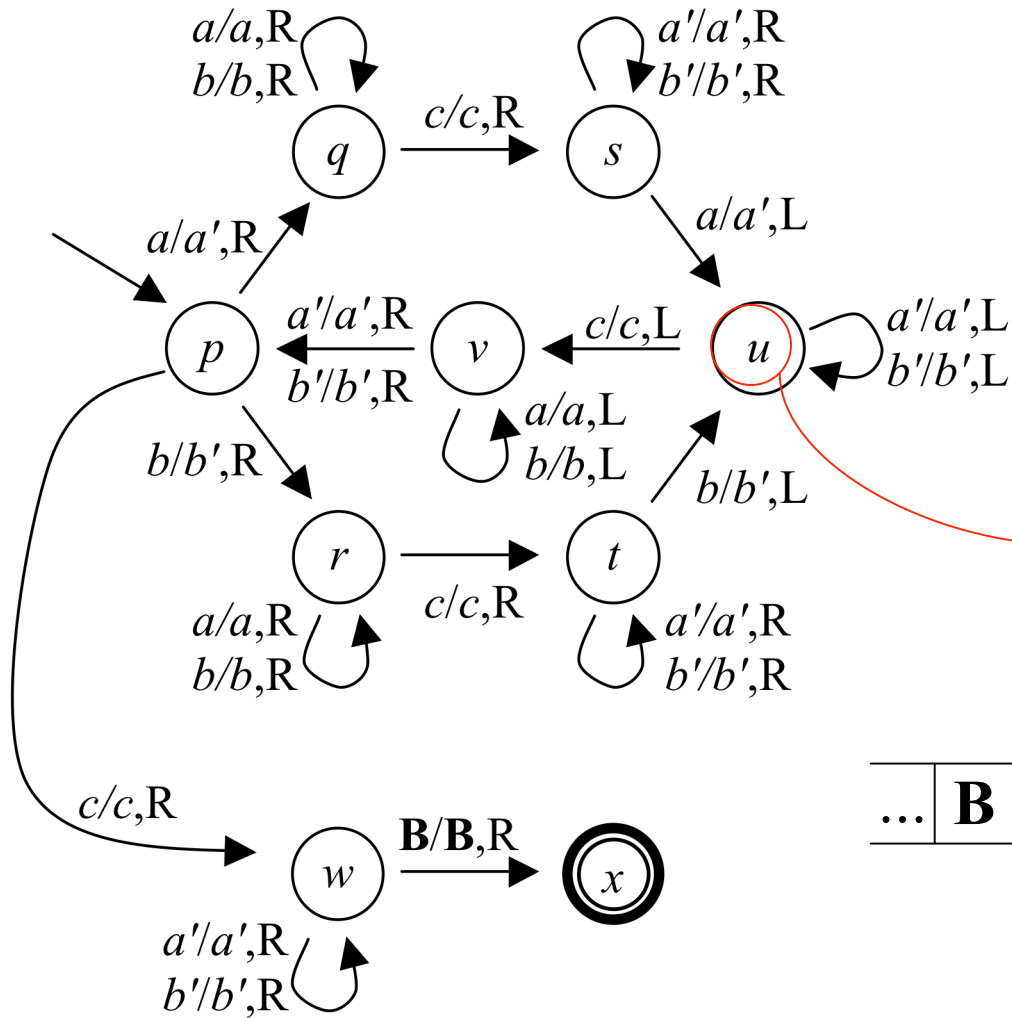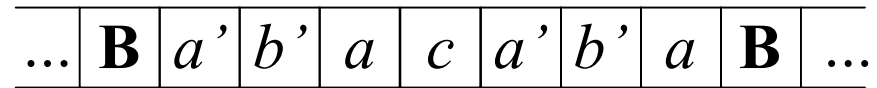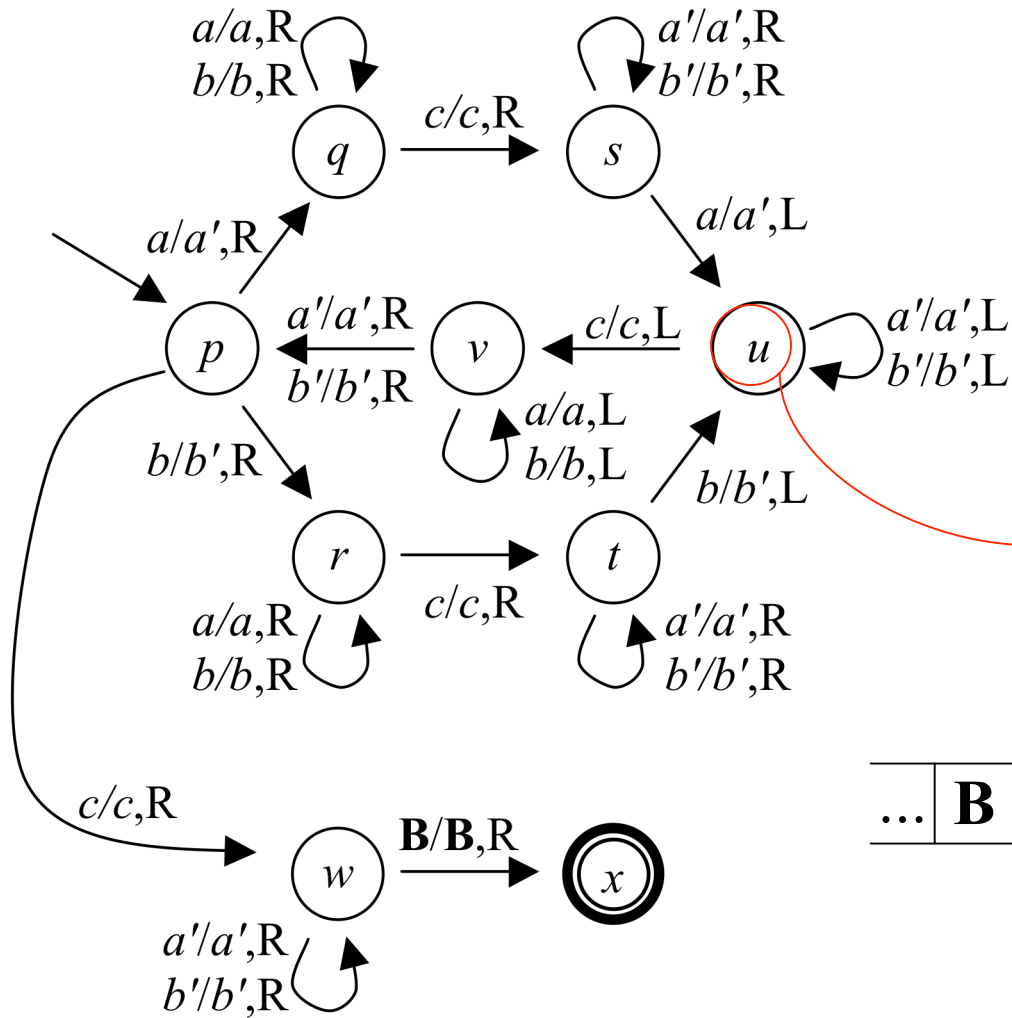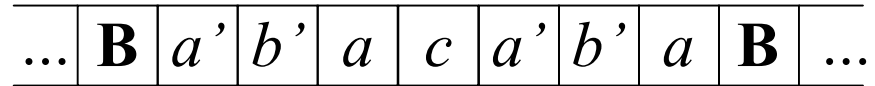| ... | **B** | *a'* | *b'* | *a* | *c* | *a'* | *b'* | *a* | **B** | ... |

Example: *abacaba*

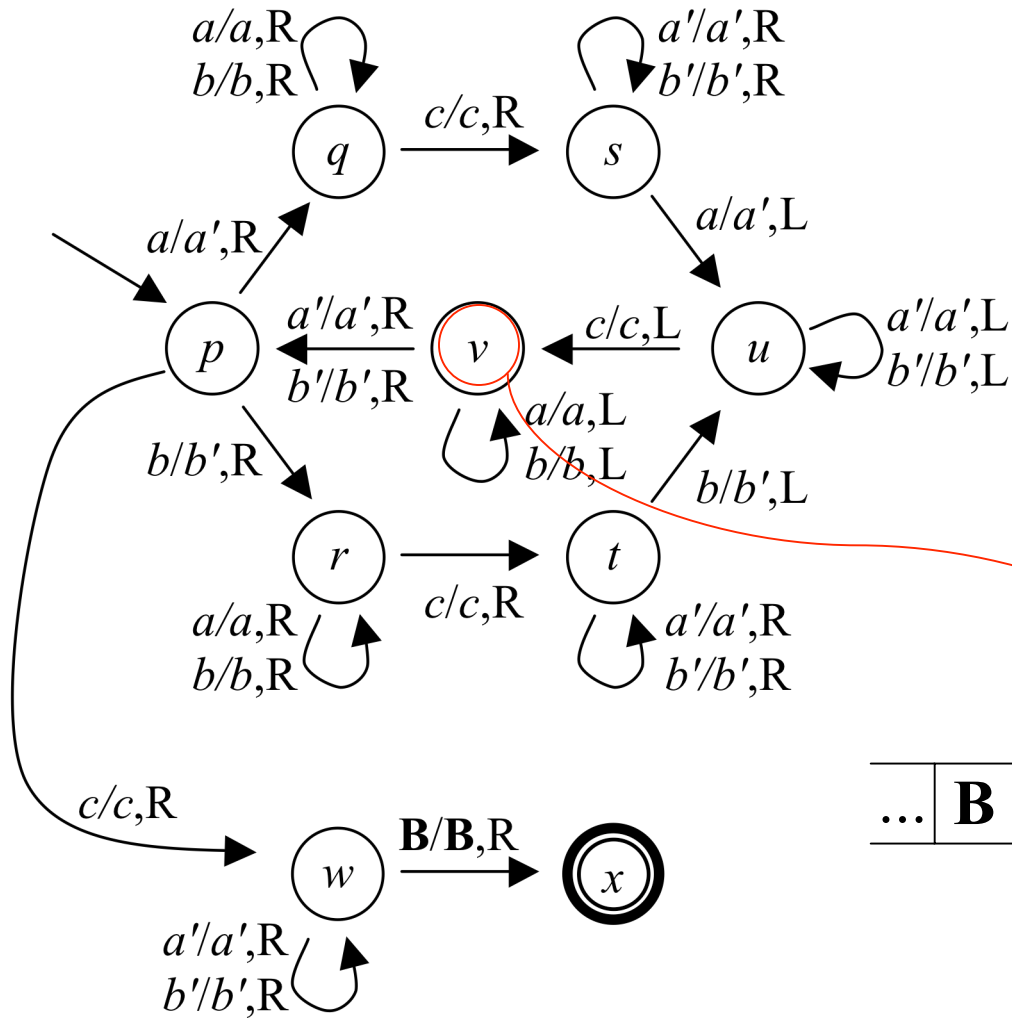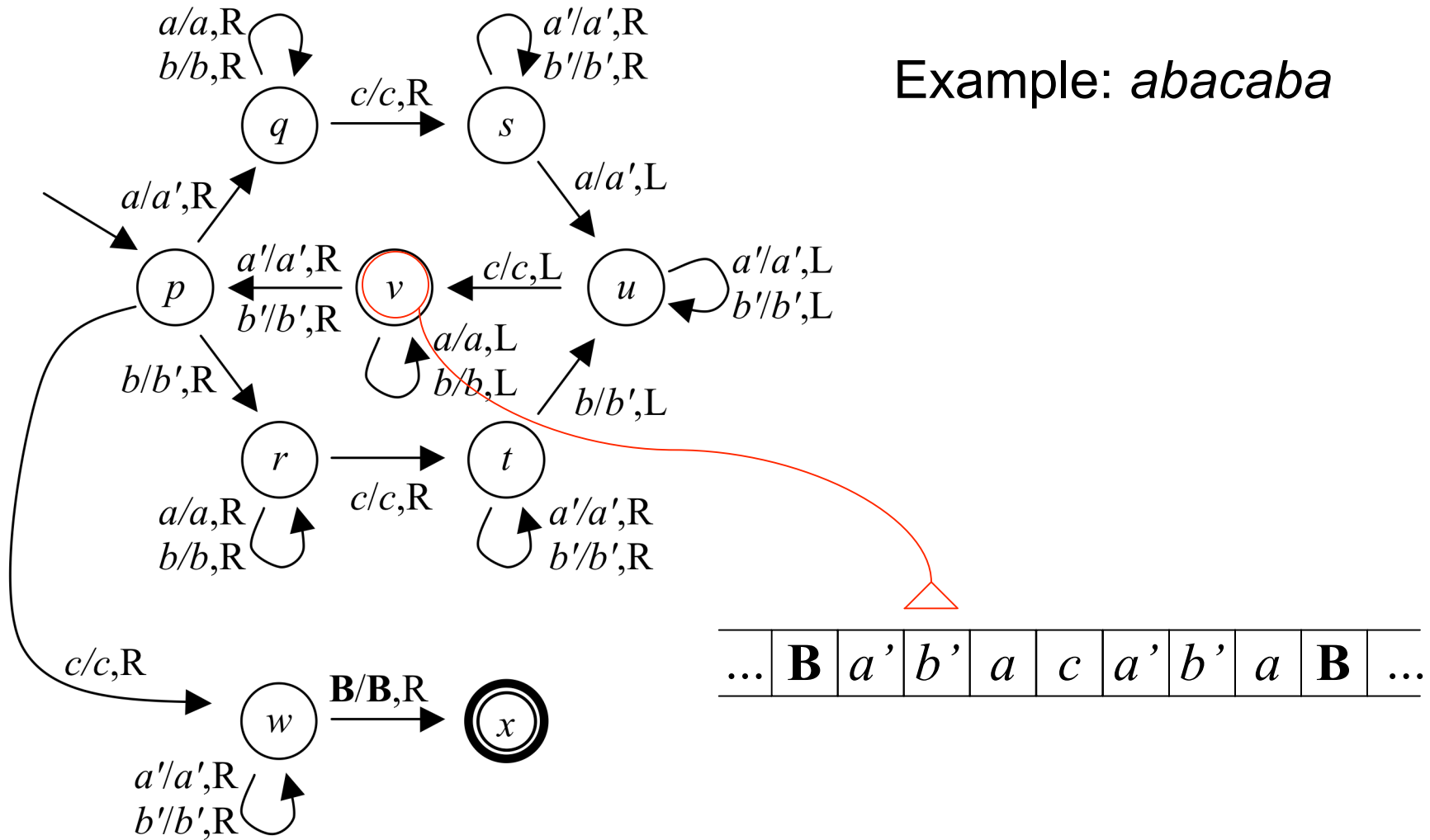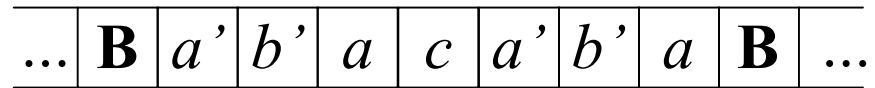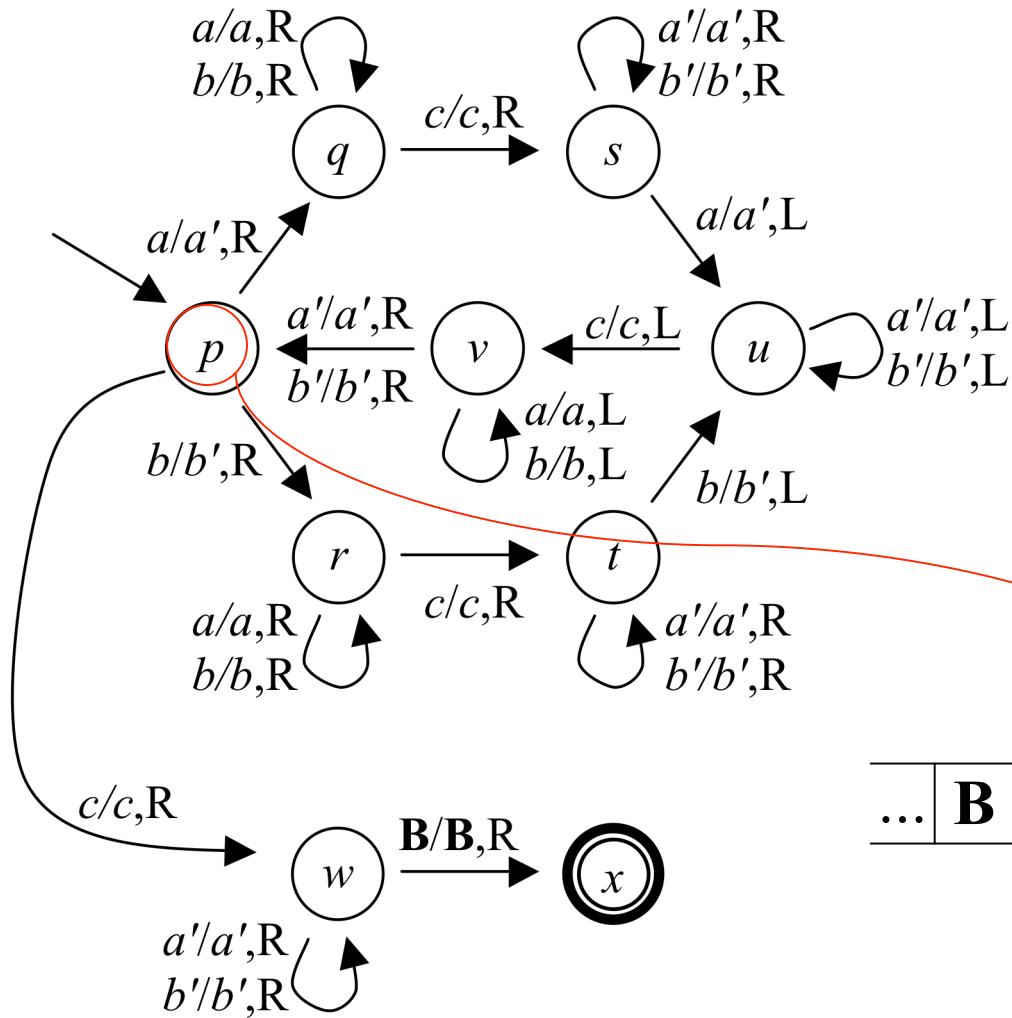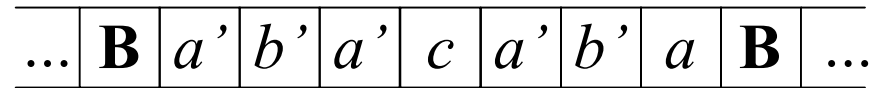Example: *abacaba*

Example: *abacaba*

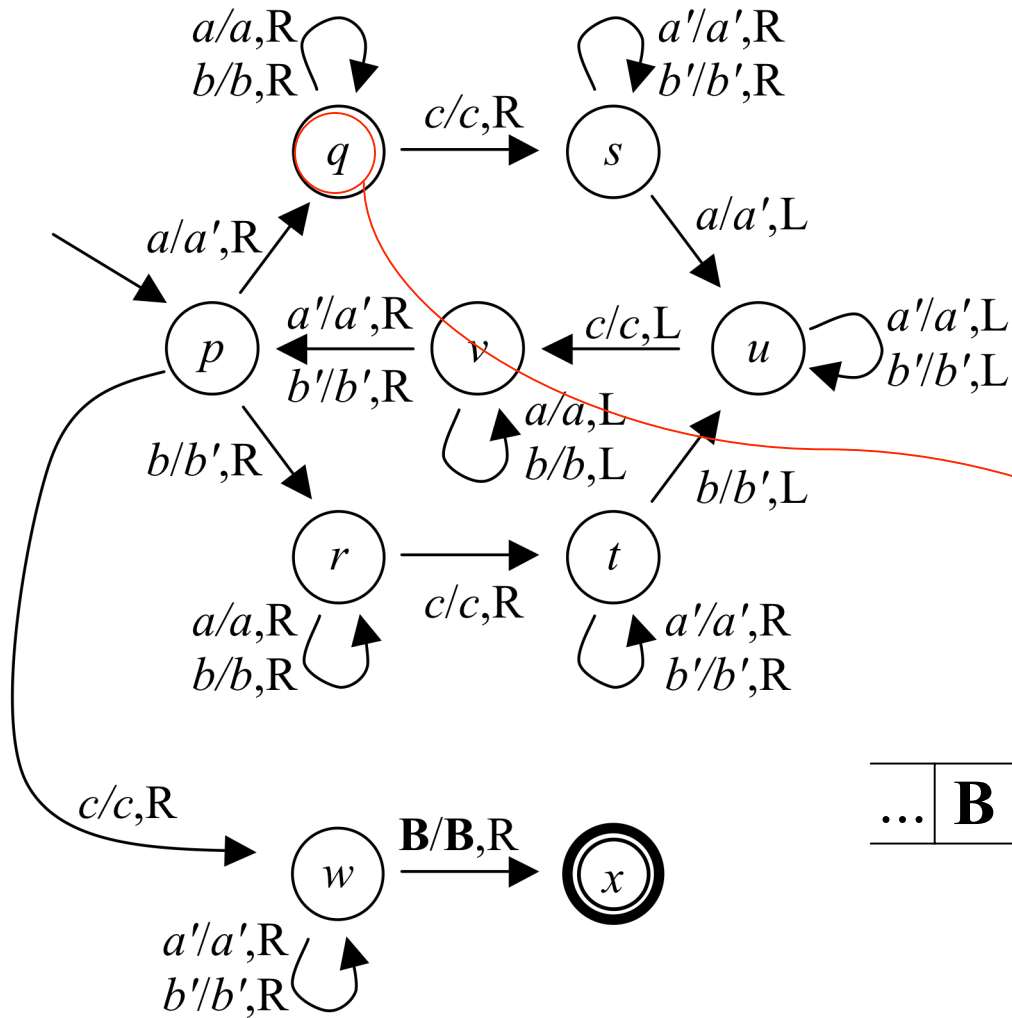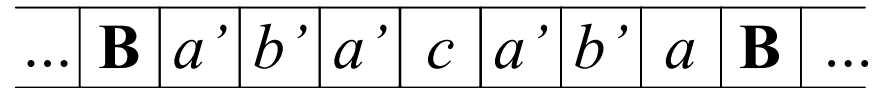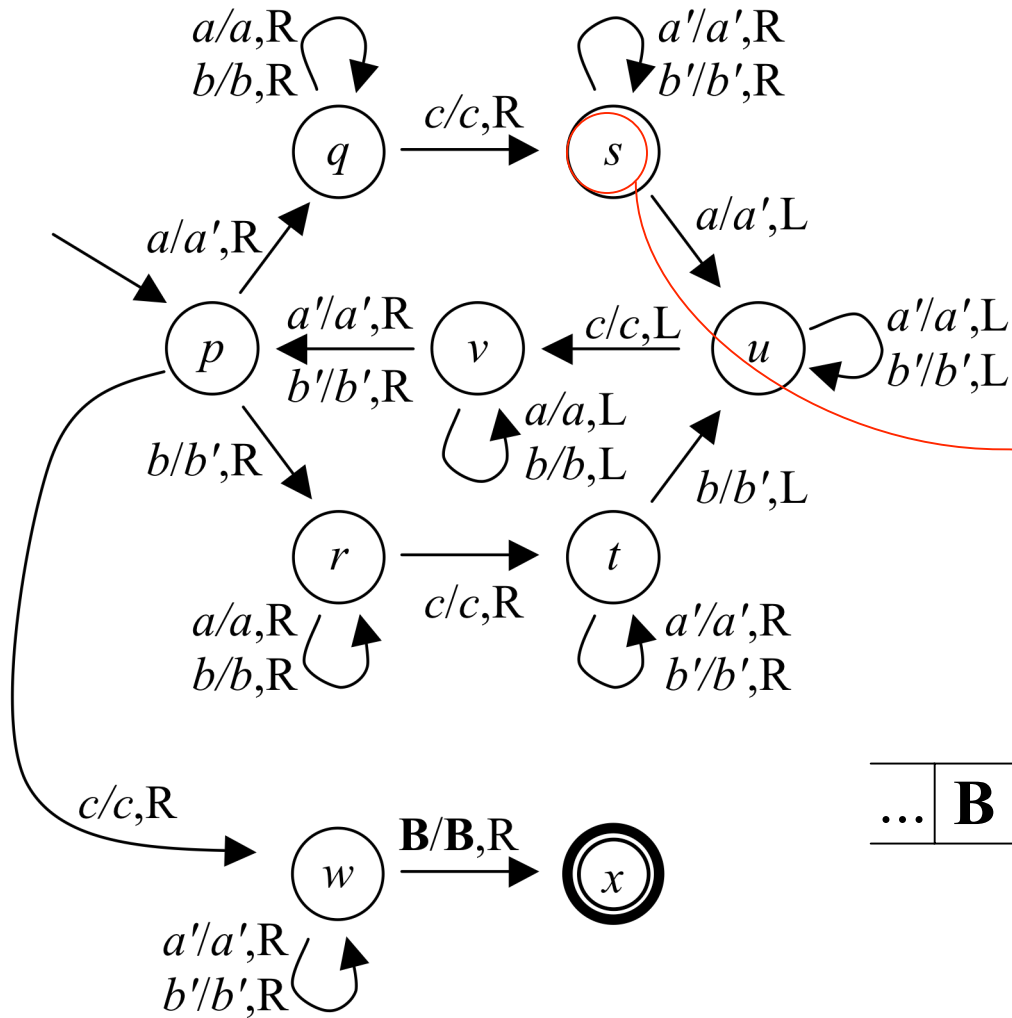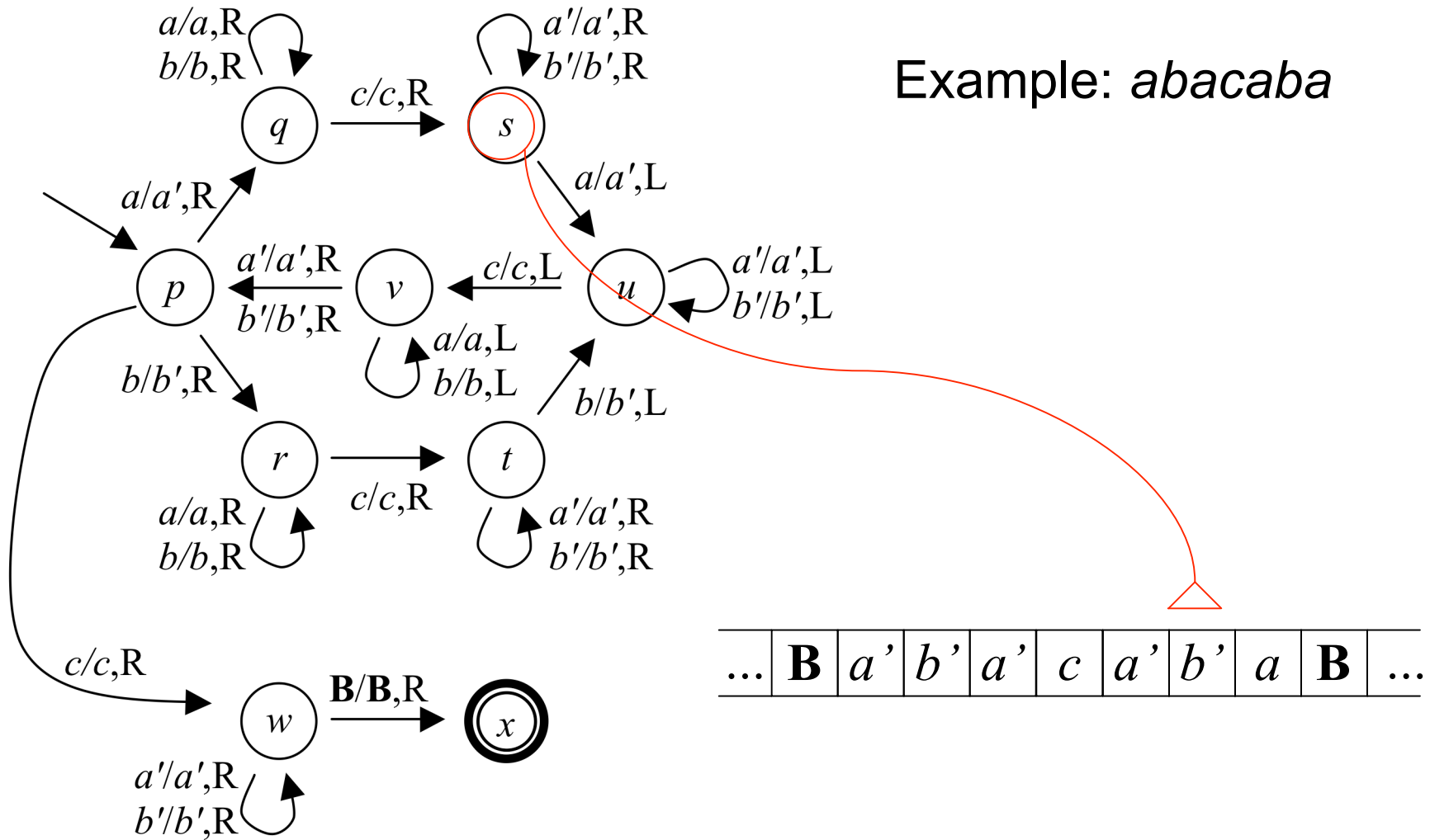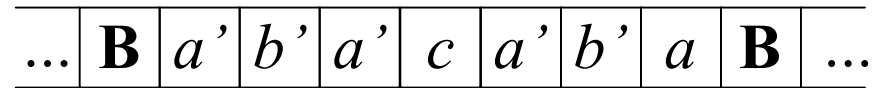Example: *abacaba*

Example: *abacaba*

Example: *abacaba*

a/a,R
b/b,R
q
c/c,R
s
a'/a',R
b'/b',R
a/a',R
p
a'/a',R
b'/b',R
v
c/c,L
u
a'/a',L
b'/b',L
a/a',L
b/b',R
a/a,L
b/b,L
r
c/c,R
t
b/b',L
a/a,R
b/b,R
a'/a',R
b'/b',R
c/c,R
w
B/B,R
x
a'/a',R
b'/b',R

... **B** | *a'* | *b'* | *a'* | *c* | *a'* | *b'* | *a* | **B** | ...

Example: *abacaba*

The Turing machine transition diagram shows states p, q, r, s, t, u, v, w, x with the following transitions:

- Start arrow into p
- $p \to q$ with $a/a',R$
- q self-loop: $a/a,R$ and $b/b,R$
- $q \to s$ with $c/c,R$
- s self-loop: $a'/a',R$ and $b'/b',R$
- $s \to u$ with $a/a',L$
- u self-loop: $a'/a',L$ and $b'/b',L$
- $u \to v$ with $c/c,L$
- v self-loop: $a/a,L$ and $b/b,L$
- $v \to p$ with $a'/a',R$ and $b'/b',R$
- $p \to r$ with $b/b',R$
- r self-loop: $a/a,R$ and $b/b,R$
- $r \to t$ with $c/c,R$
- t self-loop: $a'/a',R$ and $b'/b',R$
- $t \to u$ with $b/b',L$
- $p \to w$ with $c/c,R$
- w self-loop: $a'/a',R$ and $b'/b',R$
- $w \to x$ with $\mathbf{B}/\mathbf{B},R$

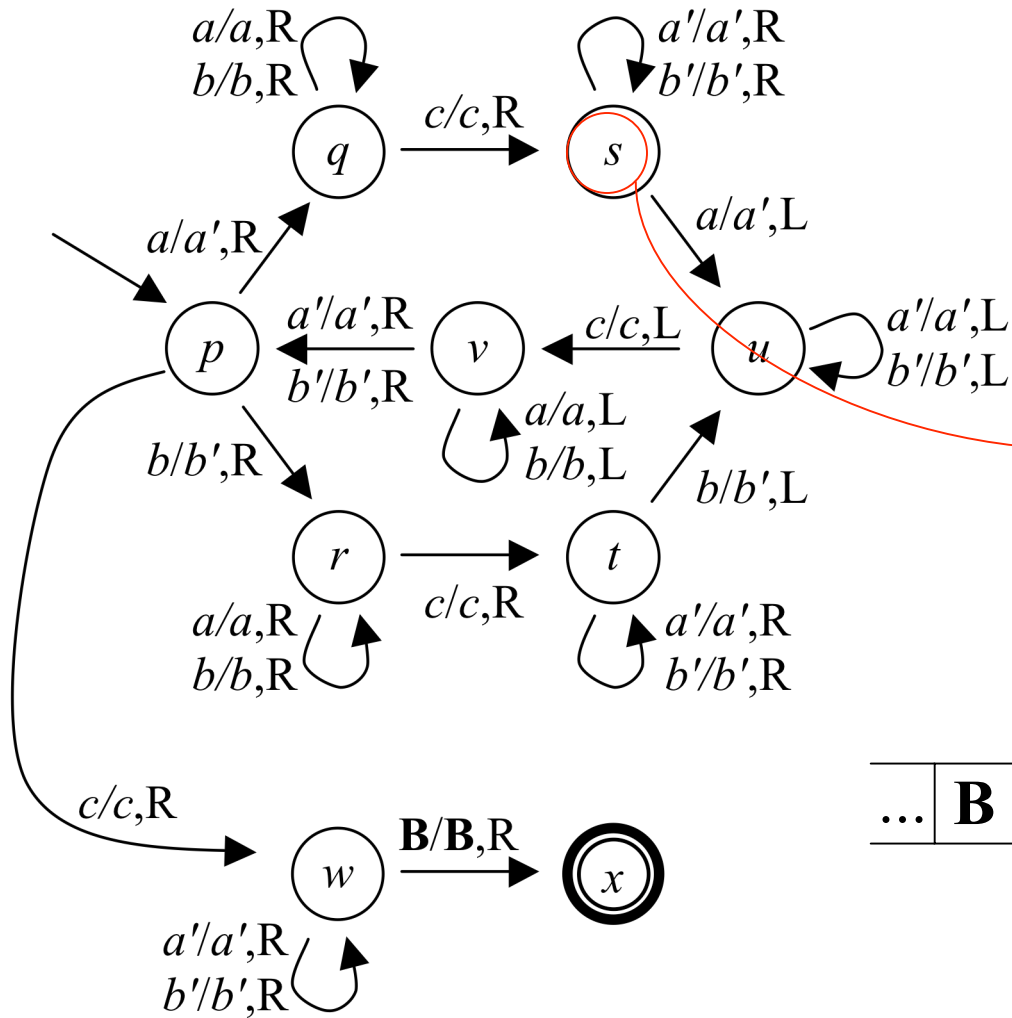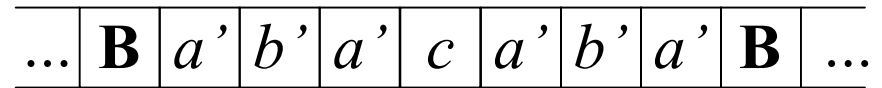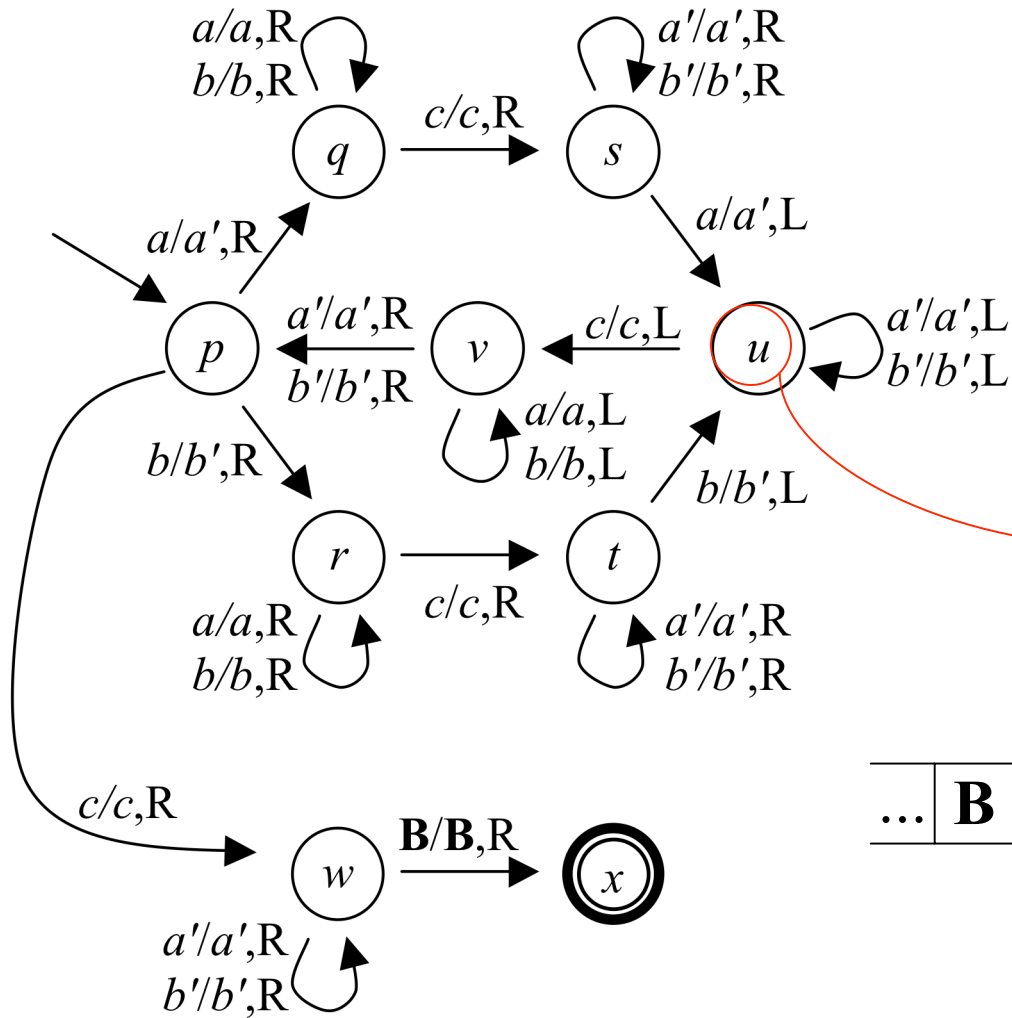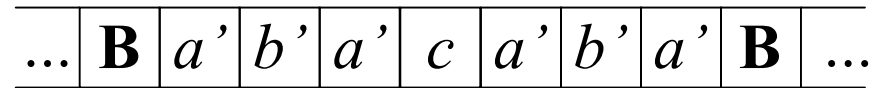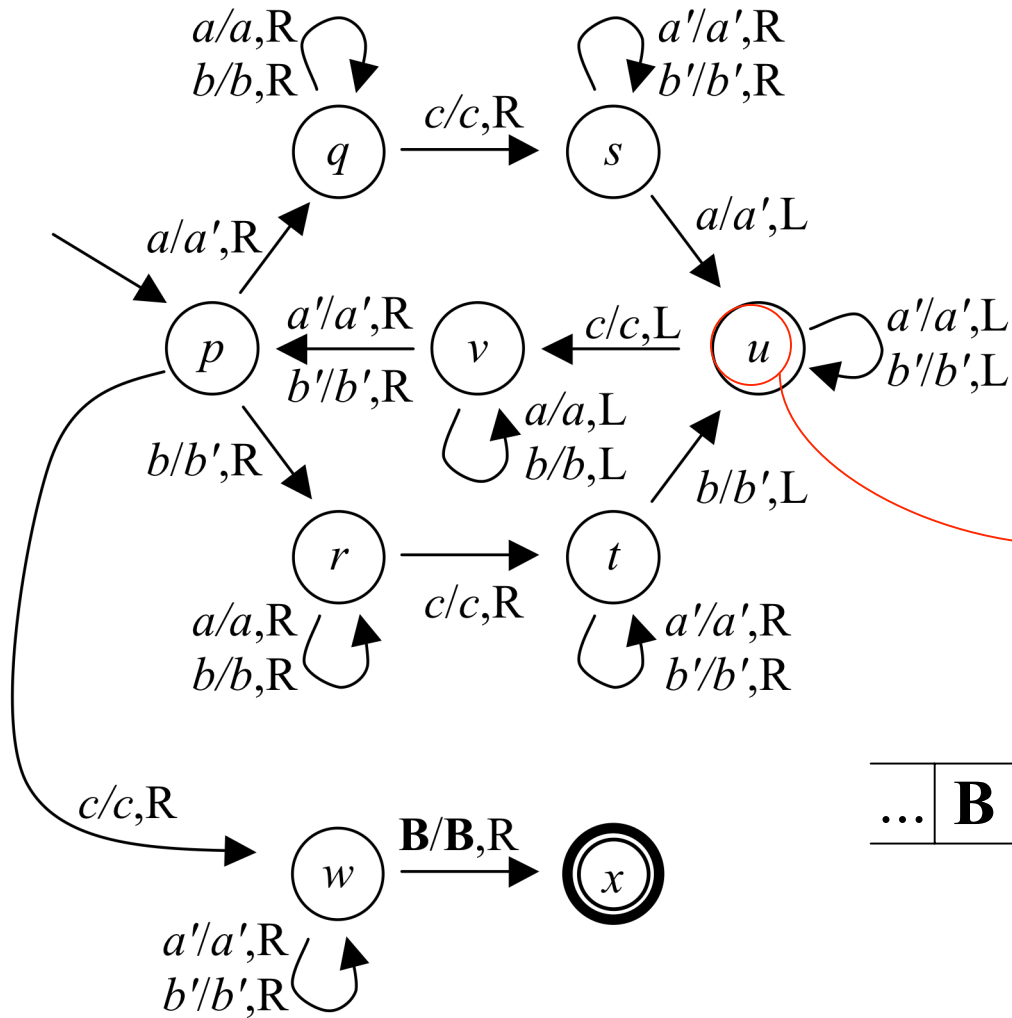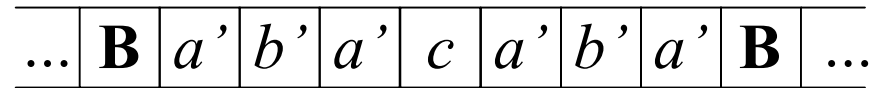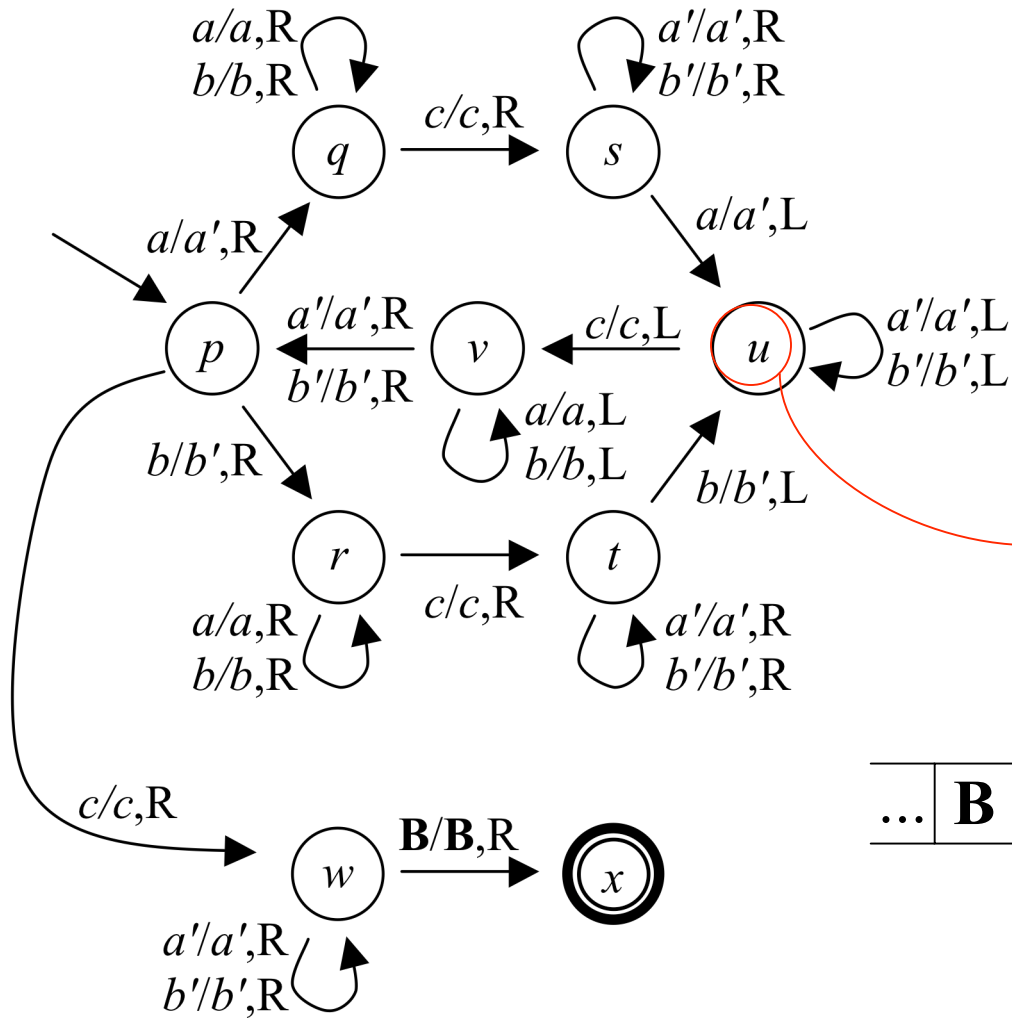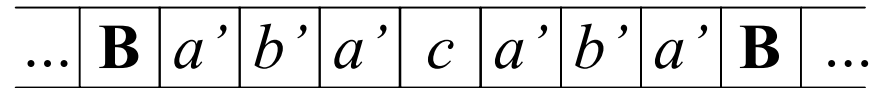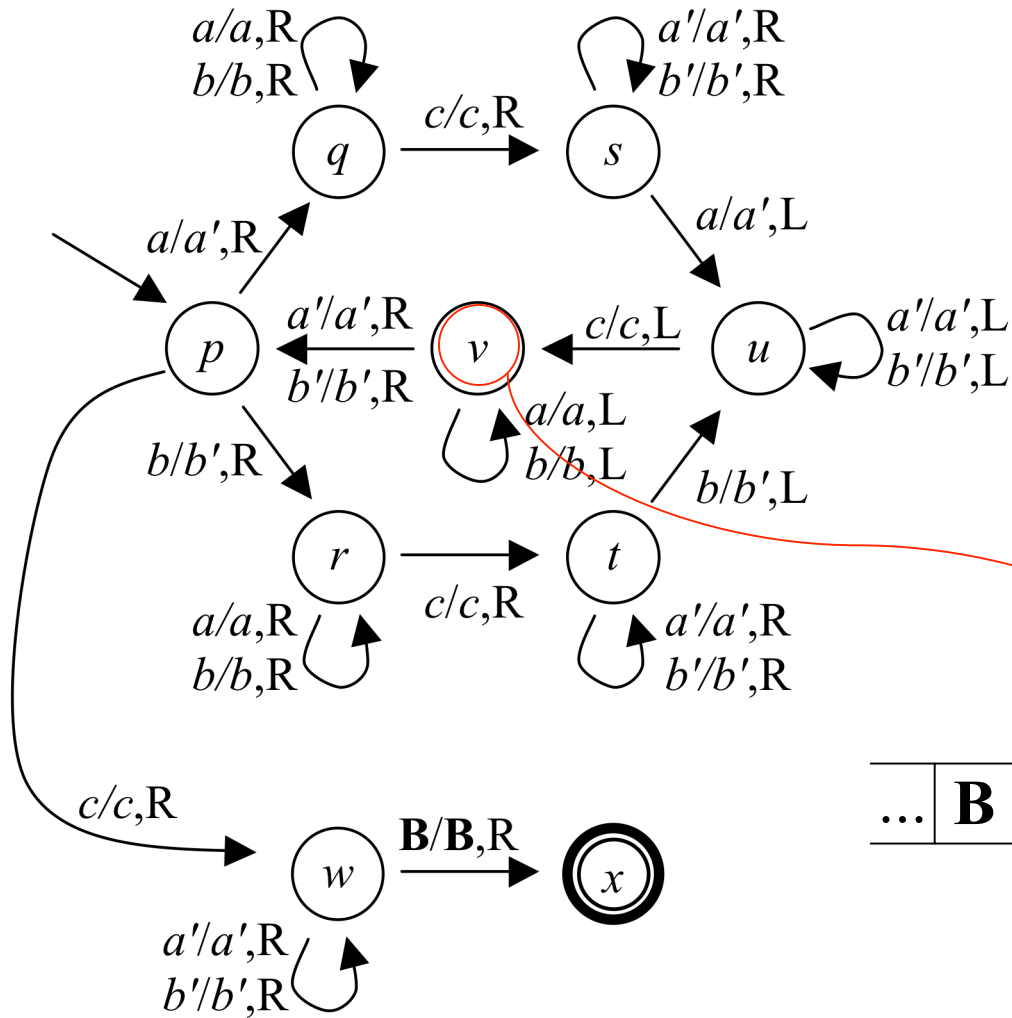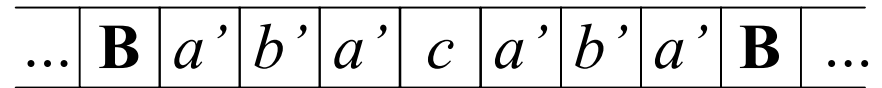Tape contents: $\ldots \mathbf{B} \mid a' \mid b' \mid a' \mid c \mid a' \mid b' \mid a \mid \mathbf{B} \mid \ldots$
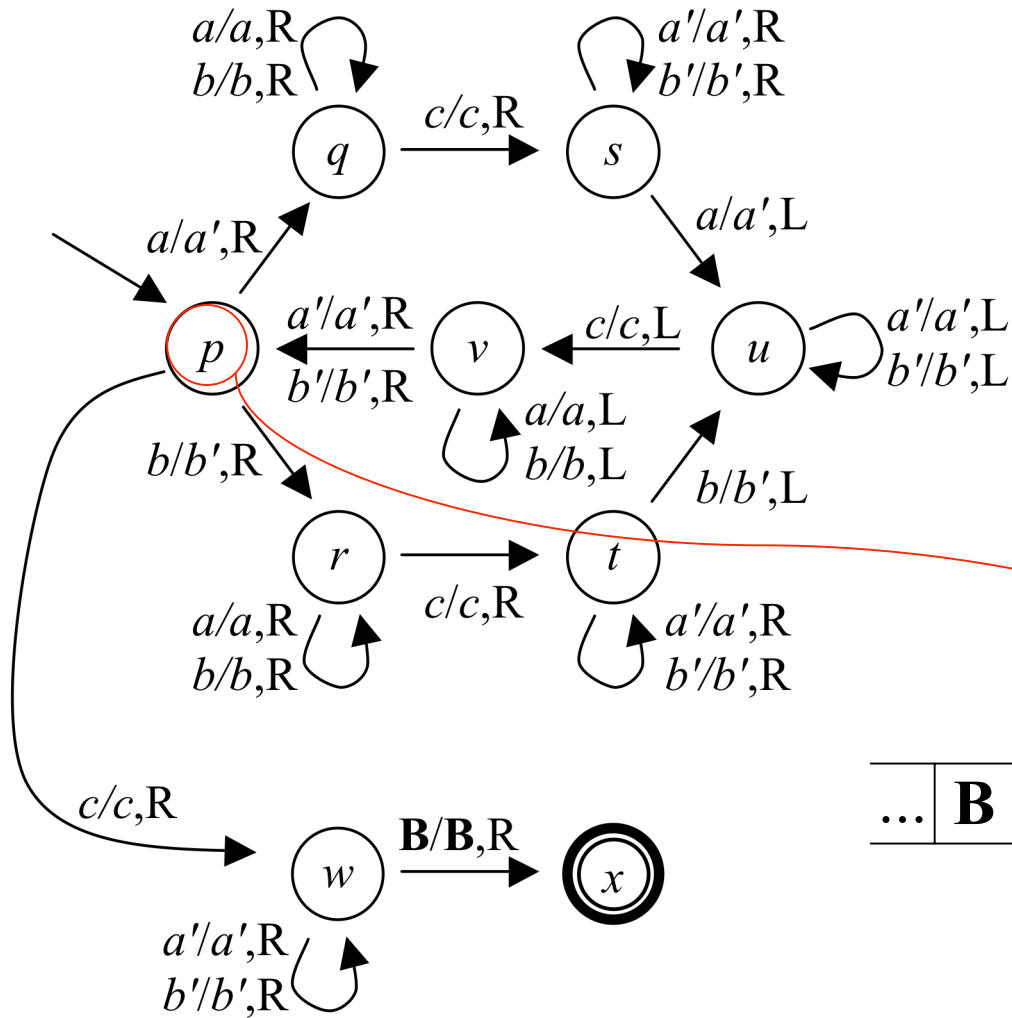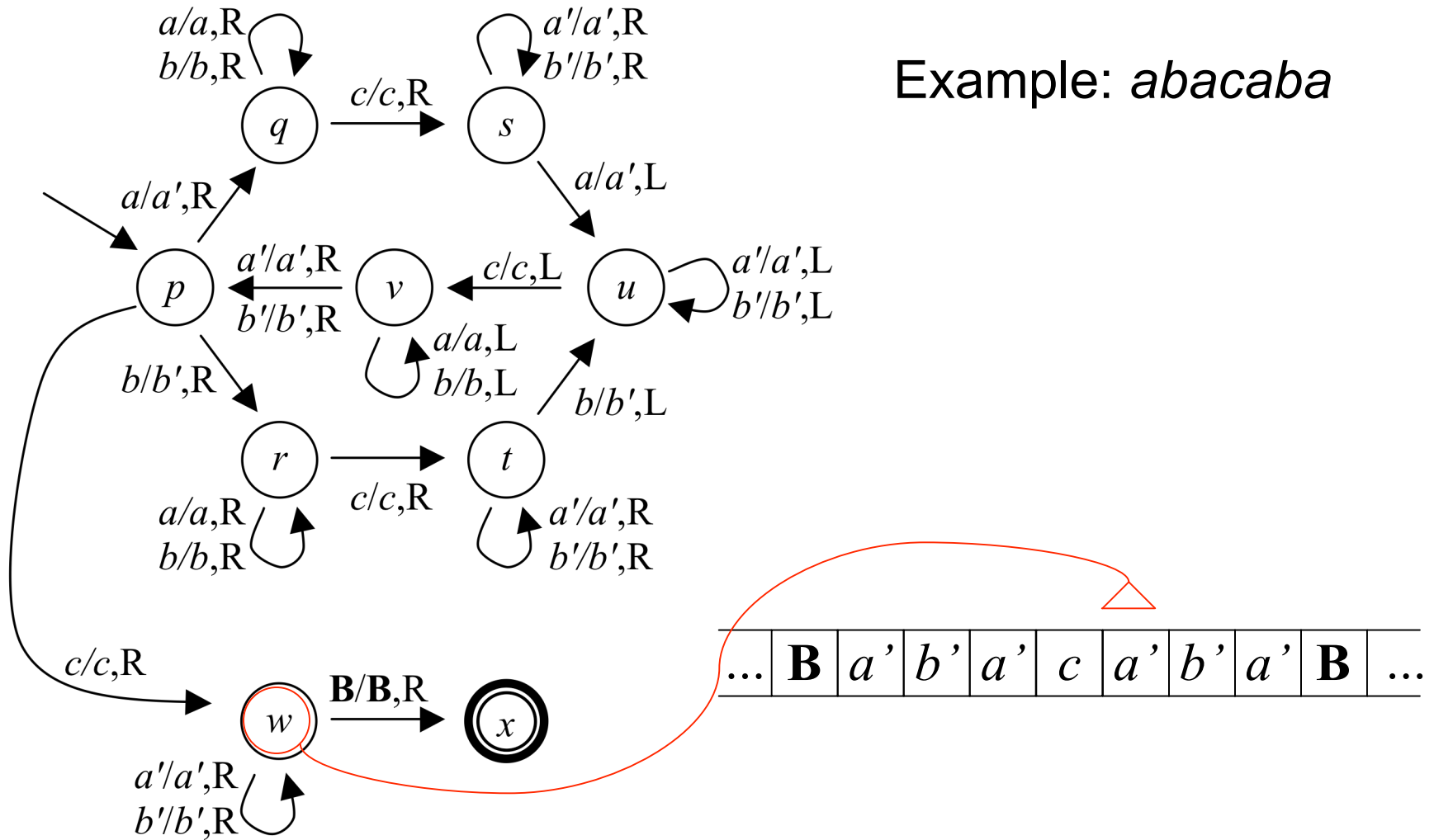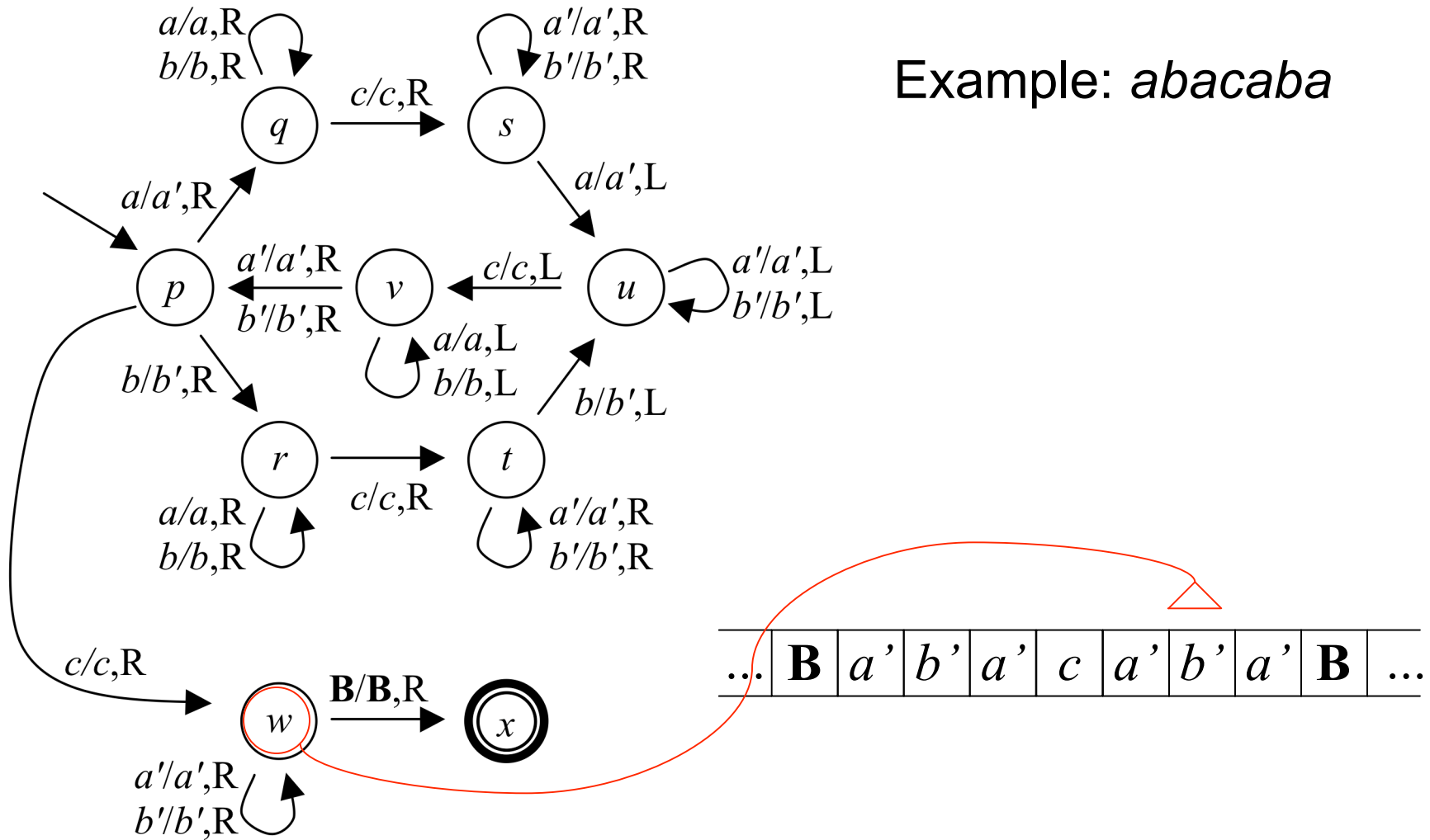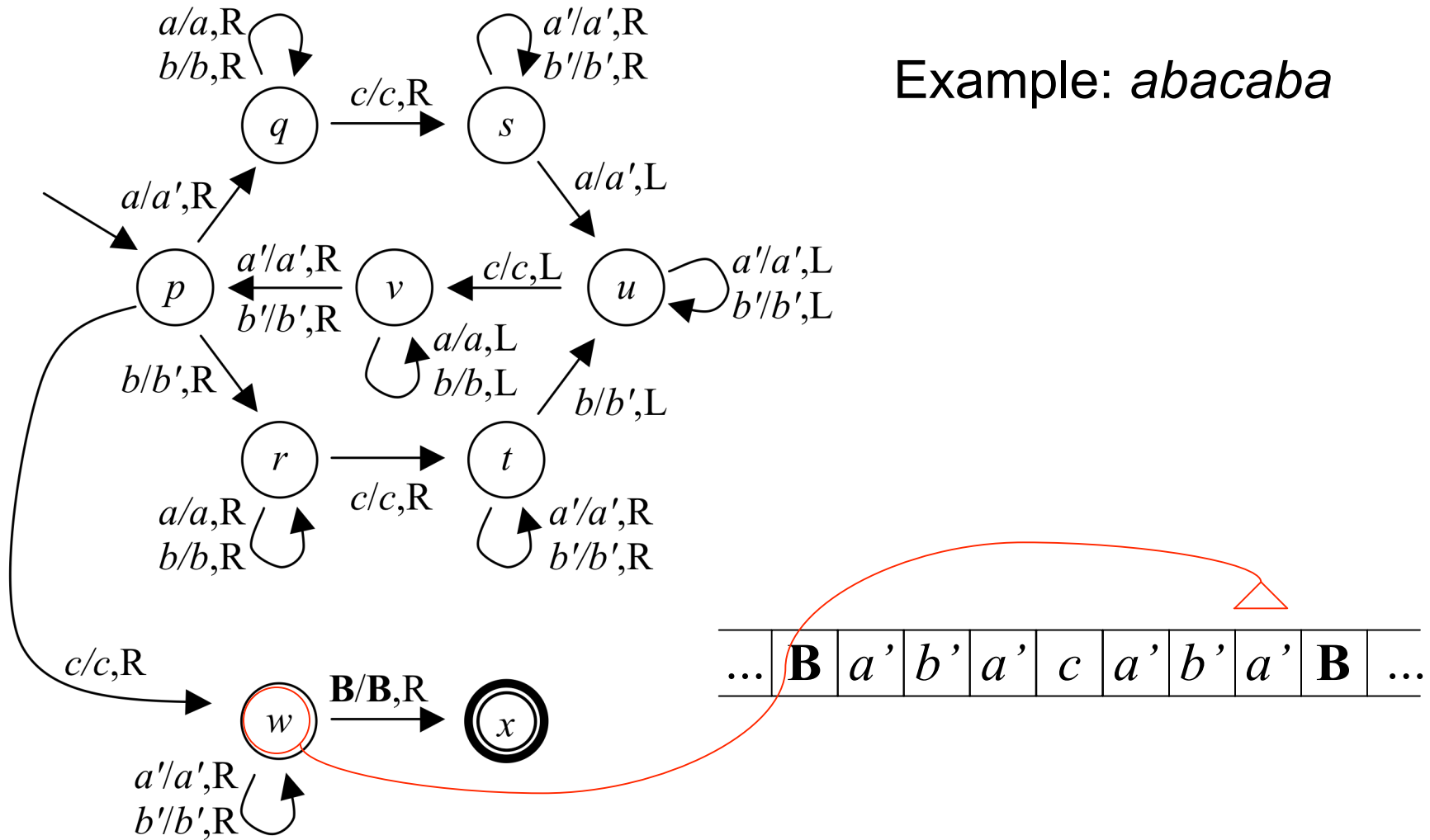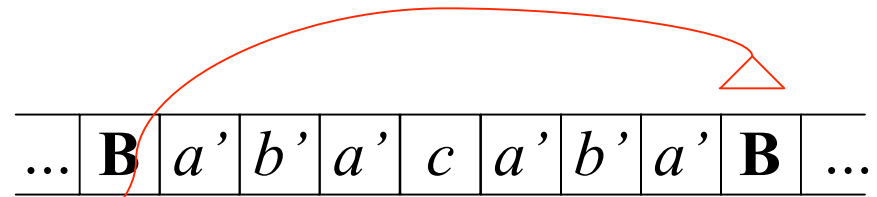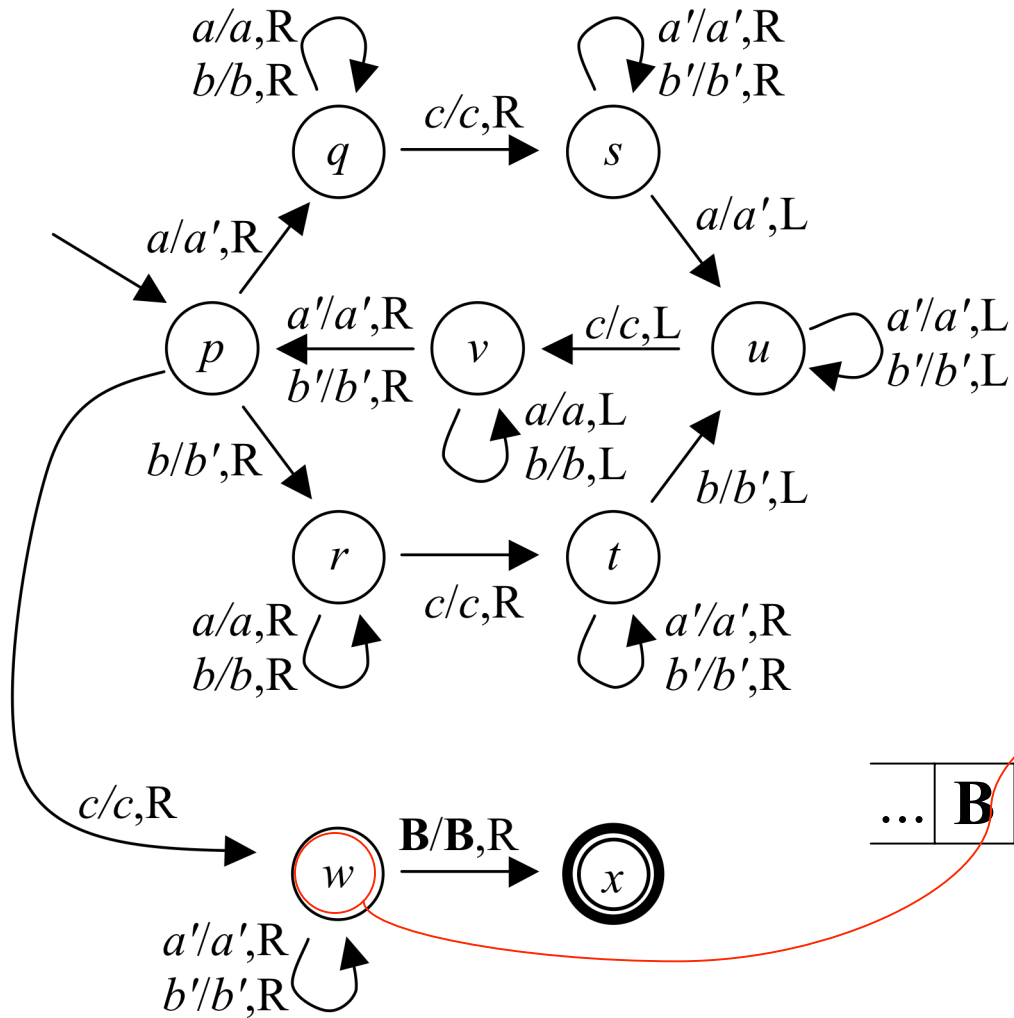
Example: *abacaba*

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Example: *abacaba*

Example: *abacaba*

Example: *abacaba*

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Example: *abacaba*