Chapter 2
Scanning

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2014년 2학기

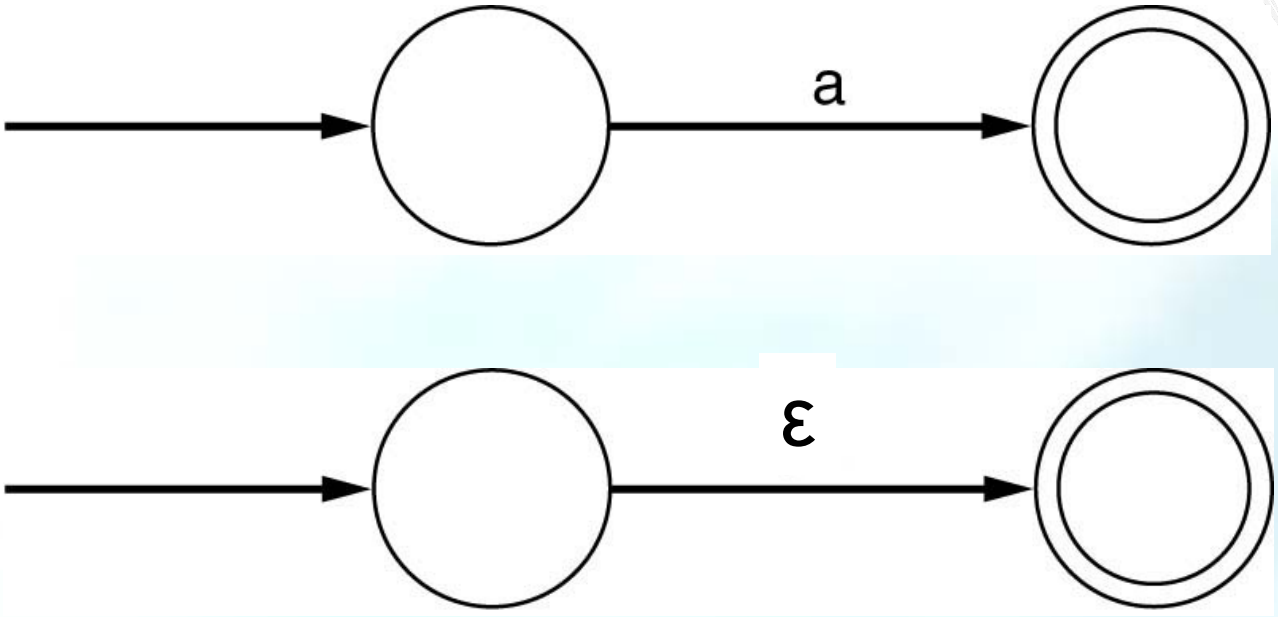
Scanner Construction

Regular expression → NFA

- **Thompson's construction**
- Regular expressions
  - Basic regular expressions
  - Concatenation
  - Choice
  - Repetition

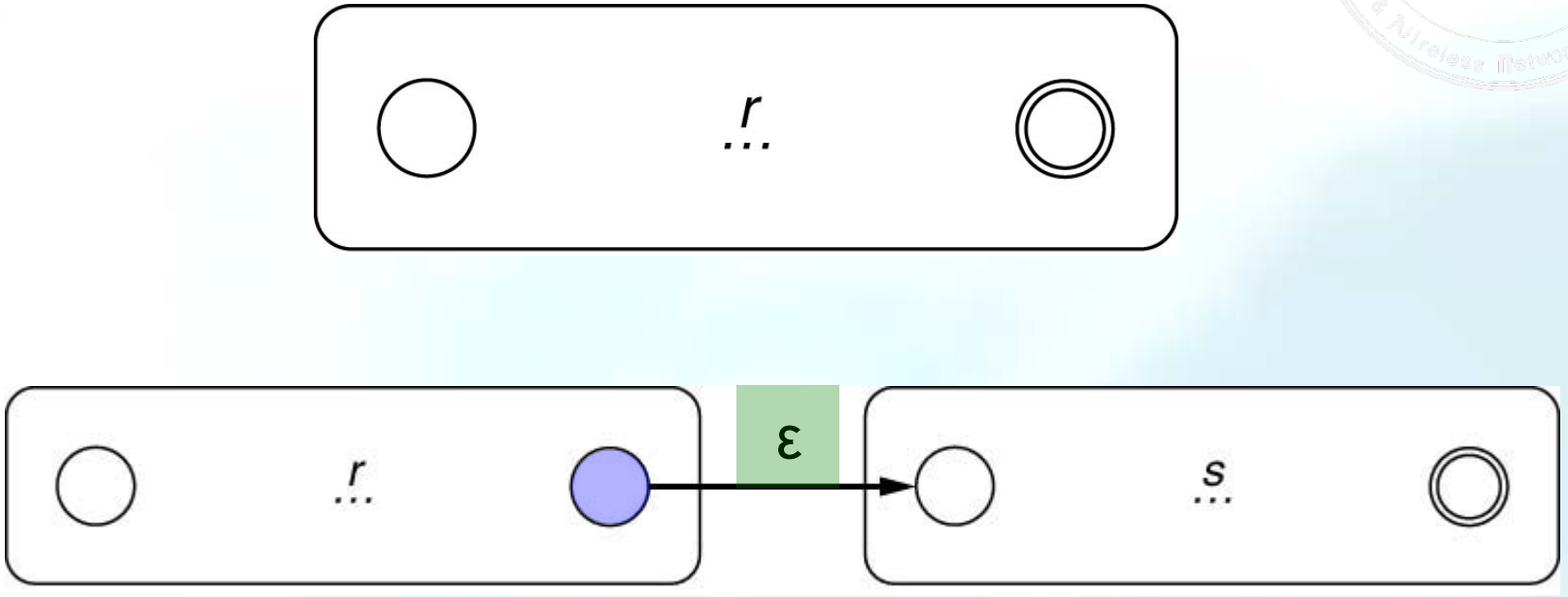
Regular expression → NFA

- Basic regular expressions
  - a, ε, **Φ**



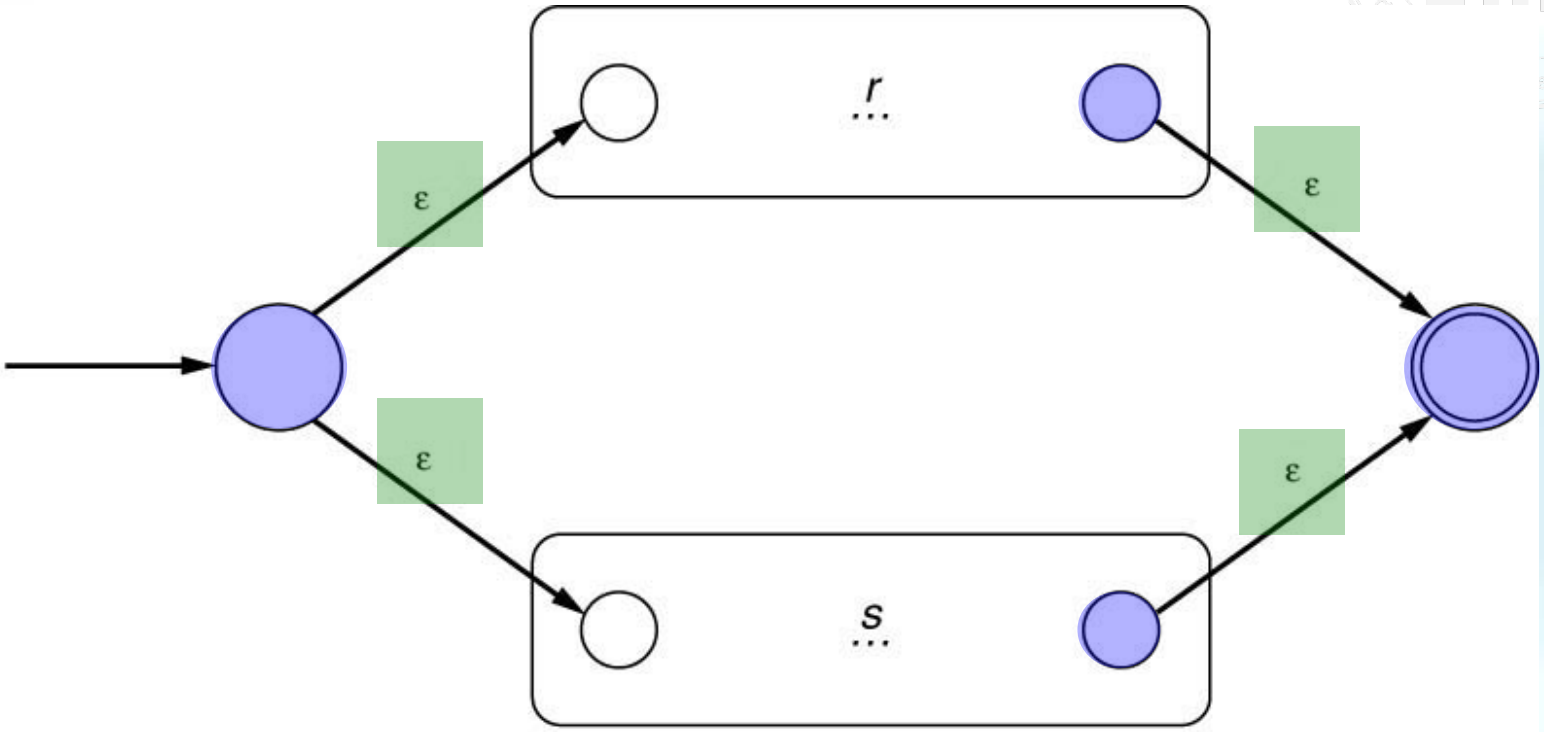
Regular expression → NFA

- Concatenation
  - *rs*



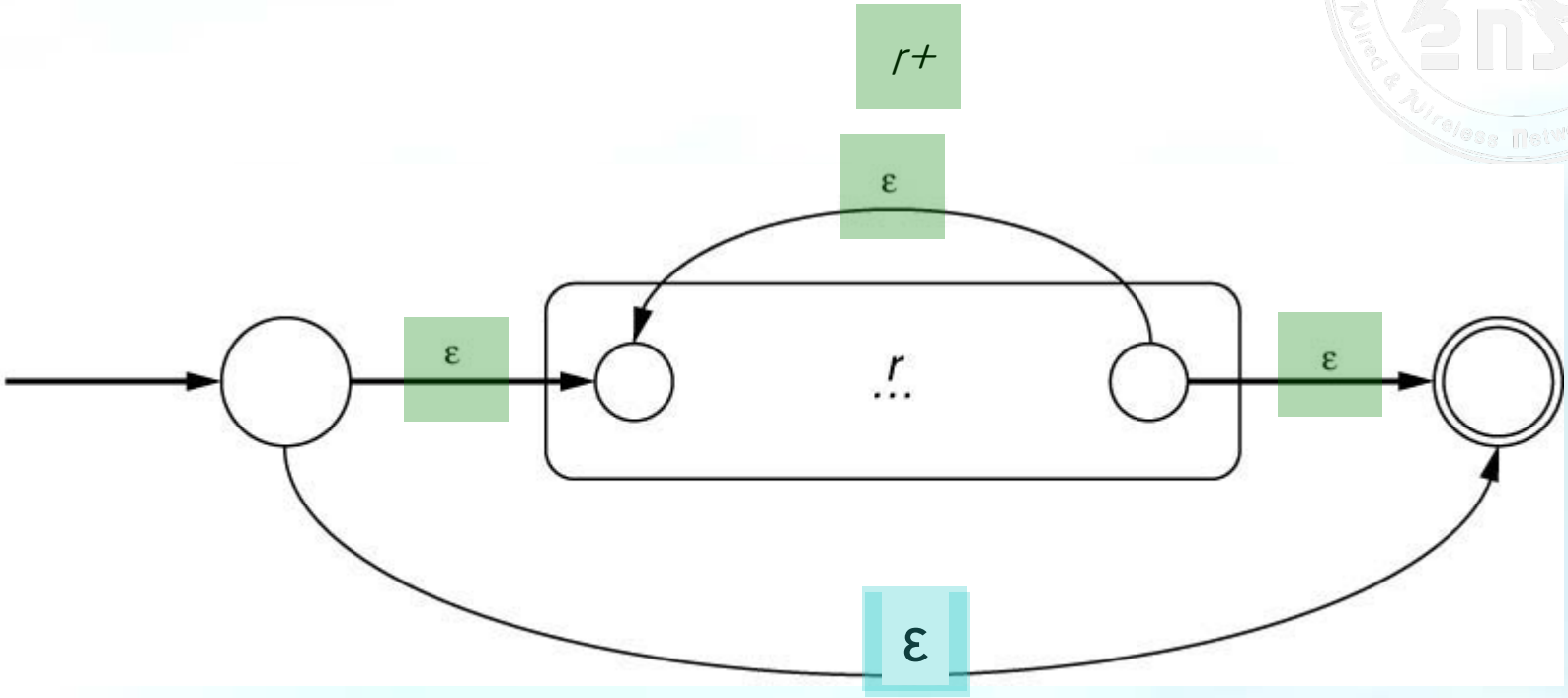
Regular expression → NFA

- Choice
  - $r|s$



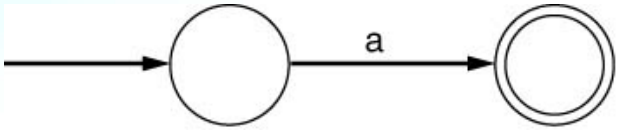
Regular expression → NFA

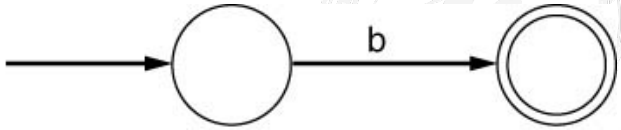
- Repetition
  - r^*

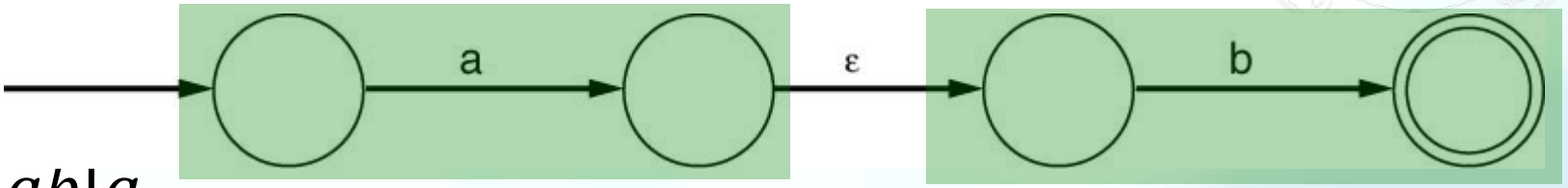


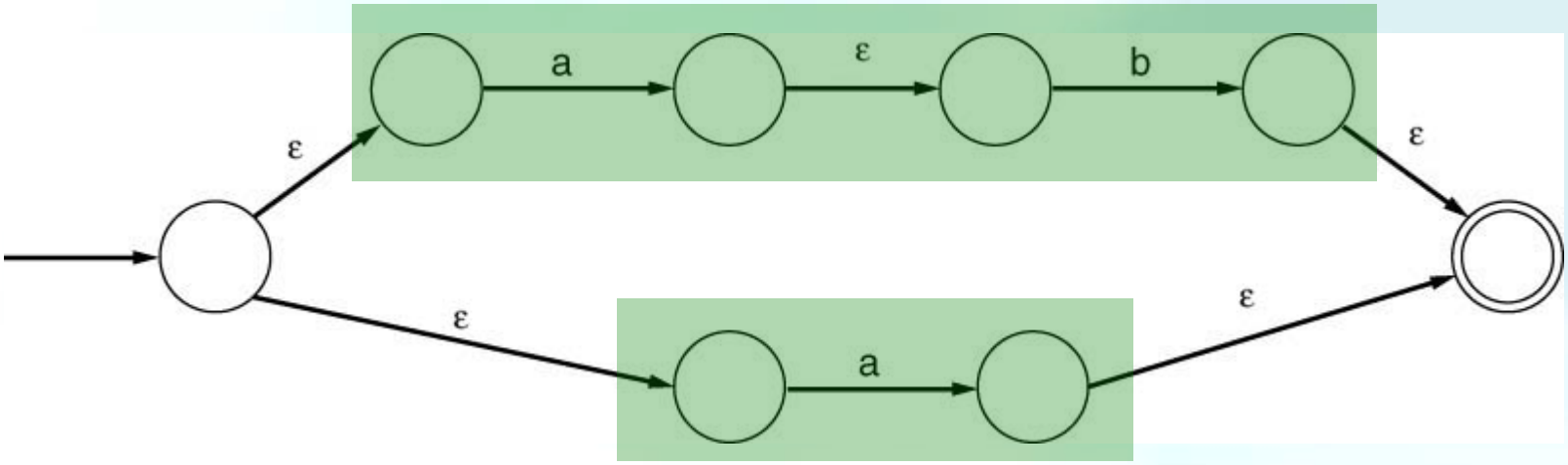
Regular expression → NFA

- $ab|a$
  - a, b
  - ab
  - $ab|a$



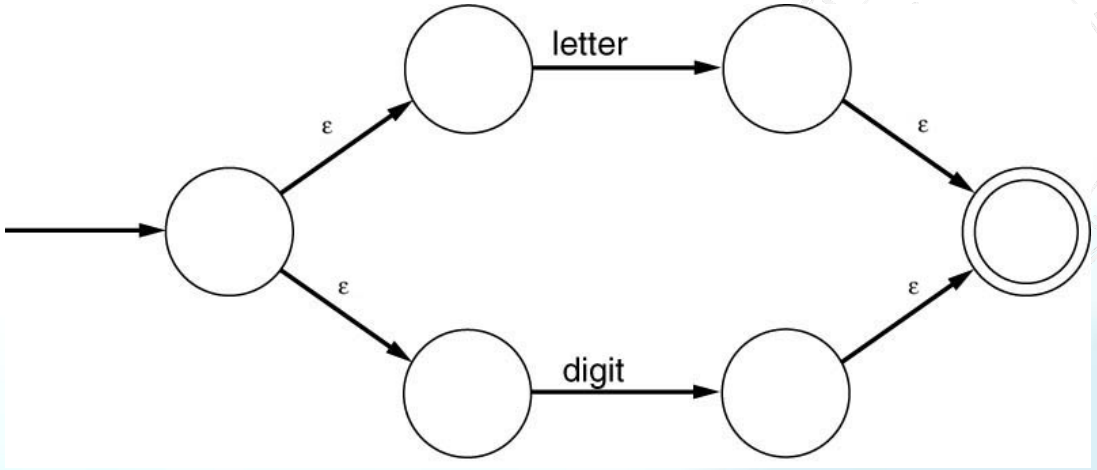




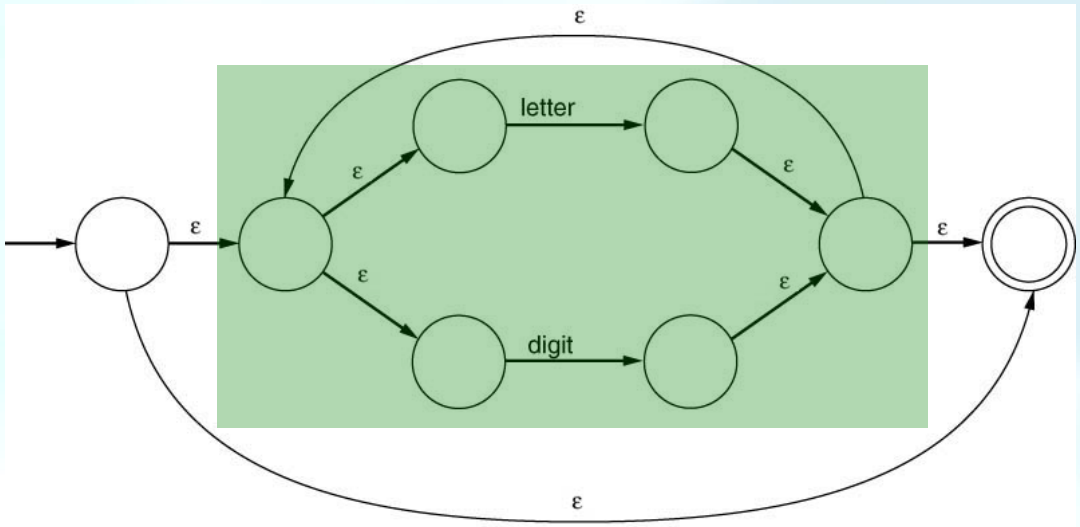


Regular expression → NFA

- *letter*(*letter*|*digit*)*
  - *letter*|*digit*

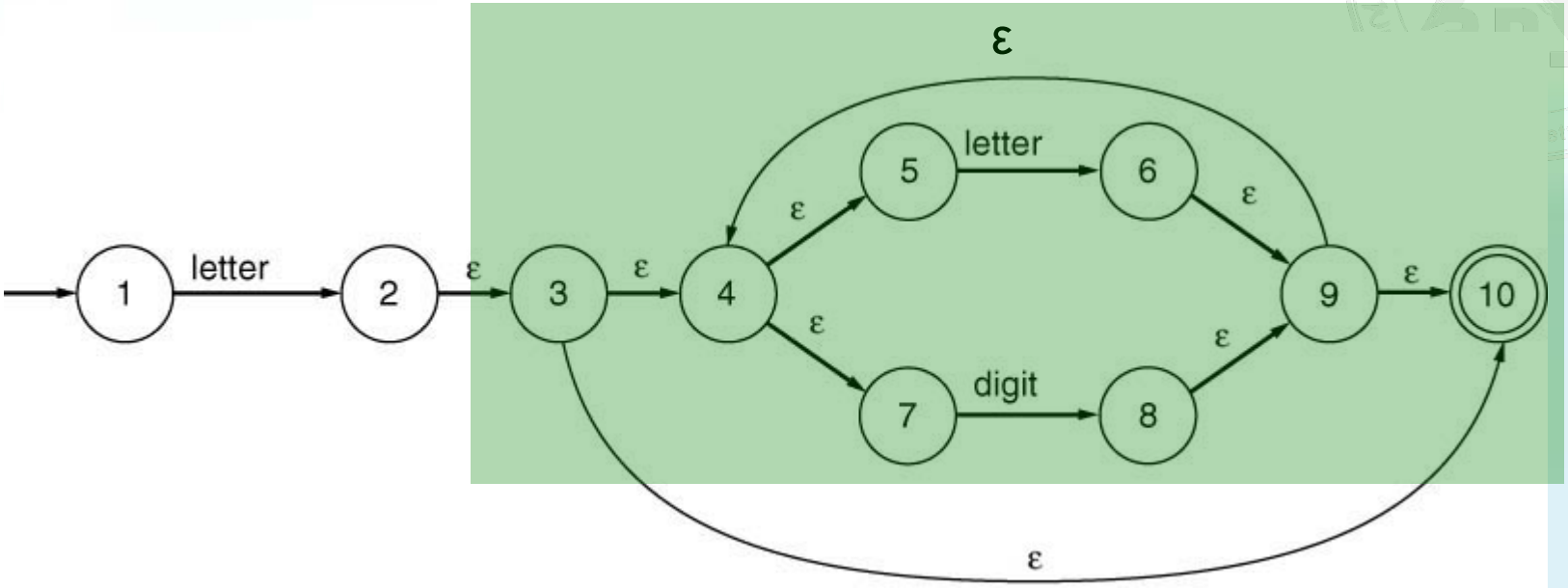


  - (*letter*|*digit*)*



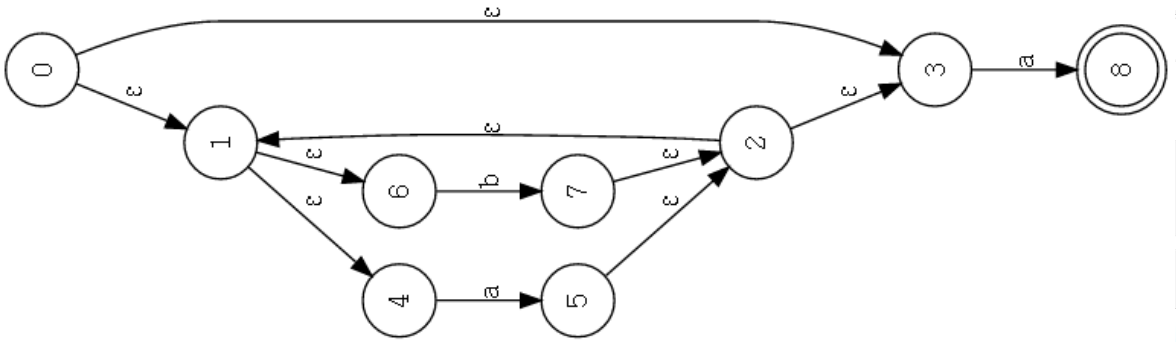
Regular expression → NFA

- *letter*(*letter*|*digit*)*

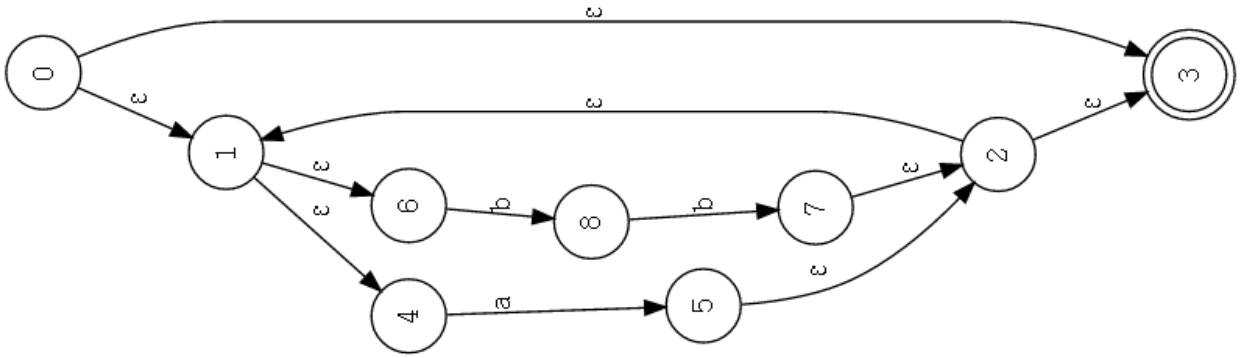


Examples

- (a | b)* a

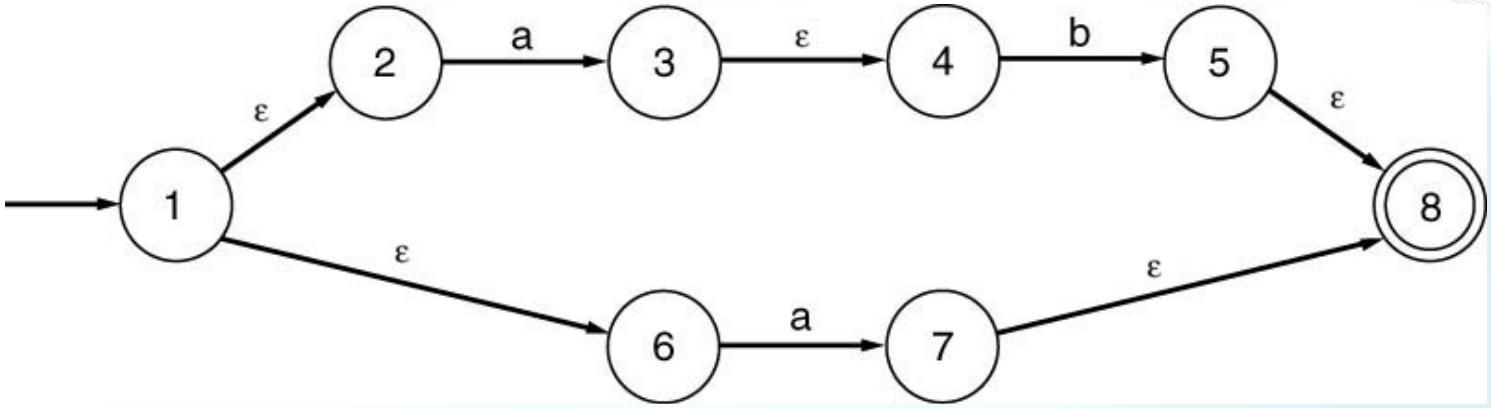


- (a | bb)*



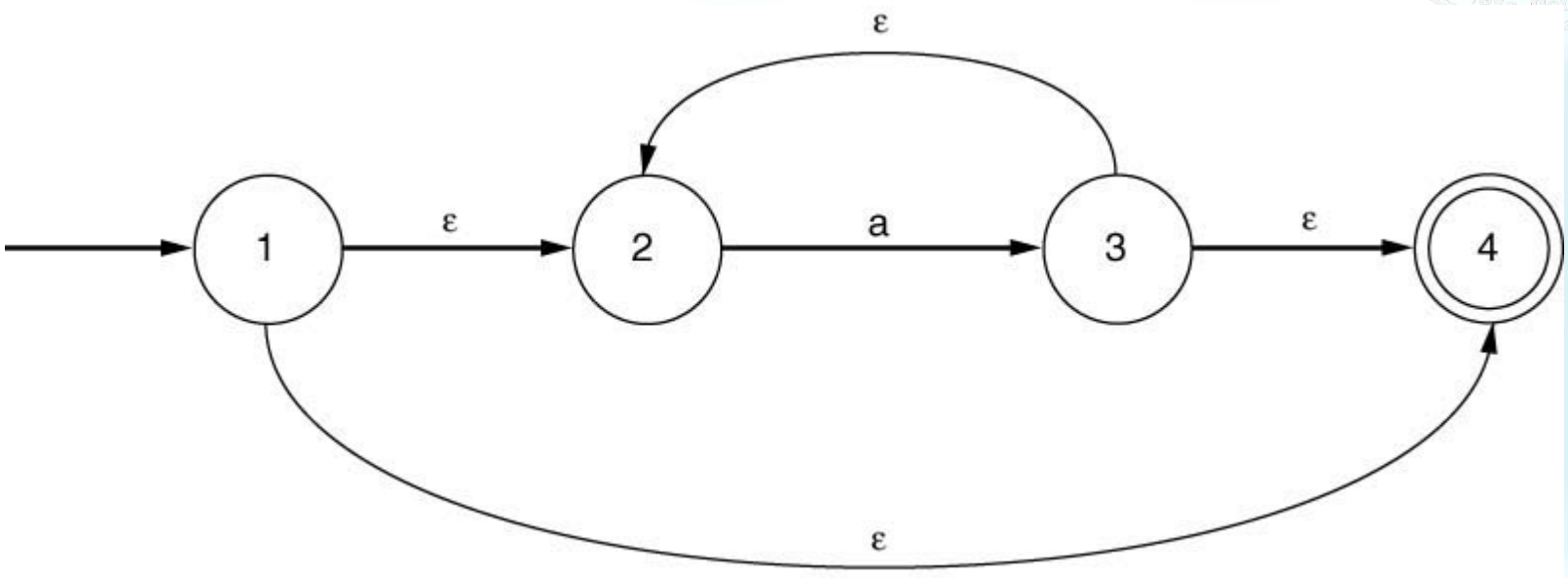
NFA → DFA

- The **subset construction** with ε – transitions.
  1. eliminating ε-transition
  2. eliminating multiple transitions on a single input character



NFA → DFA

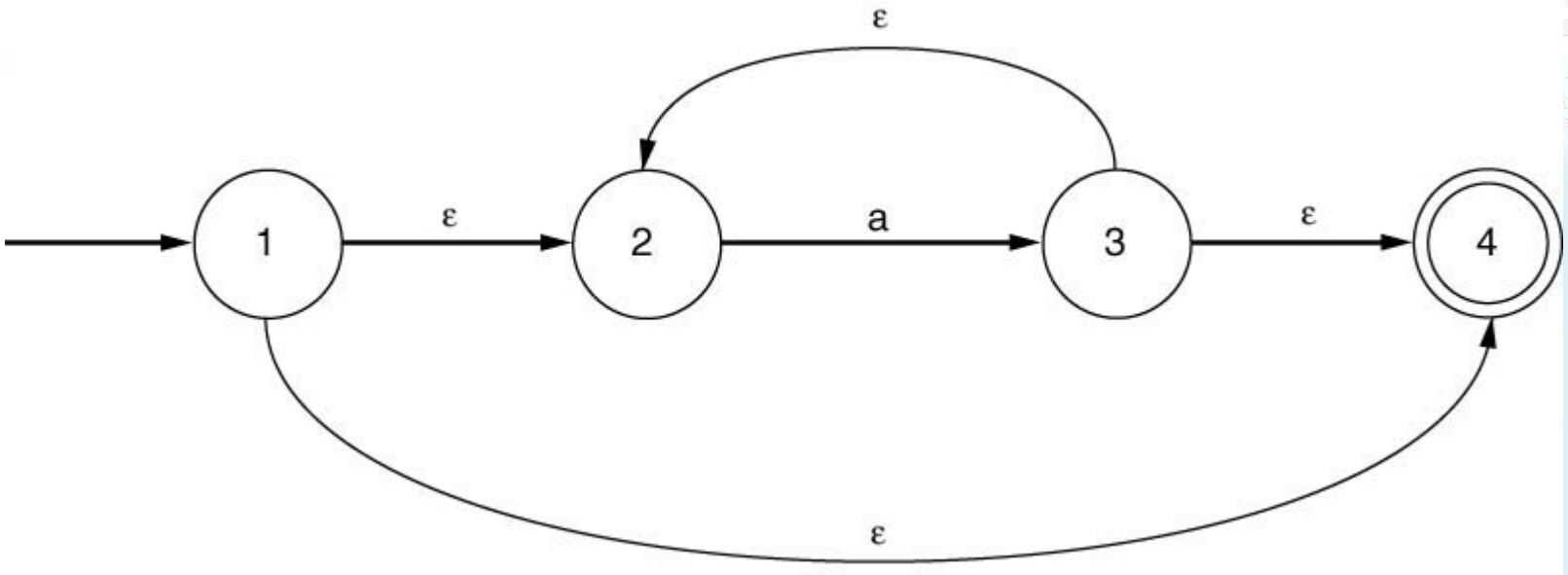
- ε – closure of a state
  - The ε – closure of a single state *s*, denoted by *s*, is the set of states reachable by only zero or more ε-transitions.



$\overline{1}$ = { 1,2,4 } $\overline{2}$={ 2 } $\overline{3}$={ 2,3,4 } $\overline{4}$={ 4 }

NFA → DFA

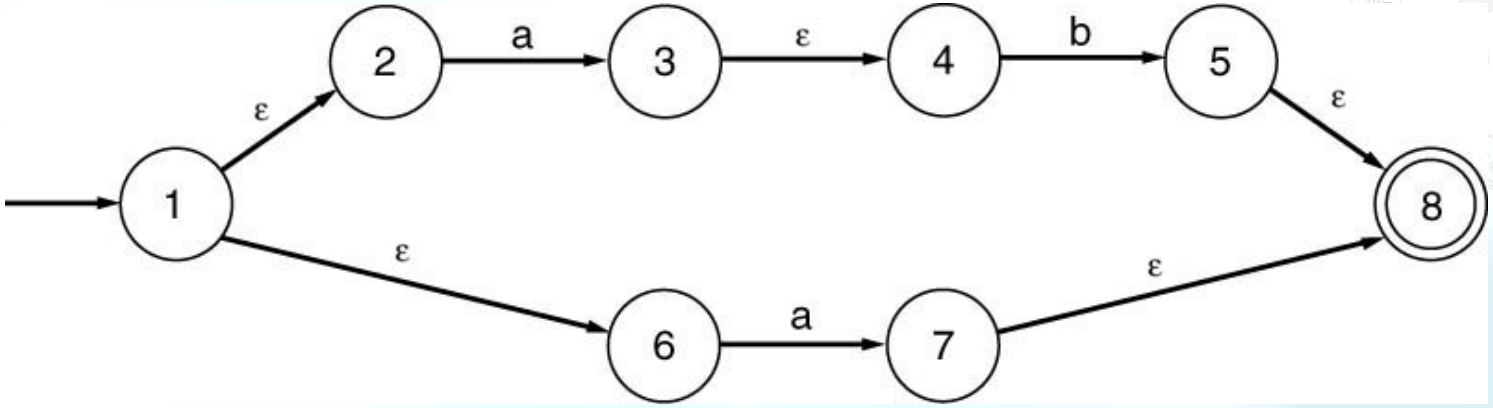
- ε – closure of some states
  - The union of the ε – closures of each state.



$$\overline{\{1,3\}} = \overline{1} \cup \overline{3} = \{1,2,4\} \cup \{2,3,4\} = \{1,2,3,4\}$$

NFA → DFA

- The Subset construction



string: ab

$\overline{1} = \{1,2,6\}$, $\overline{2} = \{2\}$, $\overline{3}=\{3,4\}$, $\overline{4}=\{4\}$, $\overline{5}=\{5,8\}$, $\overline{6}=\{6\}$, $\overline{7}=\{7,8\}$, $\overline{8}=\{8\}$

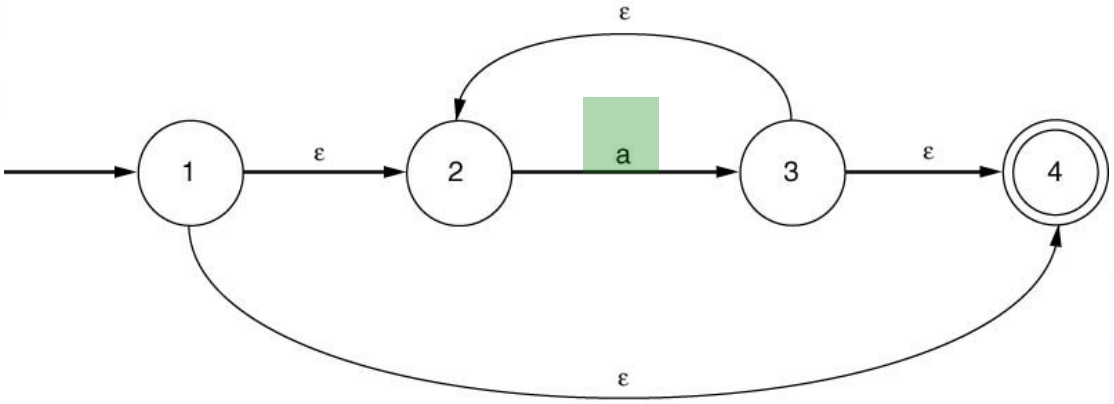
3. "a" 이동 존재 — a — 6. "b" 이동 존재 — b

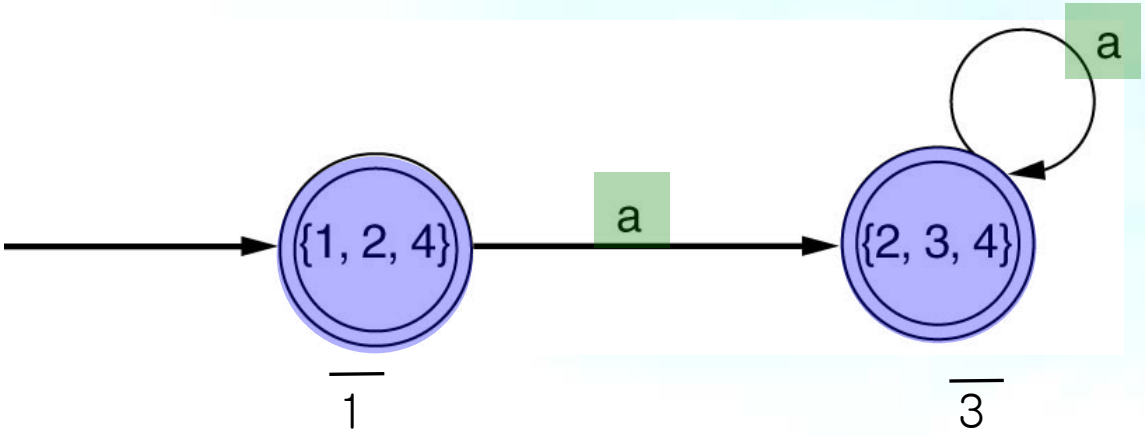
$\overline{\{1\}} = \{1,2,6\} \xrightarrow{a} \overline{\{3,7\}} = \{3,4,7,8\} \xrightarrow{b} \overline{\{5\}} = \{5,8\}$

1. start state의 ε-closure
2. {1,2,6} 에서 symbol transition이 존재하는지 확인
4. "a"이동 후 state 변경
5. {3,4,7,8} 에서 symbol transition이 존재하는지 확인
7. "b" 이동후 state 변경
8. accept state 포함하는 지 확인

NFA → DFA

- NFA → DFA (a*)





$\overline{1} = \{1,2,4\}$

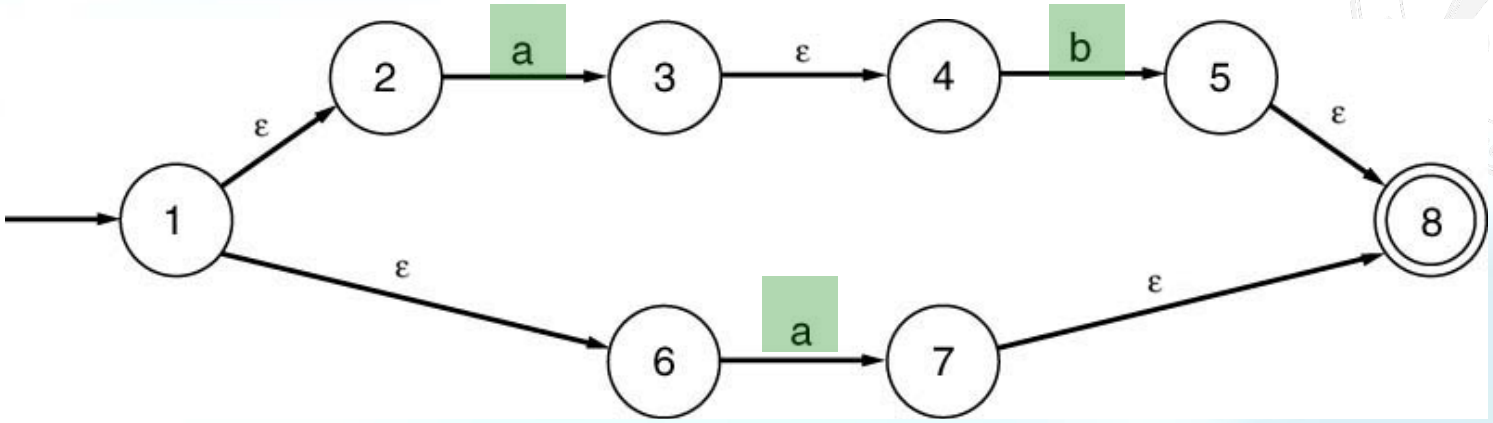
$\overline{2} = \{2\}$

$\overline{3} = \{2,3,4\}$

$\overline{4} = \{4\}$

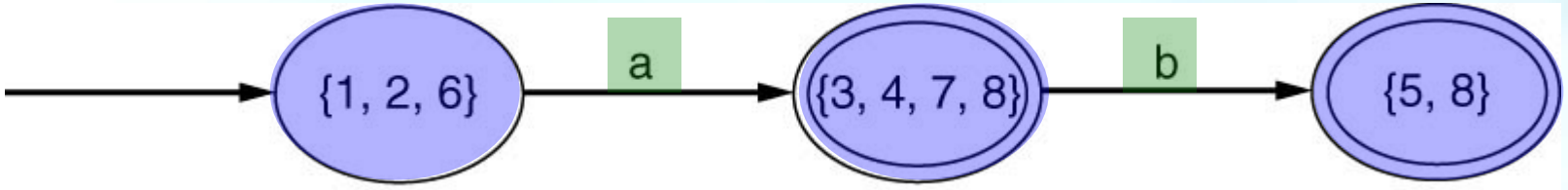
NFA → DFA

- ab|a



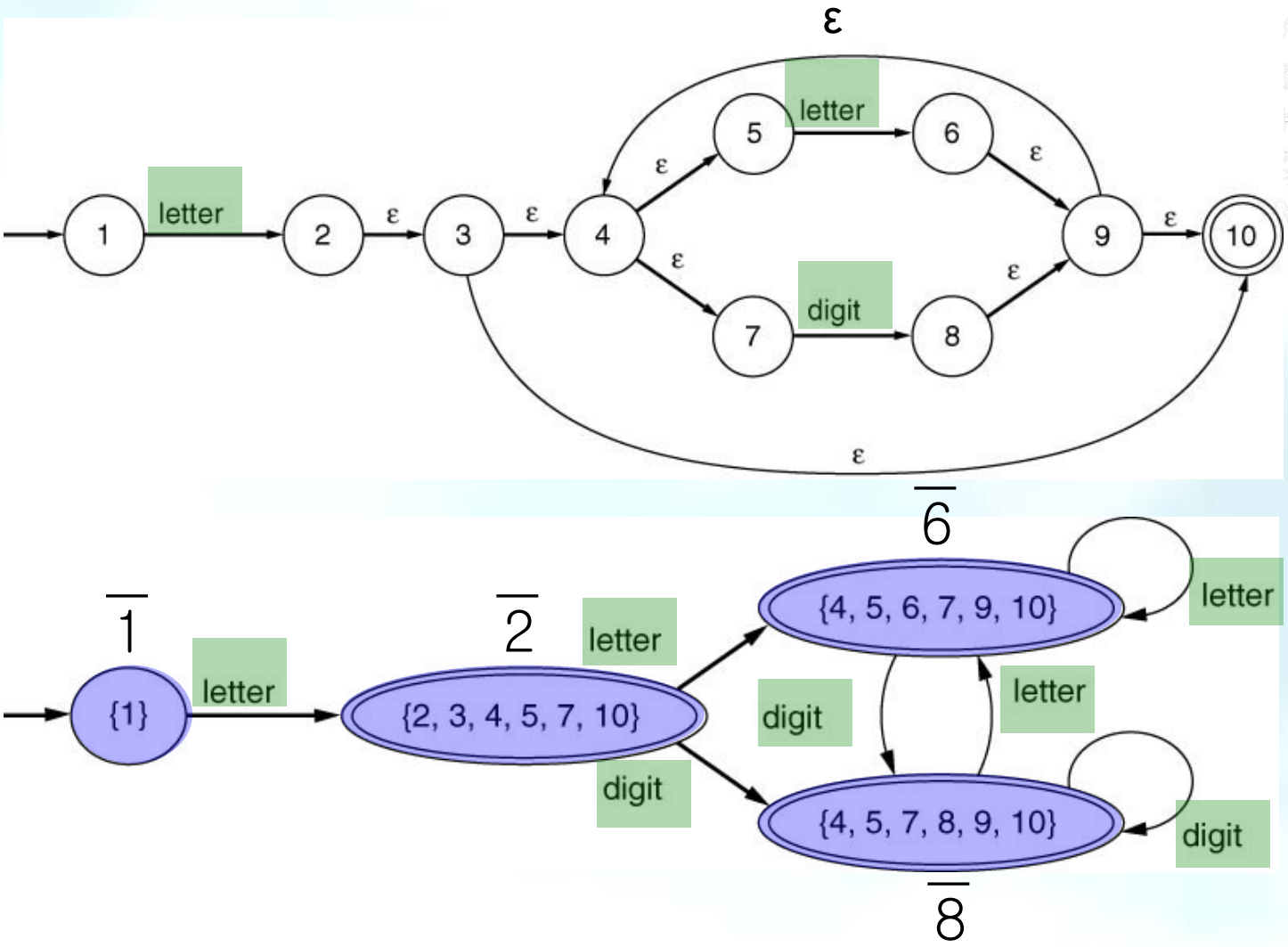
$\overline{1} = \{1,2,6\}$, $\overline{2} = \{2\}$, $\overline{3}=\{3,4\}$, $\overline{4}=\{4\}$, $\overline{5}=\{5,8\}$, $\overline{6}=\{6\}$, $\overline{7}=\{7,8\}$, $\overline{8}=\{8\}$

$\overline{1}$ $\overline{3} \cup \overline{7}$ $\overline{5}$

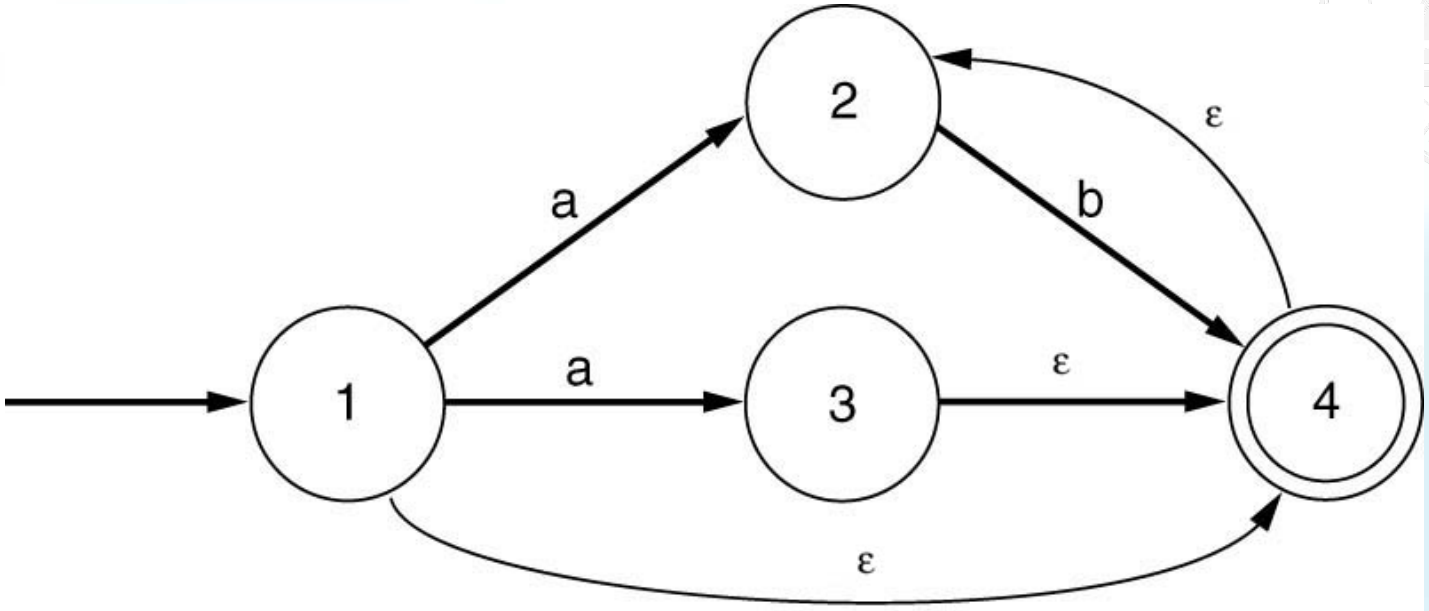


NFA → DFA

- *letter*(*letter*|*digit*)*

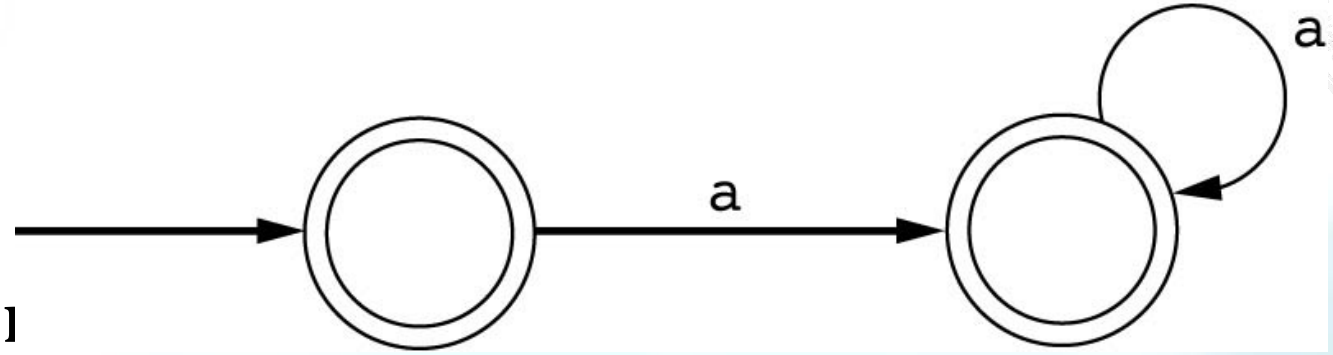


Example 2.10

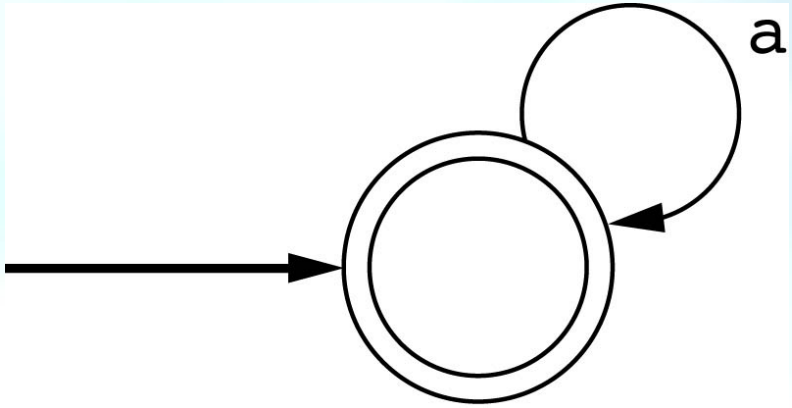


Minimizing DFA

- DFA for a* that is constructed by subset construction

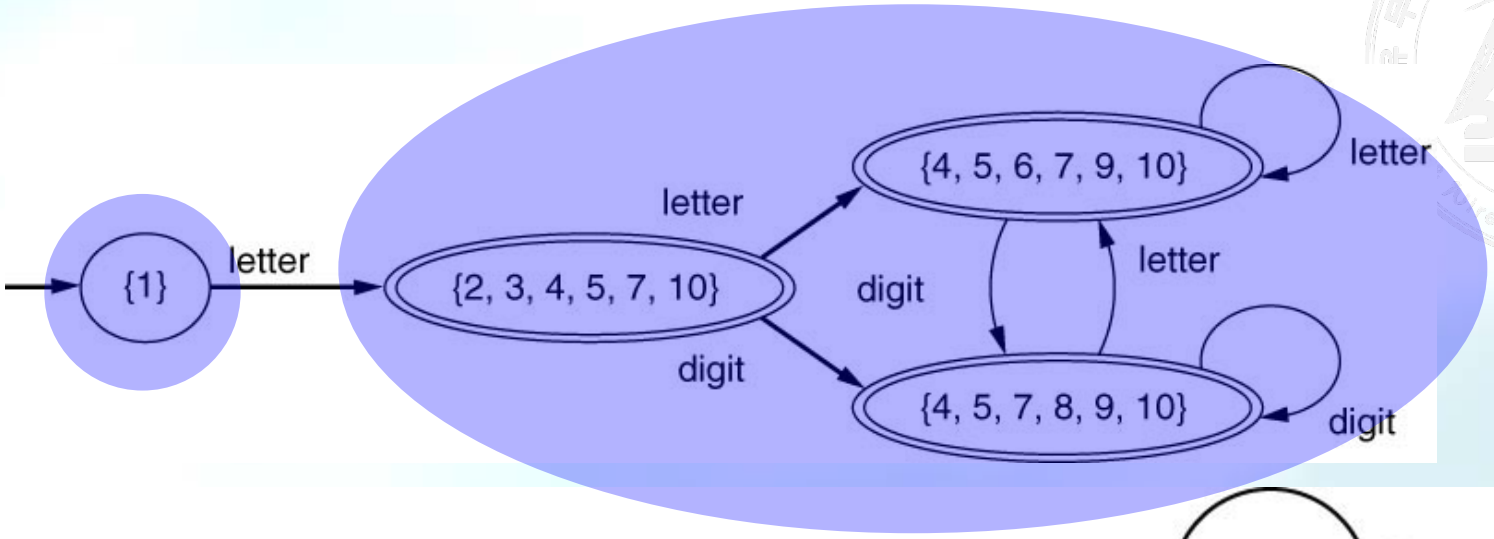


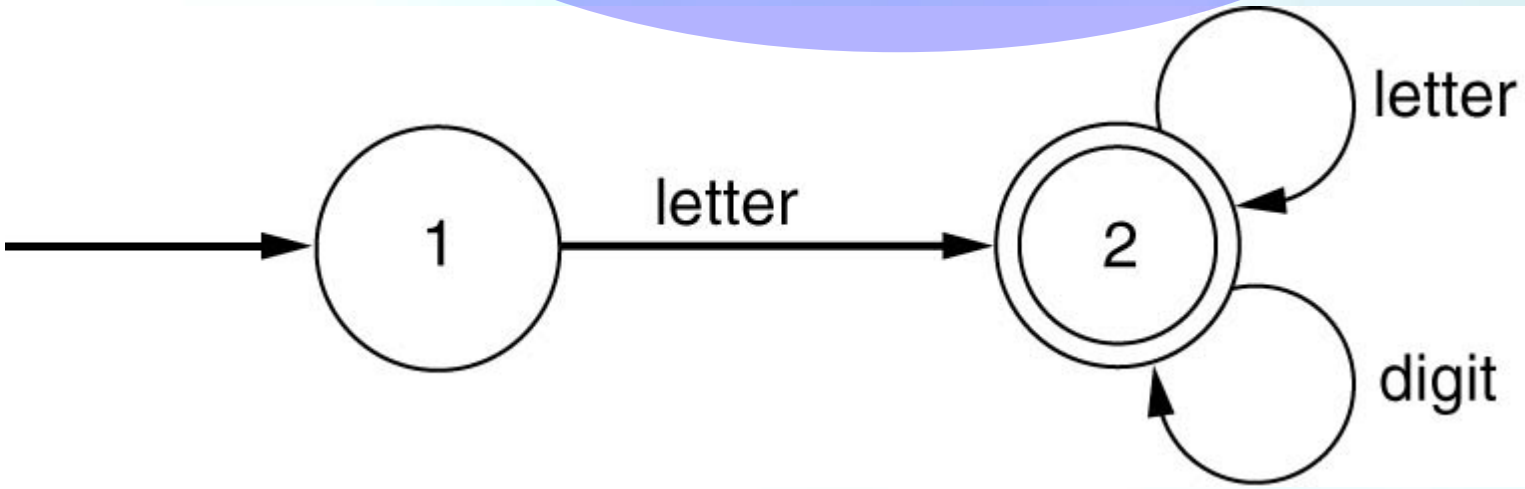
- can



Minimizing DFA

- *letter*(*letter*|*digit*)*



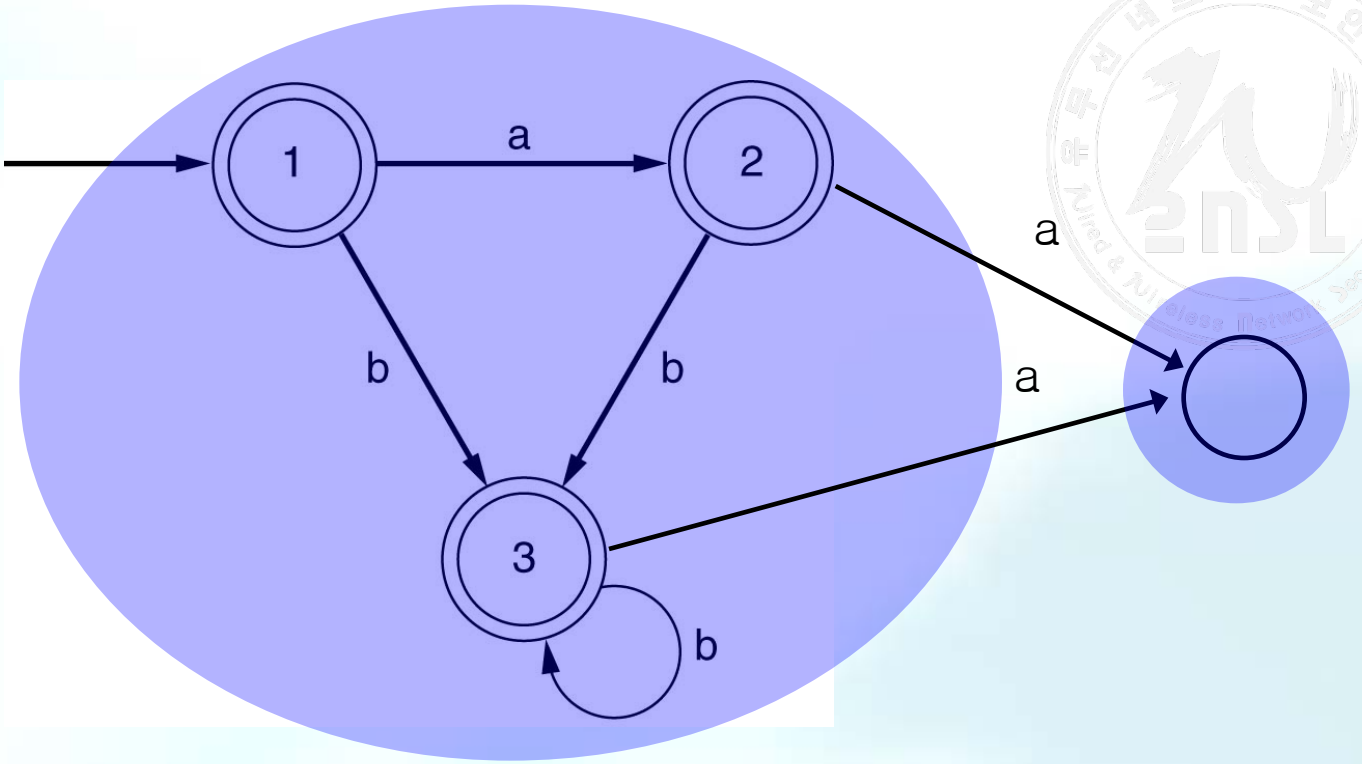


Algorithm given any DFA, there is an equivalent DFA containing a minimum number of states, and this minimum state is unique

1. unified into single states
    1. one with all the accepting states
    2. the other with all the nonaccepting states
2. Consider transitions on each character *a* of the alphabet
3. if there are two accepting/nonaccepting states that have transitions on *a* that land in different states, *a* **distinguishes** the states and the set of states must be split.

Minimizing DFA

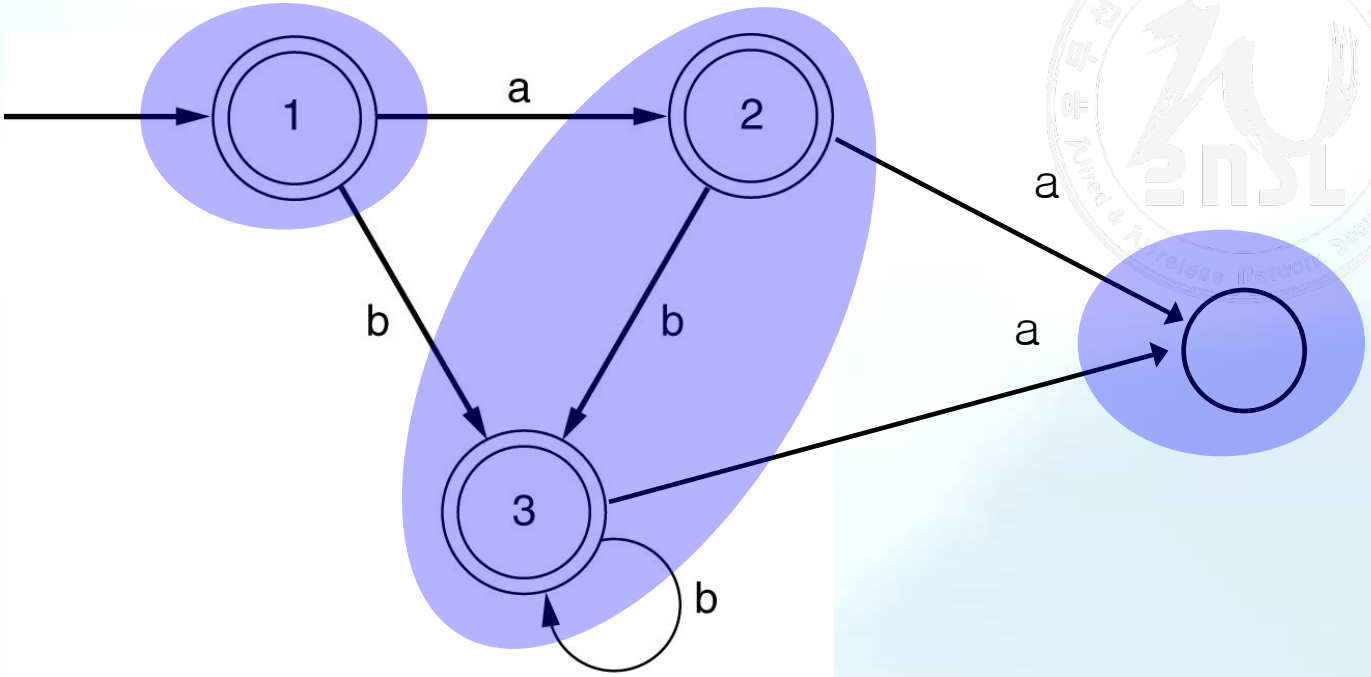
- (a|ε)b*

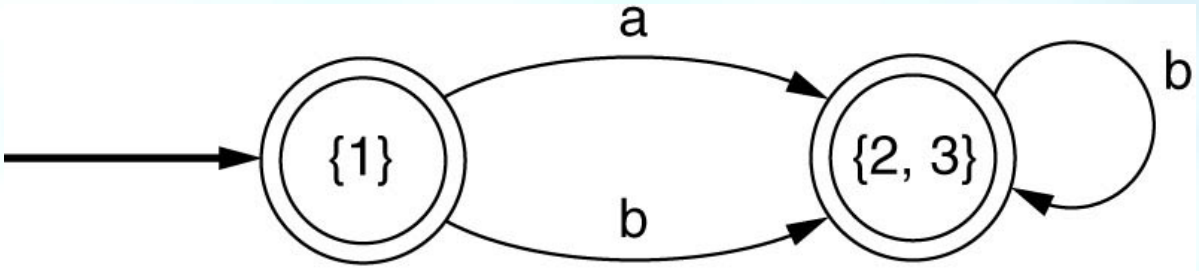


- T(1,a)≠ T(2,a)

Minimizing DFA

- (a|ε)b*





Use of Lex to generate a scanner automatically

- Lex program
  - Input: a text file containing
    - Regular expressions
    - Actions to be taken when each expression is matched
  - Output: C source code (lex.yy.c or lexyy.c)
    - Defining a procedure yylex
      - that is a table-driven implementation of a DFA
      - that operates like a getToken procedure

Metacharacter conventions in Lex

- Table 2.2

Pattern	Meaning
`a`	the character *a*
`"a"`	the character *a*, even if *a* is a metacharacter
`\a`	the character *a* when *a* is a metacharacter
`a*`	zero or more repetitions of *a*
`a+`	one or more repetitions of *a*
`a?`	an optional *a*
`a|b`	*a* or *b*
`(a)`	*a* itself
`[abc]`	any of the characters *a*, *b*, or *c*
`[a-d]`	any of the characters *a*, *b*, *c*, or *d*
`[^ab]`	any character except *a* or *b*
`.`	any character except a newline
`{xxx}`	the regular expression that the name *xxx* represents

Format of a Lex input file

{definitions}

%%

{rules}

%%

{auxiliary routines}

Table 2.3 Some Lex internal names

Lex Internal Name	Meaning/Use
lex.yy.c or **lexyy.c**	Lex output file name
yylex	Lex scanning routine
yytext	string matched on current action
yyin	Lex input file (default: **stdin**)
yyout	Lex output file (default: **stdout**)
input	Lex buffered input routine
ECHO	Lex default action (print **yytext** to **yyout**)

Homework #1

- Exercises
  - 2.1, 2.2, 2.12, 2.13, 2.16
- 주의 사항
  - Handwriting으로 제출
  - Cover page는 생략. 첫 번째 페이지에 homework 번호, 학번, 이름 기입