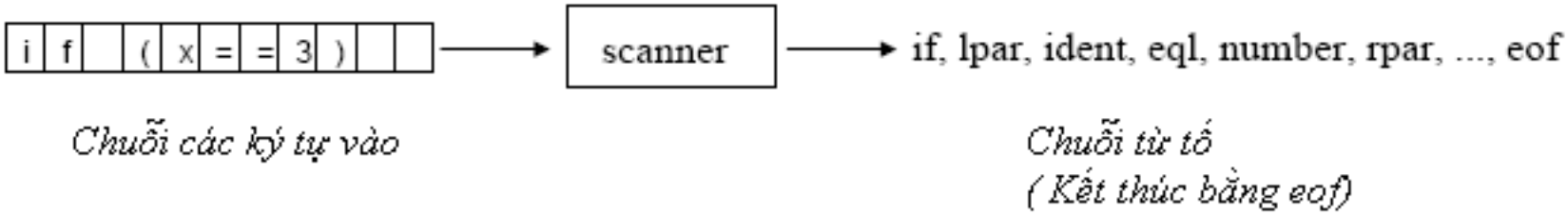
ĐẠI HỌC BÁCH KHOA HÀ NỘI
VIỆN CÔNG NGHỆ THÔNG TIN VÀ TRUYỀN THÔNG

Unit 5
Scanner

Task of a scanner

- Delivers tokens



- blanks
- Tabulator characters
- End-of-line characters (CR,LF)
- Comments

Tokens have a syntactic structure

```
ident =     letter {letter | digit}.
number =    digit {digit}.
if =        "i" "f".
eql =       "=" "=".
...
```

- Why is scanning not a part of parsing?

Why is scanning not a part of parsing?

- It would make parsing more complicated,e.g.
  - Difficult distinction between identifiers and keywords
  - The scanner must have complicated rules for eliminating blanks, tabs, comments,etc.
  - => would lead to very complicated grammars

Token classes of KPL

- Unsigned integer
- Identifier
- Key word: begin,end, if,then, while, do, call, const, var, procedure, program,type, function,of,integer,char,else,for, to,array
- Character constant
- Operators:
  - Arithmetic

    + - */
  - Relational

    = != < > <= >=

  Assign :=
- Separators

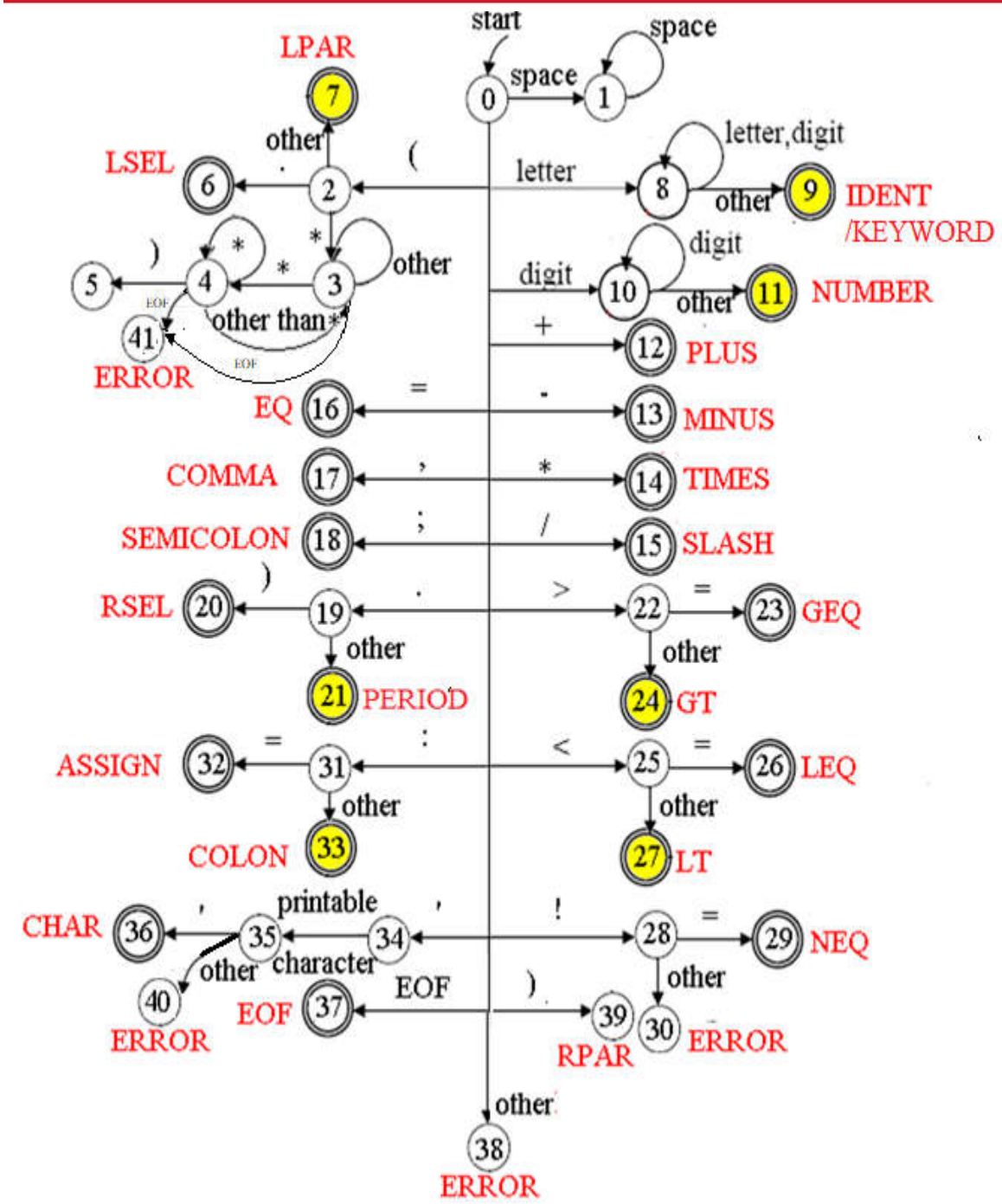
  ( ) . : ; (. .)

Finite Automata

- A finite automaton is **a state machine that takes a string of symbols as input and changes its state accordingly**.
- Finite automata theory is a part of our life.
- Have you ever seen a vendor machine , or any equipment controlled by an automaton like a washing machine,a traffic light, an elevator, etc ?
- In compiler, finite automata can be used to recognize whether a string adheres to the syntax of a language. A finite automaton can be used to build a syntax tree in a bottom-up parsing method

State diagrams of finite automata

- State diagrams are directed graphs whose nodes are states and whose arcs are labeled by one or more symbols from some alphabet Σ.
- One state is initial (denoted by a short incoming arrow)
- Several states are final/accepting (denoted by a double circle).
- DFA: For every symbol $a \in \Sigma$ there is an arc labeled a emanating from every state



The scanner as a Deterministic Finite Automaton

After every recognized token, the scanner starts in state 0 again

If an illegal character is met, the scanner would change to the states 30 or 38 which tell the scanner to stop scanning and return error messages.

Notice the yellow states

Scanner implementation based on DFA

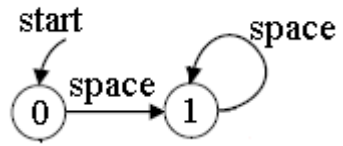
```
state = 0;
currentChar = getCurrentChar;
token = getToken();
while ( token!=EOF)
  {
      state =0;
      token = getToken();
   }
```

Token recognizer

```
switch (state)
{
case 0 : currentChar =
  getCurrentChar();
  switch (currentChar)
  {
    case space
       state = 1;
    case  lpar
       state = 2;
    case  letter
       state = 8;
    case digit
       state =10;
    case plus
       state = 12;
    .....
  }
```

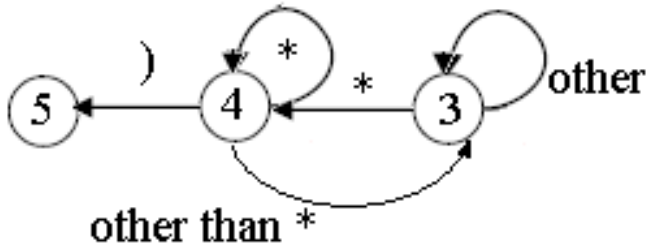
Token recognizer (cont'd)

```
case 1:
  while (current Char== space) // skip bla
       currentChar = getCurrentChar();
  state =0;
 case 2:
  currentChar = getCurrentChar();
        switch  (currentChar)
       {
       case period
             state = 6;//  token lsel
       case times
             state =3; //skip comment
          else
                   state =7; // token lpar
       }
```



Token recognizer (cont'd)

```
case 3: // skip comment
  currentChar = getCurrentChar();
  while (currentChar != times)
  {
        state = 3;
        currentChar = getCurrentChar();
  }
  state = 4;
case 4:
  currentChar = getCurrentChar();
  while (currentChar == times)
  {
        state = 4;
        currentChar = getCurrentChar();
  }
If  (currentChar == lpar)  state = 5; else state =3;
```



Token recognizer (cont'd)

```
case 9:
   if (checkKeyword (token) ==
TK_NONE)
install_ident();// save to symbol
table
else
return checkKeyword(token);
.....
```

Initialize a symbol table

- The following information about identifiers is saved
  - Name:string
  - Attribute : type name, variable name, constant name. . .
  - Data type
  - Scope
  - Address and size of the memory where the lexeme is located
  - . . .

Distinction between identifiers and keywords

- Variable ch is assigned with the first character of the lexeme.
- Read all digits and letters into string t
- Use binary search algorithm to find if there is an entry for that string in table of keyword
- If found t.kind = order of the keyword
- Otherwise, t.kind =ident
- At last, variable ch contains the first character of the next lexeme

Data structure for tokens

```
enum {
  TK_NONE, TK_IDENT, TK_NUMBER, TK_CHAR, TK_EOF,

  KW_PROGRAM, KW_CONST, KW_TYPE, KW_VAR,
  KW_INTEGER, KW_CHAR, KW_ARRAY, KW_OF,
  KW_FUNCTION, KW_PROCEDURE,
  KW_BEGIN, KW_END, KW_CALL,
  KW_IF, KW_THEN, KW_ELSE,
  KW_WHILE, KW_DO, KW_FOR, KW_TO,

  SB_SEMICOLON, SB_COLON, SB_PERIOD, SB_COMMA,
  SB_ASSIGN, SB_EQ, SB_NEQ, SB_LT, SB_LE, SB_GT, SB_GE,
  SB_PLUS, SB_MINUS, SB_TIMES, SB_SLASH,
  SB_LPAR, SB_RPAR, SB_LSEL, SB_RSEL
};
```