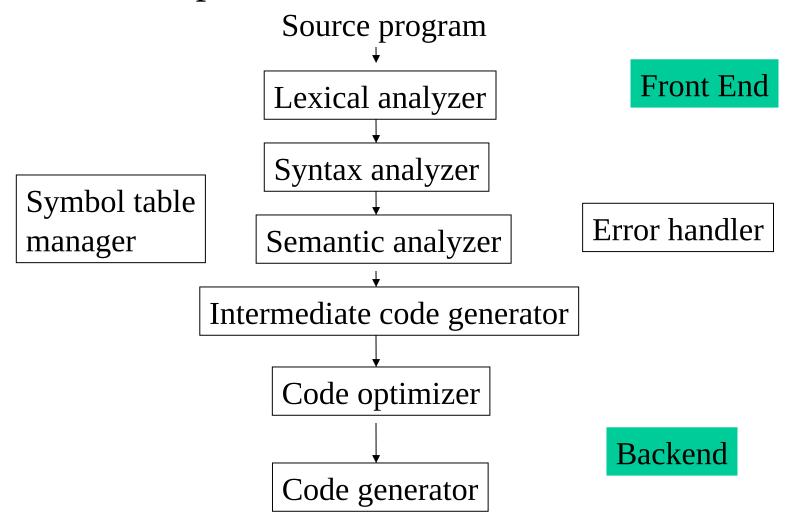
Review: Compiler Phases:

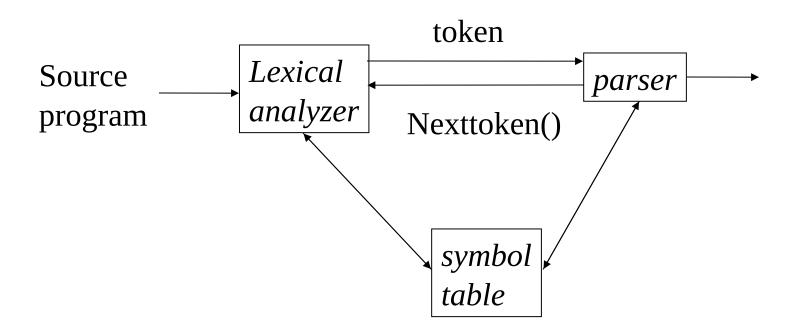


Chapter 3: Lexical Analysis

- Lexical analyzer: reads input characters and produces a sequence of tokens as output (nexttoken()).
 - Trying to understand each element in a program.
 - Token: a group of characters having a collective meaning.
 const pi = 3.14159;

```
Token 1: (const, -)
Token 2: (identifier, 'pi')
Token 3: (=, -)
Token 4: (realnumber, 3.14159)
Token 5: (;, -)
```

Interaction of Lexical analyzer with parser



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Some terminology:

- Token: a group of characters having a collective meaning. A *lexeme* is a particular instant of a token.
 - E.g. token: identifier, lexeme: pi, etc.
- *pattern*: the rule describing how a token can be formed.
 - E.g. identifier: ([a-z]|[A-Z])([a-z]|[A-Z]|[0-9])*
- Lexical analyzer does not have to be an individual phase. But having a separate phase simplifies the design and improves the efficiency and portability.

- Two issues in lexical analysis.
 - How to specify tokens (patterns)?
 - How to recognize the tokens giving a token specification (how to implement the nexttoken() routine)?

How to specify tokens:

 all the basic elements in a language must be tokens so that they can be recognized.

```
main() {
    int i, j;
    for (I=0; I<50; I++) {
        printf("I = %d", I);
    }
}
```

- Token types: constant, identifier, reserved word, operator and misc. symbol.
- Tokens are specified by regular expressions.

Some definitions

- *alphabet* : a finite set of symbols. E.g. {a, b, c}
- A *string* over an alphabet is a finite sequence of symbols drawn from that alphabet (sometimes a string is also called a sentence or a word).
- A *language* is a set of strings over an alphabet.
- Operation on languages (a set):
 - union of L and M, L U M = $\{s | s \text{ is in L or s is in M}\}$
 - concatenation of L and MLM = {st | s is in L and t is in M}
 - Kleene closure of L,

- L^{i}
- Positive closure of L,

- Example:
 - L={aa, bb, cc}, M = {abc}

- Formal definition of Regular expression:f
 - Given an alphabet \sum ,
 - (1) \mathcal{E} is a regular expression that denote { \mathcal{E} }, the set that contains the empty string.
 - (2) For each $a \in \sum$, a is a regular expression denote {a}, the set containing the string a.
 - (3) r and s are regular expressions denoting the language (set) L(r) and L(s). Then
 - -(r)|(s) is a regular expression denoting L(r)UL(s)
 - -(r)(s) is a regular expression denoting L(r)L(s)
 - $-(r)^*$ is a regular expression denoting $(L(r))^*$
 - Regular expression is defined together with the language it denotes.

• Examples:

- let
$$\sum = [a,b]$$

a | b
(a | b) (a | b)
a *
(a | b)*
a | a*b

- We assume that '*' has the highest precedence and is left associative. Concatenation has second highest precedence and is left associative and '|' has the lowest precedence and is left associative
 - (a) |((b)*(c)) = a | b*c

Regular definition.

 gives names to regular expressions to construct more complicate regular expressions.

– example:

• more examples: integer constant, string constants, reserved words, operator, real constant.