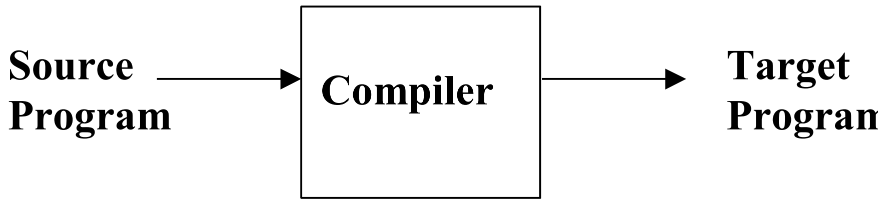
Overview of Compilation (Objectives)

- The student will be able to name and describe the different phases of a compiler.
- The student will be able to name the principles of compiler design

What is a compiler?

- A compiler is just a program that takes other programs and converts them into a form that is understood by an assembler so that it can be assembled, linked and run on a computer



Principles of Compiler Design

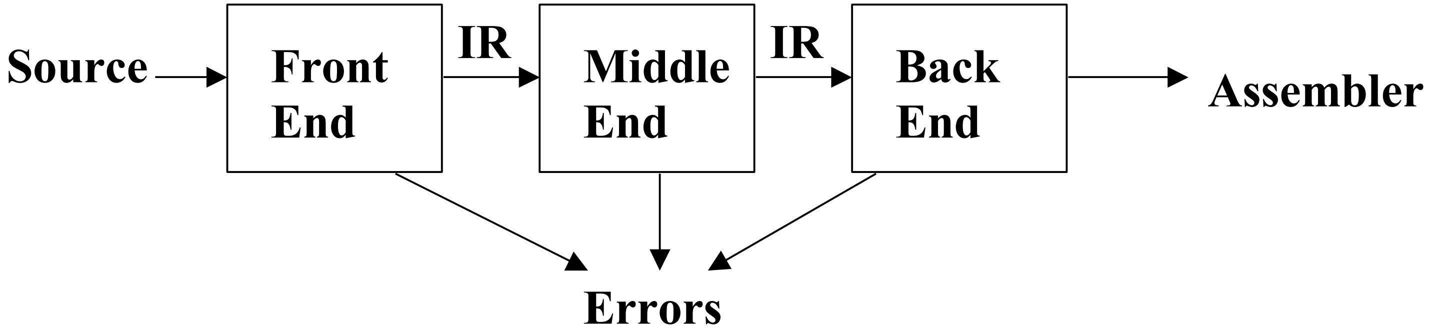
- The compiler must preserve the meaning of the program being compiled
  - The compiler must faithfully implement the defined semantics of a programming language.
- The compiler must improve the source code in a discernable way
  - A direct translation of a source program results in highly inefficient code.

Some Possible Constraints

- Code speed
  - Very fast code might be the highest need of an application
    - e.g., weather
- Code size
  - How much space the object code requires
    - e.g., embedded systems
- Feedback
  - How much feedback is given to the user when an error is encountered
- Compile time
  - programs need to be compiled as fast as possible
- Debugging support
  - code improvements may make debugging difficult

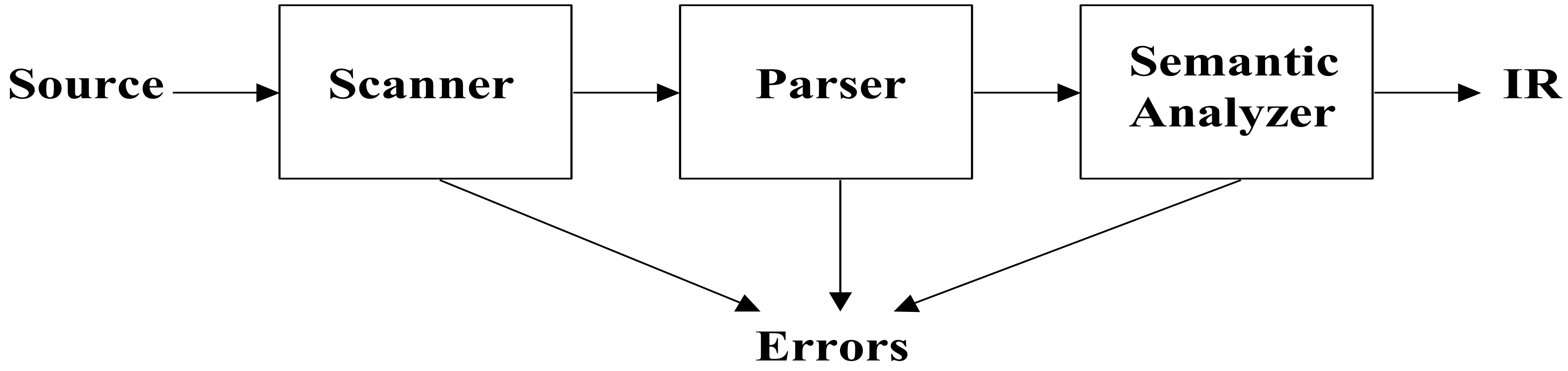
Overview of Compiler Phases

- Basic phases



Front End

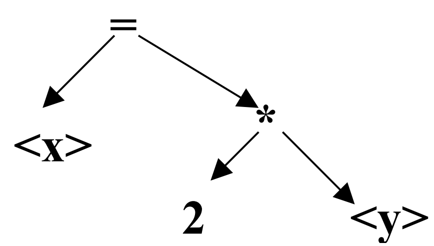
- Syntax Analysis
  - determine if programs made up of valid sentences
    - scanner - valid words (reserved words, variables, etc.)
    - parser - valid sentence structure (*if* statements, etc.)
    - semantic analyzer - determine if sentences have meaning (type checking)



Front End

- Lexical Analysis
  - convert words in a program into tokens
    - <var>
    - +, -, =
    - IF, THEN, FOR
- Parsing
  - convert sentences into their structure

x = 2*y

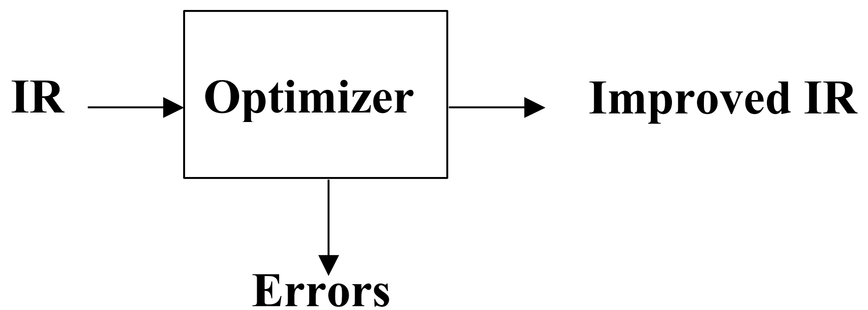


Front End

- Semantic Analysis (context-sensitive analysis)
  - after the program is parsed it is checked to make sure its meaning can be determined
    - type checking
    - number of parameters
    - variables declared
    - functions have prototypes
    - recursion supported or not
- If the program passes semantic analysis, it is converted into an intermediate representation (IR) that is used by the back end

Middle End

- Basic structure
  - often the IR is like assembler



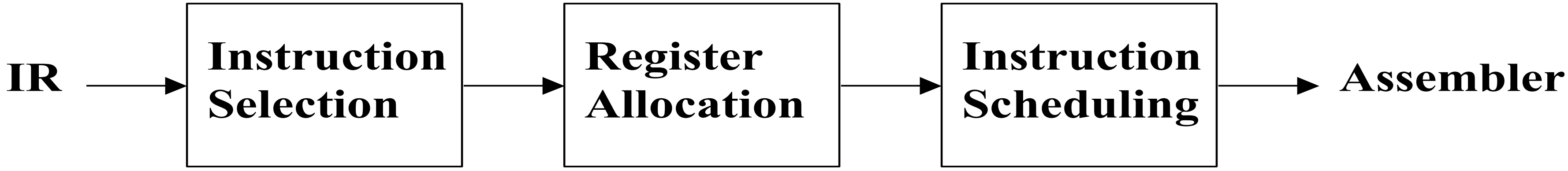
- Optimizer is machine-independent

Middle End

- Optimization
  - remove redundancy
  - remove useless code
  - move code out of loops
  - use constants where possible
  - use less expensive operations

Back End

- Basic phases



- Order of allocation and scheduling may be different

Example

- Consider the following

  w = w * 2 * x * y * w*2

- Compiler first must recognize
  - variable names
  - =, *
- Next it must determine that the statement is in the source language
- Then, it must make sure the types are correct

Example

- Next it must allocate space for the variables
  - stack?
  - data segment?
  - registers?
- Then, the front end might generate

loadAI	r_{sp},@w → r_w
loadI	2 → r_2
mult	r_w, r_2 → r_{t1}
loadAI	r_{sp}, @x → r_x
mult	r_x, r_{t1} → r_{t2}
loadAI	r_{sp}, @y, r_y
mult	r_y, r_{t2} → r_{t3}
loadAI	r_{sp}, @w → r_w
mult	r_w, r_{t3} → r_{t4}
loadI	2 → r_2
mult	r_2, r_{t4} → r_{t5}
storeAI	r_{t5} → r_{sp},r_w

Example

- Optimization is next
  - eliminate extra loads of w and 2 and extra multiplication of w*2

loadAI	r_{sp},@w → r_w
loadI	2 → r_2
mult	r_w, r_2 → r_{t1}
loadAI	r_{sp}, @x → r_x
mult	r_x, r_{t1} → r_{t2}
loadAI	r_{sp}, @y, r_y
mult	r_y, r_{t2} → r_{t3}
mult	r_{t1}, r_{t3} → r_{t4}
storeAI	r_{t4} → r_{sp},r_w

  - Code generation converts the intermediate into the target machines assembler.