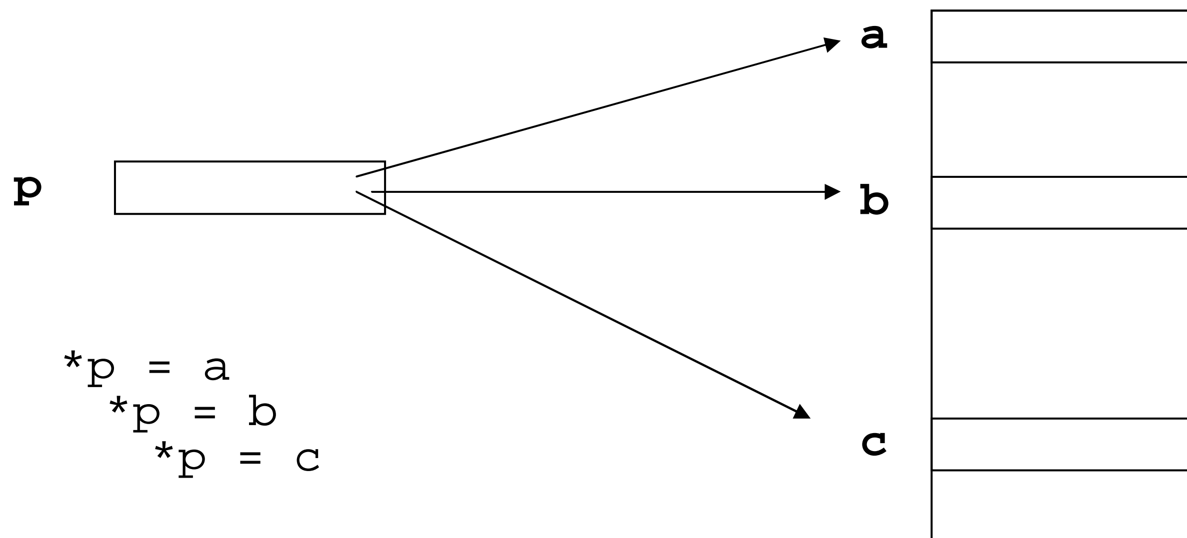
More about Program Structures

Pointers

- A pointer stores an address
  - which point to a variable of some type
- A single pointer can point to different variables at different times



Pointers to Functions

- A pointer to functions also provide you the flexibility.
  - It will call the function whose address was last assigned to the pointer.
- A pointer to a function must contain
  - The memory address of the function
  - The parameter list
  - The return type

Declaring Pointers to Functions

- `double (*pfun) (char*, int);`
  - The parentheses around the pointer name, `pfun`, and the asterisk are necessary.
  - Otherwise, `double *pfun (char*, int)` would be a function returning a pointer to a double value.

- `long sum(long num1, long num2);`
- `long (*pfun)(long, long) = sum;`

- `long product(long, long);`
- `pfun = product;`

Ex6_01.cpp on P.273

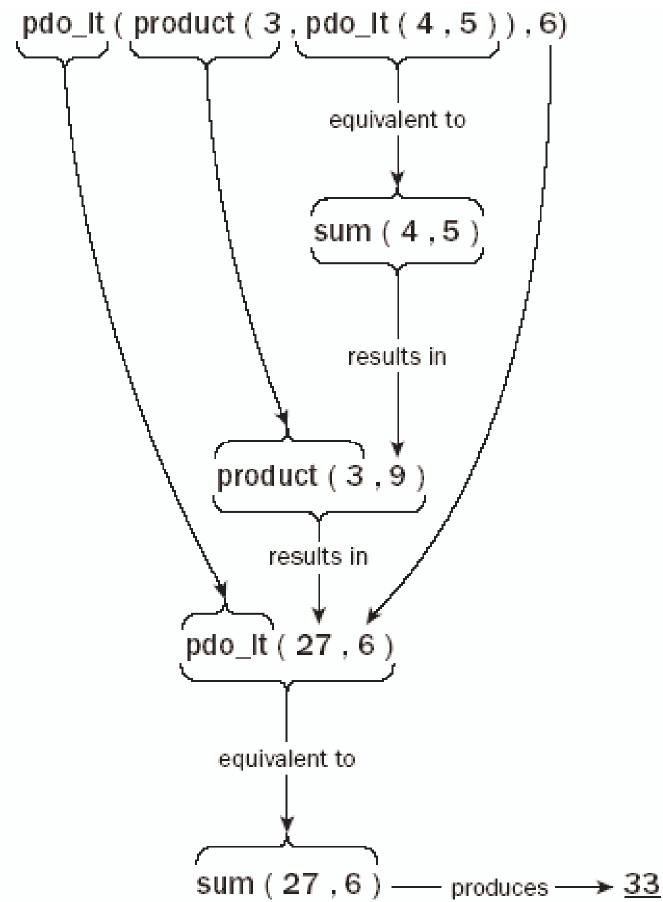


Figure 6-1

A Simpler Example

- As a matter of fact, I think Ex6_01.cpp is too complicated. I prefer the following example:

```
pdo_it = product;
cout << pdo_it(3,5) << endl;
pdo_it = sum;
cout << pdo_it(3,5) << endl;
```

A Pointer to a Function as an Argument

- Ex6_02.cpp on P.275

Arrays of Pointers to Functions

- `double sum(double, double);`
- `double product(double, double);`
- `double difference(double, double);`
- `double (*pfun[3]) (double, double) = { sum, product, difference } ;`
  - `pfun[1](2.5, 3.6);`
  - `(*pfun)(2.5, 3.6);`
  - `(*(pfun+1)) (2.5, 3.6);`

Initializing Function Parameters

- You may declare the default value of some parameters:
  - `void showit(char msg[] = “I know the default!”);`
- When you omit the argument in calling the function, the default value will be supplied automatically.
  - `showit(“Today is Wednesday.”);`
  - `showit();`
- Notes on P.279: Only the last argument(s) can be omitted.

Function Overloading

- Function overloading allows you to use the same function name for defining several functions as long as they each have different parameter lists.
- When the function is called, the compiler chooses the correct version according to the list of arguments you supply.
- The following functions share a common name, but have a different parameter list:
  - `int max(int array[], int len);`
  - `long max(long array[], int len);`
  - `double max(double array[], int len);`

Ex6_07.cpp on P.287

- Three overloaded functions of max()
- In main(), C compiler inspect the argument list to choose different version of functions.

Signature

- The signature of a function is determined by its name and its parameter list.
- All functions in a program must have unique signatures
- The following example is not valid overloading
  - `double max(long array[], int len);`
  - `long max(long array[], int len);`
- A different return type does not distinguish a function, if the signatures are the same.

Function Templates

- In Ex6_07.cpp, you still have to repeat the same code for each function, with different variable and parameter types.
- You may define a function template to ask C compiler automatically generate functions with various parameter types.

Defining a Function Template

```
template<typename T> T max(T x[], int len)
{
    T max = x[0];
    for (int i = 1; i < len; i++)
        if (max < x[i])
            max = x[i];
    return max;
}
```

Using a Function Template

- Each time you use the function `max()` in your program, the compiler checks to see if a function corresponding to the type of arguments that you have used in the function call already exists.
  - If the function does not exist, the compiler creates one by substituting the argument type in your function call to replace the parameter T.
- Compare Ex6_08.cpp and Ex6_07.cpp to see how the source code is reduced.
  - Note that using a template doesn't reduce the size of your compiled program.
- Q: Can we calculate the length of the array inside the function?

Topics in This Semester

Part 1: Object-Oriented Programming
- Defining Your Own Data Types
- More on Classes
- Class Inheritance and Virtual Functions

Part 2: Windows Programming
- Windows Programming Basics
- Microsoft Foundation Classes (MFC)
- Working with Menus and Toolbars
- Drawing in a Window
- Creating the Document and Improving the View
- Working with Dialogs and Controls
- Storing and Printing Documents
- Writing Your Own DLLs (optional)

Part 3: Database Application
- Connecting to Data Sources
- Updating Data Sources
- Applications Using Windows Forms
- Accessing Data Sources in a Windows Forms Application

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Exam

- Date: March 6th (Thursday)
- Time: 8AM-11AM
- Scope: Chapter 1 – Chapter 6

- Open Book; Turn Off Computer

Chapter 1: Programming with Visual C++ 2005

- The .NET Framework
- The Common Language Runtime (CLR)
- Using the Integrated Development Environment (IDE)

Chapter 2: Data, Variables, and Calculations

- Defining Variables
- Fundamental Data Types
  - Integer
  - Character
  - Boolean
  - Floating-Point
- Basic Input/Output Operations
- Variable Types and Casting
- Storage Duration and Scope

Chapter 3: Decisions and Loops

- Comparing Values
  - if … else …
  - switch
  - The Conditional Operator
- Repeating a Block of Statements
  - for loop
    - continue
    - break
  - while loop
  - do-while loop
- Nested loop

Chapter 4: Arrays, Strings, and Pointers

- Arrays
  - Declaring Arrays
  - Initializing Arrays
  - Character Arrays
  - Multidimensional Arrays
- Indirect Data Access – Pointer
- Dynamic Memory Allocation

Chapter 5: Functions

- Structure of a Function
- Passing Arguments to a Function
  - The Pass-by-value Mechanism
  - Pointers as Arguments to a Function
  - References as Arguments to a Function
- Returning Values from a Function
  - Returning a Pointer
  - Returning a Reference
  - Static Variables in a Function
- Recursive Function Calls

Chapter 6: More about Functions

- Pointers to Functions
- Initializing Function Parameters
- Exceptions
- Function Overloading
- Function Templates

Case Study: Implementing a Calculator

- Goal
  - Design a program which acts as a calculator.
  - It will take an arithmetic expression, evaluate it, and print out the result.
  - For example, taking the input string "2 * 3.14159 *   12.6   * 12.6 /2   + 25.2 * 25.2" will obtain the result "1133.0".
- To make it simple at the first stage,
  - The whole computation must be entered in a single line.
  - Spaces are allowed to be placed anywhere.
  - Parentheses are not allowed in the expression.
  - Only unsigned numbers are recognized.

Step 1: Eliminating Blanks from a String

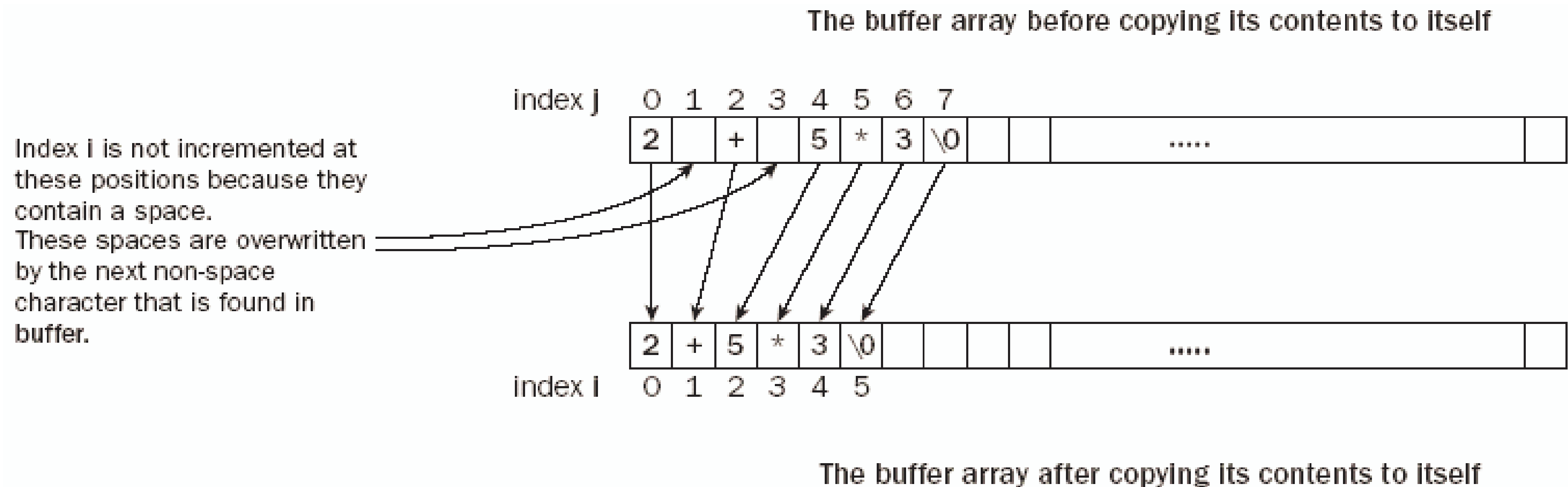


Figure 6-2

P.295

```
// Function to eliminate spaces from a string
void eatspaces(char* str)
{
   int i = 0;      // 'Copy to' index to string
   int j = 0;      // 'Copy from' index to string

   while ((*(str + i) = *(str + j++)) != '\0')
      if (*(str + i) != ' ')
         i++;
   return;
}
```

- Now, we obtain an expression with no embedding spaces.

Step 2: Evaluating an Expression

2	+	5	*	3	-	7	/	2	\0	.....	

term | addop | term | addop | term | End of input

Figure 6-3

Breaking Down an Expression into Terms and Numbers

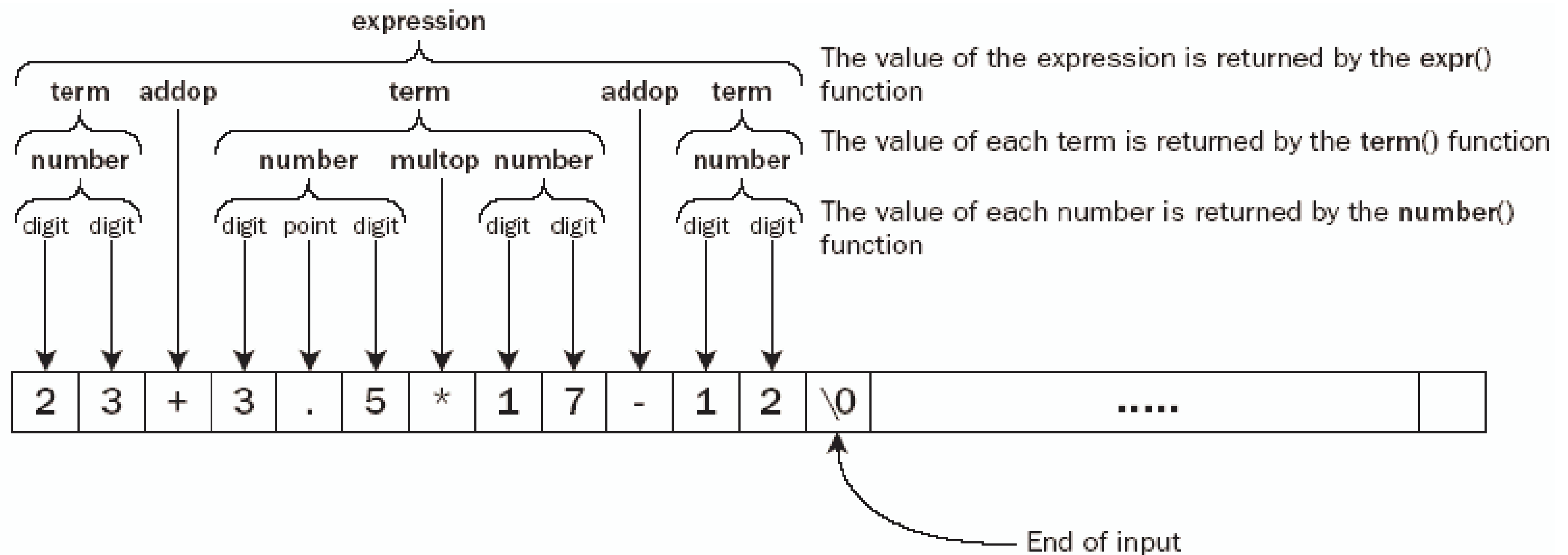
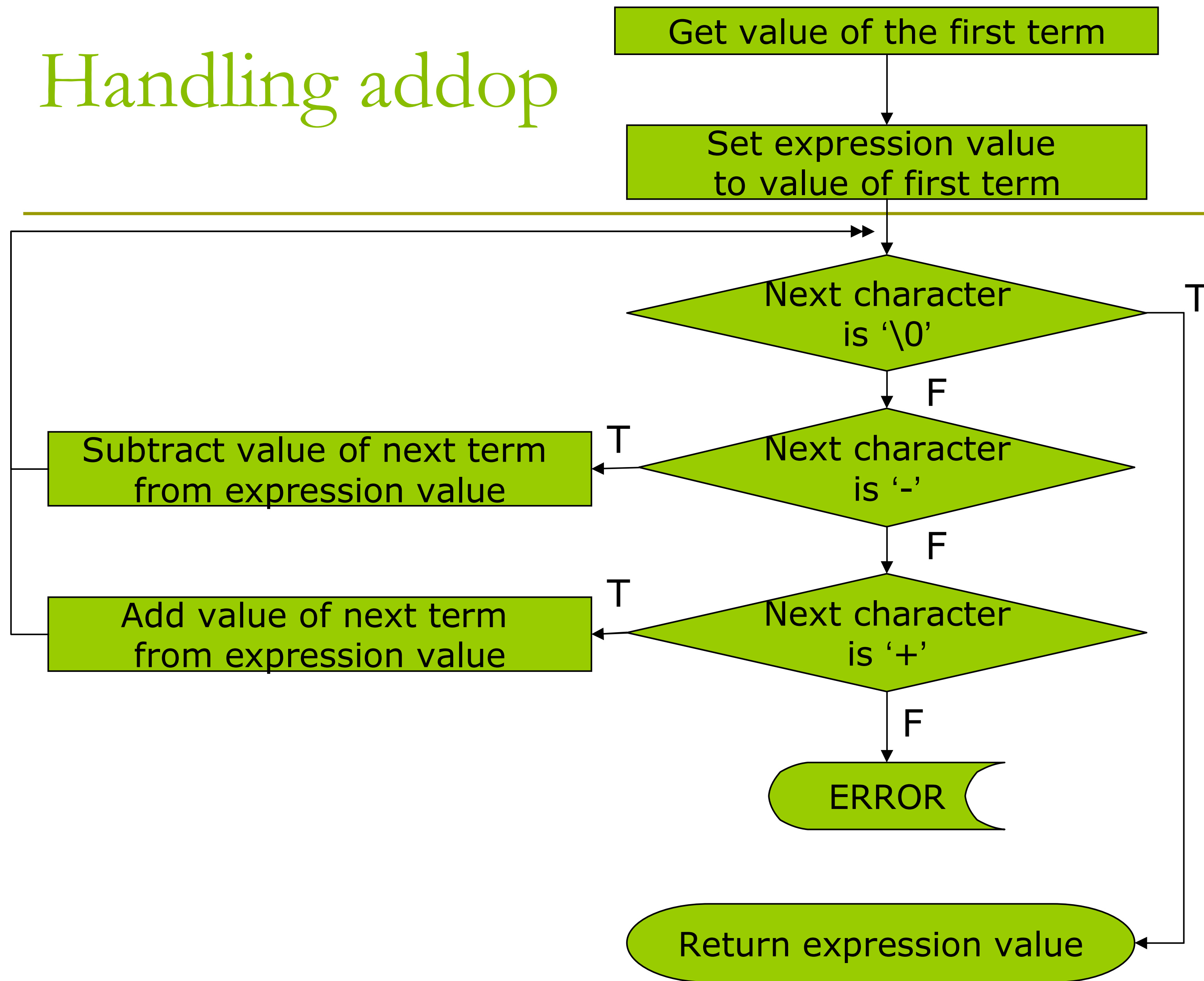


Figure 6-4

Handling addop



```
double expr(char* str)
{
    double value = 0.0;
    int index = 0;

    value = term(str, index);

    for (;;)
    {
        switch (*(str + index++))
        {
            case '\0':
                return value;
            case '-':
                value -= term(str, index);
            case '+':
                value += term(str, index);
            default:
                cout << endl << "Arrrgh!*#!! There's an error" <<
        endl;
                exit(1);
        }
    }
}
```

Getting the value of a Term

- P.298

Analyzing a Number

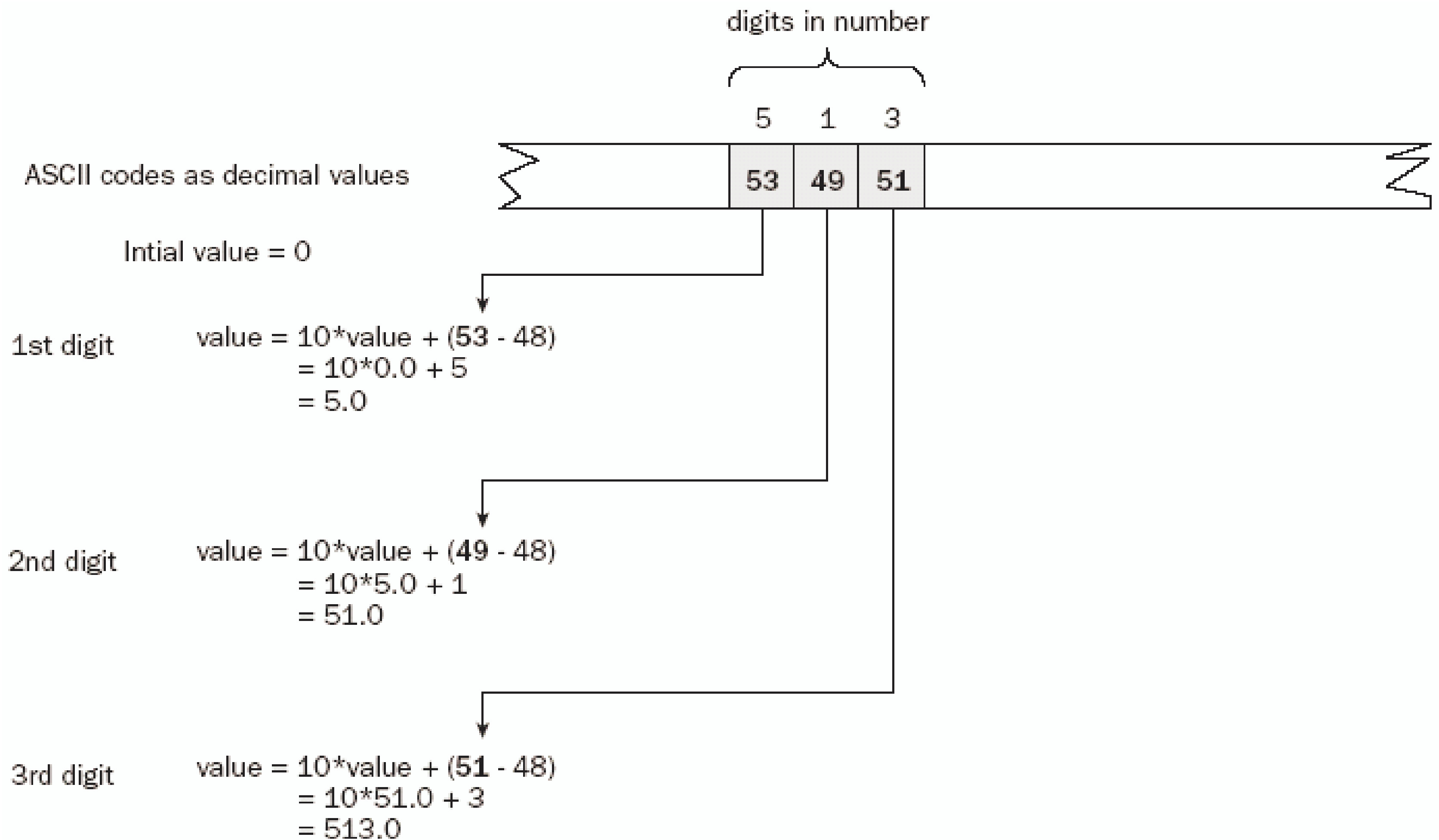


Figure 6-6

```
double number(char* str, int& index)
{
   double value = 0.0;

   while (isdigit(*(str + index)))
        value = 10 * value + ( *(str + index++) – ‘0’);

   if (*(str + index) != ‘.’)
        return value;

   double factor = 1.0;
   while (isdigit(*(str + (++index))))
   {
        factor *= 0.1;
        value = value + ( *(str + index) – ‘0’) * factor;
   }

   return value;
}
```

Handling the fractional part after the decimal point

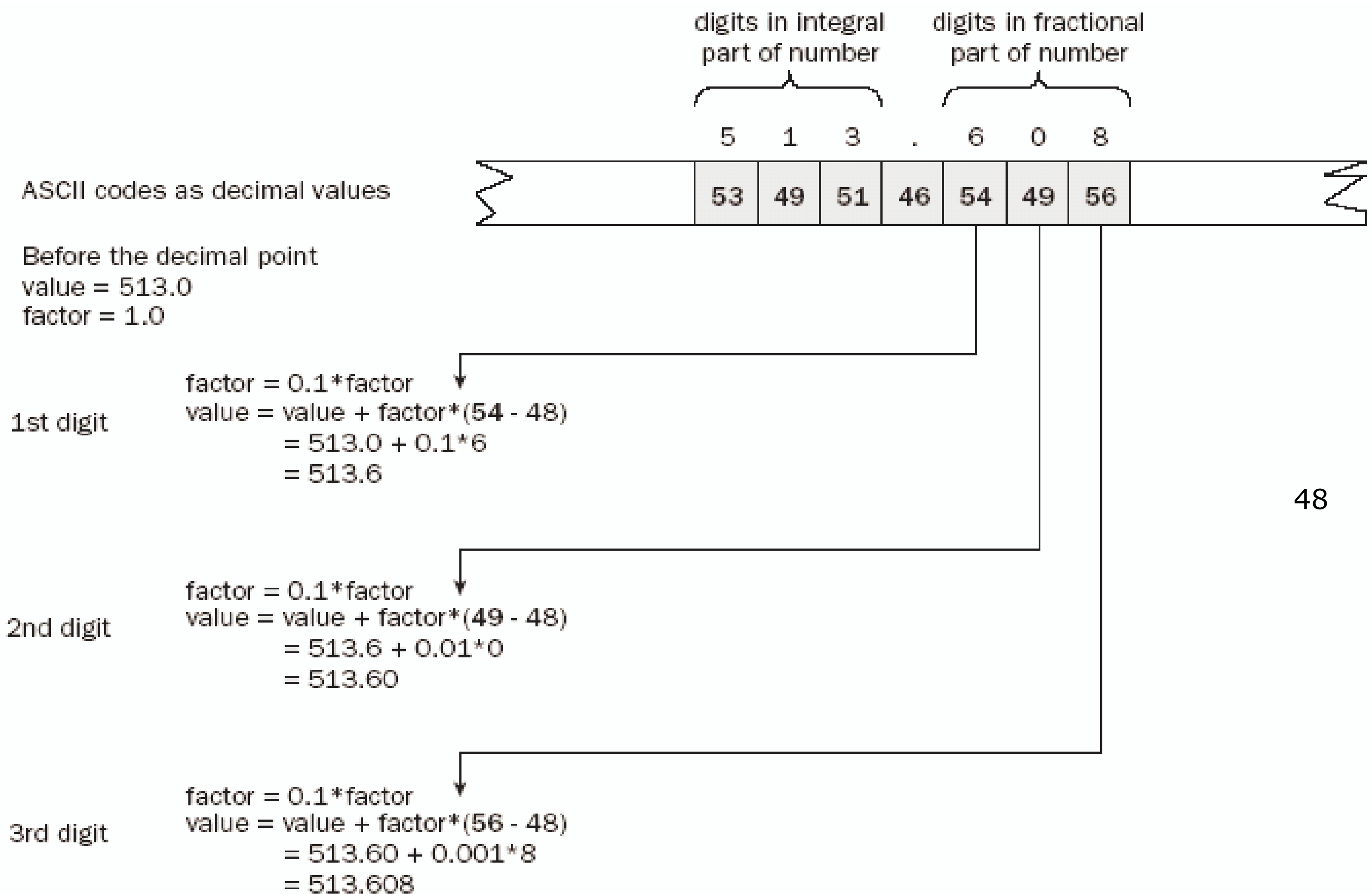


Figure 6-7

Putting the Program Together

- P.302 Ex6_09.cpp

```
#include <iostream>// For stream input/output
#include <cstdlib> // For exit() function
#include <cctype>  // For isdigit() function
```

- Use `cin.getline()` so that the input string can contain spaces.
  - See P.167

Extending the Program

- Let us try to extend it so that it can handle parentheses:
  - 2* (3 + 4) / 6 – (5 + 6) / (7+ 8)

- Idea: treat an expression in parentheses as just another number.
  - P.304
  - `expr()` recursively calls itself
    - `expr() - term() - number() - expr()`
  - The string pointed by `psubstr` is allocated in `extract()`, and must be freed as an array/

extract()

- Extract a substring between parentheses

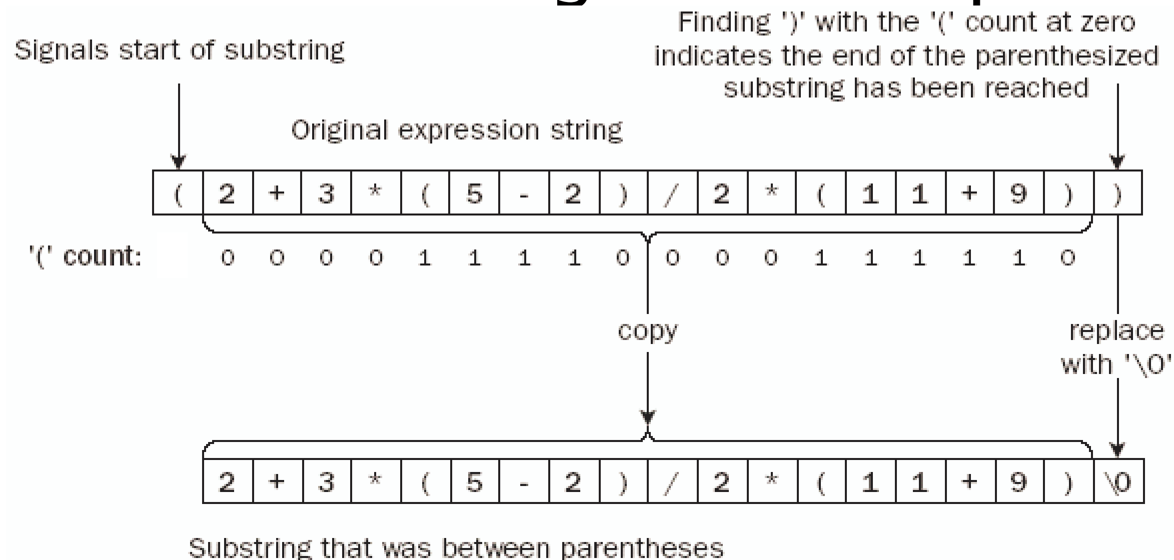


Figure 6-8

- P.306
  - Utilize `strcpy_s()` which is defined in `<cstring>` header file