Evaluating a simple expression

Parameter *s* of function *eval* contains an expression involving unsigned integers and operators + and -. There is at least one integer, followed by zero or more operator-operand pairs. There may be any number of blanks at the beginning and end of *s* and between operators and integers.

```
/** Return the value of the expression in s.
  * Precondition: s consists of a sequence of
  * at least one unsigned integer separated by
  * opera tors '+' or '-'.  There may be space
  * characters at the beginning and end of the
  * expression and between the numbers and
  * operators. */
public static int eval(String s)
```

Function *eval* will evaluate the expression in *s* and return the value. Here are examples:

eval("3")	returns 3
eval ("3 + 4")	returns 7
eval("100 - 25+50")	returns 125
eval("9")	returns 9
eval(" 7 + 7 +7 ")	returns 21

The first point to note is that there may be spaces all over the place. If we removed them, then following each integer (except the last) would be an operator + or –, and following each operator would be a digit. That could simplify out task, so we start off with a statement to remove all blanks.

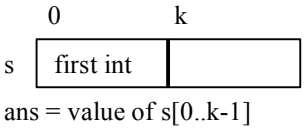
```
s= s.replace(" ", "");
```

Now, the tendency is to immediately write a loop to process parameter *s*, looking at one character at a time:

```
for (int k= 0; k < s.length(); k= k+ 1) { Process s[k] }
```

This sudden introduction of a loop leads to all sorts of complications. Before introducing such a loop, think more about the situation.

Note that there is always a first operand, and that may be all there is, so we think of writing a statement-comment. It uses two new local variables. Variable *ans* now contains the value of the first integer, and *k* contains the index of the character following the first integer, as shown in the diagram to the right.




```
// Store the first integer in s into local variable ans and set k to the character following it.
```

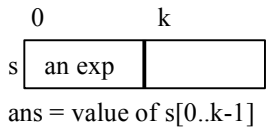
Now, the rest of *s* to process, *s*[*k*..], contains a sequence of zero or more operator-operand pairs, like

```
+234      -6    -6343     +12
```

Therefore, we think of writing a loop that, at each iteration, processes one operator-operand pair. This is the important step of having the structure of the loop reflect the structure of the data.

How is an operator-operand pairs to be processed? Its contribution to the answer can be accumulated in variable *ans*. And *k* can be set to the position following the pair. Note how the obvious loop invariant, shown to the right below, is a simple generalization of the precondition given above. Instead of the first segment containing the first int, it contains the part of the expression processed thus far.

```
// invariant: s[0..k-1] is a complete expression, ans is its value, and
//              if s[k] exists, it starts an unsigned integer
while (k < s.length() {
    // process the operator-operand pair that starts at s[k]:
    // Add its value to ans and change k to the index after that pair
}
```



Note that we avoided figuring out how to implement the two statement-comments, preferring to get the overall structure down first.

After the loop, of course, *ans* must be returned.

Evaluating a simple expression

The first statement-comment requires finding the end of the integer that starts at s[0]. The second one require finding the end of the integer that starts at s[k+1] —after the operator. The same task must be done in two places. So, we use the mañana principle and write a function header and specification.

```
/** s[h] is a digit. Return the integer t such that
  *  s[h..t-1] is a list of digits but s[h..t] isn't. */
public static int getEnd(String s, int h)
```

It is given the *String s* and an index *h*. Character *s*[*h*] is a digit. And it should return the index *following* the last digit of the integer that begins in *s*[*h*].

We implement the first statement-comment. Call *getEnd* to find the index following the integer and store it in *k*. Then use function parseInt to extract the integer in *s*[0..*k*-1] and store its value in *ans*.

We implement the second statement-comment. First, save the index of the start of the operator-operand pair in *h*. Then call *getEnd* to find the index following the integer and store it in *k*. Then use function *parseInt* to extract the integer in *s*[*h*..*k*-1] and store its value in *n*. Finally, use a conditional expression based on operator *s*[*h*] to add *n* to *ans* or subtract *n* from *ans*.

This completes the development of function *eval*.

```
/** Return the value of the expression in s. …  */
public static int eval(String s) {
   s= s.replace(" ", "");

  // Store the first integer into local variable ans,
  // set local variable k to index following first integer
  int k= getEnd(s, 0);
  int ans= Integer.parseInt(s.substring(0, k));

  while (k < s.length()) {
     // Process operator-operand pair that starts at s[k]:
     // Add value to ans, change k to index after that pair
     int h= k;  // index of start of operator-operand pair
     k= getEnd(s, k+1);
     int n= Integer.parseInt(s.substring(h+1, k));
     ans=  s.charAt(h) == "+"  ?  ans+n  :  ans-n;
  }
  return ans;
}
```

It remains to implement function getEnd! It has a loop that checks successive characters until either the end of the string or a non-digit is reached.

```
/** s[h] is a digit. Return the integer t such that
    *  s[h..t-1] is a list of digits but s[h..t] isn't. */
public static int getEnd(String s, int h) {
   int t= h+1;
   while (t < s.length()  &&
           Character.isDigit(s.charAt(t))) {
       t= t + 1;
   }
   return t;
}
```