ICS Homework 6

March 23, 2023

1 Organization

Usually we use the following representation of polynomials in math:

$$f(x) = a_n * x^n + a_{n-1} * x^{n-1} + ... + a_1 * x + a_0$$

But this form is not suitable for computation in computer. Instead, we use the following representation:

$$f(x) = a_0 + x * (a_1 + x * (a_2 + ... + x * (a_{n-1} + xa_n)))$$

1.1

Please explain why the latter representation is faster. (HINT: Consider the number of computation primitive used)

Calculate x^n is expensive. Even we calculate it iteratively, there is still one more multiplication to get $a_i * x^i$ in each iteration.

1.2

We have the following code to evaluate the polynomial on a given x, but it's very slow. Please optimize it using machine-independent optimization.

```
1
2  struct coefficient {
3      int a;
4      struct coefficient *next;
5  };
6
7  int get_n(struct coefficient *alist) {
8      int n = 0;
9      while (alist) {
10         n++;
11         alist = alist->next;
12     }
13     return n;
14 }
```

```
1
2  int get_ai(struct coefficient *alist, int i) {
3      int current = get_n(alist);
4      while (current != i) {
5          alist = alist->next;
6          current--;
7      }
8      return alist->a;
9  }
10
11 int cal(struct coefficient *alist, int x) {
12     int result = get_ai(alist, n);
13     int n = 0;
14     for (int i = get_n(alist) - 1; i >= 0; i --)
15         result = result * x +
16             get_ai(alist, i);
17     return result;
18 }
```

ANS:

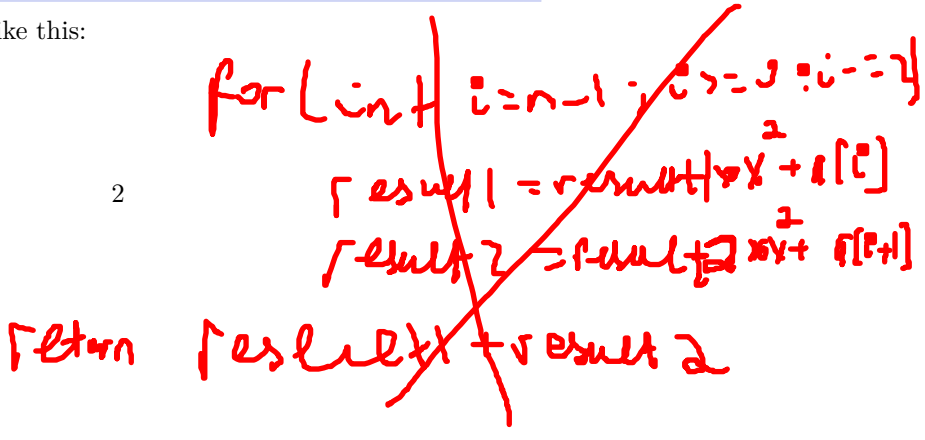
```
1  int calculate(struct coefficient *alist, int x) {
2      int result = alist->a;
3      alist = alist->next;
4      while (alist) {
5          result = result * x + alist->a;
6          alist = alist->next;
7      }
8      return result;
9  }
```

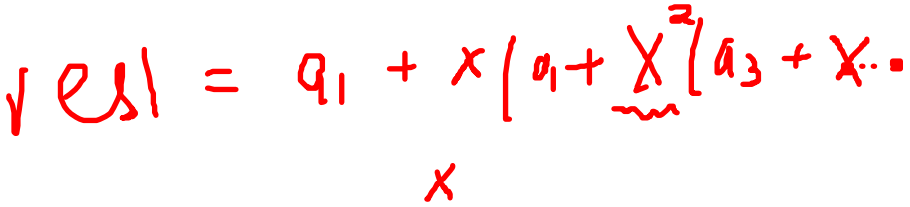
1.3

Here is the array version of the function. We place a_i in `a[i]` now.

```
1  int cal(int *a, int n, int x) {
2      int result = a[n];
3      for (int i = n - 1; i >= 0; i--)
4          result = result * x + a[i];
5  }
```

And the asm code looks like this:





```
1  loop:
2      testl %ebx, %ebx
3      jge done
4      imull %r13d, %edx
5      movl (%r14, %ebx, 4), %eax
6      addl %eax, %edx
7      subl $1, %ebx
8      jmp loop
9  done:
```

Can you use multiple accumulators to optimize this program? How or Why?
No. Each iteration must use the result generated in the last iteration.