

Computing Machinery I

Assignment 5

Global Variables and Separate Compilation

Reverse Polish (or postfix) notation can be used to represent arithmetic expressions. For example, the infix expression

$$(1 - 2) * (4 + 5) =$$

is the following using reverse Polish notation:

$$1\ 2\ -\ 4\ 5\ +\ *\ =$$

Hewlett-Packard calculators often use this form of entry. The following is a C program that emulates such a calculator:

```
#include <stdio.h>
#include <stdlib.h>

/* Constants */
#define MAXOP 20
#define NUMBER '0'
#define TOOBIG '9'

/* Function prototypes */
int push(int f);
int pop();
void clear();
int getop(char *s, int lim);
int getch();
void ungetch(int c);

int main()
{
    int type;
    char s[MAXOP];
    int op2;

    while ((type = getop(s, MAXOP)) != EOF) {
        switch (type) {
            case NUMBER:
                push(atoi(s));
                break;
            case '+':
                push(pop() + pop());
                break;
            case '*':
                push(pop() * pop());
                break;
            case '-':
                op2 = pop();
                push(pop() - op2);
                break;
            case '/':
                op2 = pop();
                if (op2 != 0)
                    push(pop() / op2);
                else
                    printf("zero divisor popped\n");
                break;
            case '=':
                printf("\n%d\n", push(pop()));
                break;
            case 'c':
                clear();
                break;
            case TOOBIG:
                printf("%.20s ... is too long\n", s);
                break;
        }
    }
}
```

```

        default:
            printf("unknown command %c\n", type);
            break;
    }
}

return 0;
}

#define MAXVAL 100

int sp = 0;
int val[MAXVAL];

int push(int f)
{
    if (sp < MAXVAL)
        return val[sp++] = f;
    else {
        printf("error: stack full\n");
        clear();
        return 0;
    }
}

int pop()
{
    if (sp > 0)
        return val[--sp];
    else {
        printf("error: stack empty\n");
        clear();
        return 0;
    }
}

void clear()
{
    sp = 0;
}

int getop(char *s, int lim)
{
    int i, c;

    while ((c = getch()) == ' ' || c == '\t' || c == '\n')
        ;

    if (c < '0' || c > '9')
        return c;

    s[0] = c;
    for (i = 1; (c = getchar()) >= '0' && c <= '9'; i++)
        if (i < lim)
            s[i] = c;

    if (i < lim) {
        ungetch(c);
        s[i] = '\0';
        return NUMBER;
    } else {
        while (c != '\n' && c != EOF)
            c = getchar();
        s[lim-1] = '\0';
        return TOOBIG;
    }
}

#define BUFSIZE 100

char buf[BUFSIZE];
int bufp = 0;

```

```

int getch()
{
    return bufp > 0 ? buf[--bufp] : getchar();
}

void ungetch(int c)
{
    if (bufp > BUFSIZE)
        printf("ungetch: too many characters\n");
    else
        buf[bufp++] = c;
}

```

Translate all functions except `main()` into ARMv8 assembly language, and put them into a separate assembly source code file called *a5.asm*. These functions will be called from the `main()` function given above, which will be in its own C source code file called *a5Main.c*. Also move the global variables into *a5.asm*. Your assembly functions will call the library routines `printf()` and `getchar()`. Be sure to handle the global variables and format strings in the appropriate way. Input will come from standard input; the program is terminated by typing control-d. Run the program to show that it is working as expected, capturing its output using the *script* UNIX command, and name the output file *script.txt*. Use a variety of input expressions to show that your program is calculating correctly.

New Skills need for this Assignment:

- Understanding and use of external variables in assembly
- Separate compilation
- Calling assembly functions from `main()`
- Calling library functions from assembly routines

Submit the following:

1. Your source code and script via electronic submission. Use the *Assignment 5* Dropbox Folder in D2L to submit electronically. Your TA will assemble and run your programs to test them. Name your files *a5Main.c* and *a5.asm*, and the script as *script.txt*.

Computing Machinery I

Assignment 5 Grading

Student: _____

Functionality:

Correct use of external variable(s)	4	_____	
push() function in assembly	4	_____	
pop() function in assembly	4	_____	
clear() function in assembly	2	_____	
getop() function in assembly	6	_____	
getch() function in assembly	3	_____	
ungetch() function in assembly	3	_____	
Linking of separate source code modules	2	_____	
Correct evaluation of expressions	4	_____	
Script showing I/O	2	_____	
Complete documentation and commenting	4	_____	
Formatting (use of columns and white space)	4	_____	
Design quality	4	_____	
Total	46	_____	_____%