EE306 Introduction to Computing

Programming Assignment # 1

The purpose of this assignment is to write a program in LC-3 machine language to unpack a null-terminated character array. In general, a packed array is an array that has more than one element in each of its memory locations. From this definition, it follows that unpacked array has exactly one element in each of its locations.

In our case, packed character array has two ASCII codes corresponding to two letters in each of its memory locations. Since each ASCII code is 8-bit wide, by storing two of them, we can efficiently use LC-3's memory that stores 16-bits in each location. Two ASCII codes are stored in corresponding memory location as follows:

- **Bits [15:8] –** i^{th} character of array
- **Bits [7:0] –** $(i+1)^{th}$ character of array

This is true provided that array's length is greater than *i*. If array length is *i*, then bits [7:0] will be all zero corresponding to NULL[1] character. Likewise, if array length is *i-1*, then bits [15:8] will be all zero.

On the other hand, for unpacked array, we need only 8 bits for ASCII code but we have 16 bits. In this assignment, you will be storing ASCII code in bits [7:0] and put all zeros in bits [15:8].

The packed array is stored in memory starting at address x4000 before your program is loaded to memory. Your program will store unpacked array in memory starting at address x6000.

Examples below show content of memory locations corresponding to arrays after program has been executed.

Table 1. State of memory after program is executed for example 1

Address	Bits[15:8]	Bits[7:0]
x4000	'H'	'I'
x4001	NULL	–
…	…	…
x6000	NULL	'H'
x6001	NULL	'I'
x6002	NULL	NULL

Table 2. State of memory after program is executed for example 2

Address	Bits[15:8]	Bits[7:0]
x4000	'H'	'e'
x4001	'l'	'l'
x4002	'o'	NULL
…	…	…
x6000	NULL	'H'

[1] A character for which all 8 bits of ASCII code are zero.

x6001	NULL	'e'
x6002	NULL	'l'
x6003	NULL	'l'
x6004	NULL	'o'
x6005	NULL	NULL

Notes:

1. You can assume array's length is less than 8192.
2. You cannot alter memory locations corresponding to original packed array.
3. You cannot make any assumption about bit patterns of ASCII codes i.e. you cannot assume that specific bits will be always 0 or 1. Your code needs to be general.
4. You can test your program by manually loading data in locations x4000 onwards.
5. The file that you will upload to Canvas for this assignment must be named **ascii.bin**.
6. The first line of your program must specify the memory address of the first instruction of your program. The LC-3 simulator will place your program starting at that address. For this assignment, you should place your program starting at x3000 (i.e. the first line of your program should contain the bit pattern 0011000000000000).
7. Use the LC3Edit program to type in your programs. Your program file needs to be in plain text format. Please ask any TA if you have any questions.