Project Report

Project Title:Implementation of Binary Search Assembly Code 8086

Course Code:CSE360

Course Title: Computer Architecture

Section: 1

Semester: Summer 2023

Group no:08

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Submission :10 September,2023

Objective:

The objective of implementing a binary search algorithm in assembly language for the Intel 8086 processor (or any other processor) is to efficiently search for a specific element in a sorted array or list. Binary search is a divide-and-conquer algorithm that can significantly reduce the number of comparisons needed to find an element compared to linear search. Binary search is a highly efficient searching algorithm, particularly for large datasets. It reduces the number of comparisons required to find an element from O(n) in a linear search to O(log n) in a binary search. Binary search provides consistent and deterministic performance, as the number of comparisons required is logarithmic, making it suitable for real-time systems and applications with strict timing requirements. Overall, the objective of implementing binary search in the 8086 assembly language is to take advantage of its efficiency, memory optimization, and deterministic performance characteristics to efficiently locate elements in a sorted array or list within the constraints of the hardware and software environment.
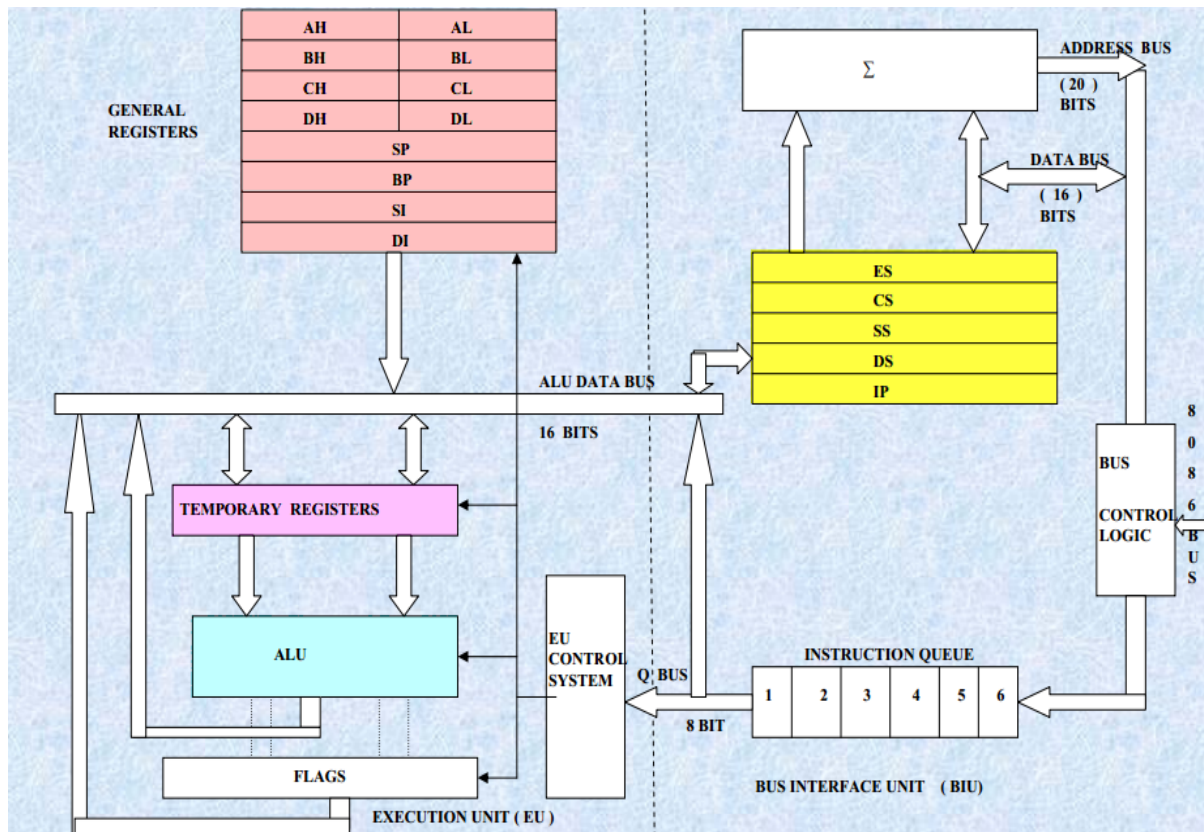
Theory:
Binary search is a divide-and-conquer technique that divides the search interval in half periodically on sorted arrays. It compares the interval's middle element to the target element and narrows the search until the target element is discovered or the search interval is empty. The binary search technique for the 8086 microprocessor is implemented in this assembly code. It closely follows the pseudocode, making comparisons and updating as needed until it discovers the target element or determines that it is not in the array. If the target is located, the "found" flag is set to 1, and the target index (in BX) can be utilized for further processing.

Design :

Flowchart & Architecture:

The flowchart of our project is given below:

```
                    ┌─────────┐
                    │  Start  │
                    └─────────┘
                         │
                         ▼
          ┌──────────────────────────────┐
          │          low = 0,            │
          │          high = N,           │
          │     mid = (low + high)/2     │
          └──────────────────────────────┘
                         │
                         ▼
          ◇─────────────────────────────◇   NO
          │  low < high || x(mid)! = find │────►
          ◇─────────────────────────────◇
                         │ YES
                         ▼
          ◇──────────────────◇   YES   ┌─────────────┐
          │ find < x(mid)     │───────►│ high = mid  │
          ◇──────────────────◇         └─────────────┘
                         │ NO
                         ▼
                ┌─────────────┐
                │  low = mid  │
                └─────────────┘
                         │
                         ▼
          ┌──────────────────────────┐
          │  mid = (high + low)/2    │◄──
          └──────────────────────────┘
                         │
                         ▼
             ┌────────────────────┐
             │  find = x(mid)     │◄──
             └────────────────────┘
                         │
                         ▼
                    ┌─────────┐
                    │   End   │
                    └─────────┘
```
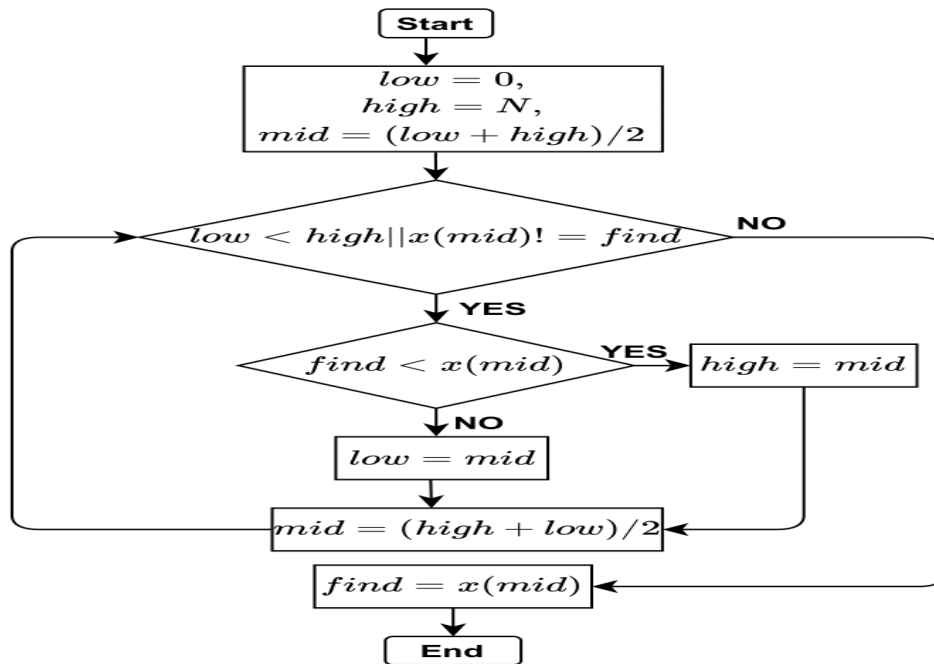
Implementation:

Implementing binary search in assembly language for the Intel 8086 processor involves writing code that performs the binary search algorithm on a sorted array of data. This assembly code performs a binary search in the sorted array **.**You can replace the target value and the array with your specific data. The code initializes the lower bound and upper bound and repeatedly calculates the middle index to compare the middle element with the target value. Depending on the comparison result, it updates the bounds and continues the search until the element is found or the bounds overlap (not found).

Code :

```
; Initializing necessary data
.data
Out1 db "Element Found At Position : "
Out2 db " !!$"
failOut db "Searched Element Not Found!!!"
ArrList dw 12h, 28h, 100h, 212h, 228h, 534h, 550h, 888h, 980h
ArrSz dw ($-ArrList)/2
Key equ 228h


; Starting main code
.code
main proc
mov ax, @data
   mov ds, ax

   mov bx, 00        ; Lower bound to base reg
   mov dx, ArrSz     ; Upper bound to data reg
   mov cx, Key       ; Key to count reg

; Main function
mainFunc:
      cmp bx, dx
      ja notMatched
      mov ax, bx
      add ax, dx
      shr ax, 1
      mov si, ax
      add si, si
      cmp cx, ArrList[si]
      jae greaterEq
      dec ax
      mov dx, ax
      jmp mainFunc
; If arrList[mid] <= key
greaterEq:
```

```asm
        je ifMatched
        inc ax
        mov bx, ax
        jmp mainFunc
; If arrList[mid] = key
ifMatched:
        add al, 01
        add al, 48
        lea si, Out2
        mov [si], al
        lea dx, Out1
        jmp dispOut
notMatched:
        lea dx, failOut
dispOut:
        mov ah, 09h
        int 21h
        mov ah, 4ch
        int 21h
        main endp
end main
```

Description:
- The main procedure (main proc) begins by setting up the data segment register (ds) with the address of the data section.
- mov bx, 00 initializes bx as the lower bound (0) for the binary search.
- mov dx, ArrSz initializes dx with the upper bound, which is the size of the array.
- mov cx, Key initializes cx with the key to be searched.
- cmp bx, dx compares the lower bound (bx) with the upper bound (dx). If bx is greater than dx, it means the search has exhausted the possibilities, so it jumps to notMatched.
- mov ax, bx copies the lower bound to ax.
- add ax, dx adds the upper bound to ax.
- shr ax, 1 divides ax by 2 by performing a right shift.
- mov si, ax stores the calculated middle index in si.
- add si, si is used to convert the middle index to an array index (since each element in the array is 2 bytes).
- cmp cx, ArrList[si] compares the key (cx) with the value at the middle index in the array. If the key is greater than or equal to the middle element, it jumps to greaterEq.
- If the key is less than the middle element, it decrements the upper bound (dx) and continues the binary search by jumping back to mainFunc.
- If the key is equal to the middle element, it jumps to ifMatched.
- If the key is greater than the middle element, it increments the lower bound (bx) and continues the binary search by jumping back to mainFunc.

- If the key is found, it increments the character in al to convert it to a digit, appends it to the end of the string in Out2, and loads the address of Out1 into dx. Then, it jumps to dispOut.
- If the key is not found (notMatched), it loads the address of failOut into dx.
- dispOut is used to display the appropriate message. It uses DOS interrupt 21h to print the message.
- main endp marks the end of the main procedure.
- end main marks the end of the program.
-

Experimental Result:


```asm
edit: E:\14th semester\cse 360\project360.asm
file  edit  bookmarks  assembler  emulator  math  ascii codes  help

01  ;initializing necessary data
02  .data
03  Out1 db "Element Found At Position : "
04  Out2 db " !!$"
05  failOut db "Searched Element Not Found!!!$"
06  ArrList dw  12h,28h,100h,212h,228h,534h,550h,888h,980h
07  ArrSz dw ($-ArrList)/2
08  Key equ 534h
09
10  ;starting main code
11  .code
12  main proc
13      mov  ax, @data
14      mov  ds, ax
15
16      mov  bx, 00          ;Lower bound to base reg
17      mov  dx, ArrSz        ;Upper bound to data reg
18      mov  cx, Key          ;Key to count reg
19  ;main function
20      mainFunc:
21          cmp bx, dx
22          ja notMatched
23
24          mov ax, bx
25          add ax, dx
26          shr ax, 1
27          mov si, ax
28          add si, si
29          cmp cx, ArrList[si]
30          jae greaterEq
31
32          dec ax
33          mov dx, ax
34          jmp mainFunc
35
36  ;if arrList[mid]<=key
37      greaterEq:
38          je ifMatched
39
40          inc ax
41          mov bx, ax
42          jmp mainFunc
43
44  ;if arrList[mid]=key
45      ifMatched:
46          add al, 01
47          add al, 48
48          lea si, Out2
49
50          mov [si], al
51          lea dx, Out1
52          jmp dispOut
53
54      notMatched:
55          lea dx, failOut
56
57      dispOut:
58          mov ah, 09h
```

line: 5   col: 47   drag a file here to open

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```
01 ;initializing necessary data
02 .data
03 Out1 db "Element Found At Position : "
04 Out2 db " !!$"
05 failOut db "Searched Element Not Found!!!$"
06 ArrList dw  12h,28h,100h,212h,228h,534h,550h,888h,980h
07 ArrSz dw ($-ArrList)/2
08 Key equ 534h
09
10 ;starting main code
11 .code
12 main proc
13      mov ax, @data
14      mov ds, ax
15
16      mov bx, 00          ;Lower bound to base reg
17      mov dx, ArrSz        ;Upper bound to data reg
18      mov cx, Key          ;Key to count reg
19 ;main function
20      mainFunc:
21          cmp bx, dx
22          ja notMatched
23
24          mov ax, bx
25          add ax, dx
26          shr ax, 1
27          mov si, ax
28          add si, si
29          cmp cx, ArrList[si]
30          jae greaterEq
31
32          dec ax
33          mov dx, ax
34          jmp mainFunc
35
36 ;if arrList[mid]<=key
37      greaterEq:
38          je ifMatched
39
40          inc ax
41          mov bx, ax
42          jmp mainFunc
43
44 ;if arrList[mid]=key
45      ifMatched:
46          add al, 01
47          add al, 48
48          lea si, Out2
49
50          mov [si], al
51          lea dx, Out1
52          jmp dispOut
53
54      notMatched:
55          lea dx, failOut
56
57      dispOut:
58          mov ah, 09h
```

line: 5   col: 47   drag a file here to open

original source c...   —   □   X

```
01 ;initializing necessary
02 .data
03 Out1 db "Element Found A
04 Out2 db " !!$"
05 failOut db "Searched Ele
06 ArrList dw  12h,28h,100h
07 ArrSz dw ($-ArrList)/2
08 Key equ 534h
09
10 ;starting main code
11 .code
12 main proc
13 mov ax, @data
14 mov ds, ax
15
16 mov bx, 00          ;Lowe
17 mov dx, ArrSz        ;Uppe
18 mov cx, Key          ;Key
```

emulator: project360.exe_   —   □   X

file   math   debug   view   external   virtual devices   virtual drive   help

Load   reload   step back   single step   run   step delay ms: 0

registers

0716:0000   0716:0000

	H	L
AX	00	00
BX	00	00
CX	00	A7
DX	00	00

CS	0716
IP	0000
SS	0710
SP	0000
BP	0000
SI	0000
DI	0000
DS	0700
ES	0700

```
07160: B8 184 ╕
07161: 10 016 ►
07162: 07 007 BEEP
07163: 8E 142 Å
07164: D8 216 ╪
07165: BB 187 ╗
07166: 00 000 NULL
07167: 00 000 NULL
07168: 8B 139 ï
07169: 16 022 ▬
0716A: 4F 079 O
0716B: 00 000 NULL
0716C: B9 185 ╣
0716D: 34 052 4
0716E: 05 005 ♣
0716F: 3B 059 ;
07170: DA 218 ╒
07171: 77 119 w
07172: 29 041 )
07173: 8B 139 ï
07174: C3 195 ├
07175: 03 003 ♥
```
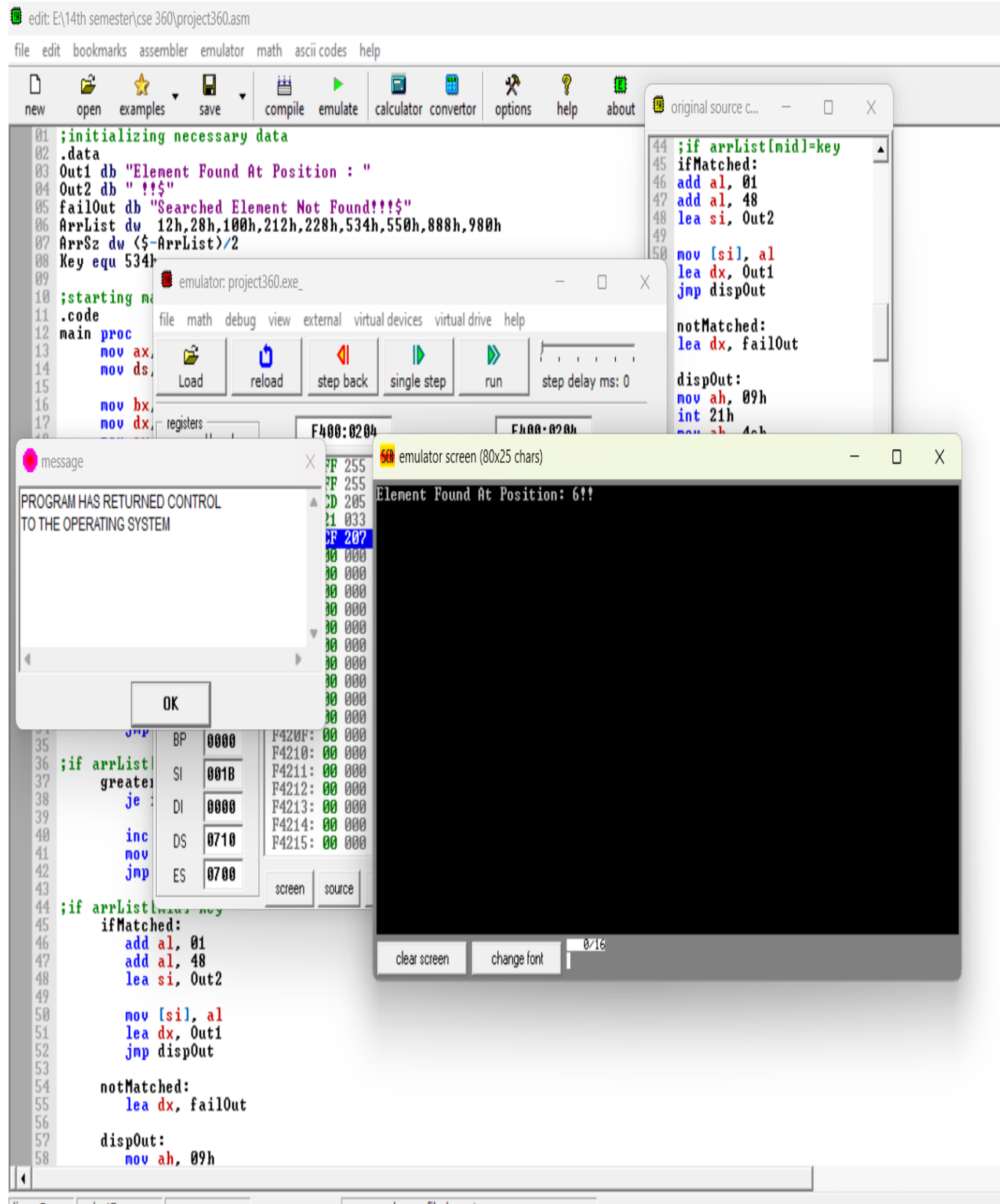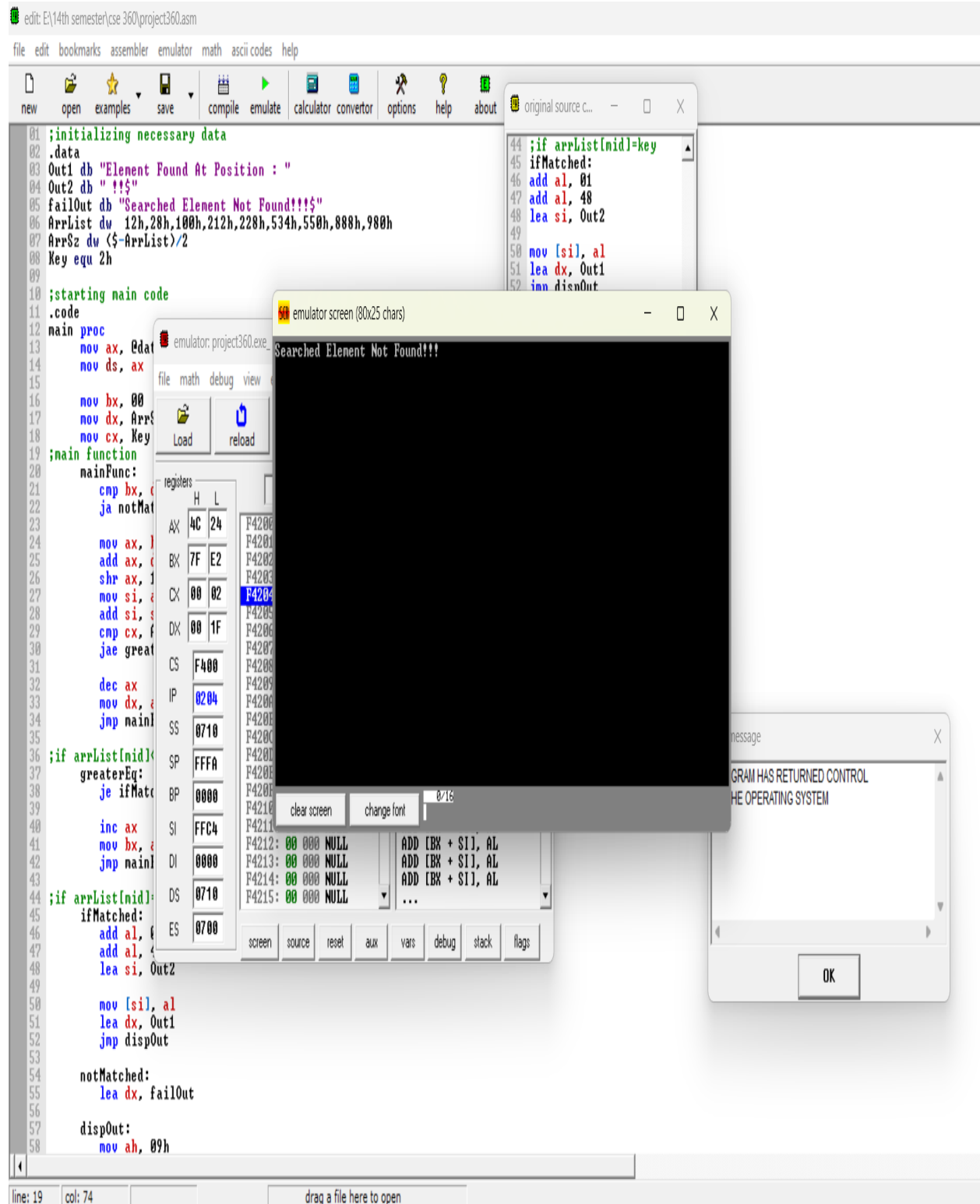
```
MOV AX, 00710h
MOV DS, AX
MOV BX, 00000h
MOV DX, [0004Fh]
MOV CX, 00534h
CMP BX, DX
JNBE 03Ch
MOV AX, BX
ADD AX, DX
SHR AX, 1
MOV SI, AX
ADD SI, SI
CMP CX, [SI] + 03Dh
JNB 027h
DEC AX
MOV DX, AX
JMP 0Fh
JZ 02Eh
INC AX
MOV BX, AX
JMP 0Fh
...
```

screen   source   reset   aux   vars   debug   stack   flags

It is ready to emulate.

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```
01 ;initializing necessary data
02 .data
03 Out1 db "Element Found At Position : "
04 Out2 db " !!$"
05 failOut db "Searched Element Not Found!!!$"
06 ArrList dw  12h,28h,100h,212h,228h,534h,550h,888h,980h
07 ArrSz dw ($-ArrList)/2
08 Key equ 534h
09
10 ;starting m
11 .code
12 main  proc
13       mov ax,
14       mov ds,
15
16       mov bx,
17       mov dx,
```

original source c...

```
44 ;if arrList[mid]=key
45 ifMatched:
46     add al, 01
47     add al, 48
48     lea si, Out2
49
50     mov [si], al
     lea dx, Out1
     jmp dispOut

notMatched:
     lea dx, failOut

dispOut:
mov ah, 09h
int 21h
```

emulator: project360.exe_

file math debug view external virtual devices virtual drive help

Load   reload   step back   single step   run   step delay ms: 0

registers

F400:0204   F400:0204

message

PROGRAM HAS RETURNED CONTROL
TO THE OPERATING SYSTEM

OK

```
BP  0000   F420F: 00 000
SI  001B   F4210: 00 000
           F4211: 00 000
DI  0000   F4212: 00 000
           F4213: 00 000
DS  0710   F4214: 00 000
ES  0700   F4215: 00 000
```

screen   source

emulator screen (80x25 chars)

```
Element Found At Position: 6!!
```

clear screen   change font   0/16

```
35       jmp
36 ;if arrList
37       greater
38       je
39
40       inc
41       mov
42       jmp
43
44 ;if arrList[mid] key
45       ifMatched:
46           add al, 01
47           add al, 48
48           lea si, Out2
49
50           mov [si], al
51           lea dx, Out1
52           jmp dispOut
53
54       notMatched:
55           lea dx, failOut
56
57       dispOut:
58           mov ah, 09h
```

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Here is the output. We find 534h also show the location which is 6

```asm
01 ;initializing necessary data
02 .data
03 Out1 db "Element Found At Position : "
04 Out2 db " !!$"
05 failOut db "Searched Element Not Found!!!$"
06 ArrList dw  12h,28h,100h,212h,228h,534h,550h,888h,980h
07 ArrSz dw ($-ArrList)/2
08 Key equ 2h
09
10 ;starting main code
11 .code
12 main proc
13     mov ax, @dat
14     mov ds, ax
15
16     mov bx, 00
17     mov dx, ArrS
18     mov cx, Key
19 ;main function
20     mainFunc:
21         cmp bx,
22         ja notMa
23
24         mov ax,
25         add ax,
26         shr ax,
27         mov si,
28         add si,
29         cmp cx,
30         jae grea
31
32         dec ax
33         mov dx,
34         jmp main
35
36 ;if arrList[mid]<
37     greaterEq:
38         je ifMat
39
40         inc ax
41         mov bx,
42         jmp main
43
44 ;if arrList[mid]=
45     ifMatched:
46         add al,
47         add al,
48         lea si, Out2
49
50         mov [si], al
51         lea dx, Out1
52         jmp dispOut
53
54     notMatched:
55         lea dx, failOut
56
57     dispOut:
58         mov ah, 09h
```

Original source code window:
```
44 ;if arrList[mid]=key
45 ifMatched:
46 add al, 01
47 add al, 48
48 lea si, Out2
49
50 mov [si], al
51 lea dx, Out1
52 jmp dispOut
```

Emulator screen (80x25 chars):
Searched Element Not Found!!!

Registers:
AX 4C 24
BX 7F E2
CX 00 02
DX 00 1F
CS F400
IP 0204
SS 0710
SP FFFA
BP 0000
SI FFC4
DI 0000
DS 0710
ES 0700

Here the input is 2h. We searched for it, but didn't find it. And the output is not found.

Conclusion and Future Improvements:

The Binary Search method is effectively implemented using the given 8086 assembly code. It shows the assembly language's efficiency and power in handling low-level tasks like searching in sorted arrays. However, it lacks the stability and error handling required for real-world applications. You may need to improve the code to handle edge cases and offer more complete error checking, depending on your individual use case.Error management, modularization, efficient division for midpoint calculation, understandable output, code comments, and comprehensive testing for enhanced reliability and usability are possible future improvements for the 8086 Assembly Binary Search code.

Bibliography:

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4. A comprehensive textbook on assembly language programming for x86 processors, including the 8086. It can serve as a valuable resource for learning assembly language.
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11. Knuth, D. E. (1968). The Art of Computer Programming, Volume 1: Fundamental Algorithms (3rd ed.). Addison-Wesley.
12. A classic book on computer algorithms and data structures that can provide insights into binary search and its efficiency.
13. Microsoft Developer Network (MSDN) - Assembly Language Programming for x86 Processors
14. Online resource with articles and tutorials on assembly language programming for x86 processors, including examples and best practices.
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