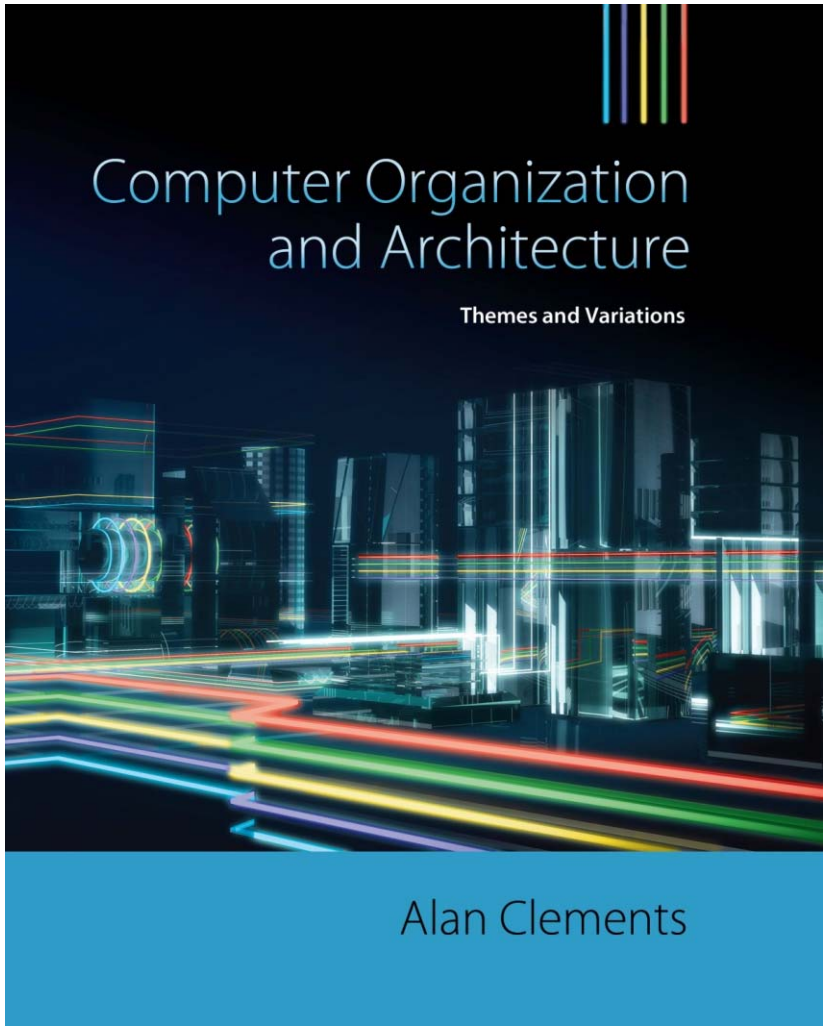
Part 0x3

Chapter 3

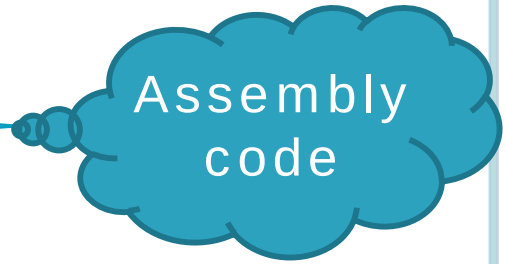
Architecture and Organization



CENGAGE Learning

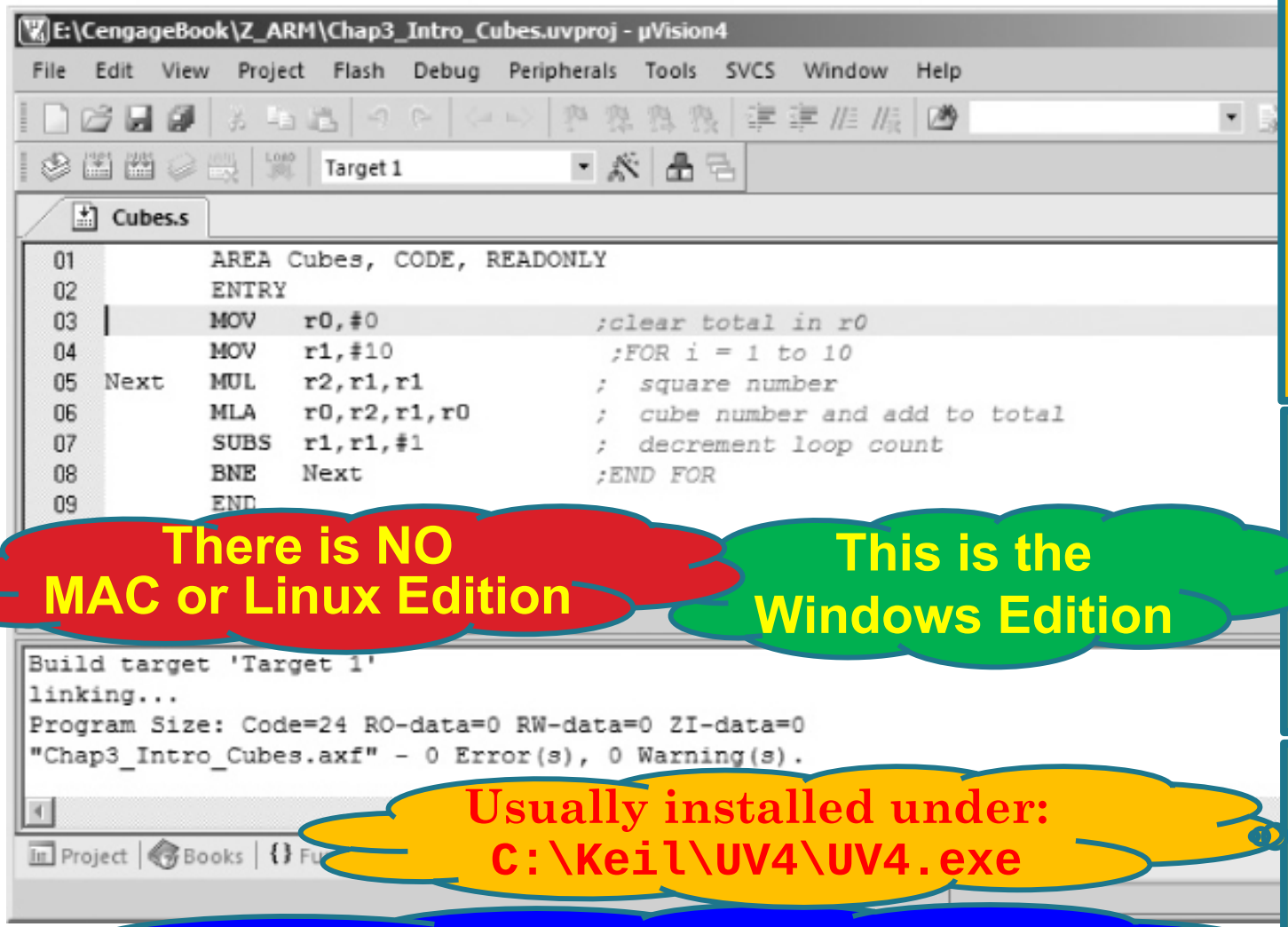
Structure of an ARM Program


```
        AREA Cubes, CODE, READONLY
        ENTRY

        MOV   r0,#0          ;clear total in r0
        MOV   r1,#10         ;FOR i = 10 to 1
Next    MUL   r2,r1,r1       ;  square number
        MLA   r0,r2,r1,r0    ;  cube number and add to total
        SUBS  r1,r1,#1       ;  decrement loop count
        BNE   Next           ;END FOR

        END
```



Snapshot of the Display of an ARM Development System

FIGURE 3.13 Assembling an assembly language program using Kiel's ARM IDE



There is NO MAC or Linux Edition

This is the Windows Edition

Usually installed under: C:\Keil\UV4\UV4.exe

This is MicorVision 4, not 5.

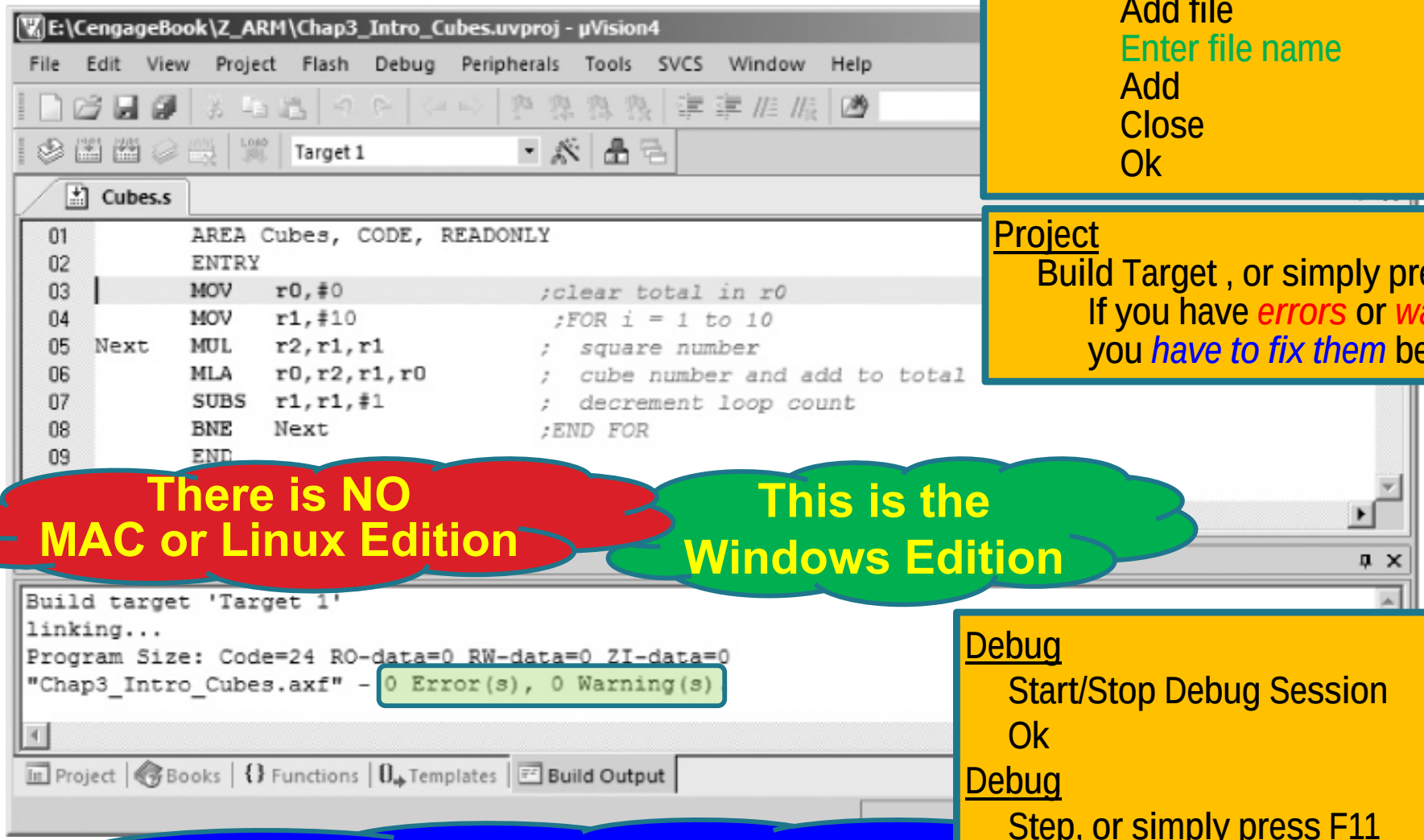
Project
- New µVision Project
  - Enter file name
  - Save
  - Select device for Target
    - ARM
      - ARM7 (Big Endian)
      - Ok

File
- New
  - Enter assembly program (i.e., code and assembler directives)

File
- Save
  - Enter file name (to simplify things, use .s as an extension
  - Save

Snapshot of the Display of an ARM Development System

FIGURE 3.13 Assembling an assembly language program



Project
Manage
Components, Environment, books
Add file
Enter file name
Add
Close
Ok

Project
Build Target , or simply press F7
If you have *errors* or *warnings*,
you *have to fix them* before continue.

There is NO MAC or Linux Edition

This is the Windows Edition

Debug
Start/Stop Debug Session
Ok

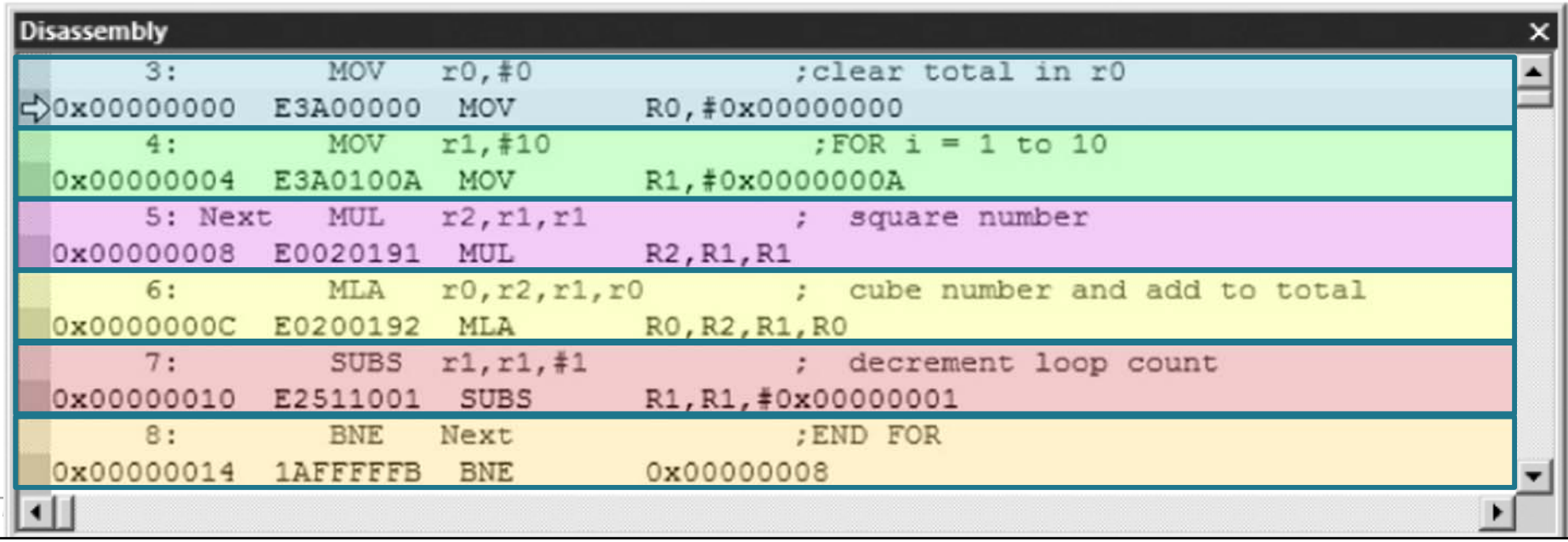
Debug
Step, or simply press F11

This is MicorVision 4, not 5.

Snapshot of the Display of an ARM Development System

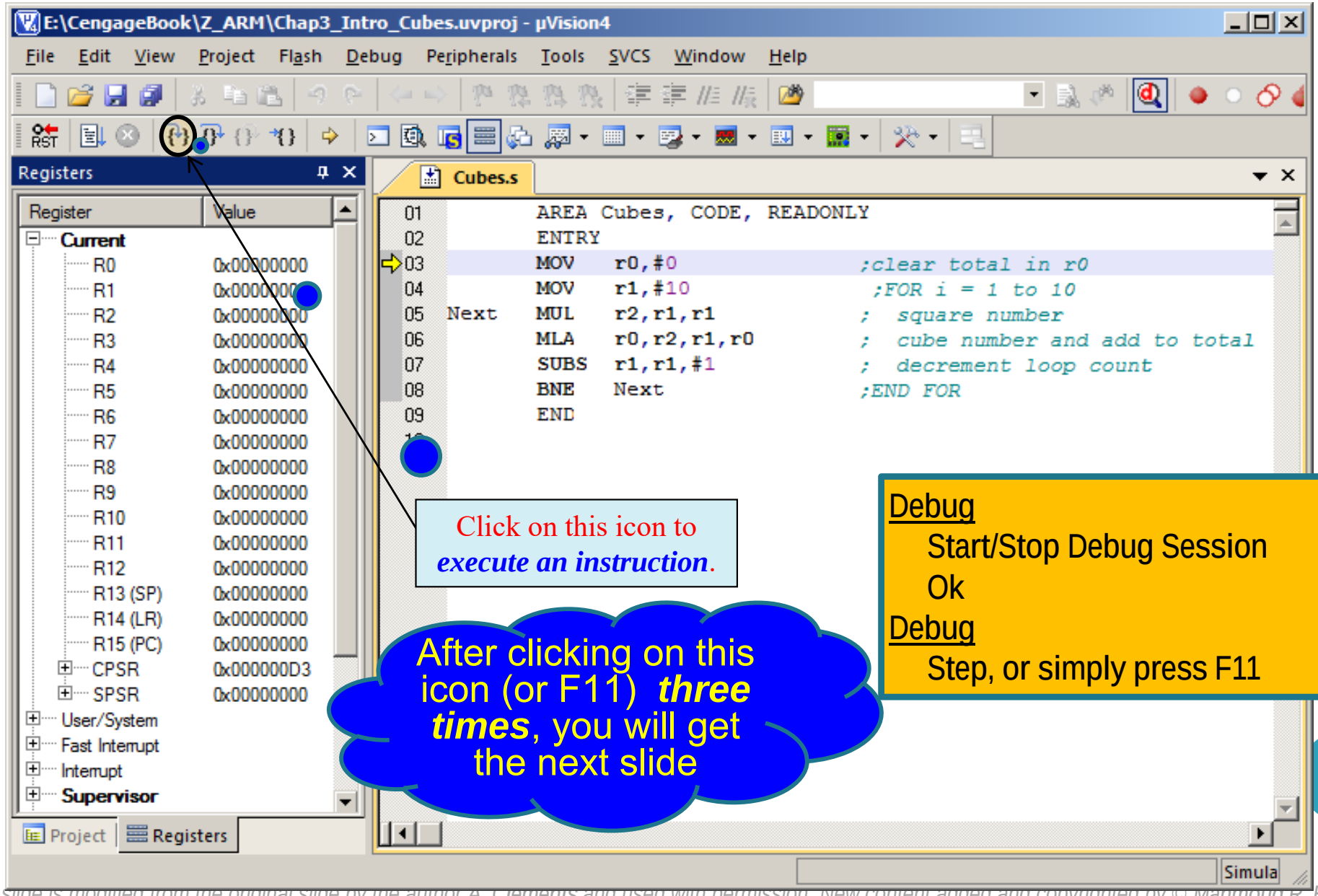
- This is the Disassembly Window that shows memory contents as both
  - hexadecimal values (machine language) and
  - assembly code.

FIGURE 3.14 The disassembly window with the hexadecimal code generated by the program



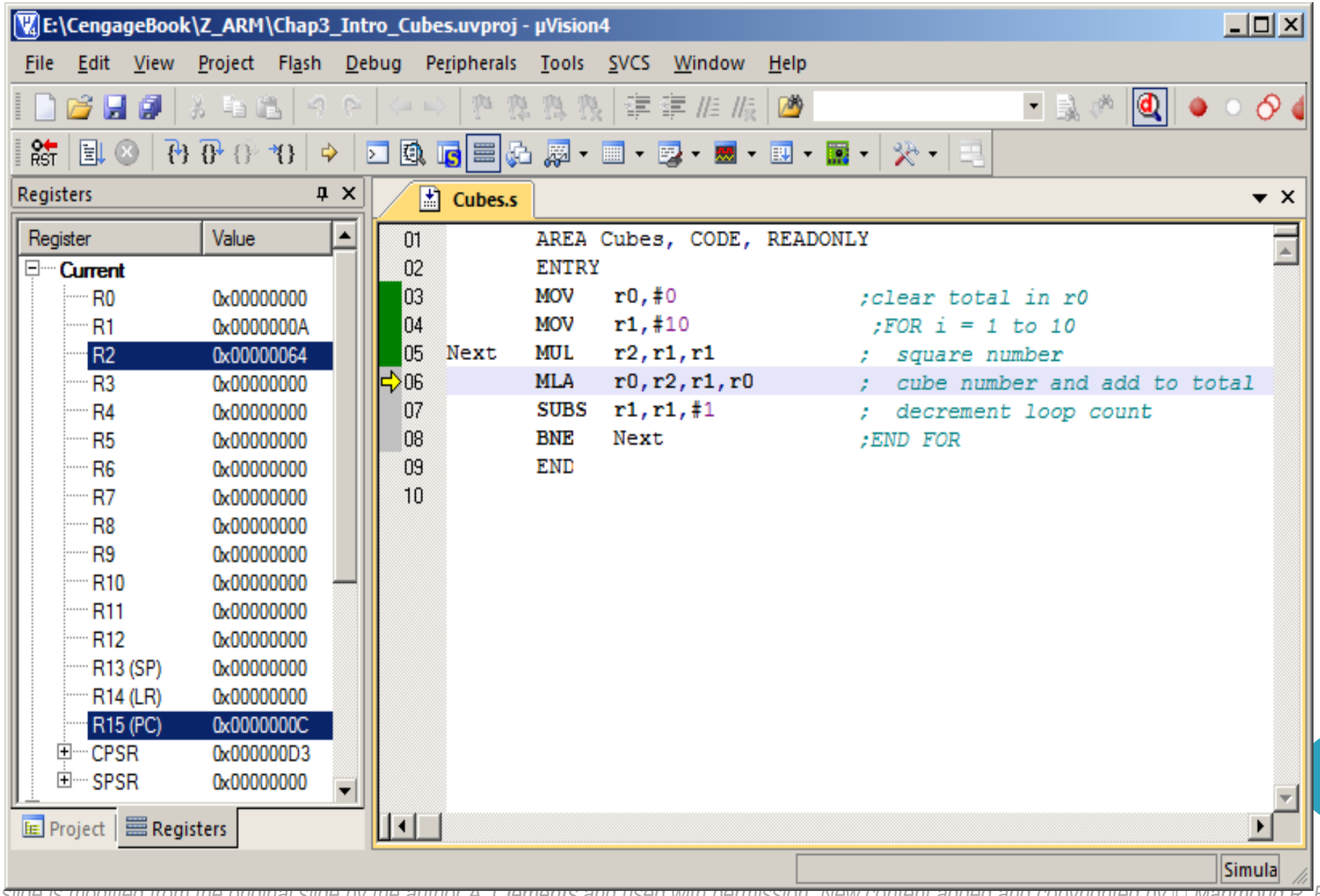
Snapshot of the Display of an ARM Development System

- Executing a program



Snapshot of the Display of an ARM Development System

- Executing a program



The Assembler---Practical Consideration

- Assembly language directives include:

AREA	To name a region of **code** or **data**
ENTRY	The execution starting point
END	The physical end of the program
name EQU v. expr	Equate a *name* to the *value* of the v. expr ***Will not make any memory allocation, i.e. similar to* `#define` *in* `C`**
{label} DCD v. expr {, v. expr} …	Set up one or more *32-bit constant* in memory *Must start at a multiple of 4 address-location*
{label} DCW v. expr {, v. expr} …	Set up one or more *16-bit constant* in memory *Must start at an even address-location*
{label} DCB v. expr {, v. expr} …	Set up one or more *8-bit constant* in memory *Can start anywhere*
{label} SPACE size expr	Reserves a zeroed block of memory *Can start anywhere*
ALIGN	Ensures that next data item is correctly aligned on 32-bit boundaries, i.e., to start at a multiple of 4 address-location

Constant-value expression

The Assembler---Practical Consideration

- The ***DCD***, ***DCW***, or ***DCB*** directives tell the assembler to
  - *reserve* one or more *32-bit*, *16-bit*, or *8-bit* of storage in memory, respectively
    - The memory-location used is the next location in sequence,
    - *In case of DCD or DCW, the used location must be on the 32-bit word boundary, or16-bit word boundary, respectively;*
      - *if not, the assembler will insert byte(s) with value of zero to ensure that the data location is on the appropriate boundary*
  - *load* whatever value(s) to the right of ***DCD***, ***DCW***, or ***DCB*** into these location(s).
  - *advance* the ***location-counter*** by one or more *four*, *two*, or *one* bytes, respectively, so that the next instruction/data will be put in the next place in memory.
- The ***Location-Counter*** is a ***variable inside the assembler*** to ***keep track of memory-locations during assembling a program***, whereas the ***Program-Counter*** is a ***register*** to ***keep track of the next instruction to be executed*** in a program ***at run time***.
- The ***ALIGN*** directive tells the assembler to *align* the current position (the ***Location-Counter***) to be on the next word boundary, i.e., to start at a multiple of 4 address-location, ***(explicit alignment)***

The Assembler---Practical Consideration

```
        AREA Directives, CODE, READONLY
        ENTRY

        MOV  r6,#XX          ;load r6 with 5 (i.e., XX)
        LDR  r7,P1           ;load r7 with the contents at location P1
        ADD  r5,r6,r7        ;just a dummy instruction
        MOV  r0, #0x18       ;angel_SWIreason_ReportException
        LDR  r1, =0x20026    ;ADP_Stopped_ApplicationExit
        SVC  #0x123456       ;ARM software interrupt
XX      EQU  5               ;equate XX to 5
P1      & 0x12345678         ;store hex 32-bit value 0x1345678
P3      DCB 25               ;store the one byte value 25 in memory
YY      DCB 'A'              ;store byte whose ASCII character is A in memory
Tx2     DCW 12342            ;store the 16-bit value 12342 in memory
        ALIGN                ;ensure code is on a 32-bit word boundary
Strg1   DCB "Hello"
Strg2   =. "X2", &0C, &0A
Z3      DCW  0xABCD
        END
```

The & sign here is a synonym for DCD

assembler directives are in RED

The = sign here is a synonym for DCB

The & sign here is a synonym for 0x

' ' is used to define a SINGLE ascii character.

The Assembler---Practical Consideration

" " is used to define a string (a sequence of ascii characters).

```
P1      & 0x12345678
P3      DCB 25
YY      DCB 'A'
Tx2     DCW 12342
        ALIGN
Strg1   DCB "Hello"
Strg2   = "X2", &0C, &0A
Z3      DCW  0xABCD
```

FIGURE 3.17 Allocating data to memory

3.18 Allocating data to memory—the memory map

```
000000000018    12          Word 0x12345678
000000000019    34
00000000001A    56
00000000001B    78
00000000001C    19          Byte 25
00000000001D    41          Byte 'A'
00000000001E    30          Half Word 12342
00000000001F    36
000000000020    H           String "Hello"
000000000021    e
000000000022    l
000000000023    l
000000000024    O
000000000025    X           String "X2"
000000000026    2
000000000027    0C          Byte 0x0C
000000000028    0A          Byte 0x0A
000000000029    00            Forced alignment
00000000002A    AB          Half Word 0xABAC
00000000002B    CD
```

To be stored as ASCII values

Strings must be used with DCB

Disassembly

```
     4:         MOV    r6,#XX          ;load
0x00000000  E3A06005  MOV        R6,#0x00000005
     5:         LDR    r7,P1           ;load r7 with the
0x00000004  E59F700C  LDR        R7,[PC,#0x000C]
     6:         ADD    r5,r6,r7        ;just a dummy ins
0x00000008  E0865007  ADD        R5,R6,R7
     7:         MOV    r0, #0x18       ;angel_SWIreason_
0x0000000C  E3A00018  MOV        R0,#0x00000018
     8:         LDR    r1, =0x20026    ;ADP_Stopped_Appl
0x00000010  E59F1014  LDR        R1,[PC,#0x0014]
     9:         SVC    #0x123456       ;ARM semihosting
0x00000014  EF123456  SWI        0x00123456
0x00000018  12345678  EORNES     R5,R4,#0x07800000
0x0000001C  19413036  STMNEDB    R1,{R1-R2,R4-R5,R12-R13}^
0x00000020  48656C6C  STMMIDA    R5!,{R2-R3,R5-R6,R10-R11,R13-R14}^
0x00000024  6F58320C  SWIVS      0x0058320C
0x00000028  0A00ABCD  BEQ        0x0002AF64
0x0000002C  00020026  ANDEQ      R0,R2,R6,LSR #32
0x00000030  00000000  ANDEQ      R0,R0,R0
```

This is X, not x