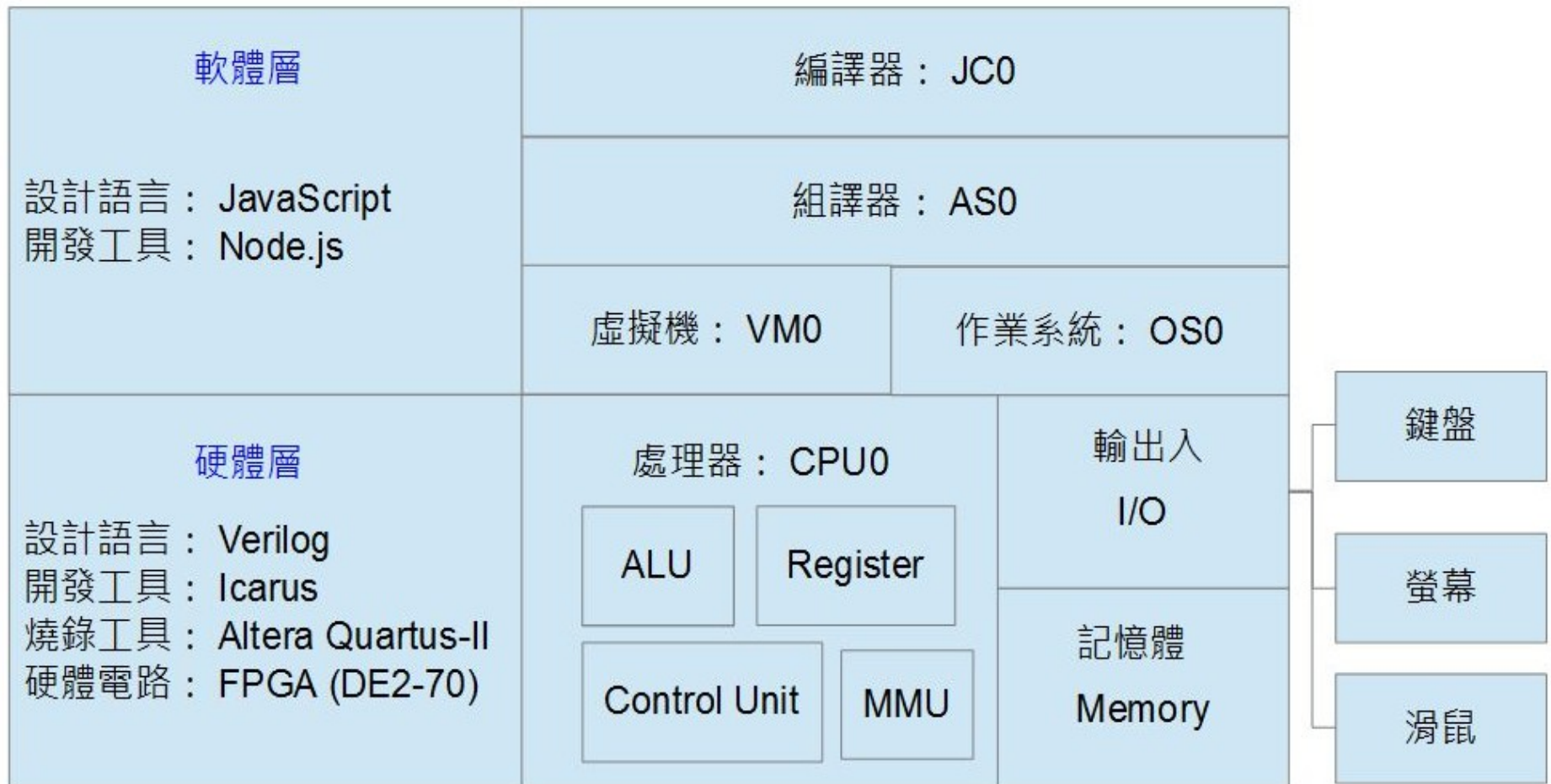


計算機結構 (開放電腦計畫)

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開放電腦計畫



組合語言 (Assembly Language)

```
LD      R1, sum      ; R1 = sum = 0
LD      R2, i         ; R2 = i = 1
LDI     R3, 10        ; R3 = 10
FOR:    CMP          R2, R3      ; if (R2 > R3)
JGT     EXIT         ; goto EXIT
ADD     R1, R1, R2     ; R1 = R1 + R2 (sum = sum + i)
ADDI    R2, R2, 1      ; R2 = R2 + 1 (i = i + 1)
JMP     FOR           ; goto FOR
EXIT:   ST          R1, sum      ; sum = R1
ST       R2, i         ; i = R2
LD      R9, msgptr     ; R9= pointer(msg) = &msg
SWI     3              ; SWI 3 : 印出 R9 (= &msg) 中的字串
MOV     R9, R1         ; R9 = R1 = sum
SWI     4              ; SWI 4 : 印出 R9 (=R1=sum) 中的整數
RET                                ; return 返回上一層呼叫函數
i:      RESW         1        ; int i
sum:    WORD         0        ; int sum=0
msg:    BYTE        "1+...+10=", 0 ; char *msg = "sum="
msgptr: WORD         msg      ; char &msgptr = &msg
```

組譯器 (Assembler)

```
LD      R1, sum      ;
LD      R2, i         ;
LDI     R3, 10        ;
FOR:    CMP          R2, R3      ;
JGT     EXIT          ;
ADD     R1, R1, R2     ;
ADDI    R2, R2, 1      ;
JMP     FOR           ;
EXIT:   ST          R1, sum      ;
ST      R2, i         ;
LD      R9, msgptr    ;
SWI     3              ;
MOV     R9, R1         ;
SWI     4              ;
RET                                ;
i:      RESW         1        ;
sum:    WORD         0        ;
msg:    BYTE        "1+...+10=", 0
msgptr: WORD        msg      ;
```

node as0 sum.as0 sum.ob0

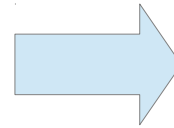
001F003C 002F0034 0830000A 10230000
2300000C 13112000 1B220001 26FFFFEC
011F001C 012F0014 009F0022 2A000003
12910000 2A000002 2C000000 00000000
00000000 312B2E2E 2E2B3130 3D000000
0044

組譯報表

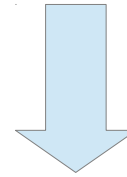
0000		LD	R1, sum	L 00 001F003C
0004		LD	R2, i	L 00 002F0034
0008		LDI	R3, 10	L 08 0830000A
000C	FOR	CMP	R2, R3	A 10 10230000
0010		JGT	EXIT	J 23 2300000C
0014		ADD	R1, R1, R2	A 13 13112000
0018		ADDI	R2, R2, 1	A 1B 1B220001
001C		JMP	FOR	J 26 26FFFFEC
0020	EXIT	ST	R1, sum	L 01 011F001C
0024		ST	R2, i	L 01 012F0014
0028		LD	R9, msgptr	L 00 009F0022
002C		SWI	3	J 2A 2A000003
0030		MOV	R9, R1	A 12 12910000
0034		SWI	2	J 2A 2A000002
0038		RET		J 2C 2C000000
003C	i	RESW	1	D F0 00000000
0040	sum	WORD	0	D F2 00000000
0044	msg	BYTE	"1+...+10=", 0	D F3 312B2E2E2E2B31303D00
004E	msgptr	WORD	msg	D F2 00000044

虛擬機 (Virtual Machine)

```
001F003C 002F0034 0830000A 10230000
2300000C 13112000 1B220001 26FFFFEC
011F001C 012F0014 009F0022 2A000003
12910000 2A000002 2C000000 00000000
00000000 312B2E2E 2E2B3130 3D000000
0044
```



node vm0 sum.ob0



$1 + \dots + 10 = 55$

編譯器

node j0c sum



```
s = sum(10);  
return s;  
  
function sum(n) {  
    s = 0;  
    i=1;  
    while (i<=10) {  
        s = s + i;  
        i++;  
    }  
    return s;  
}
```

	arg	10		
	call	T1	sum	
	=	s	T1	
	return	s		
sum	function			
	param	n		
	=	s	0	
	=	i	1	
L1				
	<=	T2	i	10
	if0	T2	L2	
	+	T3	s	i
	=	s	T3	
	++	i		
	goto	L1		
L2				
	return	s		
	endf			

中間碼轉組合語言

	arg	10		
	call	T1	sum	
	=	s	T1	
	return	s		
sum	function			
	param	n		
	=	s	0	
	=	i	1	
L1				
	<=	T2	i	10
	if0	T2	L2	
	+	T3	s	i
	=	s	T3	
	++	i		
	goto	L1		
L2				
	return	s		
	endf			



sum				
	POP	n		
	LDI	R1	0	
	ST	R1	s	
	LDI	R1	1	
	ST	R1	i	
L1				
	LD	R1	i	
	LDI	R2	10	
	LDI	R3	0	
	CMP	R1	R2	
	JLE	else1		
	LDI	R3	1	
else1				
	ST	R3	T1	
	LDI	R1	T1	
	CMP	R1	0	

作業系統 (Operating System)

- 行程管理
 - Process
 - Thread
 - Multitasking
- 記憶體管理
 - Memory Alloc/Free
 - MMU
- 檔案輸出入
 - File/Folder
 - IO