

## CSSE2010 / CSSE7201 – Introduction to Computer Systems

### Exercises – Week Twelve

### Linking & Disks

#### Exercises

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Many of the problems below are taken from or based on questions in Tanenbaum, Structured Computer Organisation, 5<sup>th</sup> edition.

1. Consider three object modules that have the following entry point tables (symbols available to other modules), external reference tables (symbols expected to be available in other modules), (partial) relocation dictionaries and code and data segment sizes. (Relocation dictionaries show all the places in the code where we need to “fix-up” (i.e. relocate) any addresses we’ve used in the code.)

##### MODULE 1

Code segment size: 45

Data segment size: 17

Entry point table:

Symbol	Segment	Address Offset
outchar	cseg	12
lastchar	dseg	0
eofchar	dseg	1
errmsg	dseg	2

External reference table:

Symbol	Used at Code Segment Offset	Type of Use
outp	23	rcall
outp	35	rcall

Relocation dictionary:

Code Segment Offset	How to fix
10	Add code-segment base address to value
11	Add code-segment base address to value
25	Add data segment base address to value
37	Add data segment base address to value

##### MODULE 2

Code segment size: 67

Data segment size: 5

Entry point table:

Symbol	Segment	Address Offset
outmsg	cseg	18
lastmsgnum	dseg	0
countcalls	dseg	1

External reference table:

Symbol	Used at Code Segment Offset	Type of Use
outchar	41	rcall

Relocation dictionary:

Code Segment Offset	How to fix
14	Add code-segment base address to value
15	Add code-segment base address to value
16	Add code-segment base address to value
17	Add code-segment base address to value
22	Add data-segment base address to value (Note – this is the second word of the two-word sts instruction)
23,24	Add code segment base address to value stored within the two ldi instructions
45	Add data segment base address to value
47	Add data segment base address to value
50	Add data segment base address to value
52	Add data segment base address to value
55	Add data segment base address to value
57	Add data segment base address to value
60	Add data segment base address to value
62	Add data segment base address to value

**MODULE 3**

Code segment size: 100

Data segment size: 25

Entry point table:

Symbol	Segment	Address Offset
outp	cseg	0
inp	cseg	40
xorport	cseg	80

External reference table:

Symbol	Used at Code Segment Offset	Type of Use
No entries		

Relocation dictionary:

Code Segment Offset	How to fix
14	Add code-segment base address to value
15	Add code-segment base address to value
16	Add code-segment base address to value
17	Add code-segment base address to value
55	Add data segment base address to value
67	Add data segment base address to value

If the module are linked in order (i.e. 1 then 2 then 3) with code starting at address 70 and data starting at address \$100 (i.e. 256), answer the following questions

- What are the code and data segment relocation constants for each module (i.e. what are the code and data segment base addresses).
- At what memory addresses will the variables eofchar and countcalls be found?
- Write down the machine code which will be in the instruction memory for the rcall instructions which refer to external symbols

2. How long does it take to read a disk with 8000 cylinders, each containing six tracks of 320 sectors? First, all the sectors of track 0 are read starting at sector 0, then all the sectors of track 1, and so on. The rotation time is 10ms, and a seek takes 5ms between adjacent cylinders and 15ms for the worst case (edge to edge seek). Switching between tracks of a cylinder can be done instantaneously. [Assume the head is positioned at track 0 initially.]
3. A disk has 256 sectors/track, a sector size of 512 bytes, and a rotation rate of 7200 RPM. What is the sustained transfer rate of the disk over one track?
4. A hard drive is advertised as having a 250GB capacity. How many gibibytes of data can it hold?