系級:　　　　　　　姓名:　　　　　　　學號:

1. (8%) For the total cost of a product line, we have to consider the Non-Recurring Engineering (NRE) cost and the unit cost. (a) Please define the NRE cost and the unit cost. (b) Now, you are a project manager developing a product with an extremely large number of copies for another companies. Which one between the NRE cost and the unit cost is more important for reducing the total cost? You must provide some reason to support your answer.

Answer:　(a) NRE cost: the one-time monetary cost of designing the system. Unit cost: the monetary cost of manufacturing each copy of the system.
(b) Reducing the unit cost is more important. Since the number of copies of the product is big, the cost of the copies could be much higher than the NRE cost.

2. (8%) For the directory design of file systems, please define (a) what is the **Acyclic-Graph Directory**, and (b) what is the difference between **Acyclic-Graph Directory** and **General-Graph Directory**. You can draw some diagrams to explain them.

Answer:　(a) Acyclic-Graph Directory: Based on tree structure, this design further allows the sharing of files in the directory structure with the constraint that there is no cycle.
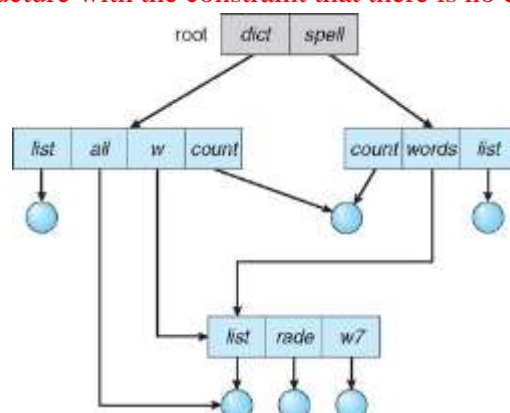
(b) General-Graph Directory: Based on a tree structure, this design further allows the sharing of files in the directory structure without any constraint.

3. (8%) (a) How many i-nodes will be used if we create a file and create 5 hard links to the file? (b) How many i-nodes will be used if we create a file and create 3 symbolic links to the file? The reasons have to be provided to support your answers.

Hints: the pictures of a hard link and a soft link
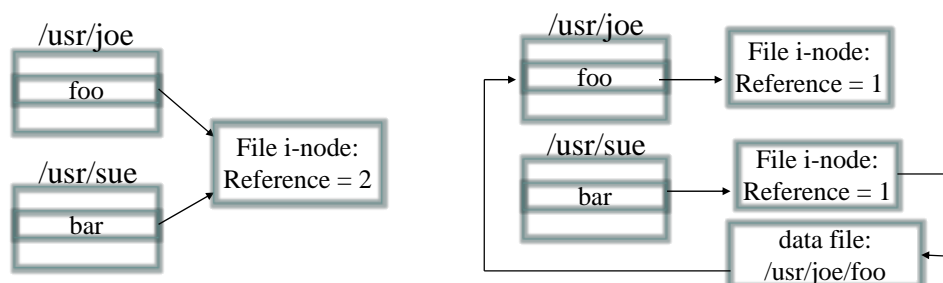
Answer:　(a) 1 i-node. Creating the file uses an i-node, and the 5 hard links share the i-node.
(b) 4 i-nodes. Creating the file uses an i-node, and the 3 symbolic links use another 3 i-nodes.

4. (12%) When we want to put a file into a hard disk, we have to develop allocation methods to assign each part of the file to some block of the hard disk. Please explain the three allocation methods (a) Contiguous Allocation, (b) Linked Allocation, and (c) Indexed Allocation. (d) For random access, why indexed allocation has better performance than linked allocation?

Answer: (a) Contiguous Allocation – each file occupies set of contiguous blocks
(b) Linked Allocation – each file has a linked list of blocks, and the file is stored in the blocks
(c) Indexed Allocation – each file has its index block(s) which has pointers to the data blocks
(d) The indexed allocation scheme can refer the index table to get the pointer to the to-be-accessed block. However, the linked allocation scheme has to sequentially access each block to get the wanted block.

5. (8%) Please provide the definitions of (1) Network-Attached Storage (NAS) and (2) Storage-Area Network (SAN).

Answer: (a) NAS is storage made available over a network rather than over a local connection
(b) SAN is a private network using storage protocols rather than networking protocol connecting servers and storage units

6. (12%) For disk scheduling, let a hard disk consist of 100 cylinders, from cylinder 0 to cylinder 99. Assume that the read-write head is now at cylinder 10 and moving toward cylinder 99. Now, there are multiple read/write requests (to be served) in the disk I/O queue, and no other request will further arrive. The queued requests are at the following cylinders: 40, 22, 33, 95, 8, 9, 68, 2. Please illustrate the scheduling results of the (a) SSTF scheduling, (b) SCAN scheduling, and (c) C-SCAN scheduling. (Note that: If the read-write head has to visit cylinder 0 or 99, you have to illustrate that in your answer.)

Answer: (a) SSTF: 9 → 8 → 2 → 22 → 33 → 40 → 68 → 95
(b) SCAN: 22 → 33 → 40 → 68 → 95 → (99) → 9 → 8 → 2
(c) C-SCAN: 22 → 33 → 40 → 68 → 95 → (99) → (0) → 2 → 8 → 9

7. (12%) There are four types of device registers which can be accessed by the host, and the device registers should be carefully managed by device drivers. Please explain the purpose for using (a) data-in register, (b) data-out register, (c) status register, and (d) control register.

Answer: (a) The data-in register is read by the host to get input
(b) The data-out register is written by the host to send output
(c) The status register contains bits which indicate device states
(d) The control register is written by the host to send command

8. (8%)What is the advantage of using **Direct Memory Access (DMA)** for large data movement?

Answer: DMA is used to avoid programmed I/O for large data movement so as to bypass CPU for transferring data directly between the I/O device and memory.

9. (12%) Please carefully explain the concepts of (a) Buffering, (b) Caching, and (c) Spooling.

Answer: (a) Buffering: Buffering is to store data in some intermediate devices, such as DRAM, while the data are transferring between devices. It can be used to cope with some problems of the device speed mismatch and the device transfer size mismatch.
(b) Caching: A cache is a region of fast memory that holds copies of data. The difference between a buffer and a cache is that a buffer may hold the only existing copy of a data item, whereas a cache, by definition, holds a copy on faster storage of an item that resides elsewhere.
(c) Spooling: A spool is a buffer that holds multiple outputs for a device, such as a printer, that cannot accept interleaved data streams.

10. (8%) For system protection, please define the **Principle of Least Privilege**.

Answer: Programs, users and systems should be given just enough privileges to perform their tasks. Such a principle can limit the damage if some entity has a bug or gets abused.

11. (8%) To implement the access matrix for system protection, there are four methods: global tables, access lists for objects, capability lists for domains, and lock-key schemes. Please explain the implementations of (1) the capability list for domains and (2) the lock-key approach.

Answer: (1) Capability list for domain is a list of objects together with operations allows on them.
(2) Each object has a list of unique bit patterns, called locks. Each domain consists of a list of unique bit patterns called keys. A process in a domain can access an object if the domain has a key that matches one of the locks