# CST 352 – Final

Wilsonville, Spring 2022

This is a take home final. You must turn in your completed final on **Canvas** by mid-night on **Wednesday 6/8/2022**. You may use any and all resources available to you to complete the final. You will be expected to turn in your own work. Do not copy/paste from a source (for example from the internet), instead read the source, understand the material and then put your answer into your own words.

## Section 1 – Terminology and Concepts (60 points)

Answer each question in this section with enough detail that the instructor understands that *you* understand the term or concept.

1. (8 points) Contrast the following terms in your own words:
   1. Process vs Thread

A process is essentially a program that contains its own subprocess and has its own isolated memory. A thread is a section of a process and is much more lightweight. Usually, a thread works within a process to complete smaller tasks that terminate more easily, thus sharing the same code and memory as the other working threads in the process.

* 1. Principal vs Subject

Subjects are like processes where they use resources or objects that are available to them. However, subjects do not have permission to access certain objects or resources without permission from the user. Principals are the users who act on behalf of the subject to use resources or access items. Principals can either be singular or grouped to give permissions to users and allow subjects to use the resources they are required to use.

* 1. Device Controller vs Device Driver

The device controller refers to specifically the hardware on the machine that controls the I/O devices that can be attached to the machine. They are almost like bridges that attach and receive or send data to either the device or machine it’s connected to. The device driver on the other hand is the software aspect of it that does the communication with the operating system, so the operating system knows how to handle either input it’s receiving from the device or how to send output to the connected device.

* 1. Internal Fragmentation vs External Fragmentation

Internal fragmentation is when there is extra space in between the allocated memory blocks because the used space does not allocate the entire blocks. External fragmentation occurs when memory space does exist for allocation, but the spaces available in memory are smaller than the size required for the piece of data.

1. (6 points) What is virtual memory and why do operating systems include it?

Virtual memory is a memory management tool that operating systems use that makes use of physical storage to act as extended memory from what is available in actual memory.

Operating systems include this to help manage the amount of usage of RAM on the system. Since RAM is less abundant than memory on your disk, it will use virtual memory to help use that limited amount of RAM more efficiently and help the overall system handle larger of multiple programs at once.

1. (6 points) What is a deadlock? Describe a scenario where one could happen. What is an operating system technique for allowing programmers to avoid deadlocks?

A deadlock occurs when a process is blocked off from a resource it needs because some other process is holding on to it, and that secondary process cannot release the resource the first process needs since the second process needs the resources the first process is holding on to.

A scenario where this could happen is if two users are using a shared folder where one user is accessing one file, but needs information from another that can’t be opened since it is being used somewhere else, and the second user in the same situation where they can’t continue until they get access to the file the first user is using, thus leading to a deadlock.

One deadlock technique that programmers can use to help avoid deadlocks is by implementing timeouts. Timeouts ensure a thread does not stay in the same position, and essentially, they give up trying to get the lock they need. This may not solve the problem of getting the lock, but it could help in releasing the resources that the other thread would need.

1. (10 points) Describe the producer/consumer pattern. Use at least the following terms in your description: thread, synchronization, mutex, event, queue. Include a diagram to illustrate your explanation.

The producer/consumer pattern is a design where one or more producer threads create items and load them into a queue. Simultaneously, one or more consumer threads are consuming items from the queue creating synchronization where the queue only allows N-at-a-time items to be either produced or consumed. The queue manages this by using a mutex that only allows a single event at a time to operate on the queue.

Item

Item

Mutex

Item Queue

Item

Item

1. (10 points) Describe the 3 layers of a modern file system. What is the role of each layer? Include a diagram with your explanation.

* Logical File System – This layer provides the resources for applications to show what we see and what is presented to us from the physical file system. Its role is to show us the physical files that are available and it only shows what the operating system allows us to see based on our permissions.
* Virtual File System – This is the layer between the Logical file system and the Physical file system that helps connect all of the physical drives and files to the logical system. Its role is to incorporate all the local or network storage devices and their file systems and keep them organized for the logical file system.
* Physical File System – This is the layer that handles the organization and storage of the files on the physical disk itself. Its role is to maintain the physical data that is stored on disk and keep the description of how this data is received or pulled from the disk.

App

Disk

Operating System

Logical File System

Virtual File System

Physical File System

1. (6 points) Contrast the First-Fit and Best-Fit algorithms. What is the significant difference? What are the pros/cons of each?

The First-Fit algorithm is different from the Best-Fit algorithm in that it will fill in space in the very first spot that finds that is big enough for the piece of data. The Best-Fit on the contrary will look instead for the smallest available piece that can fit the data. The pros of the first-fit algorithm are that is fast due to its nature of placing data in the first big enough spot it sees. However, this is also a con because it can leave wasted bits of memory space in between that could not fit certain jobs, thus leaving jobs to wait for the next available spot. The pros of the best-fit algorithm are that gaps in memory are rarely found and memory is not wasted since best-fit is positioning jobs in the correct sized spots unlike the first-fit. However, since best-fit may require examining all of the memory, it will be slower than the first-fit algorithm.

1. (7 points) What are the potential consequences to data storage when a computer crashes. Describe two operating system techniques for mitigating these risks.

When a computer crashes, your data storage may experience file system corruption, loss of data, or segments that are corrupted. Thus, rendering some files or even your system unusable. One way the operating system mitigates this risk is by taking the consistency-preserving approach where the system uses multi-step file system updates. These updates ensure the system stays in a consistent state and if crashes occur, there will be a state that is still usable with some inconsistencies in the file system that can be sorted afterwards. The second approach is the transactional approach where it’s all or nothing. If the crash happens mid-operation, it will either be like if the operation happened or didn’t happen at all.

1. (7 points) What is a security context? When and how is it established? How is it used by the operating system?

The security context is the resource that contains all of the information regarding certain users or subjects. It is first established when the user logs in to the system. The system then authenticates the user and assigns them their user identity and group identities if needed. The operating system uses this security context to figure out what that system resources the user can access with their security context.

## Section 2 – Problem Solving (40 points)

For each of the questions in this section, read the challenge and describe the operating system techniques that are used to solve the challenge. Imagine that the visionary OS designer had anticipated the challenges and built the OS to solve them before the computer was set up. Be specific in your answer and use examples whenever possible.

1. (10 points) A person wants to run multiple applications at the same time. Each application needs to be able to share a single processor. Bugs in one application should not impact the other applications.

Since there is only a single processor in the computer, the operating system is probably using a 1-N model so every application thread is being supported by the one kernel thread the system has. In this model, a queue is used for running threads and waiting threads while processing is occurring. This would take advantage of a mutex as well to ensure that the kernel thread is thread-safe and that only one program at a time is using it. In addition to the thread model that this system would use, interrupts and interrupt handling would be essential to making sure every program runs properly. The interrupts could as well help with programs that are buggy and defer them to allow the other applications to use the single thread. With interrupts implemented, it also allows for a better-scheduled system where the interrupts ensure that threads are switched on and off in a timed manner, so applications don’t suffer performance issues. Batching jobs could be helpful too. Since this system is very simplistic due to the CPU, creating simple batches would be helpful where the operating system can divide the applications processes and execute them batch by batch.

1. (10 points) A system administrator needs to add more storage capacity to a computer, without downtime. Since the computer was originally purchased, new types of hard disks have come out with much greater capacity per disk (more and larger sectors).

The operating system techniques that are used here to solve this issue are virtual file system implementation. Virtual file systems help bring together all the physical disks in the system together and make them visible to the logical file system. Thus, if the computer has a virtual file system, the administrator would only need to add in a new hard disk, and since newer hard disks contain vast amounts of data, it will expand the storage space immensely while not having downtime. The virtual file system takes care of adding the disk to the structure of the file system and creating the pathways to the physical file system.

1. (10 points) A computer is accessed by many people at a time and over time. The computer is used to stored and edit confidential documents in a number of formats. Each person expects to share their documents only with other people of their choice.

The operating system techniques that are used here are security contexts, implementing security groups, implementing access control lists (ACL), and following the principle of least privilege. Since so many people are using this one computer and are creating confidential documents, security contexts will help keep every individual from using or seeing resources they should not be touching. Additionally, security groups offer to ensure that only certain individuals can see or access certain documents. For even more security, ACLs made by the administrator will ensure that only certain groups of people can access certain resources. Lastly, following the principle of least privilege, making sure everyone has access to the least number of resources ensures no one can access more than they need and keep more confidentiality within a computer that everyone uses.

1. (10 points) A person has purchased a new laptop after their previous one suffered catastrophic failure at a local coffee shop. They bring their new equipment home and are greatly relieved to discover that their wireless mouse, keyboard, 45” screen and printer work seamlessly with their new laptop. Within 10 minutes they are leaving a positive review on the laptop vendor’s website.

The laptop’s operating system more than likely contains device controllers that allow them to plug in everything, and more importantly, the operating system has device drivers that can easily abstract to any device that is plugged in. Since there are so many types of devices that vary from manufacturer and device features, operating systems must keep in mind that the drivers it contains must be able to handle all these types of devices. Thus, this operating system implements drivers that can be abstracted to any kind of device that is plugged in. Additionally, the operating system could have a driver search feature that looks for the most compatible driver for your device. Thus, when you plug in the device, your operating system will activate this system, find the device driver, and install it so you can instantly use your devices without having to manually install the drivers yourself.