

CS110 - Principles of Computer Systems

Final Exam

(Total time = 180 minutes, Total Points = 180)

Name: (please print) _____

In recognition of and in the spirit of the Stanford University Honor Code, I certify that I will neither give nor receive unpermitted aid on this exam.

Signature: _____

This examination is closed book and closed notes. You may not collaborate in any manner on this exam. You have 180 minutes to complete the exam. Please write your answers on the exam. Note there is one problem per page so the amount of space provided does not necessarily provide an indication of the expected length of the answer. In other words, do not feel compelled to fill every nanoacre of the exam with writing. Before starting, please check to make sure that you have all 17 pages.

Question	Points	Score
1	15	
2	10	
3	10	
4	10	
5	10	
6	10	
7	10	
8	12	
9	12	
10	12	
11	15	
12	10	
13	10	
14	12	
15	10	
16	12	
Total	180	

1. (15 points) I recent got the following email message:

```
-----BEGIN PGP SIGNED MESSAGE-----  
Hash: SHA1
```

Hi,

Sorry for this last minute modification but the diner is advanced at 6:00pm so we will have the chance to have diner outside. The location remains unchanged and the shuttle will pick you up at 6pm in front of the bio-X for those who came by public transportation.

See you tomorrow,
Elie

```
-----BEGIN PGP SIGNATURE-----  
Version: GnuPG v2.0.10 (Darwin)
```

```
iEYEARECAAYFAkqpy+EACgkQxkG2oG7WrMZEVCgjjZR9GbuKU5CQDtAGLIKT+qKn  
OiMAnieBApdgLH80kpk0lN7x8NYA1Kwp  
=fFId  
-----END PGP SIGNATURE-----
```

The header and trailer on the message appear to indicate the message has been *signed*. Assuming that I can reliably retrieve Elie's public key, what does the signature tell me about each of the following attributes of the message:

- a) Authenticity
- b) Integrity
- c) Secrecy

Your answer should include a brief statement for each attribute.

2. (10 points) Explain the reasoning behind the suggestion that when building systems that need to be secure you should publish a description of the security system rather than keep it secret.

3. (10 points) Assume you have been hired as an expert witness in an anti-trust trial of an operating system vendor. The vendor is accused of exploiting its dominant position in operating systems to take control of the web browser market by bundling their web browser with the operating system. The web browser was a separate application program but in the new system it is included as a part of the operating system kernel. Your job is to argue that from the security point of view moving the browser into the operating system wasn't technically the right decision. Choose one of the security principles and use it to argue against moving the browser into the operating. Security Principles:
- Minimize secrets
 - Economy of mechanism
 - Minimize common mechanism
 - Complete mediation
 - Fail-safe defaults
 - Least privilege principle

4. (10 points) TCP/IP implements a flow control algorithm to handle the case when the speed of which data is produced on a stream is different than the speed at which it is consumed. Describe this mechanism and how it is also used to handle congestion in the Internet.

5. (10 points) Both TCP and UDP extend the naming scheme used by IP to include both an IP address and a port number. Describe purpose of this extension to the name space.

6. (10 points) Explain why acknowledgements can be used to recover from packet loss in TCP yet can not solve the distributed consensus problem (i.e. the two army problem) over an unreliable network.

7. (10 points) Modern network implementations are constructed in layers. Each layer is viewed as having three interfaces. One interface is to the layer above and a second interface is to the layer below. Where does the third interface go?

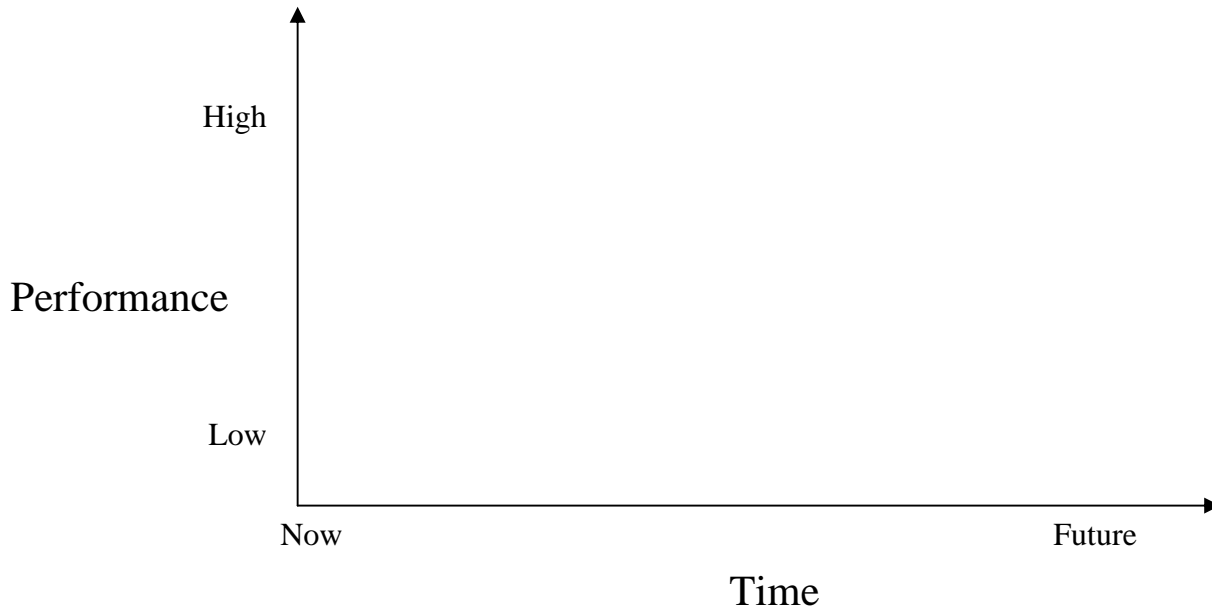
8. (12 points) Most link layers of networking stacks limited the maximum size of a packet. This limit is called the maximum transfer unit (MTU) of the link. For example, Ethernet had traditionally used a MTU of 1500 bytes. Newer versions of Ethernet link layers support MTUs of up to 9000 bytes using something called Jumbo Frames. Answer the following two questions:
- a. Would an application that used TCP/IP need to be changed to utilize Jumbo frames?
 - b. Would an application that used UDP/IP need to be changed to utilized Jumbo frames?

9. (12 points) Using your knowledge of the Internet, answer the following questions:
 - a. Explain why the best effort contract used by the Internet worked better than a guaranteed delivery mechanism.
 - b. Explain how Internet routers don't need an entry for every IP address on the Internet yet can route to them

10. (12 points) What is the inherent property of memories that cause systems to build multi-level memories rather than a single flat memory?

11. (15 points) When using enforced modularity in a system, it is typically to force modules to communicate by passing messages. For example on a modern operating system different modules run in different address spaces so the operating system provided a bounded buffer abstraction for communicating between the modules. When messages contain much data (e.g. 1GB) the cost of copying the messages between the address spaces can be substantial. Describe an optimization that can be done by a modern operating system kernel (i.e. a kernel with processes, virtual memory, etc.) to support message passing between address spaces that involves no data copying whatsoever.

12. (10 points) Draw on the following graph a curve of performance over time that would be implied by the iterative approach and the law of diminishing returns. Include a justification for your answer.



13. (10 points) Describe what is meant by *hiding latency*. Give an example.

14. (12 points) When talking about performance we mentioned two metrics: latency and throughput. For each of the following performance optimization techniques on a Unix-like file system, describe which of the metrics (latency, throughput, or both of them) the technique would help. Justify your answer.
- a. Caching
 - b. Dallying
 - c. Concurrency

15. (10 points) Explain why it would be faster to switch a CPU between two threads that are part of the same Linux process than threads that are in different processes.

16. (12 points) An argument breaks out between some CS110 students in myth cluster over the synchronization needed in the CS110 assignment #2 (Add concurrency support to a banking system). The claim is if the CPU scheduler was much smarter you wouldn't need any synchronization at all. It is only because of the limitations of the scheduler that locks and conditional variables are needed. Choose a side in this dispute and provide the argument you think best supports the side.