Principles of Computer Systems
Fall 2014

Final Exam

You have 105 minutes to answer the 6 questions in this exam. Each question is worth 10 points.

You are allowed to have any amount of printed material you like (books, papers, notes), but no laptops, tablets, cellphones, etc. are permitted during the exam. You must take the seat assigned by the course staff and present your CAMIPRO card to the staff upon request.

Please write your name and SCIPER below.

Do not open the exam until instructed to do so.

Name: _____ SCIPER: _____

The rest of this page reserved for grading

Q1		Q2		Q3	
Q4		Q5		Q6	

TOTAL

Question 1 (10 points)

Layering is a useful systems technique. The Exokernel paper is about exposing abstractions to application-level programs.

(a) In general, which of Lampson's hints help make better layering decisions? Give two examples from the "Hints for Computer Systems" paper, and explain how they help with layering decisions.
(b) Does the approach taken by the Exokernel paper violate layering? Use the same two examples from (a) to justify your answer.

Question 2 (10 points)

SSL is used to provide privacy and mutual authentication. Each SSL certificate is signed by a particular certificate authority (CA). In the case of a web browser, the client relies on many CA certificates that are stored within the browser itself to authenticate the certificates presented by the websites. Furthermore, any CA can sign any SSL certificate.

(a) Compare the process of validating an SSL certificate through a CA to the process of obtaining a DNS name/IP address mapping from a DNS server. Which one is riskier (or are they the same) and why? Differently said, which compromise has more impact, that of a CA or that of a DNS server and why?

(b) Sketch out an alternative and briefly discuss the trade-offs.

Question 3 (10 points)

In general, high-availability in computer systems relies on some sweeping simplification to reconstruct state. As one design option, hypervisors can provide high availability to applications by running them within a single virtual machine, and the sweeping simplification is that the state of the VM is the virtual disk. In that model, the hypervisors maintain consensus regarding the set of available hypervisors and the location of running virtual machines.

(a) Could container-based systems such as Docker also be used to provide high-availability to applications? Briefly justify your answer.
(b) If so, what would such a solution look like? Which properties of a Docker-based system would be leveraged (union file system, Linux kernel containers, namespace isolation, ...)? In general, how would such a solution compare to the hypervisor-based approach, and what sweeping simplification can be leveraged?
(c) If containers cannot be used to provide high-availability, explain which fundamental assumption is violated.

Answer either (a & b) or (a & c).

Question 4 (10 points)

Which of the performance hints from Lampson's paper play a major role in Naiad's efficient implementation of the notification mechanism? Justify your answer.

Question 5 (10 points)

Is the approach taken in the dynamic compilation paper lazy, speculative, or both? Justify your answer and be precise in describing how laziness and/or speculation are used.

Question 6 (10 points)

Consider an enterprise network that uses the Ethane architecture. For simplicity, assume that this network sees only TCP traffic. The network has one central controller that performs admission control and routing for every new TCP flow. The controller is continuously updated with new access-control policies and new information about the status of network links. Every time a network switch observes a new TCP flow, it asks the controller if it should accept or deny the flow, and how it should forward the flow's packets. Each network switch caches a recent controller response, even after the corresponding TCP flow has finished.

(a) Consider the scenario where a network partition causes some network switches to be disconnected from the controller. Does the CAP theorem (as clarified by Brewer in 2012) apply? How would you define "consistency" and "availability" in this context? If you think the CAP theorem applies, describe the corresponding trade-off. If you think the CAP theorem does not apply, explain why no such trade-off exists.

(b) In Ethane, the controller makes per-flow decisions. Which form(s) of locality is/are used and how do they help Ethane achieve a basic level of scalability?