DEPARTMENT OF ELECTRICAL ENGINEERING AND COMPUTER SCIENCE

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

6.033—Computer System Engineering Handout 26—April 19, 1996

Quiz 2

This quiz contains four problems whose relative weights are given below. Please write your answers in the space provided, and hand in this booklet at the end of the examination.

Put your name on this cover sheet AND at the bottom of each page of this booklet. Be sure that you don't put part of the answer to a problem on the back of a sheet for another problem.

Some parts of some problems may be much harder than others. Read them all through first and attack them in the order that allows you to make the most progress. Some problems are intentionally ambiguous; be sure to write down any assumptions you make. Show your work, or you risk losing partial credit. Be neat. If we can't figure out your answer we can't give you credit. On answers that involve numbers, be sure to clearly specify the units of your answer.

Circle your recitation:

10:00	1. Shrira/Litt			
11:00	7. Corbató/Fu	5. Ganger/Yerushalmi	12. Shrira/Kohler	2. Wetherall/Legedza
12:00	6. Wetherall/Yerushalmi			
1:00	3. Agarwal/Legedza	11. Corbató/Litt	9. Ganger/Fu	8. Saltzer/Engler
2:00	4. Agarwal/Kohler	10. Saltzer/Yerushalmi		

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Problem	**Your Score**	**Maximum Score**
1		20
2		32
3		24
4		24
Total		100

Name: ______________________________

1. Ben Bitdiddle has been thinking about RPC. He remembers that one of the problems with RPC is the difficulty of passing pointers: since pointers are really just addresses, if the server dereferences a client pointer, it'll get some value from *its* address space, not what the client intended. Ben hopes to get some insight by applying his new-found 6.033 naming knowledge to the problem.

1a. *(15 points)* Match up each concept on the left with the corresponding naming concept on the right. You won't use some of the naming concepts.

____ address space	(1) implicit context
____ pointer	(2) object
____ memory value	(3) multiple contexts
____ pair of address space and pointer	(4) closure
____ dereferencing a pointer in the current address space	(5) search path
	(6) context
	(7) name

Inspired by his naming insights, Ben decides to pass closures instead of bare pointers in his RPC system. Louis Reasoner, excited by Ben's discovery, decides to change *all* end-to-end protocols used on MIT's networks along the same lines.

1b. *(5 points)* Argue for or against Louis's changes, using 6.033 arguments.

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2. In a mobile computing environment, locating a user in the face of user movement is an important problem. Consider a system in which each user is assigned a permanent home location, which can be found simply by looking the user up in a name service.

   Alyssa P. Protocol-Hacker is designing an end-to-end protocol for locating these mobile hosts. Her first protocol is very simple: every time a user moves, store a forwarding pointer at the old host, pointing to the new host. This creates a chain of forwarding pointers with the permanent home location at the beginning and the mobile host at the end. Messages meant for the mobile host are sent to the home location, which forwards them along the chain until they reach the mobile host itself. (The chain is truncated when a mobile host returns to a previously visited location.)

   Alyssa notices that performance generally gets worse each time she moves her mobile host! "This must be because of the long chains of forwarding pointers," she muses.

   Help Alyssa design a more efficient protocol which avoids long chains. Assume that the end-to-end protocol you design is built on top of a network protocol which can reorder messages, but doesn't lose or duplicate them.

2a. *(8 points)* Alyssa's first try works like this. Each time a mobile host moves, it sends a message to its home location indicating its new location. The home location maintains a pointer to the new location. With this protocol, there are no chains at all. Nodes other than the home node do not maintain forwarding information.

   When this protocol is implemented, Alyssa notices that messages regularly get lost when she moves from one location to another. Explain briefly why or give an example.

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2b. *(8 points)* Alyssa is disappointed with her first attempt, and decides to start from scratch. In her new scheme, no forwarding pointers are maintained anywhere, not even at the home node. Say a message destined for a mobile host A arrives at a node N. If N can directly communicate with A, then N sends the message to A, and we're done. Otherwise, N broadcasts a search request for A to all the other fixed nodes in the network. If A is near a different fixed node N′, then N′ responds to the search request. On receiving this response, N forwards the message for A to N′.

Will messages get lost with this protocol, even if A moves before the message gets to N′? Briefly explain your answer.

2c. *(8 points)* Unfortunately the network doesn't support broadcast messages efficiently, so Alyssa goes back to the keyboard and tries again. Her third protocol works like this. Each time a mobile host moves, say from N to N′, a forwarding pointer is stored at N pointing to N′. Every so often, the mobile host sends a message to its permanent home node with its current location. Then, the home node propagates a message down the forwarding chain, asking the intermediate nodes to delete their forwarding state. Can Alyssa ever lose messages with this protocol? Explain briefly. (Hint: think about the properties of the underlying network.)

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2d. *(8 points)* What additional steps can the home node take to ensure that the scheme in question c never loses messages? Describe briefly.

(Go to the next page)

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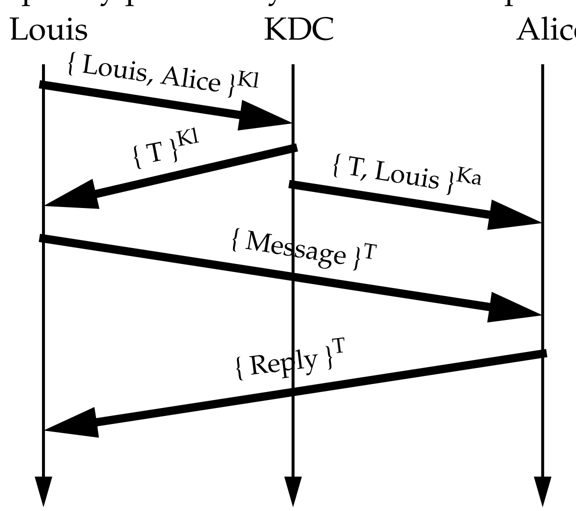
3. Louis B. Unreasonable has decided that the NSA has gotten their hands on PGP and probably made it weak or insecure. He therefore wants to write his own safer and more secure encryption system. Before doing so, he first wants to understand the most popular schemes of today, RSA and DES. RSA is a public-key system where encryption and decryption each take 1,000µs per block (a block is 0.1Kbyte or less). DES is a private-key system with a single key; encrypting or decrypting with DES only costs 10µs per block. (Only consider passive attackers for this problem.)

3a. *(6 points)* How long does it take to encrypt a file that is 1,000Kbytes in size, assuming you are using RSA? How long does it take to encrypt that same file using DES?

3b. *(6 points)* Louis was planning on using public-key encryption, but the costs you calculated for him have changed his mind. Now, his system will have central key distribution centers (KDCs) using only private-key encryption. Here's how the protocol works when Louis sends a message to Alice. (Louis's private key is Kl; Alice's private key is Ka; and the temporary private key the KDC sets up for them is T.)



How long will it take for this exchange to complete, that is, from the time Louis starts encrypting the first message to the KDC to the time Louis is done decrypting Alice's reply? *Only consider encryption times, decryption times, and network latency.* Assume the network latency is 2,000µs per message. Assume also that each message fits in one block.

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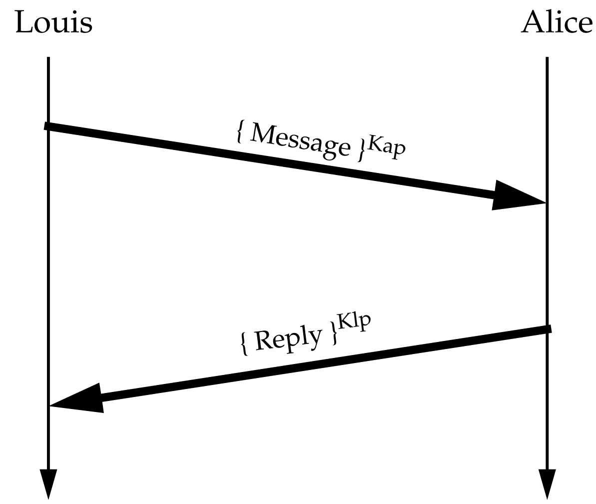
3c. *(6 points)* Alyssa P. Hacker thinks that Louis's reasoning is all wrong, particularly when messages and replies are small. She proposes a public-key encryption system; with her protocol, the same message exchange would look like this. (She assumes that Louis and Alice already know each others' public keys.)



How long will it take for this message exchange to complete with Alyssa's protocol (encryption times, decryption times, and network latencies only)? Again, the message and reply each fit in a block.

3d. *(6 points)* What guarantee does Louis's protocol provide for Alice that Alyssa's protocol doesn't? Assume that Louis keeps T secret.

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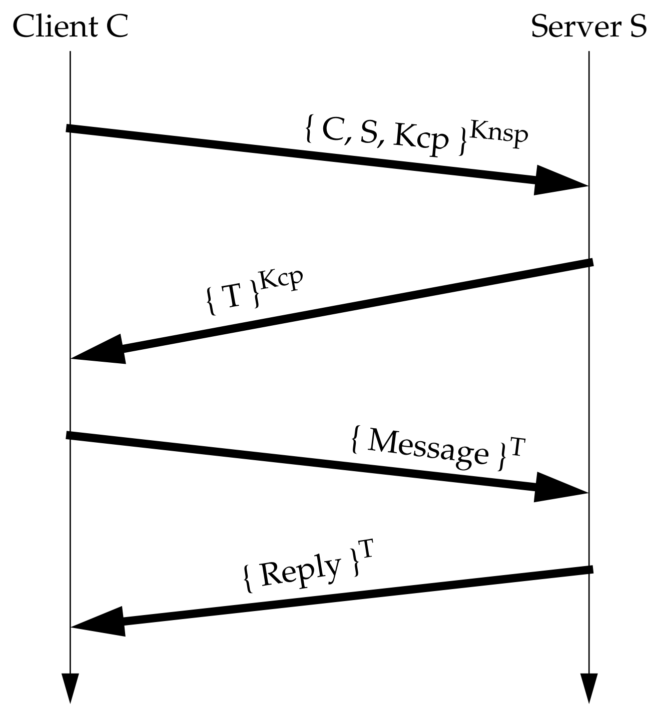
4. A startup company with an insanely high stock price, the Notsafe Communications Corporation, is designing a protocol for safe and private transactions over the Internet. Rather than rely on centralized security servers like Kerberos, the Notsafe designers are using public-key cryptography to implement their protocol. However, only the initial handshake uses public-key, since the protocol will be used for high-volume data transfers, where public-key cryptography is just too expensive. The handshake will set up a private key for communication between the parties, which then can continue for as much as a day or more.

   The Notsafe protocol has a well-known public key, K_{nsp}, which is used to establish connections. In addition, servers who want to talk the Notsafe protocol must use a Notsafe server program, which includes the secret key, K_{nss}. The protocol is graphically depicted below.



   In the first message, the client sends a handshake including C's public key, encrypted with K_{nsp}: $\{C, S, K_{cp}\}^{Knsp}$. The server decrypts this with K_{nss} and sends a response back to the client including a 32-bit private key T for the rest of the communication, encrypted with K_{cp}. Then, the client decrypts T with K_{cs} and sends messages and receives replies encrypted with T.

4a. *(2 points)* Notsafe's marketing department declares that "the risk of an intruder reading your sensitive data with Notsafe's products is less than one in one trillion." Mrs. Bach O. T. Envelope-Calculation immediately exclaims, "Poppycock!" Given the key that is being used, what might she have been thinking?

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4b. *(9 points)* List 3 fundamentally different problems with Notsafe's protocol.

4c. *(5 points)* List one possible problem that could arise from a very poor implementation of the Notsafe server (*not* a fundamental problem with the protocol itself).

4d. *(8 points)* Introduce two changes to the Notsafe protocol which improve its security and explain them briefly. *You are not expected to create a completely secure protocol*.

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