COS 116

The Computational Universe

Final Exam

May 13. 2011

This is a closed-book exam, but you may refer to the pseudocode handout from class. Write your answers in the space provided, or elsewhere in the exam (but label it clearly).

Princeton Honor Code: *Copy the pledge and sign your name below.*

> "I pledge my honor that I have not violated the Honor Code during this examination."

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1) (25 points) Recall a social network can be represented by a 2-D array A where A[i][j] =1 if i and j are friends and 0 otherwise. (We assume that if A[i][j]=1 then A[j][i] =1.)

A *threesome* in this network consists of three persons i, j, k such that each pair of them are friends. Write pseudocode that counts the number of threesomes in the social network, and also prints out each threesome **exactly once**. Assume the array A[] is already given.
(To print the value of a variable i, you can use the command `Print i.` To print one threesome per line you would print 3 numbers, followed by a command "`Print newline`".)

What is the running time of your pseudocode?

2) (20 points) In this question you have to design a very simple robot. The robot has two inputs: "rainy" and "exams just ended", each of which is binary (i.e. takes value 0 or 1) and a single output "go party" (also binary). The robot has a binary emotion: it is either "moody" or "not moody".

Every day at 8pm it checks these inputs and updates its emotion using the following rules:

If "rainy" has been true for the last two days, set "go party" to true and set emotion to "not moody" for the next day.

If "exams just ended" is true, set "go party" to true and set emotion to "not moody" for the next next day.

In all other cases set emotion to "moody" for the next day.

(a) What type of circuit is appropriate for your design?

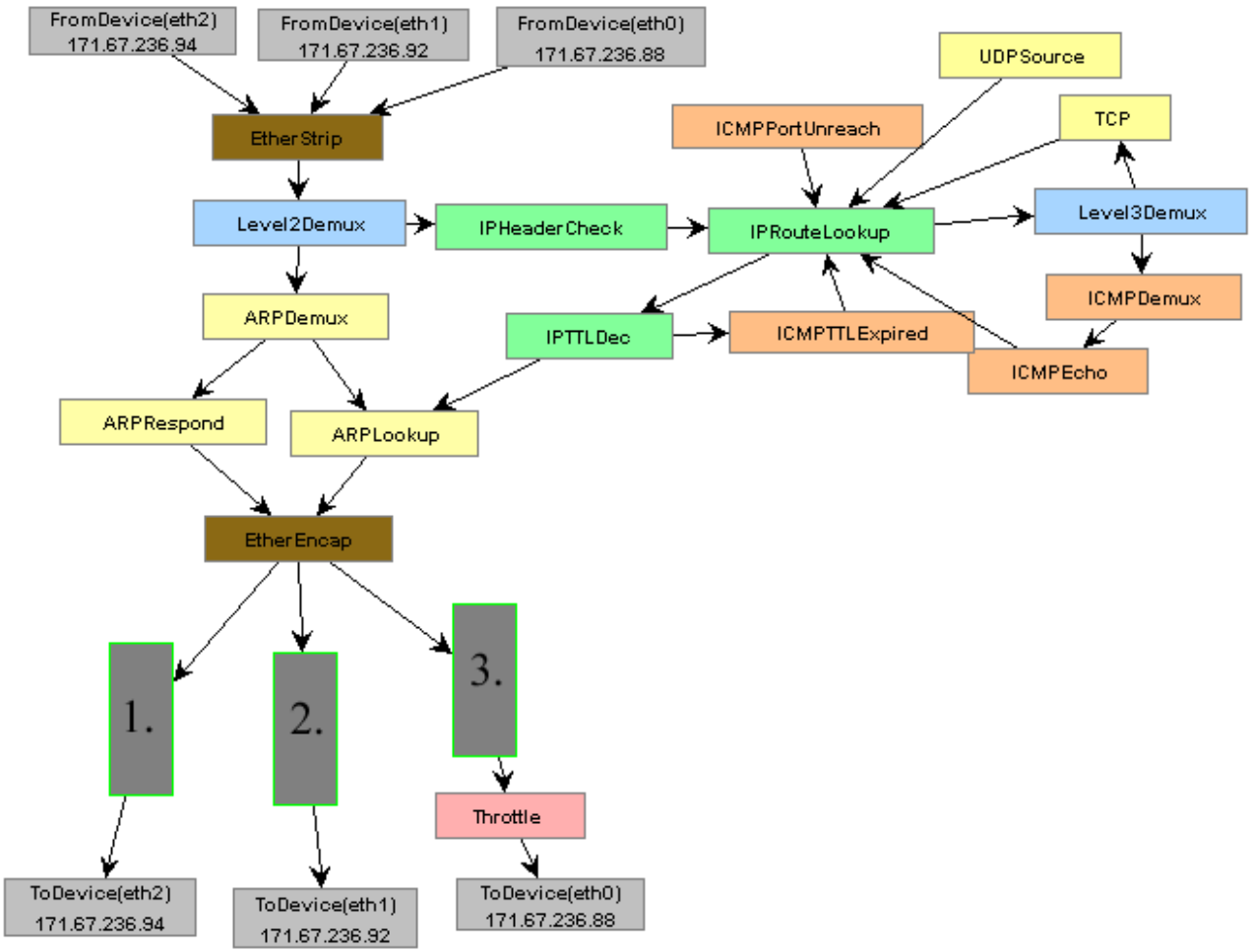
(b) Design a circuit that implements this behavior using the usual gates and memory elements you have seen in the course. Draw any truth tables you need along the way.

(c) Does your circuit have a clock? If so, what is its speed?

3) (15 points) (a) We described Public-key cryptography as a "Way for Amazon to sprinkle an unlimited number of boxes/envelopes around the world. Anybody can put a message in one of these boxes and lock it. Only Amazon knows how to open it." Explain this statement in a couple of lines, describing what is the metaphorical "box" and in what sense Amazon sprinkles it around the world.

(b) We didn't discuss this in class, but current schemes for public key cryptography also allow secure communication in the reverse direction: Amazon can lock a message in a box and send it to anybody in the world, who can use the same infrastructure as in (a) to open it and know it is from Amazon. Assuming this property, explain in a few lines how to implement a digital signature scheme for the world: it should allow everybody (who wishes to participate) a way to digitally sign all their electronic communications, such that the "signature" can be verified in court.

4) (20 points) Recall from the internet and congestion lab the following network traffic diagram of the router:



The queues to Devices eth0, eth1 and eth2 have been labelled with numbers. Recall that eth0 is the "Internet", and eth1 and eth2 are servers. Ignore the coloured rectangles (pay attention to the 9 gray rectangles and the Throttle).

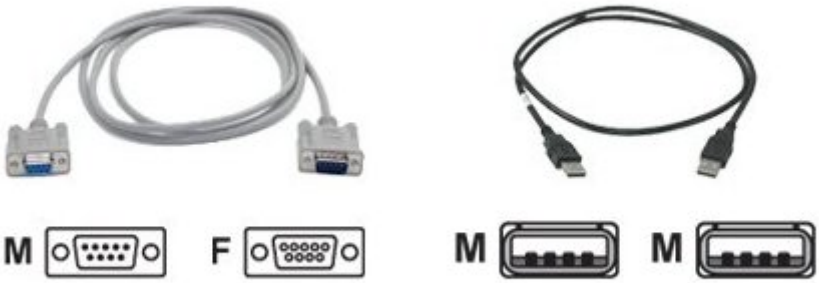
(a) What box(es) correspond to your browser in this picture, and to your mom's browser (offcampus)?

(b) What do the vertical rectangles 1,2,3 correspond to? What role do these play on the internet?

(c) What is the role of the pink box called “Throttle”? What aspect of the real internet does it stand for?

(d) If Device eth0 requests a file from Device eth2, at which of boxes 1, 2, 3 will we see activity?

(e) What do the yellow boxes UDPSource and TCP represent? What real-life applications do they correspond to, and how do they differ in their interactions with the other boxes mentioned above?



5) (8 points) On the left hand side above is a serial cable, with bandwidth 115 Kbps. On the right hand side is a USB cable, with bandwidth 12 Mbps. How many times faster is the USB cable? Why are the transmission rates so different even though electric signals travel at the same speed through the wire?

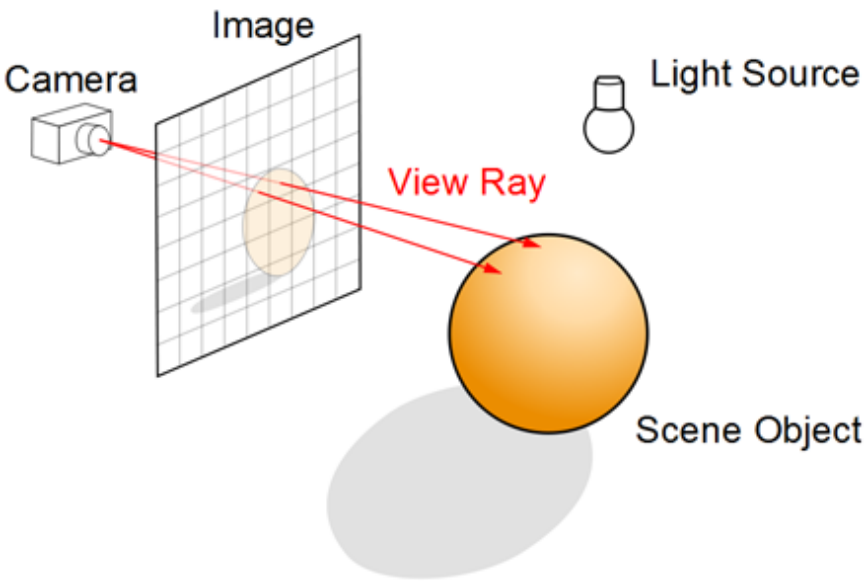
6) (8 points) What is Moore's law? Explain the following statement in a couple of lines: "Moore's law is a law not about physics but about market structure and society."

7) (8 points) Briefly describe how a company can raise its ranking in Google rank, and explain why this technique works. Why don't more companies use this technique?

8) (10 points) List 3 features of the "storm" botnet that make it hard for security experts to combat it.

9) (10 points) List three major approaches to music synthesis using computers.

10) (8 points) Consider a simple image rendering algorithm, whereby we shoot out a ray from the eye into the model, compute the first intersection of the ray with an object in the scene, and compute the brightness and color of that area and depict it on the screen. Why doesn't this method produce realistic images? List two ways in which this method is deficient.

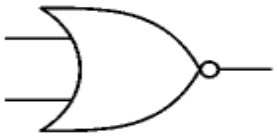


11) (8 points) In the Machine Learning lab you saw that the "spamminess" of each word in an email were multiplied together to get an overall spam score for the email. Come up with two ways in which you could improve spam detection that involve further analysis of the email text?

12) (10 points) A form of Facebook virus spreads by sending a message to the user's facebook friends with a link to an external website which when clicked infects the friend's computer with the actual virus. Name two measures you would recommend to Facebook administrators to combat this form of virus. Name one countermeasure the virus writer could take to keep the virus potent.

13) (7 points) Recall that the NOT gate outputs a 1 when the input is 0, and a 0 when the input is 1.

In the homework you saw that the NAND gate was a universal gate (combinations of NAND gates can build the AND, OR and inverter gates). The NOR gate is also a universal gate. It produces outputs equivalent to an OR gate with a **negated** output. This is a picture of a NOR gate:



Draw a circuit with one or more NOR gates that acts as a NOT gate. Prove your answer.

14) (8 points) What is Turing's definition of an intelligent computer? Recently, a computer program called Watson became the Jeopardy world champion. Does this satisfy Turing's definition?

15) (7 points) Turing's model of computation includes an infinite memory tape. Why doesn't this make it unrealistic since the universe is finite?

HAVE A GOOD SUMMER!!