15-110: Principles of Computing, Spring 2018

Problem Set 10 (PS10)

Due: Friday, April 13 by 2:30PM via Gradescope Hand-in

HANDIN INSTRUCTIONS

Download a copy of this PDF file. You have two ways to fill in your answers:

1. **Just edit (preferred) - Use any PDF editor (e.g., Preview on Mac, iAnnotate on mobile, Acrobat Pro on pretty much anything) to typeset your answers in the given spaces. You can even draw pictures or take a picture of a drawing and import it in the correct place in the document. That's it. (Acrobat Pro is available on all cluster machines.)**

2. **Print and Scan - Alternatively, print this file, write your answers neatly by hand, and then scan it into a PDF file. This is labor-intensive and must be done by the deadline.**

Once you have prepared your submission, submit it on Gradescope. A link to Gradescope is provided in our Canvas course portal.

Fill in your answers ONLY in the spaces provided. Any answers entered outside of the spaces provided may not be graded. Do not add additional pages. We will only score answers in the given answer spaces provided. If we cannot read your answer or it contains ambiguous information, you will not receive credit for that answer.

Be sure to enter your full name below along with your section letter (A, B, C, etc.) and your Andrew ID. Submit your work on Gradescope by 2:30PM on the Friday given above.

REMINDER: Sharing your answers with another student who is completing the assignment, even in another semester, is a violation of the academic integrity policies of this course. Please keep these answers to yourself.

Name (First Last) ____

Section __________ Andrew ID ________________________________

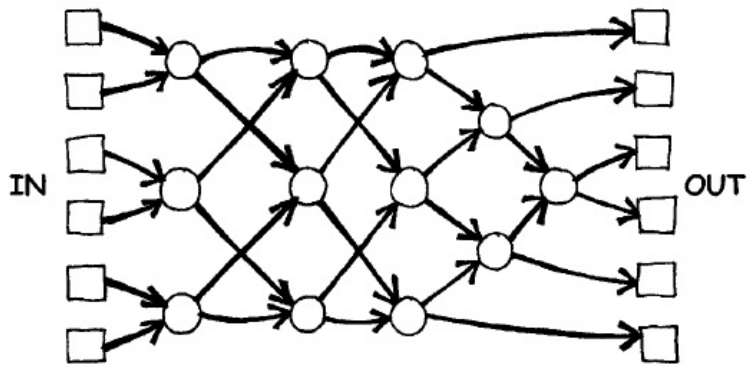
1. (2 pts) At a university, a student club wants to send out individualized invitation letters to 500 faculty for an upcoming donor event. Each letter requires the following steps, in order:

> 1. Write a personal message to the faculty member on the inside of a card (8 minutes).
> 2. Hand draw a scene with the club logo on the cover of the card with colored pencils. (12 minutes)
> 3. Cut out and form a special envelope for the card out of a sheet of premium paper. (5 minutes)
> 4. Seal the card in the envelope with glue, look up and write the address of the faculty member, and put a stamp on the card. (2 minutes)

(a) If the club utilized the principle of pipelining and had four workstations, one for each step above, and one person to work at each workstation, how many minutes would it take to complete the 500 invitations? How does this compare to one person completing the entire task? Show your work.

(b) Can this task be completed even faster with four people working concurrently? If so, explain how and compute the total amount of time needed to complete the task. If not, explain why.

2. (1 pt) Consider the following sorting network you saw in class:



Assume each comparator (i.e. the circles) takes 1 millisecond (1/1000th of a second) to compare its two elements and output its results and that the time for a data value to go from one comparator to the next is negligible. We wish to sort 2000 sets of 6 integers each.

(a) If we sort one set of 6 integers completely before starting the next set, how long will it take to sort the 2000 sets in seconds? (Remember that some of the comparators are operating concurrently.)

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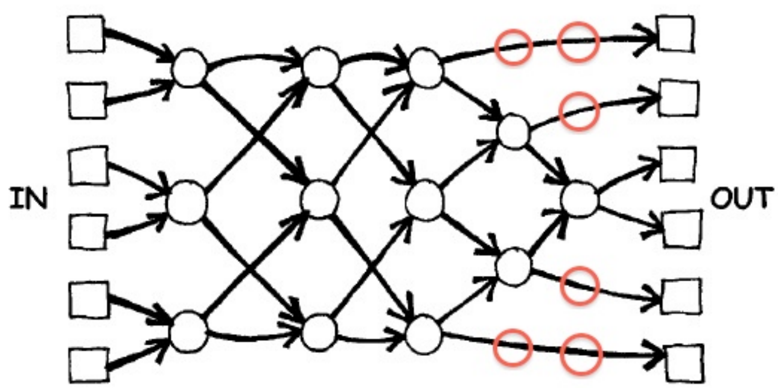
b) If we use the principle of pipelining, how long will it take to sort the 2000 sets, rounded to the nearest second? (**NOTE:** To simplify the problem, assume there are some dummy comparators inserted into the network as shown below so that all results arrive at the output terminals at the same time.)



3. (1.5 pts) Let `image` be a Python list that represents the bitmap image of a 400 X 400 pixel image. An image is a list of lists of lists of integers (i.e. a 3-dimensional list) as defined in lecture.

(a) Show how to remove the blue component of the top left pixel in Python.

(b) Show how to set the bottom right pixel to the color yellow in Python.

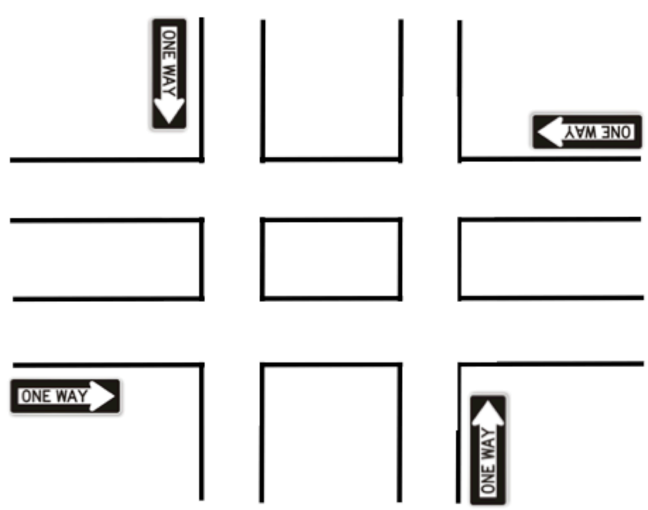
(c) We wish to convert the image to gray-scale. We do this by resetting each pixel's R, G, B values to the average of its original R, G, B values (to the nearest integer). If it takes time *t* to convert one pixel to gray-scale using 1 processing core, how long will it take to convert the entire image to gray-scale using 16 processing cores concurrently, in terms of *t*?

4. (1.5 pts) Recall that an operating system is a program needed on all computational devices.

(a) How does the operating system use the principle of *multitasking* to run a number of programs "concurrently" on a device with a single processor core?

(b) Your Python program calls the `print` function. Why is the operating system involved in this process?

5. (2 pts) A grid of city streets is shown below. Cars travel each of the four one-lane one-way streets. For this problem, cars do not make any turns, there are no stop signs and cars don't crash. It is ok for a car to stop in the middle of an intersection if there is a car blocking its path.
If a car passes both intersections, it continues on unimpeded. Show how deadlock can occur in this city grid by drawing cars as rectangles. Your picture should clearly indicate that deadlock must occur (i.e. all cars must get stuck forever). You will need to show more than 4 cars to get deadlock.



6. (2 pts) Read Appendix A of *Blown To Bits* (available on the course website). This reading explains the basics of the Internet. Based on the reading, answer the following questions.

(a) The Internet was designed so that packets of information would be directed to a computational device on the network based on its IP address. The original IPv4 address format is 32 bits. A recent article states that by 2020, there will be 50 billion computational devices that need to be connected to the Internet. Can every device have its own permanent IPv4 address? Why or why not?

(b) TCP is an example of a protocol used on the Internet. A protocol is a set of rules that govern how communication proceeds between two parties. When Alice sends an Internet packet to Bob using TCP, how does she know if Bob received it? What does she do if she thinks Bob didn't receive it?

(c) Alice sends a file by breaking it up into a large number of small packets and sends them one at a time to Bob. The packets don't necessarily arrive in the correct order. Why not? And how does Bob know how to put the file back together if the packets arrive in the wrong order?

(d) Protocols on the Internet can be viewed as an hourglass, as shown in Figure A.3 in the reading. There are protocols for applications like email and hypertext, all the way down to protocols on how individual bits are sent across optical fiber, copper wire and radio networks. If a new application is created for the Internet, do the bit-level protocols (fiber, etc.) need to be adjusted? Why or why not?