150 points. Individual Work Only. Due **Sep 26, 2024** before class (**12:15 PM**).

Objectives:

- use a software version control system
- submit jobs through a batch system
- review a technical paper (required only for CS 581 students)

Instructions:

Part #1. Create a software repository to manage your source code

1. Create a github account at https://www.github.com using your crimson email address.
2. Create a new repository (say, *Fall2024_CS481_HW1*) on the github server. Make sure that you have created a private project (click on visibility to be private).
3. You can use the browser to either add files or upload files from your local machine. If you are using a terminal, you can execute the following commands in a terminal (assuming you have the solution as *hw1.c* in the directory *CS481/hw1* and repository name is *Fall2024_CS481_HW1*; use your github username instead of <githubid>):

   cd CS481/hw1
   git init
   git remote add origin https://github.com/<githubid>/Fall2024_CS481_HW1.git
   git add hw1.c
   git commit –m “Initial check in”
   git push -u origin main
4. After this if you make changes to the file hw1.c you can update the repository using:

   git commit -m "Appropriate commit message"
   git push origin main
5. Click on the setting tab, click on Manage Access on the left side, and then click on the green box in the middle of the screen “Invite a collaborator.” Enter **mhchowdhury@crimson.ua.edu** and **chgomes@crimson.ua.edu** as the email address and click on “Add …” button.

The URL above (https://www.github.com/<githubid>/Fall2021_CS481_HW1.git) will be different for you depending on your github id and repository names, you can get the URL by selecting HTTPS and clicking on the copy icon next to the URL when you click on the green “Code” button.

Part #2: Login to the asc cluster at Alabama Supercomputing Center (ASC) and submit jobs

1. Use an SSH client and login to the *asax* cluster (Host Name: asax.asc.edu) at Alabama Supercomputing Center (ASC) using the username and password provided to you. First time you login, you will be prompted to setup DUO two-factor authentication, and after the setup process you have to login again using two-factor authentication. Use the same username and temporary password provided and then you will be prompted to change the password, please choose a secure password, and remember that password. When prompted to enter an email address enter your

crimson email address. I have attached a sample session to login, setup DUO two-factor authentication, and login again as a separate document in Blackboard.

You can access the HPC User Documentation at https://hpcdocs.asc.edu. You have to login using the username that was provided to you and the new password that you selected above. Click on “Getting Started” on the left panel and you will find a lot of useful information about Accessing the Supercomputers, SLURM Queue System, Working with Linux, etc. Click on the appropriate links to find out more. If you are new to Linux check out “Working with Linux” link first.

2. Now that you have successfully logged in, check out the solution to homework-1 that you uploaded in Step #3 (part 1), and compile it on the *asax* cluster using the following commands:

   git clone https://<usertoken>@github.com/<githubid>/Fall2024_CS481_HW1.git

   cd hw1

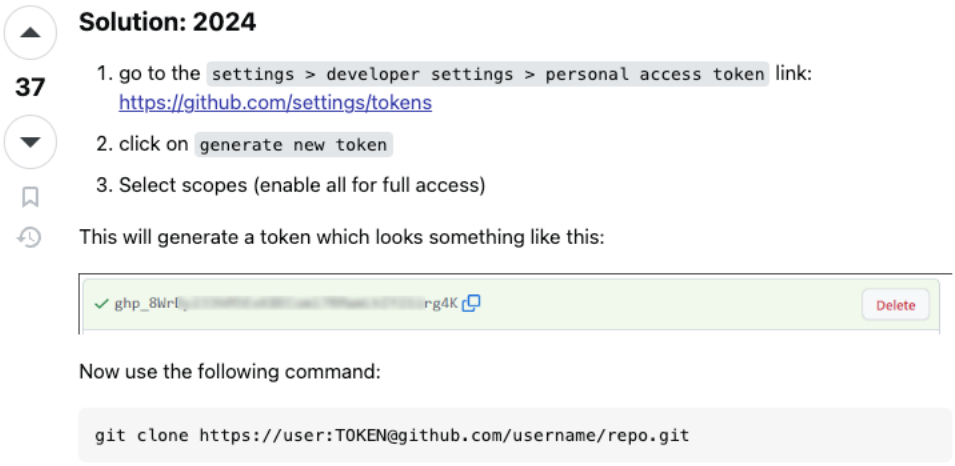
You need to add module by using: “module load intel”. After that you can compile the program.

   icx –O –o hw1 hw1.c

   ./hw1 5 5

   Check the url:

   https://stackoverflow.com/questions/2505096/clone-a-private-repository-github



The URL above will be different for you depending on your group and project names, you can get the URL by selecting HTTPS and clicking on the copy icon next to the URL on your project page on the git server.

3. After compilation, you need to logout and login again using the new password you selected.

4. Use an editor (e.g., *nano* or *vi* – see documentation on Text Editors in Linux under Getting Started) and create a file called *myscript.sh* and add the following lines (assuming you named your executable *hw1*):

   #!/bin/bash

   ./hw1 1000 100

   ./hw1 1000 100

   ./hw1 1000 100

5. Change the file permission for myscript.sh to have execute permissions using the following command:

   chmod +x myscript.sh

6. Submit the job to the cluster using the following command:

   run_script myscript.sh

You will be prompted with several questions, follow the sample session provided below (the options will be slightly different based on the queue selected). Make sure you choose the "class" queue, 1 core, and the appropriate maximum runtime and memory based on the problem size you are using.

Please do NOT execute programs on the login node, you MUST submit jobs to the batch system to execute your programs. Here is a sample session.

```
ual1@asaxlogin1:Fall2024_HW1> run_script myscript.sh
This runs a script in the current directory via the queue system
This script lets the job use multiple processors on the same node.
Report problems and post questions to the HPC staff (hpc@asc.edu)


Choose a batch job queue:

Queue                      Wall Time      Mem  # Cores
-------------------------- ---------- -------- --------
express                      4:00:00     16gb      1-4
small                       60:00:00      4gb      1-8
medium                     150:00:00     16gb     1-16
large                      360:00:00    120gb    1-128
bigmem                     360:00:00  130-500gb   1-32
benchmark                   24:00:00    500gb    1-128

Your job will have a shorter wait time if your memory request is
reasonable (about 20% more than needed), and your time request is
reasonable (about 50% more than needed).
Find this out by running 'jobinfo -j JOB_NUMBER' for a correctly
completed job.

Enter Queue Name (default <cr>: small)

Enter number of processor cores (default <cr>: 1 )
```

```
Enter Time Limit (default <cr>: 60:00:00 HH:MM:SS)

Enter memory limit (default <cr>: 1gb )

Enter a name for your job (default: myscriptshSCRIPT)

Run on;  icelake, milan (default: asax)


============================================================
=====         Summary of your script job               =====
============================================================
  The script file is: myscript.sh
  The time limit is 60:00:00 HH:MM:SS.
  The memory limit is: 1gb
  The job will start running after: 202409121325.49
  Job Name: myscriptshSCRIPT
  Queue: -q small
  Constraints:
  Queue submit command:
qsub -q small -j oe -N myscriptshSCRIPT -a 202409121325.49 -r n -M
mhchowdhury@crimson.ua.edu -l walltime=60:00:00 -l
select=ncpus=1:mem=1000mb

104402.asax-pbs1
ual001@asaxlogin1:Fall2024_HW1> qstat
Job id            Name             User              Time Use S Queue
----------------  ---------------- ----------------  -------- - -----
104402.asax-pbs1  myscriptshSCRIP* ual001         00:04:22 R small
104404.asax-pbs1  myscriptshSCRIP* ual001         00:00:00 R small
```

7. You can check the status of your job using the “squeue” command. See the user’s manual for more details.

8. Once you are comfortable with using Linux and submitting the jobs, run the Game of Life program from Homework-1 on the asax cluster and complete the table below.

Test Case #	Problem Size	Max. Generations	Time Taken Homework-1	Time Taken DMC cluster
1	1000x1000	1000	29.7277 sec	3.455576 sec
2	1000x1000	5000	166.824 sec	17.278363 sec
3	5000x5000	1000	832.167 sec	86.397196 sec
4	5000x5000	5000	4519.59 sec	432.056557 sec
5	10000x10000	1000	2085.45 sec	1730.293398 sec
6	10000x10000	5000	18277.2 sec	1729.33304 sec

Make sure you comment out any print statements you might have to print the board when you execute with larger problem sizes. Also, execute the program three times and use the average time taken. If your program creates large output files, please

make sure you write the files to /scratch/$USER directory. You have to first create the /scratch/$USER directory using the command: mkdir /scratch/$USER.

9. Compare the timing results from Homework-1 with the execution time on the asc cluster. If there is difference in the execution time between the two runs, provide a rationale for this difference.
10. [**Required for CS 581 students**] Compare the performance of your program on the ASC cluster using GNU compiler and Intel compiler and make a table similar to table in Question #8 and include the time taken with the two compilers. Make sure to include any compiler options that you use to get these results.

Part #3: Review technical paper (Required for CS 581 students)

Read the paper titled "Exponential Laws of Computing Growth" by Peter J. Denning and Ted G. Lewis published in the January 2017 issue of Communications of ACM available at Blackboard and answer the following questions in your report:

1. What is Moore's Law?
2. What is Dennard scaling?
3. What is S-curve model?
4. Is Moore's Law dead now?
5. According to the authors, what are the three levels of exponential growth in the computing ecosystem? Will this growth be sustained for the next decade?

Report:

Include the results from Part #2 along with the performance analysis and answers to questions in Part #3 in the report. Submit the report as a Word or PDF file.

Submission:

Upload the report (.doc or .pdf file) to Blackboard in the assignment submission section for this homework and include the URL for your git project repository in the comments section of the submission. Make sure to add the instructor (**mhchowdhury@crimson.ua.edu**) and grader (**chgomes@crimson.ua.edu**) as a collaborator to your github project so that I can review your code in github. You can reuse your homework 1 report for this. You need not to write the report again. You must include the GitHub repository link in the report.

Temporary Class Account Instructions

WARNING: This is a temporary account. The account and all the files in it will be deleted at the end of the semester. You are responsible to backup all your files before the end of the semester.

GETTING STARTED ON THE SUPERCOMPUTER (asax.asc.edu)

We have made an account for you on the ASC cluster at the Alabama Supercomputer Center. The course instructor will give you the account name and password. Here is some information to help you get started.

There are a couple steps needed to initially get access to this computer system.

Step 1) Get enrolled in DUO two factor authentication. Use a web browser to go to the documentation website at https://hpcdocs.asc.edu/ then put in the user name and password provided by your instructor. The first time you do this, you will be put into the DUO enrollment dialog. The attached PDF (Setting_up_DUO_2024_new.pdf) gives more information on how to enroll in DUO.

Step 2) Use a secure shell (ssh) program.

Secure shell is installed on many Macintosh, and Linux computers, and can be called with a command like this in the terminal window.

```
ssh UserID@asax.asc.edu
```

If secure shell is not installed on your Microsoft Windows computer, contact your system administrator, or look into the PuTTY software, available at https://www.chiark.greenend.org.uk/~sgtatham/putty/. The PuTTY package allows ssh connections. On the same website, you can download PSCP or PSFTP, which can be used to transfer files to or from the supercomputers.

Step 3) Login via ssh using the temporary password provided by your instructor. We recommend that you login the first time from a computer on campus, or note the possible issue described below.

NOTE: The first time you login, you will have to enter the password, authenticate via DUO, then set a new password (entered twice). Nothing is displayed when you type these passwords.

If you are not connecting from your university campus, you may get an error like "connection timed out". If this happens, sit on the computer you want to use, in the building where you want to use that computer, then go to this website: https://ip.asc.edu, then email what it tells you to hpc@asc.edu.

MORE INFORMATION

Files can be copied to and from the computers using secure copy "scp" or secure ftp "sftp". These programs are often included with secure shell software.

There are several sources of help for working with the HPC (high performance computing) systems. The Alabama Supercomputer Center HPC documentation can be found online at: https://hpcdocs.asc.edu/

The hpcdocs website is accessed with the same user name, password, and DUO authentication as you used for ssh.

Another source of help is the Linux "man" command, which shows the manual page for any UNIX command. For example, typing "man ls" will show information on using the "ls" command to list files in a directory.

In order to get the maximum possible utilization of the computers, computational jobs are executed through the SLURM job queueing system. SLURM can be accessed via commands like “squeue” to check queue status or the "run_script" command to submit a job.

The queue script will prompt you for the name of the queue and any limits you may wish to set on time, memory, or file size. It then prompts for a date and time to run the job, job name, and output directory. All prompts can be satisfied by pressing "Enter" to give default values of the queue name, job size limits, and a default job name.

All Accounts have a disk quota limit. To see your disk quota, type "quota" or "usage". Queue limits and interactive use limits can be seen by typing "qlimits".

If you need any help using the cluster or have questions about the cluster, **please post your questions on the discussion forum or course instructor first and do NOT contact** the ASC staff directly.