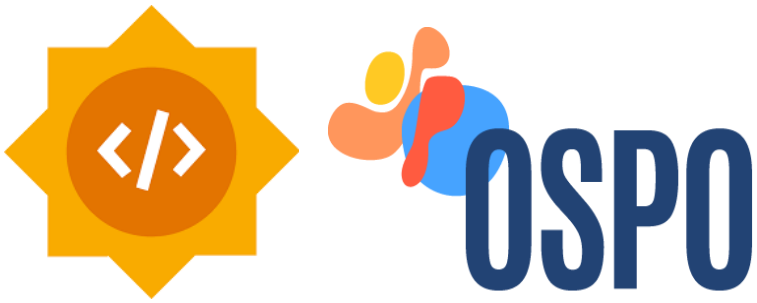

# GSOC'23 with UC OSPO

## Teaching Computer Networks with Reproducible Research: Developing a "classroom competition" for adaptive video delivery (Mentor: Fraida Fund)

SRISHTI JAISWAL

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## Introduction

- Define the problem you are trying to solve
  - ☐ Lack of reproducibility
  - ☐ Bridging the gap between research and education
  - ☐ Inadequate teaching materials
  - ☐ Encouraging collaboration
  - ☐ Importance of active learning
  - ☐ Better preparation for industry

**Lack of reproducibility:** Reproducibility is a critical aspect of scientific research, yet many students need help to reproduce results from published research. By packaging the result of an existing open-source reproducible result, this project aims to make it easier for students to reproduce and build on existing work.

**Bridging the gap between research and education:** Often, there needs to be more connection between the research being conducted and the teaching material available to the students. By developing a competition that builds on existing research, this project aims to bridge this gap and provide students with the opportunity to engage with cutting-edge research in a meaningful way.

**Inadequate teaching materials:** Many students need more high-quality teaching material to learn complex topics. By providing a competition that challenges students to design their own adaptive video policies, this project aims to provide students with a hands-on, active learning experience that can help them better understand the material.

**Encouraging collaboration:** Collaboration is a critical component of successful research and industry work, yet it is often lacking in the classroom. By creating a competition that allows students to work together and learn from their peers, this project aims to foster a collaborative learning environment.

**Importance of active learning:** Active learning is a more effective way of teaching than passive learning, yet it is often underutilised in the classroom. By developing a competition that challenges students to engage with the material and apply it practically actively, this project aims to encourage active learning.

**Better preparation for industry:** The skills developed in this project, such as designing and implementing adaptive video policies, are highly relevant to industry work. By providing students with a hands-on opportunity to develop these skills, this project aims to prepare them for careers in the field better.

So, I aim to address the challenges of reproducibility in computer networks, bridge the gap between research and education, promote active learning, and better prepare students for careers in the industry.

- **Provide background about the current state of the problem**

This project builds on an existing open-source reproducible result for adaptive video delivery, which provides a testbed (like GENI, CloudLab, FABRIC etc.) for evaluating and comparing different algorithms and techniques for adaptive video delivery. It serves as the foundation for the classroom competition being proposed in this project. This reproducible result provides a starting point for students to build upon and extend the existing work, helping to bridge the gap between research and education. The proposed competition aims to provide students with an opportunity to actively engage with the material and apply it practically, promoting active learning and better preparing them for careers in the field. By implementing other adaptive video policies from the literature and developing different network settings for evaluation, the competition will challenge students to think creatively and develop their own solutions to real-world problems. The use of a leaderboard format for sharing results will encourage collaboration and provide students with a sense of ownership over their work

- **Describe your solution**

- ➔ The existing open-source reproducible result for adaptive video delivery will be packaged in a way that makes it easier for students to reproduce and build upon the original work. This will involve providing detailed instructions and documentation, as well as developing scripts and tools that automate the process of reproducing the results.

- ➔ Other adaptive video policies from the literature will be implemented and made available to students as baselines. This will allow students to compare their own policies against existing approaches and gain a deeper understanding of the strengths and weaknesses of different algorithms and techniques.

- ➔ To further enhance the educational value of the competition, different network settings will be developed using live link traces and emulated link patterns. This will allow students to evaluate their submissions in a variety of scenarios and gain experience in developing adaptive policies that perform well under different network conditions.

- ➔ Finally, an evaluation framework will be developed for scoring student submissions on different criteria and in different network settings. The results will be made available in a leaderboard format, allowing students to track their progress and compete against their classmates.

Overall, the proposed solution aims to make learning about adaptive video delivery more engaging, interactive, and hands-on while also promoting reproducible research practices in the field. By providing a fun and competitive environment for students to learn and experiment with different algorithms and techniques, the hope is that they will gain a deeper understanding of the topic and be better prepared for future research and industry work in this area.

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## Project Goals

- **Project objectives: What do you expect to get from this project? How will the community benefit?**

The expected benefits of this project are:

➔ Improved understanding and engagement of students in the field of computer networks: By providing a fun and exciting way for students to learn about adaptive video delivery policies, this project can increase student motivation and interest in the topic.

➔ Increased reproducibility and accessibility of research results: By packaging the existing open-source reproducible result for adaptive video delivery, this project can make it easier for students to reproduce the original work and build upon it, thereby increasing the accessibility and reproducibility of research results.

➔ Advancement of research in adaptive video delivery policies: By challenging students to extend the existing work and design their own policies for head-to-head competition, this project can lead to the development of new and improved adaptive video delivery policies, advancing the state of research in the field.

➔ Community benefit: The development of this classroom competition can benefit the broader community by providing a platform for sharing and evaluating new adaptive video delivery policies, thereby contributing to the development of best practices in the field. Additionally, the open-source nature of the project can facilitate collaboration and knowledge sharing among researchers and educators.

- **Expected deliverables: What do you think the results will be from this proposal?**
  The expected deliverables from this proposal include the following:

- ➔ A packaged and easily reproducible open-source result for adaptive video delivery policies, which can be used by students to extend and build upon the original work.

- ➔ Implementation of other adaptive video policies from the literature can serve as a baseline for students to compare and evaluate their own policies. There are many standard adaptive video policies from the literature, including rate-based adaptation, buffer-based adaptation, hybrid rate and buffer-based adaptation, and context-aware adaptation, among others. The specific policies used in the competition may depend on the preferences and expertise of the instructors involved in the project.

- ➔ Development of different network settings, including live link traces and emulated link patterns, in which student submissions can be evaluated.

- ➔ An evaluation framework for scoring student submissions on different criteria and in different network settings and making the results available in a leaderboard format.

- ➔ An exciting and engaging classroom competition that motivates students to learn about adaptive video delivery and encourages them to develop their own policies.

From the student's point of view, the competition will involve designing and implementing their own adaptive video policies and evaluating them against other student submissions using the evaluation framework. They will have access to different network settings and link traces to test their policies in various scenarios. The leaderboard format will allow them to see where they stand in comparison to their peers.

From the instructor's point of view, they will provide guidance and support to students as they work on their policies. They will also be responsible for managing the

competition, providing feedback on student submissions, and ultimately selecting the winners based on the criteria outlined in the evaluation framework.

Overall, the deliverables from this project aim to provide an effective and engaging way for students to learn about computer networks and adaptive video delivery while also contributing to the development and evaluation of new policies in this field. The open-source nature of the project also allows for the broader community to benefit from the reproducible research and educational materials developed.

- **Future work based on the project (if applicable)**

Future technical work that could build upon this project includes:

➔ Expanding the scope of the competition to include other types of multimedia streaming besides video, such as audio and images.

➔ Integrating machine learning algorithms to optimise adaptive video delivery policies based on network conditions automatically.

➔ Developing more realistic network scenarios by incorporating real-world data such as user behaviour, server load, and network congestion.

➔ Creating a web-based interface for the competition, allowing students to submit their adaptive video policies and view the leaderboard results in real-time.

➔ Investigating the performance of adaptive video delivery policies on different hardware platforms, such as mobile devices and smart TVs, and optimising policies accordingly.

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## Implementation plan

- **Project methodology:**

  **How will you work to meet your objectives?**

➔ The existing open-source reproducible result for adaptive video delivery will be packaged to make it easier for students to reproduce and build on it. This will involve documenting the necessary software packages and dependencies, instructions for setting up the environment, and sample datasets.

➔ Based on the literature review, other adaptive video policies will be identified and implemented as baselines. These policies will be evaluated and compared with the existing policy to determine their effectiveness and suitability for the competition.

➔ Various network settings will be developed, including live link traces and emulated link patterns, in which student submissions may be evaluated. This will allow for a wide range of network conditions to be tested and for students to gain experience in designing adaptive video policies that work under different network conditions.

➔ An evaluation framework will be developed for scoring student submissions on different criteria, such as video quality, playback delay, and bitrate adaptation speed. This framework will also take into account different network settings to ensure that students' policies are effective across a range of network conditions. The results of the competition will be made available in a leaderboard format to motivate students to improve their policies.

In the entire project, we are adding more baseline results from the literature and adding documentation and materials for course instructors to help them to use these materials in the classroom.

**How will you interact with the mentor and other members of the relevant open-source community?**

By using the Slack channel to share progress updates, ask for feedback and advice, and engage in discussions. Scheduling regular check-ins with the mentor to review progress, discuss any challenges, and receive guidance on the next steps. By Attending relevant community events, such as meetups and conferences. This can help build relationships with community members and increase visibility for the project.

- **Describe the project's technical elements**

➔ The existing open-source result for adaptive video delivery will be packaged to make it easier for students to reproduce and build on it. This will be on the testbed for this, and I will create a project on the testbed and provide the link and project name to students. All the students need is a browser and terminal for SSH.

➔ We will research and identify other adaptive video policies (like rate-based adaptation, buffer-based adaptation, hybrid rate and buffer-based adaptation, context-aware adaptation etc.) from the literature that we can implement and test against the existing open source result. We will implement these policies using Python and integrate them into the existing codebase.

➔ To evaluate student submissions, different network settings will be developed using live link traces and emulated link patterns. These settings will simulate different network conditions, such as high and low bandwidth, high and low Latency, and packet loss, so that students can see how their policies perform under different conditions.

➔ We will develop an evaluation framework to score student submissions on different criteria, such as video quality, buffer size, and bitrate changes. We will use machine learning algorithms to learn the ideal parameter values for each adaptive video policy in different network settings. We will make the results

available in a leaderboard format so that students can see how their submissions compare to their classmates.

The competition will have a browser-based interface that students can use to submit their policies, view their scores, and compare their performance against their classmates. The interface will also provide access to the testbeds, where students can SSH into the virtual machines or containers to test their policies on the different network settings.

- ## Describe any challenges and proposed solutions

➔ For the challenge of packaging the result, a possible solution is to document the instructions for using teasbeds and provide clear instructions for students to reproduce the existing work. By providing a step-by-step guide to run the experiment.

➔ To implement other adaptive video policies from the literature, the solution could be to conduct a thorough literature review and select the most relevant policies for inclusion in the competition. This could involve collaborating with the mentor and other members of the open-source community to identify and evaluate different policies.

➔ And One crucial challenge for this project could be the availability of live link traces for evaluating the adaptive video policies. In case live link traces are not available or difficult to obtain, emulated link patterns can be used to simulate different network settings for evaluating the policies. Another potential challenge could be in ensuring that the competition remains fair and unbiased, which can be addressed by carefully defining and implementing the evaluation framework and criteria for scoring student submissions. Additionally, ensuring that the project is accessible to a diverse range of students, including those with varying levels of technical background, can also be a challenge. This can be addressed by providing clear documentation and support resources, as well as encouraging collaboration among students with different skill levels.

➔ For developing an evaluation framework, a possible solution is to define a set of evaluation metrics and criteria that can be used to evaluate student submissions objectively. This can involve working with the mentor and other experts to identify appropriate metrics and developing a scoring system that reflects the relative performance of different adaptive video policies. Finally, creating a leaderboard format to display the results can help motivate students and make the competition more engaging.

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## Project Timeline

- **Project plan and deliverables schedule**

I expect to complete the following goals in order

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| **Community Bonding Period ( 4 May - 28 May)** | • I will be discussing this with my mentor in further detail.<br>• More Familiarize with existing open source projects and all testbeds |
| **Week 1-2** | • Will discuss with the mentor and other community members about project goals and technical details<br>• Will sketch out the complete plans for the student's submission and evaluation process (like which factor we have to consider to evaluate results etc. so that competition remains fair and unbiased). |

| | |
|---|---|
| | • And will get the agreement from my mentor on precisely what I will implement and how it works. |
| **Week 3-4** | • Will develop the network setting using live link traces and emulated link patterns for student submissions to be evaluated on<br>• Wil develop an evaluation framework for scoring student submissions on different criteria such as video quality, bandwidth usage, and buffer length |
| **Week 5-6** | • Will create a leaderboard format for presenting the results of the competition<br>• **Intermediate deliverable: A completely functional (if not necessarily pretty) setup where a new video policy can be submitted and ranked by multiple metrics, then appear on the leaderboard.** |
| **Week 7-8** | • Will add more baseline results from the literature/ Implement and test other adaptive video policies from literature as baseline<br>• Refine and improve the automated evaluation process (if required)<br>• Will create a user-friendly for students to access and submit their policies |
| **Week 9-10** | • Will create documentation and materials for course instructors, to help them use these materials in the classroom. |

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|---|---|
| **Week 11-12** | • Incorporate feedback from testing and make necessary adjustments.<br>• Will write a final report summarising the project and its results |

- **Total number of hours expected to need for the project and number of weeks to complete.**

In the project idea, There is mentioned the size of the project is 350 hours for 12 weeks.

- **IMPORTANT – the timeline must specify any time conflicts that you anticipate during the program (i.e. conflicts due to travel, school, and other activities.)**

I don't have my college and any other engagements during the summers so I won't be having any kind of commitments outside GSOC'23. And also I am not travelling anywhere this summer. I will work with my full dedication, and I am very excited to work on this project.

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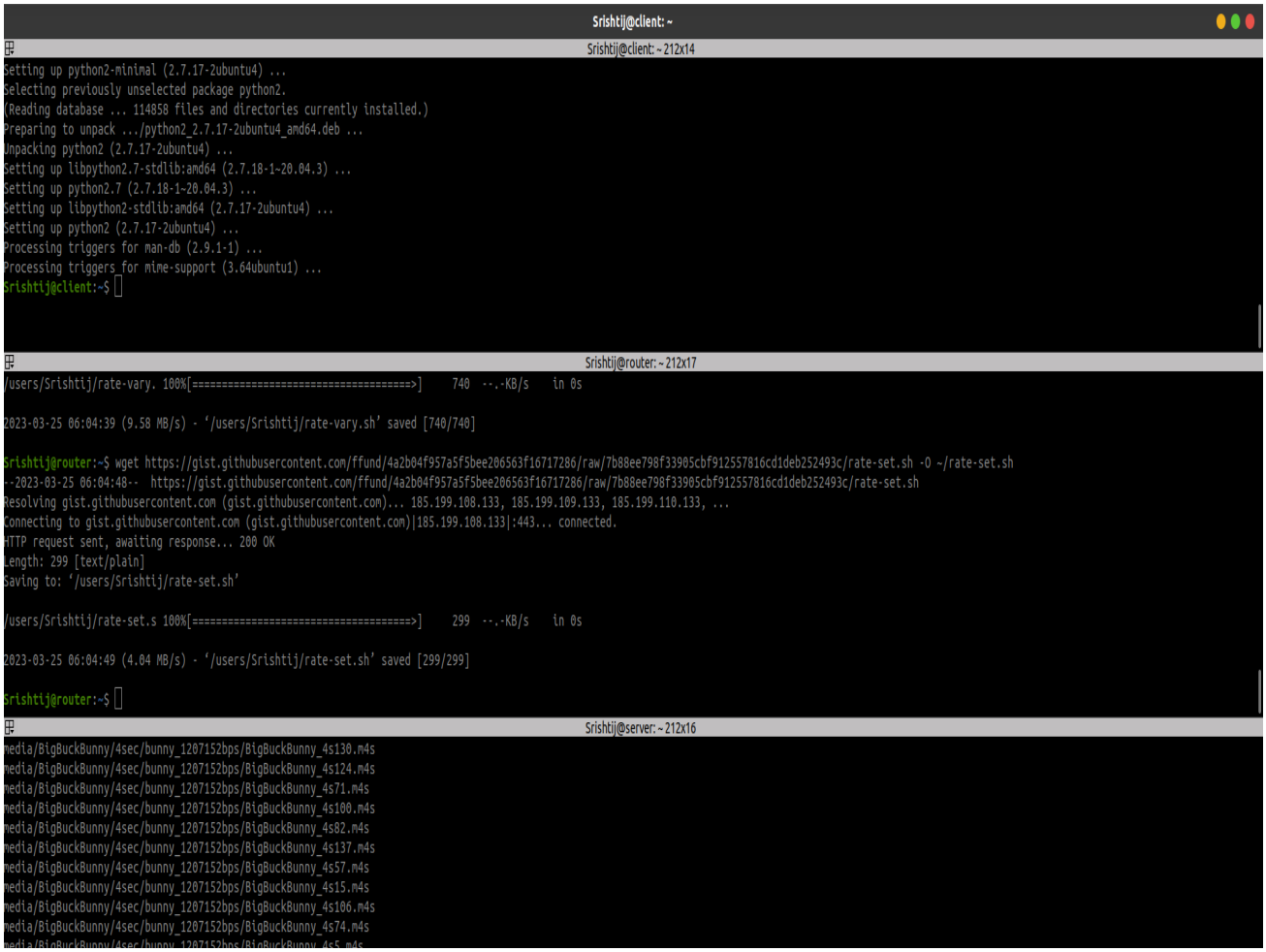
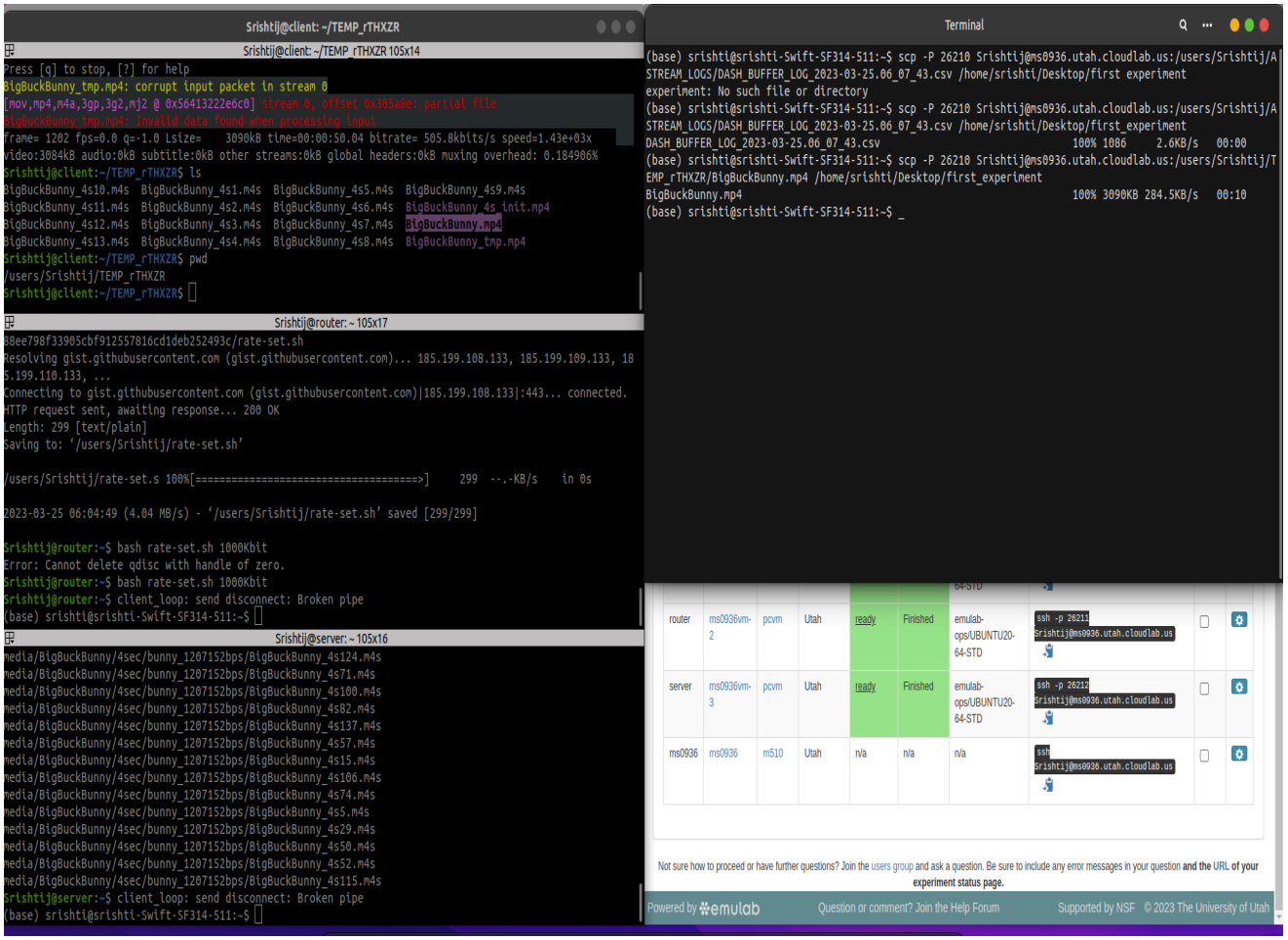
## Biographical information

- **Relevant experience**
  I am very familiar/comfortable with the Linux operating system with 2year experience, which helps for this project a lot because the experimental platforms we use for research in networking and wireless are all Linux-based. Also, I have successfully done the Adaptive video experiment in the CloudLab testbeds. Now, I am comfortable with the CloudLab testbed.

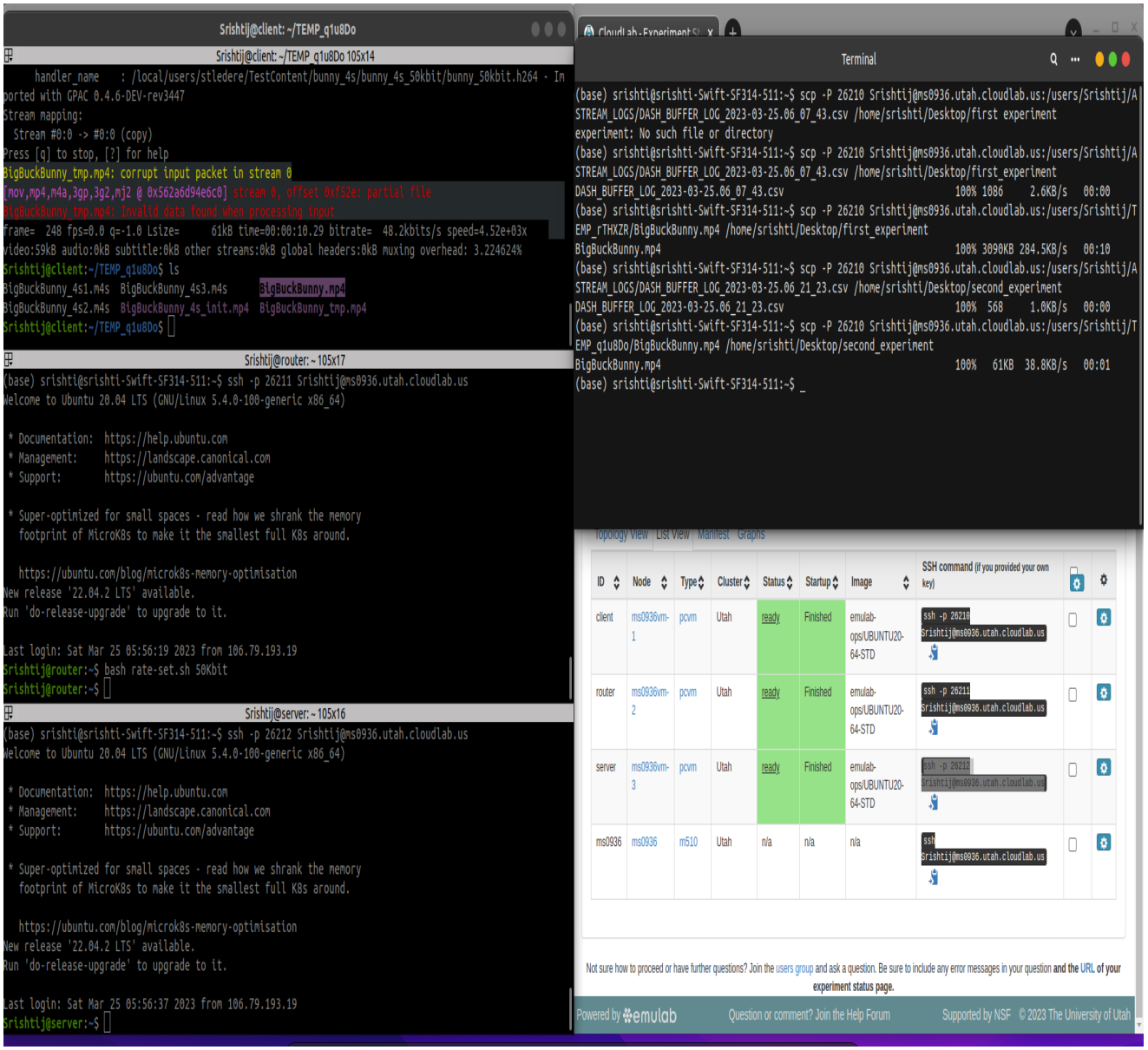
First, I logged in to each node (client, router and server) and set up the terminal and did the required things for experiments. (kindly zoom in to see the clear attached image.)



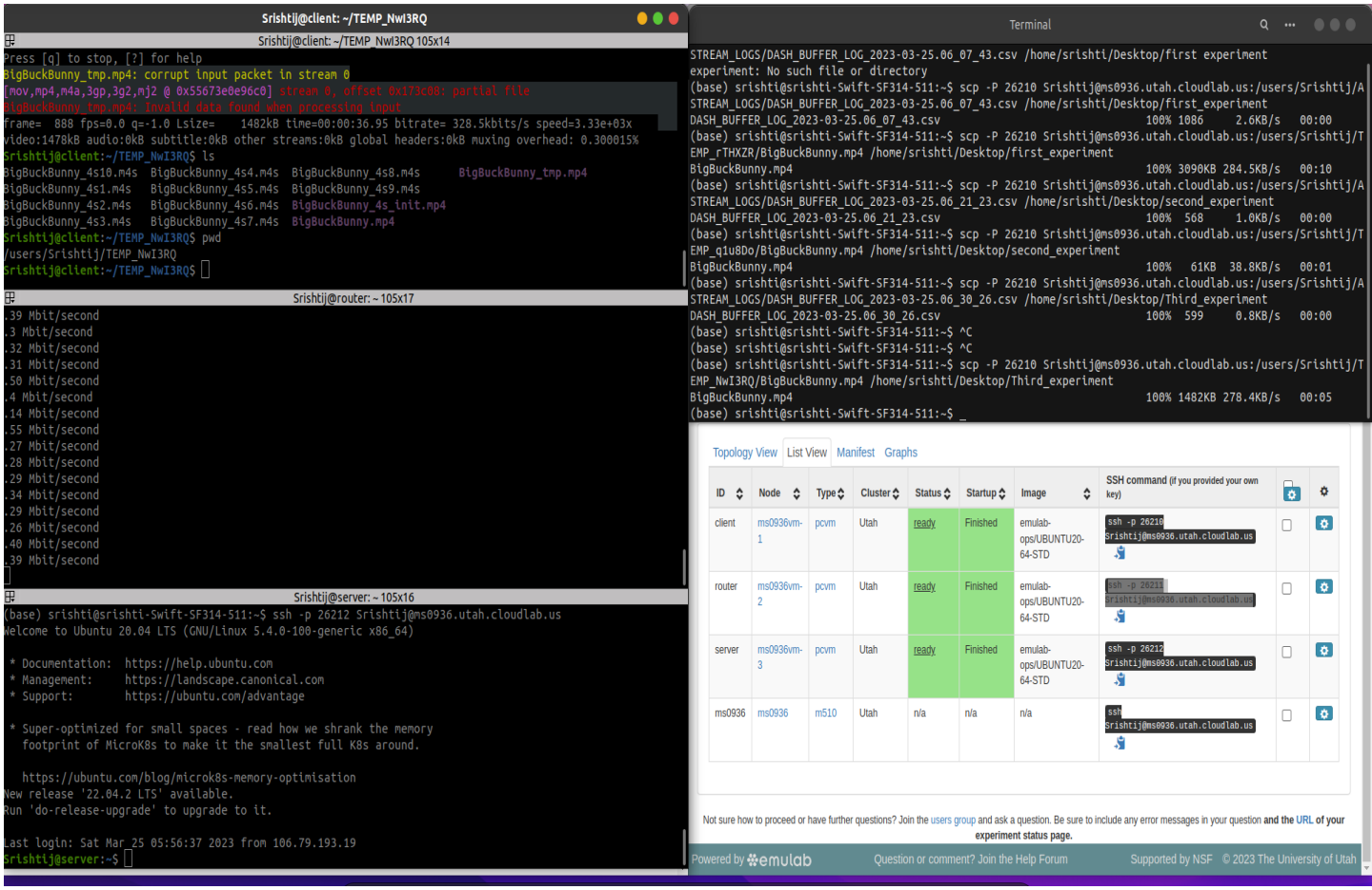

**Experiment with constant bit rate**




## Experiment: constant bit rate with interruption




## Experiment: mobile user




I am also comfortable with python. One coursework, **"Information Technology and Computing Workshop",** is also there in the 2nd semester for python language. In my current coursework, **"Operating Systems",** I have done so many experiments such as adding the system calls in the terminal, Designing a shell with history feature and signal handling, writing the programs to simulate the scheduling algorithms and doing some implementation by using multi-threading in a Virtual machine.

- **Relevant educational background**

I am currently a second-year student at the Indian Institute of Technology (BHU), Varanasi, India, pursuing an Integrated dual degree course (Bachelor of Technology + Master of Technology) with Mathematics and Computing Engineering as my major.

- **If student, include current major and any relevant coursework**

**Current major coursework:**

➔ Operating Systems
➔ Algorithms
➔ Mathematical Methods
➔ Numerical Techniques
➔ Heat and Mass Transfer

And relevant coursework which I have done previously are:

➔ Computer System Organization
➔ Information Technology and Computing Workshop (Java and Python)
➔ Discrete Mathematics
➔ Probability and statistics
➔ Linear Algebra
➔ Data Structures
➔ Computer Programming

- **Technical interests and strengths**

My Interest in programming began by attending club workshops and have been attached the programming club of my college, and I am a core member of Programming club.  I have made so many personal projects and

participated in hackathons. I have done some projects for learning HTML, CSS, Javascript,nodejs, and pug.
I have also had a decent experience in competitive programming and hence have a good understanding of various data structures and algorithms. I also have good experience in git and GitHub and community activities like reviewing and testing others' code. I am an open-source contributor. I have participated in the Social winter of code (SWOC), where I made a plugin on top of the TinyMCE rich text editor to look-up for the synonyms of the typed-in words and inserted them at the cursor position in the editor on selection.


- **Contact information**

Name: Srishti Jaiswal
Country: India
Email: Srishti33164jaiswal@gmail.com , srishti.jaiswal.mat21@itbhu.ac.in
Current affiliation: Indian Institute of Technology (BHU) Varanasi
Github Handle: https://github.com/Srishti-j18
LinkedIn: https://www.linkedin.com/in/srishti-jaiswal18/