University of Waterloo

Faculty of Engineering

Department of Electrical and Computer Engineering

StreamingOS: Low Cost Education System

Progress Report

Group 2020.15

Prepared by:

Matthew Milne – 20626854

Vidit Soni – 20627647

Vinayak Sharma – 20585279

Anurag Joshi – 20604210

Surag Sudesh – 20636861

Consultant:

Wojciech Golab

July 29th, 2019

Table of Contents

1.0 Overview of the project

1.1 Revised Project Abstract

As technology improves in the 21st century, using mobile devices for educational purposes is becoming more common in primary and secondary schools. In addition to the cost, this technology becomes quickly outdated and needs to be replaced, forcing schools to spend continuous amounts of money on maintenance. StreamingOS is a system that provides students and teachers with inexpensive thin endpoint devices, with the resource-heavy OS being streamed to these devices from a backend server using container virtualization. The objective of this project is to design a powerful, inexpensive device and streaming system that enhances the learning experience. StreamingOS uses an inexpensive endpoint device and container virtualization to visually render and stream the execution of applications from a server or the teacher's computer to these devices used by the students. The system design leverages concepts learned in distributed computing, operating systems, database theory, and networking courses. The advantage of this design over current alternatives is that it is scalable while enabling the teacher full control of what software each student views. The inexpensive hardware helps break down the barrier of the lack of technology in school settings and empowers teachers to incorporate more modern-day means of learning in their classrooms.

1.2 Original Project Timeline

Due to minimal dependencies between the different subcomponents, they can be developed in parallel if a virtual test environment has been setup. Figure 1 shows the project timeline.
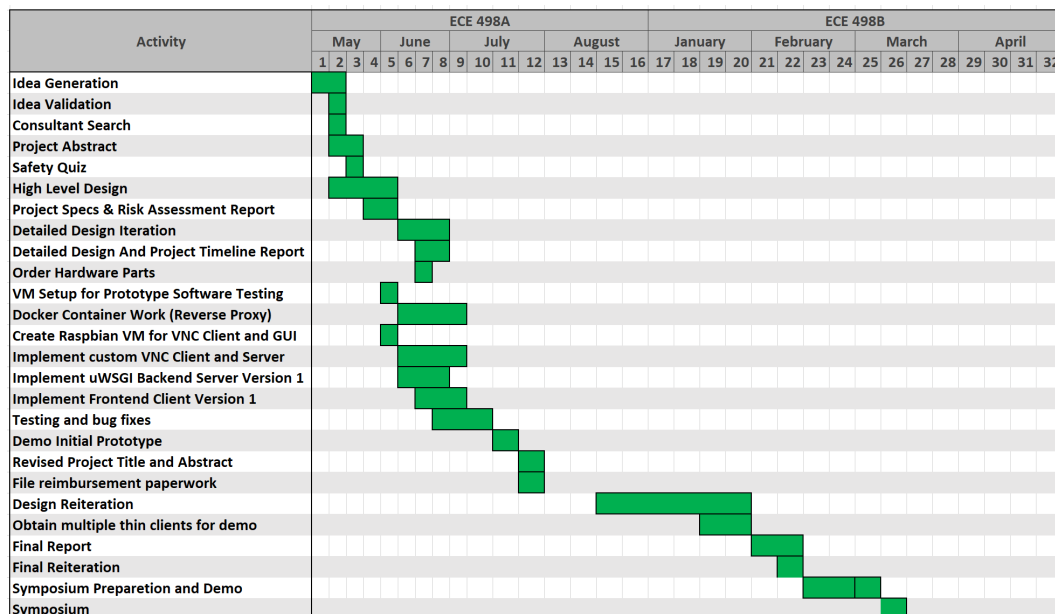
Activity	ECE 498A																ECE 498B															
	May				June				July				August				January				February				March				April			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
Idea Generation	█	█																														
Idea Validation		█																														
Consultant Search		█																														
Project Abstract			█																													
Safety Quiz			█																													
High Level Design			█	█																												
Project Specs & Risk Assessment Report						█																										
Detailed Design Iteration						█	█																									
Detailed Design And Project Timeline Report							█																									
Order Hardware Parts							█	█																								
VM Setup for Prototype Software Testing					█																											
Docker Container Work (Reverse Proxy)								█	█	█																						
Create Raspbian VM for VNC Client and GUI					█	█																										
Implement custom VNC Client and Server								█	█																							
Implement uWSGI Backend Server Version 1								█	█																							
Implement Frontend Client Version 1								█	█																							
Testing and bug fixes										█	█																					
Demo Initial Prototype											█																					
Revised Project Title and Abstract												█																				
File reimbursement paperwork												█																				
Design Reiteration																	█	█	█	█												
Obtain multiple thin clients for demo																				█												
Final Report																								█	█							
Final Reiteration																									█	█						
Symposium Preparation and Demo																											█	█				
Symposium																													█			

Figure 1 – Project Timeline

2.0 Current Status of Project

2.1 Prototype Completion

We estimate that our prototype model is roughly around 60% complete compared to the actual full model we envisioned. The first functional property we mentioned was latency and we had said that the end to end delay in our system should be less than 300ms. When we gathered data by running tests on our model, we found that the current end to end delay was roughly around 150ms. Therefore, we have met the requirements for this functional property. The next one was Authentication System. We believe we have completed this property as well since we use an OAuth 2.0 based authentication protocol for user authentication. The "Teacher Control" functionality is partially completed since we have the resources required to grant and revoke access to applications to students. However, we are currently missing on the functionality that allows the teacher to view live data from the student's screen on their screen. The next property was Multi User support. Currently, we have the feature where one teacher and around 5-6 students can be using our systems concurrently in a mini lecture room environment in an efficient manner. We believe we have partially completed this feature as well.

The next property was Network Connection. We are satisfying this property by making use of the HTTP methods for REST API calls between the client and server. Our next property was high performance and we believe we are already achieving this property since our system uses approximately 3.75 GB RAM and 11% CPU load for 3 OS containers, a reverse proxy and a database container which is quite reasonable compared to our initial estimates. We are currently missing the Students Bird Eye View functionality where the teacher will be able to see student specific data on their screens such as their marks, class attendance etc. The next non- functional property we mentioned was security which we accomplish by using Bcrypt and OAuth 2.0 for user authentication. The cost of the device currently is around $27 which is lower than our initial estimate of $75. Therefore, we satisfy this property as well. We achieve the property of reliability by making sure that the Electron application for the teacher's portal can reliably transmit commands to grant and revoke access of applications to each student. We also read database flags for containers before assigning them. We also perform some health check on endpoints for each container to ensure reliability. We have not met the property of device portability yet since our raspberry pi solution still requires a monitor, keyboard and mouse set to work. This will be a major task to solve in the upcoming term.

Lastly, we believe we have partially achieved heterogeneity since our Electron application runs on all platforms but there is a decent chunk of work left in the VNC Client part of this non-functional property. Overall, we believe that we have achieved around 60% of the functional and non-functional properties. This is also in conjunction with the estimates provided by our consultant which state that the prototype model is around 50 to 74% complete with respect to the full version.

2.2 Student Hours

Table 1 below shows the number of hours spent each student has worked on so far for the project.

Table 1 - Number of hours invested by each team member in 4A

Student	# of Hours Invested
Anurag Joshi	123
Matthew Milne	123
Surag Sudesh	124
Vidit Soni	125
Vinayak Sharma	123
Total	618

3.0 Discussion

Based on the list of functional and non-functional specifications listed in the detailed design document, the prototype is ~60% complete. The group is highly confident in the ability to finish the project before March 2020.

This is a list of tasks that need to be performed before the project can be considered complete along with expected time required.

- ➜ Improvements to latency by implementing quic protocol for VNC client server communication (~2 weeks)
- ➜ Investigate webRTC (~ 1 week)
- ➜ Implement Student Bird's Eye view using noVNC (~ 3 weeks)
- ➜ Implement software stack on a low-cost tablet (potentially Fire 7 HD) to make the solution portable (~ 5 weeks)
- ➜ Improvements to the UI/UX of the Teacher and Student Electron apps (~ 2-3 weeks)
- ➜ Implement user specific storage (~ 2 weeks)

The time estimates are calculated based on the amount of time spent during ECE 498A to perform similar tasks. Since the prototype is 60% done, most of the above-mentioned tasks can be performed in parallel with 1-2 members taking the lead for each.

During the coop term, the team plans to conduct a 1-hour meeting using Skype (or similar video conferencing software) every Sunday at 1PM EST to discuss current status, blocking issues and triage any work that needs to be done. All issues are tracked on our Trello Kanban board. Each member will spend approximately 3-5 hours per week on project work.

Any work that is not completed in the coop term, and the final end-to-end system test will be completed in the first few weeks of ECE 498B.

Appendix A: Student Logs

1) Anurag Joshi

ECE498A: Student Log					
Name: Anurag Joshi **Group:** 2020. 15 **Signature:** AJ					
By signing above, I am stating that this is an accurate account of the tasks, dates, and times that I worked on my capstone design project.					
Task	**Date**	**Start time**	**Finish time**	**Hours**	**Running total of hours**
Idea Generation	May 8	11:30	14:30	3	3
Safety Quiz Reading	May 11	2:00	3:00	1	4
Idea Generation	May 14	11:00	13:00	2	6
Idea Generation	May 15	11:30	14:30	3	9
Researching and meeting with profs	May 16	9:00	12:30	3.5	12.5
meeting with profs	May 17	10:00	13:00	3	15.5
Researching Electron vs PWA	May 19	13:00	18:00	3	18.5
Team Meet	May 20	16:00	17:30	1.5	20
Writing Project Abstract	May 20	20:00	21:00	1	21
Create Prototype of Hello World	May 22	15:00	18:00	3	24
	May 23	15:00	16:00	1	25

Safety Quiz	May 24	15:45	16:15	0.5	25.5
Team Meet	May 27	16:00	17:30	1.5	27
Start building actual app	May 29	15:00	17:00	2	29
Building Teachers App	May 30	12:00	14:00	2	31
Team Meet	May 30	15:00	16:00	1	32
Write my part in Project Spec doc	June 1	12:00	14:00	2	34
Finding suitable bootstrap templates	June 2	12:00	14:00	2	36
Team Meet	June 3	16:00	17:30	1.5	37.5
Play with bootstrap	June 4	9:00	10:00	1	38.5
Finalize Project Spec Doc	June 5	11:30	14:30	3	41.5
Team Meet	June 6	15:00	16:00	1	42.5
Creating actual HTML templates	June 12	16:00	19:00	3	45.5
Hardcoding actual page to show to team	June 13	12:00	15:00	3	48.5
Team Meet	June 13	15:00	16:00	1	49.5
Write my part in the Design Doc	June 23	10:00	12:00	2	51.5
Team Meet	June 24	16:00	17:30	1.5	53
Team meet to finalize design doc	June 26	11:30	14:30	3	56
Implement changes in the hardcoded HTML page after discussion	June 29	12:00	17:00	5	61
CSS modifications	July 2	9:00	14:00	5	66
Remove hardcoding and point to JS methods	July 3	15:00	20:00	5	71
Fill in the JS Methods to point to user data lists.	July 4	10:00	14:00	4	75
Implement granting and revoking application access code	July 6	9:00	13:00	4	79

Get the HTTP REST API calls working	July 10	13:00	20:00	7	86
Bug fixes with Status table	July 11	13:00	16:00	3	89
Fix bugs related to AJAX call ordering	July 15	11:00	14:00	3	92
Solve CORS issue when running on Electron	July 15	12:00	14:00	2	94
Create a template Student Electron Application	July 16	14:00	19:00	5	99
Create JS methods for Student App	July 16	16:00	18:00	2	101
Meeting	July 17	18:00	21:00	4	105
Meeting	July 18	11:30	14:00	2.5	107.5
Prepare for Demo	July 19	11:30	14:00	2.5	110
Put the whole system together and test end to end functionality	July 23	10:00	15:00	5	115
Minor bug fixes in Student App	July 24	11:30	14:00	2.5	117.5
Demo Setup and Demo	July 25	13:00	15:30	2.5	120
Work on the Progress Report	July 28	20:00	23:00	3	123

2) Matthew Milne

ECE498A: Student Log					
Name: Matthew Milne **Group:** 2020. 15 **Signature:**					
By signing above, I am stating that this is an accurate account of the tasks, dates, and times that I worked on my capstone design project.					
Task	**Date**	**Start time**	**Finish time**	**Hours**	**Running total of hours**
Idea Generation	May 8	11:30	14:30	3	3
Safety Quiz Reading	May 11	2:00	3:00	1	4
Idea Generation	May 14	11:00	13:00	2	6
Idea Generation	May 15	11:30	14:30	3	9
Researching and meeting with profs	May 16	9:00	12:30	3.5	12.5
Meeting with profs	May 17	10:00	13:00	3	15.5
Researching uWSGI vs Django	May 19	13:00	16:30	3.5	19
Team Meet	May 20	16:00	17:30	1.5	20.5
Writing Project Abstract	May 20	20:00	21:00	1	21.5
Get uWSGI running, and a single endpoint working	May 22	16:00	18:30	2.5	24
Work on REST API documentation	May 23	15:00	18:00	3	27
Get uWSGI running, and a single endpoint working	May 24	13:00	15:00	2	29
Safety Quiz	May 24	15:30	16:00	0.5	29.5
Team Meet	May 27	16:00	17:30	1.5	31

Creating authentication endpoints	May 30	12:00	15:00	3	34
	May 30	16:00	19:00	3	37
Team Meet	May 30	15:00	16:00	1	38
Write my part in Project Spec doc	June 1	9:00	11:00	2	40
Create SQL statements to initialize the database	June 2	9:00	11:00	2	42
Team Meet	June 3	16:00	17:30	1.5	43.5
Research OAuth 2.0	June 4	9:00	10:00	1	44.5
Finalize Project Spec Doc	June 5	11:30	14:30	3	47.5
Team Meet	June 6	15:00	16:00	1	48.5
Work on OAuth 2.0 Implementation	June 12	16:00	19:00	3	51.5
	June 13	12:00	18:00	6	57.5
Team Meet	June 13	15:00	16:00	1	58.5
Write my part in the Design Doc	June 23	9:00	13:00	4	62.5
Team Meet	June 24	16:00	17:30	1.5	64
Team meet to finalize design doc	June 26	11:30	14:30	3	67
Implement the create and delete user	June 29	10:00	14:00	4	71
	July 2	9:00	12:00	3	74
Implement user information related calls	July 3	12:00	13:00	1	75
	July 4	9:00	12:00	3	78
Implement granting and revoking calls	July 6	9:00	13:00	4	82
Testing and cleaning up calls	July 10	9:00	12:00	3	85
	July 11	13:00	16:00	2	88
	July 15	11:00	14:00	3	91

Document the REST APIs	July 15	12:00	14:00	2	93
Fixed the HTTP response code for add and revoke	July 16	12:00	14:00	2	95
	July 16	16:00	18:00	2	97
Meeting	July 17	18:00	21:00	4	101
Meeting	July 18	11:30	14:00	2.5	103.5
Prepare for Demo	July 19	11:30	14:00	2.5	105
	July 22	13:00	17:00	4	110
Put the whole system together and test end to end functionality	July 23	10:00	15:00	5	115
	July 24	11:30	14:00	2.5	117.5
Demo Setup and Demo	July 25	13:00	15:30	2.5	120
Progress Report	July 29	9:00	12:00	3	123

3) Surag Sudesh

ECE498A: Student Log					
Name: Surag Sudesh **Group:** 2020. 15 **Signature:**					
By signing above, I am stating that this is an accurate account of the tasks, dates, and times that I worked on my capstone design project.					
Task	**Date**	**Start time**	**Finish time**	**Hours**	**Running total of hours**
Idea Generation	May 8	11:30	14:30	3	3
Safety Quiz Reading	May 11	2:00	3:00	1	4
Idea Generation	May 14	11:00	13:00	2	6
Idea Generation	May 15	11:30	14:30	3	9
Researching and meeting with profs	May 16	9:00	12:30	3.5	12.5
Meeting with profs	May 17	10:00	13:00	3	15.5
Research X vs RDP vs VNC	May 19	14:00	18:30	4.5	20
Team Meet	May 20	16:00	17:30	1.5	21.5
Writing Project Abstract	May 20	20:00	21:00	1	22.5
Additional research on X vs VNC	May 22	15:00	18:30	3.5	26
Safety Quiz	May 24	15:30	16:00	0.5	26.5
Team Meet	May 27	16:00	17:30	1.5	28
Work on libVNC research and documentation	May 28	12:00	16:00	4	32
	May 39	16:00	18:00	2	34
Team Meet	May 30	15:00	16:00	1	35

Write my part in Project Spec doc	June 1	9:00	11:00	3	38
Setup dev environment and run example vnc client	June 2	9:00	12:00	3	41
Team Meet	June 3	16:00	17:30	1.5	42.5
Research VeNcrypt and disable it	June 4	9:00	10:00	1.5	44
Finalize Project Spec Doc	June 5	11:30	15:00	3.5	47.5
Team Meet	June 6	15:00	16:00	1	48.5
Implement basic VNC client using raw encoding	June 12	16:00	19:00	3	51.5
	June 13	12:00	19:00	7	58.5
Team Meet	June 13	15:00	16:00	1	59.5
Write my part in the Design Doc	June 23	11:00	15:00	4	63.5
Team Meet	June 24	16:00	17:30	1.5	65
Team meet to finalize design doc	June 26	11:30	14:30	3	68
Implement copyrect encoding	June 29	11:30	16:00	4.5	72.5
	July 3	12:00	13:00	1	73.5
Implement tight encoding	July 6	10:00	14:00	4	77.5
	July 9	10:30	13:00	2.5	80
Enable zlib compression	July 11	13:00	16:00	3	83
	July 15	10:00	13:00	3	86
Update Student Electron App to invoke proper binaries	July 15	12:00	14:00	2	88
Setup required development libraries on pi and run the vnc client	July 16	16:00	23:00	7	95
Meeting	July 17	18:00	21:00	4	99
Meeting	July 18	11:30	14:00	2.5	101.5
Performance optimizations	July 19	11:30	14:00	2.5	104

Rewrite pi client using alternate rendering engine and perf optimizations	July 21	21:00	05:00	7	111
Put the whole system together and test end to end functionality	July 23	10:00	15:00	5	116
	July 24	11:30	14:00	2.5	118.5
Demo Setup and Demo	July 25	13:00	15:30	2.5	121
Progress Report	July 28	18:00	21:00	3	124

4) Vidit Soni

ECE498A: Student Log					

Name: _____Vidit Soni_____   Group: ___2020. 15___   Signature: [signature]

By signing above, I am stating that this is an accurate account of the tasks, dates, and times that I worked on my capstone design project.

Task	Date	Start time	Finish time	Hours	Running total of hours
Idea Generation	May 8, 2019	11:30	14:30	3	3
Safety Quiz Reading	May 12, 2019	10:00	11:00	1	4
Idea Generation	May 14, 2019	11:00	13:00	2	6
Idea Generation	May 15, 2019	11:30	14:30	3	9
Researching and Meeting with Profs	May 16, 2019	9:00	12:30	3.5	12.5
Meeting with Profs	May 17, 2019	10:00	13:00	3	15.5
Research Server Stack	May 17, 2019	15:00	19:00	3	18.5
Research UWSGI and Setup Basic app	May 18, 2019	9:00	12:00	3	21.5
Team Meeting	May 20, 2019	16:00	17:30	1.5	23
Writing Project Abstract	May 20, 2019	20:00	21:00	1	24
Researched Different Databases	May 21, 2019	9:00	11:00	2	26
Setup Basic MySQL database	May 21, 2019	18:00	20:00	2	28
Researched Docker	May 22, 2019	18:00	22:00	4	32

Finish Safety Quiz	May 24, 2019	12:00	12:30	0.5	32.5
Research IPtables	May 25, 2019	14:00	18:00	4	36.5
Setup UWSGI in a Docker container	May 26, 2019	13:00	15:30	2.5	39
Team Meeting	May 27, 2019	16:00	17:30	1.5	40.5
Research IPTables	May 30, 2019	15:00	16:00	1	41.5
Work on Project Spec Doc	June 1, 2019	10:00	12:00	2	43.5
Team Meet	June 3, 2019	16:00	17:30	1.5	45
Finalize Project Specification Doc	June 5, 2019	11:30	14:30	3	48
Team Meet	June 6, 2019	15:00	16:00	1	49
Team Meet	June 13, 2019	15:00	16:00	1	50
Work on Design Document	June 22, 2019	12:00	16:00	4.5	54.5
Team Meet	June 24, 2019	16:00	17:30	1.5	56
Team Meet to Finish Design Document	June 26, 2019	11:30	14:30	3	59
Building RP, and Creating cleaning up endpoints for Routes	June 26-27, 2019	22:00	1:00	3	62
Cleaning up RP routes calls and Setting up OS Container. Testing route setup to OS container.	June 27-28, 2019	20:00	1:00	5	67
Setup Setup MySQL DB in Docker container, and setup files to create necessary tables	July 2, 2019	16:30	18:00	1.5	68.5
Setup peewee in RP codebase, and create data objects for database access/communication	July 2-3, 2019	23:00	1:00	2	70.5
Research OAuth2.0	July 3, 2019	17:00	18:00	1	71.5
Setup username and password authentication with BCrypt	July 4, 2019	19:00	21:00	2	73.5
Setup OAuth2.0	July 5, 2019	11:30	15:00	3.5	77
Setup UWSGI Permissions Server in Docker	July 6, 2019	12:00	16:00	4	81

Create Health Check and Permission Grant/Revoke Endpoints in Permission Server, and change RP code to invoke permissions server endpoints	July 7-8, 2019	18:00	1:00	7	88
Setup grant and revoke App permissions (using Shell Commands) in Permissions server, and clean up bugs within Permissions server.	July 9, 2019	9:00	14:00	5	93
Remove SQL scripts for Database initialization, and setup Functionality directly inside RP codebase. Create fake data to use.	July 10, 2019	12:00	16:00	4	97
Setup Backend (Reverse Proxy, Database, and OS Container) on Windows Test Machine with Hamachi for teammates to connect to.	July 11, 2019	18:00	21:00	3	100
Team Meeting	July 17, 2019	18:00	21:00	3	103
Team Meeting	July 18, 2019	11:30	14:00	2.5	105.5
Prepare for Demo	July 19, 2019	11:30	14:00	2.5	108
Prepare for Demo	July 22, 2019	13:00	17:00	4	112
Setup complete End-to-End system, and test Functionality	July 23, 2019	10:00	15:00	5	117
Setup complete End-to-End system, and test Functionality	July 24, 2019	11:30	14:00	2.5	119.5
Setup System and Demo	July 25, 2019	13:00	15:30	2.5	122
Progress Report Work	July 28, 2019	12:00	15:00	3	125

5) Vinayak Sharma

ECE498A: Student Log					
Name: Vinayak Sharma **Group:** 2020. 15 **Signature:**					
By signing above, I am stating that this is an accurate account of the tasks, dates, and times that I worked on my capstone design project.					
Task	**Date**	**Start time**	**Finish time**	**Hours**	**Running total of hours**
Idea Generation	May 8	11:30	14:30	3	3
Safety Quiz Reading	May 11	2:00	3:00	1	4
Idea Generation	May 14	11:00	13:00	2	6
Idea Generation	May 15	11:30	14:30	3	9
Researching and meeting with profs	May 16	9:00	12:30	3.5	12.5
Meeting with profs	May 17	10:00	13:00	3	15.5
Research on hardware: Raspberry pi vs Orange Pi Prime zero	May 19	20:00	23:30	3.5	19
Team Meet	May 20	16:00	17:30	1.5	20.5
Writing Project Abstract	May 20	20:00	21:00	1	21.5
Research about the database design	May 22	18:00	20:30	2.5	24
Work on Database documentation	May 23	15:00	18:00	3	27
Work on Hardware documentation	May 24	13:00	15:00	2	29

Safety Quiz	May 24	15:30	16:00	0.5	29.5
Team Meet	May 27	16:00	17:30	1.5	31
Researching about VNC client and learning about Docker	May 30	18:00	21:00	3	34
	May 31	16:00	19:00	3	37
Team Meet	May 30	15:00	16:00	1	38
Writing my part in Project Spec doc	June 1	18:00	21:00	3	40
	June 2	12:00	2:00	2	42
Team Meet	June 3	16:00	17:30	1.5	43.5
Research on electron app and armv6l architecture	June 4	18:00	19:00	1	44.5
Finalize Project Spec Doc	June 5	11:30	14:30	3	47.5
Team Meet	June 6	15:00	16:00	1	48.5
Research about Debian OS, Raspbian OS and understanding the armv6l architecture	June 12	16:00	19:00	3	51.5
	June 13	16:00	22:00	6	57.5
Team Meet	June 13	15:00	16:00	1	58.5
Write my part in the Design Doc	June 23	10:00	14:00	4	62.5
Team Meet	June 24	16:00	17:30	1.5	64
Team meet to finalize design doc	June 26	11:30	14:30	3	67
Setting up local environment to run the backend system: OS Container	June 29	17:00	21:00	4	71
Ordering the raspberry PI	July 4	18:00	19:00	1	72
Finding a way to install electron on armv6l architecture	July 6	20:00	2:00	5	77

Assembling the raspberry PI and buying the mouse and keyboard	July 10	19:00	23:00	5	82
Writing the scripts to run the electron app in kiosk mode	July 15	12:00	15:00	3	85
	July 15	18:00	23:00	5	90
Integrating the VNC client, electron app on Raspberry PI	July 16	16:00	23:00	7	97
Meeting	July 17	18:00	21:00	4	101
Meeting	July 18	11:30	14:00	2.5	103.5
Prepare for Demo	July 19	11:30	14:00	2.5	106
	July 22	13:00	17:00	4	110
Put the whole system together and test end to end functionality	July 23	10:00	15:00	5	115
	July 24	11:30	14:00	2.5	117.5
Demo Setup and Demo	July 25	13:00	15:30	2.5	120
Progress Report	July 28	18:00	21:00	3	123

Appendix B: Initial Prototype Demonstration Feedback Sheet

ECE498A: Initial Prototype Demonstration Feedback Sheet

Group number (e.g., 2018.083): _2020.115_

Instructions for consultant: By checking the most appropriate boxes below, please provide frank feedback to the student group about how you think their project is progressing. At this point in the term, students should have finalized their designs and their prototypes should be at least 50% (preferably 75%) complete. Students will respond to this feedback in their Progress Report. In March next year, the students will approach you again to schedule a Final Prototype Demonstration, in which you formally assess (and assign grades) on their project and prototype.

Assessment of the level of challenge and upper-year knowledge used in the project

☑ Project is significantly challenging, clearly requiring substantial 3rd or 4th year engineering knowledge
☐ Project is challenging, arguably requiring substantial 3rd or 4th year engineering knowledge
☐ Project is fairly straightforward, requiring substantial 2nd year university-level engineering knowledge
☐ Project is simple, requiring little or no university-level engineering knowledge beyond 1st year

Assessment of how complete the prototype construction is

☐ More than 90% done   ☑ 50% to 74% done   ☐ Less than 25% done
☐ 75% to 90% done   ☐ 25% to 49% done   ☐ Impossible to judge

Your confidence that, by next March, the prototype will be 100% complete and satisfy all essential design specs

☐ Very high   ☑ High   ☐ Unsure   ☐ Low   ☐ Very low

Your confidence that the group is working well as a team

☑ Very high   ☐ High   ☐ Unsure   ☐ Low   ☐ Very low

Your confidence that the group has put appropriate effort and time (ideally 120 hours per student) into the project

☐ Very high   ☑ High   ☐ Unsure   ☐ Low   ☐ Very low

Other feedback to the students:

— GOOD TEAM WORK

— GOOD PRESENTATION

— REQUIREMENTS NEED A MINOR CLEANUP

— THE TARGET USE CASE REMAINS A LITTLE FUZZ)

Consultant's signature: _____   Date: _July 25, 2019_