IPRO 344

Audio Quality & Energy Efficiency for Mobile Devices and Intercoms

Project Plan

Instructor: Dr. Thomas Wong

Teaching Assistant: Tao Shen

Sponsor: Shure Inc.

Team:

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Chia-Hao Tu

Illinois Institute of Technology

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1. Abstract

IPRO 344 began as an investigation into the applications of Class D amplifiers for low-power and high-quality audio devices. This semester's IPRO will focus on integrating the Class D amplifier into a drive-through order system. In addition to the Class D amplifier, this semester's team will be investigating high-fidelity microphones, microphone preamplifiers, and speaker mounting.

2. Objectives

The IPRO 344 team has set forth the following objectives:

- Investigate microphones that most accurately capture customers' voices in outdoor environment.
  - Investigate various microphone polar patterns, namely, omnidirectional, cardioid, and super-cardioid.
- Implement a pre-amplifier for the selected microphone.
- Determine the scale of speaker that is placed in the kiosk to provide reasonable sound volume and range.
- Design a kiosk based on the existing ones for the prototype of the drive-thru system.
- Evaluate the audio quality of the developed system.
- Develop a prototype of improved sound quality drive-thru system.

3. Background

A. Shure Inc. provided microphones to the project. IIT ECE department provided a laboratory to the IPRO 344 team for the development of the prototype.

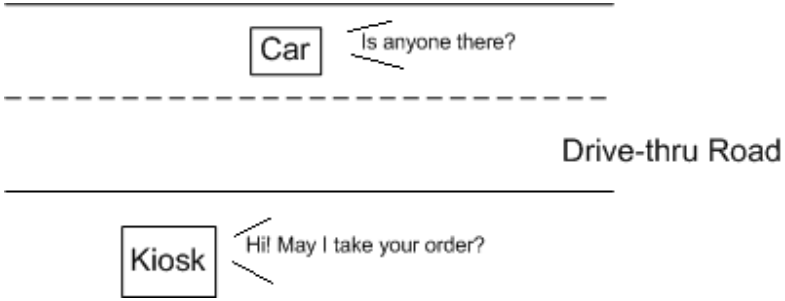
B. There is commercial interest and value in improving drive-thru systems in terms of the quality of communication, which supports the need for a prototype to explore a range of possible solutions.

C. The emphasis of drive-thru system operations has been on increasing speed-of-service, which has benefits for both the customer and the service provider. However, improvement in order accuracy is now regarded as at least as important as speed-of-service in delivering value for the customer and assuring efficient operations for the service provider.

For examples:

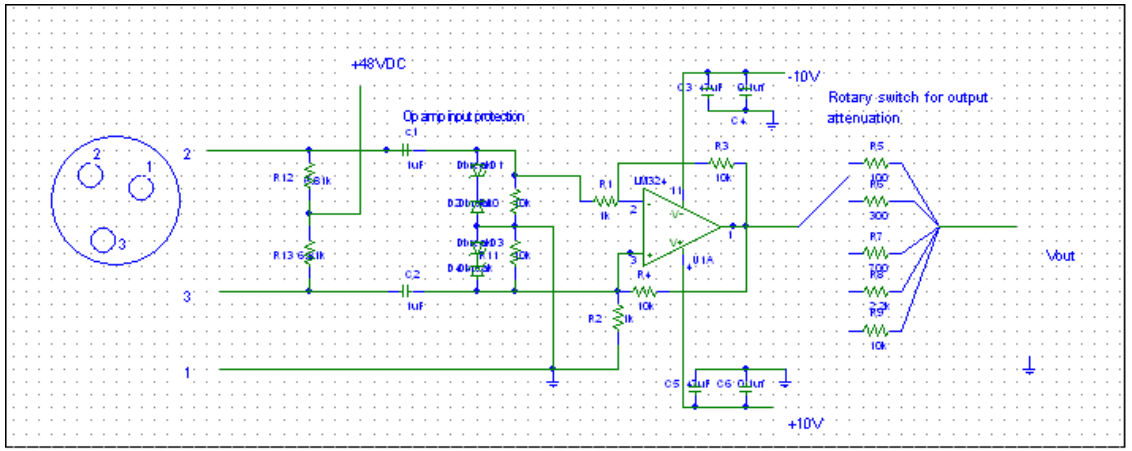
1. Environmental interference interrupts the communication between the customer and the clerk:
    a. Heavy rain/wind.
    b. Engine noises.

2. Customer's position relative to kiosk makes the communication difficult:
    a. Customer parks too far from the kiosk.
    b. Customer is not speaking into microphone.



To improve the accuracy and the sound quality of the drive-thru system, IPRO 344 team investigates proper outdoor/weather-proof speakers and pre-amplifier design for Shure's microphone.

Proposed pre-amplifier design for the Shure microphone:



Shure Microphone preamp design

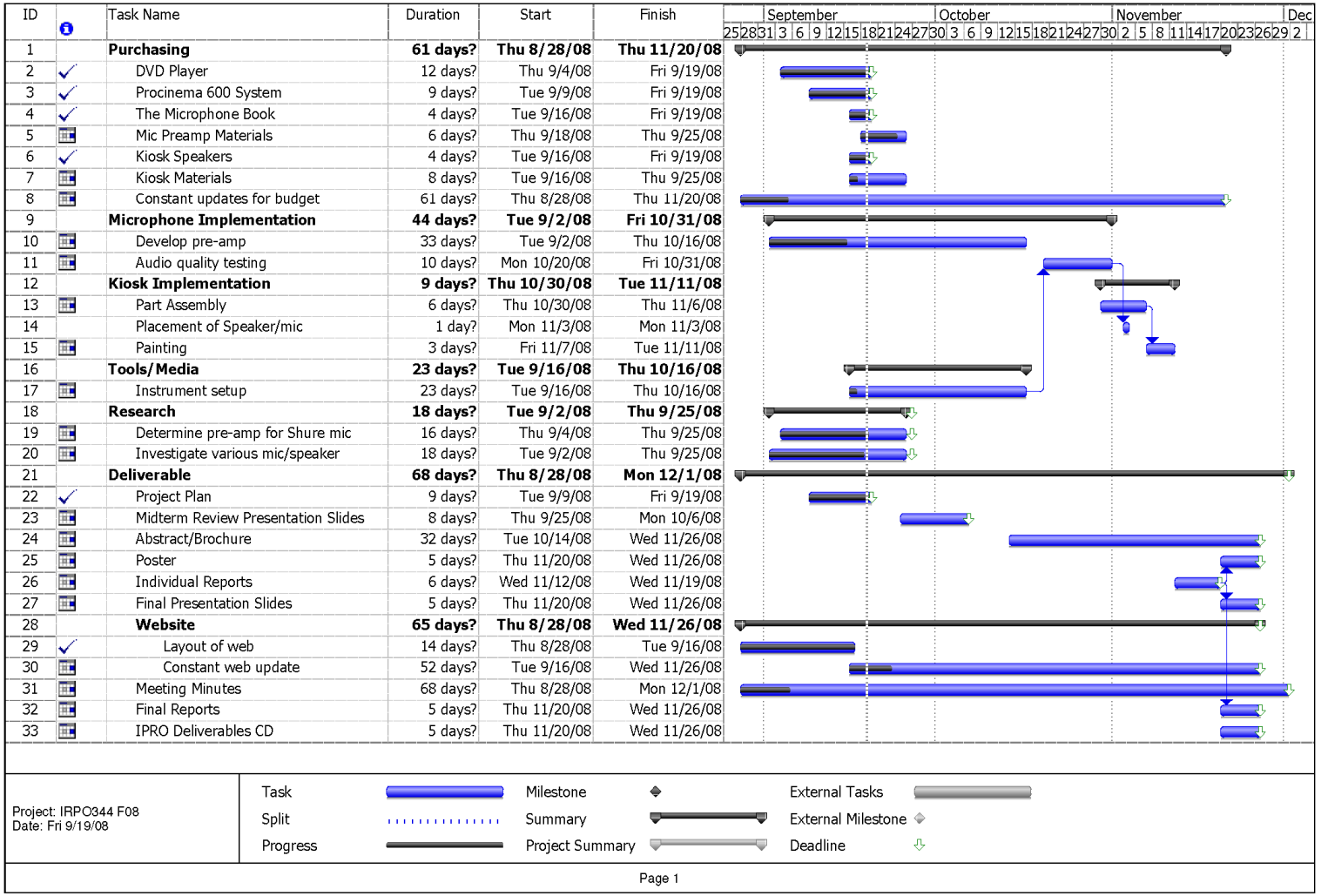
The plan is to implement a professional balanced microphone preamp. This design utilizes three sections: a Phantom power supply with op amp protection, a difference amplifier, and an output attenuator. The phantom power circuit is isolated by DC-blocking capacitors c1 and c2. Next, zener diode limiters protect the op amp inputs from spikes at initial powering. The difference amplifier uses a single 5532-type op amp for 20dB of gain. The

output trim will allow us to adjust for nominal input level to our class D amplifier. A stepped attenuator was chosen as opposed to a potentiometer for controlled repetition in later experiments. Overall, this design will provide a compatible low-noise preamplifier for our Shure MX-100 series microphones.

D. Previous IPRO 344 studied class-D amplifier, pre-amplifier, and post-amplification filter to propose an efficient and low-power/high quality audio system for mobile devices. For more details, please see the attached Abstract from previous IPRO 344.

*See the attachment for S08 IPRO 344 Abstract to better understand the overview of previous IPRO 344.

4. Methodology



ID	Task Name	Duration	Start	Finish
1	**Purchasing**	**61 days?**	**Thu 8/28/08**	**Thu 11/20/08**
2	DVD Player	12 days?	Thu 9/4/08	Fri 9/19/08
3	Procinema 600 System	9 days?	Tue 9/9/08	Fri 9/19/08
4	The Microphone Book	4 days?	Tue 9/16/08	Fri 9/19/08
5	Mic Preamp Materials	6 days?	Thu 9/18/08	Thu 9/25/08
6	Kiosk Speakers	4 days?	Tue 9/16/08	Fri 9/19/08
7	Kiosk Materials	8 days?	Tue 9/16/08	Thu 9/25/08
8	Constant updates for budget	61 days?	Thu 8/28/08	Thu 11/20/08
9	**Microphone Implementation**	**44 days?**	**Tue 9/2/08**	**Fri 10/31/08**
10	Develop pre-amp	33 days?	Tue 9/2/08	Thu 10/16/08
11	Audio quality testing	10 days?	Mon 10/20/08	Fri 10/31/08
12	**Kiosk Implementation**	**9 days?**	**Thu 10/30/08**	**Tue 11/11/08**
13	Part Assembly	6 days?	Thu 10/30/08	Thu 11/6/08
14	Placement of Speaker/mic	1 day?	Mon 11/3/08	Mon 11/3/08
15	Painting	3 days?	Fri 11/7/08	Tue 11/11/08
16	**Tools/Media**	**23 days?**	**Tue 9/16/08**	**Thu 10/16/08**
17	Instrument setup	23 days?	Tue 9/16/08	Thu 10/16/08
18	**Research**	**18 days?**	**Tue 9/2/08**	**Thu 9/25/08**
19	Determine pre-amp for Shure mic	16 days?	Thu 9/4/08	Thu 9/25/08
20	Investigate various mic/speaker	18 days?	Tue 9/2/08	Thu 9/25/08
21	**Deliverable**	**68 days?**	**Thu 8/28/08**	**Mon 12/1/08**
22	Project Plan	9 days?	Tue 9/9/08	Fri 9/19/08
23	Midterm Review Presentation Slides	8 days?	Thu 9/25/08	Mon 10/6/08
24	Abstract/Brochure	32 days?	Tue 10/14/08	Wed 11/26/08
25	Poster	5 days?	Thu 11/20/08	Wed 11/26/08
26	Individual Reports	6 days?	Wed 11/12/08	Wed 11/19/08
27	Final Presentation Slides	5 days?	Thu 11/20/08	Wed 11/26/08
28	**Website**	**65 days?**	**Thu 8/28/08**	**Wed 11/26/08**
29	Layout of web	14 days?	Thu 8/28/08	Tue 9/16/08
30	Constant web update	52 days?	Tue 9/16/08	Wed 11/26/08
31	Meeting Minutes	68 days?	Thu 8/28/08	Mon 12/1/08
32	Final Reports	5 days?	Thu 11/20/08	Wed 11/26/08
33	IPRO Deliverables CD	5 days?	Thu 11/20/08	Wed 11/26/08

5. Project Budget

Overall Total	$1,712.84				
Microphone / Preamp					
Part	**Description**	**Price**	**Quantity**	**P*Q**	**Supplier**
71-CMF551K0000BHEB	1/8W .1% 1k resistor	$0.36	2	$0.72	Mouser
71-CMF5510K000BEEB	1/8W .1% 10k resistor	$0.48	4	$1.92	Mouser
71-CMF5520K000BHEB	1/8W .1% 20k resistor	$0.36	2	$0.72	Mouser
660-MF1/4DCT52R1500F	1/4 1% 150 resistor	$0.05	3	$0.15	Mouser
594-5073NW200R0J	200 ohm 5%	$0.16	1	$0.16	Mouser
594-5073NW820R0J	820 ohm 5%	$0.16	1	$0.16	Mouser
660-MF1/4LCT52R222J	2.2k 5%	$0.05	1	$0.05	Mouser
71-CMF075K0000JNEK	5k 5%	$0.18	1	$0.18	Mouser
594-5073NW20K00J	20k 5%	$0.16	1	$0.16	Mouser
71-CCF02100KJKE36	100k 5%	$0.19	1	$0.19	Mouser
105-14572	6X2 rotary switch	$4.76	1	$4.76	Mouser
863-LM833NG	dual LM833 opamp	$0.91	2	$1.82	Mouser
523-AC3FDZ	xlr female connector	$3.96	1	$3.96	Mouser
502-BPJF02X	rca female connector	$1.70	1	$1.70	Mouser
71-CPF3-D-6.81	6.81k .5% phantom resistor	$0.69	4	$2.77	Mouser
594-2222-021-90545	68uF 63v Polar Electrolytic Capacitor	$0.71	1	$0.71	Mouser
108-0038-EVX	spst switch toggle 5a	$2.83	2	$5.66	Mouser
APC-15D	**"+/-15V" PSU 160mA**	$63.00	1	$63.00	Astrodyne
ASL40-48A	"+48V" PSU open Frame	$40.00	1	$40.00	Astrodyne
546-1411RU	8inX6inX3.5in case Al	$15.93	1	$15.93	Mouser
575-343308	IC socket 8P dip	$1.03	2	$2.06	Mouser
589-8100-4565	6.5inX4.5in protoboard	$19.67	1	$19.67	Mouser
728-FM2106-3005-SS	11mm PCB Standoff	$1.00	4	$4.00	
PSU jack		$3.99	2	$7.98	RadioShack
Psu connector		$3.99	2	$7.98	RadioShack

647-UKT1V470MDD	47uF Audio electrolytic	$0.15	4	$0.60	Mouser
81-RPER71H104K2P1A03	Monolithic Multilayer 0.1uF	$0.13	6	$0.78	
Nady CM100 ((#275560)	reference microphone (48V)	$45.00	1	$45.00	Guitar Center
			total	$232.79	
Kiosk Speakers					
Part	**Description**	**Price**	**Quantity**	**P*Q**	**Supplier**
Polk Atrium 55	8 ohm, 10-80 Watts, 4.5" woofer, 0.75" tweeter, outdoor speakers with enclosure	$149.99	1	$149.99	Crutchfield
Polk Audio db401	4 ohm, 4-45 Watts, 4" woofer, 0.75" tweeter, marine certified, 2-way coaxial speakers, NO enclosure	$79.99	1	$79.99	Crutchfield
Polk Audio db521	4 ohm, 4-45 Watts, 5.25" woofer, 0.75" tweeter, marine certified, 2-way coaxial speakers, NO enclosure	$89.99	1	$89.99	Crutchfield
			total	$319.97	
Stereo Equipment					
Part	**Description**	**Price**	**Quantity**	**P*Q**	**Supplier**
DVD Player	Dvd player for sound source.	$160.00	1	$160.00	Purchasing team
Theatre System	Subwoofer and speaker system	$900	1	$900.00	Purchasing team
			total	$1,060.00	
Part	**Description**	**Price**	**Quantity**	**P*Q**	**Supplier**
1/2" MDF	Wood used for exterior walls, 4x8	$18.86	2	$37.72	Home Depot
1x2	Wood used for framing, 8'	$0.98	2	$1.96	Home Depot
1x3	Wood used for framing, 8'	$1.44	2	$2.88	Home Depot
Screws	#8 x 1, 100 pcs	$3.61	1	$3.61	Home Depot
Screws	#8 x 1.5, 100 pcs	$5.57	1	$5.57	Home Depot
Elmer's Carpenter's Glue	Wood Glue for all joints, 3.25 oz.	$1.97	1	$1.97	Home Depot

Alex Fast Dry White Caulk	Caulk for interior joints	$2.24	1	$2.24	Home Depot
R-30 insulation	58 sq. ft.	$40.69	1	$40.69	Home Depot
Rust-Oleum Spray Paint	Brown, satin finish	$3.44	1	$3.44	Home Depot
			total	$100.08	

6. Team Structure and Assignments

Name	Major, Year	Skills and Strength	Experience and Academic Interest	Team Responsible	Other Team involvements
Barnett, Alex	Electrical Engineering, 3th year	Audio knowledge, Soldering.	Audio circuit assembly and repair modification	Research	Microphone/Kiosk and Web
Carrozza, Michael	Electrical Engineering, 4th year	Firm understanding of all electromagnetic phenomena	Life experiences include 12 years as an AT&T technician. Also involved in research with WinCOM in the area of cognitive radio.	Web	Research, Microphone, and Presentation
Gullikson, Kevin	Physics, 3rd year	Good problem solving skills, C, C++, python	Phys 300, which is basically EE for physic majors	Poster	Kiosk and Minutes
Lee, Harry	Electrical Engineer, 3rd year	Good at solving problems	Finished all 300 level course.	Purchasing	Documentation and Kiosk
Li, Li	Electrical Engineering, 4th year	Matlab,Python, signal processing	WinCom Lab at IIT, ECE	Tools and Media	Poster and Microphone

Raza, Mohammad	Electrical Engineering, 3rd year, Biomerical Engineering 4th year	Matlab, C, C++, fabrication	Electroencephalogram amplifier design and fabrication	Microphone	Tools and Media, Presentation
Shegarifi, Roozbeh	Electrical Engineer, 3rd year	Good with electronics, and communication skills	Taking 400 level course	Kiosk	Purchasing and Documentation
Shen, Tao	Electrical Engineering, Graduate Student		Electromagnetic field theory, microwave system, circuit design	Teaching Assistant	Teaching assistant
Soo, Min Kang	Electrical Engineering, 4th year	Matlab, VHDL, Verilog, Matlab, Power Point	Power reduction, SoC, and Embedded system	Documentation	Web and Research
Terry, Nastasja	Mechanical Engineering, 5th year	Construction, material selections	Phys 300, worked in previous IPRO344	Presentation	Microphone/Kiosk, Minutes, Presentation
Tu, Chia-Hao	Electrical Engineering, 4th year	AutoCAD, Matlab, PSIM, PSS/E	Coursework in engineering electronics and power electronics	Project Coordinator	Poster and Microphone

Sub-Team 1: Web Team

Purpose: The objective of the web team is to design and implement an attractive and user friendly website. Information conveyed through the website includes the team's background, goals, current research, prototypical progress, and links to

previous IPRO websites. The intended audience for the website is existing and future sponsors, students and faculty of IIT, and IPRO judges.

Team Members:

- Mike Carrozza – Team Leader
- Alex Barnett
- Min Soo Kang

Tasks:

- Develop an overall visual look for the website that is simple and appealing.
- Convey important and non-proprietary information regarding our product.
- Introduce the viewer to the team members and their background.
- Use cascading styles sheets and HTML to develop static HTML pages.
- Communicate with IIT's Web Server to manage files.
- Continually update website with current progress and research.

Sub-Team 2: Purchasing Team

Purpose: The Objective of this team is to purchase and deliver all necessary equipments and parts needed to conduct our project.

Team Members:

- Henry Lee – Team Leader
- Roozbeh Shegarifi

Tasks:

- Come up with the budget for the project.
- Communicating with IPRO office on having the money available if needed.
- Check different supplier for the cheapest price if possible.
- Ordering the equipments and part.
- Make sure that the items we order comes in on time.

Sub-Team 3: Documentation Team

Purpose: The objective of Documentation team is to create and maintain all documents related to IPRO 344 through official channels. The collected document help next IPRO team understand the purpose of IPRO 344 and identify the progress of it.

Team Members:

- Ming Soo Kang– Team Leader
- Harry Lee
- Roozbeh Shegarifi

Tasks:

- Collect and maintain all documents.
- Support Poster team for offering information to make a poster.
- Support Presentation team for preparation of presentation.

Sub-Team 4: Microphone Team

Purpose: Microphone team is responsible for assembly of microphone pre-amplifiers and improvement of audio sound quality.

Team Members:

- Mohammad Raza– Team Leader
- Li Li
- AlexBarnett
- Chia-Hao Tu
- Michael Carrozza

Tasks:

- Communicate closely with research team on the design of microphone pre-amplifiers.
- Work with Tools/Media team to investigate the sound quality captured by microphone with the specified pre-amplifier design.

Sub-Team 5: Kiosk Team

Purpose: Kiosk Team is in charge of taking all the equipment gathered and constructing the actual kiosk. Find a good way to mount the speaker and microphone so we can get optimal quality from it.

Team Members:

- Roozbeh Shegarifi – Team Leader
- Nastasja Terry
- Kevin Gullikson
- Alex Barnett
- Harry Lee

Tasks:

- Build the actual kiosk.
- Correctly mounting the speakers and microphone.
- Mimic the acoustic properties of an actual drive through kiosk.

Sub-Team 6: Tools/Media Team

Purpose: The tools and media team is responsible for proposing and installing tools/instruments for the team.

Team Members:

- Li Li – Team Leader
- Mohammad Raza

Tasks:

- Work closely with implementation and research teams to determine instruments needed for the project.
- Setup of instruments.

Sub-Team 7: Poster Team

Purpose: The objective of the poster team is to create a poster to display on IPRO day. This poster should clearly show what the goals of this IPRO were and what we accomplished. The poster should stand out so as to attract attention.

Team Members:

- Kevin Gullikson – Team Leader
- Li Li
- Min Soo Kang
- Chia-Hao Tu

Tasks:

- Work with the documentation team to compile any technical information we may want to display.
- Work with the Presentation team to decide what information we want to present on their slideshow and our poster.
- Submit a budget to the purchasing team for the poster board, as well as any markers, etc. we may need to decorate it.
- Create the poster, set up for IPRO day and be there to present it.

Sub-Team 8: Research Team

Purpose: The research team provides information for other teams to utilize in the project implementation. The research team will utilize datasheets, web tutorials, and published research to collect and convey data to the Microphone Preamplifier and Kiosk teams.

Team Members:

- Alex Barnett – Team Leader
- Min Soo Kang
- Mike Carrozza

Tasks:

- Determine the requirements of current Shure microphone.
- Propose potential designs to the microphone preamplifier team.
- Investigate logistics of speaker connection and cabinet requirements.
- Investigate potential Kiosk microphone.
- If time permits, investigate solutions to wind and Diesel interference.

7. Designation of Roles

Agenda Maker- Chia-Hao Tu

Meeting Minute Taker- Terry Nastasja and Kevin Gullikson

Time Keeper- Chia-Hao Tu

Filing and Organizing Weekly Timesheets- Terry Nastasja

Weekly Task Lists- Kevin Gullikson

iGroups Coordination- Chia-Hao Tu

Master Schedule Maker- Chia-Hao Tu

IPRO344 Representative/Presenter- Nastasja Terry, Michael Carrozza, and Mohammad Raza