# ILR #6
# Amazon Picking Challenge

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Team E
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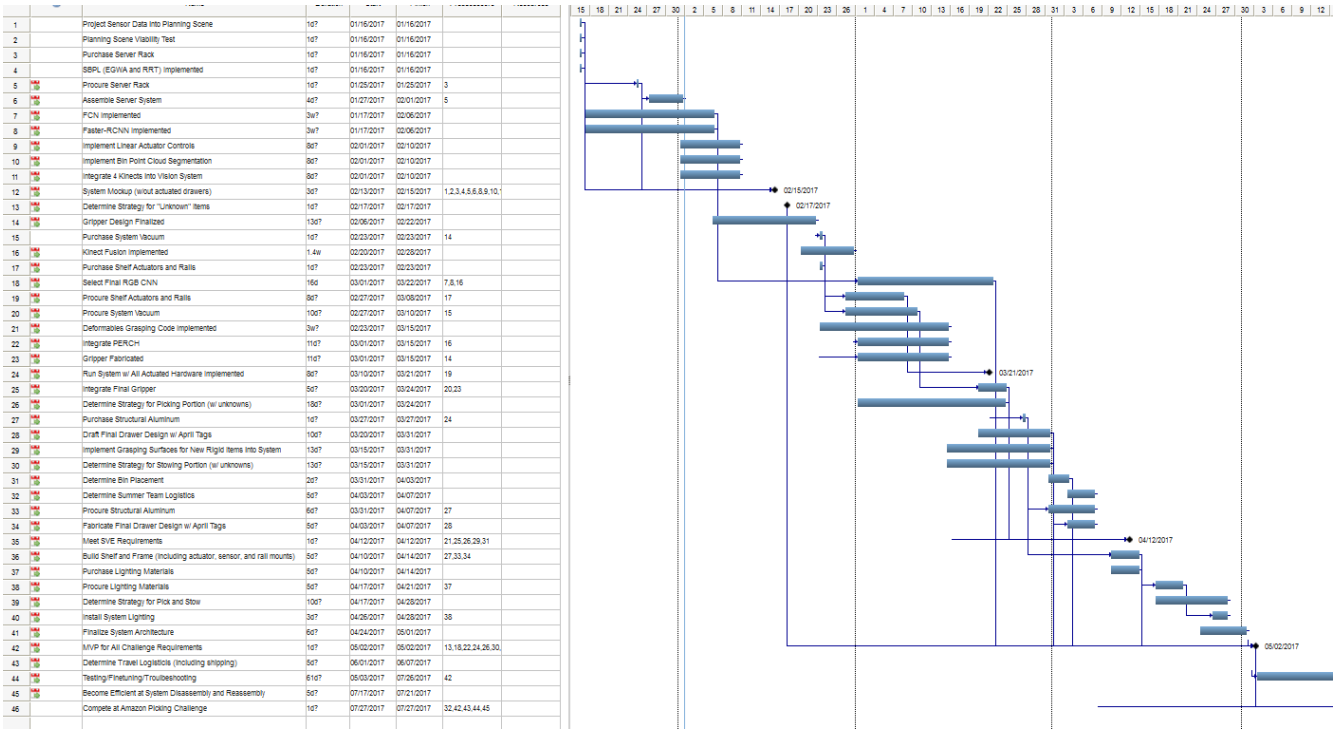
# Individual Progress

My primary responsibilities for the last couple weeks were to organize and outline our project's goals and deadlines. This included drafting subsystem descriptions, a Gantt chart, and creating weekly tasks for all teammates. Leo and I worked together to refine a ROS architecture for the vision portion. I also researched potential grippers and came up with a conceptual idealization, and worked on both the drawer actuator mechanism and a wooden frame mockup with Akshay.

## *Project Management*

I divided project management tasks into subsystem descriptions, a Gantt chart, and weekly task assignments. This involved gathering up all the team's schedule and setting a weekly meeting date. The Gantt chart was created using the Google drive app extension Gantter, and can be seen in Figure 1. The goal of the chart was to lay out all major milestones and tasks for both the MRSD course project and the challenge which will occur in late July.



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|---|---|---|---|---|---|---|
| 1 | | Project Sensor Data into Planning Scene | 1d? | 01/16/2017 | 01/16/2017 | |
| 2 | | Planning Scene Viability Test | 1d? | 01/16/2017 | 01/16/2017 | |
| 3 | | Purchase Server Rack | 1d? | 01/16/2017 | 01/16/2017 | |
| 4 | | SBPL (EGWA and RRT) implemented | 1d? | 01/16/2017 | 01/16/2017 | |
| 5 | | Procure Server Rack | 1d? | 01/25/2017 | 01/25/2017 | 3 |
| 6 | | Assemble Server System | 4d? | 01/27/2017 | 02/01/2017 | 5 |
| 7 | | FCN implemented | 3w? | 01/17/2017 | 02/06/2017 | |
| 8 | | Faster-RCNN implemented | 3w? | 01/17/2017 | 02/06/2017 | |
| 9 | | Implement Linear Actuator Controls | 8d? | 02/01/2017 | 02/10/2017 | |
| 10 | | Implement Bin Point Cloud Segmentation | 8d? | 02/01/2017 | 02/10/2017 | |
| 11 | | Integrate 4 Kinects into Vision System | 8d? | 02/01/2017 | 02/10/2017 | |
| 12 | | System Mockup (w/out actuated drawers) | 3d? | 02/13/2017 | 02/15/2017 | 1,2,3,4,5,6,8,9,10, |
| 13 | | Determine Strategy for "Unknown" Items | 1d? | 02/17/2017 | 02/17/2017 | |
| 14 | | Gripper Design Finalized | 13d? | 02/06/2017 | 02/22/2017 | |
| 15 | | Purchase System Vacuum | 1d? | 02/23/2017 | 02/23/2017 | 14 |
| 16 | | Kinect Fusion Implemented | 1.4w | 02/20/2017 | 02/28/2017 | |
| 17 | | Purchase Shelf Actuators and Rails | 1d? | 02/23/2017 | 02/23/2017 | |
| 18 | | Select Final RGB CNN | 16d | 03/01/2017 | 03/22/2017 | 7,8,16 |
| 19 | | Procure Shelf Actuators and Rails | 8d? | 02/27/2017 | 03/08/2017 | 17 |
| 20 | | Procure System Vacuum | 10d? | 02/27/2017 | 03/10/2017 | 15 |
| 21 | | Deformables Grasping Code Implemented | 3w? | 02/23/2017 | 03/15/2017 | |
| 22 | | Integrate PERCH | 11d? | 03/01/2017 | 03/15/2017 | 16 |
| 23 | | Gripper Fabricated | 11d? | 03/01/2017 | 03/15/2017 | 14 |
| 24 | | Run System w/ All Actuated Hardware Implemented | 8d? | 03/10/2017 | 03/21/2017 | 19 |
| 25 | | Integrate Final Gripper | 5d? | 03/20/2017 | 03/24/2017 | 20,23 |
| 26 | | Determine Strategy for Picking Portion (w/ unknowns) | 18d? | 03/01/2017 | 03/24/2017 | |
| 27 | | Purchase Structural Aluminum | 1d? | 03/27/2017 | 03/27/2017 | 24 |
| 28 | | Draft Final Drawer Design w/ April Tags | 10d? | 03/20/2017 | 03/31/2017 | |
| 29 | | Implement Grasping Surfaces for New Rigid Items into System | 13d? | 03/15/2017 | 03/31/2017 | |
| 30 | | Determine Strategy for Stowing Portion (w/ unknowns) | 13d? | 03/15/2017 | 03/31/2017 | |
| 31 | | Determine Bin Placement | 2d? | 03/31/2017 | 04/03/2017 | |
| 32 | | Determine Summer Team Logistics | 5d? | 04/03/2017 | 04/07/2017 | |
| 33 | | Procure Structural Aluminum | 6d? | 03/31/2017 | 04/07/2017 | 27 |
| 34 | | Fabricate Final Drawer Design w/ April Tags | 5d? | 04/03/2017 | 04/07/2017 | 28 |
| 35 | | Meet SVE Requirements | 1d? | 04/12/2017 | 04/12/2017 | 21,25,26,29,31 |
| 36 | | Build Shelf and Frame (including actuator, sensor, and rail mounts) | 5d? | 04/10/2017 | 04/14/2017 | 27,33,34 |
| 37 | | Purchase Lighting Materials | 5d? | 04/10/2017 | 04/14/2017 | |
| 38 | | Procure Lighting Materials | 5d? | 04/17/2017 | 04/21/2017 | 37 |
| 39 | | Determine Strategy for Pick and Stow | 10d? | 04/17/2017 | 04/28/2017 | |
| 40 | | Install System Lighting | 3d? | 04/25/2017 | 04/28/2017 | 38 |
| 41 | | Finalize System Architecture | 6d? | 04/24/2017 | 05/01/2017 | |
| 42 | | MVP for All Challenge Requirements | 1d? | 05/02/2017 | 05/02/2017 | 13,18,22,24,26,30, |
| 43 | | Determine Travel Logistics (including shipping) | 5d? | 06/01/2017 | 06/07/2017 | |
| 44 | | Testing/Finetuning/Troubleshooting | 61d? | 05/03/2017 | 07/26/2017 | 42 |
| 45 | | Become Efficient at System Disassembly and Reassembly | 5d? | 07/17/2017 | 07/21/2017 | |
| 46 | | Compete at Amazon Picking Challenge | 1d? | 07/27/2017 | 07/27/2017 | 32,42,43,44,45 |

Figure 1: APC Project Gantt chart, 1st draft

Due to communication issues and lack of direction last semester I felt it was important that there be documentation which can act as a reference source for the team at all times. To that end I drafted subsystem descriptions for all parts of the project which incorporate current design choices and implementation. These documents were created in Google Docs and were shared with my teammates after having them reviewed by the SBPL lab. One portion of the current Vision subsystem description is the ROS architecture, which I refined and drafted with Leo, seen in Figure 2.

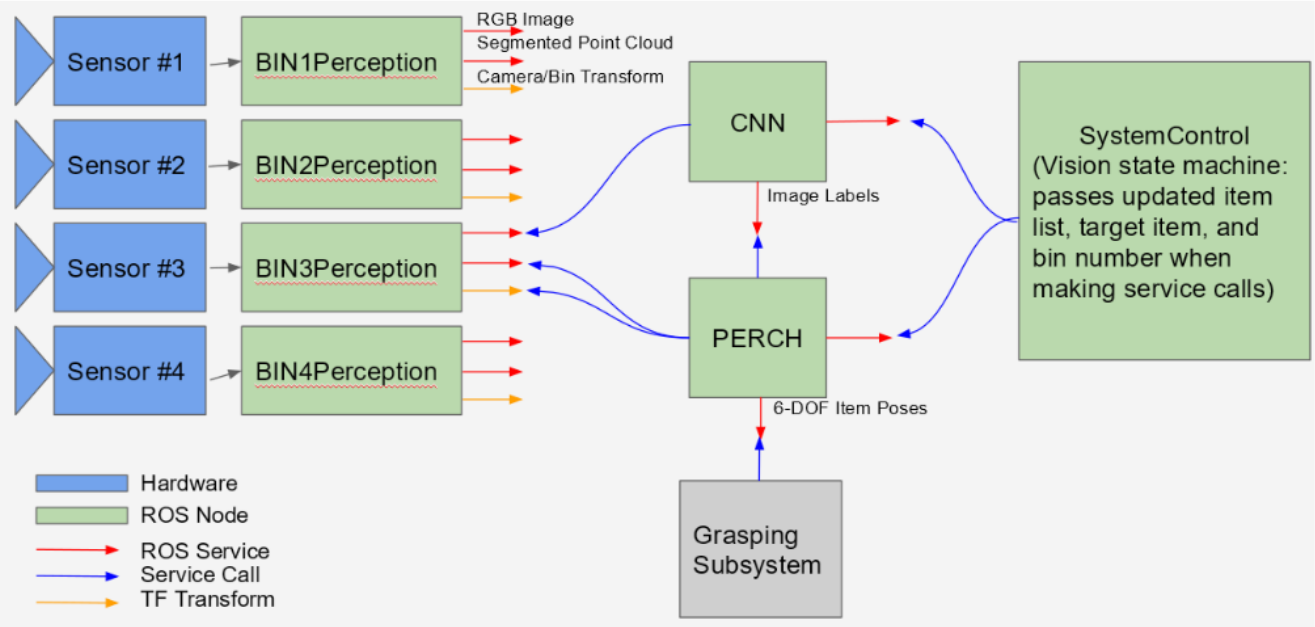


Figure 2: ROS Architecture diagram for the Vision subsystem

In order to make sure the project is moving according to the outlined design and schedule I have been using Trello as a task management tool. I created colored labels for each team member, and have been assigning tasks as needed every Saturday during team meetings (I draft up all the necessary tasks prior to each meeting).

### *Gripper Idealization*

Gripper hardware selection has been delayed until receiving the new item list. Research has continued however into appropriate grippers being used in industry for these applications, and for items from past challenges. This research has shown that only a vacuum system with an additional two-finger component seems to be a proven method for tackling all potential challenge items. Vacuum research has shown that the most effective vacuum systems involve multiple orifices within a foam body, which allows for compliance and conformity to the item being picked. To that end a gripper ideal would be a foam multiple-orifice suction system, which has the ability to translate into a two-

finger gripper. A simple CAD mockup of this idealization is seen in Figure 3.

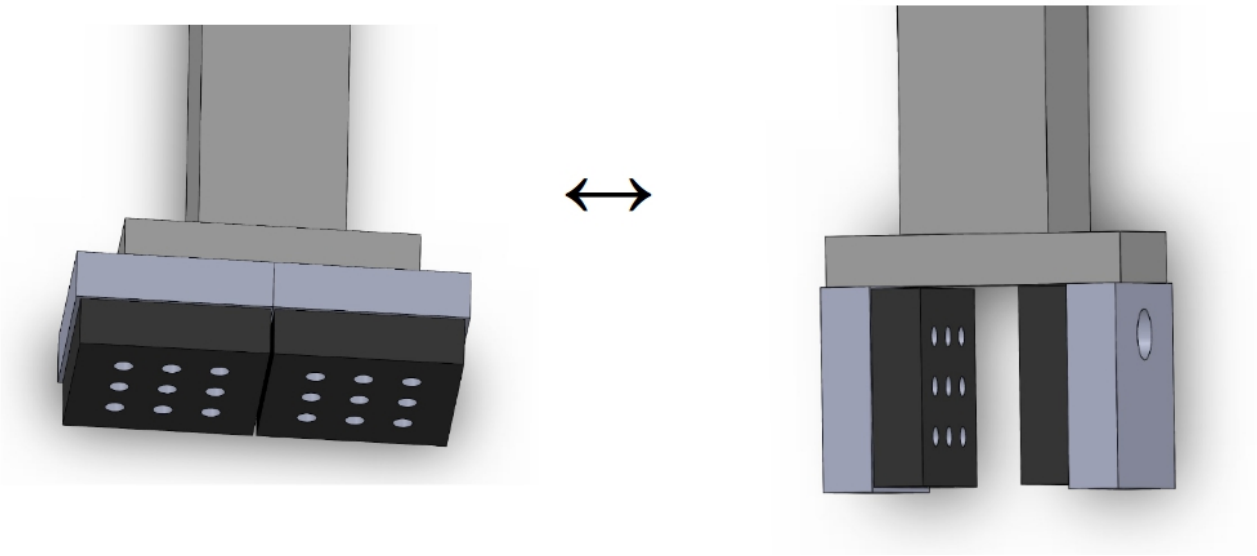

Figure 3: Gripper idealization

### *Shelf Actuator Design*

Akshay and I visited with NREC designers in order to solidify an implementation for our fold-out drawer design. The meeting lasted about an hour. The final choice involves a chain drive, with a hook or fork on one end and a leaf spring on the other. The hook acts to engage a pin inside the drawer when moving in one direction, folding it out, and the spring leaf pushes the drawer back in place when the chain moves in the opposite direction. The drawer itself rests on either sliders or rollers. A CAD mockup can be seen in Figure 4.

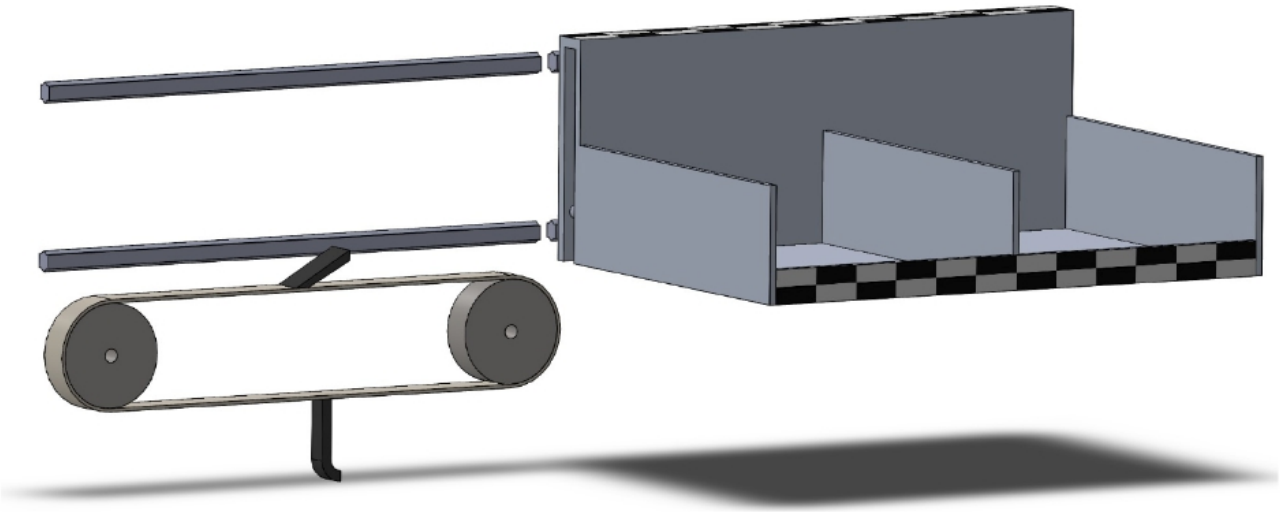

Figure 4: Drawer actuation CAD

Figure 5: System idealization during competition runtime.

The idealizations were reviewed as part of a team meeting with Professor Apostolopoulos. After the meeting the team feels confident that we can create a system which approaches our idealization, budget permitting. Drafting up new models for such a system has become a new goal that we hope to have finished before winter break.

### *Check-in w/ RAF, Vacuum System Quote*

I finally had some productive feedback from RAF that has resulted in finding affordable flexible hosing, which is within working dimensions for our system (roughly between 1" and 1.5" I.D.). They have also shown me a distributor website with several pumps that may satisfy our needs for airflow and pressure, all of which operate at 230VAC. Moving forward I need to perform some tests on the current shop vac for comparison to their pressure/flow curves, and check-in about power requirements and availability for the competition.

## Challenges

### *Making Assumptions*

As the project manager it has been a continual challenge to guess at how long tasks will take to get completed. Several tasks have already been up to a week behind schedule due to unforeseen difficulties. I am doing my best to communicate with my teammates to better understand realistic task timelines, and I am trying to always keep the project ahead of schedule in general as a contingency plan against delays. I am still forced to make assumptions in places however, and find myself adapting to necessary schedule changes when those assumptions prove to be incorrect.

## Teamwork

I worked together with Leo in order to draft a ROS architecture for the Vision system, and with Akshay in order to design the actuation mechanism for the drawers.

Jin worked with Leo and Akshay in order to develop basic calibration mechanisms within ROS. Akshay worked with our new MSCV team member in order to implement Faster-RCNN and FCN for RGB identification purposes. Matt and Leo also worked together to get our new server up and running and to spec required hardware to meet our

computing needs.

## Future Plans

Moving forward this for the next two weeks the primary focus will be establishing an MVP with our new system. This system in theory will utilize Faster-RCNN in order to identify and localize items, which will then be picked by our arm. The arm should also be operating with our linear actuator at that time, and the system should incorporate at least 2 Kinects as part of working toward our eventual 4-5 Kinect goal. I will be taking tasks as needed and managing the team to do our best to accomplish these goals.