# Internet of Connected Devices

Spring Schedule and Risk Assessment

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# 1. Work Breakdown Structure

## 1.1. Work Breakdown Overview

To ensure timely completion of the project meeting all standards set forward by our sponsor, Direct Supply, and the senior design curriculum, the team has broken tasks down into 5 sprint like phases lasting on average 4 weeks. While we are not necessarily employing true agile methods, these phases are similar to sprints in the way they overview the work the team should focus on to ensure all phases of our project are completed. Each phase is centered on a major task or key project deliverable (such as the final prototype) and is then broken into the detailed subtasks team members will need to complete. The phases are generally independent and concurrent work will be necessary particularly in testing phases. Each has been given a lead within our team to ensure accountability and specialization in specific requirements when carrying out the individual subtasks. The work breakdown chart as shown in figure 1.2.1 details the individual breakdown of tasks visually showing the subtasks as well as expected completion deadlines and project lead.

The first major task continues the technical work we started last semester while working to connect the pulse oximeter and Raspberry Pi using low energy bluetooth. Our goal was to have this part of the project done before the Christmas holidays but unfamiliarity with the version of the BLE ATT protocol we were using led to challenges. It is imperative for the team that this task is finished quickly as it is the key to the internet of things component of the project. We will be using working sessions with our sponsor to ensure that we do not fall behind. Ryan will take the lead on this task and work to have it done in mid February with a working session February 9th. Though this task may slide to be a little late, it will not hinder other parts of the development and can be worked on concurrently with this semester's focus on machine learning. Major subtasks of this deliverable include determining the correct protocol and finding a testing tool that can interpret the packets we are already receiving and parsing using a bluetooth sniffer.

The second major task includes automating the data transfer between the Pi and pulse oximeter. Zhou will head this task and look to complete it by the end of February with a bare bones script by February 24th. We intend to use the Bluepy protocol (a python library with built in connect and parse functionality for BLE) though more research is needed now that we are aware that full GATT has not been implemented on the pulse oximeter. Significant example

code exists online for similar applications of Bluepy. Much of this task will include testing to ensure we are correctly transfering the data.

Real time display of the pulse oximeter data is a fundamental goal for this project. This task is key to our final prototype and Franco will be looking for a easy way to display relevant information using the touchscreen on the Pi. In addition to testing, we will need to determine with our sponsor what information will need to be graphed and displayed as well as how and which machine learning elements will be included. This task is generally open ended and will require relying on developing a specific interface based on good user centered design principles and will be defined as the project moves forward.

Testing and verification is a major part of product development and the senior design curriculum. Verification of design is due April 1st after demonstrating the final working prototype. For this deliverable, we will need to generate and follow our testing plan ensuring functionality within the project requirements we outlined last semester. Franco will be leading testing. For our project, we will need to design unit tests for our software including the data transfer script, the display protocol, and the machine learning algorithm and function. These will need to be tested individually as well as combined. The hardware will need to be tested including different pulse oximeters and Pi platforms. The connectivity will need to be measured and labeled for range. A major component of early testing will include creating a data set of pulse oximeter information to be used to train the machine learning algorithm.

The final portion of development will include defining and implementing machine learning to contextualize the data we receive from the pulse oximeter. There are still many components of this that are up for interpretation and many details will need to be finalized. Ryan and Sam will head this project. This component will be developed throughout the semester with portions of it required for the prototype. We have set a May 1 deadline for this as it will require significant time tweaking the algorithm and gathering data for the learning sessions.

## 1.2. Work Breakdown Structure Chart

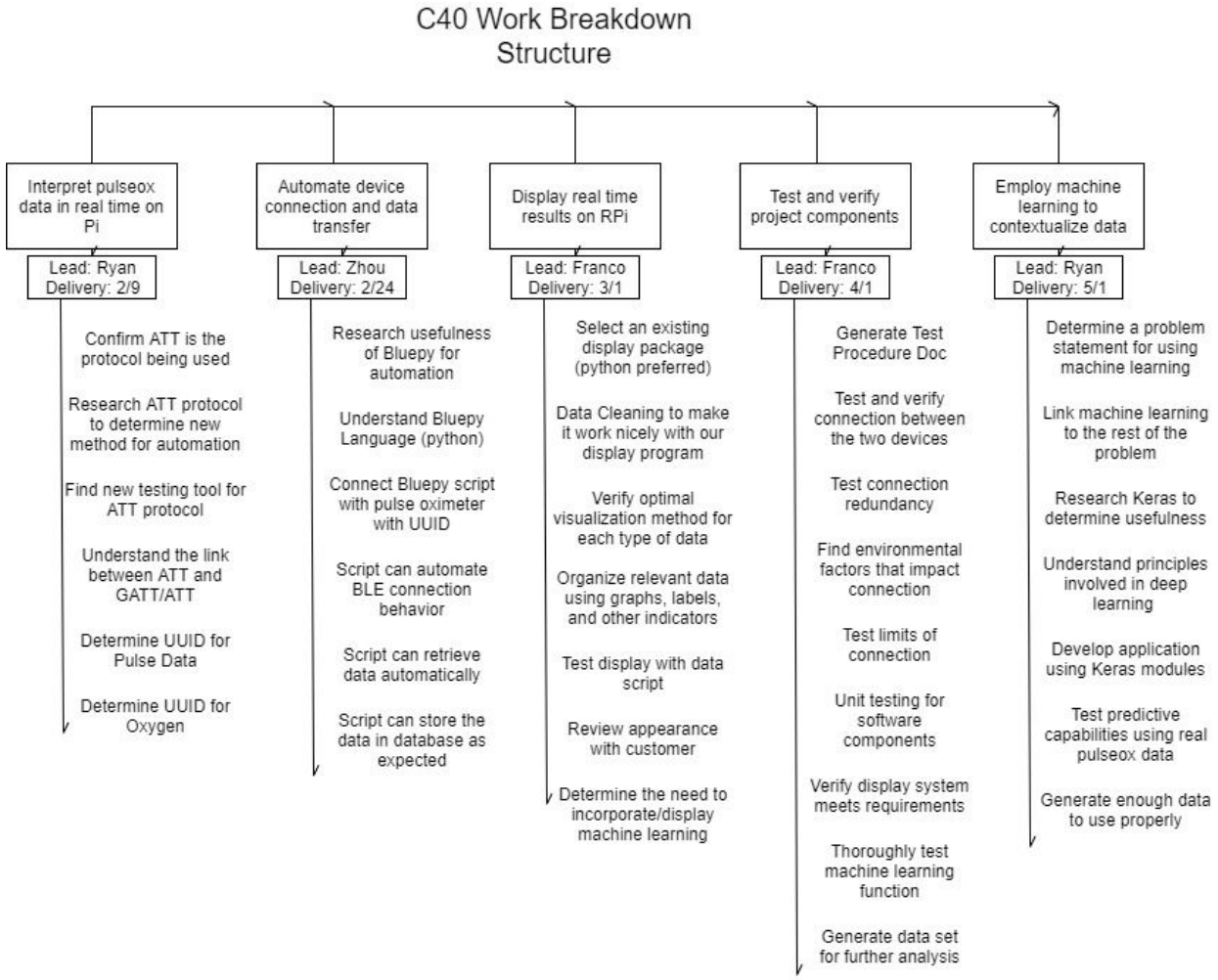


Figure 1.2.1 - Work Breakdown Structure

Pictured above in figure 1.2.1 is the work breakdown chart. The chart clearly identifies major and minor tasks described in section 1.1 and meets requirements from the Harvard Business Manual including considering cycles and timing relationships. Target deliveries match with course deliverables and major task leads will be accountable for subtasks particularly research into each topic.

# 2. Gantt Chart Analysis

## 2.1. Gantt Chart

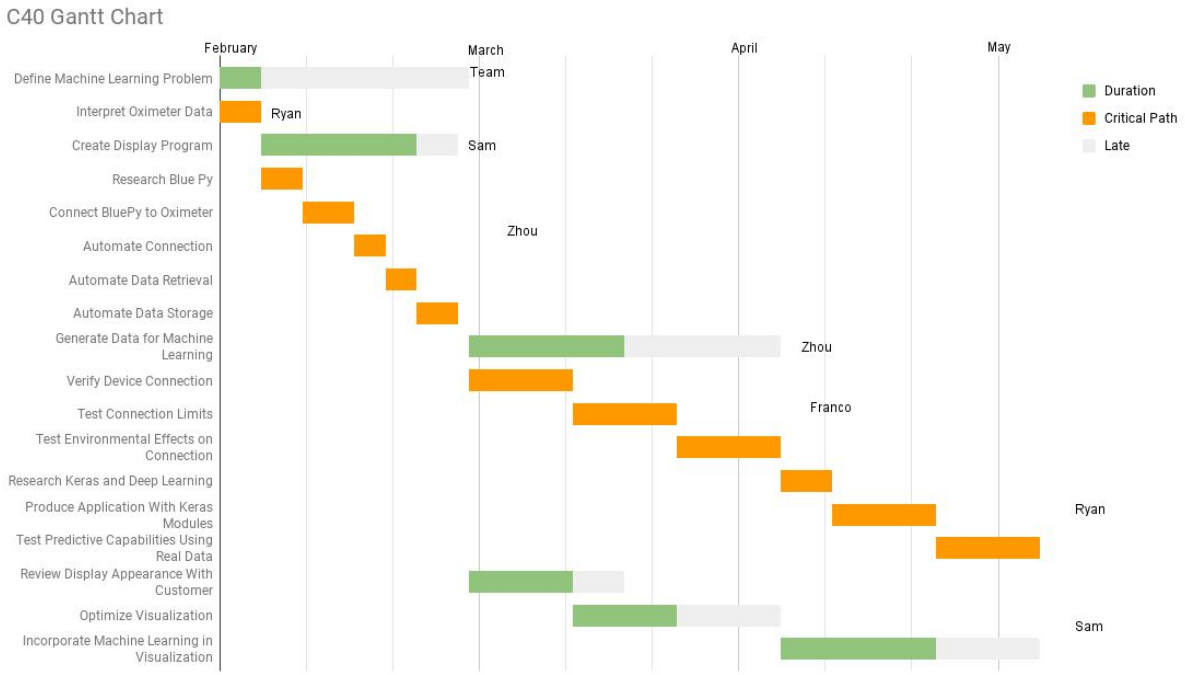


Figure 2.1.1 - Gantt Chart

## 2.2. Critical Path Analysis

The critical path is displayed in orange in the Gantt chart. It includes all tasks that directly lead to the completion of our final product. Each task in the critical path requires that the previous task be completed in order to continue. Any time that we are late on a task in our critical path will be time subtracted from future tasks. Thus it is important that we maintain this schedule as closely as possible.

Since much of the work we do in the project will build off of previous work done we had to place most tasks on the critical path. The tasks we do hope to be able to do in parallel with the critical path are the generation of data for the machine learning component of the project as well as the development of the program that will visualize the collected data for the project.

### 2.3. Task Ownership

Sections of the Gantt chart have names of the team members that are responsible for leading those tasks and ensuring their successful completion. While looking forward to the rest of the semester we approximated where our group members may step up to take a lead on a certain task. This is to ensure accountability for each task especially tasks that are scheduled in parallel. The lead for each task is expected to focus their research efforts in this specific field so that they can teach other members of the team and communicate effectively about their project aspect. Moving forward we hope to keep the ownership of tasks flexible while still having guidelines for our group to follow.

## 3. Risk Mitigation Plan

### 3.1. Potential Threats

Section 1.1 outlines all major tasks for our project. For each of them, there are several potential threats to consider and are identified in table 3.2.1. This includes lists all of the potential problems, severity, probability, composite risk and risk mitigation plans for each of these risks.

The first major task is to finish connecting the pulse oximeter and Pi. Not correctly reading the packets from the pulse oximeter on the Pi will result in a major failure of the project as experienced by the 2016 C40 team. Understanding the BLE connection and protocol has been a challenge and will continue to be a major point of focus. Major threats to automating using scripts include the library failing to meet our requirements as well as unreliability. Not automatically reading, transfering, downloading data from pulse oximeter is a major failure for this project. Because of the level of importance and problems that we have been warned about, we are carefully following our risk mitigation plan of asking for help from Direct Supply.

Testing and verification is generally low risk assuming that we do not uncover issues at this stage or fail to meet the written requirements. The biggest issue at this stage would be that the other components of the project are not done in time to properly test leading to a rushed testing period. This phase of the project could also fail to gather the necessary information using the pulse ox, Pi pair to use of our machine learning algorithms.

Machine learning is by far the most complicated and interpretable parts of our project. If the problem is not clearly defined, the results we get using machine learning will be of very little

use to direct supply. It is very important to communicate with the sponsor and advisor to ensure that this section meets the requirements.

Section A represents risks not related to the technical progress of the project and are centered around our planning, scheduling, communication, and team dynamic. While these are certainly risks to the project, our group has worked well together so far and has added additional help to ensure we meet all of the necessary deliverables and timeline. Failure in this category is significantly mitigated by this document.

## 3.2. Risk Assessment Chart

| No. | Potential Problem | Probability | Severity | Risk | Risk Mitigation Plan |
|---|---|---|---|---|---|
| **1** | **Interpret blood oxygen and pulse data from oximeter in real time after connecting to the device on the Pi** | | | | |
| 1.1 | ATT Protocol is not the protocol being used | 0.4 | 4 | 1.6 | Work with Kent and Direct Supply to find the correct protocol used by the Pulse Ox |
| 1.2 | Device's BLE protocol is unable to be used with automation methods | 0.1 | 7 | 0.7 | Work with our sponsors to discuss how they interface with the device. |
| 1.3 | No Testing tool for ATT Protocol exists | 0.2 | 4 | 0.8 | Work with Kent to implement our own testing procedure for the device. |
| 1.4 | Unable to find UUID's for relevant data | 0.6 | 1 | 0.6 | Work with Kent and Direct Supply to help us better understand the protocol used by the Pulse Ox |
| **2** | **Automate data acquisition from the pulse oximeter using a BluePy script** | | | | |
| 2.1 | BluePy does not work well with automation | 0.05 | 1 | 0.05 | Proper research of the script to ensure it functions before too much time is committed to development with the script. |
| 2.2 | PulseOx data does not interface well with BluePy script. | 0.2 | 7 | 1.4 | See if this can be fixed through data cleaning. |
| 2.3 | Script unable to work with the Bluetooth Low Energy connection protocol | 0.25 | 8 | 2 | Do a detailed research about BLE connection protocol |
| **3** | **Create a display program that shows real time results on the Pi** | | | | |

| | | | | | |
|---|---|---|---|---|---|
| 3.1 | Pre-existing data visualization package does not work for visualizing live data | 0.1 | 6 | 0.6 | Attempt to modify one of the many pre-existing data visualization packages |
| 3.2 | Customer doesn't approve of our user interface | 0.15 | 4 | 0.6 | (Preventative) Get more detailed requirements from customer |
| **4** | **Test and verify connection between the two devices. Generate data set for further analysis** | | | | |
| 4.1 | Unable to generate a helpful testing procedure that finds data issues | 0.2 | 3 | 0.6 | Review literature on developing proper testing procedure and speak to advisors on the matter |
| **5** | **Employ machine learning to contextualize data** | | | | |
| 5.1 | Keras package doesn't fulfill the machine learning requirements of our project | 0.2 | 5 | 1 | Do a proper investigation into the Keras package before devoting too much time to it. Search for alternatives if it doesn't look promising. |
| 5.2 | Unable to gather a large enough data set for a meaningful machine learning phase | 0.35 | 6 | 2.1 | Attempt to gain access to a pre-existing set of health data online |
| **A** | **Administrative and Team Issues** | | | | |
| A.1 | Severe Illness of Team-member | 0.05 | 5 | 0.25 | Modify schedule and make sure tasks on the critical path are covered by the rest of the team |
| A.2 | Miss deadline for printed materials for design day | 0.01 | 4 | 0.04 | Pay for an outside service such as FedEx Business. Properly document important administrative deadlines. |
| A.3 | Conflict within team | 0.1 | 3 | 0.3 | Proper and frequent communication to mitigate team conflict. Follow established guidelines on the matter. |
| A.4 | Missed class deliverables | 0.2 | 8 | 1.6 | (Preventative) Proper communication and frequent discussion of deadlines. |

Table 3.2.1 - Risk assessment rankings

## 3.3. Preventative Action

While making Table 3.2.1 we formatted our risk mitigation plans with preventative action in mind. Most issues we could run into over the course of this project can easily be mitigated through proper research of the protocols and coding packages we plan to implement. Other issues we could run into such as administrative issues can also be prevented by putting in a greater effort in communication and frequently checking deadlines. Our project notebook will play a critical role in keeping all of our technical progress on track according to the schedule set forth in this document.

## 3.4. Contingency Plans

Throughout the execution of our project, several of these risks are bound to become reality. In this event, the team will continue to use the risk mitigation plan for that task in an attempt to keep related components on course. The schedule will need to be be modified to absorb changes to ensure the final project is delivered on time. Communication with sponsors and advisors is an important step to ensure that trust remains between the project group and stakeholders.

Specific contingency plans for failure to network the Pi and pulse oximeter include modifying the plan for accepting real time data and instead using a sniffer to dump to a file and read data back on the display. The 2016 team used this with limited success to get around problems with directly connecting the two devices.

Machine learning presents the team with a big challenge to gather enough relevant data. Should the verification process fail to generate sufficient data for training the machine learning function, the team will generate artificial data and use online data sets to train the function to display our experience with machine learning and that this viable for use within the project and this field.

# 4. References

[1] “IoT Connected Devices” - Marquette University College of Engineering Senior Design. Courtney Connery, Noel Lopez, Clayton Armbrust, Changyan Liu, Brandon Guerrero, May 2017

[2] Principles of Design 4920, Marquette University, ISBN: 11211939805

[3] Project Management Manual, Harvard Business School, #9-697-034

[4] “Direct Supply”, directsupply.com, 2018 [online] [Accessed: 21- January-2018].