Supporting Document for the SWARM Tech project presentation:

Members: Matthew, Nicolas, Walia, Luke, Peter, Jackson

Introduction:

The following document will outline the various sections of Swarm tech's current beehive monitoring prototype. It will follow the accompanied slide deck and demonstrate deeper explanation of the concepts on each slide.

Swarm Tech's design focuses on bulk reproducibility for operations with at least 5 – 8 hives. Having these many hives allows for the upfront costs to be justified in the cost of the additional hive monitoring hardware.

Subsystem Designs – Circuitry & Arduino

One of the core systems within our design is our physical hardware, this controls the gathering of the data and relaying the information to the server to be utilized in the necessary forms. The figure shown is a very early wiring diagram for two humidity/temperature sensors and one set of the loading cells and their communication chip. This figure is missing the SD card reader, GSM shield, and the specific power sources. The figure is meant to demonstrate the actual feasibility of the function of these components together, yet what do these sensors and components achieve to help solve the problem?

The humidity and temperature sensors are what gather the required data. These sensors are connected through the I2C bus on the Arduino, what this means is we can have enough of these sensors for all the hives running off one Arduino.

The load cells and HX711 chip are what measure the weight of the hive. This weighing system is the bottle neck for the number of hives that can be monitored per Arduino due to its utilization of communication points on the Arduino.

The SD card reader is a vital fail-safe feature of our design; where we would like our server to be functioning perfectly all the time, malfunctions can occur, to combat this there will be an SD card onboard the device to save the data being collected in case the data can't be sent remotely. This will have a high enough capacity that it won't need to be wiped and reset for long durations of time, even possible each winter cycle.

Finally, the GSM shield, this is the key to our remote data transfer, this component allows for the Arduino to send SMS messages via a sim card, this will allow us to send the data to the website or/and even send a text to your phone.

Subsystem Designs – Base plate & Load Cells

Based on the prescribed requirements and concerns of the given situation, collecting the weight of the hive is the most important data point to collect to monitor the health of the bees. Based on this we have dedicated much thought to the function and efficiency of this data collection system. In the figure on the right of the slide you will see our current 3D model of the base plate and the placement of the load cells.

The base plate is necessary as this provides a stable place for the beehive to rest while fitting the necessary components. The base plate is designed to have the necessary size to allow for the beehive to sit comfortably within it, this will then allow the beehive to make direct contact with the four load cells, applying pressure so they can measure its weight. This information is then saved on the SD card and sent to the server accompanied by the temperature and humidity data.

Subsystem Designs – Server (backend)

The concept of a server is to host information that can be accessed from anywhere with an internet connection. In this instance SWARM Technologies would use a web server. A web server is a physical server that hosts a webpage and performs all calculations out of view of the user (client).

The process diagram illustrated in the server slide begins on the border between the Arduino SMS system and the server system. Once the Arduino sends the SMS message to the cell tower, the Arduino system has concluded, and the server system initiates. The cell tower sends the SMS message to the GSM module attached to the server. A GSM module is like an internet modem someone would have in their house. The difference between a GSM module and a Wi-Fi modem is that the GSM module receives signals via SMS messages and uses a SIM card to verify network permissions to the cell carrier. GSM SIM cards are significantly cheaper than personal use SIM cards someone would use in a phone as these are for commercial use.

The separation between server option A and server option B is that option A has the GSM module and server computer that would be in the beekeeper's house, in this case, Lola Bees. The hardware for the server would be a Raspberry Pi 4, minicomputer. This computer costs between $35 - $80 and is used instead of a > $1000 server typical companies might use. The benefits of using this type of server are that you do not rely on a third party to do any diagnostics on your server. Server option B is a third-party web hosting platform such as Google or Amazon Web Services (AWS). These third parties can be beneficial for static webpages (a web pages that do not require data to flow continuously). In this instance of the server, the data would need to be sent via GSM module to the third-party web hosting platform, which would prove to be expensive and troublesome for all parties involved.

Pros and cons of each option are illustrated in slides but to conclude, server option A would be more advantageous to Lola Bees' structure. The biggest pro is the ease of setting up and the low cost of operation. Working on the code of the server would be as easy as plugging the server into a display monitor and troubleshooting the code. An exceptionally large bee keeping operation might benefit from a web hosting platform provided they made an agreement with a corporation to host their services and have them design all web related components to their desired specifications. This would exclude them from the on-site hardware and would add complexity to coordinate these functions.

Subsystem Designs – Website (frontend)

The Front-end aspect of the website helps display the information that you, the client, have requested us to monitor. The website will receive information multiple times a day and organize the data in an accessible way. Humidity, Temperature and weight will all be recorded in a file that differs for whichever day the data was sent in. The information will then be organized into charts and tables so trends can be identified. We will organize the different files so you can see data from the hives at any given time. We also know that you wish to compare larger samples of data, to achieve this the website should also display different graphics of data over multiple days or weeks.

The website should be up and running all the time so you can easily access it from your phone or computer. Due to the front-end aspect of the website relying heavily on information received from the server/Arduino, you will easily be able to see if any of the devices are not running properly as the data will not show up. In this case you would also likely receive an email but just in case this feature doesn't work you could see any potential problems from the data being missing. The layout or design of the website can be changed if you would like the data to be displayed differently and we are open to suggestions that would make things easier.

Bill of Materials (Price Breakdown)

This bill of materials is a general outline of the various products needed in order to complete the hive monitoring system. The items listed here are mostly physical pieces of hardware required for the complex wireless messaging system. The rest mostly revolve around the sensors themselves and keeping them organized and safe from external damage – eliminating potential repair costs. This chart also shows how many hives are supported through each individual purchase, which can be used to find the estimated total cost per hive.

Our current estimated cost per hive is around $50, but that doesn't consider the costs of a $5 monthly SIM card fee as well as running a server to host a website. While the cost of running a server may seem expensive at around $40-$80, this is a one-time expense which will be able to support a limitless amount of hives. Even with this extra expense, the number of features this design supports are worth it.

A major focus that we took into consideration has been the fact that this design should be made to support multiple hives. We narrowed down our bill of materials to be more supportive of bulk materials to support as many hives as possible in turn making it cheaper, the more hives that are supported. This resulted in 20 hives being supported for an estimated price of $44.34 per hive. This figure is lower than the current budget restriction, which allows for some 'wiggle room' if there are any additional costs.

Current Prototype Schedule

The current prototype schedule is a rough schedule for when each subtask is completed. Currently Swarm Tech is on schedule, having finished our bill of materials and prototyping.

We hope to begin constructing the physical aspects of our design (Arduino, sensors, base plate etc.) when we get back to campus at the end of February. We are already building the website and server; on the slide deck you can see an outline of what a given page would look like. The final prototype should be finished mid-April which would include data monitoring for at least one hive and ideally have one Arduino that can monitor multiple hives. We would be happy to help mass produce and further support the production of this product to fit all the hives, given you select our design.