Department of Computer Science & Engineering
The University of Texas at Arlington

Project Charter
CSE 4316: Senior Design I
Spring 2021

Automated
Home Brewing
System

Figure 1: Project Logo

Team Friendship
Automated Home Brewing System

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Revision History

Revision	Date	Author(s)	Description
0.1	03.11.2021	LB	document creation
0.2	03.25.2021	ALL	complete draft

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1 Problem Statement

The reason we chose this project was because it was suggested to us by Chris Conly and everyone though it had something in it that interested them. It will help us learn about programming microcontrollers, handling communications between devices via different protocols, and web development.

2 Methodology

Our goal is to be able to plug a recipe into a web application, that will tell the sensors, heat source, and pumps exactly how to produce the beer.

Our project will simplify the brewers job by heating and pumping the water to the containers through automation. This will ensure the water is kept at the desired temperature throughout the whole process and will help the brewer monitor all parts of the brewing process without requiring them to manually reheat/distribute the water. Automation will be done through the use of heat sensors, pumps, and microcontrollers that will communicate to a web-app/phone app. The brewer will be able to control the what temperatures the water will be set to and the amount of time they would like to spend on any step of the brewing process.

- put together sensors into something that can interface with a web server
- interface with the sensors through a web portal of some kind
- program the sensor to complete recipe specifications
- to control the heating coils to positively impact the beer
- the variables that concern
- wait and monitor, upon completion enjoy beer

3 Value Proposition

There is a non-zero chance Chris Conly will get beer. The project will help automate the process of homebrewing, saving time, and enabling it to be a more frequent activity. It would allow for a better end product that is more consistent than what a human could manage. It would enable for larger scale brewing operations due to the increased organization. Resume bolstering capabilties.

4 Development Milestones

Below is a list of milestones and their estimated completion dates.

- Project Charter first draft - March 2021
- System Requirements Specification - March 2021
- Getting all the materials to build the project
- Architectural Design Specification - April 2021
- CoE Innovation Day poster presentation - April 2021
- Detailed Design Specification - Summer 2021
- Assembly of the hardware/sensors - Summer 2021
- Demonstration of brewing system - Summer 2021
- Completion of the web app with successful communication to the sensors - July 2021
- COMPLETION OF PROJECT - AUGUST 2021
- First full beer brew completed - August 2021
- Final Project Demonstration - August 2021

5 Background

A typical brewing day involves monitoring and keeping a hot liquor tank (HLT) at a desired temperature, then the brewer has to send the hot water from the HLT to the empty mash tun for pre-heating. After a set amount of time, the water from the mash tun will be sent back to the HLT to make sure the mash tun is at the desired temperature. While in the process of pre-heating, the HLT has to be monitored and will be continuously heated up to the desired temperature.

The next step is to start the mash by mixing in the grain with the hot water inside the mash tun. The water inside the mash tun must be kept at a specific temperature for a set amount of time. If the water drops below the desired temperature, a pump is turned on and the water is sent through a pump to a coil inside the HLT to heat the water.

Once the desired amount of time has passed, the HLT will be heated up to a higher temperature and then sent to the mash tun to rinse the sugars. At the same time, beer inside the mash tun will be pumped into the boil kettle. After all the beer has been sent to the boil kettle, the brewer must boil the beer and set a timer to add hops to the beer after each cycle. Once the boil is finished, the beer inside the boil kettle will be sent through a chiller to the fermenter.

The process of brewing without automation requires constant monitoring and heating of the liquids inside the brewing kettles. Without constant supervision during the brewing process, it would be easy for a beginner to make mistakes and ruin the batch. The main idea of the our project is to simplify the brewing process by monitoring and controlling the temperature of the liquids inside of the different kettles. While also controlling where the liquids will go during all steps of the brewing process.

6 Related Work

There are a few options available, but it depends on how much you'd like to pay. On the more budget end, the BrewPI is a DIY kit that you could put together. You have to buy all the parts seperately, but they are all available off of one website. The BrewPI Spark is capable of controlling the temperature of a "hacked" fridge, the temperature of the heater inside of the fridge, and it monitors the temperature of the beer itself. The BrewPI Spark then communicates with another Raspberry PI that runs a web server that can be viewed on a computer or phone. It does not have mash temperature control or a way to control pumps or valves. The system has commercially available parts, but there is a very large do-it-yourself component to this project. All the parts can be purchased for around nine hundred dollars. [4]

The Pico Pro is an "all in one" brewing machine. You don't need to purchase pieces of a kit and put it together yourself. The brewing capacity is 1.75 gallons. It handles the heating of liquids and transfers the contents of the machine into a small keg via a pump. It doesn't offer any special capabilities other than being able to scan proprietary PicoBrew recipes. Setup is very minimal, there is not a lot of components that need to be put together. The product is commercially available for five hundred and fifty dollars. [1]

The Grainfather G30 uses a single chamber for all of it's brewing except when it chills the wort in the wort chiller. The brewing capacity of the Grainfather is a little over 6 gallons. The grain father is all electric and is intended to be used mainly indoors. [2] It has a phone application that is used to control heat and power. It has a pump for transferring liquids between the main vessel and the wort chiller. There is minimal set up and the product can be purchased for one thousand dollars. [3]

The Brewie is one of the more expensive options. It has two very large chambers for brewing. It is capable of mashing, sparging, hopping, cooling, draining, and fermentation. It has built in weight sensors, pressure sensors, self cleaning capabilities, and a built in cooler for wort chilling. It has a brewing capacity of up to 5.28 gallons. Set up is minimal and the product can be purchased for one thousand five hundred dollars. [6]

The closest competitor to our product is the BrewPI. The big disadvantage that it has is that you need to buy each individual part from BrewPI, then put it together yourself. There could arise an issue with sourcing so many different parts from a single small scale business. We want to offer a similar product, but with significantly less reliance on doing it yourself. Our team is positive we can produce a product that costs well under the full price of the BrewPI.

7 System Overview

Our solution to automating several parts of the brewing system will require us to monitor and control the temperatures of the liquids inside of the HLT and the mash tun to the desired temperature that the brewer sets. Along with controlling the temperatures of the liquids, we will also control when liquid will be passed through the different kettles using pumps.

The main workhorse of the project will be the microcontrollers. We've chosen the ESP32 to be the main microcontroller in the project. The ESP32 will control heating the water in the hot liquor tank, which will pump the hot water from the HLT to the mashing tun for preheating. The microcontrollers will control the pumps and the heating elements as well.

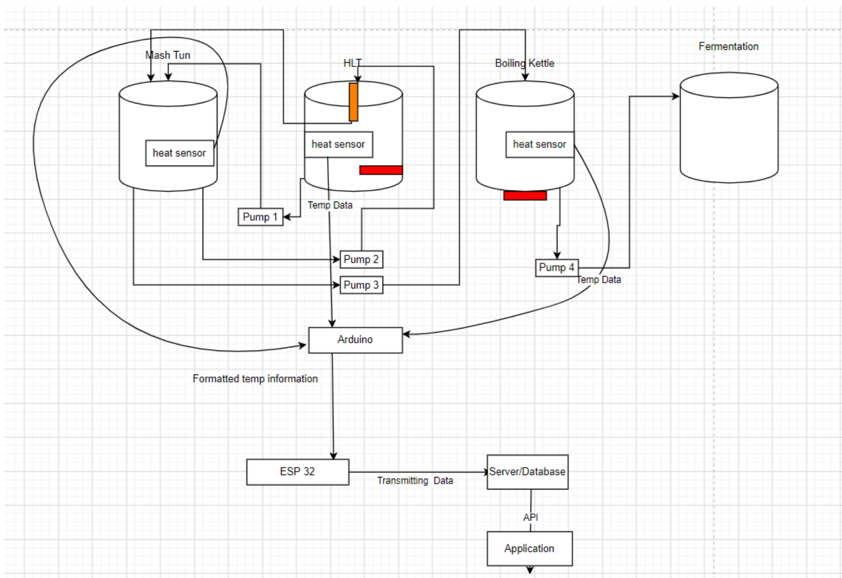

Figure 2: System Overview

Equipment:

- Four brewing kettles
- Three heat sensors
- Three pumps
- heating element
- heat exchanger coils
- microcontrollers/ESP32

8 Roles & Responsibilities

The stakeholders are the members of this team, Chris Conly, and the CSE Department. The main point of contact will be our mentor Chris Conly.

Our team may rotate product owners and scrum master for each phase of the project. The teammates below will work on these aspects of the project. However, it is not a permanent position. We are free to change our roles depending on what is required of us over the course of the project.

Software:

- Ju Young Jung
- Sunghwa Cho
- Marcos Juarez Casillas

Hardware:

- Sujan Dumaru
- Matthew Shultz
- Luke Brown

Roles of team members responsible for the hardware include:

- Implementing microcontrollers and sensors.
- Assembling the brewing system.
- Sending data to the web server through the different microcontrollers.

Roles of the team members responsible for the software include:

- Server acquisition and maintanence.
- Choosing which web stack to use.
- Receiving, parsing, manipulating, and presenting the data receieved from the brewing system.
- Creating a UI that allows the brewmaster to control the brewing system.

9 Cost Proposal

9.1 Preliminary Budget

The list below contains the cost of items as of starting this project

- Four brewing kettles 5 gallon $39.99 each $159.96 total
- Three DS18B20 Thermometer Temperature Sensor Probe Module $3.57 each $10.71 total
- Three EXTRAUP 115Volt 330 GPH Low Suction Electric Pump With Suction Hose Kit $59.99 each $179.97 total
- 4 Weldless Stainless Steel Kettle Heating Element $37.99 each $151.96 total
- NY Brew Supply copper wort chiller, 1/2" x 50' $122.99 total
- ESP32 $10.00 total
- 2 Arduino Uno R3 Microcontroller $24.99 each $49.98 total
- Total: $673.57

We will be using MariaDB for the database which is free open source software.

We also expect some price fluctuation as we do more research into the brewing requirements, as well as server hosting as needed.

9.2 Current & Pending Support

We are given a budget of $800 from the UTA cse department. We do not have any sponsers for this project.

10 Facilities & Equipment

Because we are currently facing an unusual situation in the COVID-19 pandemic, we will be conducting lab experiments and building equipment at a place where not many people present. Facilities can be either home or UTA CSE Senior Design lab.

Facilities has to have enough space to work on equipment, a power supply, and a table with a flat surface. Requirements for the facilities will be either leased or already present in the lab.

Required materials for this project are four containers; one for a hot liquor tank, the other for a mash tun, one for a storage kettle, and lastly a fermentation kettle. Three pumps will be used to push the liquid in tanks to other tanks when the environment in tanks meets a certain condition. A heater is used in the hot liquor tank to keep the water at a certain temperature. A coil gets water from the mash tun when the temperate of the water in the mash tun drops below the targeted temperature and heats up the water for a certain temperature. A thermometer reading water temperature in a hot liquor tank, a timer for brewing time, and relays controlling the heater, pumps, and reading temperature sensor will be purchased or borrowed from UTA.

An application and a website will be created to provide an interface between users and the brewing system. Online database, the domain name for the website will be purchased.

11 Assumptions

- All parts will be available for construction before first sprint cycle
- Some members will be able to meet in a suitable location for assembly and testing
- A facility will be available for testing and brewing before the second sprint
- The database server will be accessible outside of local network (port forwarding or web server with public address)
- A facility will be available for a prolonged brewing process
- We will have the time to run more than one test brew

12 Constraints

The following list contains key constraints related to the implementation and testing of the project.

- Final prototype demonstration must be completed by August 1st, 2021
- The entire brewing process can not be shown at the Summer 2021 Senior Design Presentations because brewing takes a certain time to produce beer.
- Total development costs must not exceed $800
- Social distancing requires virtual meetings which lead to a limitation on a tasting of the final product from brewing equipment.
- Extra searching and studying time is required since a lack of hardware-related experiences.

13 Risks

The following high-level risk census contains identified project risks with the highest exposure. Mitigation strategies will be discussed in future planning sessions.

Risk description	Probability	Loss (days)	Exposure (days)
COVID 19 Exposure before assembly or in person testing	0.20	14	2.8
Leaking parts damage electrical equipment	0.30	6	1.8
Shipping delays from COVID 19 for certain hardware components	0.20	10	2.0
Part incompatibility	0.30	3	0.9
Unforeseen requirements for hardware	0.10	3	0.3

Table 1: Overview of highest exposure project risks

14 Documentation & Reporting

14.1 Major Documentation Deliverables

14.1.1 Project Charter

The project charter will be maintained on a GitHub repository. Updates will be suggested by all members and approved by Luke for pushing to the main branch. The initial version will be delivered by March 19, 2021. At the end of every sprint the team will decide if updates to this document are needed, and who will be in charge of them. Since the document may be updated throughout the whole development cycle of the project, the final version could be delivered during the last sprint in the summer semester, but a "final" version will be delivered at the end of sprint 4 on May 3rd, 2021.

14.1.2 System Requirements Specification

The System Requirements Specification (SRS) document will be maintained in an Excel document, shared through Google Drive to allow all members to collaborate on it. This document will be updated at the beginning and end of every sprint unless members decide that there are no updates needed. The initial version will be delivered on March 23rd, 2021, at the beginning of sprint 3. Due to the nature of SCRUM, this document will be constantly evolving, and a final version will not be ready until the team is close to the completion of the project. A somewhat final version will be delivered at the end of sprint 4 on May 3rd, 2021.

14.1.3 Architectural Design Specification

The architecural design specification (ADS) will be maintained throughout the development cycle to match the SRS. The initial version will be delivered on April 14, 2021. Any revisions made between then and the end of sprint 4 will result with the delivery of the final version on May 3rd, 2021.This document will be maintained in a GitHub repository where the whole team can see and make updates as needed.

14.1.4 Detailed Design Specification

The detailed design specification (DDS) document will be developed and maintainedalong with the ADS due to their similarities, with the goal of delivering the initial and final at the same time as the ADS. This document will be maintained in a GitHub repository where the whole team can see and make updates as needed.

14.2 Recurring Sprint Items

14.2.1 Product Backlog

The product backlog will be created once the SRS initial version is complete. The team will work during sprint 3 to turn all the requirements from the SRS into products in the product backlog. The products will be listed in a priority order, decided by the team. This priority order may be changed at the end of every sprint if needed. This document will be maintained on a Google Drive file where the whole team can see and make updates as needed.

14.2.2 Sprint Planning

The team will meet at the beginning of each sprint to determine the sprint goals, and members will pick products from the product backlog to complete during the sprint. There will be a total of about 7 sprints, 4 in the spring

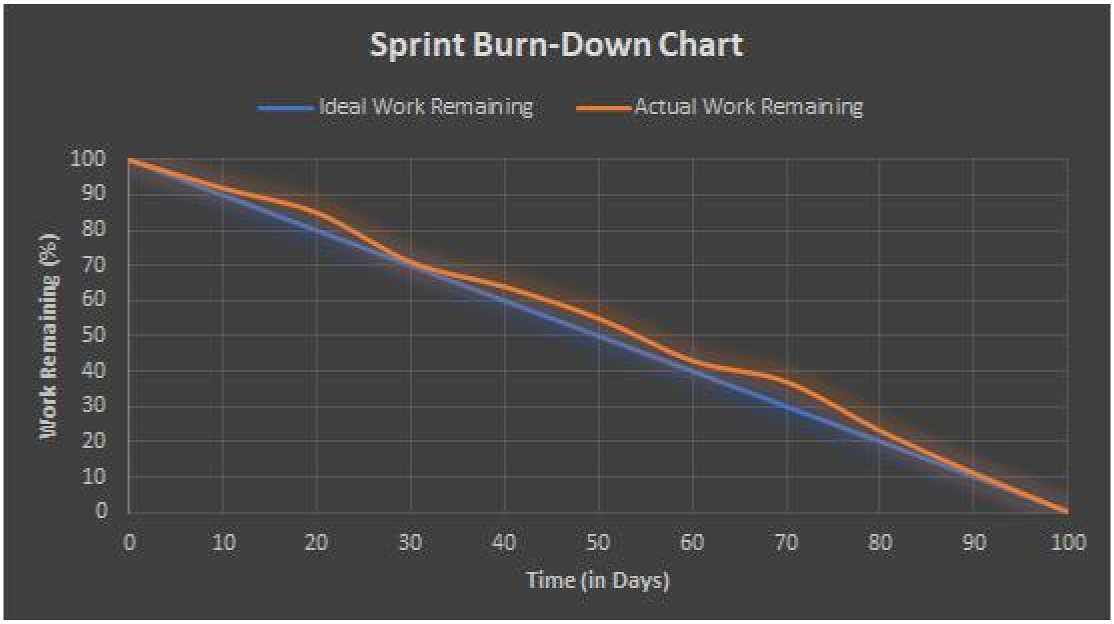

Figure 3: Sprint Burndown Chart

and 3 in the summer. Sprints will be around 2 weeks in lenght, unless the team decides it would be beneficial to change the length.

14.2.3 Sprint Goal

The sprint goal will be decided by the team in the sprint planning meeting. This goal will set the theme for what the team will accomplish individually and as a team. Professor Conly will aid in the sprint goal if needed to ensure we are on track with the project goals. Each item will have an expected amount of effort needed, which can be updated at any time.

14.2.4 Sprint Backlog

During the sprint planning, the team will decide which items should be completed during the sprint, and put them on a Google Drive document. The items chosen will be decided based on the sprint goal.

14.2.5 Task Breakdown

Each team member will pick items from the product backlog at the sprint planning meeting. The rest of the team will give input on the priority and amount of items picked by each member to ensure enough progress is made, as well as not overwhelming people with too many items. The sprint backlog will be maintained and updated on Google Drive.

14.2.6 Sprint Burn Down Charts

The sprint burn down charts will be updated at the end of each sprint using the information from the sprint backlog. The graph will be created on Excel to easily access the data from the backlog. No specific person is assigned to this task, rather whoever is done with their tasks and would like to volunteer. We will try to rotate this responsability.

14.2.7 Sprint Retrospective

At the end of every sprint, the team will meet and take some time to share what they think of the sprint system being implemented. Each team member will share what they think the team should start doing, what the team should stop doing, and what the team should continue to do. The conclusions will be applied on the following sprint.

14.2.8 Individual Status Reports

On the weekend landing in the middle of the sprint, each team member will give an update on their current progress for the sprint. The update will contain informatino such as what has been accomplished, what still needs to be accomplished, and any problems encountered that may delay progress. This update will be shared on Discord.

14.2.9 Engineering Notebooks

Each member will update their engineering notebook as many times as needed during each sprint, but at least one page per week. Due to the pandemic, each member can choose a family member, roommate, friend, or teammate to sign as a witness if they feel comfortable meeting in person. Pictures of each members progress can be shared on Discord to keep each other accountable.

14.3 Closeout Materials

14.3.1 System Prototype

The final system prototype will be a complete brewing system with microcontrollers, sensors, and a web server. The webserver will allow the brewing master to control the brewing system and present data to the brew master on the website. Presentations will be held at the end of August, 2021. A Prototype Acceptance Test can be administered along with the Field Acceptance Test.

14.3.2 Project Poster

The project poster will include pictures of the webserver that will be used to control the brewing system. Along with pictures of the prototype throughout all stages of the building process. The poster will be presented along with the final project demonstration. The size of the poster will be 2 feet x 3 feet.

14.3.3 Web Page

The project web page will contain instructions to brew a patch, as well as information on the current patch.

14.3.4 Demo Video

The demo video will be us giving a short explanation of what the brewing process looks like using our project, including the setup, the brewing itself, the monitoring done, and the final product. The video will be short, around 5 minutes or less.

14.3.5 Source Code

The code will be maintained on GitHub, available to the public. The licence terms will be listed in a readme file on the repository.

14.3.6 Source Code Documentation

Doxygen will be used to generate documentation and the final documentation will be provided in PDF format.

14.3.7 Hardware Schematics

The hardware shematic will be provided once the team has receieved their equipment and have received proper training on how a brewing system should be set up.

14.3.8 Installation Scripts

There will be scripts for initialising the database server.

The hard ware installation and setup will be provided at a later date as we have a better idea of what they will be using.

14.3.9 User Manual

A digital user manual will be provided.

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