GNG1103

Final Design Report

AUTOMATION
OF
MODULAR HOME

Submitted by

Automation-D1

Robert Boucher, 300079532

Veronique Gagne, 300059236

Tristan Grondin, 300051208

Nathan Lee, 300058330

Nathan Liu, 300076999

Adeeb Urfani, 300081090

April 15 2019

University of Ottawa

Abstract

This report is about the entire design process taken to achieve the final result of a fully autonomous house. This project was part of the Engineering Design course offered at the University of Ottawa also known as GNG 1103. A client approached this class and brought a problem that needed to be solved; to have a low cost modular house that does not produce any carbon emissions whatsoever including an autonomous interior. The entire class was split up into specialized groups so that the project could get done on the timeline given. This report is about the autonomous 1 team, and in this report, it demonstrates the entire design process that was taken since day one of the project all the way to the final day it was due being design day at the University of Ottawa.

Table of Contents

Abstract **2**

Table of Contents **3**

List of Figures **6**

List of Tables **7**

List of Acronyms **8**

1 Introduction **9**

1.1 Relevance 9

1.2 Requirements 9

1.3 Key Aspects 9

2 Need Identification and Product Specification Process **11**

2.1 Problem Statement 11

2.2 Design Criteria 11

2.3 Benchmarking 11

2.3.1 Lighting 12

2.3.2 Heating 12

2.3.3 Water 13

2.4 Metrics 13

2.5 Target Specifications 14

3 Conceptual Design **16**

3.1 Lighting 16

3.2 Heating 16

3.3 Water 17

4 Project Plan, Execution, Tracking & Bill of Materials **18**

4.1 Project Plan 18

4.2 Project Execution and Tracking 19

4.3 Bill of Materials 19

5 Analysis 21

6 Prototyping, Testing and Customer Validation 22

6.1 Lighting 22

6.2 Heating 22

6.3 Water 23

7 Final Solution 25

7.1 Lighting 25

7.2 Heating 25

7.3 Water

7.4 Solution Put Together 25

8 Conclusions and Recommendations for Future Work 26

9 Bibliography 27

APPENDICES 28

APPENDIX I: User Manual 29

APPENDIX II: Design Files 30

APPENDIX III: Other Appendices 31

List of Figures

List of Tables

List of Acronyms

Acronym	Definition
PIR	Passive Infrared Sensor
WAVO	Women Against Violence in Ottawa
EDS	Engineering design specifications
CBY	Colonel By
SITE	Science Information Technology Engineering

1 Introduction

1.1 Relevance

A client from the non-profit organization Women Against Violence in Ottawa was explaining the difficulty of the situation they are in as of the day the class was approached. This non-profit organization are in establishment to help women in the Ottawa district that are currently being abused by their family, husband, or boyfriend whether that being physically, mentally or any other sort of abuse. With this problem, the quick solution for these women are to simply get away from the situation. With them running away from their lives and homes, that means they no longer have anywhere safe to live anymore. Therefore, temporary housing must be provided for them as they recuperate and better their situation. This is where the non-profit organization Women Against Violence in Ottawa help by providing temporary houses for these women. As of currently they have run out of houses to provide these women and in return have to turn down women that are seeking refuge. Therefore, when the Engineering Design class was approached to provide a solution to this problem, the entire class full of young aspiring engineers were ecstatic about solving such a real world and relevant problem.

1.2 Requirements

The client expressed the concerns they had that they would like to see be solved. Their requirements were to have a fully modular home which translates to the house being easily portable as well combinable with other houses to make a bigger house. Another concern was to have the house be fully functional while also using only renewable energy sources as no carbon emissions will be made. Using renewable energy will save money through the exclusion of purchasing electricity and water from the city as well as avoiding the Ontario carbon tax which is seen to rise for the next upcoming years. The client also stressed that the house be fully automated so that the user in the home would not have to do much work in regards to basic functions throughout the house.

1.3 Key Aspects

The automation 1 team was provided with the task of automating all the basic necessities that one would find in a home. The team discovered the three basic necessities found in all homes once doing some research. Those three necessities are lighting, heating, and water. Therefore this team focused on these key focal points when going through the design process. Focusing on these important aspects are what makes this

design better than all the other modular houses being design at the current time period due to the fact that no other houses focused on the basic necessities and left out running water in the designs which is what automation 1 team made sure to implement.

2 Need Identification and Product Specification Process

2.1 Problem Statement

Automation 1 team is tasked to provide a fully automated interior system regarding lighting, heating, and water throughout the house to make the usability of these services easier to perform by the user while also being as efficient as possible.

2.2 Design Criteria

Based on the needs and concerns of the client, the requirements and concerns below were defined.

Functional requirements	Non-functional requirements	Constraints
Ability to provide running water	Aesthetics	Cost
Ability to light the house		Power usage
Ability to heat the house		
Control for heating		
Automatic water sensor		
Automatic lights		

Table #: Functional, non functional requirements and constraints

2.3 Benchmarking

With the client saying that there was a need to implement a fully automated system throughout the house, the automation 1 team immediately started to brainstorm multiple possible solutions to this problem once the initial interview with the client was completed in order to empathize with the client. Each one of the three subsections, lighting, heating, and water had come up with their own possible solutions to solve each one of these problems. However not all the solutions could be viable, therefore, benchmarking was done to see what solution out of the many that were ideated was in fact the best solution.

2.3.1 Lighting

For lighting, three design concepts were ideated. The first one was to have a fully automatic system where the lights would only turn on when motion would be detected in the house; therefore, the lights would theoretically only be on when a human is present. The second conceptual design was to have a semi manual and semi automated lighting system where the lights would turn on via a motion sensor to detect if somebody is present as well as with a light switch which is only used to turn off the lights completely whether a human is present or not. The third and final conceptual design was to have a fully manual system where no motion sensors would be used and the lights would only turn on through a commonly used light switch. With all of these design concepts available to choose from, only one could come to fruition. Therefore a benchmarking table was performed to see what the best design was.

	Importance	Automatic	Automatic/manual	Manual
Cost	1	2	2	3
Power efficiency	3	3	2	1
User controllability	2	1	3	1
Total		13	14	8

Table #: Benchmarking for lighting [from delv D]

2.3.2 Heating

Three main concepts were ideated for heating. The first concept revolved around an LCD screen to display the temperature, with buttons in place for the user to adjust their desired temperature. The second concept relied on a touchscreen, which would be powered by a raspberry pi. The touchscreen would have an interface that would allow the user to change the desired temperature as well as view the current ones. The final concept was very similar to the first concept, with the only difference being a dial in place of the LCD screen and buttons. In all of these prototypes, automation would be implemented in a system that would automatically turn the heat down if no one was detected inside the house, and would automatically turn it back up otherwise. In order to decide which interface would be used, the following benchmarking table was used.

	Importance	Concept 1	Concept 2	Concept 3
Cost	2	2	1	3

UI Simplicity	3	2	3	1
Electrical Need	2	2	1	3
Heat optimizations	3	3	2	1
Total:		23	19	18

Table #: Benchmarking for Heating [Delv D]

2.3.3 Water

Three designs were ideated for the water system. The first design is a fully automatic sink, where the individual needs to be within a certain range of the ultrasonic sensor for it to instruct the solenoid valve to open or close. Additionally, the design includes wood, a hose and a sink. The second design is fully manual and requires the user to turn on the faucet for a flow of water. The third and final design is very similar to the first design since it is automatic. However, it uses higher quality and more expensive components. In order to decide which concept to use, a benchmarking table was used.

	Importance	Automatic (1)	Manual	Automatic (2)
Cost	2	2	3	1
Efficiency	3	3	1	3
User controllability	2	2	1	2
Total		17	11	15

Table #: Benchmarking for Water [Delv D]

2.4 Metrics

Based on the functional requirements and benchmarking tables, a list of measurable attributes was made.

- Amount of energy used (we need to find a number for this like watts or someshit idk)
- Anything else u think of

-Measurable attributes (ex: weight size speed)

2.5 Target Specifications

Design specifications	Relation (=, < or >)	Value	Units	Verification method
Running water	=	yes		
Lights	=	yes		
Heating				
Control for heating				
Automatic water sensor				
Automatic lights				

Table #: EDS: Functional requirements

Design specifications	Relation (=, < or >)	Value	Units	Verification method
Aesthetics	=	yes	N/A	Test

Table #: EDS: Non-functional requirements

Design specifications	Relation (=, < or >)	Value	Units	Verification method
Cost	<	100	$	
Power usage	<		kWh	Test

Table #: EDS: Constraints

3 Conceptual Design

3.1 Lighting

There were three conceptual designs that were brainstormed when trying to figure out a way to solve a way of providing lighting throughout the house. The first design was to have a fully automated system to operate the lights. This would work using a PIR motion sensor where it would detect whether somebody is present in the house or not. If the motion sensor would detect a person it would flick a relay sending voltage to the desired light bulb completing the circuit and thus getting a wattage output from the light bulb. If the user were to leave the house, then the sensors would stop detecting motion and then turn off the lights respectively. If the user would like to go to bed without the lights being on but yet still remain in the house, a timer would be set to always turn off at a given time in the day. That time was determined by conducting research. After gathering research, a website called Withings, a health news organization have already conducted data gathering and have concluded that on average, people go to bed at 11:40 pm while waking up at 70:05 am. With this information the lights would turn off at 11:40 pm and then turn back on at 70:05 am if the user is still present in the home.

The second design was to have a semi automated and semi manual system where the lights would work just like in the first conceptual design however the lights would not turn off at night automatically but there would be an actual light switch the user could flick which will turn off the lights immediately upon the users request.

The third conceptual design for the lighting system would be to have a fully manual system. This system would have no sensors whatsoever and would operate with only using a light switch that the user would always be in control of to operate the lights in the house.

Based on the benchmarking table, the second conceptual design was deemed the best one. Therefore, that is the design we chose to implement for the lighting system.

3.2 Heating

There was three different conceptual designs created to control the heating system. The main difference between the three is the input method. The first concept would have

worked by using a two seven segment displays, two buttons, a temperature monitor, an arduino and the heater itself. The user interface of the system uses the displays and the two buttons. The two buttons will be responsible for increasing and lowering the temperature set by the user. The display would show the room's current temperature as well as the temperature set by the user. As the display cannot output both the current room temperature and the temperature set by the user it would switch to showing the set temperature for a short period after the user changes it then switch back to the room temperature. To combine all the components together a cover will be 3d printed to provide a cleaner look to the system.
The controller for this system is the arduino uno. The arduino would compare the temperature set by the user and the current room temperature from the temperature sensor an if the set temperature is higher it would trigger a relay to turn on the heater. To improve the system the arduino would automatically set the room temperature 15 degrees if the home is vacant

The second concept consisted of a touch screen display a raspberry pi computer and a temperature monitor. For this system the touch screen would be utilized for user input and to display system information to the user. The screen would display many features such as time, a light controller and the heating controller. The heating controller would consist of two arrows change the set temperature as well as the current room temperature. The controller for the system is the raspberry pi computer.

The third concept is a simple dial interface. This would consist of a potentiometer, a temperature sensor, the arduino and the heater. The potentiometer in this system will be used as a dial for the user to set there desired temperature. The temperature sensor would monitor the current room. The arduino would collect the information the the two component compare them and if the set temperature is higher then the room temperature it would trigger the relay turning on the heater.

After reviewing all the designs a fourth concept came to be. Aspects from all the designs came together to create another concept. This concept used the dial from concept three and a lcd screen which was a step up from seven segment diaplay, but not as good as a touch screen.

After each concept was reviewed on the benchmarking table, the fourth concept was determined to be the best design. Therefore it is the one that was implemented into the heating system

3.3 Water

The water team came up with three possible conceptual designs. Deciding which idea went with was based on two categories. Cost and Efficiency. During the client meeting, the client stated that she wanted a tap which would have a sensor installed on it which would determine the flow of water.

The primary design incorporates a sensor, a sink, a faucet, a hose and wood. The wood will be utilized to go about as a base for the sink. A cost was not recorded for wood since everything relies upon if the brunsfield center has it accessible or not. If not accessible, we should get a few or obtain some from the construction group. This idea will cost around $40 and is extremely effective due to the motion sensor on account. It likewise addresses the issues of the client.

The second design does exclude the movement sensor. It includes, a sink, a faucet, a hose and some wood. The wood will fill a similar need as concept 1 and a similar issue with respect to its cost is additionally present in this idea. This idea will cost around $36 and isn't extremely efficient because there is no motion sensor. With the movement sensor not being available the tap should run physically, which means a lot of water will be wasted at times if left on by accident. It did not meet the needs of the client.

Concept 3 incorporates a sensor, a sink, a faucet, a hose and some wood. A similar reason and issues for wood an in the past ideas are additionally present in this idea as well. This idea will cost around $77.50 and is by a wide margin the most efficient as a result of the over the expensive motion sensor and faucet. It additionally addresses the issues of the client however is definitely not a practical alternative since it is costly.

Based of the benchmarking table, the first conceptual design was the best one. Hence why it was the design we chose for the water system.

4 Project Plan, Execution, Tracking & Bill of Materials

4.1 Project Plan

Creating a project plan and timeline allowed the automation team to divide the project into tasks. A respectable amount of time was then assigned to each task, ensuring that the project would be completed by the project deadline — design day. Task dependencies were identified to ensure a smooth workflow, and group effort was used to achieve maximum efficiency by assigning each task to a certain person. Task ownership was determined by considering the person's expertise, availability and interest in the work. Furthermore, extra time was allotted to each task to account for any problems that the group may encounter.

The best way to organize the tasks, duration, dependencies and task ownership is to use a Gantt chart. Figure # is the Gantt chart the automation team developed in deliverable E [reference delv E].

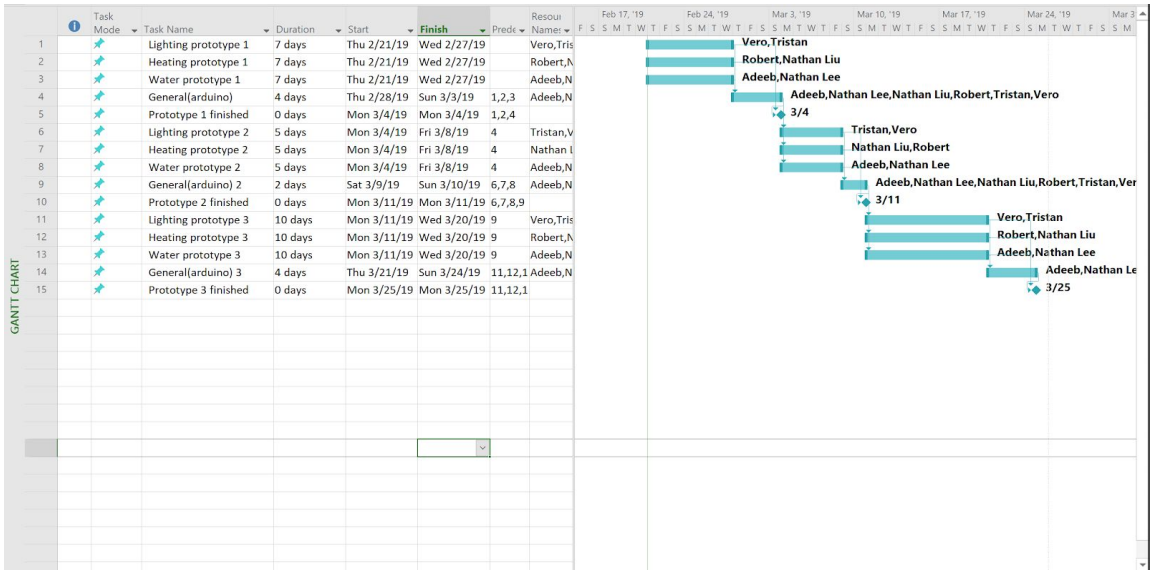


Figure #: Gantt chart

The tasks and duration are clearly stated in the table, while the timeline displays the task dependencies along with the task ownerships.

4.2 Project Execution and Tracking

The automation team had to find a method of tracking progress in order to ensure that each task was getting completed on time. A list of all tasks required to complete the project along with the task owner was put together. Task resources was also included in the list. To track the progress of the project, the team used Trello. Trello is a web-based list-making application that can be used to track the team's progress. Each team member has access to view and edit the Trello list. [reference trello] The team created three lists: to do, doing, and done. At first, all the tasks were added in the to do list. As the tasks were started and completed, they were changed from one list to the other. This allowed to clearly keep track of the team's progress. Team members were also able to keep an eye on each other's progress and ensure no one was falling behind in their tasks. Furthermore, having a list to follow helped motivate the team to complete tasks. It was exciting to move tasks from the 'to do' list to the 'done' list, and see the 'to do' list get smaller as the project got closer to completion.

4.3 Bill of Materials

The allotted budget to complete the automation of the house was $100. This did not give the team any room for error and they had to find the cheapest materials of sufficient quality. Improvisation was also needed when it came to assembling certain parts of the project by using extra materials, such as wood, from other teams. It was necessary as to not go over the budget. However, after deciding on which materials to buy, it was clear that the team would not be able to stay under budget. After discussing this problems with the PM, the team and PM came to the conclusion that it was okay to go slightly over budget. With that said, the total final amount spend on materials was $113.79. Table # shows each material purchased along with their price. The table is based from the estimation of cost table [delv E], but is updated to account for changes that were made throughout the prototyping and testing stages.

Item	Cost/each	Quantity	Total	Taxes	Total
Light bulbs (pack of 2)	$2.30	1	$2.30	$0.30	$2.60
Sink	$2.50	1	$2.50	$0.32	$2.82
Light switches	$1.98	2	$3.96	$0.51	$4.47
Light fixtures	$1.98	2	$3.96	$0.51	$4.47
Light switch cover plate	$1.71	1	$1.71	$0.22	$1.93

Light switch junction box	$1.98	1	$1.98	$0.27	$2.25
Light fixture junction box	$1.98	2	$3.96	$0.51	$4.47
Merets (pack of 25)	$2.99	1	$2.99	$0.40	$3.39
Wires	$1.60	10	$16.00	N/A	$16.00
Arduino	$25.00	1	$25.00	N/A	$25.00
Ultrasonic sensor	$4.95	1	$4.95	$0.68	$5.63
Potentiometer	$1.35	1	$1.35	$0.22	$1.57
LCD display	$8.95	1	$8.95	$1.22	$10.17
4-channel relay	$7.95	1	$7.95	$1.08	$9.03
Solenoid valve	$7.95	1	$7.95	$1.07	$9.02
PIR motion sensor	$3.95	2	$7.90	$1.07	$8.97
Shipping	$2.00	N/A	$2.00	N/A	$2.00
Total			$105.41	$8.38	$113.79

Table #: List of materials with costs

5 Analysis

For each subsection group of the project, there was a need to see what aspects were better to use than others. Therefore, calculations and research were necessary in order to get to the final conclusion. For the lighting group, they needed to see what size of wire to use for connecting the lights to the AC current from the battery. It was concluded that the size of wire that would be used would be a 24 gauge wire. After doing some research and asking the solar team of how many amperes would be coming out of the battery, it was concluded that the wires needed would have to be massive which would not fit within the provided budget. However, because the only load that would be connecting to the battery would be a 60 Watt light bulb, it would be completely safe staying with the 24 gauge wire as the light bulb would only be drawing in less than 1 ampere. For water, they needed to do some research on how safety regulation apply to water and electricity being within close proximity. After going online and asking several questions to the TA's, it was determined that they needed to priorities to keep the electrical wires away from where the output of the sink would be as much as possible. For the heating part of the project, they needed to see what the minimum required heat to be in a home at all times in order to meet standards set by the client as well as home inspection agencies. In the end, the minimum temperature for the house to always be at is 20 degrees Celsius. In conclusion, research was done to ensure that everything would perform correctly as well as to make sure that target specifications would be met at all times.

"Provide all formulas, calculations, data collection that you have done for your design. Include charts, graphs and tables to help the reader better understand the analysis"

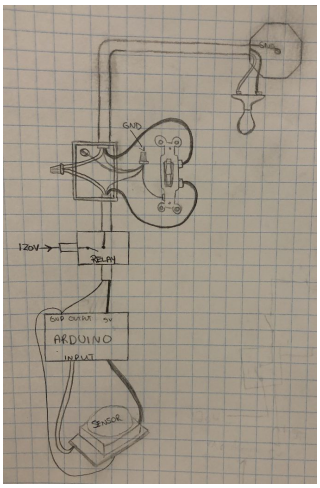
- Calculation for wire gauge
- Calculate if things meet target specifications

6 Prototyping, Testing and Customer Validation

6.1 Lighting

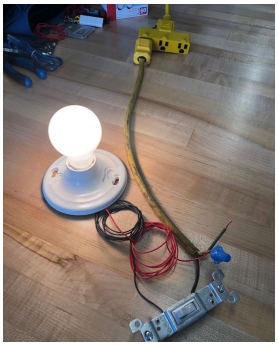
Prototype 1:

The first prototype was to draw the circuit diagram of how the lighting system would operate. When creating the diagram, research had to be done on what sensor and pins to use in the arduino to make the system automated. It was finalized that a PIR sensor would be used to sense motion and then shortly after, the pins were theoretically discovered and drawn to got to a relay which would turn on the lights. The code was also developed through this prototype and was not yet tested but theoretically seen to work. Feedback was given after demonstrating this prototype to the client and questions were asked. During this period the automation team provided answers to the questions that were asked, but the client expressed how the user would go to sleep with the lights on all the time. Therefore, with the client feedback, changes were made to the design which now implements a light switch which will always turn off the lights no matter what.



Prototype 2:

The second prototype was to actually make the circuit physically and see if the theoretical calculations and research were correct. After building the circuit and connecting all the pins of the sensors, arduino, and relay to the breadboard, the code was then uploaded. When the developed code was uploaded to the arduino, there were troubleshooting that had to be done both with the code and with the physical circuit itself. Once the desired output was observed, this concluded that the system was working as intended. This prototype was showed to the client to get feedback. The feedback was very well perceived as the client was asking multiple questions that the automation team was prepared for and provided answers that satisfied the client.



Prototype 3:

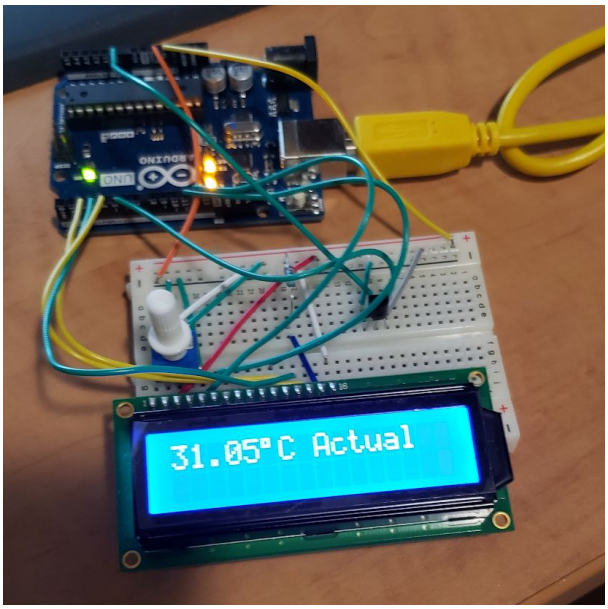
The third prototype was to upscale what was achieved in the second prototype. Once the physical structure of the house was completed, the automation 1 team could implement all the circuits and sensors inside the house. One sensor was placed outside the house to detect motion outside followed by a light fixture to illuminate the exterior of the house when the user is

present. Inside the house located another sensor followed by another light bulb. All the wiring and relay as well as the arduino were located inside the house and away from sight in the ceiling in order to be protected by the elements. The feedback that the client gave on the final prototype was that they were very pleased with the final design and astounded that everything working accordingly. All the criteria that the client gave at the beginning of th project was all met and is what concluded the project.

6.2 Heating

Prototype 1:

The first prototype involved wiring to create a rudimentary recreation of our chosen concept, as seen in the following figure [delv F].



The prototype as seen here contains all of the parts described in the concept, with a dew alterations. The buttons have been replaced with a single dial, however, at this point the dial's function has not been implemented yet. The temperature sensor and LCD screen on the other hand have been integrated into the code, meaning this prototype can read the current temperature and output such onto the screen. Wiring has been completed at this point, but has not been properly tested for bugs.

Figure #: Heat Prototype 1

Prototype 2:

Prototype two focused more on code, bug testing, and aesthetic. The code at this point covers the LCD and dial, but not the dial, ending in a result similar to that of prototype 1. In terms of bug testing, it was realized that the temperature sensor needed to be isolated in order to properly read the temperature, and as a result had to be fixed

before the final product. Beyond that, tests were relatively smooth, with the dial smoothly changing in terms of value in the code, and the screen properly displaying any updates.

For aesthetic, a casing for the screen and dial was created in solidworks in order to be 3d printed. When brought to the client, they expressed their satisfaction with the design, also asking if it was possible to remotely let the user know if the temperature is up to the user's desired temperature. It was considered for future prototypes, but was ultimately scrapped due to time and money constraints.

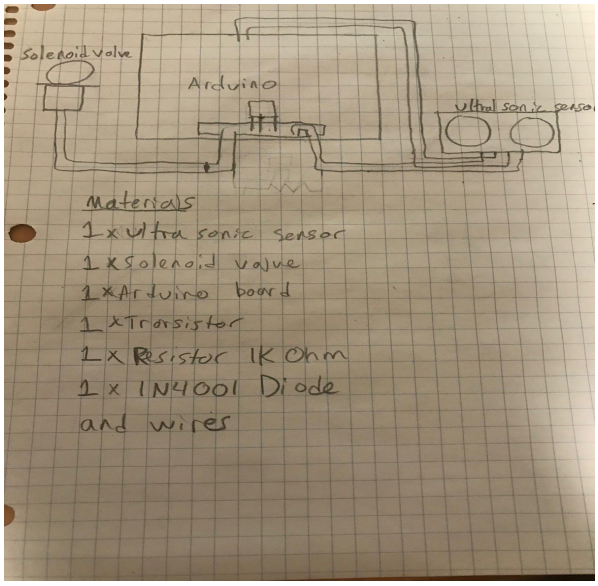
Prototype 3:

For the third prototype, the casing was printed, and all the wires were sautered such that we could install all of the parts onto the casing. In addition, the code was completed to include the dial and a second line to display on the LCD screen that showed what temperature the user desired. In addition, the code also included the automated heating system, which used sensors from the lighting system to check if the user was in the home or not. If they were, the heater would turn on, and likewise if no one was detected inside the home the heating would be turned off. At this point the temperature sensor was also isolated in the circuit, and the code was corrected for any bugs [delv H].

` Figure #: Heat Prototype 3

6.3 Water

Prototype 1:



For the first prototype of the water automation, we structured a straightforward outline which pursued the plan idea we proposed in the conceptual design. The water framework was the most straightforward out of the three sub-groups and will comprise of the materials recorded in the above picture.We chose to run with a solenoid valve as our source which will result in the surge of water. We wanted to use a diode since it would eliminate the power a magnetic coil loses due to the inductive load. The next stage would be the set up the code and ensure it is perfect with the ultrasonic sensor. When this is done, the solenoid would begin opening and shutting.

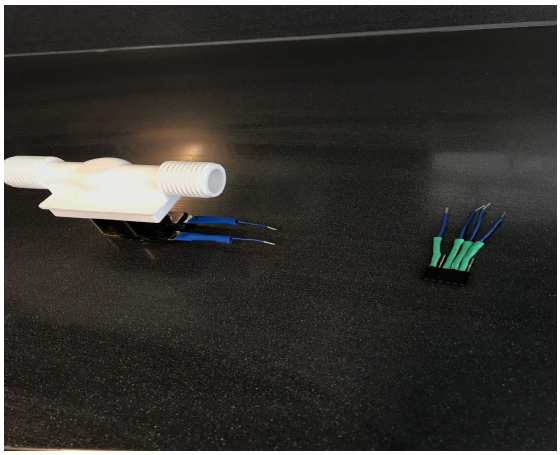
Prototype 2:

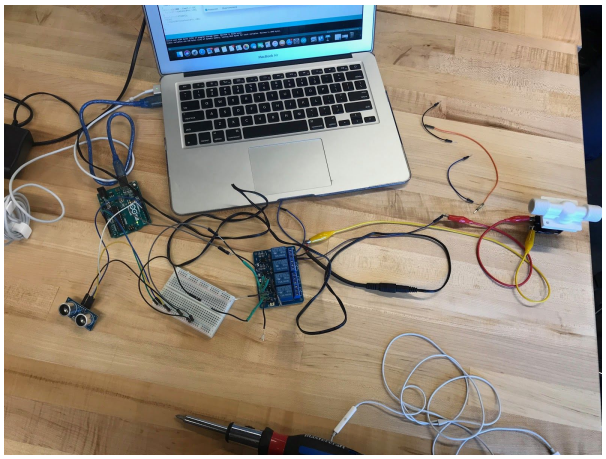
```
int solenoidPin = 4; // this is the output pin on the arduino we are using
int ultraPin = 10;  // input for ultrasonic

void setup() {
  // put your setup code here, to run once:
  pinMode(solenoidPin, OUTPUT);           //Sets the solenoidPin as an output
  pinMode(ultraPin, INPUT);               //Sets the ultraPin as the input

}

void loop() {
  // put your main code here, to run repeatedly:
  if digitalRead(ultraPin, HIGH){
  digitalWrite(solenoidPin, HIGH);  //switch solenoid ON
  }
  else{
  digitalWrite(solenoidPin, LOW);     //switch solenoid OFF
  }

}
```

For the second prototype for water, the principle contrast from the first prototype was the way that we built a code to enable the client to turn the solenoid on and off. Genuine development of the sink had not yet begun because our materials were not yet present. The following 2 weeks would see us begun the process of making our sink which would have to be ready for design day.

As to the customer, there was not a lot to demonstrate to her presently but rather she was satisfied with our general format/thought for how the water will be provided. We later suggested emailing her photos of our first structure of the sink in the coming days but she said she was okay by not getting an email.

Prototype 3:





For the last model concerning water, we finished the code and tried it with an Arduino Uno utilizing a breadboard and relay. The test was a triumph and we had the capacity to turn on the ultrasonic sensor to open the solenoid pipe when there was development within 20 cm of

the ultrasonic. We were additionally ready to keep the solenoid enacted for 3 seconds after the development was recognized utilizing the millis() function. This capacity enabled us to get the accurate number of milliseconds the program was running for. Utilizing this we made an if statement which expresses that if the milliseconds on the solenoid went on for more than 3 seconds, the ultrasonic sensor would turn the solenoid off.

Proceeding to the base/sink. It was still yet to be finished but was eventually ready for design day. We finally got our PVC lock and in the meantime we were additionally ready to drill a hole into the center of the bowl we purchased. All that needed to be done was ensure the fact that the only thing flowing through the PVC lock was water and that the hole was properly sealed. In conclusion we have to ensure we introduce the sink/bowl on some base to ensure it had something holding it up in set up of the house. We chose the remaining wood in the Brunsfield Center to go about as the help because of our budget. The internal diameter across

of the bowl has been outlined in the above picture and all that remains is the fact that we have to use a jigsaw to drill the hole before we mount the sink.

7 Final Solution

7.1 Lighting

The final solution for the lighting part of the project was two light bulbs, one outside to aluminate the front door, and one light inside the house to illuminate the interior. These lights are operated by a relay which closes the proper circuit to turn on the appropriate lightbulb. The relay is triggered by sensors that are placed throughout the house. There is one sensor inside the house that keeps track of whether somebody is inside the house or not and is physically tucked away in the upper corner of the house so that it cannot be tampered with. There is another sensor outside the house which indicates whether there is a person present outside the house or not. The outside sensor is located just under the light bulb so that if it were to rain, the sensor would be protected via the bulb. All of these electronic devices are connected to the arduino which performs all the algorithms necessary to get the proper output. This arduino was uploaded with code that was developed by the automation team and is powered by a battery that was located in the bottom corner of the house.

7.2 Heating

The final solution for the heating system included a temperature controller on the wall and a heater that was placed in the corner of the room. The temperature controller was created using a potentiometer, a temperature sensor and a liquid crystal display. The potentiometer was used so the user would be able to set their desired room temperature. The role of the lcd was to communicate the current room temperature to the user as well as showing the desired temperature set by the user. These components were then placed inside a 3d printed cover which included a cutout for the lcd and a larger dial which was connected to the potentiometer. These components communicate with the arduino microcontroller. The heater was operated by a relay which was also controller by the arduino. To determine when the heater should turn on the arduino would compare the set temperature and the current temperature. Whenever the set temperature was higher then the current room temperature it would trigger the relay and turn on the heater. In order to save some power whenever the house was vacant the arduino would automatically set the desired room temperature to fifteen degrees. Each of these components received power via the battery which was located in the corner of the room

7.3 Water

The final solution of water was a little tricky since we had to fit everything we had built up to this point inside a small space in the house. To do this we built a frame to place the sink (bowl) into. Then drilled this frame into the wall of the house and right above this we made a space to put the solenoid and ultrasonic sensor. We had to create a faucet to place our solenoid and sensor into. To do this we designed an object that we could place the solenoid on top of while also attaching the ultrasonic sensor right below it. This allowed us to use the ultrasonic sensor confidentiality since we knew it was not going to get wet (if we had water) in that position. After everything was installed the last thing we had to do was connect the our solenoid and ultrasonic sensor to the Arduino. Unfortunately, the solenoid was not able to work for design day since we could not keep it plugged in for long or else it would get too hot. Overall, our design fit in our house and was technically functional but not really convenient since it easily overheated.

7.4 Solution Put Together

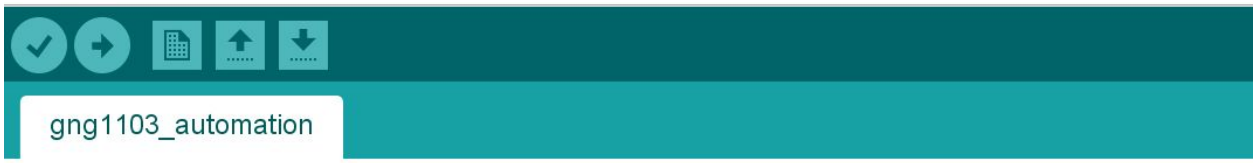
With all these aspects of the project developed separately, there was a point were all the heating, lighting, and water portions needed to be combined to give the final solution. In the third prototype, it was concluded that each system worked properly they were installed within the house. As there was only one arduino microcontroller to operate the entire house it was necessary that each part had to combine there code to make one final code file. For this to occur it was vital that each different part had used separate pins on the arduino which makes the communication factor part of this project vital to the success. After one final code file was developed and worked properly, each part of the automation team needed a power source to function. Therefore, the solar team provided a battery that had enough voltage to operate all the systems. The lighting portion needed to draw current from the battery in order to turn on the light bulbs. The heating part needed the electricity to turn on there heating system, and the water part also needed a potential difference to turn on and off their solenoid valve. Plenty communication was done with the construction team as to not impede on their vital structure as well as not placing any module on a panel that was deemed to be removable.

Blurb about how it all comes together and combined code

https://pastebin.com/PqFz4b4C

gng1103_automation

```
*/

#include<Wire.h>
#include<LiquidCrystal_I2C.h>
#include <NewPing.h>
LiquidCrystal_I2C lcd(0x27, 2, 1, 0, 4, 5, 6, 7, 3, POSITIVE);
#define heatDelay 60000
#define heatDelayAvg 5000
#define RelayDelay 5000
#define TRIGGER_PIN  11  // Arduino pin tied to trigger pin on the ultrasonic sensor.
#define ECHO_PIN     12  // Arduino pin tied to echo pin on the ultrasonic sensor.
#define MAX_DISTANCE 20 // Maximum distance we want to ping for (in centimeters). Maximum sensor distance is rated at 400-500cm
#define solenoidPin 10 //setting relay to pin 9 to which will turn on solenoid

int relayfix = 0;
int relay[4] = {0,0,0,0};
int heatD1 = 3;
int heatLoop = 0;
int heatCheck = 0;
int heatRelayT;
int heatPTAvg;
int heatCT;               //current time
int heatPT;               //placeholder time
float Timer1;
NewPing sonar(TRIGGER_PIN, ECHO_PIN, MAX_DISTANCE); // NewPing setup of pins and maximum distance.

int relay_outside = 8;
int relay_inside = 9;
volatile byte relay_outsideState = LOW;
volatile byte relay_insideState = LOW;
int sensor_outside = 2;
int sensor_inside = 3;
long lastDebounceTime1 = 0;
long debounceDelay1 = 10000;
long lastDebounceTime2 = 0;
long debounceDelay2 = 10000;

void setup() {
  lcd.begin(16,2);
  pinMode(6, OUTPUT);
  pinMode(solenoidPin, OUTPUT);  //sets solenoid pin to output
  lcd.backlight();
  Serial.begin(9600);
  heatPT = heatPTAvg = heatRelayT = 0;
  pinMode(relay_outside, OUTPUT);
  digitalWrite(relay_outside, HIGH);
  pinMode(relay_inside, OUTPUT);
  digitalWrite(relay_inside, HIGH);
  attachInterrupt(digitalPinToInterrupt(sensor_outside), detectMotion1, RISING);
  attachInterrupt(digitalPinToInterrupt(sensor_inside), detectMotion2, RISING);
}
```




```
void loop() {
  heatingloop();
  waterloop();
  lightloop();
}
void lightloop(){
  if((millis() - lastDebounceTime1) > debounceDelay1 && relay_outsideState == HIGH)
  {
    digitalWrite(relay_outside, HIGH);
    relay[2] = 0;
    relay_outsideState = LOW;
    Serial.println("OFF Outside\n");
  }

  if((millis() - lastDebounceTime2) > debounceDelay2 && relay_insideState == HIGH)
  {
    digitalWrite(relay_inside, HIGH);
    relay[3] = 0;
    relay_insideState = LOW;
    Serial.println("OFF Inside\n");
  }
  //delay(50);
}
void detectMotion1() {
  Serial.println("Motion Outside\n");
  if(relay_outsideState == LOW)
  {
    digitalWrite(relay_outside, LOW);
    relay[2] = 2;
  }
  relay_outsideState = HIGH;
  Serial.println("ON Outside\n");
  lastDebounceTime1 = millis();
}
void detectMotion2() {
  Serial.println("Motion Inside\n");
  if(relay_insideState == LOW)
  {
    digitalWrite(relay_inside, LOW);
    relay[3] = 2;
  }
  relay_insideState = HIGH;
  Serial.println("ON Inside\n");
  lastDebounceTime2 = millis();
}
```

gng1103_automation

```
}
void waterloop(){
  delay(29);                    // Wait 50ms between pings (about 20 pings/sec). 29ms should be the shortest delay between pings.
  Serial.print("Ping: ");
  Serial.print(sonar.ping_cm()); // Send ping, get distance in cm and print result (0 = outside set distance range)
  Serial.println("cm");
  if(sonar.ping_cm()!=0){
    digitalWrite(solenoidPin, HIGH);
    relay[1] = 0;
    Timer1 = millis()/1000;
  }
  if(millis()/1000 - Timer1 >= 3){
    digitalWrite(solenoidPin, LOW);
    relay[1] = 2;
  }
  Serial.println(Timer1);
}
void heatingloop(){

  int heatDTemp = 15; //default temperature

  int sensorVal = analogRead(A0);
  int dialval = analogRead(A3);
  heatCT = millis();

  float temperature = calcTemp(sensorVal);  //Translates the data from temperature sensor into celcius;
  float dtemp = settemp(dialval);  //translates the potentiometer output to desired temperature
  float tempAvg = calcAvg(temperature);

  relayfix = 0;
  for(int b = 0; b < 4;b++){
    relayfix = relayfix + relay[b];
  }

  if(digitalRead(heatD1)==1){
      heatPT = heatCT;
      dtemp = settemp(dialval);  //translates the potentiometer output to desired temperature

  } else if(fabs(heatCT - heatPT) >= heatDelay && digitalRead(heatD1)==0) {
      dtemp = heatDTemp;
  }

  heater(temperature,dtemp); //turns on heater if required
  lcdHeat(temperature,dtemp);  // prints the the temperature on the lcd

  Serial.println(temperature);

  if(heatLoop < 100 && heatCT - heatPTAvg >= heatDelayAvg) {
    heatLoop++;
    heatPTAvg = heatCT;
  } else if(heatLoop > 100) {
    heatLoop = 0;
    heatCheck = 1;
    heatPTAvg = heatCT;
  }
}
```

gng1103_automation

```
float calcTemp(int sensorVal) {
  float voltage = ((sensorVal/1024.0)*5.0);
  float temperature = (voltage-0.5)*100;
  return (temperature-relayfix);
}

float calcAvg(float temperature) {
  float heatAvg[100];
  float Average = temperature;

  if(heatCT - heatPTAvg >= heatDelayAvg) {
      heatAvg[heatLoop] = temperature;
      if(heatCheck == 1) {
        Average = 0;
        for(int a = 0; a < heatLoop; a++){
          Average = Average + heatAvg[a];
        }
        Average = Average/100;
      }
  }

  return Average;
}

void lcdHeat(float temperature,int dtemp) {
  lcd.setCursor(0,0);
  lcd.print(int(temperature));
  lcd.print(char(223));
  lcd.print("C Actual");
  lcd.setCursor(0,1);
  lcd.print("Set to ");
  lcd.print(dtemp);
  lcd.print(char(223));
  lcd.print("C ");
}

float settemp(float dialval){
  float dtemp = (dialval/30.0);
  return dtemp;
}

void heater(int temp,float dtemp){
  int relay1;
  if(heatCT - heatRelayT >= RelayDelay) {
    heatRelayT = heatCT;

  if (float(dtemp) >= temp){
    relay1 = 1;
    digitalWrite(6, LOW);
    relay[0] = 2;
  }
  else if(dtemp <= temp+1){
    relay1 = 0;
    digitalWrite(6, HIGH);
    relay[0] = 0;
  }
  }
}
```

8 Conclusions and Recommendations for Future Work

In conclusion, this project report was successful as the client was pleased with the final result. Once the project was complete and fully installed within the house, tests were performed to make sure everything was working correctly. As the tests were performed, some results that were demonstrated were not supposed to be the proper output. Therefore, trouble shooting was done and completed before the final deadline day. Once the deadline hit the house was moved from the structures lab located in the CBY at the University of Ottawa to its final destination on the front lawn of the SITE building within the campus of the University of Ottawa. While the house was being demonstrated during design day, the client approached the house to see the final result and was pleased with what they saw. The client then proceeded to ask questions about how the final design was brought about. This project was completed and successful when the client announced their satisfaction with the final solution. For future work, performing what was done in this report will result in a successful solution; however, some improvements could have been made. Improvements such as planning out a better schedule with more slack time would have helped. Having more slack time in the schedule would have helped due to unexpected problems that have arose during the project. In conclusion, the project was a success and further improvements would be to create more slack time within the schedule so unexpected problem will have more time allocated in order to solve.

9 Bibliography

What time people go to bed source:

https://blog.withings.com/2014/11/04/study-of-the-sleep-patterns/

Carbon tax source:

https://news.ontario.ca/mndmf/en/2019/4/ontario-introduces-transparency-measures-to-reveal-true-cost-of-carbon-tax-on-home-heating-and-gas.html

APPENDICES

APPENDIX I: User Manual

APPENDIX II: Design Files

APPENDIX III: Other Appendices