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Group B128 Structured System and Product Development Miniproject

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Introduction

Preface

The following report is a compilation of the development process of this project, where the theory from the courses, the requirements implied by the company and the group's own thoughts are combined in order to come up with a product.

About the project

Dolle A/S the world's largest manufacturer of attic ladders as well as market leader in Europe with established presence in more than 40 countries worldwide. Having such a vast production, they are concerned about what happens to the merchandise once it has left the factory; therefore they decided to come up with a project which would allow their attic ladders to be intelligent, in the sense of having some sort of interaction with their surroundings and are able to recollect data which would later be used for the company's improvement.

Being introduced to product (customer needs) Laura

In order to have a better understanding about the project, we decided to evaluate our knowledge.

What do we know	***What do we know that we don't know***
We need to create an intelligent ladder We need to implement temperature and humidity sensors	What makes a ladder intelligent? Why would Dolle's customers have an interest on these ladders?
It must be within a budget	
It must recollect and send data	

Who is our costumer? This question has been widely discussed, in the beginning we thought we were developing a service for the buyers of the ladders, but as we got further in this project, we realized that our main customer is Dolle and that Dolle's customers come in second plane. Therefore we have two customers, a main one, the one we are designing the project for, and a second one, the ones who will use the product.

What are the needs of the customers? The main need is to solve the lack of information Dolle has from its attic ladder but, is there any other potential unknown need?

When first introduced to the project, many issues arose. The first one, and which might seem a bit obvious, was "What does it even mean to be an intelligent attic ladder?", "What can a smart ladder do?" or "Why would anyone want an intelligent attic ladder?"
Our first thoughts were to make the ladder open and close by itself, but we found out that wouldn't make it intelligent, but automatic.
At this point, we were told that two requirements were a temperature and a humidity sensor. But why would that be useful for the customers buying an attic ladder? And why would anyone want to have a company monitoring the environment of their private properties? Therefore we decided that if we wanted the customers to happily buy a smart ladder, they needed to gain something from it.

In order to sell the idea, we started looking for "common problems in attics", because we believed that if we could solve some issues, the customers would be eager to introduce this new device in their homes. Through this process we found out that: expansion of the wood, mold, mites or fungi were probably the most common problems in attics.

Unfortunately, we were told that our initial approach was not entirely right, for our main customers were Dolle A/S itself, and afterwards the ladder buyers. Therefore, our duty now was to focus on recollecting data which helped the company to improve itself. Knowing the humidity to which their ladders are exposed depending on the countries might help them on production in the sense that they could export ladders made of a different material to those areas where the humidity becomes a threat to wood, or by monitoring the average

environment, they could come up with a cheaper material which would still be adequate, or perhaps a more durable one depending of the kind of input they get from the sensors.
Another key factor would be to know how often are attics accessed to, and do the cultural or geographic surrounding affect on how much the ladder will be used? Just by adding a push button as a counter to how many times is the attic ladder opened would give a great insight, and could also serve as a test to recognize which countries have a greater demand on the use of ladders leading to a potential expansion of the market and economic growth.

Product development

Customer needs

After having brainstormed on the introduction to the project, it was necessary to understand what needs the customer have for this product.
The needs were based on the information gained in the lectures along with the information provided by Dolle A/S.
The needs were:

The ladder must be Intelligent

By this is meant that the ladder must be capable of sensing its surroundings and communicate this information, meaning it must be capable of sending the information it measures from its surroundings.

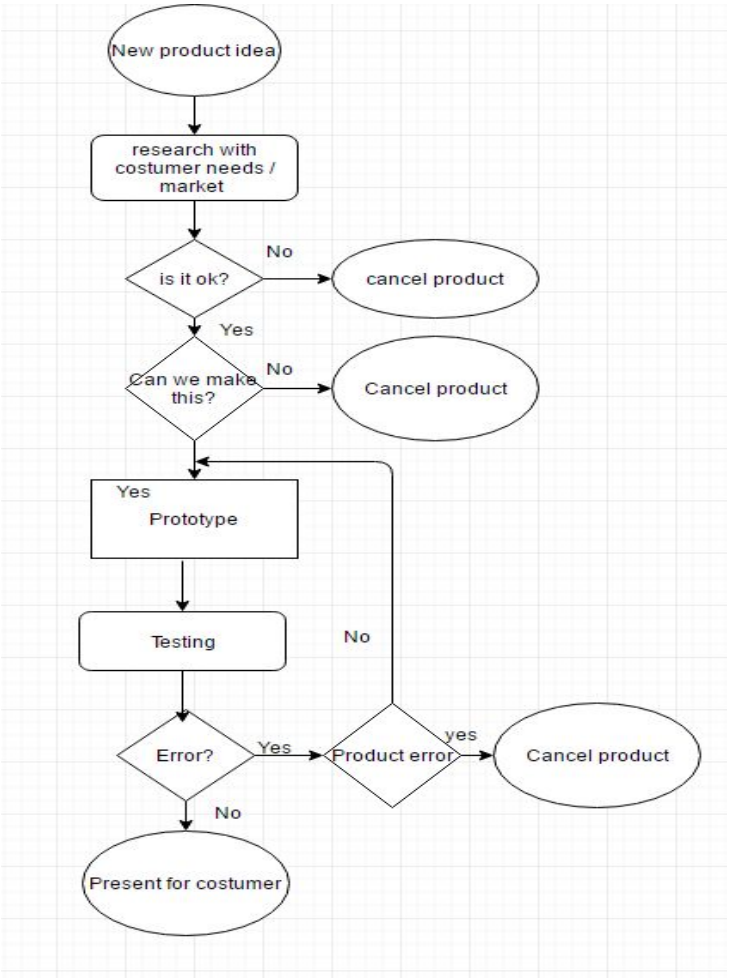
The ladder must sense temperature and humidity

This is a need that Dolle set up as two of the sensors that Dolle wanted as part of the intelligent ladder. However it was also needed to research, other sensors that could allow for better quality of information.

Cost must be low

Information was given during this project that attic ladder is a competitive market where prices are as effective as possible, meaning cost is a priority and must be kept low.

These were the customer needs presented to us. As the group began on the product development, a flowchart of the process was set up. This was to effectivize the development process along with setting up a way to evaluate on the project process.



Initial idea generation

During the initial brainstorm the six thinking hats were utilised in order to make sure the team had the right level of thinking during each of the phases. During the brainstorm the green hat

(creative thinking) and the black hat (logical negative) were found especially effective, since they allow to setup up discussions based on what the needs were during the process.

In the beginning there was a focus point on the fact that this product would have to monitor on aspects of Dolle's customers' homes. How do we convince the users of the attic ladder to purchase this product while knowing that there will be technology that monitors and transmits certain data about their house? This lead us to conclude that there must be some value for the user of the attic ladder in our product.
Along with this, the brainstorm also focused in on what the product should monitor. Since temperature and humidity were required, we decided to also monitor the activation rate in the sense of keeping track on how often the ladder is used. This would allow Dolle to know with which frequency the ladder is used during its lifetime.

The first idea for the product revolved around the "internet of things" meaning the concept of a smart home where the house itself is all interconnected. This meant that the things the product measured for Dolle, could be sent to an app that the user could access allowing them to have knowledge about their own attic.
This thought was expanded upon, with the idea of expanding Dolles product into a service. Going from being the seller of attic ladders, into an attic monitoring service along with a ladder.
This would provide Dolle with their information, and also give users a reason to buy an attic ladder with this technology on it.
The general concept for this was that with the information provided by the product, Dolle's customers would gain insight about their attic, allowing them to monitor things like temperature, humidity or similar concepts which are often important to know when maintaining an attic. This would be convenient for the customer and by making it so, the users might accept a product that monitors their home.

Along with this, there was also an idea of Dolle being directly in contact with the user, if any damages should occur to the ladder. If it was possible for the ladder to measure when there were any damages to the ladder. This would allow Dolle to directly contact the user in these situations.
These ideas were researched further and used as the initial ideas.

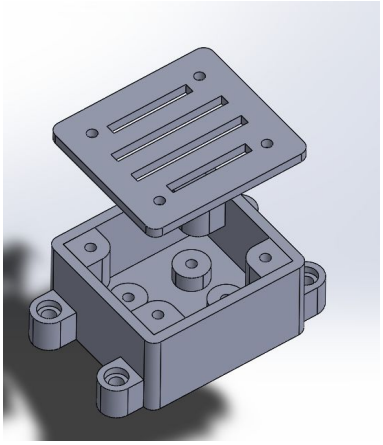
Screening of ideas

By researching the initial ideas certain plans showed not to be as accomplishable as first thought. The idea of measuring whether there were any damages to the ladder, was a hotly

discussed topic, it was found that all potential solutions to this were very unreliable and had a high margin of error. It was thought of to use infrared sensors, but since in our idea Dolle would have to contact the user to setup repairs whenever there were any damages, it was found too imprecise.
However, the idea of monitoring the attic through the attic ladder and providing the user with information while also providing Dolle with data were believed both accomplishable but also inexpensive due to the fact that most of the sensors are pretty affordable.
It was also believed to be an easily expandable idea, since any other sensors deemed necessary, could be added to the prototype almost immediately.

Final design

The final design was made based on the research and idea development.
The product will be in a small box, screwed onto the side of the ladder



The prototype should measure:
Temperature
Humidity
Activation rate (push button)
Pressure
Along with that it should have calculations to allow to calculate absolute humidity.
The information collected by the prototype should be logged to a file (.txt or excel) for ease of access. An app must be made that can access the data the user. The app must have a user friendly UI.
Delimitation Torben
There will be no focus upon setting up servers and actually connecting the prototype to the internet.

The power supply will not be made during this project.
The app will not be created in this prototype.

Requirements

Due to the need of ensuring a sustainable product, some requirement specifications are an important issue. Throughout this project it was clearly stated that having a humidity and a temperature sensors were indispensable, but no further details were specified.

The project must be equipped with a humidity and temperature sensor. The importance of having a humidity and a temperature sensor comes for the need of knowing the environmental conditions the attic ladder will be exposed to, so the company can study how this affects the materials they are using and whether or not they are appropriate and will meet the life expectancy. In order to meet this, our prototype will have a DHT11 sensor which is able to measure both and since we want to provide Dolle with an accurate the monitoring of the atmosphere, a barometer was also included in the prototype.

It is also quite important to know the frequency the attic ladder is used, because depending on whether it is being used once a month or daily the wood will suffer a faster or slower damage. Therefore, if we could count how often the ladder is being used, we can predict how resistant the material should be. In order to meet this end, the prototype will be provided with a push button which counts the number of times the ladder is opened.

The sensors and the push button must be connected to a machine so they can recollect the data and save it or send it For this prototype an Arduino Uno will be used.

The recollection of the data and some calculations such as: average temperature, relative humidity, etc. must take place in the machine. To meet this requirement an Excel sheet will we implemented; this sheet will automatically refresh itself with the new data and keep op doing the calculations.

Problem statement

Up to what extent is it possible to develop an intelligent attic ladder which can be easily introduced in the customers' homes?

Since this project consists of mechanical, electronic and software components, the following sections will describe each state of the product.

Prototype

Our working prototype is an arduino uno board, equipped with a DHT11, a barometer and a push button. These are the primary sensors used.
The arduino board is then meant to be placed inside a box and screwed attached to the side of the attic ladder.
The box is placed so that the pushbutton is naturally pressed, and then when a user opens the attic ladder the button will be released, which will have the arduino count one. This will also be time-stamped so Dolle can see when it is used for storing.
All the data will be logged until files, on a computer. One of these files will be an excel sheets with an automated graph that refreshes itself whenever new data is sent.
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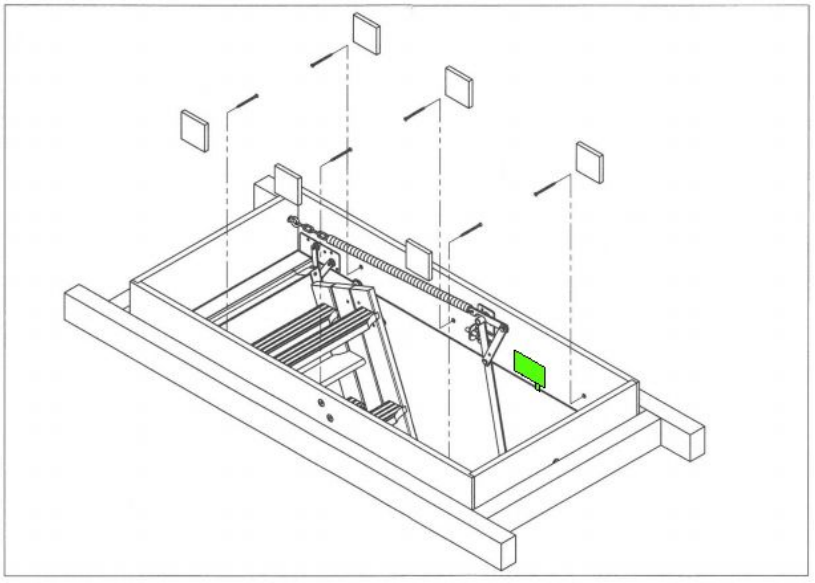

Along with the data collected there will be certain calculations the code will do allowing for collection of not only relative humidity but also absolute humidity, given the exact amount of water there is in the air for more precise information.

Conclusion

It is possible for this group to develop an attic ladder that can sense certain factors in its nearby surroundings both for the development section of Dolle A/S but also to provide easy access to information on the user's attic.

Use Case	Make an attic ladder intelligent
Description	Attic ladders are used worldwide, but when it comes to the industries which manufacture them, there doesn't exist any kind of input to help them develop future attic ladders for their customers.
Assumptions	There is a need for the factories to know how the ladders are being used. All intelligent ladders must be provided with a temperature and humidity sensor.
Actors	Attic ladder, people buying the ladder, Dolle A/S
Steps	Temperature and humidity sensors are running 24/7 and are giving input for factory. Whenever the ladder is open, a counter will be activated that will take track of exactly when and how many times is the ladder accessed weekly, monthly and yearly. It will be also possible to sort out if attic ladders are more used at night or day time. If while in use the temperature or humidity are out of balance, the ladder will inform the user.
Variations	N/A
Non-functional	N/A
Issues	What does it mean to be "intelligent"?

http://www.dolle.eu/about-dolle-1

Hardware
Prototype

The working prototype is an arduino uno board, equipped with a DHT11, a bmp085 and a push button. These are the primary sensors used.
The arduino board is then meant to be placed inside a box and screwed attached to the side of the attic ladder.
The box is placed so that the pushbutton is naturally pressed, and then when a user opens the attic ladder the button will be released, which will have the arduino count one. This will also be time-stamped so Dolle can see when it is used for storing.
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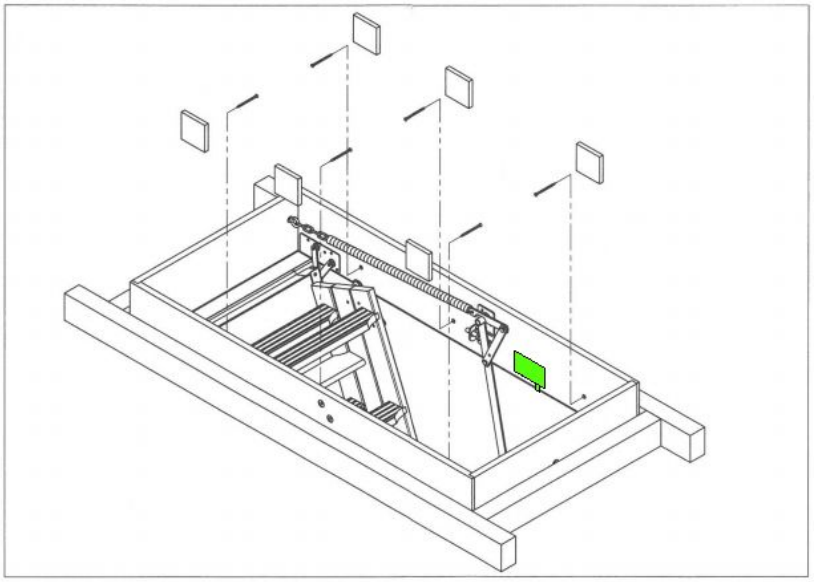

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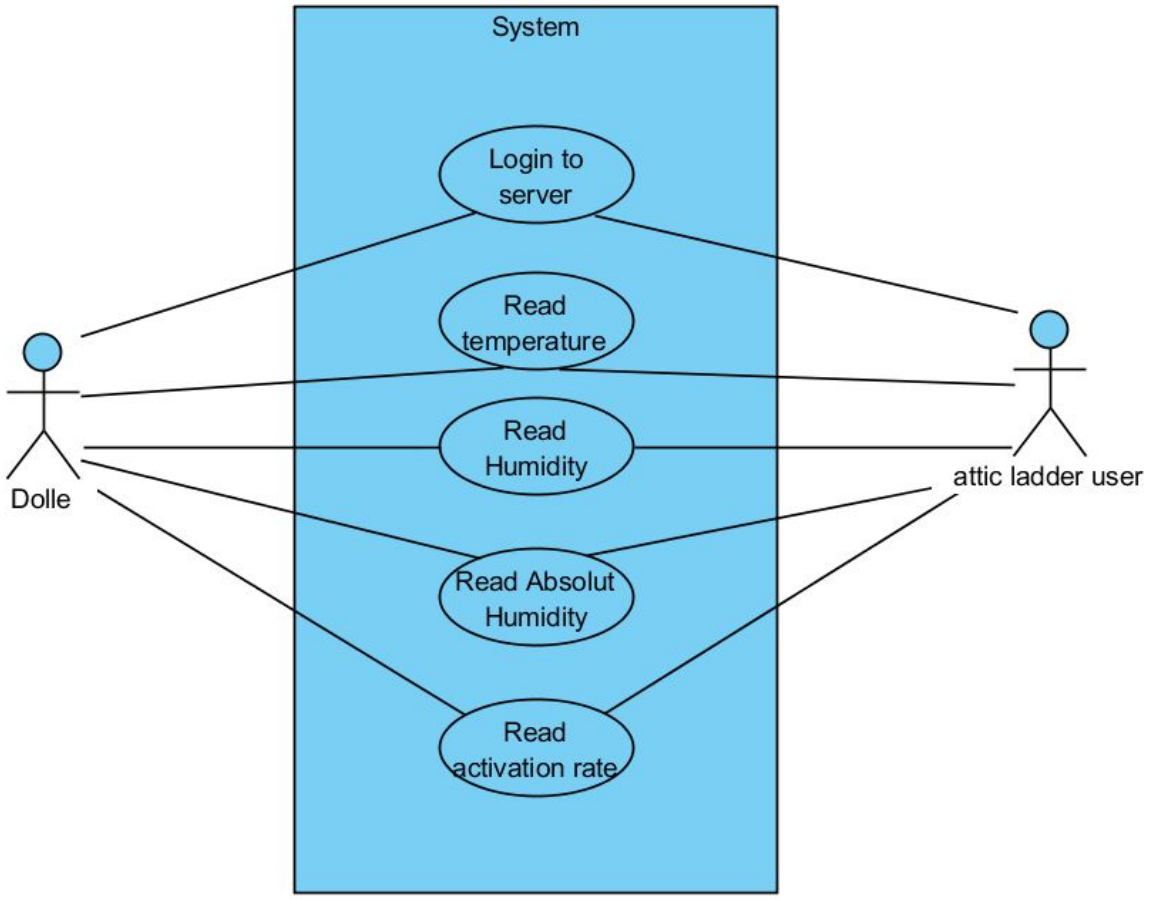
Use case

Software



Arduino

The code in the arduino have some sensor specific libraries defined along with this the pins used in the arduino are defined. These are needed for the sensors to work.
In the void setup the serial is defined and setup, this will be used to transmit data from the sensors with.
In the void loop the sensors are setup, along with this there are serial commands, this defines for the arduino what data should be transmitted over the serial port. There are also commands for the gobetwino, this is the program used to transmit data to .txt files.

```
#include <dht11.h>
#include <Wire.h>
```

```
#include <bmp085.h>
#define PRES_0M 101325.0
//#S|READDATA[]
dht11 DHT11;
#define DHT11PIN 7
const int buttonPin = 2;     // the number of the pushbutton pin
 const int ledPin =  12;      // the number of the LED pin


// variables will change:
int buttonState = 0;         // variable for reading the pushbutton status
int lastButtonState = 0;
int counter = 0;
void setup() {

   Serial.begin(9600);
   bmp085_init();
  Serial.println("DHT11 TEST PROGRAM ");
  Serial.print("LIBRARY VERSION: ");
  Serial.println(DHT11LIB_VERSION);
  Serial.println();
  // initialize the LED pin as an output:
   pinMode(ledPin, OUTPUT);
   // initialize the pushbutton pin as an input:
   pinMode(buttonPin, INPUT);
}

void loop() {
   // read the state of the pushbutton value:
   buttonState = digitalRead(buttonPin);
   // check if the pushbutton is pressed.
   // if it is, the buttonState is HIGH:
   float temp, atm, alt;
   long pres;
  pres = bmp085Pressure();
  //atm = pres / PRES_0M;
  // alt = bmp085PascalToMeter(pres, PRES_0M);
   if(buttonState != lastButtonState)
   {

   if (buttonState == HIGH) {
     digitalWrite(ledPin, HIGH);
     counter ++;
   }

   }
```

```
   else {
     // turn LED off:
     digitalWrite(ledPin, LOW);
   }

   unsigned long active;
   active = millis();
  lastButtonState = buttonState;
    // Serial.println("\n");
if((unsigned long)( active % 1000 == 0 ))
{
  int chk = DHT11.read(DHT11PIN);

  Serial.print("Read sensor: ");
  switch (chk)
  {
    case DHTLIB_OK:
    Serial.println("OK");
    break;
    case DHTLIB_ERROR_CHECKSUM:
    Serial.println("Checksum error");
    break;
    case DHTLIB_ERROR_TIMEOUT:
    Serial.println("Time out error");
    break;
    default:
    Serial.println("Unknown error");
    break;
  }
//Serial.println("#S|MINIPROJEC|[DHT11.temperature]#");
//Serial.println("#S|MINIPROJEC|[DHT11.humidity]#");
//Serial.println("#S|MINIPROJEC|[counter]#");
//Serial.println("#S|MINIPROJEC|[pres / 1000]#");
Serial.print("#S|MINIPROJEC|[");
Serial.print(DHT11.humidity);
Serial.println("]#");
Serial.print("#S|MINI2|[");
Serial.print(DHT11.temperature);
Serial.println("]#");
Serial.print("#S|MINI3|[");
Serial.print(pres);
Serial.println("]#");
Serial.print("#S|MINI4|[");
Serial.print(counter);
Serial.println("]#");
  Serial.print("Humidity (%): ");
```

```
  Serial.println((float)DHT11.humidity, 2);

  Serial.print("Temperature (°C): ");
  Serial.println((float)DHT11.temperature, 2);
    Serial.print("buttonState pressed : ");
  Serial.println(counter);
  Serial.print("Pressure : ");
 Serial.print(pres / 1000);
 Serial.print(" kPa ");
  Serial.println();
}
}
```

C++

The C++ program is meant to take data from the a text file and modify and print them out onto a console window. The program uses a vector to store the data and then uses classes for certain variables.
The program is currently printing the temperature values out, but in the finished solution the end goal, it will print and analyse all data out to an easy to read ui.

```
 /*
03/06/2015 by B128

This is a small program for converting data and printing the result to a terminal window

The program is meant to be a part of a larger system for analysing data
*/

#include <iostream>
#include <fstream>
#include <string>
#include <vector>

using namespace std;

int i = 0;

//Primary class

class SensorData {

  public:
    SensorData (int);
    int number;
```

```
};

SensorData::SensorData (int a) {
  i = a;
}

//Sub-class

class Humidity: public SensorData
{
    public:
    int Hum;
};

//Main funktion: Reads data from *.txt file, calculates and prints to terminal

int main () {

  vector<int> numbers;

  ifstream myfile ("Data.txt",ios::in); //Reads Data.txt from beginning to end

  int number;
  int hum;

  if (myfile.is_open()) //#50 and #61 creates and structures an array
  {
    while ( myfile >> number)
    {
      numbers.push_back(number);
    }
    myfile.close();
  }

  else cout << "Unable to open file";

    for (int i=0; i<numbers.size(); i++) {
    hum = numbers[i] - 2; //Simple example of calcution, modifing the array
    cout << "Temp. is: " << numbers[i] << " Result is: " << hum << '\n';
    }

    cin.get();
  return 0;
}
```