Concept Generation

1.5.1 Concept Generation Tools

One hundred concepts were generated by using a multitude of concept generation methods. The 100 concepts are shown in Appendix D. The methods that were used include brainstorming, crap-shoot, morphological analysis, and the forced analogy method. The morphological analysis was used to generate the majority of the concepts in the appendix. This method was very useful for generating all the different combinations of feasible designs considering the device features, the communication method, the data processing and the environmental factors that had to be taken into consideration. This system has its limitations because there is a tendency to have very similar concepts.

The second highest number of concepts were generated using the crap-shoot method. By thinking about random things completely unrelated to the design, we were able to generate concepts by thinking about the problem in a new way. A lot of the ideas were not useful, but certain aspects of the impractical ideas were useful for some of the better ideas that were used. Also, some ideas were generated using forced analogy method. Forced analogy is a very useful and fun-filled method of generating ideas. The idea is to compare the problem with something else that has little or nothing in common and gaining new insights as a result. Therefore, we were comparing the A/C System with random things such as sea, whales, pencils and try to find any kind of resemblance. It helped develop unexpected design concepts. These ideas were then filtered again and from there the high fidelity and medium fidelity choices were chosen.

1.5.2 High Fidelity

For each of the High-Fidelity concepts, the team has chosen to use an RFID card reader that will control the volume of air flow within the users' preferred room for communication. Variable air volume system was chosen over other options due to its simplicity and effectiveness. In order to control the output temperature a heat exchanger would have to be located in each room, and if the humidity was controlled, there would have to be two heat exchangers. For the scope of this project, using a constant output temperature with a variable air volume will allow for precise control of the room temperature. However, what makes each choice unique is the way the data is being manipulated for future predictions. An RFID chip will be placed on users in a common and comfortable place so that their information can be obtained from an RFID reader within their preferred room. The RFID chip will hold the user's information with a unique ID code to differentiate them from other users within the facility. These RFID chip readers will be placed within multiple rooms to be able to pick up the users' preference which will then be sent to a data collection enterprise where the information will be manipulated (Figure 1).

Our first algorithm that can be used to predict the user's preference would be Supervised Learning, which is a basic learning function that maps inputs to outputs. An example of this can be seen below in Figure 2. Therefore, for this to work the team would have to generate a multitude of various inputs and outputs that would simulate a user's daily use over a period of time and use the Supervised learning to make predictions for the future. A second choice would be to use Fuzzy Control System that rates characteristics such as time of day, temperature, and how often during the day, on a scale of 0 & 1. This can be seen below in Figure 3. For this to work, the team must use the output of this system and rate which characteristic is done the most to adjust the temperature in the future. The third and final choice for one of the high-fidelity concepts would be to use Structured Query Language (SQL) that could query the users' inputs into a database that can have a multitude of tables for the many users' inputs. An example of this can be seen below in Figure 4. By having the capacity to hold a large amount of information the team can pull the information that is queried the most for future predictions.

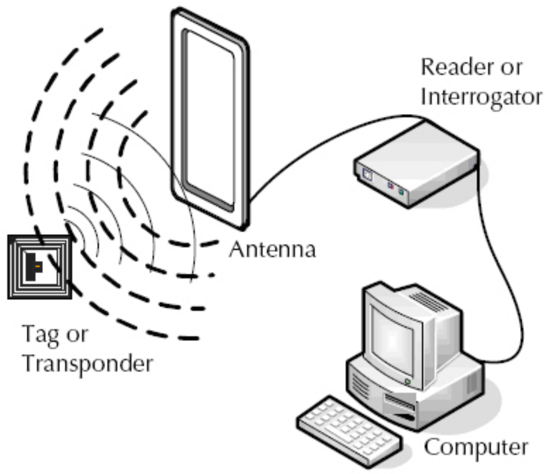

Figure 1. RFID System

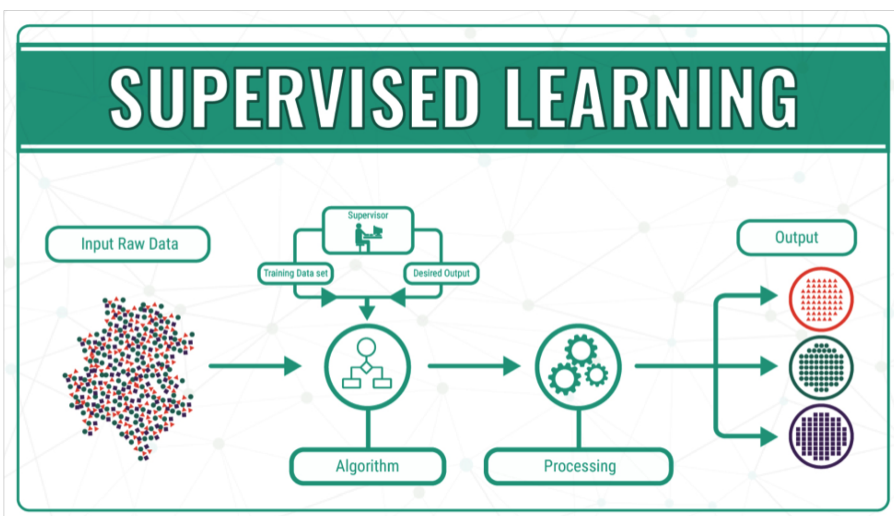

Figure 2. Supervised Learning

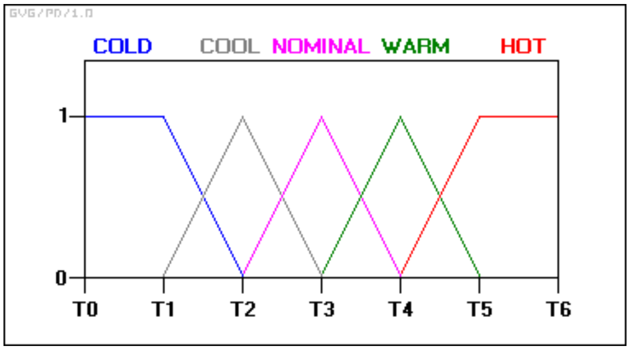

Figure 3. Fuzzy control system

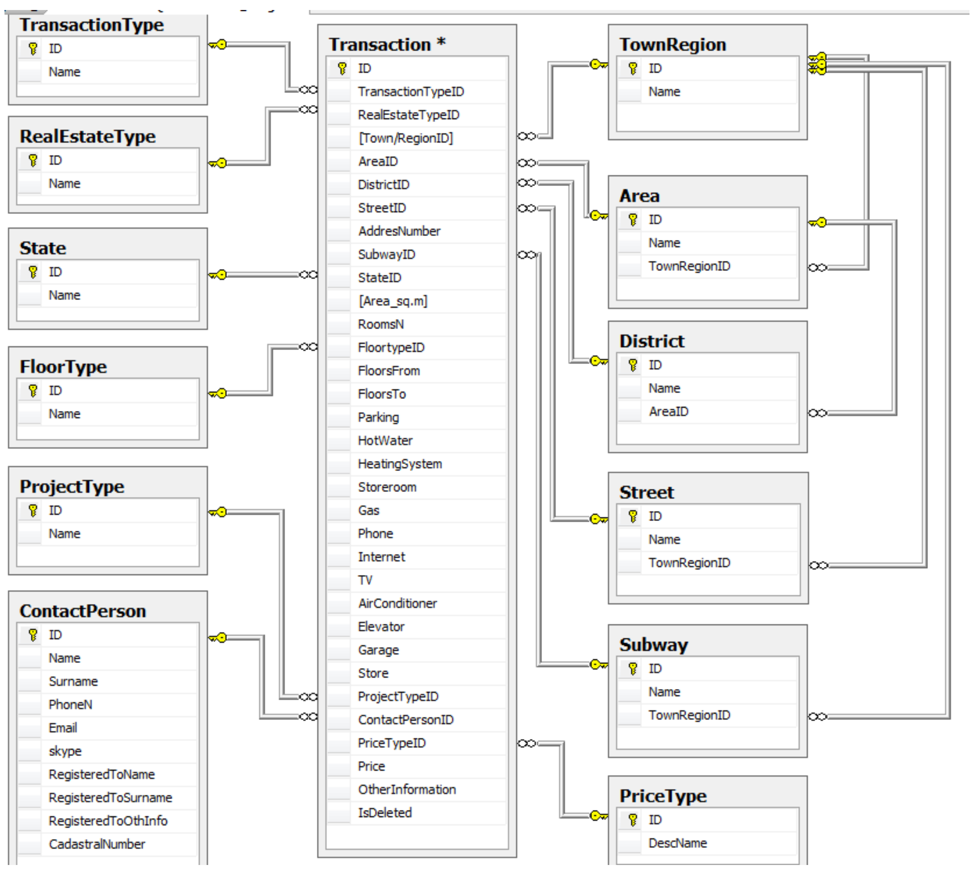

Figure 4. SQL Relationships

1.5.3 Medium Fidelity

For each of the Medium Fidelity concepts the team has chosen to use a Bluetooth connection for communication that can be used with either a Supervised Learning algorithm, a Fuzzy Control System, or a Structured Query Language to manipulate the users' data for a prediction of use. Then the team could also build an Application that could be used to send a lightweight message with the user's various characteristics through a local Wi-Fi host. By using a Bluetooth connection for sending information, the user would need to be within a range of 33 feet, however, there is not a cap to how much information could be sent at once. This was chosen as a medium fidelity option due to the advantages it can present in contrast to the RFID. The other concepts would be to build an Application that can send the users' information through their local Wi-Fi host. Because the application will take Wi-Fi to use, the range of connectivity is directly related to the range of connection output by the Modem. The Application will too use either Supervised Learning, Fuzzy Control System, or SQL to manipulate the users' data for future prediction.

1.5.4 Morphological Chart Concept Generation

The morphological chart we constructed allowed different design attributes to be integrated within one another. This type of methodology allowed for the conception of a vast number of ideas pertaining to the functions of our system. As displayed in Appendix D, concepts numbered 1 through 63 (Table 1) were generated using our morphology chart (Figure 5). From there, we were able to discuss the pros and cons of each individual design against one another. For instance, would an RFID communication method paired with Supervised Learning work more cohesively than a Bluetooth communication method paired with Fuzzy Logic? Discussing these different deviations amongst ourselves allowed for an open discussion on which attributes would work best for our final system. It also allowed for every combination of attributes to be compiled and examined. This was an integral part of determining our high and medium fidelity concepts.

Communication Method	Type of Data Manipulation	Environmental Outputs
RFID	SQL	Temperature
		Volume of Air
BlueTooth	Fuzzy Logic	Humidity (Moisture in Air)
		Temperature and Volume
Application	Supervised Learning	Temperature and Humidity
		Air Flow

Figure 5. Morphology Chart depicting various attributes of the design

1.5.5 Other Concept Generation Methods

Although the morphological chart was a very useful tool when it came to generating concepts, other tools had to be used in order to diversify our ideas as much as possible. One of those tools was the classic crapshoot method. The crapshoot method was when the team basically tossed ideas out randomly without being shut down. Although this helped in coming up with ideas (65 to 100 on Table 1), the great majority of those ideas were ludicrous and couldn't possibly be used to solve the problem. Overall, the crapshoot method yielded about 30 concepts. About five of our concepts were generated by using the forced analogy method.

Table 1
Concept description table

#	Concept	Method	Description
1	RFID	SQL	Chip picks up as enter room and changes air volume

2	RFID	Supervised Learning	Chip picks up as enter room and changes air volume
3	RFID	Fuzzy Control System	Chip picks up as enter room and changes air volume
4	RFID	SQL	Chip picks up as enter room and changes air temperature
5	RFID	Supervised Learning	Chip picks up as enter room and changes air temperature
6	RFID	Fuzzy Control System	Chip picks up as enter room and changes air temperature
7	RFID	SQL	Chip picks up as enter room and changes air humidity
8	RFID	Supervised Learning	Chip picks up as enter room and changes air humidity
9	RFID	Fuzzy Control System	Chip picks up as enter room and changes air humidity
10	RFID	SQL	Chip picks up as enter room and changes air volume temperature
11	RFID	Supervised Learning	Chip picks up as enter room and changes air volume temperature
12	RFID	Fuzzy Control System	Chip picks up as enter room and changes air volume temperature
13	RFID	SQL	Chip picks up as enter room and changes air temperature and humidity
14	RFID	Supervised Learning	Chip picks up as enter room and changes air temperature and humidity
15	RFID	Fuzzy Control System	Chip picks up as enter room and changes air temperature and humidity
16	RFID	SQL	Chip picks up as enter room and changes air humidity and volume
17	RFID	Supervised Learning	Chip picks up as enter room and changes air humidity and volume
18	RFID	Fuzzy Control System	Chip picks up as enter room and changes air humidity and volume
19	RFID	SQL	Chip picks up as enter room and changes air humidity, volume and temperature

20	RFID	Supervised Learning	Chip picks up as enter room and changes air humidity, volume and temperature
21	RFID	Fuzzy Control System	Chip picks up as enter room and changes air humidity, volume and temperature
22	Bluetooth	SQL	Picks up as enter room and changes air temperature
23	Bluetooth	Supervised Learning	Picks up as enter room and changes air temperature
24	Bluetooth	Fuzzy Control System	Picks up as enter room and changes air temperature
25	Bluetooth	SQL	Picks up as enter room and changes air volume
26	Bluetooth	Supervised Learning	Picks up as enter room and changes air volume
27	Bluetooth	Fuzzy Control System	Picks up as enter room and changes air volume
28	Bluetooth	SQL	Picks up as enter room and changes air humidity
29	Bluetooth	Supervised Learning	Picks up as enter room and changes air humidity
30	Bluetooth	Fuzzy Control System	Picks up as enter room and changes air humidity
31	Bluetooth	SQL	Picks up as enter room and changes air temperature and volume
32	Bluetooth	Supervised Learning	Picks up as enter room and changes air temperature and volume
33	Bluetooth	Fuzzy Control System	Picks up as enter room and changes air temperature and volume
34	Bluetooth	SQL	Picks up as enter room and changes air volume and humidity
35	Bluetooth	Supervised Learning	Picks up as enter room and changes air volume and humidity
36	Bluetooth	Fuzzy Control System	Picks up as enter room and changes air volume and humidity
37	Bluetooth	SQL	Picks up as enter room and changes air humidity and temperature
38	Bluetooth	Supervised Learning	Picks up as enter room and changes air humidity and temperature

39	Bluetooth	Fuzzy Control System	Picks up as enter room and changes air humidity and temperature
40	Bluetooth	SQL	Picks up as enter room and changes air humidity, temperature and volume
41	Bluetooth	Supervised Learning	Picks up as enter room and changes air humidity, temperature and volume
42	Bluetooth	Fuzzy Control System	Picks up as enter room and changes air humidity, temperature and volume
43	Application	SQL	Takes user input to change air volume
44	Application	Supervised Learning	Takes user input to change air volume
45	Application	Fuzzy Control System	Takes user input to change air volume
46	Application	SQL	Takes user input to change air temperature
47	Application	Supervised Learning	Takes user input to change air temperature
48	Application	Fuzzy Control System	Takes user input to change air temperature
49	Application	SQL	Takes user input to change air humidity
50	Application	Supervised Learning	Takes user input to change air humidity
51	Application	Fuzzy Control System	Takes user input to change air humidity
52	Application	SQL	Takes user input to change air volume and temperature
53	Application	Supervised Learning	Takes user input to change air volume and temperature
54	Application	Fuzzy Control System	Takes user input to change air volume and temperature
55	Application	SQL	Takes user input to change air temperature and humidity
56	Application	Supervised Learning	Takes user input to change air temperature and humidity
57	Application	Fuzzy Control System	Takes user input to change air temperature and humidity

58	Application	SQL	Takes user input to change air humidity and volume
59	Application	Supervised Learning	Takes user input to change air humidity and volume
60	Application	Fuzzy Control System	Takes user input to change air humidity and volume
61	Application	SQL	Takes user input to change air humidity, volume and temperature
62	Application	Supervised Learning	Takes user input to change air humidity, volume and temperature
63	Application	Fuzzy Control System	Takes user input to change air humidity, volume and temperature
64	Sign-up sheet	N/A	User write preferences on sign-up sheet
65	Priority preference	Seniority	Set preferences based on age
66	Priority preference	One person changes	Set preferences based on one single person
67	Priority preference	Tenure	Set preferences based on the ownership of the building/room
68	Priority preference	Majority	Set preferences based on the majority of the group
69	Priority preference	Highest performer	Set preferences based on the best performer of the group
70	Heat Retention Oil	N/A	Use an oil that allows the body to retain more heat during cold times
71	Double Layered Walls	N/A	Allows to keep the interior cool or warm depending on the outside temperature
72	Reflecting windows	N/A	Reflects sunlight to keep the interior rooms at a lower temperature
73	Online sign up sheet	N/A	Ask each person individually for the preferences for each room they enter
74	Jacket	N/A	The use of a jacket allows the individual to keep warm during cold days
75	Remove layers of clothing	N/A	Either remove or add layers of clothing depending of feeling
76	Drink alcohol	N/A	Alcohol can have a warming effect on the body with ingested

77	Ibuprofen	N/A	Certain types of medicines can change how a person feels the temperature around them
78	Online survey	N/A	Submit an online survey of people's preferences
79	Paper survey	N/A	Submit a hard copy survey of people's preferences
80	In person vote	N/A	The setup of the preference is based on a personal vote
81	Online vote	N/A	The setup of the preference is based on an online vote
82	Sit closer to vent	N/A	Sit closer to vent in order to feel the effects better
83	Exercise	N/A	Exercising allows the body to generate large amounts of heat
84	Stop exercising	N/A	By not exercising the person can maintain a lower body temperature on hot days
85	Open window	N/A	Open window in order to cool the room when hot
86	Go outside	N/A	Changing locations can help in reducing the dissatisfaction of a specific temperature.
87	Cold drinks	N/A	Drink cold drinks in order to cool down
88	Hot drinks	N/A	Drink hot drinks in order to heat the body up
89	Cold food	N/A	Eat cold food in order to cool down
90	Hot food	N/A	Eat hot food in order to warm up
91	Blanket	N/A	Invest in a regular blanket to cover up with
92	Heated blanket	N/A	Invest in a blanket that warms the body up
93	AC blanket	N/A	Invest in a blanket that cools the body down
94	Ceiling fan	N/A	Install a ceiling fan and turn on or off when needed
95	Ductless split system	N/A	
96	Thermostat in every room	N/A	Install a thermostat in each room for each user
97	Fan that attaches to your phone	N/A	Have a fan that attaches to one's phone

98	Palm tree servant fan	N/A	Have person next to you blow air with a palm
99	Heat lamp	N/A	Install a heat lamp in the room
100	Greenhouse Type Room	N/A	Build a room that implements the greenhouse effect to keep the temperature at a constant value