**Comfort Control**

**2. DESIGN REQUIREMENTS/CONSTRAINTS**

Comfort Control is made to further increase efficiency of heating, ventilation, and cooling (HVAC) systems by creating an automated ventilation system. Comfort Control not only has the ability to control the timing of when the HVAC system is running but also allow for each room’s climate to be controlled separately. The following design constraints listed in the technical design constraints and practical design constraints subsections must be met during the design and implementation process.

**2.1. Technical Design Constraints**

Table 2.1 contains five technical design constraints to which the Comfort Control system must adhere.

**Table 2.1: Technical Design Constraints**

|  |  |
| --- | --- |
| **Name** | **Description** |
| Range | The Comfort Control thermostat hub must maintain connection with the Wi-Fi router and each room’s thermometer probe, which can reach up to 70 feet apart in an average household. |
| Air Flow | The Comfort Control vents must open by at least 0.5 inches to allow for adequate airflow. |
| Integration | The Comfort Control thermostat must operate with existing thermostat connections. |
| Size | The Comfort Control system must monitor and control the climate of at least ten devices. |
| Accuracy | The Comfort Control thermometers must read accurate temperatures within half of a degree Fahrenheit. |

**2.1.1. Range**

Comfort Control must be able to connect and control system devices from up to 70 feet apart in order to control each vent independently. Based on the average house size, 2,600 square feet, the average longest distance from the thermostat hub to the Wi-Fi router is approximately 70 feet which is calculated from one corner to the adjacent corner of a square house of average size [8]. Wi-Fi has a range of 150 feet indoors. The thermostat hub must maintain connection with the Wi-Fi router in order to allow the user to monitor and control the system remotely via the internet and smartphone application.

**2.1.2. Air Flow**

Comfort Control vents must be designed to allow for adequate airflow and to decrease pressure in the ducts and on the HVAC unit. The vents will raise and lower by at least 0.5 inches to allow for air to properly flow, and for a 6''x10'' vent, this will give an area of approximately 16 square inches for air to pass through.

**2.1.3. Integration**

The Comfort Control thermostat hub must be fully integrable with existing thermostat connections. The typical thermostat connection includes one 24-volt AC supply line and three control lines for heat, cool, and fan. Because the thermostat hub will be controlled by a low-powered computer, the hub must convert the 24-volt supply from the HVAC unit to 5 volts DC. The thermostat hub must be able to output 24 volts to the control lines connected back to the HVAC unit.

**2.1.4. Size**

To accommodate the average household size, the Comfort Control system must be able to control the devices required to maintain a comfortable climate in each room. The average household has at least five rooms, and since the system requires one thermometer probe and at least one vent per room, the hub must be able to connect to and control at least ten devices.

**2.1.5. Accuracy**

The Comfort Control thermometers must read an accurate temperature from each room with no more than half of a degree Fahrenheit (F) error. The Comfort Control thermostat uses the rooms’ temperature readings to decide when to open and close the rooms’ vents, and since this happens when a rooms’ temperature is 2 degrees F above or below its set temperature, the temperature probes need to be accurate.

**2.2 Practical Design Constraints**

Table 2.2 contains five practical design constraints to which the Comfort Control system must adhere.

**Table 2.2 Practical Design Constraints**

|  |  |  |
| --- | --- | --- |
| **Type** | **Name** | **Description** |
| Economic | Cost | The Comfort Control system's cost must remain under $200 for a basic package and under $100 for additional vent and thermometer probe packages. |
| Social | Application | The Comfort Control smartphone application must be able to display the rooms’ temperatures, change the set temperatures, and allow changes to the schedules. |
| Sustainability | Sustainability | The Comfort Control system must be capable of receiving and installing updates. |
| Manufacturability | Availability | The Comfort Control vents and thermometer probes must be easily obtained to allow for system expansion. |
| Health and Safety | Safety | The Comfort Control components must be properly shielded. |

**2.2.1 Economic**

The Comfort Control system must remain under $200 for a basic package which would include a Comfort Control thermostat, one temperature probe, and two automated vents. Each additional room expansion package should remain under $100 which would include one temperature probe and two automated vents. These prices would allow for Comfort Control to compete with existing smart HVAC products while offering customers a high quality system for an acceptable price that Comfort Control can still profit from. Due to Comfort Control's design, there will be little to no maintenance cost.

**2.2.2 Social**

To compete with current smart thermostats and enhance user experience, the Comfort Control system must be accompanied by a smartphone application that allows for monitoring of all room temperatures, changing the set temperatures of each room, and editing the schedule of on and off times for the system.

**2.2.3 Sustainability**

Comfort Control must be designed for long-term use and receive updates when needed. Having the ability to update the software of the system will allow Comfort Control to become more efficient as technology advances are made. The hardware must be able to accept updates and be compatible with software updates. Before sending updates to Comfort Control systems, software must be tested and reported.

**2.2.4 Manufacturability**

The Comfort Control system must be easily expanded to more rooms with additional thermometer probes and vents. The options for vent sizes must include all average household vent sizes, e.g. 4''x8'', 4''x10'', 6''x10'', and 6''x12''. The vents will be 3D printed, and the thermometer probes must be designed with minimal components to increase manufacturability.

**2.2.5 Health and Safety**

The Comfort Control system must be designed and installed so that the system is safe for the homeowners. This entails making sure that all wiring is housed properly so that there is no shock risk. This also includes making sure the vents do not have sharp edges that could cause cuts or exposed moving parts that could present a pinching hazard.

**References**

[8] M. Perry, "Today’s new homes are 1,000 square feet larger than in 1973, and average living space per person has doubled," in AEIdeas, 2015. [Online]. Available: https://www.aei.org/publication/todays-new-homes-are-1000-square-feet-larger-than-in-1973-and-living-space-per-person-has-doubled-over-last-41-years/. Accessed: Sep. 8, 2016.