# Introduction to the HVAC Zoning and Vent Control App

The HVAC Zoning App for Hubitat controls a Heating, Ventilation, and Air Conditioning system.

- Single and Two-stage Forced Air Heating and Cooling Equipment (Heat pumps not yet supported)
- Zoned and Non-zoned duct systems, including systems with controllable registers and duct fans
- Ventilation equipment, including ventilation equipment that utilizes the air handler blower
- Humidifiers and Dehumidifiers, including equipment that utilizes the air handler blower
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***Why control the HVAC system from Hubitat?***

- Zone control hardware does not have access to as much information as a home automation system and therefore cannot take advantage of that information to control the HVAC system.
- Available zone control hardware provides only a few configuration options. Software based solutions can offer much more flexibility and customization.

***Requirements***

- A Hubitat hub
- A Hubitat-connected thermostat in each zone
- Hubitat-connected switch devices to control the equipment (Zooz ZEN16 is recommended)

***What if Hubitat or devices fail?***

The software includes a number of features to mitigate the consequences of failures. If wired according to recommendations, the system reverts to operating as a single zone system even if Hubitat goes completely offline.

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# Is HVAC Too Mission-Critical for Home Automation?

This is a legitimate concern, so I want to address it right away. Those of us that have implemented home automation in our homes know that stuff doesn't always work. It is annoying when a light doesn't go on in response to a motion detector as we programmed, but we still have ways to avoid stumbling into things in the dark when that happens. Most people would view a failures of the HVAC system as more severe than failure of a light bulb. We cannot accept having our furnace not run or run continuously if something goes wrong in the home automation system. As described below, there are ways to avoid that.

## What do we mean by 'critical'?

In some ways, our HVAC system is much more critical than the other devices we commonly include in home automation systems. If a ZWave door lock doesn't work like it is supposed to, you probably still have ways to get into your house and to lock your door when you leave. You may not have other ways to heat and cool you house. In other respects, however, the HVAC system is less critical. Having a light come on 30 seconds later than it should is really annoying. Since the HVAC system impacts your environment gradually and usually in response to temperature changes you don't even notice, a delay of 10 minutes or more would likely go unnoticed. With HVAC, it is critical to avoid the major failure states of heating or cooling not running at all or running continuously. Most people are willing to accept temperatures a few degrees away from setpoint when there is some sort of failure.

## What if a device, like a thermostat, quits?

Home automation devices quit or work intermittently for a variety of reasons. They may be battery operated and the batteries run out. The ZWave or Zigbee mesh may have weak spots. The HVAC App depends on thermostats communicating their operating state to the home automation system.

To mitigate failures of individual thermostats, the App keeps track of when each thermostat reports any type of change, including temperature, setpoint, operating mode, or operating state. If a thermostat does not report ANY changes for three hours, the App regards the thermostat as off-line and treats it as though it is in the idle operating state. No heating or cooling is commanded in the idle operating state (although the zone may accept heat to help out other zones as described in more detail elsewhere.) Thus, a runaway situation where heating or cooling stays on indefinitely due to a faulty thermostat is avoided. In a multi-zone system, other thermostats will likely continue operating and the zone with the faulty thermostat won't stray too far from comfortable due to air exchange between zones. In a single zone system, failure of the single thermostat will have the same effect as failure of Hubitat, which is described below.

Whenever a system attempts to detect and respond to failures, it is important to consider the consequences of false positives. In this situation, that means considering the impact if the absence of changes is actually due to a very stable environment in the zone and not due to any failure. If this happens when the zone is supposed to be idle, then treating it as idle will obviously have no impact. It is unlikely that the temperature would stay constant for three hours when heating or cooling is being provided, but not inconceivable. There may be other zones also calling for heat and the system can provide only enough to maintain temperature. In this situation, the temperature will begin to fall when the zone is treated as idle. Once the thermostat reports the temperature decrease, normal operation will resume. In the meantime, other zones that are demanding heating will receive more heating than they otherwise would have.

<u>What if we lose our internet connection?</u>

A big advantage of Hubitat relative to other home automation platforms is local processing, so most functions are not impacted by loss of internet. If you have thermostats or other sensors that rely on a cloud service, those devices will be unavailable when the internet is down. That is one reason that ZWave or Zigbee thermostats are preferred over cloud connected thermostats.

<u>What if Hubitat has a major failure?</u>

If you pay attention to the Hubitat Community, you will notice that sometimes people will say that their Hubitat froze during a reboot or lost communication with ZWave devices after a software update. When these problems occur, it can take days to resolve them. That is obviously a concern if the Hubitat was managing the HVAC system.

To mitigate this risk, I recommend wiring the system such that, if Hubitat fails, it reverts to being a non-zoned system with a wired thermostat. There are several steps that accomplish this. I recommend using ZEN16 multi-relays to control your HVAC equipment and zone dampers. The ZEN16s have a feature which puts the outputs in a predetermined state if no signal is received for a specified period of time. This feature is used to turn the equipment off and open all dampers if no signals are received for a set time, such as two hours. In the case of a complete Hubitat failure or loss of communication with the ZEN16 relays, the dampers will be open and the equipment will not be commanded to operate by Hubitat. Therefore, runaway is precluded.

Finally, one thermostat is wired directly to the equipment in parallel with the ZEN16 outputs. This thermostat should be one that continues to operate as a wired thermostat without Hubitat. The equipment will run in response to the temperature in the zone with the wired thermostat. Since the App outputs and the thermostat are both connected to the equipment in a “wired or” configuration, the equipment will turn on when either Hubitat or the wired thermostat commands it to run.

# Forced Air HVAC Systems

Figure 1 illustrates an air handler, which is the heart of a forced air Heating, Ventilation, and Air Conditioning (HVAC) system. An air handler includes a blower which draws air from return ductwork and propels it through at least one heat exchanger and through supply ductwork to various rooms in a residence. In the air handler illustrated in Figure 1, there are two heat exchangers: a furnace to heat the air during cold weather and an air conditioning evaporator coil to cool the air during hot weather. Only one of the two heat exchangers would be used at a time. In climates that do not need both heating and cooling, one of the two heat exchangers may not be present. Also, some air handlers use a heat pump heat exchanger which can alternately provide either heating or cooling. (Note: the App does not currently support heat pumps.)

The air handler has controls which receive signals indicating when to provide heating, cooling, or fan. As will be discussed later, these signals may come directly from a thermostat or may come from a zone controller. If air conditioning is present, the controller will send signals to a compressor unit that is located outdoors. In response, the compressor will circulate refrigerant through refrigerant lines to the evaporator.

Some air handlers provide two stages of heating, cooling, or both. The first stage usually provides about 60% as much heating or cooling capacity as the second stage, although the percentage varies between models. When the full capacity is not needed to maintain the desired temperature, using the first stage is more efficient and provides better comfort. There are various control strategies for deciding when to use first stage and when to use second stage. A common strategy is to use first stage for a set amount of time (10 to 12 minutes) and then go to second stage for the remainder of the heating or cooling call. More sophisticated strategies require more inputs. Modulating equipment can adjust capacity to effectively any level between a minimum capacity and a maximum capacity. (Note: the App does not currently support modulating equipment.)

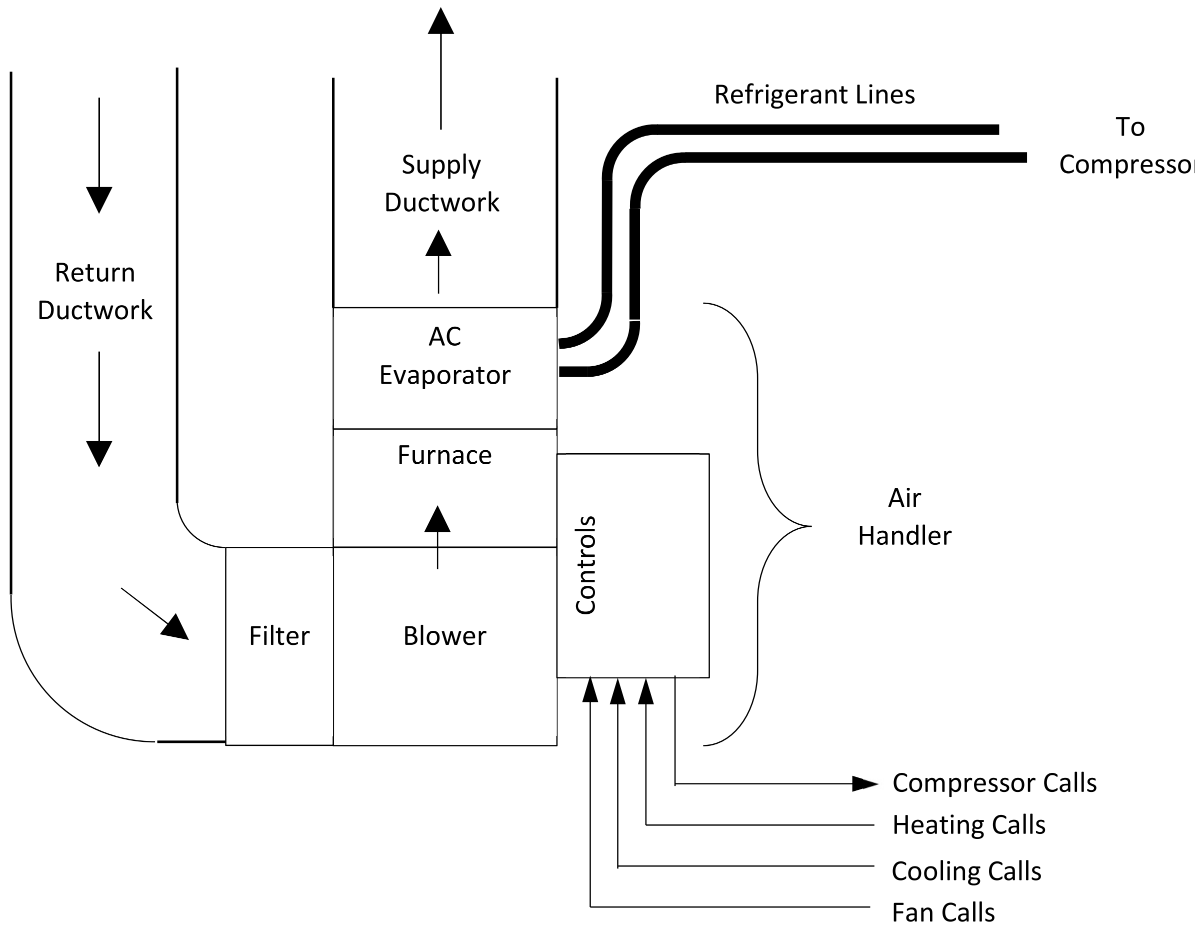



Fig. 1 - Air Handler

Figure 2 shows the supply side of a typical un-zoned forced air HVAC system. The air handler takes in air from a return duct (not shown), and then blows heated or cooled air into a plenum. From the plenum, the air flows through one or more trunk ducts. Branch ducts conduct the air from the trunk ducts to registers in individual rooms. Air from the rooms then flows back to the air handler through the return ducts.

A thermostat measures the temperature of the air and compares it to a heating setpoint, a cooling setpoint, or both. In heating mode, when the air is cooler than the heating setpoint, the thermostat sends a heat call to the air handler, causing the air handler to run in heating mode to warm up the interior air. Once the air at the thermostat is warmer than the heating setpoint, the heating call ends and the air handler shuts off. To avoid cycling on and off too frequently, the thermostat doesn't call for heat until the air is a little less than the setpoint and doesn't end the heat call until the air temperature exceeds the setpoint by some margin. Cooling mode works similarly. The thermostat calls for cooling when the air temperature is a little above the cooling setpoint and ends the cooling call when the air temperature has decreased below the cooling setpoint by some margin.

Designers of the duct system try to set up airflow rates to each room based on average heat loss (or gain) rates. Upstairs rooms tend to have high cooling loads relative to their heating loads. If the designer sets the airflow to these rooms based on heating loads, they end up being under-cooled during summer. If, on the other hand, the designer sets the airflow to these rooms based on cooling loads, then they tend to be over-heated during winter. The designer may end up picking a middle level with the result that the upstairs rooms end up a little too warm all year. Basements, on the other hand, tend to have very low cooling loads relative to their heating loads.

Sometimes, a few rooms may temporarily have unusually high internal heat gains, for example from sunshine coming in particular windows, people gathering in particular rooms, cooking, running a fireplace, etc. Designers of un-zoned ductwork cannot do anything about these temporary differences between rooms. The system makes the space around the thermostat comfortable but other spaces may be uncomfortably warm or cold.

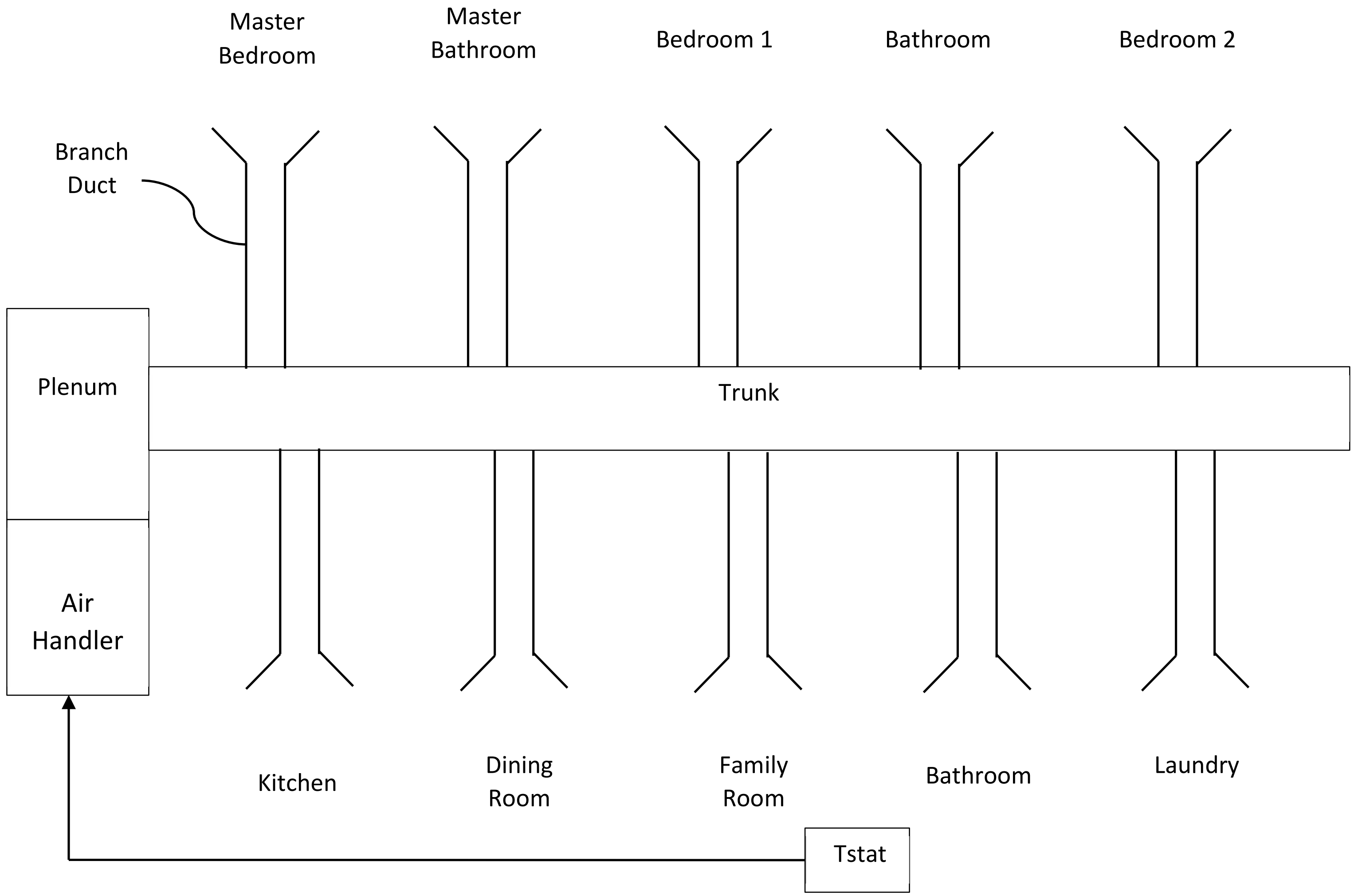



Fig. 2 - Single Un-zoned Ducted HVAC system

Figure 3 shows a HVAC system with two independent air handlers and duct systems. This solves the problems with upstairs and downstairs having different loads. The upstairs system may have a larger air conditioning capacity and a smaller heating capacity than the downstairs system. The upstairs system uses its own thermostat, so it runs when and only when air upstairs needs conditioning. There can still be variations between rooms on each of the floors based on unequal internal gains.

A drawback of this approach is that it requires two air handlers and, usually, separate air conditioning compressors. These tend to be the most expensive parts of the system. Although the equipment can be smaller, two units are considerably more expensive than one unit with double the capacity. This setup is common in two story houses in regions of the country where basements are not common. It is uncommon for a residence to have more than two independent ducted systems.

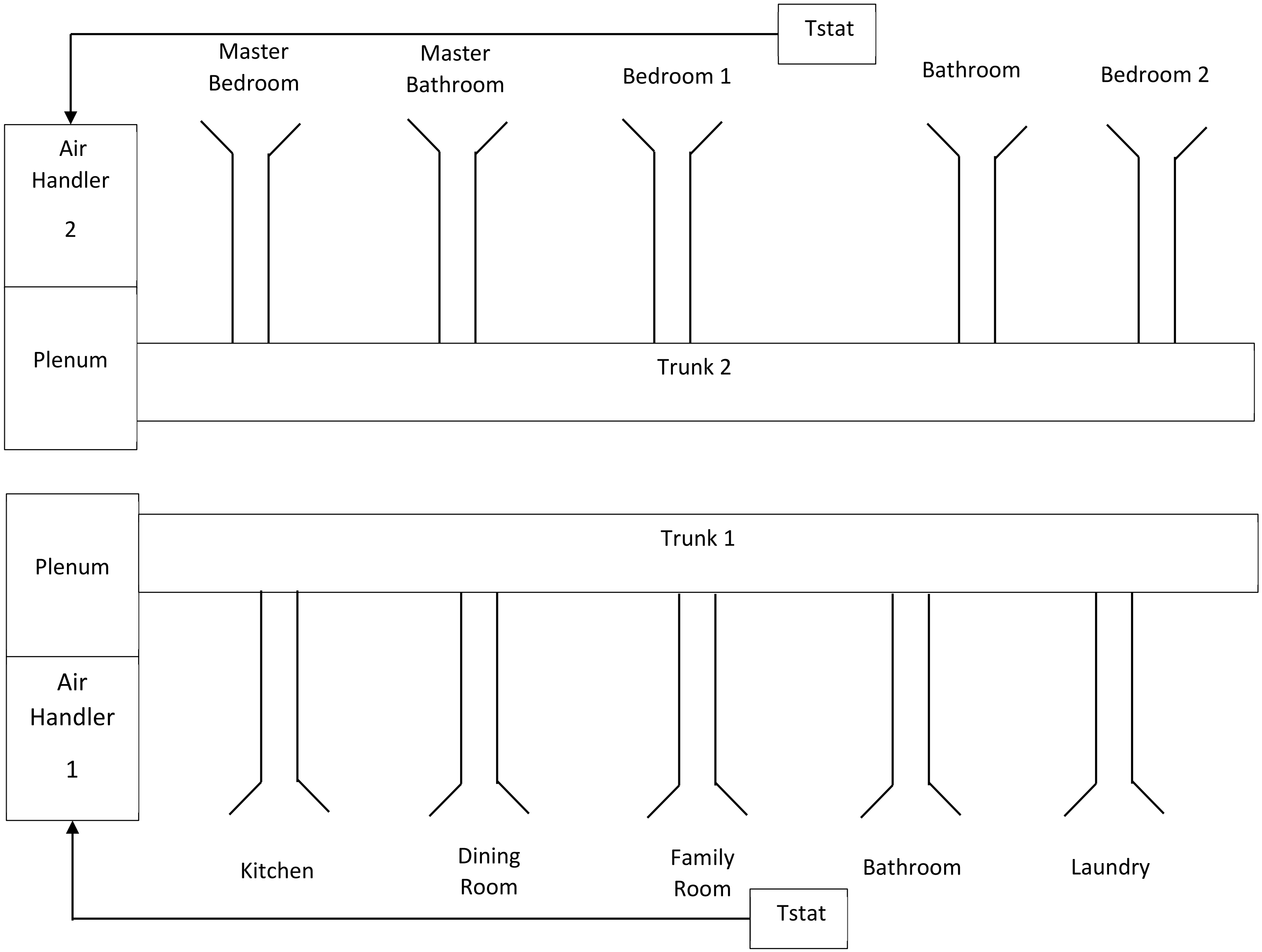



Fig. 3 - Multiple Un-zoned Ducted HVAC systems

Figure 4 shows a two-zone ducted HVAC system. Like the dual un-zoned system of Figure 3, the upstairs rooms and downstairs rooms are served by separate trunk ducts. However, both truck ducts are served by a single air handler. Zone dampers open and close to either allow air to flow into a truck duct or block air from flowing into the trunk duct. Each zone has a separate thermostat. A zone controller takes in commands from the thermostats and sends commands to the air handler and to the zone dampers.

If the downstairs thermostat is calling for heat but the upstairs thermostat is not, the zone controller opens the damper for the downstairs, closes the zone damper for the upstairs, and commands the air handler to produce heat. If both zones call for heat, the zone controller opens both zone dampers. If the zones have conflicting calls, the zone controller must choose which call to serve. Most commonly, this happens when one zone calls for heating or cooling while the other zone calls for fan only. In that case, the zone controller would likely give the heating or cooling call preference and ignore the fan command until the heating or cooling call is satisfied. It is rare to have one zone call for heating while another zone calls for cooling, but it can happen. In that case, the zone controller must alternate or give one type of call preference.

Two zone and three zone residential systems are common. However, it is problematic if any zone is too small relative to the size of the whole system. The air handler must be sized to serve the heating and cooling loads of the whole house. When only the small zone is calling for heating or cooling, the air handler may produce more airflow than the single zone can handle. Pushing that much air through a single trunk duct and a few branch ducts may result in excessive pressure which can be harmful to the fan motor. It may also be noisy. This problem is exacerbated if the residents shut off the airflow to some of the registers, either intentionally or by blocking them with furniture or something else.

In addition to partitioning the house into zones as equally as feasible, there are a few things a system designer can do to mitigate the small zone issue. Some systems have a bypass duct between the plenum and the return duct with a damper that automatically opens if the pressure exceeds a threshold. Opening this damper reduces the amount of air going through the remainder of the ductwork. However, the air flowing into the air handler is warmer in winter and cooler in summer which can be problematic. In summer, the cooler air entering the air handler increases the likelihood of frost on the heat exchanger coils, making the heat exchanger much less efficient, and possibly causing equipment damage. (see https://www.greenbuildingadvisor.com/article/the-achilles-heel-of-zoned-duct-systems )

A better remedy is to adjust the closed position of some of the dampers such that some air flows into those zones even when they are not calling for heating or cooling. That works as long as the residents don't close off registers.

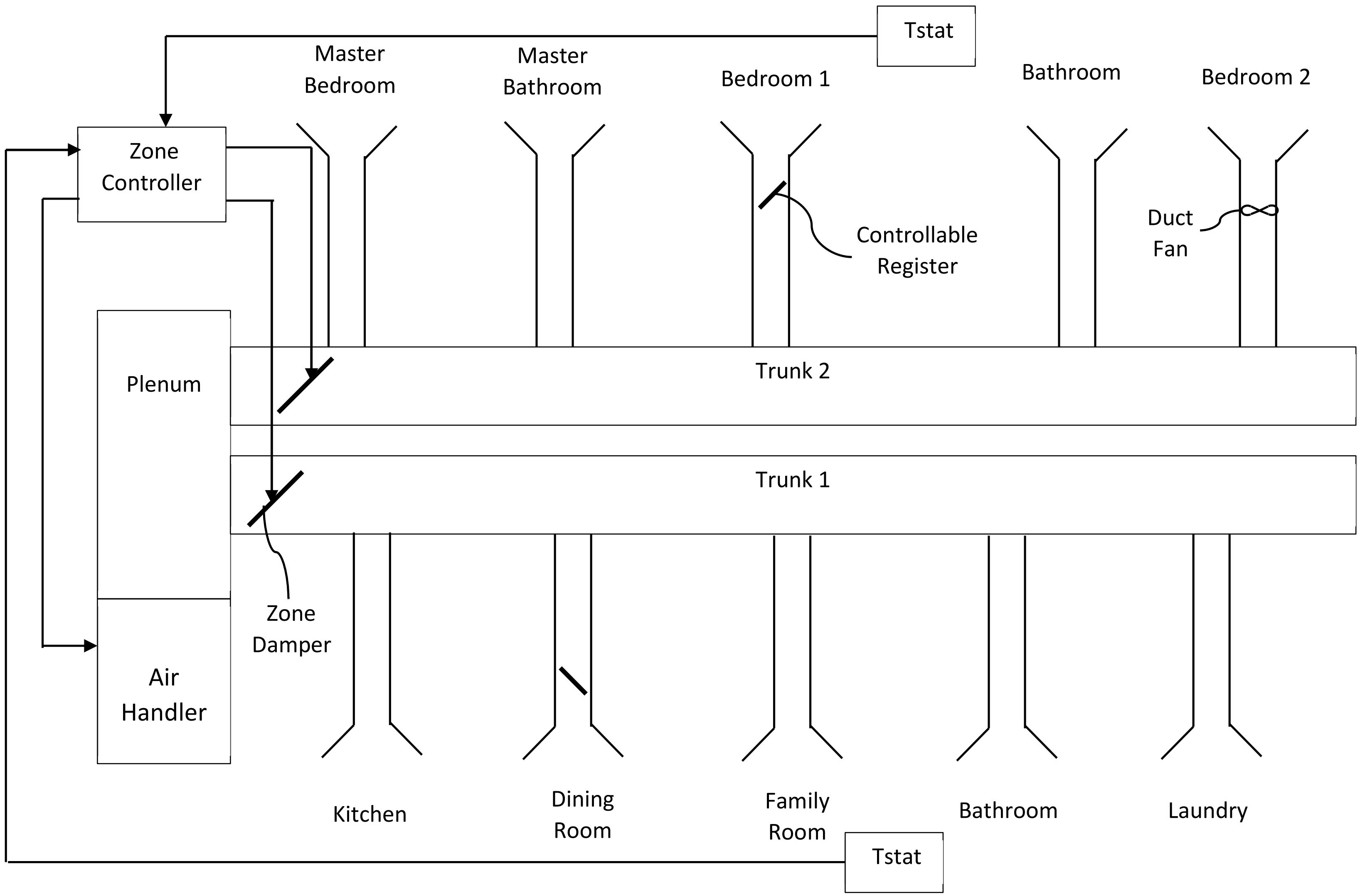



Fig. 4 - Zoned Ducted HVAC system

Residents often do modify the duct system by closing registers or installing controllable registers or duct fans. They may have rooms that they use infrequently, and they want to keep those rooms less conditioned to reduce heating and cooling bills. Sometimes, a room may tend to run warm or run cold relative to other rooms. As shown in Figure 4, there are controllable registers for the dining room on the first floor and for one of the bedrooms on the second floor. These may be electronically controlled, such as Keen (see https://keenhome.io/pages/how-it-works ). When these are closed, the respective zone effectively gets even smaller. It may end up smaller than the duct system designer planned for. Duct fans increase airflow to under-served rooms, such as a room that is far from the air handler.

# Zone Control and Equipment Control in the App

## General Principles of Operation

Like a conventional zone controller, the App receives requests from each zone, decides which requests it can serve, then selects the zones to be served and commands the equipment accordingly. In a conventional zone controller, the requests are binary. A zone is either requesting heat or not requesting heat. With the App, the zone requests a specified airflow rate. The App ensures that no more than the requested airflow rate is delivered to that zone. To accomplish this, the App needs information about the airflow capacity of each zone and the airflow provided by the equipment. This information is entered during setup. Exact data is not needed to make the system function properly. Rules of thumb should typically be adequate, as discussed in the sections below about describing your system to the App. These settings can be adjusted later if necessary.

There are a number of opportunities for users to specify how the App should handle various situations. The user can select from built-in control rules that are based on information commonly available in a Hubitat implementation, such as modes, presence sensors, etc. But no App developer can anticipate all of the information that may be available in a given home automation system and how that information could be useful for controlling an HVAC system. To make use of this information, the App permits users to specify virtual switches to control various decisions. Users can set the state of the virtual switch using rules based on whatever information is available in their system. The App then uses the switch state instead of or in addition to built-in control rules. In this way, behavior of the HVAC system may react indirectly to inputs never envisioned by the App programmer. This is how the Hubitat HVAC Zoning App makes use of the information that is not typically available to a zone control board from the furnace manufacturer.

Similarly, the App outputs are switch devices. During setup, the user specifies which switches the App should set for each output. In some cases, the user may specify a physical switch that directly controls the system. In other cases, the user may create a virtual switch and link that switch to physical devices through rules.

The App is structured hierarchically. There is a main App which controls the equipment and child apps for each zone. Some zones may be directly served by the equipment. These zones are typically selected by opening controllable dampers at the entrance of a trunk duct. Other zones are subzones of other zones, such as rooms with controllable registers (i.e. Keen vents) or duct booster fans. A subzone only gets airflow when the higher level zone is receiving flow.

Each zone demands heating or cooling when its thermostat issues a heating or cooling call. In addition, a zone can volunteer to accept heating or cooling in the absence of a heating or cooling call. If a zone has subzones, then a heating or cooling demand from a subzone is honored only when the parent zone is accepting heating or cooling, respectively. Specifically, if the zone is accepting heat and a subzone demands heat, then the zone demands heat. The main App gathers requests from the top level zones and decides when to operate the equipment accordingly. If a zone is calling for heating but is not large enough to handle the airflow that the equipment generates in heating mode, the App looks for other top level zones that have volunteered to accept heating and selects those zones also.

For best system performance, zones should volunteer to accept heating or cooling only when either: i) the zone would not become uncomfortable if heating or cooling is provided, or ii) nobody is in the zone to notice. Toward that end, the App has a few built-in rules which may be selected to determine whether or not to volunteer. For example, the App may determine that heating or cooling would not make the room too warm or cold based on the difference between the current temperature and the setpoint, temperature trends, and/or recent heating or cooling calls. The App may determine that the space will not be occupied based on hub modes or presence sensors. Finally, the user can use a switch that can be set by rules based on other information in the particular home automation system.

Figure 5 illustrates the equipment control logic. When there have been no heating or cooling calls for awhile, the system is in Idle state. When a heating call starts, the system checks to see whether it can be served. If the zones calling for heat collectively have enough capacity for first stage heating, then the request can be served. If the capacity of calling zones is not sufficient, the App looks for zones that volunteer to accept heat and treats those as if they are calling for heat. The App turns on the heating equipment, selects the calling zones, and goes into HeatingL (locked heating) state. It stays in this state for a fixed amount of time to ensure that excessively short heating runs are avoided. If heating calls from zones change, the heating equipment stays on and the App selects enough zones to accept the airflow, directing it first to zones that have demanded heat, then, if necessary to zones that have volunteered to accept heat, and finally, if necessary to other zones. After sufficient time, it transitions into Heating state. It continues in heating state until there is no longer a servable heat call. After it ends a heat run, it transitions into a PauseH state for a fixed amount of time to ensure that there is a sufficient interval between runs. At the end of that interval, it goes into IdleH state, in which it will serve heating calls that arise but will not serve cooling calls. If no heating calls occur for a set time, it transitions back to Idle state where either heating or cooling calls may be served. This ensures that it does not rapidly transition between heating and cooling. These intervals are user adjustable. Cooling is handled in an analogous fashion. Whenever the system is an Idle or Pause state, the blower may be operated to serve fan requests or for ventilation, humidification, or dehumidification as described in more detail in a later section.

For two-stage equipment, it is generally desirable to use first stage as often as possible because that is most efficient and provides the greatest comfort.  However, second stage should be commanded when either the first stage is incapable of maintaining the setpoint temperature or if more rapid temperature increases are desired, such as after a setpoint change. The user may select from several built-in rules for triggering second stage. The decision can be based on a combination of continuous runtime in first stage, a temperature / setpoint difference, the total demanded heating airflow, and/or the current outdoor temperature. Additionally, the criteria may include a virtual switch which can be set based on other available information in the home automation system. The rule for selecting second stage may be different for heating than for cooling.

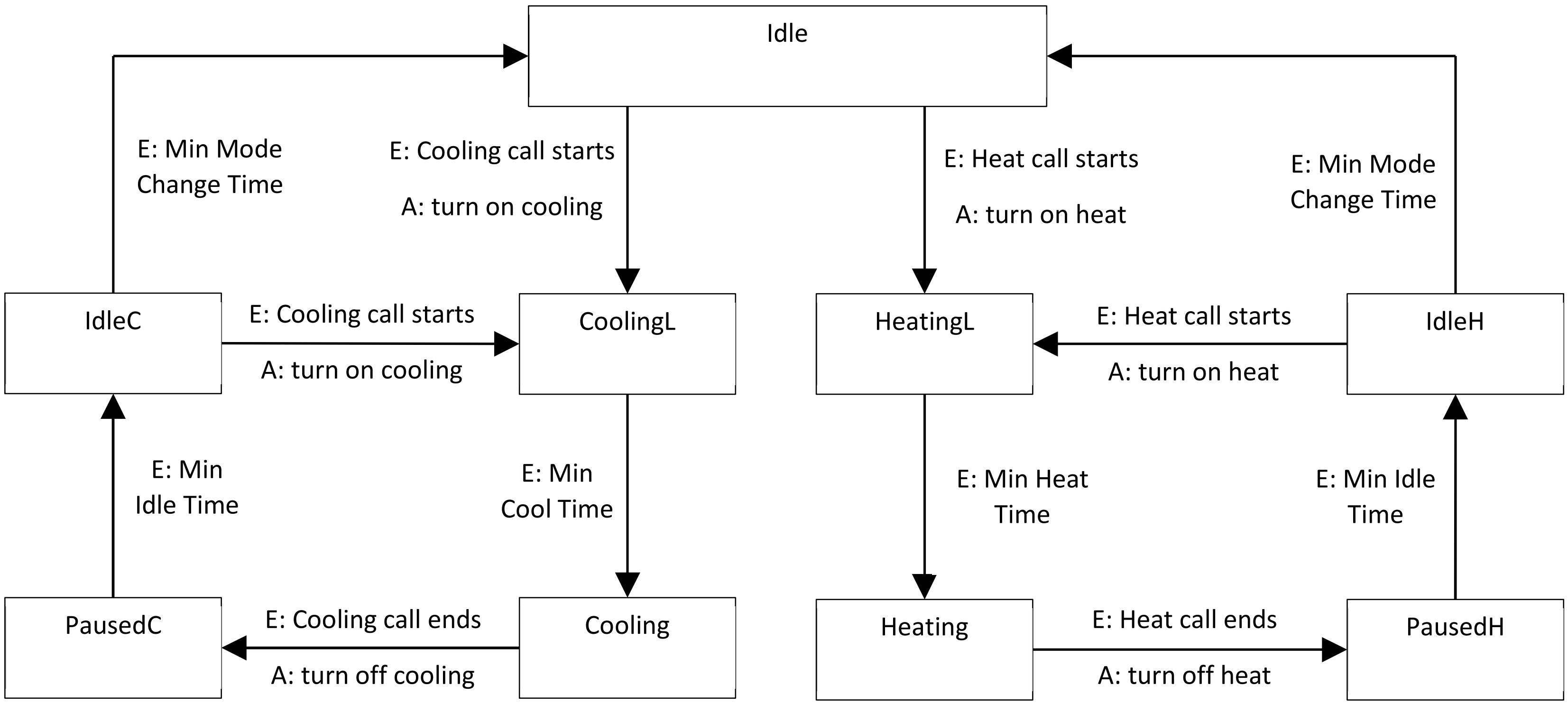



Fig. 5 – Equipment Control Logic

## Ventilation, Humidification, and Dehumidification Systems

A comfortable, healthy indoor environment requires more than just regulating the air temperature. The humidity must also be within acceptable limits and the air should be exchanged periodically with fresh outdoor air. Figure 6 illustrates some of the equipment that may be integrated with the air handler to provide these additional types of conditioning.

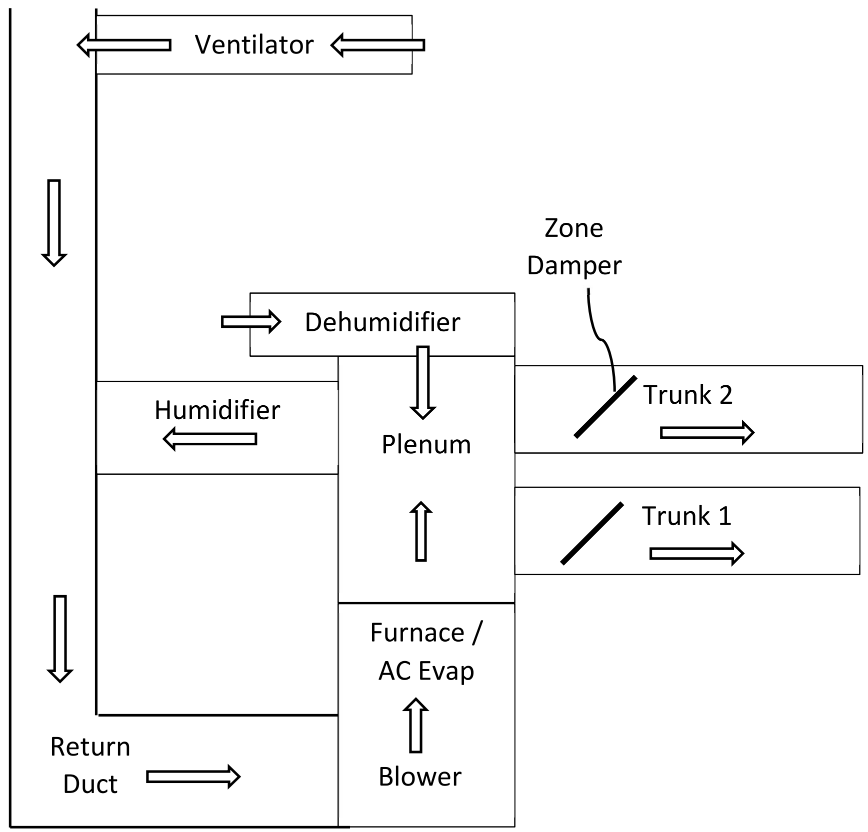



Fig. 6 – Ventilation, Humidity Control Equipment

Ventilation

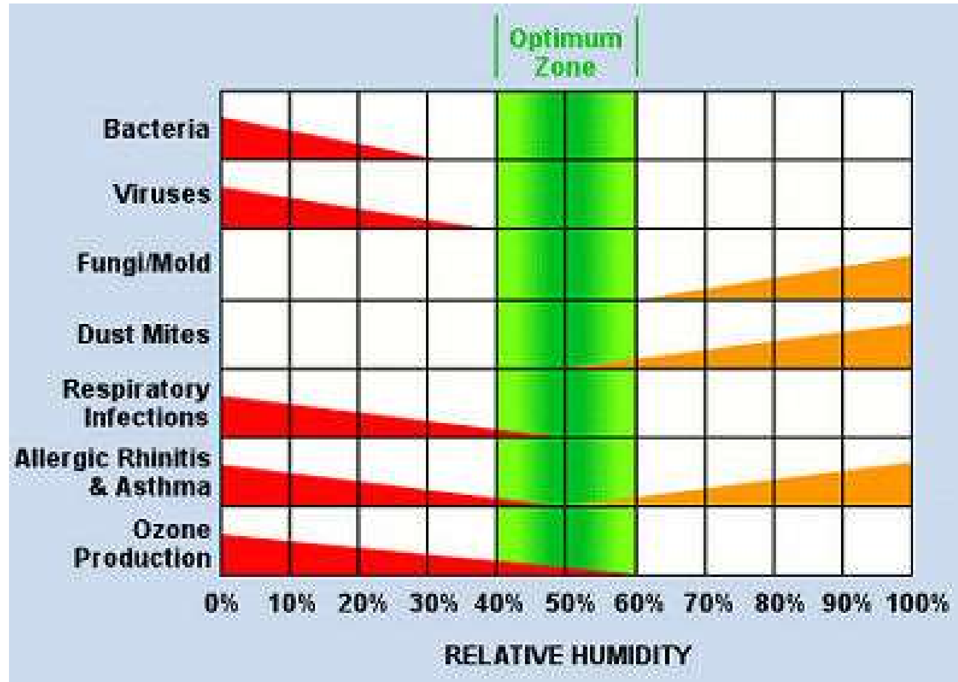
Indoor air tends to get polluted over time due to activities inside the house.  Breathing reduces the concentration of oxygen and increases the concentration of carbon dioxide.  Activities like cooking tend to produce Volative Organic Compounds (VOCs), some of which are unhealthy.  Some items within a home may off-gas hazardous VOCs.  Therefore, it is necessary to regularly exchange stale indoor air for fresh outdoor air.  However, excess air exchange increases the heating and cooling loads and costs.  Older homes typically are not very airtight, so these homes often experience excessive air exchange, leading to higher heating and cooling cost.  To combat these costs, builders have learned how to build houses that have low air leakage.  In newer homes or homes that have been upgraded to be more airtight, it is necessary to use mechanical systems to intentionally bring in an appropriate amount of fresh outdoor air.

There are several types of mechanical ventilation systems.  An exhaust only system uses a fan, such as a bathroom fan, to blow air out of the house.  That depressurizes the inside of the house causing air to come in wherever there are leakage paths.  Supply ventilation, on the other hand, uses a fan to blow outdoor air into the house, pressurizing the house and causing air to leave through leakage paths.  Balanced systems blow approximately equal amounts of air into the house and out of the house.  With a Heat Recovery Ventilator (HRV), the incoming and outgoing air streams go through a heat exchanger such that the incoming air is preconditioned to be near the same temperature as the indoor air.  Enthalpy Recovery Ventilators (ERVs) exchange both heat and moisture between the air streams.

With supply ventilation and balanced ventilation, the incoming fresh air should be distributed around the house.  (Exhaust ventilation doesn't provide an opportunity to control how fresh air is distributed.)  Some systems use separate ventilation ductwork to distribute the fresh air.  In other systems, the fresh air is injected into the return ductwork, as shown in Figure 6, and the air handler distributes the fresh air through the supply ductwork.  This is referred to as an interconnected ventilation system.  Interconnected ventilation systems are cheaper to install than systems with separate ductwork.  However, the operating costs are higher because the blower must run more than it otherwise would in order to distribute the fresh air.

The fraction of time that a ventilation system needs to run depends on what is happening in the house.  For example, when there are many guests in the house for a holiday, a lot of ventilation is needed.  When only a couple people are in the house, a moderate amount of ventilation is needed.  If the residents decide the outdoor temperature is comfortable enough to open windows, no mechanical ventilation at all is needed.  However, conventional ventilation controls don't have access to information about what is happening in the house, so typically an average amount is selected.

Humidification




Excessively low humidity in a house is a problem for several reasons. As illustrated by the diagram below, health threats such as bacteria and viruses are more prevalent when the relative humidity is very low. In some houses, attempting to keep the indoor humidity at 40% in the winter results in condensation on windows because the window surface is colder than the air in the middle of the room.

Some types of humidifiers operate independently of the forced air HVAC system. A common type of humidifier that is integrated with the HVAC system is illustrated in Figure 6. An HVAC integrated humidifier is typically located in a bypass duct that connects the plenum to the return duct. The bypass duct often includes a manual damper that must be opened before the humidifier will work properly. When the air handler operates in heating mode, heated air from the plenum goes through the bypass duct back to the return duct. The hot air blows through a mesh while water is dripped on the mesh, causing the water to evaporate into the air. This type of humidifier only works while the air handler is operating in heating mode. Another type of humidifier operates by injecting steam into the plenum. This type of humidifier requires the blower to be operating, either by itself or in conjunction with heating, to distribute the humid air.

## Dehumidification

Excessively high humidity in a house is a problem for several reasons. As illustrated by the diagram above, health threats such as fungus and mold are more prevalent when the relative humidity is high. Also, high humidity makes high temperatures more uncomfortable.

When an air conditioner operates in a home with high humidity, the air conditioner will reduce the humidity in addition to reducing the temperature. A number of factors influence how effective an air conditioner is at reducing humidity. An oversized air conditioner (which is common) is less effective at removing humidity than a properly sized air conditioner. Some air handlers have a dehumidify mode which reduces the airflow rate during air conditioning causing the system to remove more humidity while being slightly less effective at reducing temperature. In some climates, the air conditioner provides all the dehumidification that is needed. However, in other climates, the humidity may be problematically high while the temperature is not high enough to cause the air conditioning to run enough to adequately control the humidity. Sometimes, people set the cooling setpoint at an uncomfortably low temperature in order to get the humidity under control. In these climates, a better solution is to use dedicated dehumidification equipment that is not intended to reduce the air temperature.

Some types of dehumidifiers operate independently of the forced air HVAC system. A common type of dehumidifier that is integrated with the HVAC system is illustrated in Figure 6. The preferred way to install an HVAC integrated dehumidifier is for it to draw air from its own inlet and output the dehumidified air into the supply plenum for distribution through the house. With this installation, the dehumidifier’s fan pushes the air through the supply ductwork without requiring the air handler blower to run. In an alternative installation, the dehumidifier may output the dehumidified air into the return plenum instead. With the alternative installation, the air handler blower must operate to distribute the air through the supply ductwork. This increases the runtime of the blower. More importantly, when the dehumidifier and the air conditioner are both in use, the alternative installation makes the air conditioner less effective at removing humidity.

# Ventilation and Humidity Control Logic in the App

## Ventilation

The App ensures that ventilation is on for a specified percentage of each hour. To make it convenient to adjust this percentage based on conditions in the house, the App reads the percentage from a dimmer control. Normal ventilation is suspended if the dimmer control is turned off. Rules can be used to adjust the ventilation percentage based on whatever information is available to a particular home automation system. For example, the home automation system may determine the number of people in the house using presence sensors and command more ventilation when more people are present. If an air quality sensor indicates a high degree of indoor pollution, the percentage may be increased. If the home automation system knows, based on contact sensors, that the windows are open, rules may temporarily turn normal ventilation off. These adjustments are intentionally not programmed into the App because the App cannot anticipate what relevant information will be available in a particular installation.

The user may optionally indicate a switch for forcing the ventilation to be on. This is useful if the ventilation system accomplishes bathroom ventilation, for example. The switch could be the same switch used to turn on a light in the shower so that ventilation always runs when someone is showering. Or, it could be a virtual switch set by rules.

The App also allows users to indicate which zones should be selected when ventilation is running without heating or cooling equipment. This is useful for directing the fresh air to the zones that are occupied. Zones may be selected to receive ventilation based on hub modes and presence sensors. Additionally, the selection may utilize a virtual switch which can be set using rules. For example, a zone with bedrooms may be selected when mode is night, whereas a zone with the family room and kitchen may be selected during daytime modes. Specifying that a zone should receive ventilation does not guarantee that fresh air gets to those zones because heating and cooling calls take priority as described below. However, on average, it increases the percentage of fresh air going to the desired rooms.

The strategy used by the App to control ventilation depends upon whether the ventilation system requires the blower to operate when ventilating or not. If the blower is not required, then ventilation control is not impacted by heating and cooling calls. For these systems, the App simply turns the ventilation on for the first portion of each hour.

If the blower is required, the App attempts to schedule ventilation at the same time as heating or cooling calls. Coordination of the ventilation with heating and cooling calls provides several advantages:

- The blower runs less, saving energy. For example, if the ventilation system should run 30% of the time and the heating system needs to run 30% of the time, it is best if these are the same 30%.  If there is complete coordination, the blower only needs to run 30% of the time.  Without coordination, the blower could run as much as 60% of the time.
- It is less common for the blower to continue to run at the end of a cooling call. This makes the air conditioning more effective at reducing indoor humidity. When an air conditioning call ends, the evaporator coils are covered with droplets of water. If the blower continues to run, these droplets re-evaporate instead of dripping away and being permanently removed from the indoor air.
- Although an ERV or HRV pre-conditions the air so that it is not as cold in winter or hot in summer as outdoor air, it is still colder in winter and warmer in summer than the target setpoint. When ventilation runs by itself, it may be uncomfortable to have this air blown on occupants.  If the ventilation happens at the same time as a heating or cooling run, the fresh air is fully conditioned.

Humidification

Conventionally, an HVAC integrated humidifier is controlled by a humidistat mounted near the air handler. The humidistat may have a dial for setting the humidity setpoint which is labeled with outdoor temperatures in addition to percent humidity. This is based on the idea that the humidity setpoint should be as high as possible without causing condensation to form on windows. At low outside temperatures, the indoor humidity must be lower to avoid condensation on windows. The risk of condensation also depends upon the quality of the windows, which is not generally accounted for in the scale. In practice, few people adjust the control as outdoor temperatures change during the heating season. If you wish to continue using this type of control, then enter none for humidifier when setting up the App and it will continue to operate as before.

When the App is configured to control a humidifier, the App reads the relative humidity setpoint from a dimmer control. Humidification is suspended if the dimmer control is turned off.  Rules can be used to adjust the relative humidity target based on whatever information is available to a particular home automation system.  For example, the home automation system may include an outdoor temperature sensor upon which the humidity target can be based to avoid condensation. (See https://community.hubitat.com/t/release-ideal-indoor-winter-humidity-calculator/29039 for an App to do this.) An indoor humidity sensor must be specified.

Three types of humidifiers are supported by the App. If the humidifier is separate from the HVAC system, it is turned on when then indoor humidity is less than the target. This is checked every 30 minutes. If the humidifier requires heating, it is turned on during heating runs if the indoor humidity is less than the target at the beginning of the heating run. If the humidifier requires fan, it is turned on when the humidity is less than the target and the fan is also turned on if a heating run is not in progress. As with the non-integrated type, the condition is checked every 30 minutes.

The App allows users to indicate which zones should be selected when humidification is running.  This is only relevant for a humidifier that requires fan but not heat. Zones may be selected to receive humidification based on hub modes and a humidity sensor, which isn't necessarily the same sensor used to control whether or not the humidifier runs. Additionally, the selection may utilize a virtual switch which can be set using rules. If humidification occurs at the same time as ventilation or heating, the zones are selected based on the ventilation or heating rules respectively.

Dehumidification

When the App is configured to control a dehumidifier or to control the dehumidification mode of an air conditioner, the App reads the relative humidity setpoint from a dimmer control.  Dehumidification is suspended if the dimmer control is turned off.  The relative humidity target for dehumidification is set separately from the target for humidification. If both are set, the App forces them to be at least 10% apart from one another. The App runs the dehumidifier when the indoor humidity is higher than the setpoint and the air conditioner is not running. If the dehumidifier sends its output to the return plenum, then the blower is also turned on. The ventilation control treats the blower being on for dehumidification as an equipment on state.

The App allows users to indicate which zones should be selected when dehumidification is running.  Zones may be selected to receive dehumidification based on hub modes and a humidity sensor, which isn't necessarily the same sensor used to control whether or not the dehumidifier runs. Additionally, the selection may utilize a virtual switch which can be set using rules. If ventilation and dehumidification occur at the same time, the zones are selected based on the ventilation rules.

# Physical Device Setup

Air handlers are typically set up to receive commands from thermostats via low voltage (24VAC) wiring.  It is necessary to modify the wiring such that the equipment gets its control signals from devices controlled by the home automation system.  The purpose of this section is to provide guidance in that process. Two examples are provided, a relatively simple example and a more complex example. Particular installations may need to combine features of each depending on what equipment and duct configuration are present.

<u>Compatible Thermostats</u>

Before embarking on re-wiring your system, make sure you have suitable thermostats.  The App will not do a good job unless it gets the necessary information from your thermostats in a timely manner.  Specifically, the home automation system needs to receive events for operating state changes (i.e. cooling, heating, fan only, idle).  Some thermostat integrations don't do a good job of promptly sending state change information from the thermostat to the home automation system. I will update this document as I get feedback about thermostat makes and models that work well and those that don't.

- Thermostats that have been confirmed to work well
  - Zen (Zigbee) – Once I got the thermostat installed and properly configured, it reliably and promptly communicated operating state changes via Zigbee at the same time that it sends them via the 24VAC interface. I particularly like that it reports temperature to the tenth of a degree. However, it doesn't report temperature changes very often unless Refresh is called.
  - GoControl (ZWave) – Reporting is prompt. I haven't used it long enough yet to have an opinion about battery life.
  - Honeywell T6 (ZWave) – I have not personally tested this one, but a commenter on Hubitat Community conducted tests and found that it reports state changes promptly.
  - Vivint CT-200 (ZWave) – I have not personally tested this. A commenter on Hubitat Community says that it does report state changes promptly and reliably.
- Thermostats that work with caveats
  - Radio CT100 (ZWave) – Uses Generic Thermostat device driver in Hubitat. State changes and temperature changes are not reported promptly via Zwave unless refresh is called. This may be satisfactory if the refresh function is called regularly (i.e. every five to ten minutes). However, when I call refresh every five minutes, I have noticed that the battery life seems pretty low, so wired power is recommended.

    - Radio CT101 (ZWave)– I have not personally tested this model. However, a commenter on Hubitat Community mentioned that it does not update operating state reliably unless you send refresh requests, like the CT100.
    - Centralite Pearl (Zigbee) – I have not tested this one, but a commenter on Hubitat Community said it doesn't report temperature changes promptly unless you call refresh(). The commenter didn't mention whether it reports state changes promptly or not.
    - Hubitat virtual thermostat plus a temperature sensor - Rule machine may be used to change the virtual thermostat temperature value based on the temperature sensor. The hysteresis of the virtual thermostat should be set higher than the granularity of the temperature sensor to avoid oscillations. (Although the minimum equipment on time and minimum equipment off time in the App make that not that big of a problem.)
- Thermostats that are NOT recommended
    - Emerson Sensi (cloud) – An integration is available for SmartThings but not for Hubitat.  The SmartThings integration does not reliably report state changes, although it appears to reliably report temperature changes and setpoint changes.
    - Ecobee (cloud) – Integrations are available for both Hubitat and SmartThings. These integrations rely on polling as opposed to event-based reporting. State changes among idle, heating, and cooling are reported correctly most of the time, but I observed occasional reports of idle state when I knew the thermostat was in cooling state. It doesn't seem to report fan commands in the state changes (at least not those related to the Auto-5 fan setting).
- Thermostats that have not yet been tested
    - Nest (cloud) – I suspect that Nest has the same issues as the other cloud integrations, but I haven't tested it.

When a thermostat does not reliably report state changes to the home automation system via an integration or via a direct radio interface, it is theoretically possible to use additional hardware to physically sense the low voltage signals that would typically be provided to an air handler or zone controller and communicate those signals to the home automation system. I have had some success doing this, but I have also had enough failures that I do not recommend it to others unless you are up for engineering it yourself.

Zooz ZEN16 Multirelays


The examples below use Zooz ZEN16 multirelays, so I wanted to share some of what I have learned about using these devices. Each of the three relays in these devices are designed to handle at least 15 amps. As such, I found that the connectors are designed for much larger wire diameter than the 18 gauge thermostat wire typically used for HVAC wiring. I had trouble tightening the provided screw enough to securely hold thermostat wire. Furthermore, if you attach the ZEN16 to a board, the screw heads are on side against the board and therefore unreachable. The solution I came up with is shown in the photo. I placed short pieces of 12 gauge wire in the ZEN16 connectors before attaching the ZEN16 to a board. Then, I connected thermostat wire to the 12 gauge wire using lever nuts.

The ZEN16s can be powered by the 24VAC transformer in the furnace as shown in the wiring diagrams below. Alternatively, they can be powered by USB cables, which may be more convenient.

In some setups, like Example #2 below, a large number of terminals are connected to 24VAC (red) and Neutral (blue). I found it useful to attach bus bars to the board for at least these two signals.

Example #1 – Single Primary Zone with Subzones

This first example includes one primary zone with three subzones. Two of the subzones are created by controllable vents. This example assumes that the controllable vents have an integration with the home automation system such that they can be selected directly as switches. One of the subzones is created by a duct fan. The air handler is a single stage air handler (or a two stage air handler that manages staging by itself, which is treated by the App as a single stage air handler). The duct fan is assumed to be a plug-in fan which can be plugged into a smart plug. The Enthalpy Recovery Ventilator (ERV) is also controlled with a smart plug.

A Zooz ZEN16 multirelay is used to send heating calls, cooling calls, and fan calls to the air handler. The W1, Y1, and G terminals of the air handler are connected to both the ZEN16 and to the thermostat. This is called a "wired-OR" configuration. The air handler will respond if either the app or the thermostat call for heating, cooling, or fan. When the primary zone calls for heating or cooling, both the thermostat and the ZEN16 will send the same commands. However, the thermostat will not send commands when a heating or cooling call is generated as a result of a subzone heating or cooling command. The purpose for retaining the wired thermostat connections is to make the system robust to issues with the home automation system, such as if it goes offline or reboots. Calls from the thermostat will continue to trigger the air handler through the hard-wired connection. The ZEN16 can be configured to go to a default state when it hasn't received any signals for a specified time. This setting can be used to ensure that it does not continue to call for heating or cooling if the home automation system goes offline during a heating or cooling call.

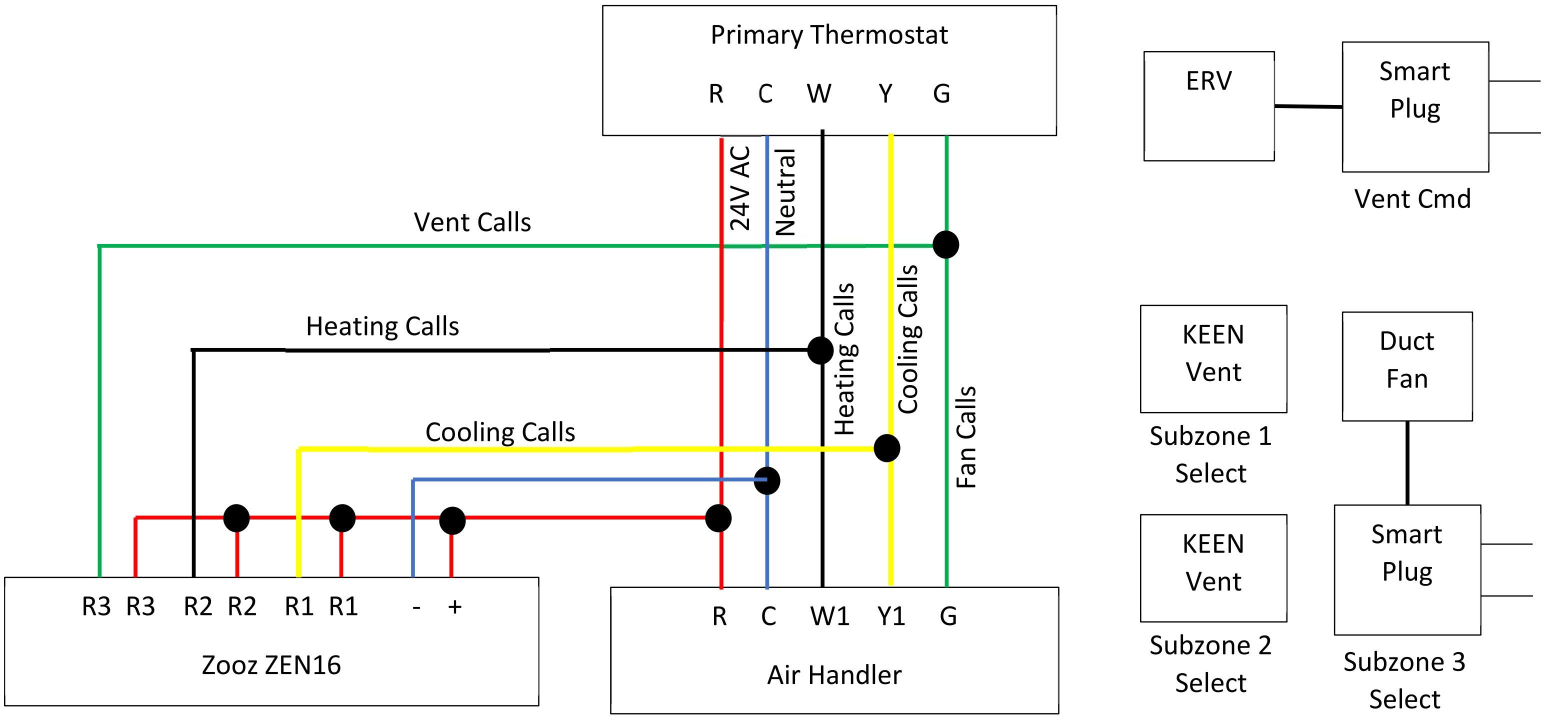



Fig. 7 – One Primary Zone with Subzones

Example #2 – Three Primary Zone System

This second example is a three zone system with zone dampers for each zone. None of the zones have subzones in this example, but if they did, each subzone would be selected in the same ways that are illustrated in Example #1.

Four ZEN16s are used in this example. One ZEN16 (labeled Equip) is devoted to communicating first stage heating and cooling calls, as well as fan calls to the air handler. A second ZEN16 (labeled Staging) sends second stage heating and cooling calls. A third ZEN16 (labeled Zone Select) is devoted to controlling the zone dampers. Finally, a fourth ZEN16 (labeled Vent & Hum) controls the ventilator, the humidifier, and the dehumidifier. The thermostats for one of the three zones is wired to the air handler in a wired-OR fashion like Example #1. If the home automation system goes offline for some reason, the system will operate like a non-zoned system as shown in Figure 2.

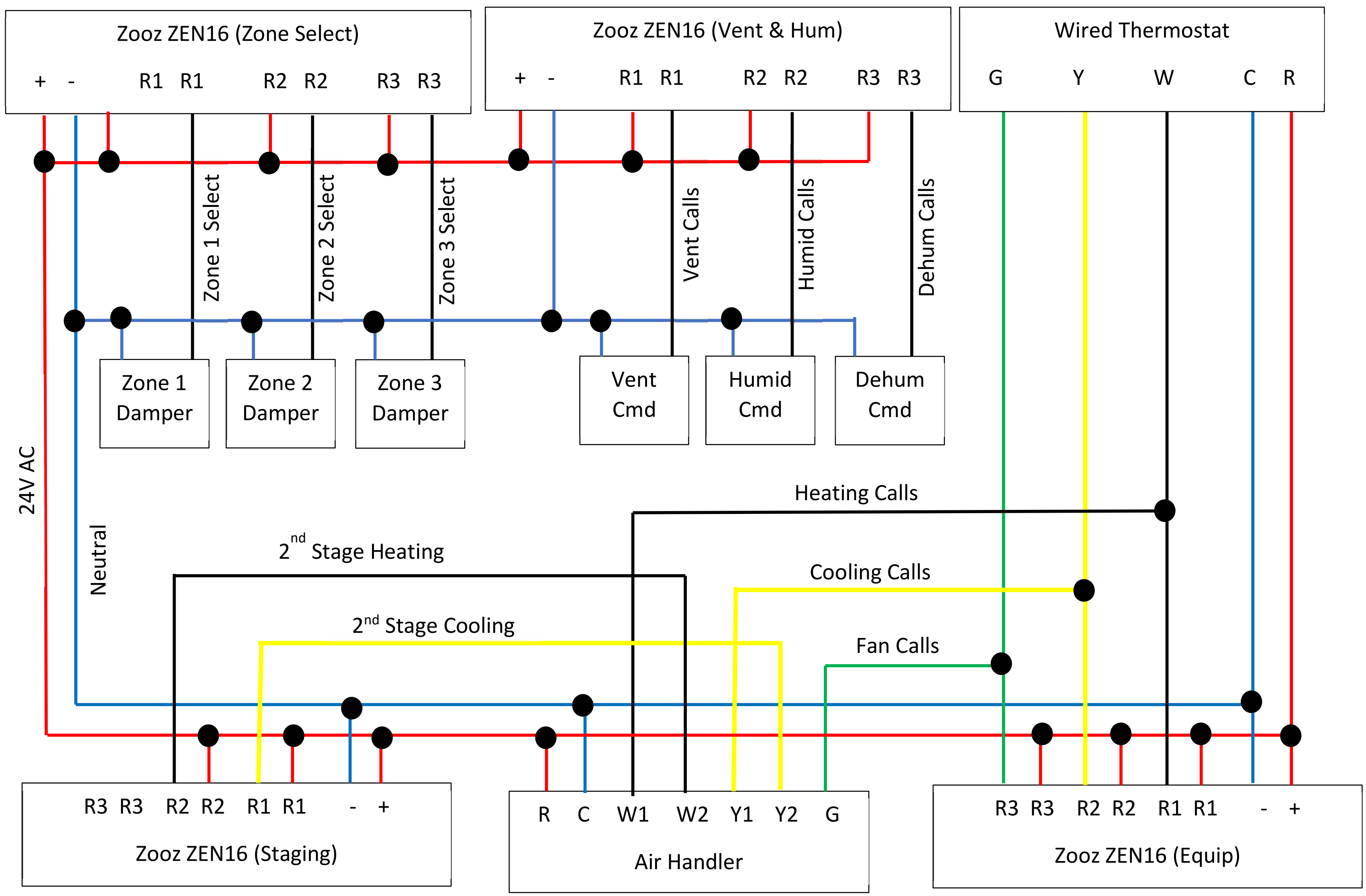



Fig. 8 – Three Primary Zones

# Downloading, Installing, and Configuring the App

## Downloading and Installing

The easiest way to install the App is to use Hubitat Package Manager. Alternatively, the following files can be manually downloaded from github and saved.

Download the following files into Hubitat's App Code section and save them:

https://raw.githubusercontent.com/rbaldwi3/HVAC/master/HVAC_Zoning.groovy

https://raw.githubusercontent.com/rbaldwi3/HVAC/master/HVAC_Zone.groovy

Download the following file into Hubitat's Drivers Code section and save it:

https://raw.githubusercontent.com/rbaldwi3/HVAC/master/HVAC_Zone_Status.groovy

## Gather Information You Will Need

During installation of the App, you will be asked for information about your equipment and your duct system. It is easier to gather the information in advance so you don't need to interrupt the process of installing the App to find information. First, you will be asked for the airflow rate provided by your air handler in various modes (first and second stage heating, first and second stage cooling, and fan only). Ideally, this data should be obtained from your equipment technical manual, but don't worry if you don't have that handy or if it doesn't make sense to you. Some rules of thumb will likely get close enough that the system operates properly.

The model number of the furnace is usually on a sticker and indicates the nameplate capacity. Model numbers beginning with 040 are 40,000 btu/hr, 060 are 60,000 btu/hr, etc. If you take the number represented by the first three digits of the model number and multiply by 20, that is a decent approximation of the airflow in the highest heating stage. For example, if the model number is 0801716, use 1600 cfm for the airflow of the highest stage. For a two-stage furnace, the airflow for the first stage is about 60% of the airflow for the higher stage. If you have a two stage furnace, but are letting the furnace select stages by itself, then enter it into the App as a single stage furnace with the airflow based on the unit's second stage.

Air conditioners typically have nameplate capacities in multiples of 12,000 btu per/hr, which is called one ton of cooling capacity. For example, a four ton air conditioner has a nameplate cooling capacity of 48,000 btu/hr. The capacity of an air conditioner, in thousands of btu/hr, is typically indicated by three digits in the model number, starting with a 0. For example, the model number GSXC160361C has a capacity of 36,000 btu/hr, or three tons. The airflow for an air condition is typically about 400 cfm per ton of nameplate capacity in the highest stage. For a two stage air conditioner, the airflow for the first stage is about 75% of the airflow for the second stage, or about 300 cfm per ton of nameplate capacity. Therefore, if you have a three ton (36,000 btu/hr) two stage air conditioner, enter 900 cfm for first stage and 1200 cfm for the second stage if you will be letting the App control staging. As with furnaces, if you are going to let the air handler decide when to use second stage, then tell the App that it is a single stage air conditioner and enter the highest stage airflow. The fan-only airflow rate is typically about half of the heating airflow rate.

If you have a dehumidifier that is interconnected with the supply plenum, then you will be asked to enter the airflow of the dehumidifier. The dehumidifier airflow will typically be much lower than the heating or air conditioning airflow. A reasonable rule of thumb would be 2 cfm per pint of dehumidification capacity. In other words, for a dehumidifier rated at 75 pints per day, enter 150 cfm of airflow.

You will also be asked to enter a maximum airflow for each zone. As a rule of thumb, count the number of registers in the zone and use 200 cfm for each 4x10 register and 300 cfm for each 6x10 register. It is the capacity of the zone relative to the equipment airflow that matters. The entered zone capacities can be changed later if the system isn't functioning properly. If the entered capacity of a zone is less than the entered air flow rate of the equipment, then the App will not serve that zone by itself. It will either wait until other zones also make heating or cooling calls or other zones volunteer to accept heating or cooling. Therefore, entering zone capacities that are too small will result in the App not serving that zone as well. As a general rule, any primary zone capacity less than half of the lowest stage heating and cooling capacity is a concern. For subzones, low capacity is less of an issue since subzones are not served by themselves anyway. If you enter too large of a capacity for a zone, the App may command your equipment to push too much airflow through the ductwork to that zone. If there is a pressure sensor in the ductwork, it will indicate excessive pressure. A common symptom of excessive flow to a zone is noisy ducts. If you notice excessive noise when one zone is the only zone calling for heating or cooling, consider reducing the capacity entered for that zone to less than the number you entered for the corresponding equipment airflow.

<u>Create Needed Virtual Devices</u>

During installation, you will be asked to specify a number of devices. The needed physical devices should have been created based on the physical device setup section. You may also need to create some virtual devices. Which virtual devices you need to create will depend on what equipment you have and what options you select for many of the control rules. Here is a checklist of devices to consider:

- Every zone, including subzones, requires a thermostat. If you are relying on a temperature sensor as opposed to a physical thermostat for any of your zones, create a virtual thermostat device.
- Virtual dimmer devices are used to control ventilation, humidification, and dehumidification.
- One of the control options for deciding when to use second stage for heating or cooling is a switch. If you intend to use this option, create the necessary virtual switch devices.
- For each zone, switches are one of the control options for deciding when the zone should accept ventilation or dehumidification or volunteer to accept heating or cooling. If you intend to use this option, create the necessary virtual switch devices.

Configuring the App

Within the Apps section, click the Add User App button and select HVAC Zoning. Configuring the App involves entering information about the equipment on several pages and then configuring the zones. Upon adding the App, the first thing you will need to do is assign a label for the App, which is what it will be called in the Apps tab in Hubitat.

Next, you will be asked to specify what heating and cooling equipment is to be controlled. The choices are Furnace only, Air Conditioning only, or Furnace and Air Condition. (Heat pumps are not presently supported.) For both heating and cooling, if present, you must specify whether the equipment is single stage or two stage.  If you have two stage equipment, but it is set up to handle staging logic by itself, then you should specify single stage. Modulating equipment and equipment with more than two stages is not currently supported.

If you have air conditioning, you will be asked whether it supports a dehumidify operating mode. Move the slider to the right if the equipment has dehumidify mode and you will be having the App utilize this mode. The dehumidify mode switch operates opposite of other switches. The switch is turned off during cooling calls to utilize dehumidify mode and turned on during cooling calls to use the normal mode. If selected, the App will utilize dehumidify mode during cooling calls if the sensed humidity is greater than an upper limit.


Next, you will be asked to indicate what ventilation, humidification, and dehumidification will be controlled by the App. For ventilation equipment, the choices are None, Requires Blower, and Doesn't Require Blower. If you indicate Requires Blower, the App will attempt to coordinate ventilation commands with heating and cooling calls and will command the fan when ventilation is commanded outside of heating and cooling calls. If you indicate Doesn't Require Blower, the App will command ventilation for the desired percentage of each hour but will make no attempt to coordinate ventilation with other equipment. If you have ventilation equipment but you don't want the App to control it, then indicate None.

For humidification equipment, the choices are None, Separate from HVAC ductwork, Requires Fan, and Requires Heat. If you have a humidifier but you don't want the App to control it, then indicate None. If you indicate Separate from HVAC ductwork, the App will command humidification whenever the sensed indoor humidity is less than a lower limit. If you indicate Requires Heat, then the humidifier will be commanded to operate during heating calls if the sensed indoor humidity is less than a lower limit.

For dehumidification equipment, the choices are None, Separate from HVAC ductwork, Outputs to Supply Plenum, and Outputs to Return Plenum. As with other equipment types, if you have a dehumidifier but you don't want the App to control it, then indicate None. If you indicate Separate from HVAC ductwork, the App will command dehumidification whenever the sensed indoor humidity is less than a lower limit without regard to what the heating and cooling equipment is doing. If you indicate Outputs to Supply Plenum, then the dehumidifier will be commanded to operate whenever the heating and cooling equipment is NOT operating and the sensed indoor humidity is above an upper limit. If you indicate Outputs to Return Plenum, operation is similar to Outputs to Supply Plenum except that the fan is commanded whenever dehumidification is commanded.


On the second page, you will be asked to enter the airflow rates for your equipment. Depending upon which equipment types you specified, you may not be asked for all of the data in the screenshot below.


After you enter the airflow data, you need to specify a switch for each of the outputs. The App will turn these switches on to turn the equipment on (except for Air Conditioner Dehumidify mode, which works backwards). Physically connecting the switches to the equipment is discussed in the previous section. Depending upon which equipment types you specified, you may not be asked for all of the devices illustrated in the screenshot below.

Equipment Control Switches

Command Heat stage 1 (probably labeled W/W1 on furnace) *
Heat Cmd

Command Heat stage 2 (probably labeled W2 on furnace) *
Heat2 Cmd

Command Cooling stage 1 (probably labeled Y1 on furnace) *
Cool Cmd

Command Cooling stage 2 (probably laeled Y/Y2 on furnace) *
Cool2 Cmd

Command Dehumidify mode *
Dehum Mode Cmd

Command Fan (probably labeled G on furnace) *
Fan Cmd

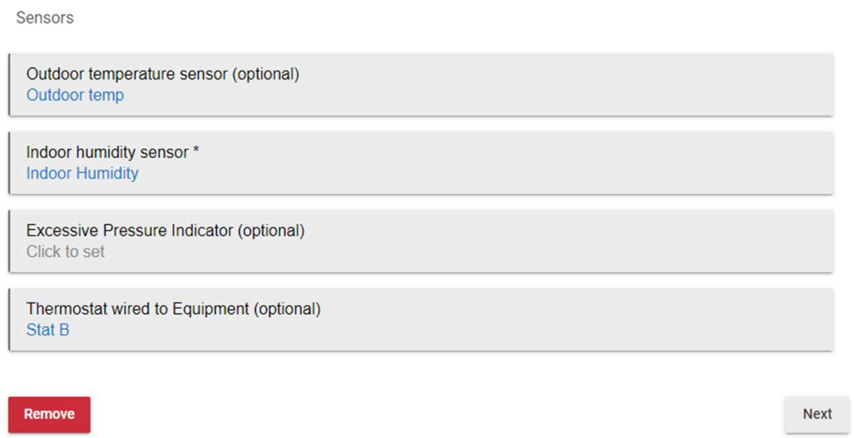
Command Ventilation Equipment *
Vent Cmd

Command Humidifier *
Hum Cmd

Command Dehumidifier *
Dehum Cmd

Next, you will be given the opportunity to indicate some additional sensors, some of which are optional. For example, if you indicate an outdoor temperature sensor, you will be able to use the readings from that sensor to control equipment staging if you choose to. If you have humidification equipment or dehumidification equipment, or your air conditioner has a dehumidify mode, an indoor humidity sensor is required. Otherwise, it is optional. If you have an over-pressure sensor readable by your home automation system, you can optionally indicate that device to the App. If an over-pressure is indicated, the App will adjust to relieve the over-pressure by deselecting stage 2 if it is selected and selecting additional zones.

If you have one of your thermostats wired to your equipment, which is recommended but not required, then you should indicate that thermostat on this settings page. Specifying a wired thermostat on this page tells the App that it should avoid issuing any command that would be incompatible with the command from that thermostat. For example, if that thermostat is calling for heat and another thermostat is calling for cooling, the wired thermostat gets priority. Also, time limits between heating calls or between cooling calls are not enforced for this thermostat.

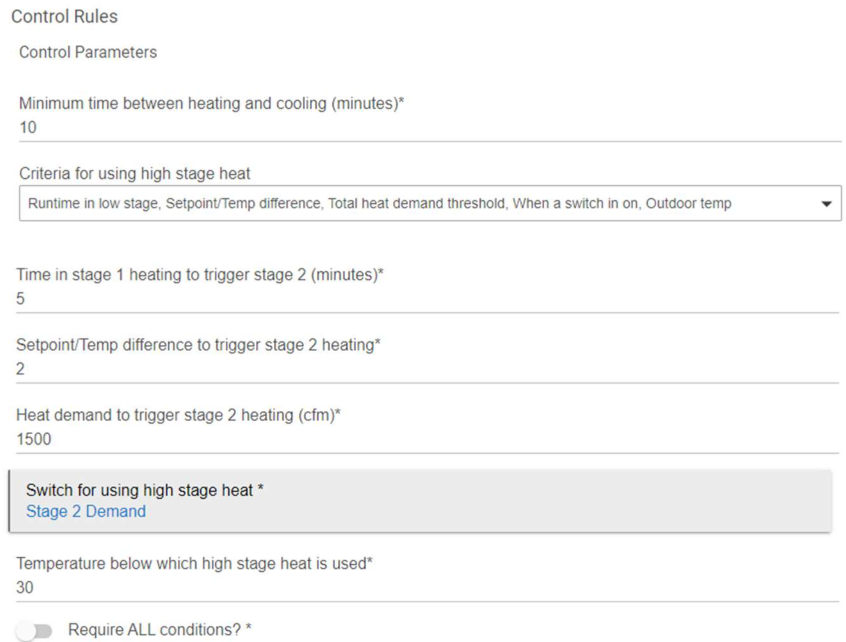



On the third settings page, you need to specify some control parameters.  It is hard on equipment to change rapidly between heating and cooling.  Sometimes, during transition seasons, one zone may call for heat at the same time that another zone is calling for cooling.  You can enter a minimum time between finishing serving a heating or cooling call and starting to serve the opposite type of call.  One exception to this happens if you have a thermostat wired to the equipment.  If that thermostat calls for heating or cooling, any command for the opposite mode will immediately terminate.

If you indicate two stage heating or cooling equipment, the App will ask for some parameters about when second stage should be used. A variety of criteria are available, including:

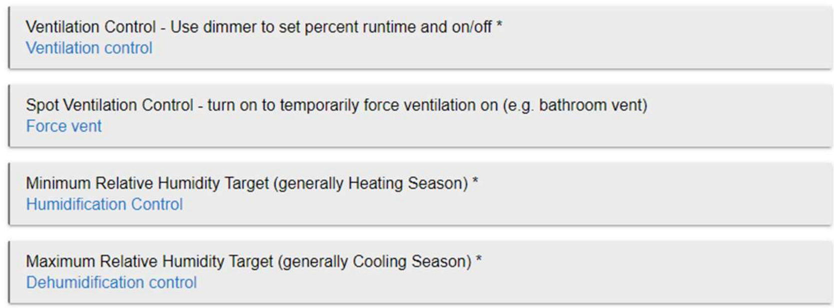
- Runtime in low stage,
- Setpoint/Temp difference,
- Total demand from all zones,
- When a switch in on, and
- Outdoor temp (if a sensor was specified).

You can choose as many criteria as you wish. If you choose no criteria, second stage will never be selected. If you choose two or more criteria, the App will ask whether it should select high stage when any one criteria is satisfied, or only when all criteria are satisfied. For some of the criteria, the App will need to ask for additional information.




For both heating and cooling, if present, the App will ask for the minimum time which the equipment should run once turned on and the minimum time it should remain off once turned off. Higher numbers ensure that the equipment does not cycle on and off too frequently. This is especially important for cooling, because the equipment does not do a good job of removing humidity unless it runs for at least 10-15 minutes at a time.

Virtual dimmers are used to control ventilation, humidification, and dehumidification. A dimmer device has both an on/off setting and a 0-100 level setting. For ventilation, the dimmer level is used to indicate what percentage of each hour ventilation should run. Ventilation is not run when the dimmer switch is in the off position. Optionally, you may indicate a switch device for temporary (spot) ventilation. When the spot ventilation switch is on, ventilation runs regardless of the amount of time that it has run recently and regardless of whether the ventilation dimmer is on or off. For humidification and dehumidification, the level is used to set the relative humidity targets. The on/off aspect may be used to turn humidification and/or dehumidification off.




You may indicate that outputs should be refreshed periodically, even if the state hasn't changed. You may also ask for inputs to be polled periodically. Usually, this has no effect because the inputs should report state changes so that the App can act on them immediately. However, if an event is missed for some reason, this allows the App to catch up to the current state of input devices. If the input devices support the refresh() function, the App uses that function before retrieving their state.

Configuring the Zones

The final setting page for the main App is used to create zones.  At least one zone must be created using the Create New Zone button.  After zones are created, they can be edited or removed by clicking the button with the zone's name. A child App is created for each zone.


On the first page of settings for each zone, you will be asked to give the zone a name and indicate the thermostat for that zone. Every zone is required to have a thermostat. Virtual thermostats may be used if desired. Next, you are asked the airflow capacity of the zone.

Next, you indicate the type of zone. The choices are Always selected, Normally Open Damper, Normally Closed Damper or Duct Fan, and Proportional Damper. An Always selected zone does not have any device for blocking airflow to that zone. If you have a single zone system, the single zone would be an Always Selected zone. Also, if you have added a number of controllable registers to your previous un-zoned duct system, the remaining rooms may be an Always Selected zone. Conventional zoning dampers are Normally Open dampers. The switch for controlling such a damper is turned on when the zone is not selected and turned off when the zone if selected. Normally Open Damper or Duct Fan type zone is selected by switching a switch to the on position. A Proportional Damper type is capable of being commanded to a partially open state. Controllable registers typically have this capability. (The App does not make extensive use of intermediate positions, except when the zone is being called upon to accept heating or cooling because the calling zones do not have enough capacity.)

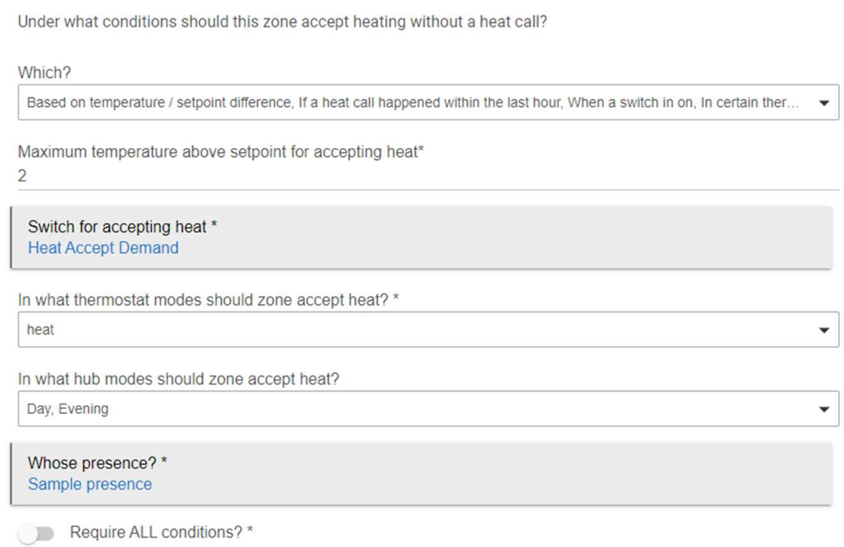

To make one zone be a subzone of another zone, the subzone should be selected when defining the parent zone. Therefore, it is best to define the subzones first. If you didn't do that, you will need to skip this step when defining the parent zone and come back later to edit the parent zone after the subzone is defined. Due to limitations on how Apps can be set up, the list that comes up when selecting subzones may be over-inclusive. Selection of any zone that is not currently a primary zone will be ignored.


Some zone dampers do not completely shut off all flow in the closed position. Entering the percent open when in the closed position makes the App better at serving small zones without reliance on other zones volunteering to accept heating or cooling. If this zone is a Normally Open Damper type of a Normally Closed Damper or Duct Fan type, you will be asked to specify a switch device to select the zone. If the Zone is a Proportional Damper, you will be asked for a dimmer device instead. If you have a room with several controllable registers, select one of them to be directly controlled by the App and then create rules in Rule Machine to set the others based on that one.


Next the App will ask you to specify criteria for when the zone should accept heating or cooling without a heating or cooling call from its own thermostat. This helps the App serve small zones. This is more important for zones with subzones since the subzones only get served when the parent zone is being served. If the parent zone is volunteering to accept heat, a heating call in a subzone will be relayed to the App. Otherwise, the subzone will only receive heating or cooling during a call from the parent zone. For accepting heat, a variety of criteria are available, including:

- Based on temperature / setpoint difference,
- If a heat call happened within the last hour,
- If temperature is NOT increasing,
- If temperature is decreasing,
- When a switch in on,
- In certain thermostat modes,
- In certain hub modes, and
- When certain people are NOT present.

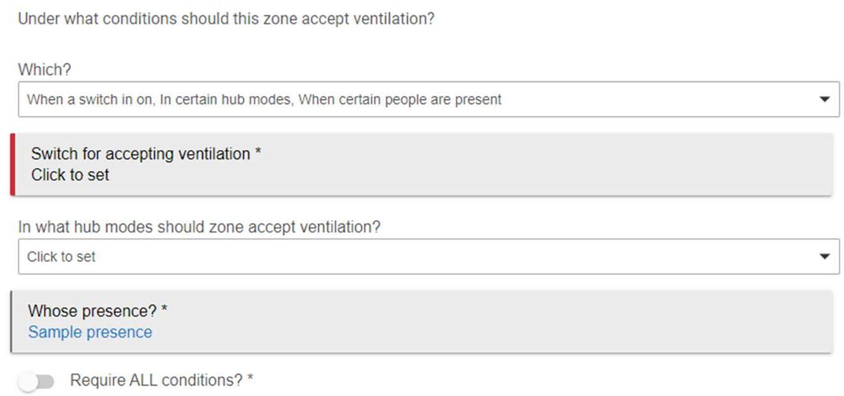
Analogous criteria are available for cooling. You can choose as many criteria as you wish. If you choose no criteria, the zone will never volunteer. If you choose two or more criteria, the App will ask whether it should volunteer when any one criteria is satisfied, or only when all criteria are satisfied. For some of the criteria, the App will need to ask for additional information. If you wish to use additional inputs or more complex logic, you can select the switch option and implement the logic in Rule Machine. The Zone Status device for each zone includes attributes recent_heat, recent_cool, temp_increasing, and temp_decreasing in case you want to utilize that information.




Next the App will ask you to specify criteria for whether the zone should be selected when ventilation is running without a heating or cooling call. If you don't have ventilation or your ventilation doesn't require your blower, then you can ignore this section. A variety of criteria are available, including:

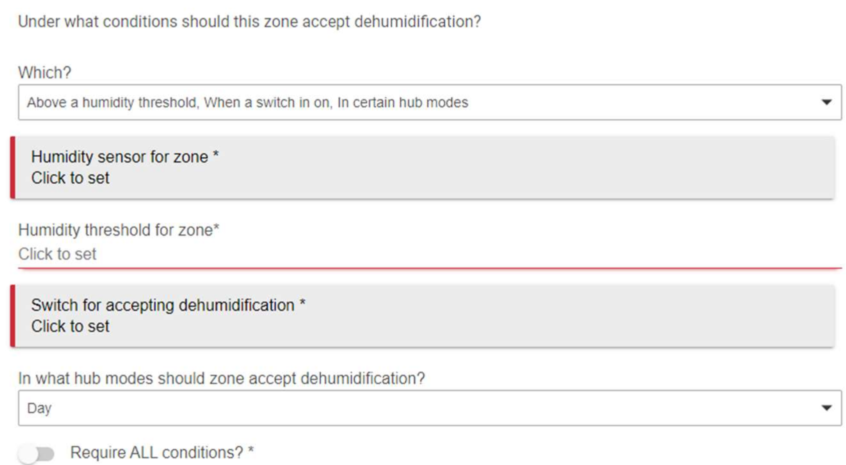
- When a switch in on,
- In certain hub modes, and
- When certain people are present.

You can choose as many criteria as you wish. If you choose no criteria, the zone will never receive ventilation outside of cooling and heating calls.




Next the App will ask you to specify criteria for whether the zone should be selected when only a dehumidifier or a humidifier is running. These sections are only relevant if you have an integrated dehumidifier or a humidifier that requires fan respectively. If you don't have these types of equipment, then you can ignore these sections. A variety of criteria are available, including:

- A humidity sensor in the zone,
- When a switch in on, and
- In certain hub modes.



Periodic output refresh and input refresh serve the same function for zones as they do for the main App. Some thermostats don't do a good job of reporting state changes unless the refresh function gets called. If you have such a thermostat, periodic input refresh results in the refresh function being called regularly.

When you click Done, the App processes your inputs.  Clicking Remove deletes the zone from the App.