ClimateTalk 2.0
Zoning Application Profile

Document revision: 01
Release: June 12, 2013

Abstract

ClimateTalk is a universal language for innovative, cost-effective solutions that optimize performance, efficiency and home comfort. The ClimateTalk Open Standards define a set of messages and commands to enable interoperability, enhanced user interface, and machine to machine control independent of the physical layer connecting the devices.

This document defines the application requirements corresponding to OSI Layer 7 that are specific to a Zoning subsystem operation and interaction with other devices on a ClimateTalk network.

Updates

This specification may be updated at any time and may be superseded by a more recent version or amended to from time to time. Users should be certain they are using the current ClimateTalk version and the latest revision of the documents.

The released versions of all specifications are available at http://www.ClimateTalk.org

Version History

ClimateTalk Version	Document Revision	Release Date	Comments
V 2.0	00	2013-01-18	Initial Release
V 2.0	01	2013-06-12	Updated 5.3.3 Warm Start Procedure – Thermostat to include requests for configuration, identification, and status data from all nodes on the network.

Contributors

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1.0 Overview

1.1 ClimateTalk Model

ClimateTalk is an open standard that defines a set of messages and commands to enable interoperability, enhanced user interface, and machine to machine control independent of the physical layer connecting the devices.

The messages and commands defined by ClimateTalk Information Model (CIM) are the presentation and application layers as defined by the OSI Model[1]. ClimateTalk Applications are fully defined at Layer 7 of the OSI model by a combination of a Device Specific Application Profile, the Generic Application Specification and the Command Reference.

ClimateTalk messages can be carried over any physical medium following the OSI model. The ClimateTalk Presentation Layer defines how messages are executed over the various physical mediums in use.

CT-485 and CT-LWP are wired serial physical and network layers designed to support the formation of ClimateTalk networks and transport ClimateTalk messages, but other OSI based protocols – including wireless transports - can be used as well.

1.2 Scope

This document defines the specific application requirements for a Zoning subsystem designed to ClimateTalk Open Standards to control, operate, and monitor an HVAC system in multiple zones. This profile builds on the *Generic Application Specification* defining requirements common to all ClimateTalk enabled devices.

The ClimateTalk Open Standards package shown in Figure 1 - OSI Layers for ClimateTalk Implementation Figure 1prescribes the mandatory requirements to ensure proper network formation of interoperable devices. Membership in the ClimateTalk Alliance as well as successful completion of mandatory conformance testing is required for listing a product as a ClimateTalk Certified Device.

This zoning profile shall define the necessary interaction requirements between the following subsystems and ClimateTalk CIM:

- Zone Controller
- Zone User Interface
- Zone Temperature Control

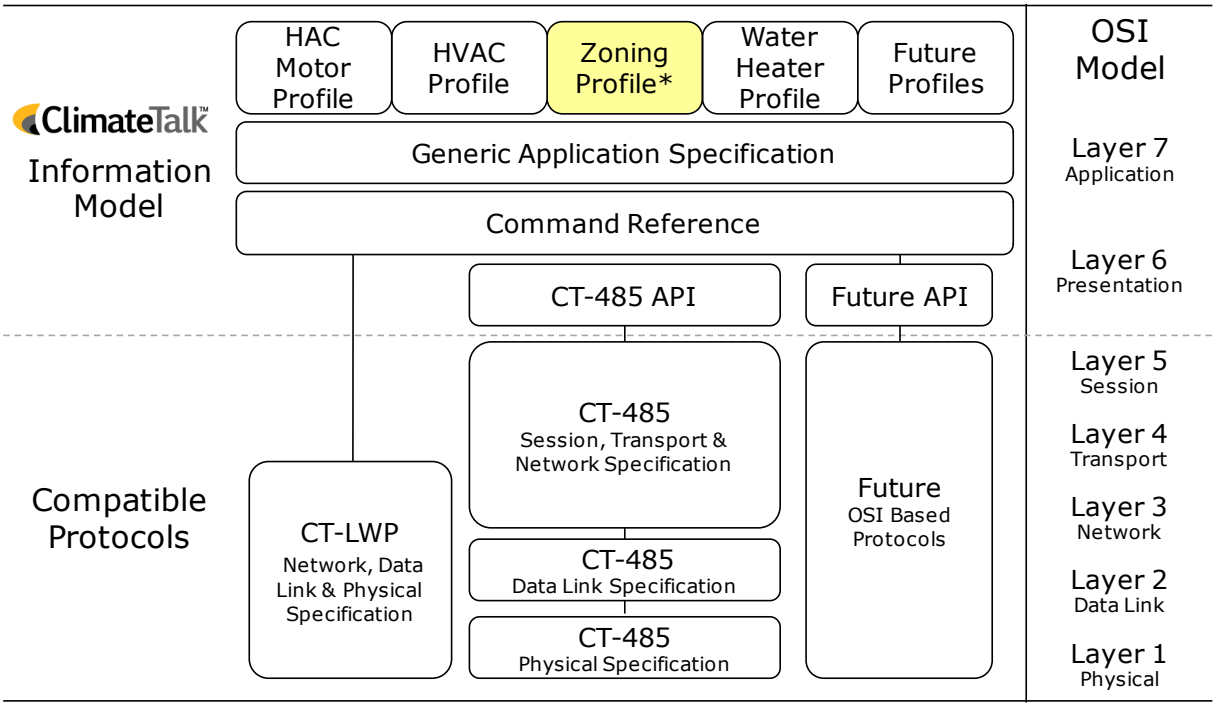
This zoning profile also defines the following subsystems without any interaction requirements between the subsystem and ClimateTalk CIM:

- Zone Damper
- Occupancy Sensor
- Remote Temperature Sensor

[1] http://www.iso.org/iso/iso_catalogue/catalogue_tc/catalogue_detail.htm?csnumber=20269

- Supply Air Temperature Sensor
- Return Air Temperature Sensor
- Outside Air Temperature Sensor

Figure 1 - OSI Layers for ClimateTalk Implementation



**This Document*

This profile defines new requirements for the following subsystems and required modifications for each subsystem for proper operation when combined with a zoning subsystem as defined in *ClimateTalk HVAC Application Profile*:

- HVAC Application Profile - Thermostat
- HVAC Application Profile - Furnace
- HVAC Application Profile – Air Handler
- HVAC Application Profile – Air Conditioner
- HVAC Application Profile – Heat Pump

This profile also defines the testable requirements used to validate that a Water Heater is behaving properly within a ClimateTalk network. Each device must comply with the mandatory requirements defined in this document as well as all other ClimateTalk standards applicable to the device functionality.

2.0 Normative References

A good understanding of the most recent version of the following documents is required to apply the contents of this specification correctly.

ClimateTalk HVAC Profile

ClimateTalk Generic Application Specification

ClimateTalk Command Reference

ClimateTalk CT-485 Application Protocol Interface

ClimateTalk CT-485 Networking Specification

ClimateTalk CT-485 Data Link Specification

ClimateTalk CT-485 Physical Specification

3.0 Terminology

3.1 Definitions

Attempt Delay	The amount of time a subsystem waits for a response from another subsystem to a request.
Auto-Pairing	A simplified method or sequence of events required to group a zone with the applications associated with that zone to simplify installation.
Balance Point	The outside temperature below which the thermostat will switch to alternate heating sources when the primary heat source is a heat pump.
Cold Start	A start of a subsystem from a state of not being powered to being powered.
Coordinator	ClimateTalk device which establishes the network and through which messages are routed.
Critical Fault	A subsystem with a critical fault is one that is not able to do its core functionality and is notifying the other subsystems for fault tolerant operation.
Generic Device	Any device that is part of an HVAC system that does not have specific requirements defined in the ClimateTalk specification.
HVAC Controller	The subsystem responsible for controlling the HVAC demands to the subsystems responsible for meeting the demands. A zone controller or thermostat is examples of a HVAC Controller. Only one HVAC Controller is possible.
HVAC Subsystem	Any subsystem involved in the control of HVAC operation. Examples: Thermostat, Furnace, Air Handler, Air Conditioner, and Heat Pump.
Legacy Operation	Control of HVAC subsystems using 24VAC on/off signals designated as W, Y, E, R, G, O, B etc.
Minor Fault	A subsystem with a minor fault is one that has a fault but is still able to do its core functionality.
Profile	Set of rules governing the implementation of certain aspects of the protocol, which will include timings and communication rules to function properly.
Shared Data	Configuration information for each subsystem on the network that is stored by multiple subsystems on the network. This allows for automatic configuration of replacement subsystems.
Subordinate	ClimateTalk subsystem node. Subordinates may not speak until spoken to by the coordinator.
Warm Start	A re-start of a subsystem from a state where the subsystems need to return to idle and relearn the network. This is defined as receiving a network node list.

3.2 Acronyms

AC	Air Conditioner
AH	Air Handler
DBID	Database Identification
EU	Engineering Units
GW	Gateway
HP	Heat Pump
IEEE	Institute of Electrical and Electronics Engineers
IFC	Integrated Furnace Control
MDI	Message Data Interface
OAT	Outdoor Air Temperature
RAT	Return Air Temperature
SAT	Supply Air Temperature
SW	Software
SD	Shared Data
TSTAT	Thermostat
XOVER	Crossover (Formerly Known as OBBI)
ZCTRL	Zone Controller
ZDAMP	Zone Damper
ZTC	Zone Temperature Control
ZUI	Zone User Interface

3.3 Word Usage

The conventions used in this document are modeled after the definitions of the 2009 IEEE Standards Style Manual. The IEEE Standards Style Manual may be obtained from http://standards.ieee.org/guides/style/.

can Equivalent to *is able to* or *is capable of*.

may Equivalent to *is permitted to* or *is allowed to*. The use of *may* means that something is optional, and does not imply a requirement.

must Used to describe situations where no other course of action is possible.

shall Equivalent to *is required to*. Use of the word *shall* means that the specification shall be implemented exactly as described in order to ensure correct operation and interoperability with other devices.

should Equivalent to *is recommended that*. This is used in situations where there are several possible options, but one option is preferable to the others.

4.0 Initial Installation Requirements

4.1 Configuration

Subsystems shall be auto-configurable over the network to make setting up the HVAC system simpler. A configuration request may be made of any subsystem on the network. The reply data payload shall have enough well defined information to configure the subsystem based on its actual capabilities.

Refer to the Configuration MDI for a more specific bit-by-bit break down of the exact detail of the information sent back on the network by the zone controller.

4.2 HVAC System Determination

A subsystem can determine what type of system it is part of by using the network node list, which lists all the nodes currently active in the system. Table 1 – HVAC System Configurations identifies the most common types of systems and the subsystems that are part of the system.

Table 1 – HVAC System Configurations

System	Furnace	Air Handler	Air Conditioner	Heat Pump
Conventional	Active	Not Present	Active	Not Present
Dual Fuel	Active	Not Present	Not Present	Active
Heat Pump	Not Present	Active	Not Present	Active

Table 2 – Less Common HVAC Configurations illustrates the different possibilities if normal subsystems are not present for any reason, including communications or subsystem failure. These possibilities provide less capability and that the primary controller shall adjust accordingly.

Table 2 – Less Common HVAC Configurations

System	Furnace	Air Handler	Air Conditioner	Heat Pump
Furnace w/ Cool	Active (Cool)	Not Present	Not Present	Not Present
AC Cool	Not Present	Active (No Heat)	Active	Not Present
Gas Heat	Active	Not Present	Not Present	Not Present
Electric Heat	Not Present	Active	Not Present	Not Present
Electric System	Not Present	Active	Active	Not Present
Fan Only	Not Present	Active (No Heat)	Not Present	Not Present
Outdoor System	Not Present	Active (No Heat)	Not Present	Present

Note that zone controllers are the primary controllers of the HVAC system and thus are required to be present and active for the system to function.

4.2.1 Subsystem Capabilities

A thermostat, furnace, air handler, air conditioner, and heat pump shall be zoning capable to ensure proper operation of HVAC system. Any subsystem not zoning capable shall be properly handled by the zone controller on the network.

Table 3 – Active Subsystem Functions

Subsystem	Function
Zone Controller	Primary Controller of HVAC Functions
Zone User Interface	Simple Heat/Cool/Fan Demand Requestor
Thermostat	Simple Heat/Cool/Fan Demand Requestor
Zone Temperature Controller	Simple Heat/Cool/Fan Demand Requestor
Zone Damper	Airflow Zone Control
Furnace	Heating
Air Handler	Airflow Circulation and Electrical Strip Heating
Air Conditioner	Cooling
Heat Pump	Heat and Cooling

Passive subsystem functions are nodes with no required requirement other than to provide their key function for the active subsystems application specific requirements.

Table 4 – Passive Subsystem Functions

Subsystem	Function
Occupancy Sensor	Detects Activity in Area
Outside Air Temperature	Reports Outside Air Temperature
Return Air Temperature	Reports Return Air Temperature
Supply Air Temperature	Reports Supply Air Temperature

An Air handler shall be considered having strip heating unless otherwise specified.

A furnace may have an extra relay added to allow for a single-stage cooling system to be connected to and controlled by the furnace. A legacy 24VAC system may communicate with the thermostat or other controlling device in this way without requiring any extra hardware. If the configuration of the furnace shows that there are cooling relays present, the furnace shall be considered a cooling control.

4.2.2 Crossover Capabilities

A crossover is a CIM subsystem that shall be responsible for all CIM mandatory/optional requirements specified for a furnace, air handler, air conditioner, or heat pump as defined in this profile.

4.3 Network Node List

Upon receiving a network node list from the network, the subsystem shall determine the actual network environment from the data payload. The list identifies the subsystem's own network status and what other nodes are active on the network.

A subsystem shall consider itself online only after receiving a node list with itself being identified in the node list. For devices where multiple instances of a subsystem can be on the network, the network node list message should be inspected to see which instance of the node in the node list corresponds to the subsystem receiving the message. Refer to Send Method 0 explanation in the *Generic Application Specification* for more information.

If the subsystem is online and receives a network node list, the subsystem will initiate a warm restart. See section 5.3 for details.

4.3.1 Node Type

Each subsystem is assigned a node type. The node type is used by other subsystems to determine what devices are present on the network and therefore what functions the HVAC system is capable of performing.

Refer to the ClimateTalk Command Reference Specification for the list of node types and their values.

4.3.2 HVAC Capabilities

Upon not detecting a zone controller on the network, the HVAC Profile will have to be adhered to instead of this Zoning Profile.

5.0 Warm and Cold Start Procedures

The follow section shall discuss the requirements in subsystems becoming active on a ClimateTalk CIM network.

5.1 Types of Start Up

Two types of start-up are defined, cold start and warm start. A cold start occurs when the device is powered up after a power failure.

A warm start occurs when the device receives a new network node list from the coordinator. A warm start will cause the subsystem to go into an idle state and then go through the steps of getting on the network without completely resetting the subsystem. This prevents damage to the subsystem or any other part of the system should a new device be installed on the network or a device be removed from the network.

5.2 Cold Start Procedure

All subsystems shall do the following:

1. Start up in default state.
2. Check shared data for validity, if applicable.
3. Wait to receive a network node list. On receiving the node list, do Warm Start Procedure.

5.3 Warm Start Procedure

The following procedures are defined for subsystems working with the zoning profile. These subsystems may include subsystem specified in other profiles.

5.3.1 Zoning Warm Start Procedure – All Non-HVAC Controller Subsystems

1. Go to an idle state.
2. Check the network node list. Am I on the list?
    a. If no, stop and wait.
    b. If yes, continue on with the zoning warm start procedure.
3. Has shared data been checked for validity?
    a. If no, check shared data for validity.
    b. If yes, continue with zoning warm start procedure.
4. Is shared data valid?
    a. If no, request shared data from the network.
    b. If yes, transmit shared data to the network.
5. Check the network node list. Is a HVAC Controller on the list?
    a. If no, stop and wait.
    b. If yes, continue with zoning warm start procedure.
6. Check HVAC Controller is a zone controller
    a. If no and a thermostat, perform Thermostat Warm Start in *ClimateTalk HVAC Application Profile*.

   b. If yes, continue with zoning warm start procedure.
7. Check to see if fault conditions exist.
   a. If no, transmit a Diagnostics Set – Clear message to the zone controller.
   b. If yes, transmit a Diagnostics Set – Fault message to the zone controller.
8. Subsystem is now considered to be a communicating control on the network.
9. If the subsystem is a heat pump or air conditioner, check the network node list to see if an air handler or furnace is active on the network.
   a. If yes, perform what is defined *ClimateTalk HVAC Application Profile*.
   b. Warm Start Procedure.

5.3.2 Warm Start Procedure – Zone Controller

1. Go to an idle state. Prepare to auto-configure the HVAC system.
2. Clear all diagnostic and dynamic messages in memory.
3. Does the zone controller use shared data?
   a. If no, continue with warm start procedure.
   b. If yes, has shared data been checked for validity?
      i. If no, check shared data for validity.
      ii. If yes, continue with warm start procedure.
   c. Is shared data valid?
      i. If no, request shared data from the network.
      ii. If yes, transmit shared data to the network.
4. For each subsystem listed in the network node list, do the following:
   a. Request configuration.
   b. Request status.
5. If the subsystem is a thermostat, do the following:
   a. If thermostat configuration identifies thermostat is not zoning capable, zone controller displays a major fault indication to the installer and transmit a subsystem busy command to the thermostat.
   b. If thermostat is zone capable, zone controller shall function with a thermostat like a zone stat as defined in this profile.
      i. Request Identification data (used for zone association)
6. Make control decisions and reissue commands as necessary.

5.3.3 Warm Start Procedure – Thermostat

1. Go to an idle state.
2. Check the network node list. Am I on the list?
   a. If no, stop and wait.
   b. If yes, continue on with the zoning warm start procedure.
3. Check the network node list. Is a zone controller on the list?
   a. If no, perform what is defined in HVAC Profile Warm Start Procedure.
   b. If yes, continue with zoning warm start procedure.
4. With a zone controller active on the network, the thermostat shall do the following:
   a. If thermostat is not zone capable, an installation fault will be created and proper fault indication shall be displayed to the installer shall occur.
   b. If thermostat is zone capable, the thermostat shall perform the requirements as a zone stat is defined in this profile.
5. For each subsystem listed in the network node list, do the following:
   a. Request Configuration data

   b. Request Identification data.
   c. Request Status data (optional)
6. Check to see if fault conditions exist.
   a. If no, transmit a Diagnostics Set – Clear message to the zone controller.
   b. If yes, transmit a Diagnostics Set – Fault message to the zone controller.
7. Subsystem is now considered to be a communicating control on the network.

6.0 Ease of Installation Requirements

The following sections highlight the technical requirements involved in the requirements to allow for an easy installation of this system.

6.1 Pairing

Pairing is the process by which zone devices (thermostats, zone user interfaces, zone temperature controls, sensors, etc.) are associated with dampers controlled by the zone controller.

This section defines the pairing process in which the applications for each zone are identified and associated with physical temperature zones.

6.1.1 Pairing Assumptions

The pairing process defined in this section was developed with the following list of assumptions:

- Legacy zone dampers (non-communicating)
- Multiple dampers per zone
- Single HVAC demand source per zone
- Ability to reconfigure zones at any time
- Simple feedback confirmation for non-graphical display applications like sensors
- Each zone device has a unique identifier (i.e. Identification Serial Number)

6.1.2 Pairing Process

After the installer has wired all dampers, the zone devices may be paired with their respective zone.

The following information is required for the pairing process:

- Physical temperature zone assignments (i.e. which zone number corresponds to which physical zone)
- Unique identifier of each zone device to be paired

One option to provide the pairing of a zone device to a particular temperature zone is detailed below. The reference to 'thermostat' in this section is for illustration only and could be any zone device associated with a particular temperature zone.

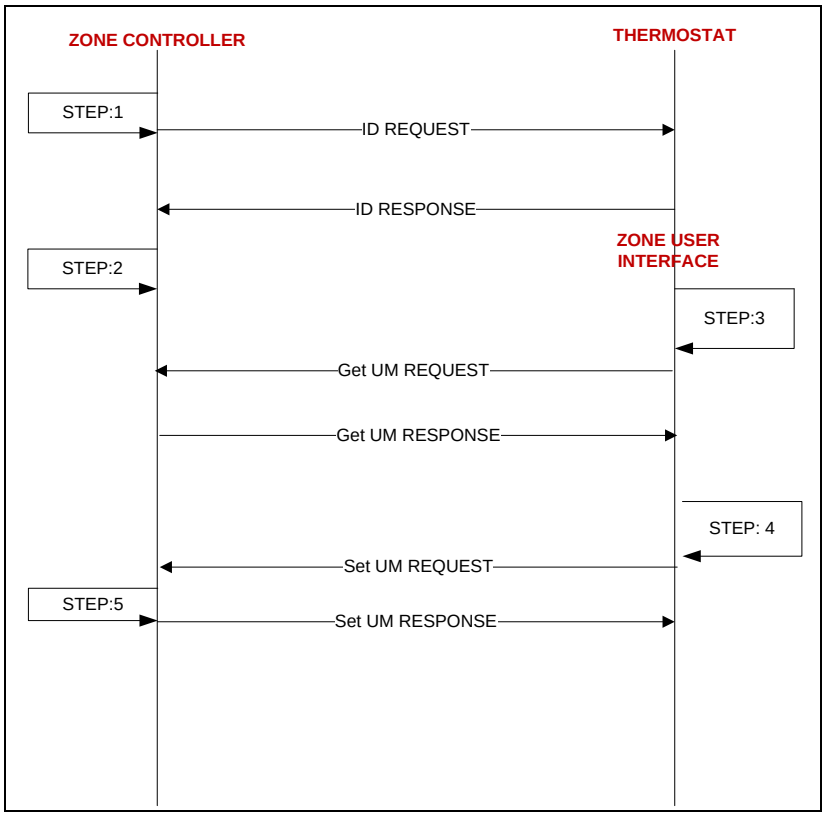


Figure 2: Zone Pairing Sequence Diagram

ID = Identification Message Data Interface message
UM = User Menu

- Step 1:
  - Upon receiving a new network node list, Zone Controller shall initiate an ID Pull request of all available thermostats on the network.
  - Upon receipt of a valid ID pull response, the Zone controller can use the Identification data of each thermostat on the network to uniquely identify them within the same network.

- Step 2:
  - Zone controller determines if the thermostat is in its stored zone association list. If not, the zone controller shall provide a major fault indication to the installer and transmit a subsystem busy command to the thermostat. This provides an indication for the installer to select the proper zone for the thermostat.
  - If all thermostats are already associated with a zone, a modification of selected thermostat / zone pairing can be performed via the same zone control user menu accessed to initially associate a thermostat with a zone. This is discussed in the following step.

- Step 3:

  - To initially establish a thermostat zone pairing or to change the thermostat zone selection, an installer\home owner shall use a thermostat or zone user interface that supports ClimateTalk User Menus to access the Zone Controller zone association user menus.
  - The zone controller constructs an editable user menu selection allowing the association of each thermostat to a particular zone. The user menu will include the unique identification data as part of the displayed name for the thermostat. The serial number for the thermostat will be available on a label of the thermostat and/or accessible from the thermostat's own user menu.

- Step 4:
  - For each thermostat, a zone selection is made and a user menu update request is sent to the zone controller.
  - Zone controller shall inspect the selections to ensure each zone is assigned to one thermostat.

- Step 5:
  - If zone assignment is invalid (perhaps two thermostats assigned to same zone), the zone controller shall reject the zone pairing request and respond to the user menu update request with an indication the zone assignment has failed.
  - If the zone controller has no reason to reject the update request, it shall save the unique Identification data and corresponding zone assignment to its non-volatile memory. The zone controller shall respond to the user menu update request with an indication of a successful request.
  - Repeat from step 4 until all thermostats have been associated with their corresponding zone.

- When system power is cycled or as new node lists are received, the thermostat zone pairing process shall re-start at Step 1.

6.2 Shared Data

Use of shared data allows easy configuration of the system instead of configuring each operational parameter via dip switches. Replacement boards can retrieve their configuration information from other devices on the network, making installation of replacements easy.

The storage, retrieval and transmission of shared data are optional for zone controller, thermostats, furnace, air handler, air conditioner, and heat pump device types.

The zone controller shall have the higher priority over a thermostat in the storage of shared data. For example, if a thermostat and a zone controller are on the network and both have shared data to be stored, the zone controller shall have a higher priority of storing its shared data replicated on other subsystems.

6.3 Automatic System Verification

The system may provide for verification of the installed system and give the installer feedback about problems that can be detected by the system and their resolution.

6.4 Identification Parameters

All subsystems shall store the ClimateTalk specification version number, the software version number, software revision number, and unique serial number at the very minimum. Additional parameters are detailed in each subsystem's Identification MDI.

The optional part of the Identification MDI includes details such as installation date, address of installation, etc. that can be used during end of life or fault trend analysis.

All subsystems shall respond to an identification message request with a payload containing the Identification MDI. Note that the mandatory and optional part of the identification message are not demarcated by DBIDs, hence a subsystem not implementing any of the optional Identification parameters shall fill these bytes with Nulls. If the subsystem supports the optional parameters, it shall accept an Identification Message Set with the values for these optional parameters.

A subsystem shall respond to an Identification Set Control command and set its identification parameters to the values contained in the data payload of the command. It also shall respond to an identification request with a payload containing the version numbers of the ClimateTalk Application, Software Version, Software Revision, and unique serial number at the very minimum. Further details on the Identification Data are contained in the Command Reference Document.

6.5 Display Device

This section shall define the additional display devices the zoning profile shall introduce to the ClimateTalk.

6.5.1 Zone User Interface

A zone user interface with a graphical display is a mandatory display device to implement the full user menu capability as defined in the *Generic Application Specification*.

A zone user interface with non-graphical capabilities shall be required to provide the user menu implementation for only selectable user menu options.

6.5.2 Zone Controller

A zone controller subsystem maybe considered an optional display device.

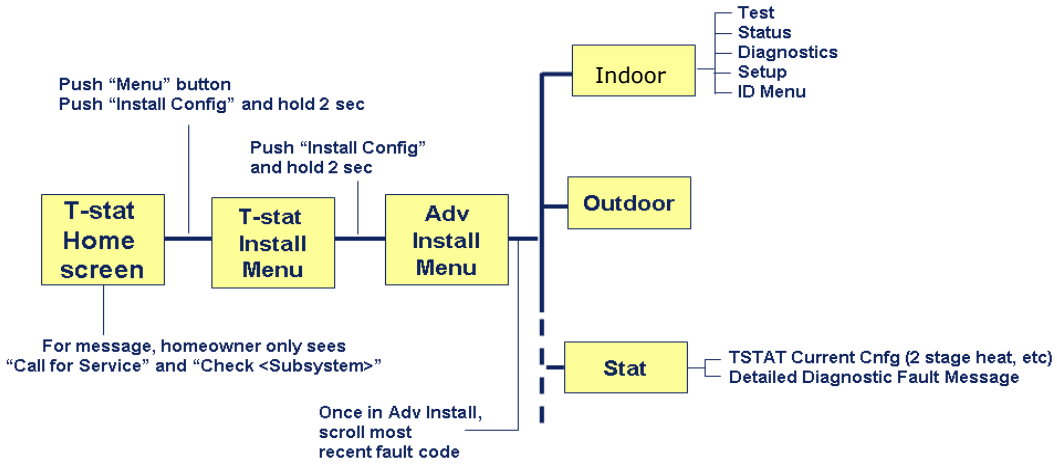
6.5.3 Thermostat

A thermostat is considered a display device and in this profile shall perform the function as a zone user interface display device.

6.6 Installation User Menu

Each subsystem may provide a custom user menu for configuration and diagnostic purposes through the requests of a display device like a thermostat, zone stat, or zone controller. The user menu may include items specific to the subsystem and shall be dynamically served to the display device when a user accesses the menu. If the subsystem does not provide a user menu and one is requested, it shall respond with an Unknown Application Payload message. The format of this message is defined in the *Generic Application Specification* in the section for Error Reporting.

Figure 3 – Example of User Menu Navigation on Thermostat Display Device



6.7 Subsystem Installation Test

A display device can initiate a subsystem installation test on any subsystem by issuing a subsystem installation test control command. It is optional for the display device to support an interface to initiate and monitor a Subsystem Installation Test. It is also optional for subsystems to implement this feature. If a subsystem does not support a Subsystem Installation test and if it receives a request to perform one, it shall respond with an Unknown Application Payload message. The format of this message is defined in the *Generic Application Specification* in the section on Error Reporting.

7.0 Normal Operation

7.1 Subsystem Functions

Table 5 – Functions by Subsystem defines which HVAC functions each subsystem is capable of. An "M" indicates that the subsystem is required to support that function. An "O" indicates that the function is optional and may not be present in the system.

Table 5 – Functions by Subsystem

Function	Heat Pump	Air Conditioner	Furnace	Air Handler
Alternate Heat			M	
Auxiliary Heat			M	M
Cool	M	M	O	
Defrost	M		M	M
Dehumidify	O	O		
Emergency Heat			M	M
Fan			M	M
Heat	M		M	
Humidify			O	O

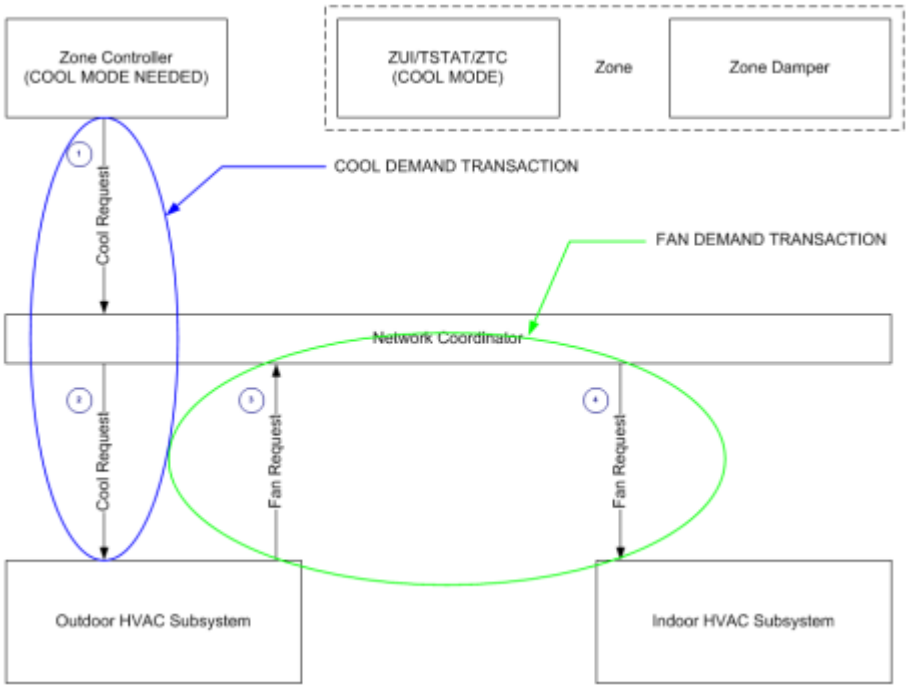
In the diagrams in the sections below, references to a "cooling subsystem" means any subsystem capable of providing cooling, references to a "heating subsystem" means any subsystem capable of providing heat, etc.

7.2 Application Legend

The following section shows the sequence of events from an application point of view and does not reflect the precise network traffic or routing information that is outlined in the networking section. Figure 4 – Application Messaging Sequence Diagram Example demonstrates the flow of events that occurs when devices communicate over the network. The network coordinator displayed in the figure is not necessarily a separate device but could be in any of the controls on the network. In this case, the transmission from the application to the coordinator is handled in a more virtual method, but still considered isolated from the application.

The numbered circles give a possible sequence of commands for each function and should not be interpreted as a requirement. Since each subsystem has the ability to perform their requirements when allowed by their applications, the traffic on the bus may not follow precisely the sequence of events shown.

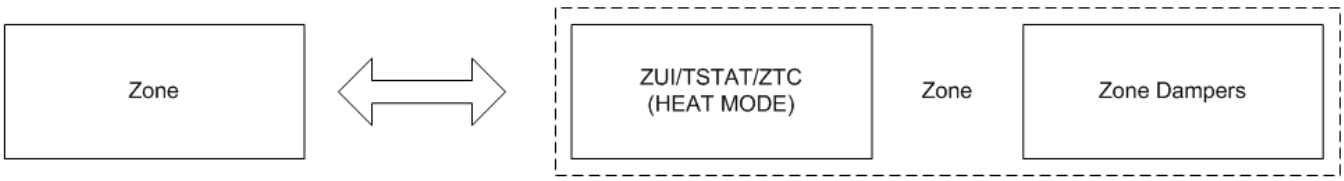
Figure 4 – Application Messaging Sequence Diagram Example



7.2.1 Zone Definition

In some sequence diagrams, a zone maybe represented to include a Zone User Interface (ZUI), Thermostat (TSTAT) with zoning capability, Zone Temperature Controller (ZTC) and Zone Damper as seen in Figure 4. The following figure can also be interchange from a zone and combination of zone stat and zone damper:

Figure 5 – Zone Representation



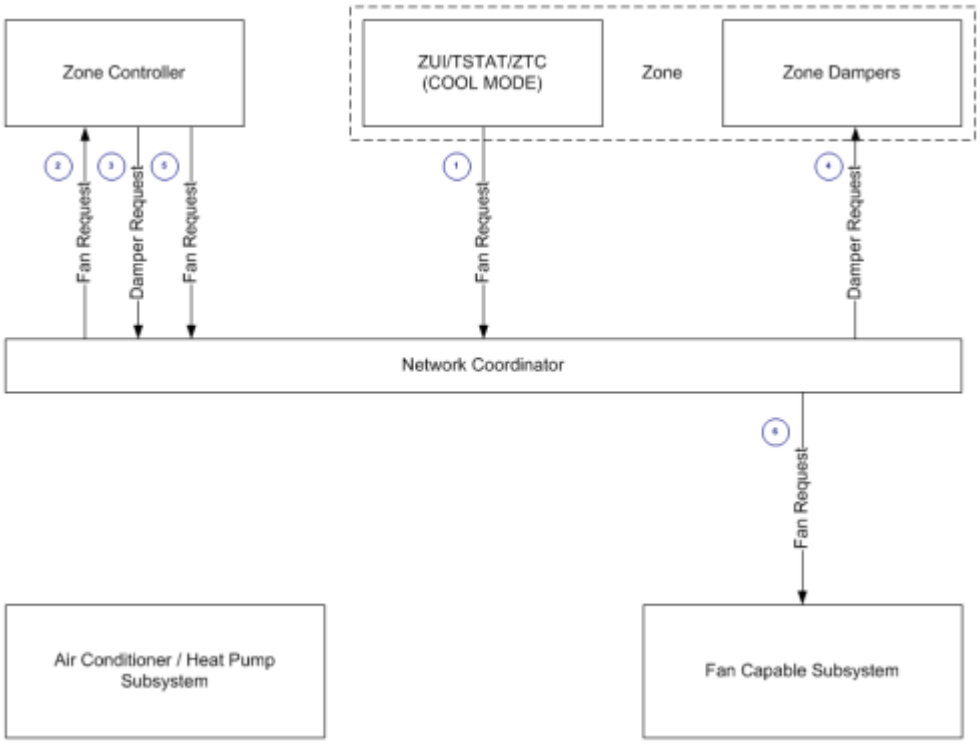
7.3 Mandatory Normal Operation

The following sections shall go into the normal operation of subsystems implementing this profile.

7.3.1 Standard Call for Fan Demand

This sequence is used when the system mode is set for fan. The request for fan demand from the zone shall have the lowest priority if the fan capable subsystem receives any other Fan Demand Control Command from another subsystem.

Figure 6 – Fan Demand Sequence Diagram



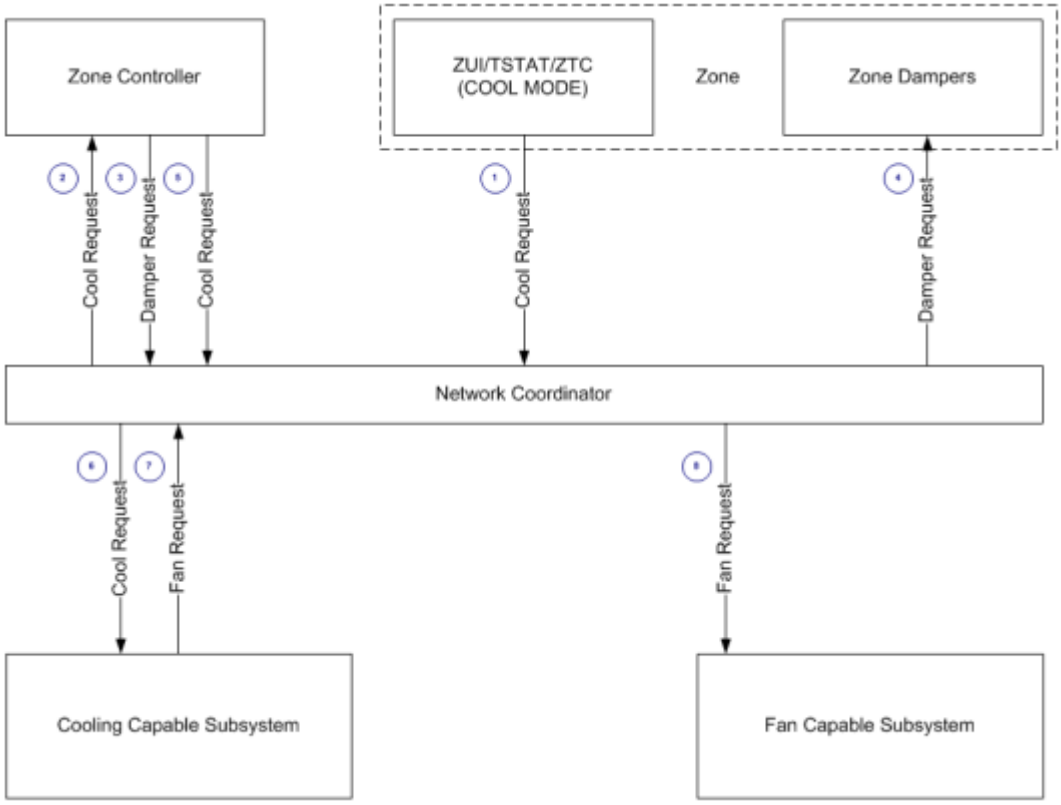
When fan operation is required, the system shall do the following:

1. The zone stat or thermostat transmits a Fan Demand Control Command to the zone controller. The data payload contains the amount of fan demand required.
2. The zone controller opens the respective zone damper.
3. The zone controller transmits a Fan Demand Control Command to the fan capable subsystem. The data payload contains the amount of fan demand required.
4. For all commands, the requesting subsystem shall refresh the command according to the refresh time provided in the initial request for as long as the demand remains unmet.
5. Once the demand has been met, the requesting subsystem shall transmit the appropriate Control Command to turn off and close the function.

7.3.2 Standard Call for Cool Demand

This sequence is used when the cooling capable subsystem receives a demand for cool.

Figure 7 – Cool Demand Sequence Diagram



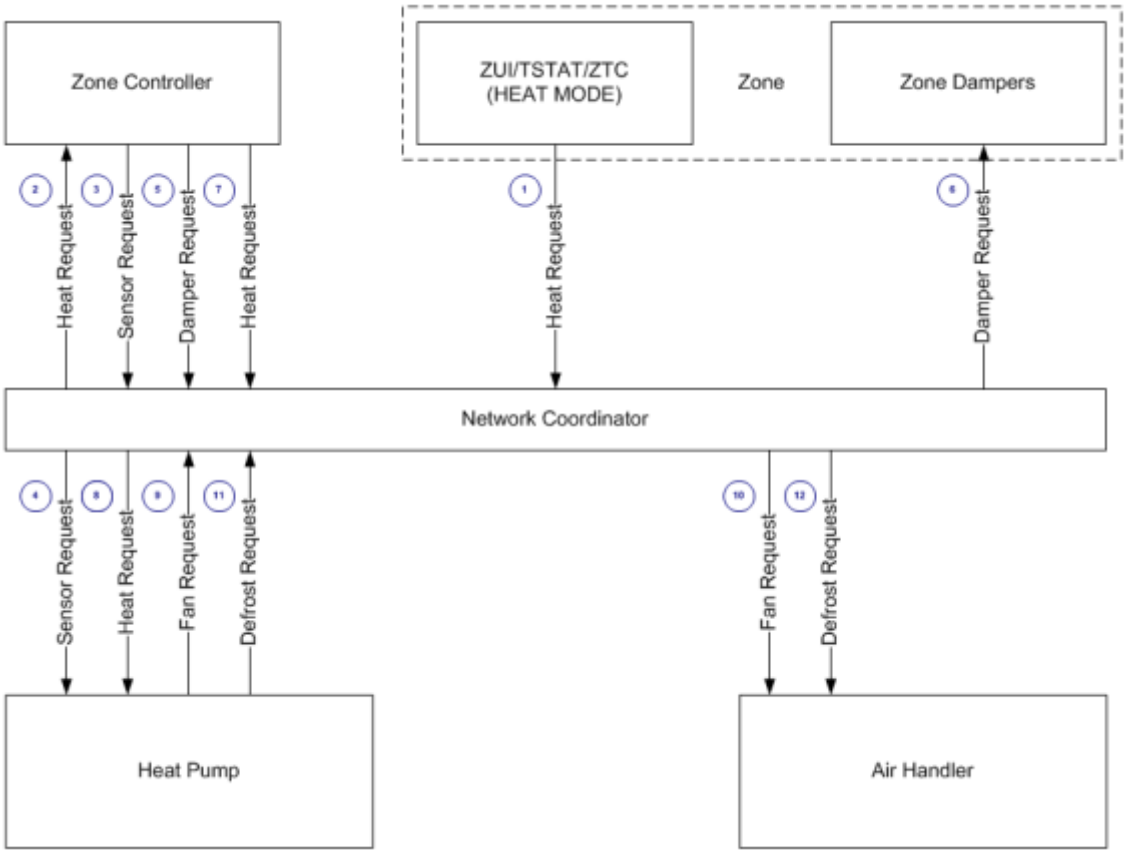
When cooling is required, the system shall do the following:

1. The zone stat or thermostat transmits a Cool Demand Control Command to the zone controller. The data payload contains the amount of cool demand required.
2. The zone controller opens the respective zone damper.
3. The zone controller shall transmit a Cool Demand Control Command to the cooling capable subsystem. The data payload shall contain the amount of cool demand required.
4. The cooling subsystem shall transmit a Fan Demand Control Command to the fan capable subsystem. The data payload shall contain the amount of fan demand required.
5. For all commands, the requesting subsystem shall refresh the command according to the refresh time provided in the initial request for as long as the demand remains unmet.
6. Once the demand has been met, the requesting subsystem shall transmit the appropriate Control Command to turn off and close the function.
7. If the system mode is changed prior to satisfying the current demand (e.g. the user switches from cool to heat modes), the zone stat or thermostat shall first turn off the current demand before initiating commands for the new mode.

7.3.3 Standard Call for Defrost Demand

This sequence is used when the heat pump needs defrost to an air handler with heating capability.

Figure 8 – Heat Pump Defrost Demand Sequence Diagram



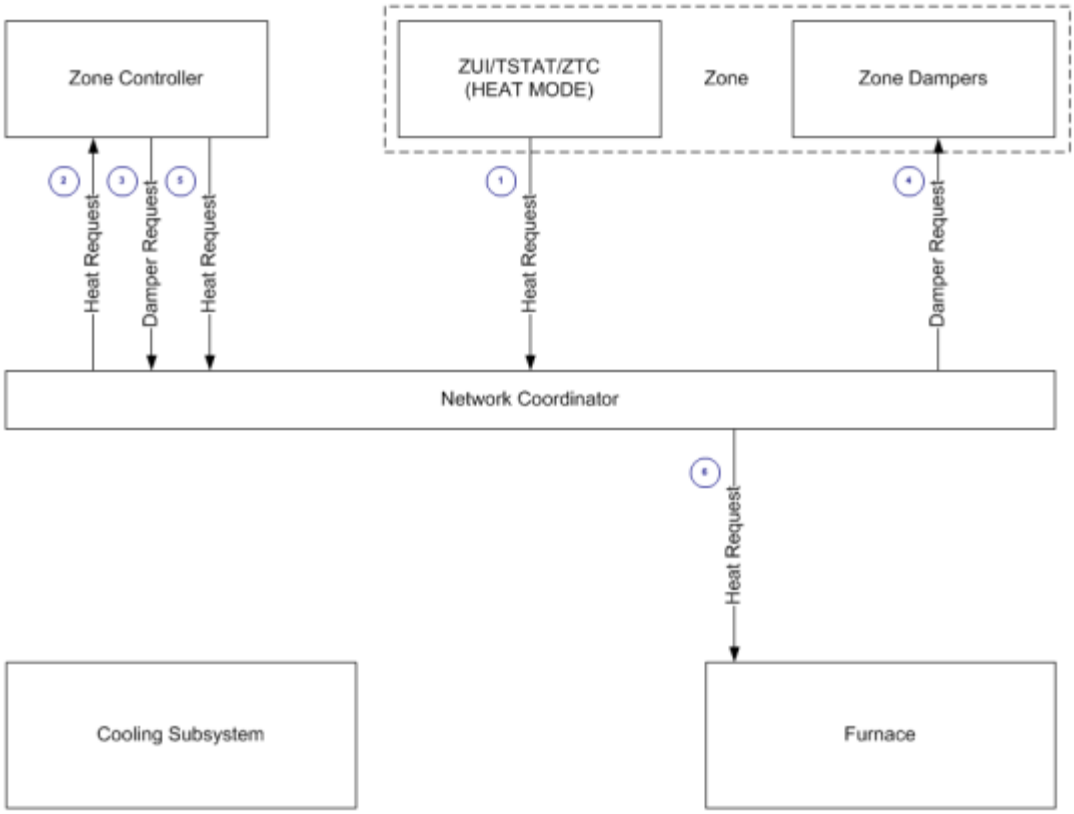
When defrosting of the outdoor unit is required, the system shall do the following:

1. Steps 1 – 8 refer to Section 7.3.5.
2. The heat pump shall transmit a Defrost Demand Control Command to the air handler. The data payload will contain the amount of defrost heat demand required.
3. For all commands, the requesting subsystem shall refresh the command according to the refresh time provided in the initial request for as long as the demand remains unmet.
4. Once the demand has been met, the requesting subsystem shall transmit the appropriate Control Command to turn off and close the function.
5. If the system mode is changed prior to satisfying the current demand (e.g. the user switches from heat to cool modes), the zone controller shall first turn off the current demand before initiating commands for the new mode.

7.3.4 Standard Call for Heat Demand – Furnace

This sequence is used when the furnace is the priority system for receiving a call for heat.

Figure 9 – Furnace Heat Demand Sequence Diagram



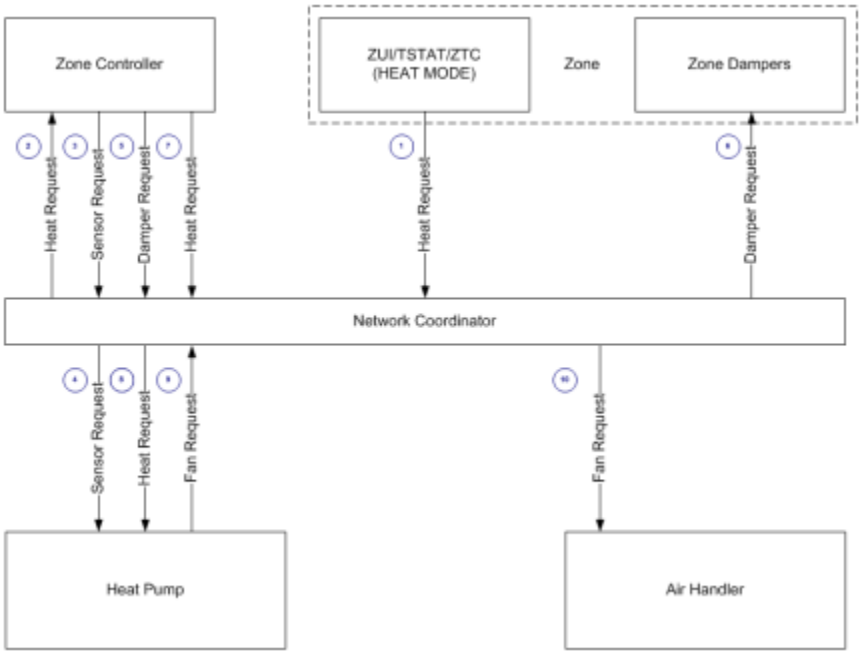
When heating is required, the system shall do the following:

1. The zone stat or thermostat transmits a Heat Demand Control Command to the zone controller. The data payload contains the amount of heat demand required.
2. The zone controller opens the respective zone damper.
3. The zone controller shall transmit a Heat Demand Control Command to the furnace. The data payload will contain the amount of heat demand required.
4. For all commands, the requesting subsystem shall refresh the command according to the refresh time provided in the initial request for as long as the demand remains unmet.
5. Once the demand has been met, the requesting subsystem shall transmit the appropriate Control Command to turn off and close the function.
6. If the system mode is changed prior to satisfying the current demand (e.g. the user switches from heat to cool modes), the zone controller shall first turn off the current demand before initiating commands for the new mode.

7.3.5 Standard Call for Heat Demand Above Balance Point – Heat Pump

This sequence is used when the heat pump is the priority system for receiving a call for heat.

Figure 10 – Heat Pump Heat Demand Above Balance Point Sequence Diagram



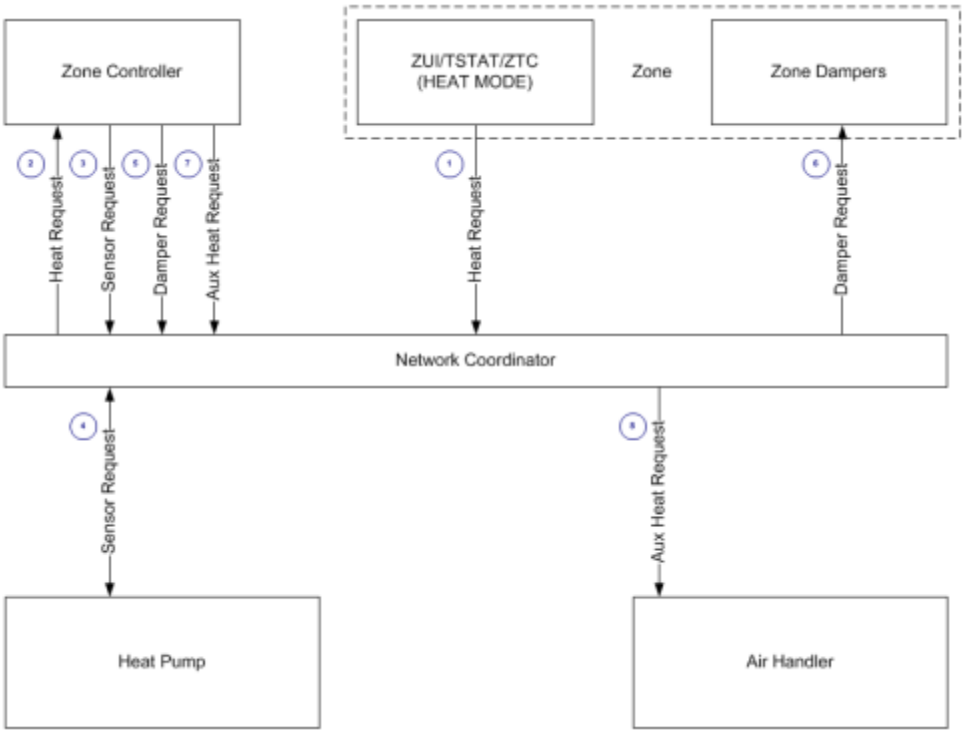
When heating is required and the outside temperature is above the balance point, the system shall do the following:

1. The zone stat or thermostat transmits a Heat Demand Control Command to the zone controller. The data payload contains the amount of heat demand required.
2. The zone controller shall transmit a Sensor Request to the heat pump. The data payload shall contain the outdoor temperature reading.
3. The zone controller opens the respective zone damper.
4. If the outdoor temperature is above the balance point, the zone controller shall transmit a Heat Demand Control Command to the heat pump. The data payload shall contain the amount of heat demand required.
5. The heat pump shall transmit a Fan Demand Control Command to the air handler. The data payload shall contain the amount of fan demand required.
6. For all commands, the requesting subsystem shall refresh the command according to the refresh time provided in the initial request for as long as the demand remains unmet
7. Once the demand has been met, the requesting subsystem shall transmit the appropriate Control Command to turn off and close the function.
8. If the system mode is changed prior to satisfying the current demand (e.g. the user switches from heat to cool modes), the zone stat shall first turn off the current demand before initiating commands for the new mode.

7.3.6 Standard Call for Heat Demand Below Balance Point – Heat Pump

This sequence is used when the heat pump is the priority system for receiving a call for heat.

Figure 11 – Heat Pump Heat Demand Below Balance Point Sequence Diagram



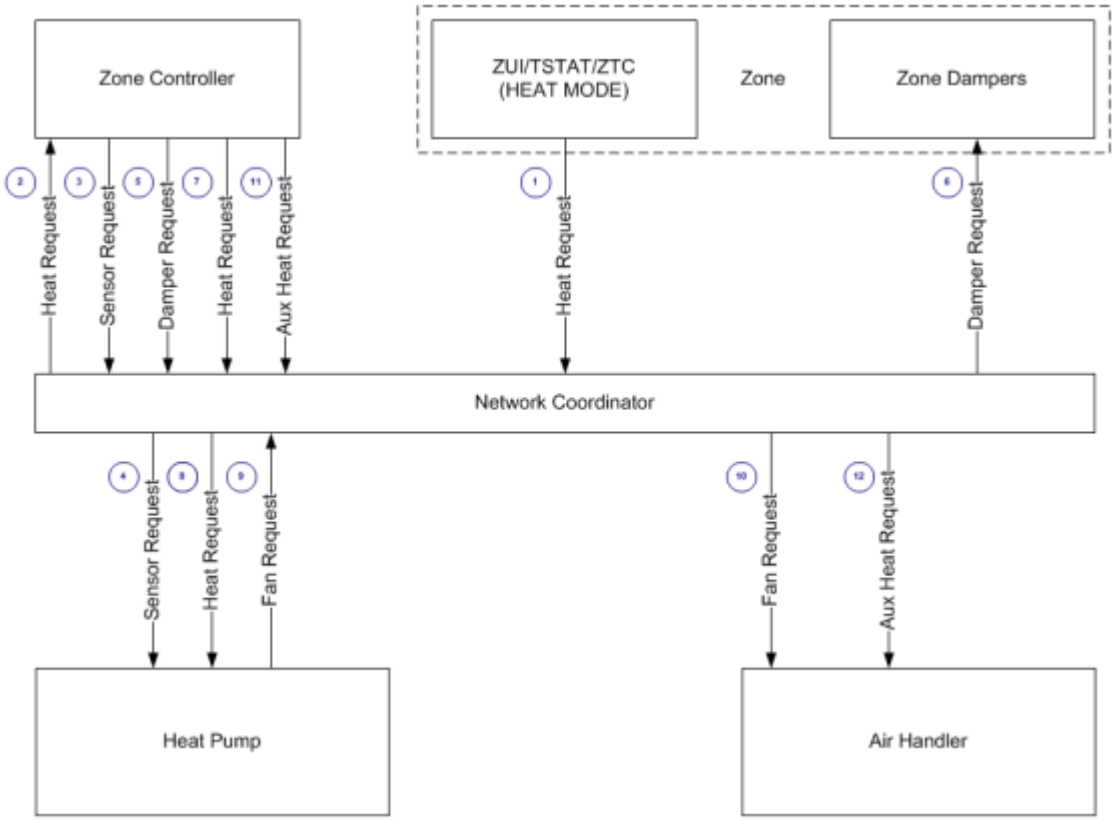
When heating is required and the outside temperature is below the balance point, the system shall do the following:

1. The zone stat or thermostat transmits a Heat Demand Control Command to the zone controller. The data payload contains the amount of heat demand required.
2. The zone controller shall transmit a Sensor Request to the heat pump. The data payload shall contain the outdoor temperature reading.
3. The zone controller opens the respective zone damper.
4. If the outdoor temperature is below the balance point, the zone controller shall transmit an Auxiliary Heat Demand Control Command to the air handler. The data payload shall contain the amount of heat demand required.
5. For all commands, the requesting subsystem shall refresh the command according to the refresh time provided in the initial request for as long as the demand remains unmet
6. Once the demand has been met, the requesting subsystem shall transmit the appropriate Control Command to turn off and close the function.
7. If the system mode is changed prior to satisfying the current demand (e.g. the user switches from heat to cool modes), the zone controller shall first turn off the current demand before initiating commands for the new mode.

7.3.7 Standard Call for Auxiliary Heat Demand – Heat Pump

This sequence is used when the air handler is the priority system for receiving a call for aux heat.

Figure 12 – Heat Pump Auxiliary Heat Demand Sequence Diagram

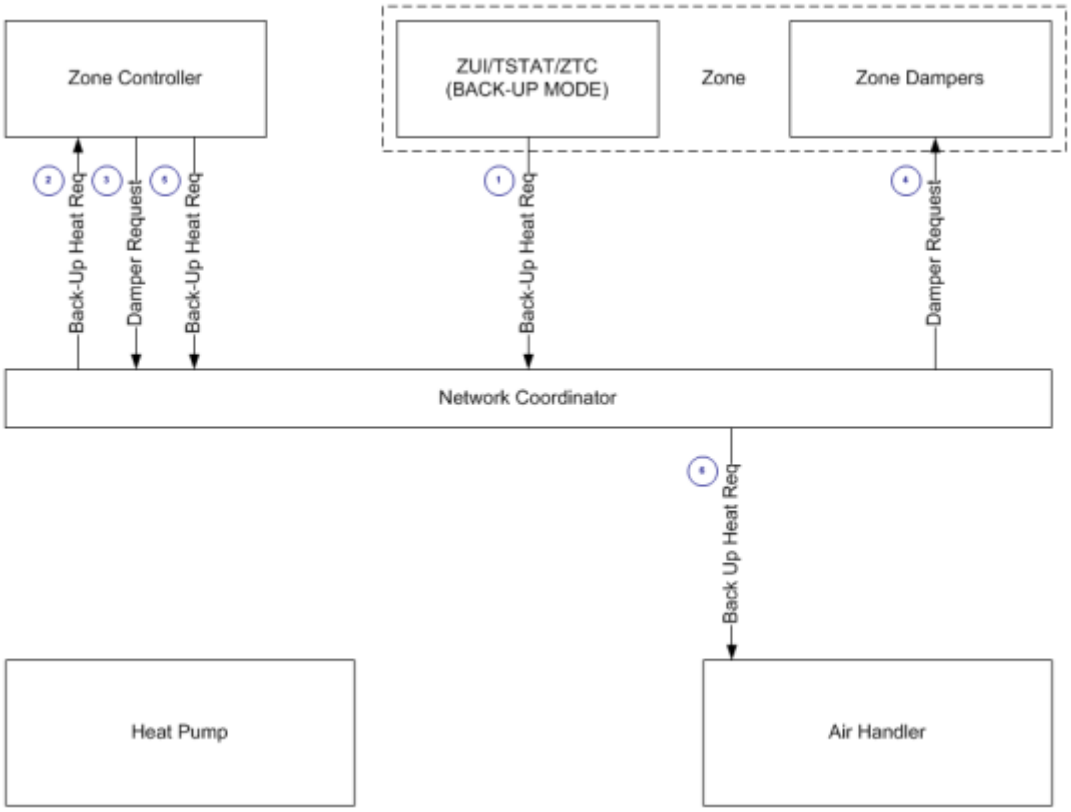


When auxiliary heat is required, the system shall do the following:

1. Steps 1 – 8 refer to Section 7.3.5.
2. The zone controller transmits an Auxiliary Heat Demand Control Command to the air handler. The data payload will contain the amount of auxiliary heat demand required.
3. For all commands, the requesting subsystem shall refresh the command according to the refresh time provided in the initial request for as long as the demand remains unmet.
4. Once the demand has been met, the requesting subsystem shall transmit the appropriate Control Command to turn off and close the function.
5. If the system mode is changed prior to satisfying the current demand (e.g. the user switches from heat to cool modes), the zone controller shall first turn off the current demand before initiating commands for the new mode.

7.3.8 Standard Call for Back-Up Heat Demand – Heat Pump

Figure 13 – Heat Pump Back-Up Heat Demand Sequence Diagram

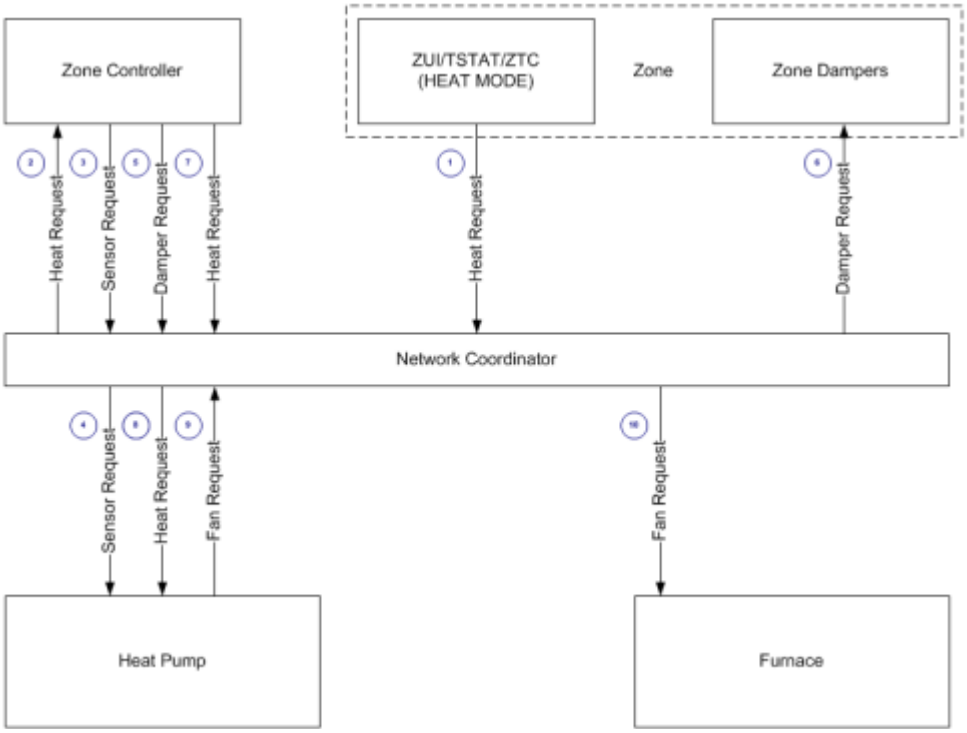


When back-up heat is required, the system shall do the following:

1. The zone stat or thermostat transmits a Back-Up Heat Demand Control Command to the zone controller. The data payload contains the amount of Back-Up Heat demand required.
2. The zone controller opens the respective zone damper.
3. The zone controller transmits a Back-Up Heat Demand Control Command to the air handler. The data payload shall contain the amount of heat demand required.
4. For all commands, the requesting subsystem shall refresh the command according to the refresh time provided in the initial request for as long as the demand remains unmet.
5. Once the demand has been met, the requesting subsystem shall transmit the appropriate Control Command to turn off and close the function.
6. If the system mode is changed prior to satisfying the current demand (e.g. the user switches from heat to cool modes), the zone controller shall first turn off the current demand before initiating commands for the new mode.

7.3.9 Standard Call for Heat Demand Above Balance Point – Dual Fuel System

Figure 14 – Dual Fuel Heat Demand Above Balance Point Sequence Diagram

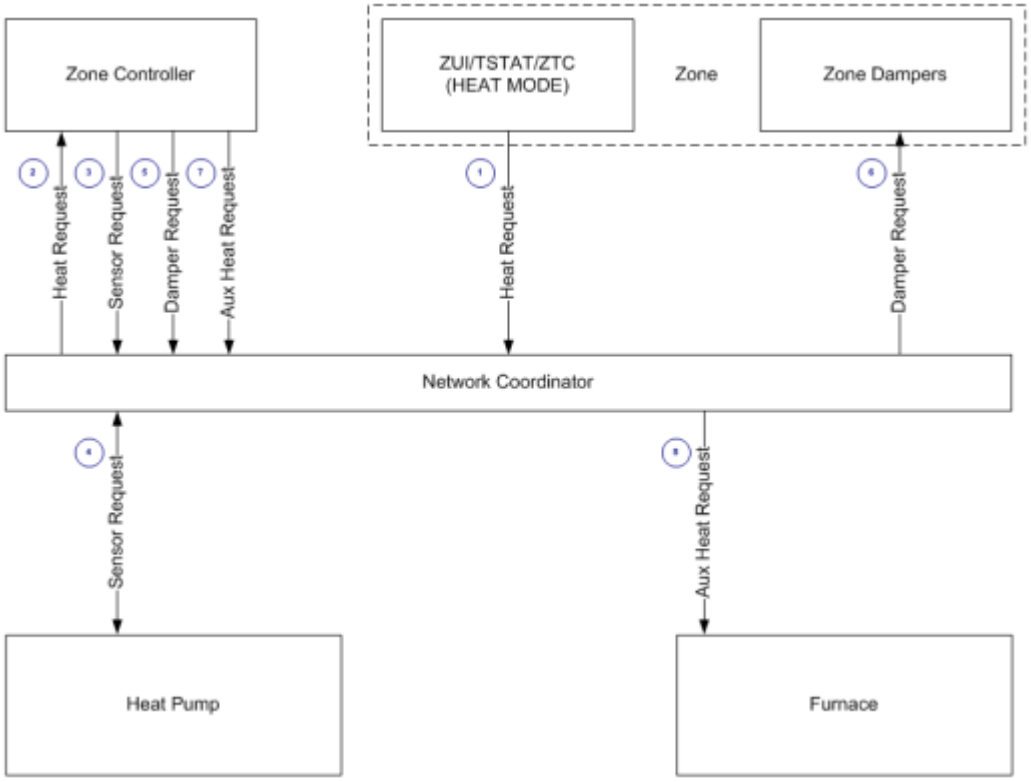


When heating is required and the outside temperature is above the balance point, the system shall do the following:

1. The zone stat or thermostat transmits a Heat Demand Control Command to the zone controller. The data payload contains the amount of heat demand required.
2. The zone controller shall transmit a Sensor Request to the heat pump. The data payload shall contain the outdoor temperature reading.
3. The zone controller opens the respective zone damper.
4. If the outdoor temperature is above the balance point, the zone controller shall transmit a Heat Demand Control Command to the heat pump. The data payload shall contain the amount of heat demand required.
5. The heat pump shall transmit a Fan Demand Control Command to the furnace. The data payload shall contain the amount of fan demand required.
6. For all commands, the requesting subsystem shall refresh the command according to the refresh time provided in the initial request for as long as the demand remains unmet.
7. Once the demand has been met, the requesting subsystem shall transmit the appropriate Control Command to turn off and close the function.
8. If the system mode is changed prior to satisfying the current demand (e.g. the user switches from heat to cool modes), the zone controller shall first turn off the current demand before initiating commands for the new mode.

7.3.10 Standard Call for Heat Demand Below Balance Point – Dual Fuel System

Figure 15 – Dual Fuel Gas Heat Demand Below Balance Point Sequence Diagram

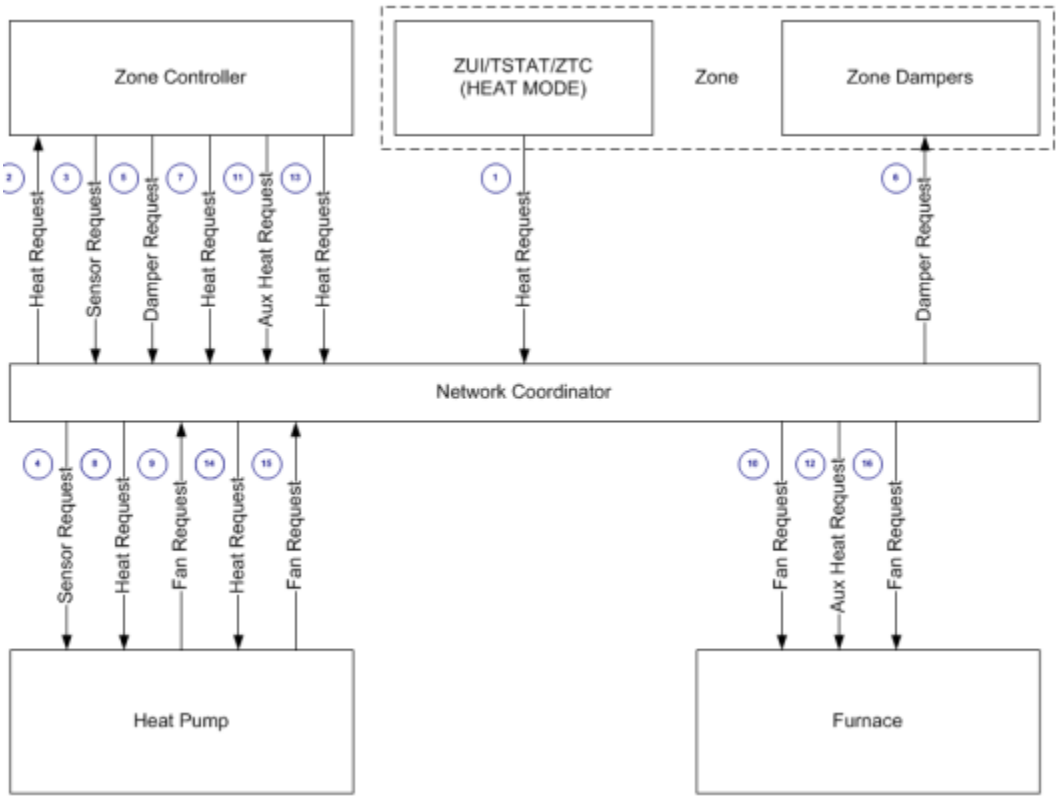


When heating is required and the outside temperature is below the balance point, the system shall do the following:

1. The zone stat or thermostat transmits a Heat Demand Control Command to the zone controller. The data payload contains the amount of heat demand required.
2. The zone controller shall transmit a Sensor Request to the heat pump. The data payload shall contain the outdoor temperature reading.
3. The zone controller opens the respective zone damper.
4. If the outdoor temperature is below the balance point, the zone controller shall transmit a Heat Demand Control Command to the furnace. The data payload shall contain the amount of heat demand required.
5. For all commands, the requesting subsystem shall refresh the command according to the refresh time provided in the initial request for as long as the demand remains unmet.
6. Once the demand has been met, the requesting subsystem shall transmit the appropriate Control Command to turn off and close the function.
7. If the system mode is changed prior to satisfying the current demand (e.g. the user switches from heat to cool modes), the zone controller shall first turn off the current demand before initiating commands for the new mode.

7.3.11 Standard Call for Aux Heat Demand – Dual Fuel System

Figure 16 – Dual Fuel Aux Heat Demand Sequence Diagram

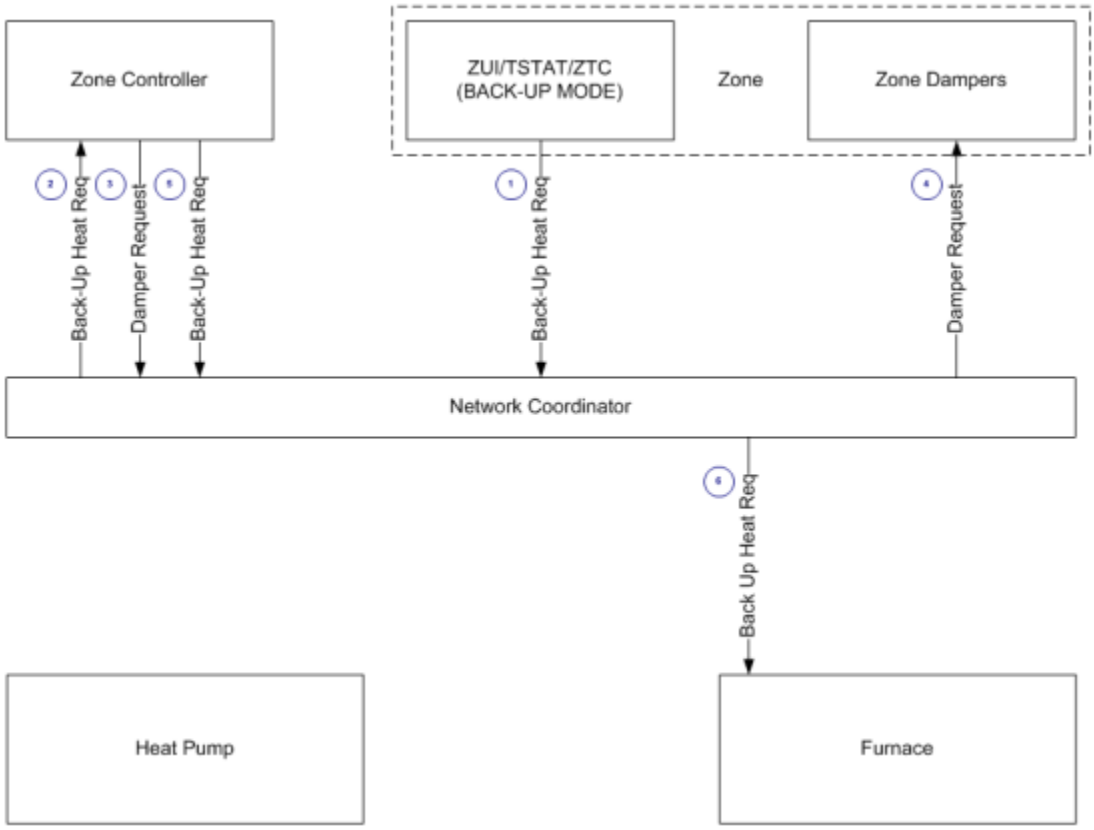


When alternate heat is required, the system shall do the following:

1. Steps 1 – 8 refer to Section 0.
2. The zone controller transmits an Auxiliary Heat Demand Control Command to the furnace. The data payload will contain the amount of auxiliary heat demand required.
3. After a minute, the zone controller shall transmit a Heat Demand Control Command to turn off the heat pump.
4. The heat pump transmits a Fan Demand Control command to turn off the fan to the furnace.
5. For all commands, the requesting subsystem shall refresh the command according to the refresh time provided in the initial request for as long as the demand remains unmet.
6. Once the demand has been met, the requesting subsystem shall transmit the appropriate Control Command to turn off and close the function.
7. If the system mode is changed prior to satisfying the current demand (e.g. the user switches from heat to cool modes), the zone controller shall first turn off the current demand before initiating commands for the new mode.

7.3.12 Standard Call for Back-Up Heat Demand – Dual Fuel System

Figure 17 – Dual Fuel Back-Up Heat Demand Sequence Diagram



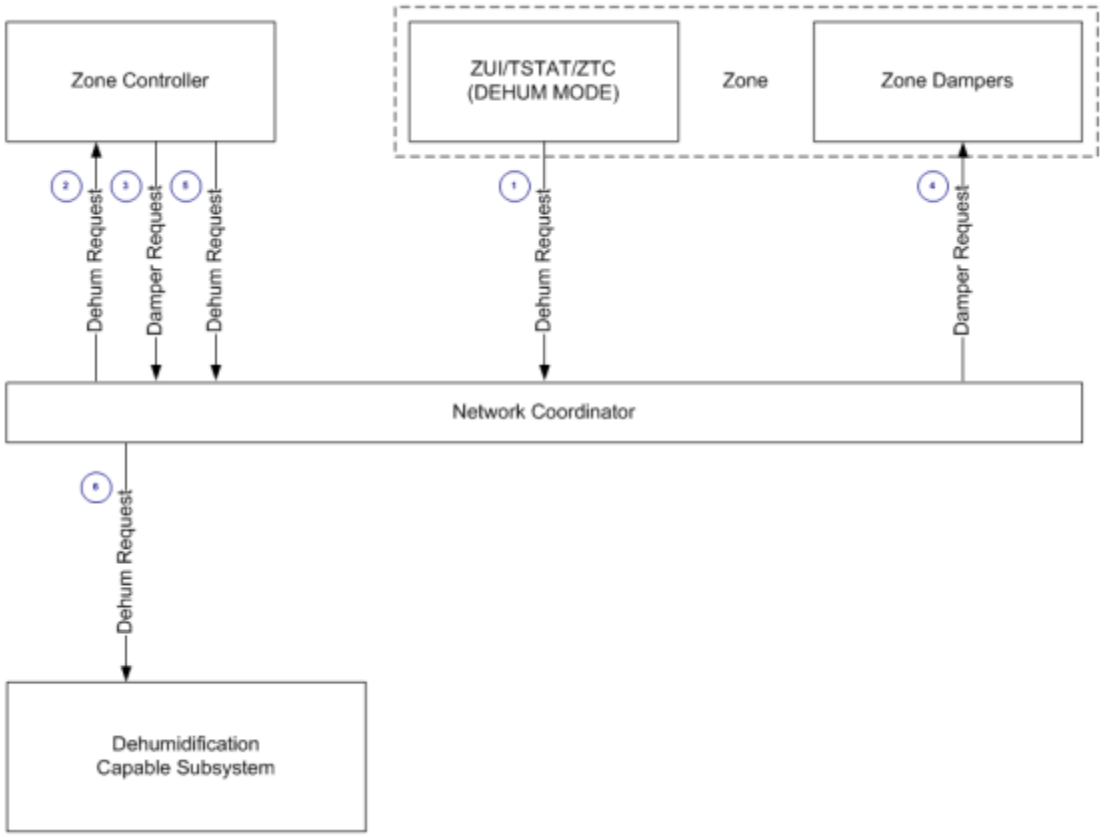
When back-up heat is required, the system shall do the following:

1. The zone stat or thermostat transmits a Back-Up Heat Demand Control Command to the zone controller. The data payload contains the amount of back-up heat demand required.
2. The zone controller opens the respective zone damper.
3. The zone controller transmits a Back-Up Heat Demand Control Command to the furnace. The data payload shall contain the amount of heat demand required.
4. For all commands, the requesting subsystem shall refresh the command according to the refresh time provided in the initial request for as long as the demand remains unmet.
5. Once the demand has been met, the requesting subsystem shall transmit the appropriate Control Command to turn off and close the function.
6. If the system mode is changed prior to satisfying the current demand (e.g. the user switches from heat to cool modes), the zone controller shall first turn off the current demand before initiating commands for the new mode.

7.4 Optional Normal Operation

7.4.1 Call for Dehumidification

Figure 18 – Dehumidification Demand Sequence Diagram

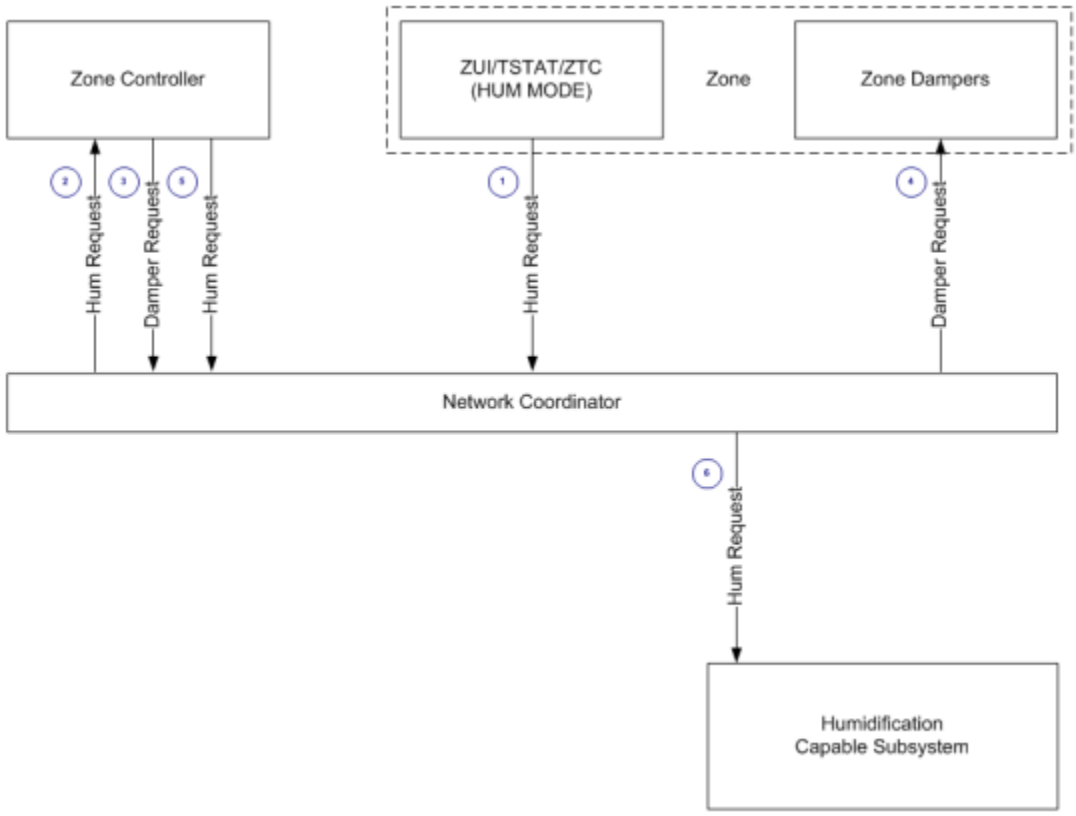


When dehumidification is required, the system shall do the following to meet the demand.

1. The zone stat or thermostat transmits a Dehumidification Demand Control Command to the zone controller. The data payload contains the amount of dehumidification demand required.
2. The zone controller opens the respective zone damper.
3. The zone controller shall transmit a Dehumidification Demand Control Command to the Dehumidification capable subsystem. The data payload shall contain the amount of dehumidification demand required.
4. For all commands, the requesting subsystem shall refresh the command according to the refresh time provided in the initial request for as long as the demand remains unmet.
5. Once the demand has been met, the requesting subsystem shall transmit the appropriate Control Command to turn off and close the function.

7.4.2 Call for Humidification

Figure 19 – Humidification Demand Sequence Diagram



When humidification is required, the system shall do the following to meet the demand.

1. The zone stat or thermostat transmits a Humidification Demand Control Command to the zone controller. The data payload contains the amount of humidification demand required.
2. The zone controller opens the respective zone damper.
3. The zone controller shall transmit a Humidification Demand Control Command to the Humidification capable subsystem. The data payload shall contain the amount of humidification demand required.
4. For all commands, the requesting subsystem shall refresh the command according to the refresh time provided in the initial request for as long as the demand remains unmet.
5. Once the demand has been met, the requesting subsystem shall transmit the appropriate Control Command to turn off and close the function.

8.0 Diagnostics

8.1 Fault Reporting

As specified in Section 5.3, subsystems shall report any faults to the primary HVAC controller, zone controller via a Set Diagnostics Message. For the zoning profile, the zone controller is this primary controller. The zone controller can transmit the fault message to other display devices on the network.

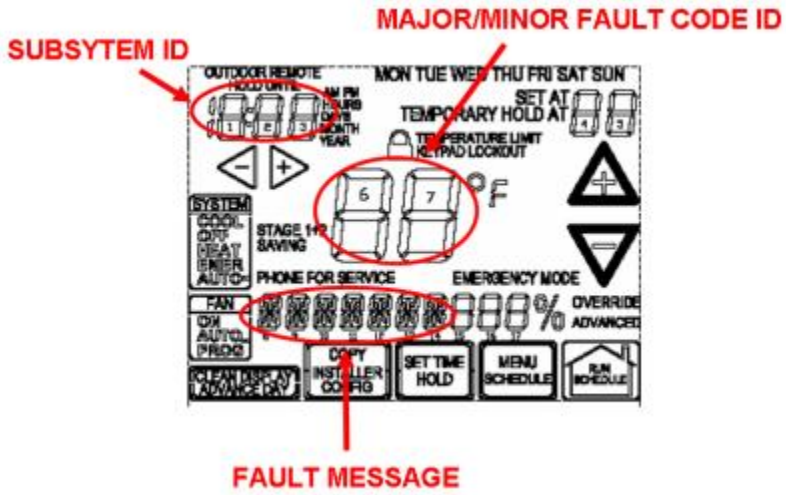
If the subsystem supports diagnostic messaging, then the subsystem is responsible for clearing fault messages when the fault has been resolved. Subsystems are also responsible for transmitting a diagnostic message at every Warm Restart per Section 5.3

All subsystems on the network may inform the contractor or home owner of any problem with its operation, usually through a message area on a display device per Section 6.5.

There are two types of faults: major and minor. Major faults mean the subsystem is inoperable, minor faults mean the subsystem needs maintenance.

The diagnostic message shall indicate either a major fault code or a minor fault code, and include an alphanumeric message of up to 15 characters. See the ClimateTalk Command Reference for details on the diagnostic message format.

Figure 20 – Thermostat Display Device Advanced Fault Menu Navigation Example



The code and node type in the transmitted fault message will be used by the display device to inform the installer or homeowner about the fault as its display and alert functionality will allow. An example implementation is shown in Figure 20 – Thermostat Display Device Advanced Fault Menu Navigation Example.

8.2 Subsystem Busy

The subsystem may need to be placed in a debug state while installed in an active system. In order to inform the zone controller that this condition has occurred, the subsystem shall transmit the Subsystem Busy control command to the zone controller. The zone controller shall initiate commands to put the subsystem in an idle mode. The zone controller may initiate the same command to a thermostat or zone stat for proper display and putting zones in an idle state. The subsystem will need to refresh the command periodically to keep the subsystem in the idle state.

See the ClimateTalk Command Reference for more information regarding the Subsystem Busy control command.

8.3 Proactive Diagnosis

By understanding the configuration of the network, controlling subsystems may be able to be proactive in illustrating faults in the system prior to them being realized by the home owner.

8.3.1 System Operation Monitoring

The zone controller is responsible for controlling the subsystems under its subnet to provide the proper heat, cool, dehumidification, and/or any other home owner comfort feature.

Through issued control commands, and status checks, the zone controller has more information on the system operational status than any other subsystem. Using information thus collected, the zone controller may be designed to proactively notify the homeowner/installer of a mis-configured setup that would cause the system to not operate properly.

8.3.1.1 Zone Controller Fault Active

Upon detection of a freeze protection or over-heat fault, the zone controller shall transmit a fault in diagnostic set message to the active subsystem supply heat or cool.

The active subsystem shall request a status request from the zone controller. Upon confirmation that the fault is either over-heat or freeze protection, the active subsystem shall disengage heat or cool but keep operating as the demand was active.

Once the zone controller detects the fault is cleared, the zone controller shall transmit a clear in a diagnostic set message to the active subsystem.

The active subsystem shall request a status request from the zone controller. Upon confirmation that the fault is cleared, the active subsystem shall re-engage heat or cool as before the fault was detected.

8.3.2 Missing Subsystem

The zone controller is responsible for detecting the active node types and requesting each subsystem's configuration to determine their capability.

If the configuration is missing an indoor unit, the zone controller can treat this as an indication of an invalid system, and notify the installer/homeowner of the same. Further, if a subsystem that was operational suddenly goes off the network without the zone controller having experienced a power outage, the zone controller could notify the homeowner/installer of an existing subsystem that went missing.

8.3.3 Missing Zone Controller

At any time a zone controller is not active on a network, the application that was identified to be in zone one shall provide the heat or cool demands as a back-up. Dampers shall default open.

8.3.4 Current Diagnostic Message

Any subsystem may have the ability to individually query a fault message by an index to handle an advanced diagnostics display page. The subsystems may have the corresponding ability to respond to such a request with the current fault information.

8.3.5 Informational Messaging

Subsystems on the network can have the ability to send a display device an informative message that may be displayed on the normal operation of the displaying device.

For example, a furnace can send a dynamic message of "air filter clogged" to a display device like a thermostat. The thermostat will display this alpha-numeric informative message on the top level operational status instead of buried deep down in advance installer menu.

8.4 Remote Access

A subsystem shall have the capability of interacting with a diagnostics and/or gateway device to allow for simple system diagnosis of the system. For subsystems to implement the zoning profile, the following sections shall be required for remote access.

8.4.1 Zone Controller

The zone controller shall have the capability of interacting with a diagnostics and/or gateway device to allow for simple system diagnosis of the system.

8.4.1.1 Operational Abilities

A diagnostics or gateway device may want to interact with the network by requesting the thermostat to be put into whatever modes are being authorized by that requesting device. The following sections shall discuss the types of modifications of the network is capable of via the thermostat.

The zone controller shall support the ability to receive a control command from a diagnostic or gateway device and perform the operation requested.

Table 6 – Zone Controller Supported Operations

Operation	Control Command
Change Filter Time Remaining	0x14 - Edit Air Filter replacement interval
Change UV Light Maintenance Time	0x5B – Edit Humidifier Pad replacement interval
Change Humidifier Pad Maintenance Time	0x5C –Edit UV Lamp replacement interval

8.4.1.2 Change Filter Time Remaining

The zone controller shall have the ability to receive a new amount of time to be used to decrement in the notification the homeowner when it is time to change the filter the till otherwise directed would then use this type of control command.

8.4.1.3 Change UV Light Maintenance Time

The zone controller shall have the ability to receive a new amount of time to be used to decrement in the notification the homeowner when it is time to change the filter the till otherwise directed would then use this type of control command.

8.4.1.4 Change Humidifier Pad Maintenance Time

The zone controller shall have the ability to receive a new amount of time to be used to decrement in the notification the homeowner when it is time to change the filter the till otherwise directed would then use this type of control command.

8.4.2 Zone User Interface

The zone user interface shall have the capability of interacting with a diagnostics and/or gateway device to allow for simple system diagnosis of the system.

8.4.2.1 Configuration

The zone user interface's configuration could also be available from the network to determine if a set up parameter needs to be adjusted to allow for a simple diagnostics resolution.

8.4.2.2 Operational Status

The zone user interface could allow for the ability of its status to be requested by these devices to get a better understanding of the zone stat's current setting to decide if there any diagnostics requirement to be determine from this data.

8.4.2.3 Operational Abilities

A diagnostics or gateway device may want to interact with the network by requesting the thermostat to be put into whatever modes are being authorized by that requesting device. The following sections shall discuss the types of modifications of the network is capable of via the zone user interface.

The zone user interface shall support the ability to receive a control command from a diagnostic or gateway device and perform the operation requested.

Table 7 - Supported Operations

Operation	Control Command
Modify Heat Set Point Temperature	0x01 – Heat Set Point Temperature Modify
Modify Cool Set Point Temperature	0x02 – Cool Set Point Temperature Modify
Modify Heat Profile	0x03 – Heat Profile Change
Modify Cool Profile	0x04 – Cool Profile Change
Modify System Mode	0x05 - System Switch Modify
Modify Hold Status	0x06 – Permanent Set Point Temp and Hold
Override Hold	0x08 – Hold Override
Set Time/Day	0x0F – Real Time/Day Override
Modify Dehumidification Set Point	0x5D – Dehumidification Set Point Modify
Modify Humidification Set Point	0x5E – Dehumidification Set Point Modify

8.4.2.3.1 System Switch Modify

The zone user interface shall have the ability to receive a new system switch mode like heat, cool or off that the zone user interface is operating at the till otherwise directed would then use this type of control command.

8.4.2.3.2 Set Point and Hold Modify

The zone user interface shall have the ability to receive a new set point and hold modify that the zone user interface is operating at the till otherwise directed would then use this type of control command.

8.4.2.3.3 Hold Override

The zone user interface shall have the ability to receive a command to take the zone user interface out of any type of hold and run the internal program that the zone user interface is operating at the till otherwise directed would then use this type of control command.

8.4.2.3.4 Set Time/Day

The zone user interface shall have the ability to receive a different time and day that the zone user interface is operating at the till otherwise directed would then use this type of control command.

8.4.2.3.5 Heat/Cool Profile Modification

The zone user interface shall have the ability to receive a new internal program that the zone stat is operating at the till otherwise directed would then use this type of control command.

8.4.2.3.6 Dehumidification/Humidification Set Point Modify

The zone user interface could have the ability to receive a new dehumidification/humidification set point that the zone user interface is operating at the till otherwise directed would then use this type of control command.

8.4.2.4 Sensor Data

The zone user interface's sensor data shall also be available from the network to determine any sensor data for that zone.

8.5 Subsystem Replacement

This section goes into the process which subsystems have to do at installation to allow for replacements to occur and subsystems regain what was configured at a previous installation to allow for a generic subsystem board to learn the system configuration and recover.

This recovery process is enabled by shared data and allows for returning a system to an operational mode that it was in, prior to any failures in a subsystem.

This section also describes the procedure a subsystem shall follow when an upgrade has been performed in a previously existing network.

8.5.1 Subsystems Replacement Criteria

The subsystems that allow for the optional requirement of implementing subsystem replacement and the mandatory storage of other subsystems shared data shall be the defined HVAC controllers like a thermostat or zone controller, indoor unit like an air handler or furnace, and outdoor unit like a air conditioner or heat pump.

8.5.2 Adding Replacement Subsystems

When a generic replacement has been powered up within a previously installed network that had the broken subsystem, the cold-start procedure requires for a shared data validity check.

Upon determining that the control has no shared data, the warm-start procedure requires the subsystem to query the network for shared data. The shared data rules (detailed in the *Generic Application Specification*) will ensure that the previous control that was used had pushed the latest modified version of Operational shared data to the network, which will be available to the replacement control upon request. Upon receiving this data, the subsystem will determine whether that data is valid for its use. If not, a proper diagnostic message will be sent to the installer to be detected.

8.5.3 Adding New Subsystems

A new subsystem could be a completely new subsystem like an upgrade. When a new subsystem has been powered up within a previously installed network, the cold-start procedure requires a shared data validity check.

At that time the subsystem shall determine it has valid shared data, the warm-start procedure requires the subsystem to transmit this shared data to the network for replication. This in turn would be replicated to each active subsystem while replacing the previous shared data of the old subsystem. Thus, if the control in the new unit will need to be replaced with a generic replacement board in the future as detailed in 8.5.2, the latest shared data that is suitable for the new unit will be ensured to be present on the network for retrieval.

8.6 Subsystems End of Life

There are two ways a subsystem could come from cradle to grave. One, subsystems replaced in installations that are being upgraded. Second, subsystems replaced due to failure have enormous amount of data that could help create better controls.

8.6.1 Fault Analysis

Returned subsystems may contain internal data from operation or fault history data. This information can be considered for root cause error analysis.

8.6.2 Trending Data

Analysis of operational data could also aid in the design of future controls. This data could be compiled in a database to discover operating trends.

8.6.3 Historical Data Retrieval

Subsystems have the ability to store operating information. This makes it possible to perform trend analysis described in the previous section. Requirements for each subsystem will define the type of data it should be recording through its operational life.

9.0 Annex A – Bibliography

"TIA-485 (Revision A), Electrical Characteristics of Generators and Receivers for Use in Balanced Digital Multipoint Systems" *Telecommunications Industry Association*, 1998.

Zimmermann, Hubert (April 1980). "OSI Reference Model — The ISO Model of Architecture for Open Systems Interconnection". *IEEE Transactions on Communications*