ClimateTalk 2.0
HVAC Application Profile

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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 Heating, Ventilation and Air-Conditioning (HVAC) 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This specification may be updated at any time and may be superseded by a more recent version or amended to from time to time.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 0.9		2008-11-07	Pre-Release
V 1.0		2009-08-24	Initial Release
V 1.1		2011-06-23	Errata Package
V 1.3		2011-11-02	Additional Errata Updates, Revised Formatting
V 2.0	00	2013-01-18	Version 2.0 Release – Incorporation of Zoning MRD, Crossover, and other CIM requirements. Update requirements for Remote Access. Add Device name association and MDI information.
V 2.0	01	2013-06-12	Updated 5.2.2 Warm Start Procedure - Thermostat. Request of status data is optional. Request of Identification data is optional. Updated 6.3 Identification Parameters. Unique serial number is mandatory for identification data. Updated 7.0 Subsystem Functions to include Cool as an optional IFC subsystem function. Updated 7.3.1 Call for Dehumidification and 7.3.2 Call for Humidification to establish a routing priority for dehumidification and humidification.

Contributors

The following is a list of ClimateTalk Alliance member companies that were actively engaged in the development of this standard:

3 Notch, LLC

A.O. Smith Water Products Company

Arzel Zoning Technology Inc.

Ecobee inc.

eControls, Inc.

Emerson Electric Company

EWC Controls

Nogginhaus LLC

Research Products Corp.

Rheem Manufacturing Company

Zonefirst

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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.

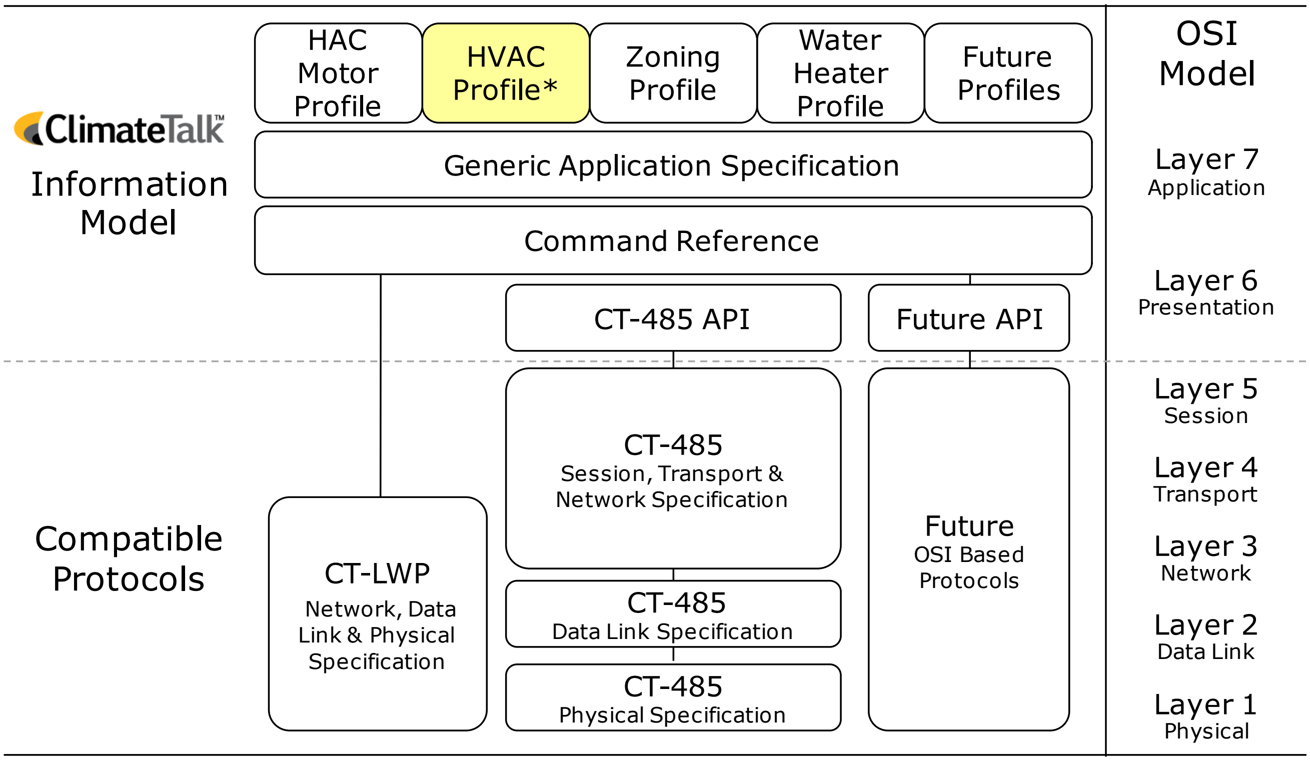
1.2 Scope

This document defines the specific application requirements for a HVAC subsystem designed to ClimateTalk Open Standards. This profile defines how HVAC subsystem components control, operate, and monitor an HVAC system on a ClimateTalk network. This document defines the interaction and distribution of control and data among a thermostat, an indoor unit (furnace or air handler) and an outdoor unit (air conditioner or heat pump). 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 prescribes 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.

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

Figure 1 - OSI Layers for ClimateTalk Implementation



**This Document*

This profile also defines the testable requirements used to validate that the devices in an HVAC subsystem are 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 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

ClimateTalk HAC Motor Profile

ClimateTalk CT-LWP Specification

3.0 Terminology

3.0 Definitions

Attempt Delay	The amount of time a subsystem waits for a response from another subsystem to a request.
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.
Control ID	Unique 2-byte Identifier assigned to each device by the ClimateTalk Alliance that is used to identify the control application.
Coordinator	ClimateTalk device which establishes the network and through which messages are routed.
Generic Device	Any device that is part of an HVAC system that does not have specific requirements defined in the ClimateTalk specification.
HVAC Nodes	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.
Manufacturer ID	Unique 2-byte Identifier assigned to each manufacturer by the ClimateTalk Alliance that is used to identify the subsystem.
Null Byte	Hexadecimal zero, also shown as 0x00.
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.

3.1 Acronyms

AC	Air Conditioner
AH	Air Handler
DAY	Day
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
MOR	Morning
NHT	Night
OBBI	On-Board Bus Interface
OCC1	Occupied, 1st Time Step
OCC2	Occupied, 2nd Time Step
SW	Software
SD	Shared Data
TSTAT	Thermostat
UNO1	Unoccupied, 1st Time Step
UNO2	Unoccupied, 2nd Time Step

3.2 Word Usage

The conventions used in this document are modelled 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

4.0 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 furnace.

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

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

Table 2 – Less Common HVAC Configurations illustrates the different possibilities if normal subsystems are not present for any reason, including communications or subsystem failure.

Table 2 – Less Common HVAC Configurations

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

4.1.1 Subsystem Capabilities

Table 3 – Subsystem Functions

Subsystem	Function
Furnace	Heating
Air Handler	Airflow Circulation and Electrical Strip Heating
Air Conditioner	Cooling
Heat Pump	Heat and Cooling

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.

4.1.2 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.

4.2 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.

Upon seeing a node type corresponding to itself in the list, the subsystem shall consider itself online.

If the subsystem is online and receives a network node list, the subsystem will initiate a warm restart. See section 5.2 for details.

4.2.1 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* for the list of node types and their values.

4.2.2 Zoning Capabilities

Upon detection of a zone controller on the network, the Zoning Profile will have to be adhered instead of this HVAC Profile.

5.0 Warm and Cold Start Procedures

5.0 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 initially or 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.

For example, a new heat pump is installed on a system with an air handler. The air handler is currently answering a call for fan. The air handler receives a new network node list from the coordinator and idles itself. The appropriate subsystem will re-initiate the call for fan to the air handler if the air handler is the proper device to receive that call once the heat pump is installed and operational.

5.1 Cold Start Procedure

All subsystems shall do the following:

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

5.2 Warm Start Procedure

5.2.1 Warm Start Procedure – All Subsystems Except 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 warm start procedure.
3. Has shared data been checked for validity?
    a. If no, check shared data for validity.
    b. If yes, continue with 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 thermostat on the list?
    a. If no, stop and wait.
    b. If yes, continue with warm start procedure.
6. Check to see if fault conditions exist.
    a. If no, transmit a Diagnostics Set – Clear message to the thermostat.
    b. If yes, transmit a Diagnostics Set – Fault message to the thermostat.
7. Subsystem is now considered to be a communicating control on the network.
8. 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, do the following steps.
        i. Request Configuration from the indoor unit to verify max CFM.
        ii. Request Status of the indoor unit to verify fan and defrost control operation states.
        iii. Re-Command the indoor unit if necessary.

5.2.2 Warm Start Procedure - Thermostat

1. Go to an idle state. Prepare to auto-configure the HVAC system.
2. Clear all diagnostic and display messages in memory.
3. Does the thermostat 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 data
    b. Request Identification data (optional)
    c. Request Status data (optional)
5. Make control decisions and reissue commands as necessary.

5.3 External Fan Capabilities

Subsystems that require information from the indoor blower motor / fan operation shall request configuration data from the indoor subsystems on the network. The indoor subsystem's reply data payload shall define the capabilities of the fan.

6.0 Ease of Installation Requirements

6.0 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.

From an application standpoint, the storage, retrieval and transmission of shared data is optional for all device types. There are, however, mandatory network shared data services for coordinator capable devices and all HVAC subordinate devices. Designs must consider the non-volatile storage requirements for network shared data. The details of such are defined in the Networking Specification under Network Shared Data Sectors.

6.1 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.

6.1.1 Manual Configuration

Subsystems may need to be manually configured at the installation site. Subsystems may accept generic user interface data from the thermostat via the Set Display Message command.

6.2 Subsystem Installation Test

The Subsystem Installation Test control command is used by a remote device to initiate an installation test in a subsystem.

Subsystems are not required to support an installation test. If a subsystem does not support installation tests and it receives a request to perform one, it shall respond with an Unknown Application Payload message. The format for this message is defined in the *Generic Application Specification* in the section on Error Reporting.

If a subsystem supports installation tests, it may support the ability to have the test be initiated by a remote device. The remote device sends a Subsystem Installation Test control command to the subsystem, requesting that it initiate the test. On receiving this command, the subsystem runs the test. The status and results of the test may be sent to the remote device via the Set Display Message command.

The test may be ended by the remote device or the subsystem itself at any time via the Subsystem Installation Test control command.

The remote device may be a thermostat or diagnostic tool or another subsystem. The ability of a particular device to display information to a user will vary depending on the type of display the device has. Devices with dot-matrix or other visually rich displays are required to support the initiation and monitoring of a Subsystem Installation Test. Devices with segmented or other visually poor displays are not required to support initiation and monitoring of a Subsystem installation test.

The format of the Subsystem Installation Test control command and the Set Display Message command is in the ClimateTalk Command Reference document.

6.3 Identification Parameters

All subsystems shall store the ClimateTalk specification version number, the software version number, the software revision number, and unique serial number at the very minimum. The remaining parameters in the Identification MDI are optional.

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, and Software Revision at the very minimum. Further details on the Identification Data are contained in the *ClimateTalk Command Reference*.

6.4 Installation User Menus

Subsystems may provide a subsystem-specific user menu for configuration and diagnostic purposes. Users access the menu via the thermostat. The thermostat shall request the menu from the subsystem when the user accesses it on the thermostat.

If a subsystem receives a request for its user menu and it does not have one, it shall inform the thermostat that the feature is not supported by responding with an Unknown Application Message Type message. See the *ClimateTalk Generic Application Specification* section on Error Reporting for the format of this message.

6.4.1 Mandatory Support for User Menus

A thermostat with a graphical display is a mandatory display device and shall implement the full user menu capability as defined in the *ClimateTalk Generic Application Specification*.

A thermostat with non-graphical capabilities shall be required to provide the user menu implementation for only those fields that are changeable by the user. These fields are called “selectable”. For more information on selectable fields, see the User Menu section of the *Generic Application Specification*.

7.0 Normal Operation

7.0 Subsystem Functions

Table 4 – 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 4 – 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		
Back-Up Heat			M	M
Fan			M	M
Heat	M		M	
Humidify			O	O

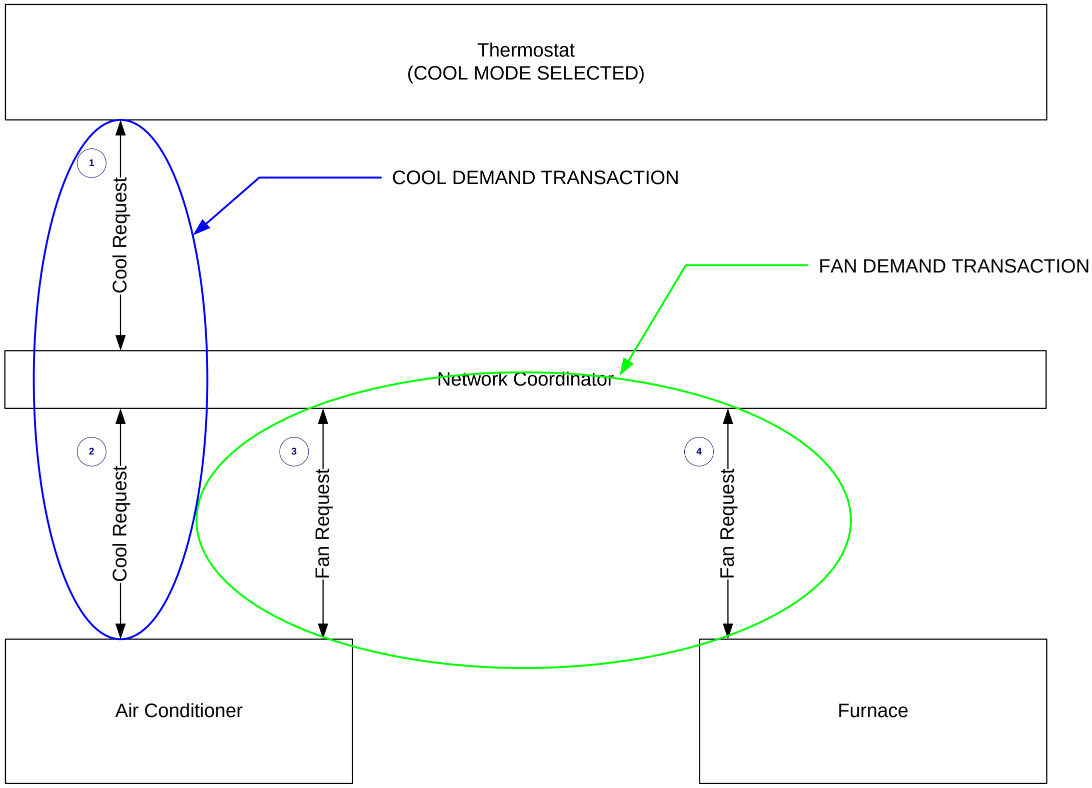
In the diagrams in the sections below, references to a "cooling subsystem" means any subsystem capable of providing cooling, references to a "heating subsystem" means any subsystem capable of providing heat, etc.

7.1 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 2 – 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 2 – Application Messaging Sequence Diagram Example

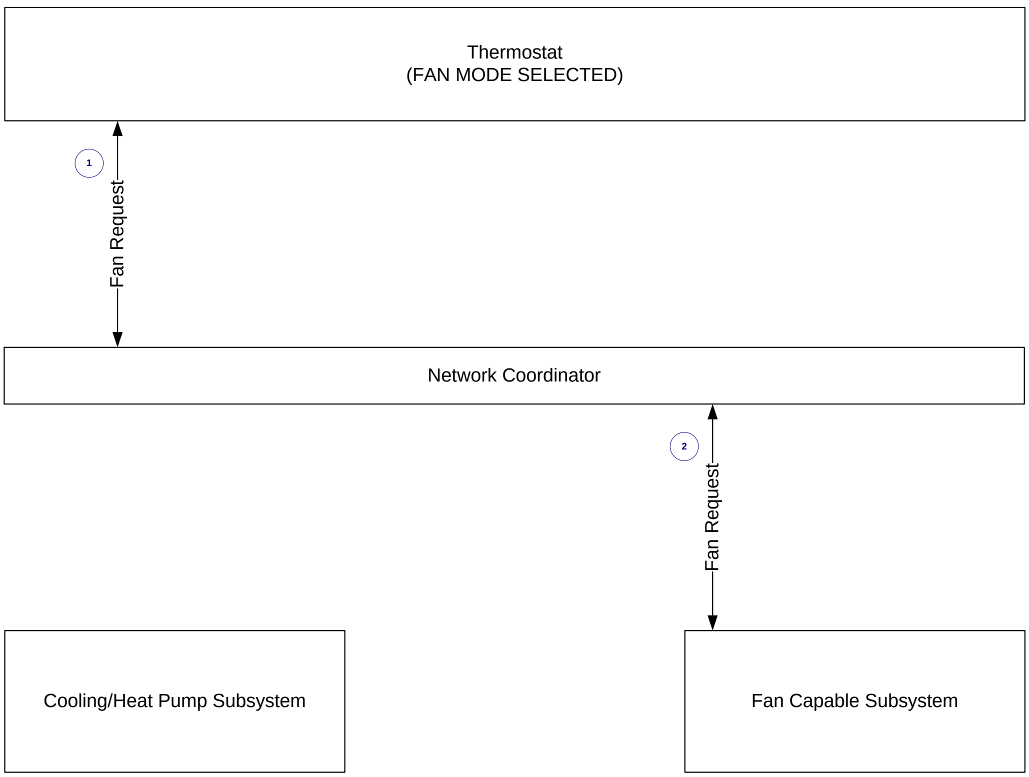


7.2 Mandatory Normal Operation

7.2.1 Standard Call for Fan Demand

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

Figure 3 – Fan Demand Sequence Diagram

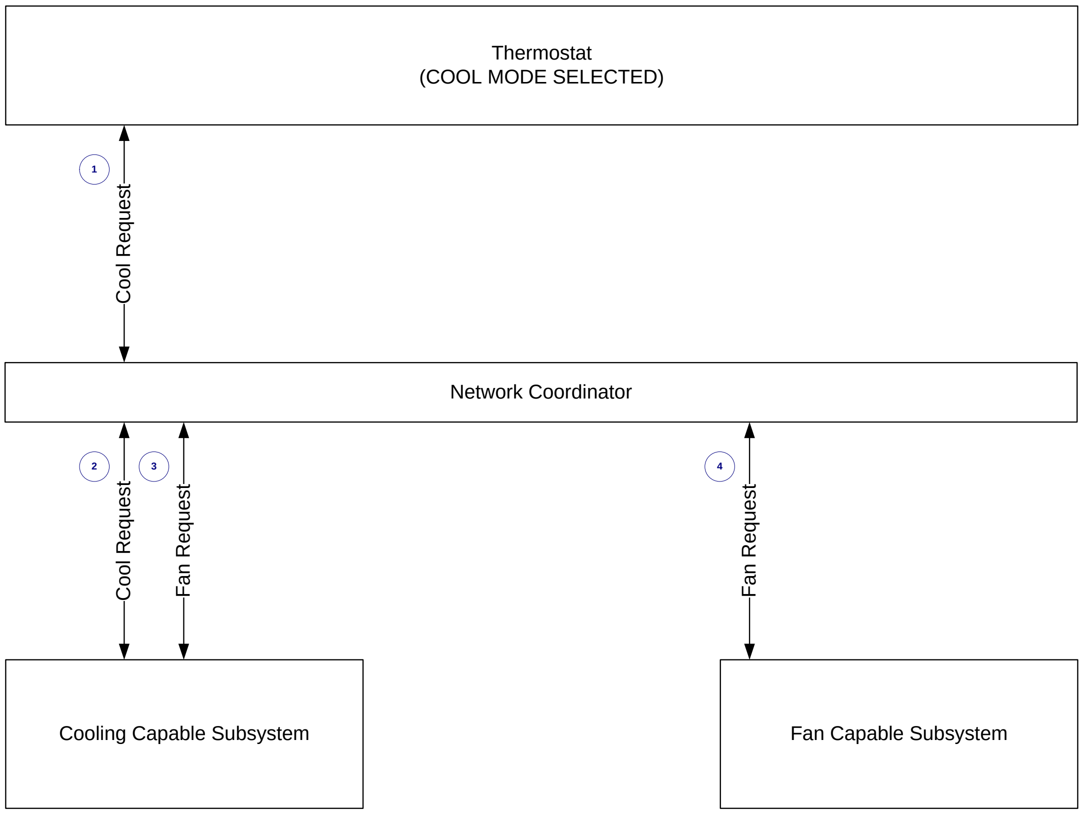


When fan operation is required, the system shall do the following:

1. The thermostat transmits a Fan Demand Control Command to the fan capable subsystem. The data payload contains the amount of fan demand required.
2. The thermostat shall refresh the fan demand command according to the refresh time provided in the initial request for as long as the demand for the fan remains unmet.
3. Once the fan demand has been met, the thermostat shall transmit a Fan Demand Control Command to the fan capable subsystem requesting it to turn off.

7.2.2 Standard Call for Cool Demand

Figure 4 – Cool Demand Sequence Diagram

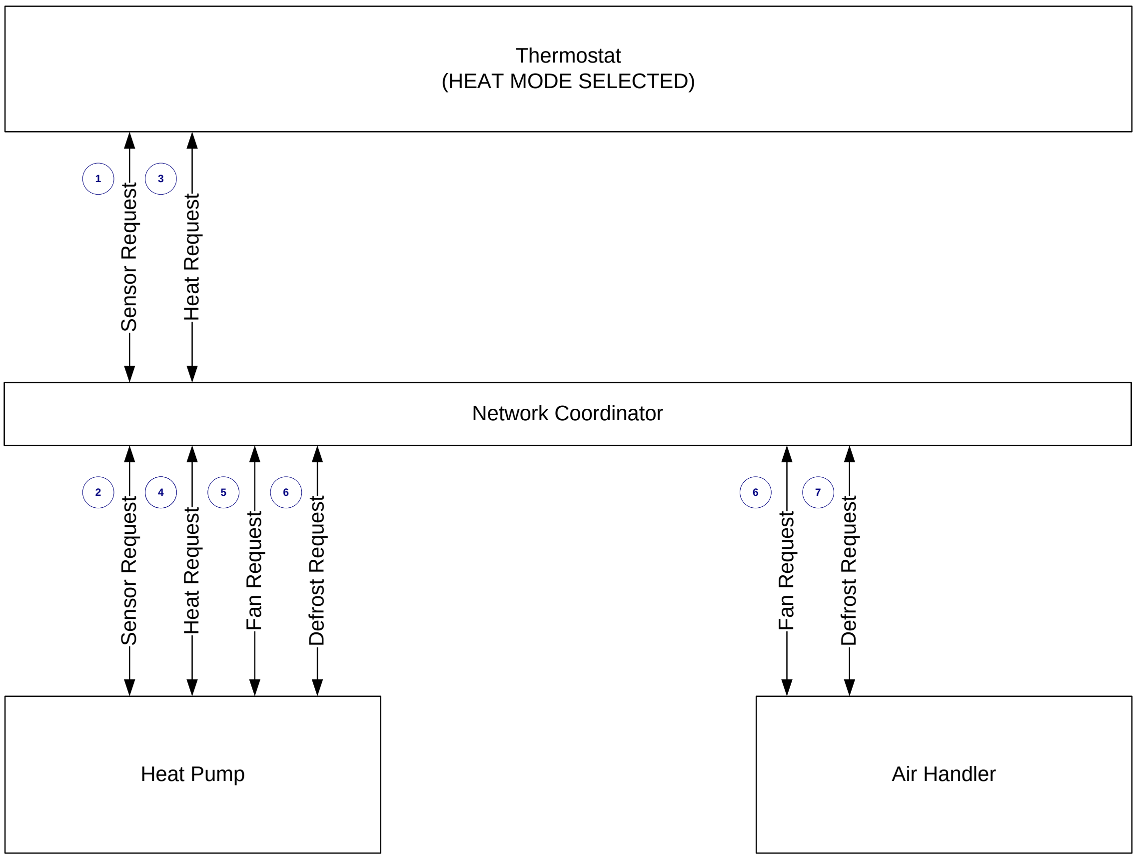


When cooling is required, the system shall do the following:

1. The thermostat shall transmit a Cool Demand Control Command to the cooling capable subsystem. The data payload shall contain the amount of cool demand required.
2. 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.
3. The thermostat shall refresh the cool demand command according to the refresh time provided in the initial request for as long as the demand for cooling remains unmet.
4. Once the cooling demand has been met, the thermostat shall transmit a Cool Demand Control Command turning off the cooling subsystem. The cooling subsystem shall transmit a Fan Demand Control Command turning off the fan.
5. If the system mode is changed prior to satisfying the current demand (e.g. the user switches from cool to heat modes), the thermostat shall first turn off the current demand before initiating commands for the new mode.

7.2.3 Standard Call for Defrost Demand

Figure 5 – Heat Pump Defrost Demand Sequence Diagram



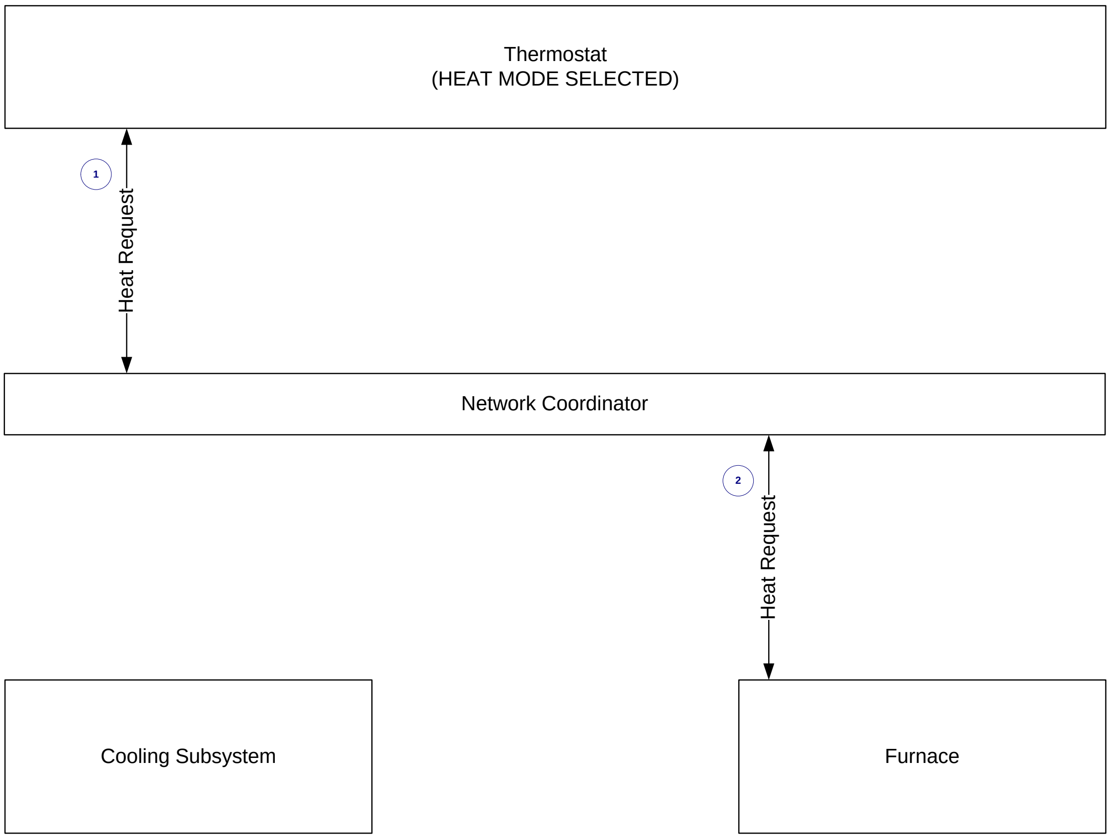
When defrosting of the outdoor unit is required, the system shall do the following:

1. Steps 1 – 6 refer to Section 7.2.5.
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 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 thermostat shall first turn off the current demand before initiating commands for the new mode.

7.2.4 Standard Call for Heat Demand – Furnace

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

Figure 6 – Furnace Heat Demand Sequence Diagram

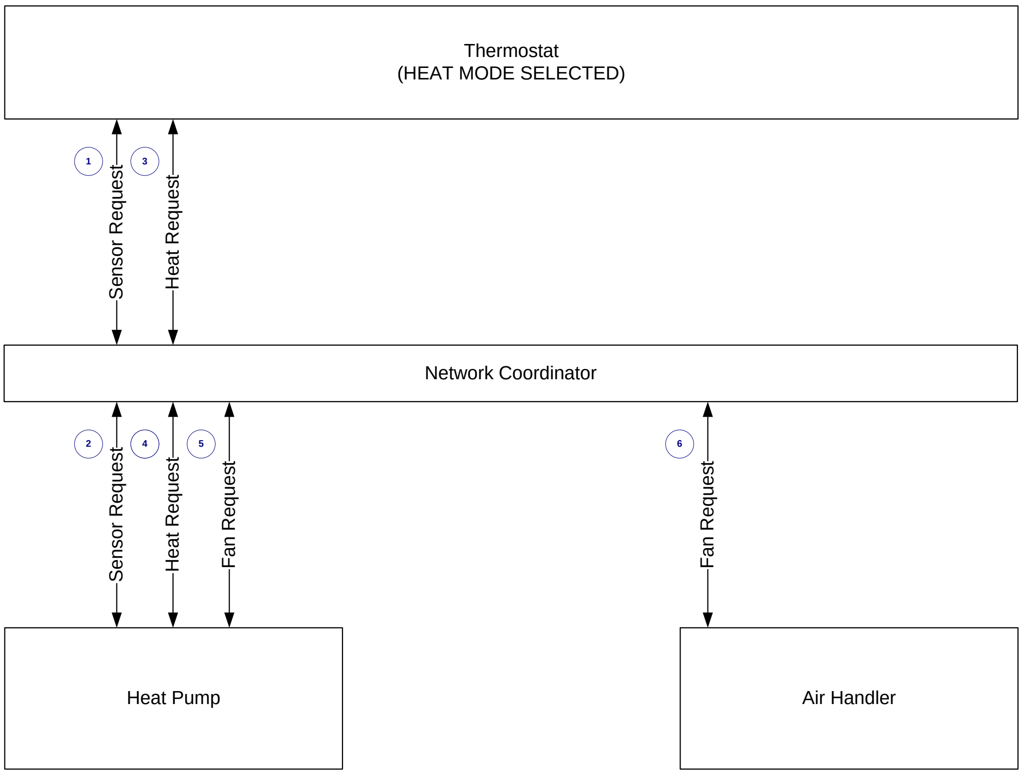


When heating is required, the system shall do the following:

1. The thermostat shall transmit a Heat Demand Control Command to the furnace. The data payload will contain the amount of heat demand required.
2. The thermostat shall refresh the Heat Demand Command according to the refresh time provided in the initial request for as long as the demand for heating remains unmet.
3. Once the heating demand has been met, the thermostat shall transmit a Heat Demand Control Command turning off the furnace.
4. If the system mode is changed prior to satisfying the current demand (e.g. the user switches from heat to cool modes), the thermostat shall first turn off the current demand before initiating commands for the new mode.

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

Figure 7 – Heat Pump Heat Demand Above Balance Point Sequence Diagram

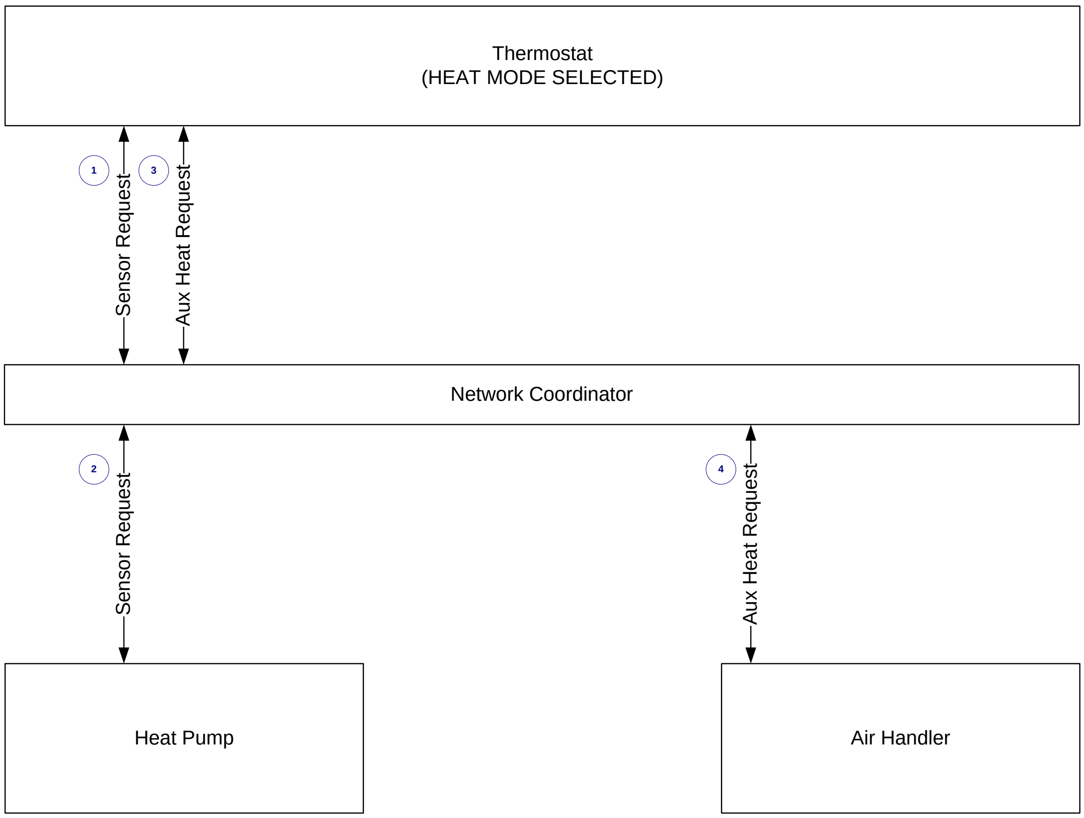


When heating is required and the outside temperature is above the balance point, the system shall do the following:

1. The thermostat shall transmit a Sensor Request to the heat pump. The data payload shall contain the outdoor temperature reading.
2. If the outdoor temperature is above the balance point, the thermostat shall transmit a Heat Demand Control Command to the heat pump. The data payload shall contain the amount of heat demand required.
3. 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.
4. The thermostat shall refresh the Heat Demand Command according to the refresh time provided in the initial request for as long as the demand for heating remains unmet. The heat pump shall refresh the Fan Demand Command according to the refresh time provided in the initial request for as long as demand for fan is required.
5. Once the heating demand has been met, the thermostat shall transmit a Heat Demand Control Command to the heat pump turning off the heat. The heat pump shall transmit a Fan Demand Control Command to the air handler turning off the fan.
6. If the system mode is changed prior to satisfying the current demand (e.g. the user switches from heat to cool modes), the thermostat shall first turn off the current demand before initiating commands for the new mode.

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

Figure 8 – Heat Pump Heat Demand Below Balance Point Sequence Diagram

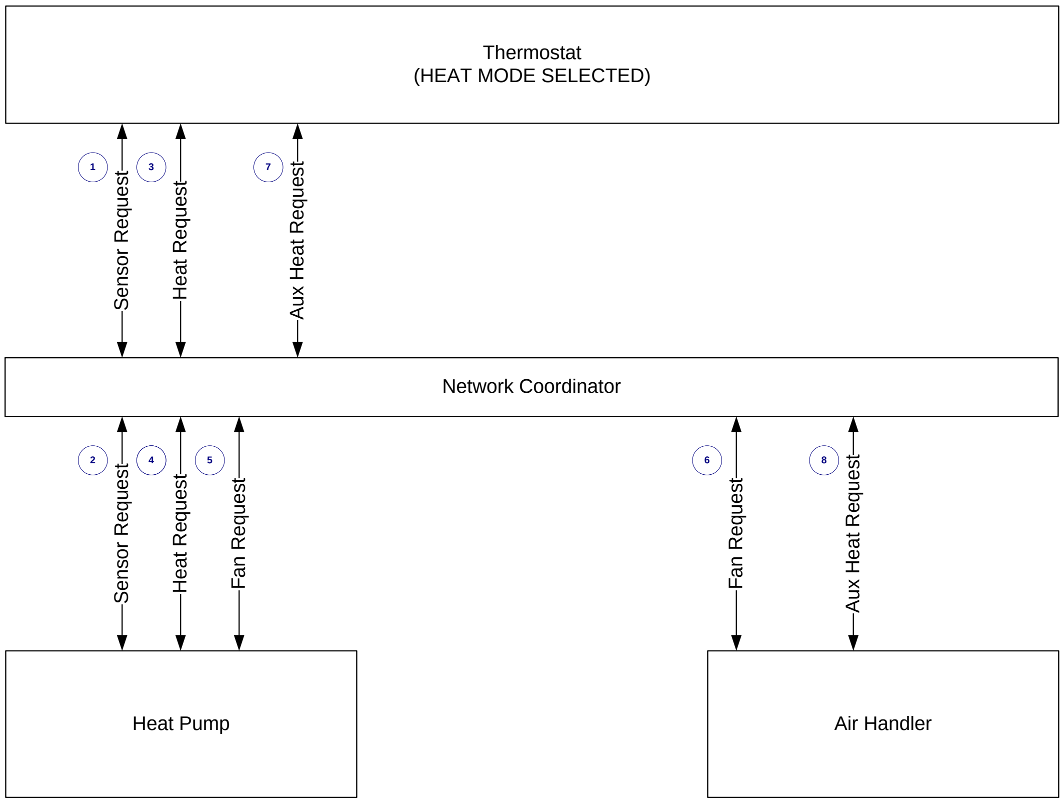


When heating is required and the outside temperature is below the balance point, the system shall do the following:

1. The thermostat shall transmit a Sensor Request to the heat pump. The data payload shall contain the outdoor temperature reading.
2. If the outdoor temperature is below the balance point, the thermostat shall transmit an Auxiliary Heat Demand Control Command to the air handler. The data payload shall contain the amount of heat demand required.
3. The thermostat shall refresh the Auxiliary Heat Demand Command according to the refresh time provided in the initial request for as long as the demand for heating remains unmet.
4. Once the heating demand has been met, the thermostat shall transmit an Auxiliary Heat Demand Control Command to the air handler turning off the heat.
5. If the system mode is changed prior to satisfying the current demand (e.g. the user switches from heat to cool modes), the thermostat shall first turn off the current demand before initiating commands for the new mode.

7.2.7 Standard Call for Auxiliary Heat Demand – Heat Pump

Figure 9 – Heat Pump Auxiliary Heat Demand Sequence Diagram

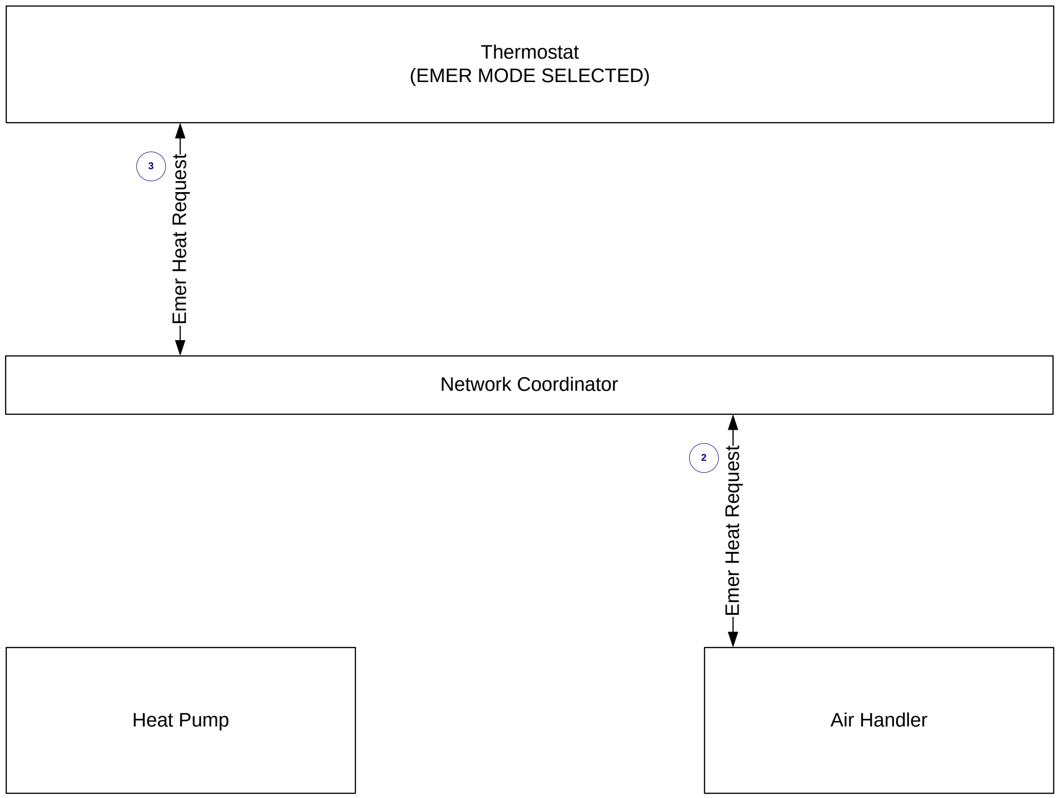


When auxiliary heat is required, the system shall do the following:

1. Steps 1 – 6 refer to Section 7.2.5.
2. The thermostat 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 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 thermostat shall first turn off the current demand before initiating commands for the new mode.

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

Figure 10 – Heat Pump Back-Up Heat Demand Sequence Diagram

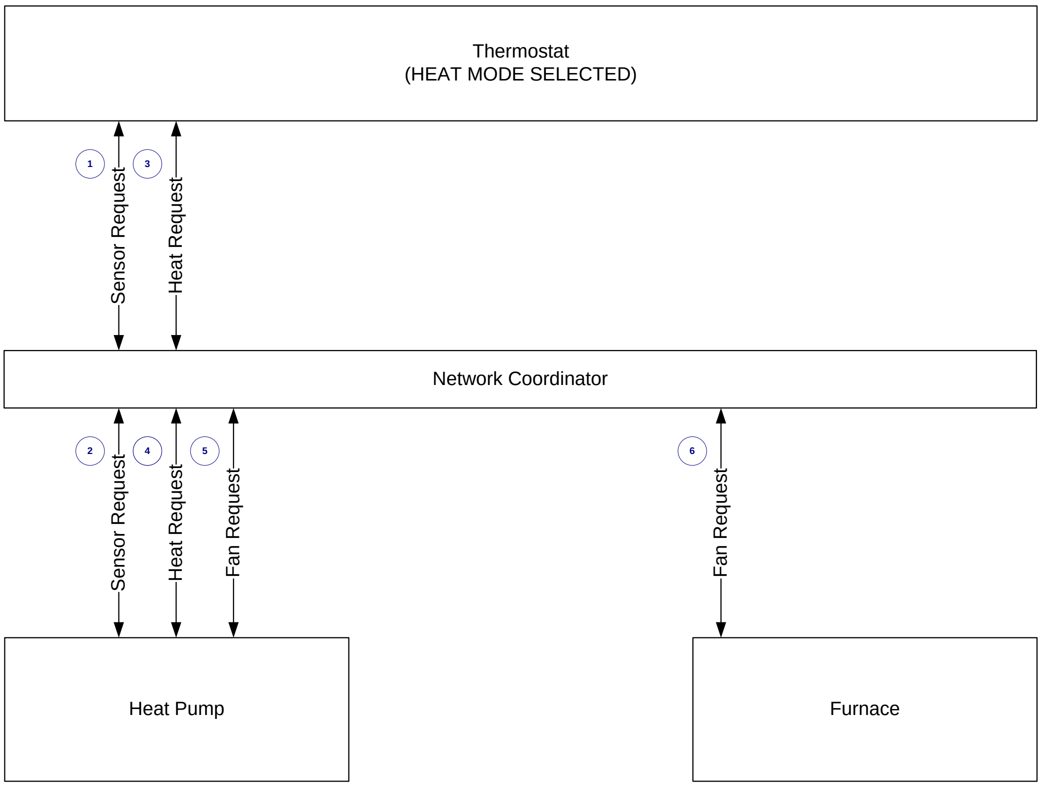


When back-up heat is required, the system shall do the following:

1. The thermostat transmits a Back-Up Heat Demand Control Command to the air handler. The data payload shall contain the amount of heat demand required.
2. The thermostat shall refresh the Back-Up Heat Demand Command according to the refresh time provided in the initial request for as long as the demand for heating remains unmet.
3. Once the heating demand has been met, the thermostat shall transmit a Back-Up Heat Demand Control Command to the air handler turning off the heat.
4. If the system mode is changed prior to satisfying the current demand (e.g. the user switches from heat to cool modes), the thermostat shall first turn off the current demand before initiating commands for the new mode.

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

Figure 11 – Dual Fuel Heat Demand Above Balance Point Sequence Diagram

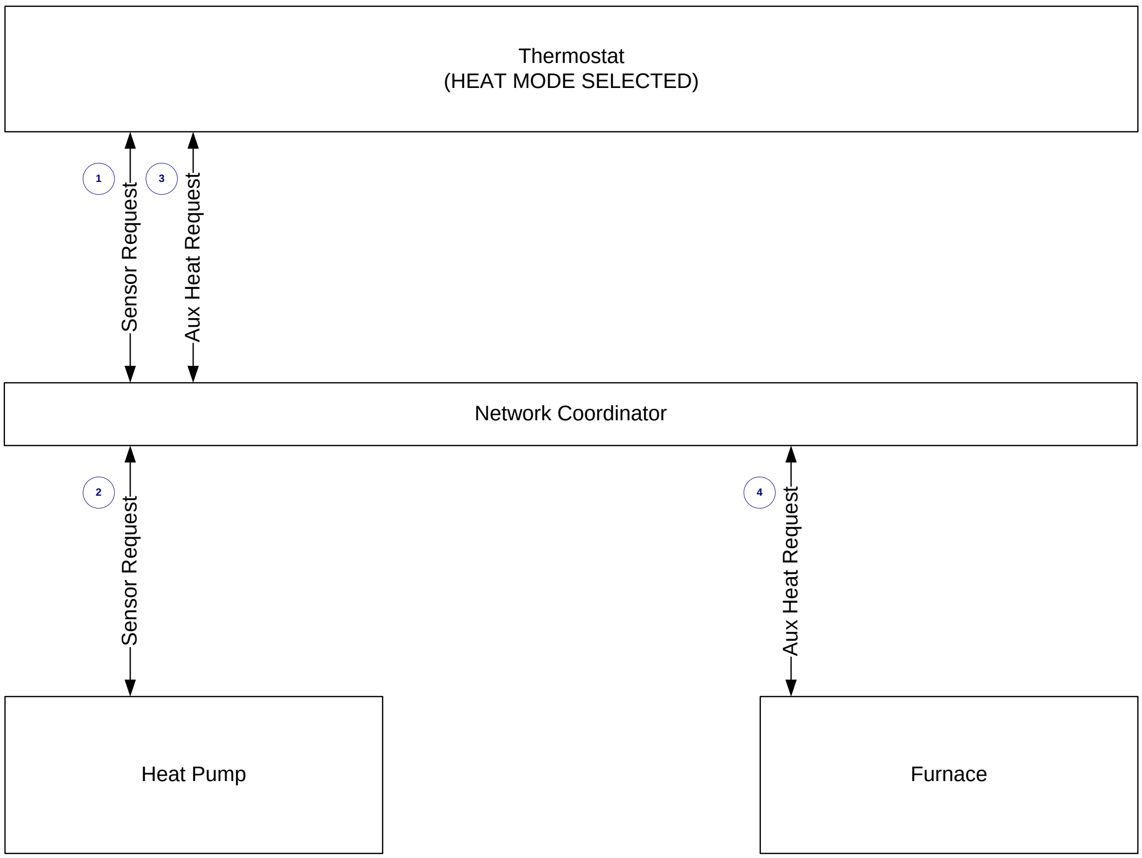


When heating is required and the outside temperature is above the balance point, the system shall do the following:

1. The thermostat shall transmit a Sensor Request to the heat pump. The data payload shall contain the outdoor temperature reading.
2. If the outdoor temperature is above the balance point, the thermostat shall transmit a Heat Demand Control Command to the heat pump. The data payload shall contain the amount of heat demand required.
3. The heat pump shall transmit a Fan Demand Control Command to the furnace. The data payload shall contain 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 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 thermostat shall first turn off the current demand before initiating commands for the new mode.

7.2.10Standard Call for Heat Demand Below Balance Point – Dual Fuel System

Figure 12 – Dual Fuel Gas Heat Demand Below Balance Point Sequence Diagram

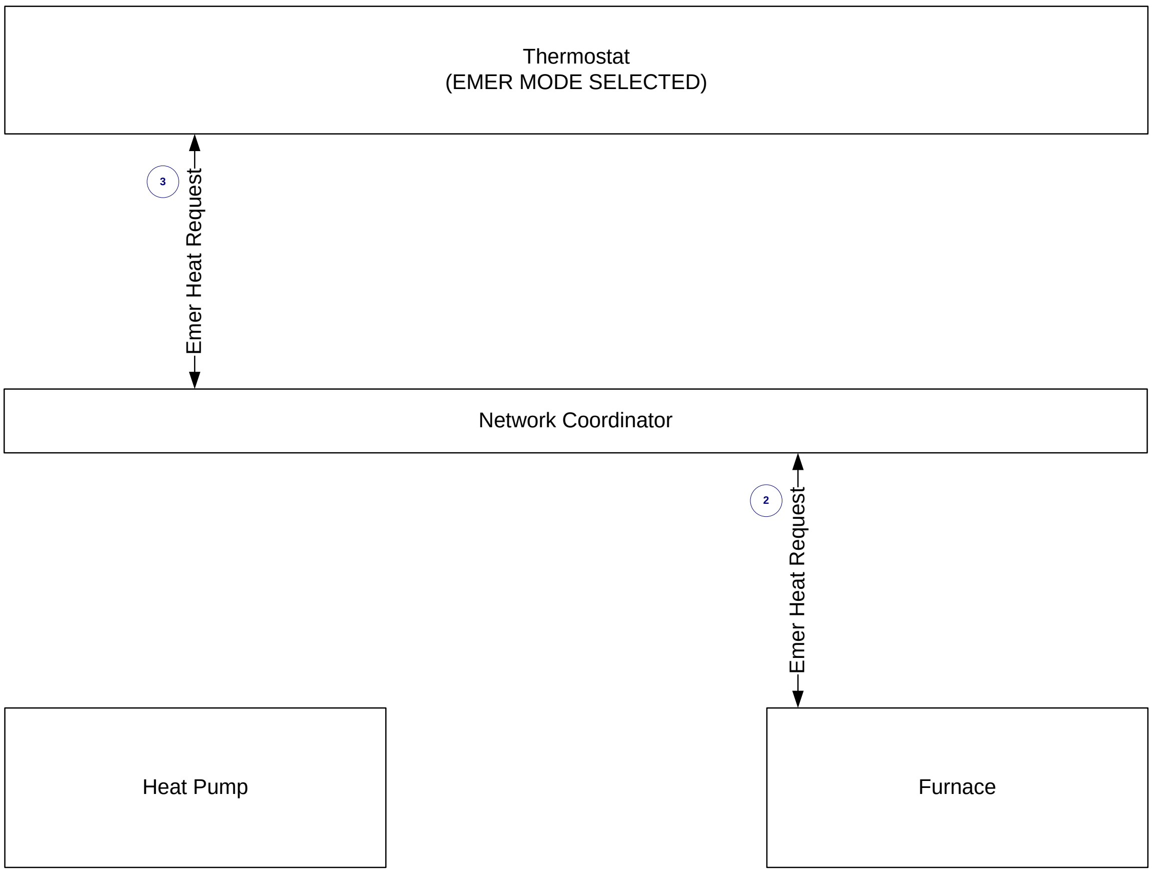


When heating is required and the outside temperature is below the balance point, the system shall do the following:

1. The thermostat shall transmit a Sensor Request to the heat pump. The data payload shall contain the outdoor temperature reading.
2. If the outdoor temperature is below the balance point, the thermostat shall transmit an Auxiliary Heat Demand Control Command to the furnace. The data payload shall contain the amount of heat demand required.
3. The thermostat shall refresh the Auxiliary Heat Demand Command according to the refresh time provided in the initial request for as long as the demand for heating remains unmet.
4. Once the heating demand has been met, the thermostat shall transmit an Auxiliary Heat Demand Control Command to the furnace turning off the heat.
5. If the system mode is changed prior to satisfying the current demand (e.g. the user switches from heat to cool modes), the thermostat shall first turn off the current demand before initiating commands for the new mode.

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

Figure 13 – Dual Fuel Back-Up Heat Demand Sequence Diagram

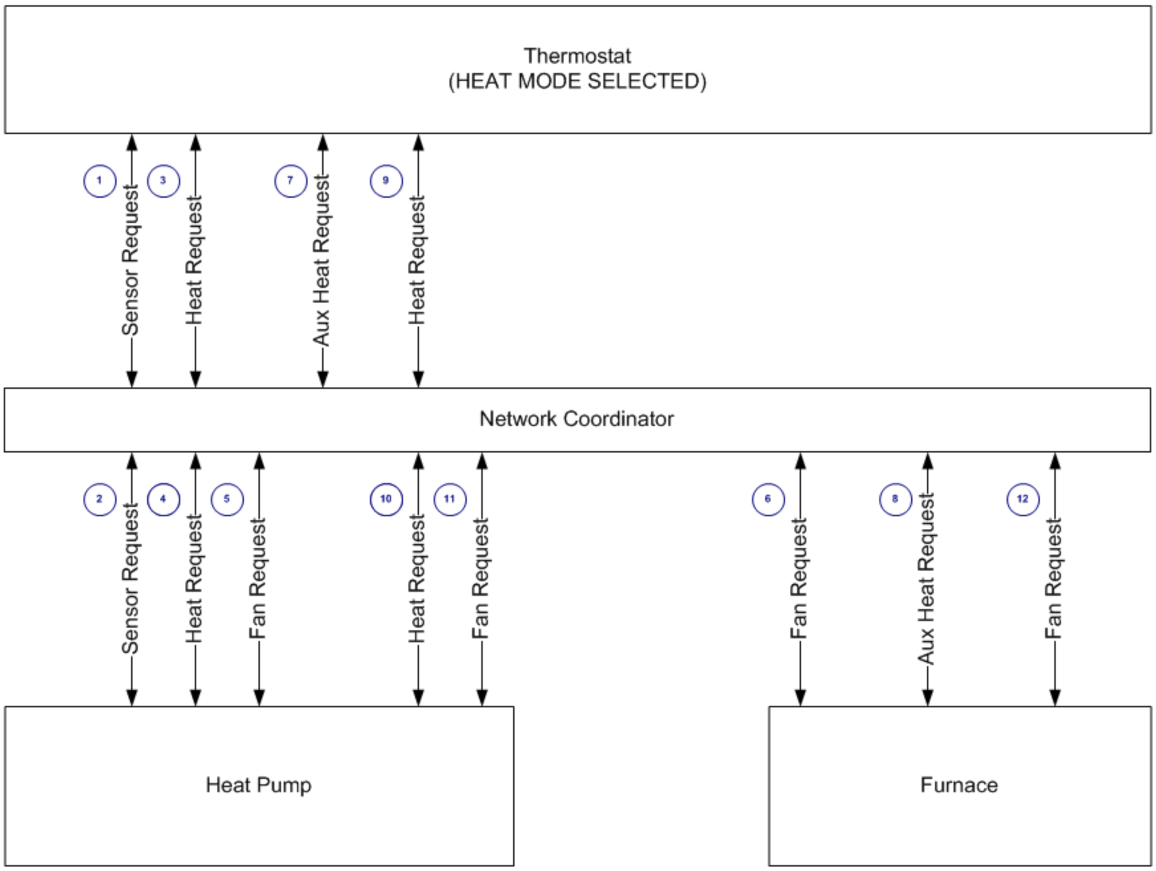


When back-up heat is required, the system shall do the following:

1. The thermostat transmits a Back-Up Heat Demand Control Command to the furnace. The data payload shall contain the amount of heat demand required.
2. The thermostat shall refresh the Back-Up Heat Demand Command according to the refresh time provided in the initial request for as long as the demand for heating remains unmet.
3. Once the heating demand has been met, the thermostat shall transmit a Back-Up Heat Demand Control Command to the furnace turning off the heat.
4. If the system mode is changed prior to satisfying the current demand (e.g. the user switches from heat to cool modes), the thermostat shall first turn off the current demand before initiating commands for the new mode.

7.2.12Standard Call for Auxiliary Heat Demand – Dual Fuel System

Figure 14 – Dual Fuel Auxiliary Heat Demand Sequence Diagram



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

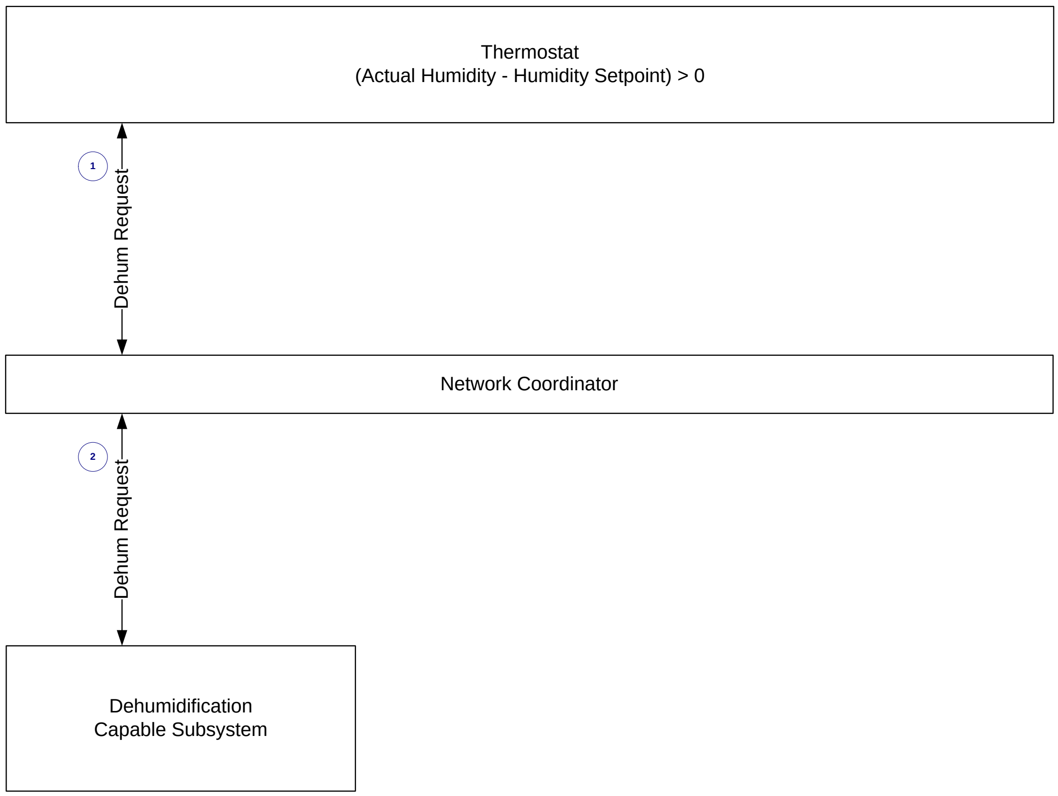
1. Steps 1 – 6 refer to Section 7.2.9.
2. The thermostat transmits an Auxiliary/Alternate Heat Demand Control Command to the furnace. The data payload will contain the amount of alternate heat demand required.
3. After a minute, the thermostat shall transmit a Heat Demand Control Command to turn off the heat pump.
4. The heat pump transmits a Fan Demand Control command to the furnace. The data payload will contain the amount of fan demand required based on the new heat demand requirements.
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 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 thermostat shall first turn off the current demand before initiating commands for the new mode.

7.3 Optional Normal Operation

7.3.1 Call for Dehumidification

Figure 15 – Dehumidification Demand Sequence Diagram

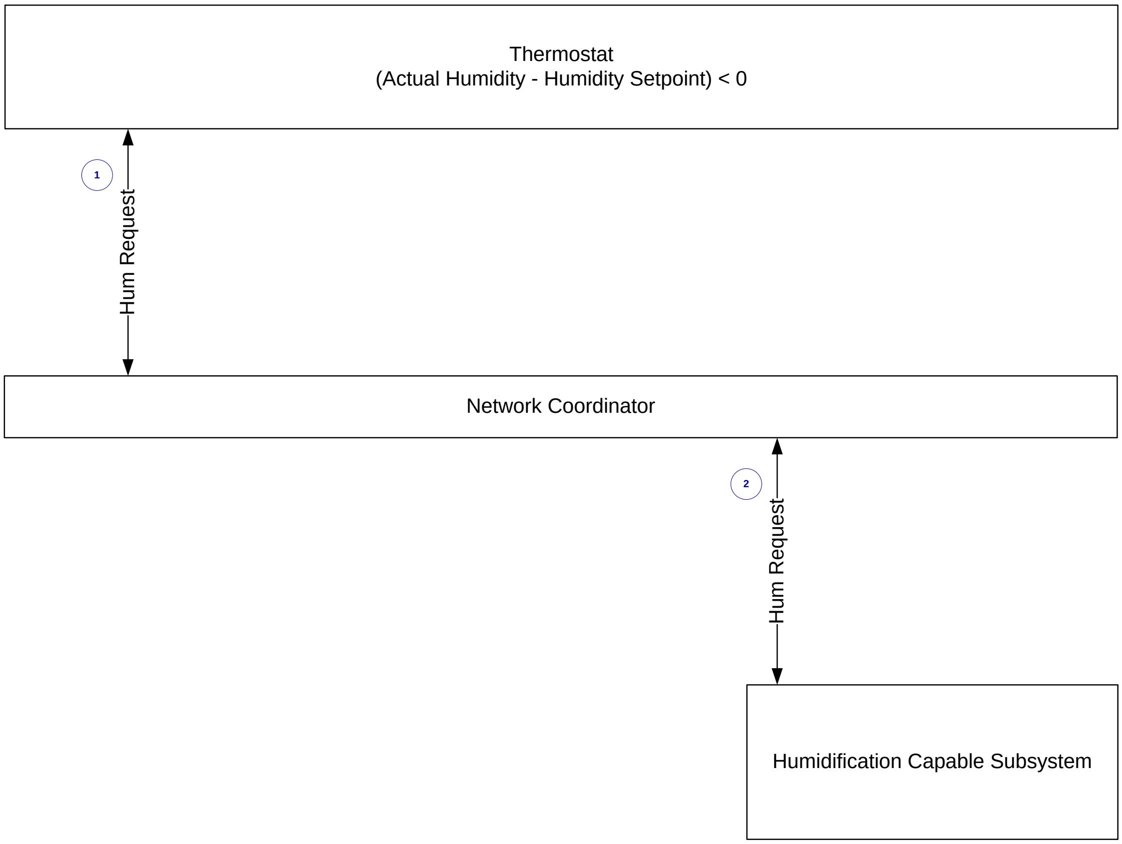


When dehumidification is required and a dehumidification capable subsystem is present (as determined by a subsystem's configuration response), the system initiating the request shall do the following to meet the demand.

1. The subsystem initiating the dehumidification request shall transmit a Dehumidification Demand Control Command to the Dehumidification capable subsystem. The subsystem initiating the dehumidification request shall transmit the Dehumidification Command to the first device in the following list that has identified itself as being capable of servicing the dehumidification request: Dehumidifier, HP, AC, IFC, AH, XOVER. The data payload shall contain the amount of dehumidification demand required.
2. The requesting subsystem shall refresh the dehumidification command according to the amount of refresh time provided in the initial request for as long as the dehumidification demand is unmet.
3. Once the dehumidification demand has been met, the requesting subsystem shall transmit a Dehumidification Demand Control Command with the amount of demand set to zero. The dehumidification subsystem shall turn off.

7.3.2 Call for Humidification

Figure 16 – Humidification Demand Sequence Diagram



When humidification is required and a humidification capable subsystem is present (as determined by a subsystem's configuration response), the system shall do the following to meet the demand.

1. The subsystem initiating the humidification request shall transmit a Humidification Demand Control Command to the Humidification capable subsystem.. The subsystem initiating the humidification request shall transmit the Humidification Command to the first device in the following list that has identified itself as being capable of servicing the humidification request: Humidifier (Evaporative), Humidifier (Steam), IFC, AH, XOVER. The data payload shall contain the amount of humidification demand required.
2. The thermostat shall refresh the humidification command according to the refresh time provided in the initial request for as long as the humidification demand is unmet.
3. Once the humidification demand has been met, the requesting subsystem shall transmit a Humidification Demand Control Command with the amount of demand set to zero. The humidification subsystem shall turn off.

8.0 Diagnostics

8.0 Fault Reporting

As specified in Section 5.2, subsystems report any faults to the thermostat via a Set Diagnostics Message.

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 5.2

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

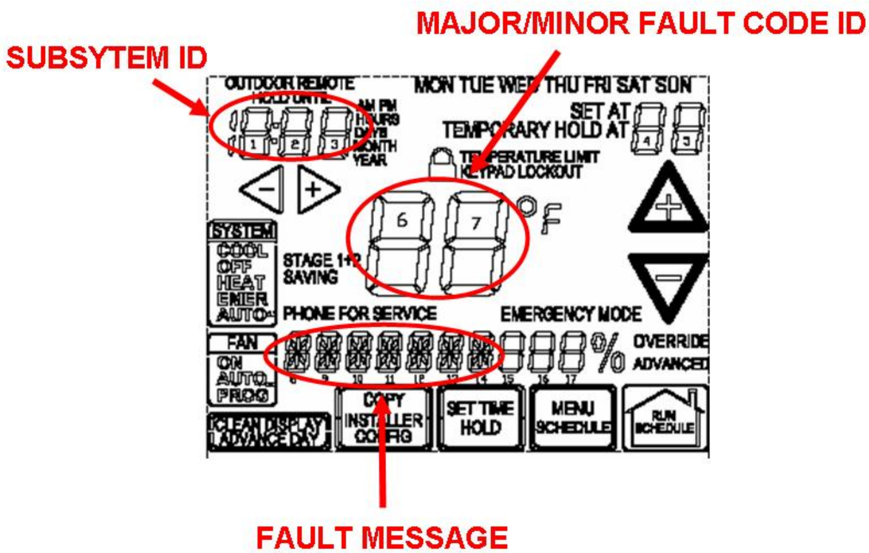
Other devices may display diagnostic fault information if they have display capabilities but are not required to.

There are two types of faults: major and minor. If there is a Major Fault, the subsystem is inoperable, if there is a Minor Faults, mean the subsystem is still operable but needs maintenance.

A 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.

The code and node type in the transmitted fault message will be used by the thermostat to inform the installer or homeowner about the fault as its display and alert functionality will allow. An example implementation is shown in Figure 17 – Thermostat Advanced Fault Menu Navigation Example.

Figure 17 – Thermostat Advanced Fault Menu Navigation Example



8.1 Subsystem Busy

If a subsystem needs to be placed in a debug state while part of an active HVAC system, the subsystem shall transmit a Subsystem Busy control command to the thermostat. Upon receiving the Subsystem Busy command, the thermostat shall initiate commands to put the subsystem into an idle state. The subsystem shall refresh the Subsystem Busy command until it is ready to accept commands. The thermostat shall continue to refresh the idle state commands until it no longer receives Subsystem Busy commands from the subsystem.

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

8.2 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.

8.2.1 System Operation Monitoring

The thermostat 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 thermostat has more information on the system operational status than any other subsystem. Using information thus collected, the thermostat may be designed to proactively notify the homeowner/installer of a mis-configured setup that would cause the system to not operate properly.

8.2.2 Missing Subsystem

The thermostat 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 thermostat 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 thermostat having experienced a power outage, the thermostat could notify the homeowner/installer of an existing subsystem that went missing.

8.2.3 Current Diagnostic Message

The thermostat may have the ability to individually query a fault message by an index to handle an advanced diagnostics potential display page which would be required by the subsystem to respond accordingly. The subsystems may have the corresponding ability to respond to such a request with the current fault information.

8.2.4 Informational Messaging

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

For example, a furnace can send a display message of "air filter clogged" to 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.

9.0 Remote Access

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

9.0 Operational Data

The configuration and operational data of each device in the HVAC subsystem shall be available for query by the remote access device as listed in the following table;

Table 5 - Operational Data Available for Remote Access

Data a Remote Access Device can Request	Command	
Configuration	Get Configuration	Mandatory
Operational Status	Get Status	Mandatory

This data shall be available for remote monitoring of system performance and potential diagnostic resolution. select control commands to be modified as defined in Section 9.1 Control Commands, however, the HVAC subsystem will retain local command of all operations.

9.1 Control Commands

A user may want to access the subsystem operational data or modify system settings thru a diagnostics or gateway device. The following sections define the mandatory and optional capabilities for remote access.

9.1.1 Mandatory Remotely Accessible Control Commands

The HVAC subsystem shall support the ability to receive a control command from a diagnostic or gateway device and perform the operation requested as listed in Table 6 – Mandatory Remote Access Supported Operations.

Table 6 – Mandatory Remote Access Supported Operations

Operation	Control Command
Modify System Mode	0x05 - System Switch Modify
Modify Heat Set Point Temperature	0x01 – Heat Set Point Temperature Modify
Modify Cool Set Point Temperature	0x02 – Cool Set Point Temperature Modify
Modify Hold Status	0x06 – Permanent Set Point Temp and Hold
Override Hold	0x08 – Hold Override

Operation	Control Command
Set Time/Day	0x0F – Real Time/Day Override
Modify Heat Profile	0x03 – Heat Profile Change
Modify Cool Profile	0x04 – Cool Profile Change
Manual Fan Demand	0x07 – Fan Key Selection
Publish Price	0xE0 – Publish Price
Subsystem Installation Test	0x51 – Subsystem Installation Test (required for graphical thermostats only)

9.1.1.1 System Switch Modify

The System Switch Modify command can be used to turn off the system or to modify the system modes. All modes implemented in the system installation shall be remotely modifiable and selectable. For example, on an ac/furnace installation, the Heat – Off – Cool modes can be selected thru remote access commands.

9.1.1.2 Set Point and Hold Modify

The Set Point and Hold Modify commands modify the current set point temperature and have it hold it at that temperature until otherwise directed.

9.1.1.3 Hold Override

The Hold Override command overrides the current set point and returns the setpoint to the temperature per the thermostat schedule. This command can be used to put the thermostat into a hold condition at the current set point.

9.1.1.4 Set Time/Day

The Set Time/Day command shall allow for an remote access device to update the time and day used as a reference for the thermostat program schedule.

9.1.1.5 Heat/Cool Profile Modification

The Heat and Cool Profile Modification commands enable remote updating of time and temperature (set-back) scheduling.

9.1.1.6 System Auto-Checks

Subsystems shall provide a method to test for proper operation within a system upon receiving an initiation to run it either via a thermostat, diagnostics device, or gateway.

9.1.1.7 Publish Price

The Publish Price command provides a method to inform the thermostat about the price and tier of electricity.

9.1.1.8 Subsystem Installation Test

If the thermostat is graphical displayed device, the thermostat shall support the ability to transmit and display subsystem installation test. Refer to Section 6.2 for more information.

9.1.2 Optional Remotely Accessible Control Commands

Table 7 lists the optional control commands that could be requested to subsystems by a diagnostic or gateway device. For more information on available optional control commands, refer to the *ClimateTalk Command Reference*.

If any of the features below are supported by the thermostat, it shall support the corresponding control command as a mandatory control command.

Table 7 –Optional Remote Access Supported Operations

Operation	Control Command
Beeper Enable	0x09 – Beeper Enable
Fahrenheit/Celsius Display Modification	0x0C – Fahrenheit/Celsius Display
Comfort Recovery (EMR) Modifciation	0x0E – Comfort Recovery (EMR) Modify
Filter Maintenance Timer	0x14 – Change Filter Time Remaining
Vacation Mode or Away Mode	0x15 – Vacation Mode
Display Temperature Offset	0x1A – Temp Display Adj Factor Change
Compressor Lockout Feature	0x33 – Compressor Lockout
Custom Message Area Display Data	0x46 – Custom Message Area Display Data
Set Point Temp and Temporary Hold	0x47 – Set Point Temp and Temporary Hold
Continuous Display Light Feature	0x48 – Continuous Display Light
Advance Real Time/Day Modification	0x4E – Advance Real Time/Day Override
Keypad Lockout Feature	0x4F – Keypad Lockout
Set Point Temp/Timed Hold Modification	0x53 – Set Point Temp/Time Hold
Comfort Mode Feature	0x55 – Comfort Mode Modification
Limited Heat and Cool Range Feature	0x56 - Limited Heat and Cool Range

Operation	Control Command
UV Light Maintenance Timer	0x5B – Change UV Light Maintenance Timer
Humidifier Pad Maintenance Timer	0x5C – Change Humidifier Pad Maint Timer

Table 8 shows the appropriate control commands that could be requested to subsystems by a thermostat or a diagnostic device. For more information on the optional control commands, refer to the command reference specification.

Table 8 – Other Subsystems Optional Remote Access Operation

Subsystem	Operation	Control Command
All	Factory Reset	0x45 – Restore Factory Defaults
Crossover	Reversing Valve Configuration	0x59 – Reversing Valve Config
Crossover	Hum/Dehum Configuration	0x5A – Hum/Dehum Config

10.0 Subsystem Replacement

Subsystems that support Shared Data may be auto-configured by the HVAC system when a subsystem in replaced. This allows the replacement subsystem to obtain the operational parameters of the original subsystem before it failed. The operational parameters stored in shared data include airflow profiles and other manufacturer specific operational data. User settings including set points and scheduling are not stored in the Shared Data set.

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

10.0 Subsystems Capable of Auto-Configuration

Subsystems capable of auto-configuration after replacement are:

1. HVAC System Controller, such as a thermostat
2. Indoor Unit, which may be an air handler or furnace
3. Outdoor Unit, which may be an air conditioner or heat pump

10.1 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.

10.1.1 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 10.1, the latest shared data that is suitable for the new unit will be ensured to be present on the network for retrieval.

10.2 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.

10.2.1 Fault Analysis

Returned subsystems could carry a lot of internal data from its operational or fault historical data controls are now capable of be storing in each subsystem to allow for root cause analysis.

10.2.2 Trending Data

Along with any type of data that could result in better controls from learning of any type of field faults, operational data could also aid in future controls on how the controls actual operate in majority of the time. If the data could be put into a database to discover operational trends to help determine how to make subsystems operate better, this returns of subsystems could provide that extra data.

10.2.3 Historical Data Retrieval

Subsystems have the ability to track more information to allow for the trend analysis described in the previous section. But, a control has to be defined what type of data it should be recording through its operational life.