Best Practices Guide

Wireless Comm Network Design
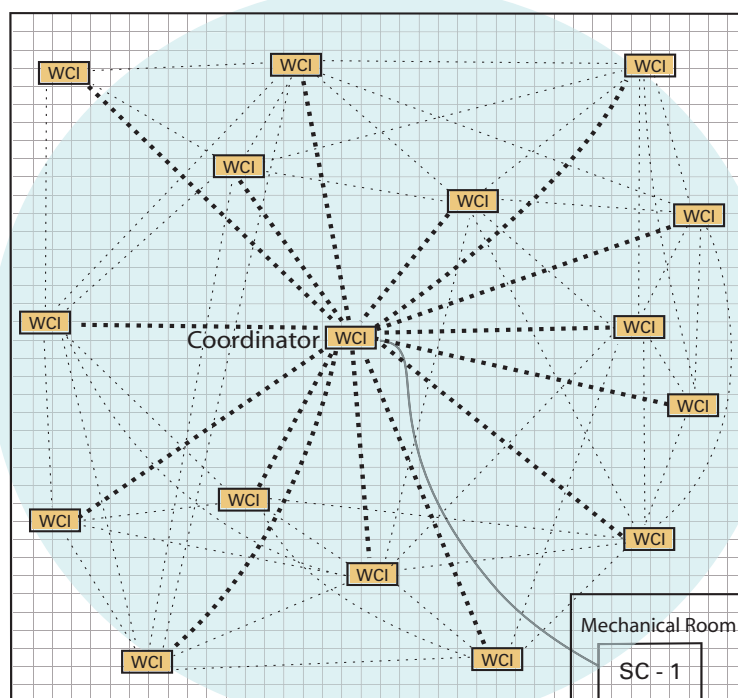
November 2012

BAS-SVX55A-EN

Introduction

Read this manual thoroughly before operating or servicing this unit.

Warnings, Cautions, and Notices

Safety advisories appear throughout this manual as required. Your personal safety and the proper operation of this machine depend upon the strict observance of these precautions.

The three types of advisories are defined as follows:

⚠WARNING Indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury.

⚠CAUTION Indicates a potentially hazardous situation which, if not avoided, could result in minor or moderate injury. It could also be used to alert against unsafe practices.

NOTICE: Indicates a situation that could result in equipment or property-damage only.

Important Environmental Concerns

Scientific research has shown that certain man-made chemicals can affect the earth's naturally occurring stratospheric ozone layer when released to the atmosphere. In particular, several of the identified chemicals that may affect the ozone layer are refrigerants that contain Chlorine, Fluorine and Carbon (CFCs) and those containing Hydrogen, Chlorine, Fluorine and Carbon (HCFCs). Not all refrigerants containing these compounds have the same potential impact to the environment. Trane advocates the responsible handling of all refrigerants-including industry replacements for CFCs such as HCFCs and HFCs.

Important Responsible Refrigerant Practices

Trane believes that responsible refrigerant practices are important to the environment, our customers, and the air conditioning industry. All technicians who handle refrigerants must be certified. The Federal Clean Air Act (Section 608) sets forth the requirements for handling, reclaiming, recovering and recycling of certain refrigerants and the equipment that is used in these service procedures. In addition, some states or municipalities may have additional requirements that must also be adhered to for responsible management of refrigerants. Know the applicable laws and follow them.

⚠WARNING

Proper Field Wiring and Grounding Required!

Failure to follow code could result in death or serious injury. All field wiring MUST be performed by qualified personnel. Improperly installed and grounded field wiring poses FIRE and ELECTROCUTION hazards. To avoid these hazards, you MUST follow requirements for field wiring installation and grounding as described in NEC and your local/state electrical codes.

⚠WARNING

Personal Protective Equipment (PPE) Required!

Failure to wear proper PPE for the job being undertaken could result in death or serious injury. Technicians, in order to protect themselves from potential electrical, mechanical, and chemical hazards, MUST follow precautions in this manual and on the tags, stickers, and labels, as well as the instructions below:

- **Before installing/servicing this unit, technicians MUST put on all PPE recommended for the work being undertaken. ALWAYS refer to appropriate MSDS sheets and OSHA guidelines for proper PPE.**

- **When working with or around hazardous chemicals, ALWAYS refer to the appropriate MSDS sheets and OSHA guidelines for information on allowable personal exposure levels, proper respiratory protection, and handling recommendations.**

- **If there is a risk of arc or flash, technicians MUST put on all PPE in accordance with NFPA 70E or other country-specific requirements for arc flash protection, PRIOR to servicing the unit.**

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Overview

Trane Wireless Comm provides wireless communication for Tracer™ building automation systems that use the BACnet™ protocol. Wireless communication significantly simplifies building controls projects by minimizing the engineering, estimating, and project management tasks associated with communication link and zone sensor wiring. Wireless communication also makes problem solving easier on new buildings, control upgrades, and building expansion projects.

By leveraging the advantages of self-healing wireless mesh with the extended signal range and easy installation of Trane Wireless Comm, the time required to troubleshoot installations is expected to be less than that of conventional wired systems.

Structure and Function

Trane Wireless Comm is enabled by two new devices: the Wireless Comm Interface (WCI) and the new TU Adapter with integrated wireless radio. WCIs are wired to Tracer controllers and BACnet Communication Interface (BCI) IMC connections. The WCIs that are attached to Tracer SC system controllers act as the "hub" or coordinator of each wireless network. The WCIs that are attached to unit controllers or BCIs act as routers ("routing" messages toward the intended destination). WCIs not connected to controllers can also act as routers to repeat messages, to extend the effective range as necessary (note that very few repeaters are expected to be required).

Where conventional wired systems can fail with a single poor connection or nick in a wire, wireless mesh provides redundant paths between WCIs. Wireless mesh networks self-heal by rerouting messages when messages are blocked, ensuring reliable performance.

Servicing and Maintenance

For servicing and maintenance, a Trane technician uses the Tracer TU service tool with the TU Communications Adapter in wireless mode. The technician can then discover, access, and service the device or any other device in the network.

Types of Devices Supported by the WCI

- Tracer™ SC system controller
- Tracer™ UC400 programmable controller
- Tracer™ UC600 programmable controller
- BCI-I: BACnet Communications Interface for IntelliPak™ systems
- BCI-R: BACnet Communications Interface for ReliaTel™ systems
- Tracer™ TU
- Wireless zone sensors

Quantity of WCIs per Network

Each Trane wireless network can have a total of 31 WCIs (30 member WCIs plus 1 coordinator WCI). Each network requires one WCI to function as network coordinator.

Quantity of Networks per Tracer SC

A Tracer SC can support up to 8 wireless networks.

Automatic Network Formation

When a WCI is connected to a Tracer SC, it is auto-assigned as the coordinator. To enable the coordinator, Tracer SC must be configured for wireless communication. The coordinator WCI opens the network to allow all WCIs having matching addresses to automatically join the network.

If no Tracer SC is present, a centrally located WCI must be designated to act as the coordinator. You can manually set the coordinator WCI so all WCIs having matching addresses automatically join the network.

Note: For additional information, see *"Establishing the Network," p. 16* in BAS-SVX40.

Wireless Zone Sensors

The WCI also communicates with Trane wireless zone sensors, eliminating the need for analog receivers.

Wired Zone Sensors

Systems using Wireless Comm can also use wired zone sensors.

Network Security

The WCI uses standard ZigBee™ Building Automation security practices by the use of AES128 encryption, keys, and device authentication.

Related Literature

BAS-SVX40: Wireless Comm Interface (WCI) Installation, Operation, and Maintenance: Describes how to address, install, modify and troubleshoot a Trane wireless network. Focuses on the Wireless Comm Interface (WCI), which provides the wireless networking capability.

X39641171-01: Wireless Comm Interface (WCI) Installation Instructions: A quick-start guide to addressing and installing a Wireless Comm Interface (WCI).

X39641157-01: Tracer TU Communications Adapter User Instructions: Allows the Tracer TU service tool to connect to a remote unit controller through a zone sensor or wireless connection.

BAS-PRC039-EN: Wireless Comm Interface (WCI) Product Data Sheet

Network Design

The design of a wireless network has a direct impact on performance and reliability. For example, performance can be improved by locating the coordinator near the center of the network. Reliability can be enhanced by avoiding wireless signal obstructions.

Trane Wireless Comm makes designing a network with robust performance and reliability easy. The purpose of this section is to ensure a fast, trouble-free installation.

Use Best Practices When Locating Wireless Devices

- Locate wireless devices so that they are easily accessible and their covers can be removed.
- Locate wireless devices in direct line of sight when possible.
- Avoid metal, concrete, and brick obstructions between wireless devices.
- Avoid placing devices inside metal enclosures.
- Locate wireless receivers and repeaters in elevated space.
- Vertically mount wireless devices.
- Locate wireless devices that are on the same network on the same building level.

Obtain Application Site Information

To begin designing a wireless mesh network, you need access to the following:

- A detailed, scale floor plan of the application site, including walls, columns, and other interior features such as stairwells and elevator shafts. The floor plan should also include the proposed HVAC system layout.
- Architectural and mechanical specifications of application site with construction materials identified.

Identify Obstructions

Identify major and minor obstructions on a copy of the floor plan.

Examples of major obstructions are:
- Elevator shafts
- Stairwells
- Mechanical/electrical rooms
- Metal-reinforced walls
- Large metal-reinforced columns
- Concrete walls
- Cinder blocks
- Glass walls with metal coating
- Multiple rows of office equipment such as tall file cabinets, book shelves, computer racks, and metal partitions
- Plumbing or electrical risers
- HVAC equipment chases

For estimating purposes, several minor obstructions can be considered a single major obstruction. Examples of minor obstructions are:
- Metal light fixtures
- Sheetrock walls with metal studs
- Multiple rows of cabinets or shelves or small columns
- Glass walls without a metal coating

Design the Network Layout

Consider the following factors when designing a network layout:

Typical signal range

The WCI has a typical signal range (radius) of 200 ft—potentially more for line-of-sight installations, less for obstructed installations.

Quantity of WCIs per network

Each Trane wireless network can have a total of 31 WCIs (30 network member WCIs plus 1 network coordinator WCI). Each network requires one WCI to function as the network coordinator.

Quantity of networks and WCIs per Tracer SCs

A Tracer SC can support up to 8 wireless networks with a maximum quantity of 120 member WCIs plus up to 8 coordinator WCIs.

Maximum wiring length

Wiring between a WCI and a controller cannot exceed 656 ft (200 m).

Locate Wireless Devices on the Network

To begin designing a wireless network, establish the location of the equipment that will be controlled by WCIs.

1. On a copy of a floor plan drawn to scale, identify potential WCI locations and mark them. WCI locations are typically determined by the location of the equipment that will be on the wireless network.

2. Choose a central location for the network coordinator and mark it on the floor plan.

Figure 1. Floor plan with WCI locations and coordinator identified
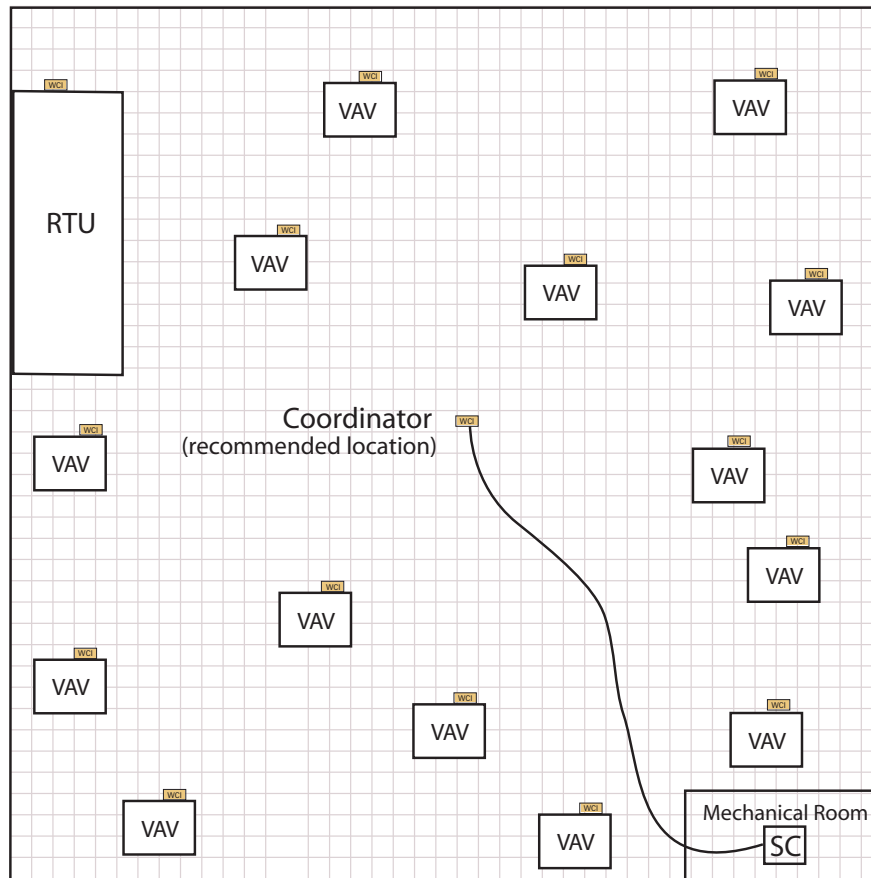
3. Draw a circle with a 200 ft. radius to scale to represent the typical radio range for a WCI.

4. Place the center of the circle on the coordinator as in Figure 2. This will allow you to see which WCI signals have a direct route to the coordinator and which ones need to hop to one or more WCIs before reaching the coordinator.

   Note: *Ideally, each device should need to hop no more than twice to reach the coordinator.*

5. Relocate the circle to other WCIs to examine how robust the network is for that node, that is, how many potential routes that node can rely on.
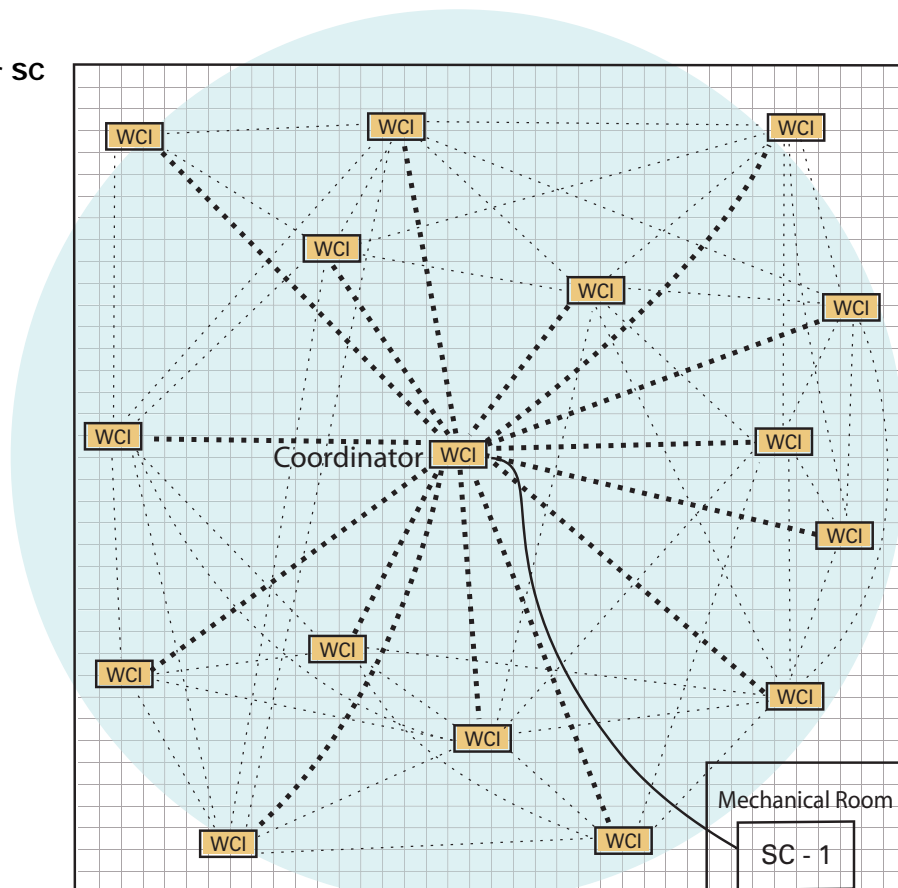
A Simple Network Structure

Figure 2 illustrates a simple network in which all nodes are located within the 200 ft signal range of the single coordinator WCI. They require only one hop to reach the coordinator. Example a) shows the network with a Tracer SC; example b) shows the same network without a Tracer SC.

These figures, and all of the network figures in this manual, illustrate the most direct route between the WCIs and the coordinator WCI by the use of heavy dashed lines. Other potential routes are shown with light dashed lines.
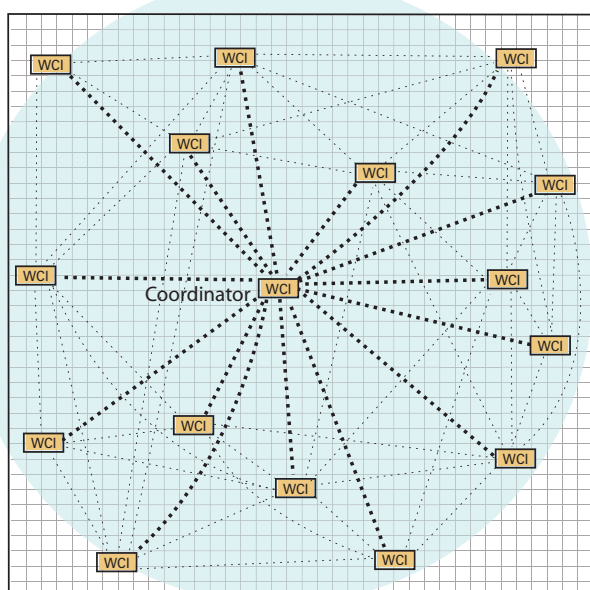
The blue sphere indicates a typical WCI radio range of 200 ft. It is centered over the coordinator WCI in every illustration. In Figure 2, all WCIs are within the blue sphere.

Figure 2.   All devices located within the 200 ft signal radio range of the coordinator WCI
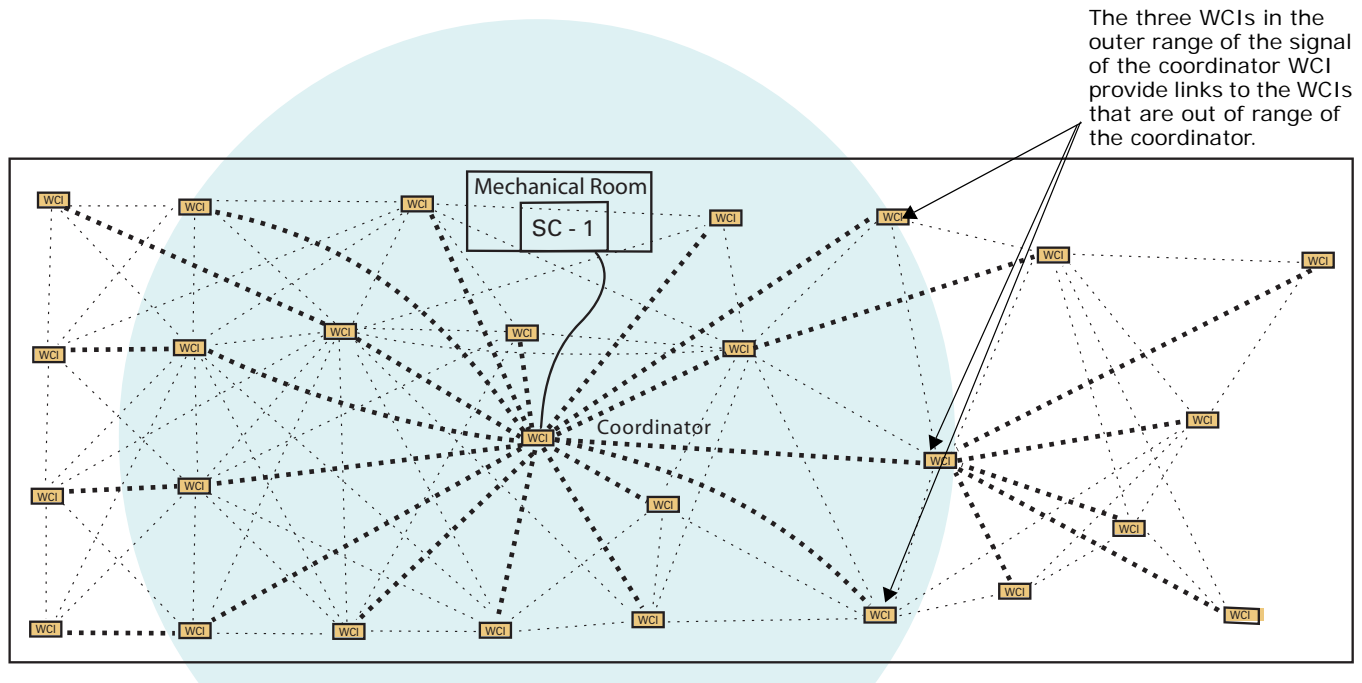
a) With a Tracer SC

b) Without a Tracer SC

A More Complex Network Structure

and illustrates a network spread out over a larger space. Every node can reach the coordinator in two hops or less, making a single coordinator adequate for the 27 devices.

Figure 3.   Larger installation requiring node-hopping to reach coordinator

The three WCIs in the outer range of the signal of the coordinator WCI provide links to the WCIs that are out of range of the coordinator.

Multiple Networks in a Tracer SC Group

The most common reason for using multiple networks in an application is to accommodate more than 30 devices. Other reasons are physical distance and construction materials that limit radio signal range.

Figure 4 illustrates a network with a total of 37 devices and two subnets.

Again, the network has been designed so that no more than 2 hops are required from any device to its coordinator. The WCIs located at the right edge of the coordinator's signal range provide links for six WCIs that are out of range and require an extra hop to reach the coordinator.

Figure 4. Application with two networks—Acceptable range for outlying nodes

WCIs at the right edge of the coordinator signal range provide links for six WCIs that are outside the radio range. No WCI needs more than 2 hops to reach the coordinator.
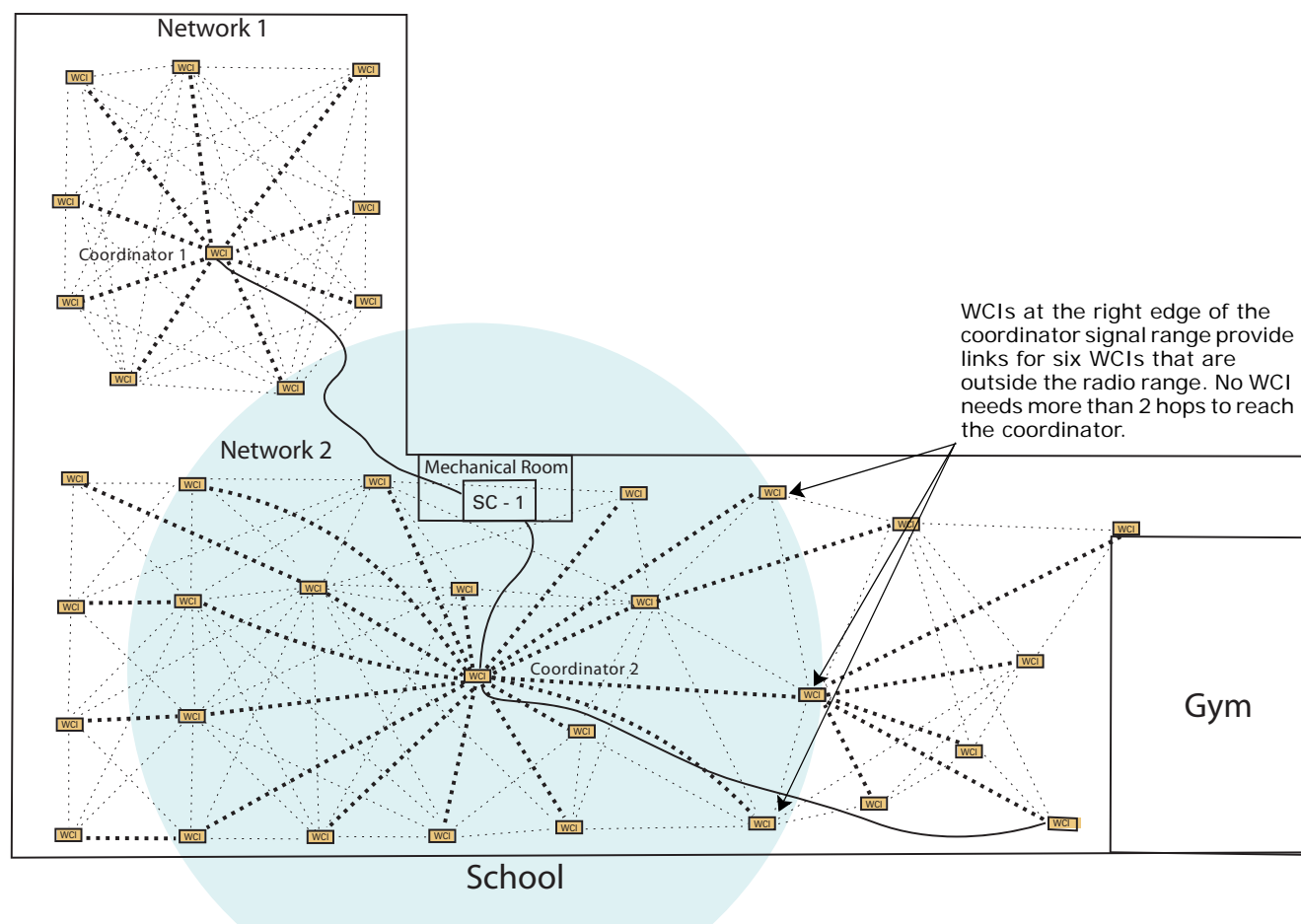
Figure 5 shows an example of the same building with nodes in the outlying areas requiring four hops to reach the coordinator WCI. This network design is not recommended because reliability and performance will be jeopardized.

Figure 5. Network Requires Too Many Hops Between Nodes—Not Recommended
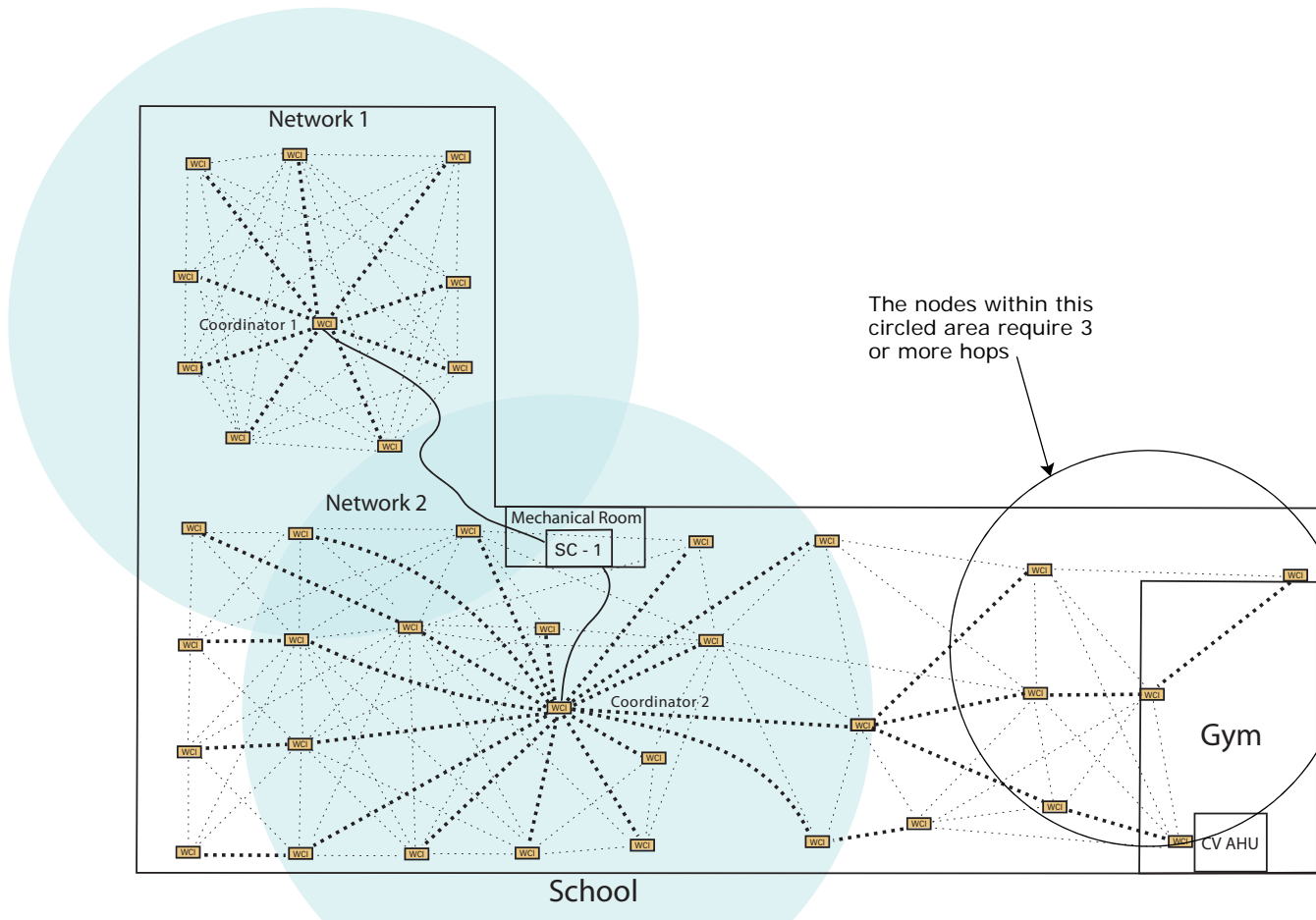
To alleviate the problem of too many hops, the Tracer SC group shown in Figure 5 has been divided into three networks in Figure 6. In this example, all devices can reach a coordinator using no more than two hops.

Figure 6. Network with Three Subnets—Alleviates Multi-Hop Issue
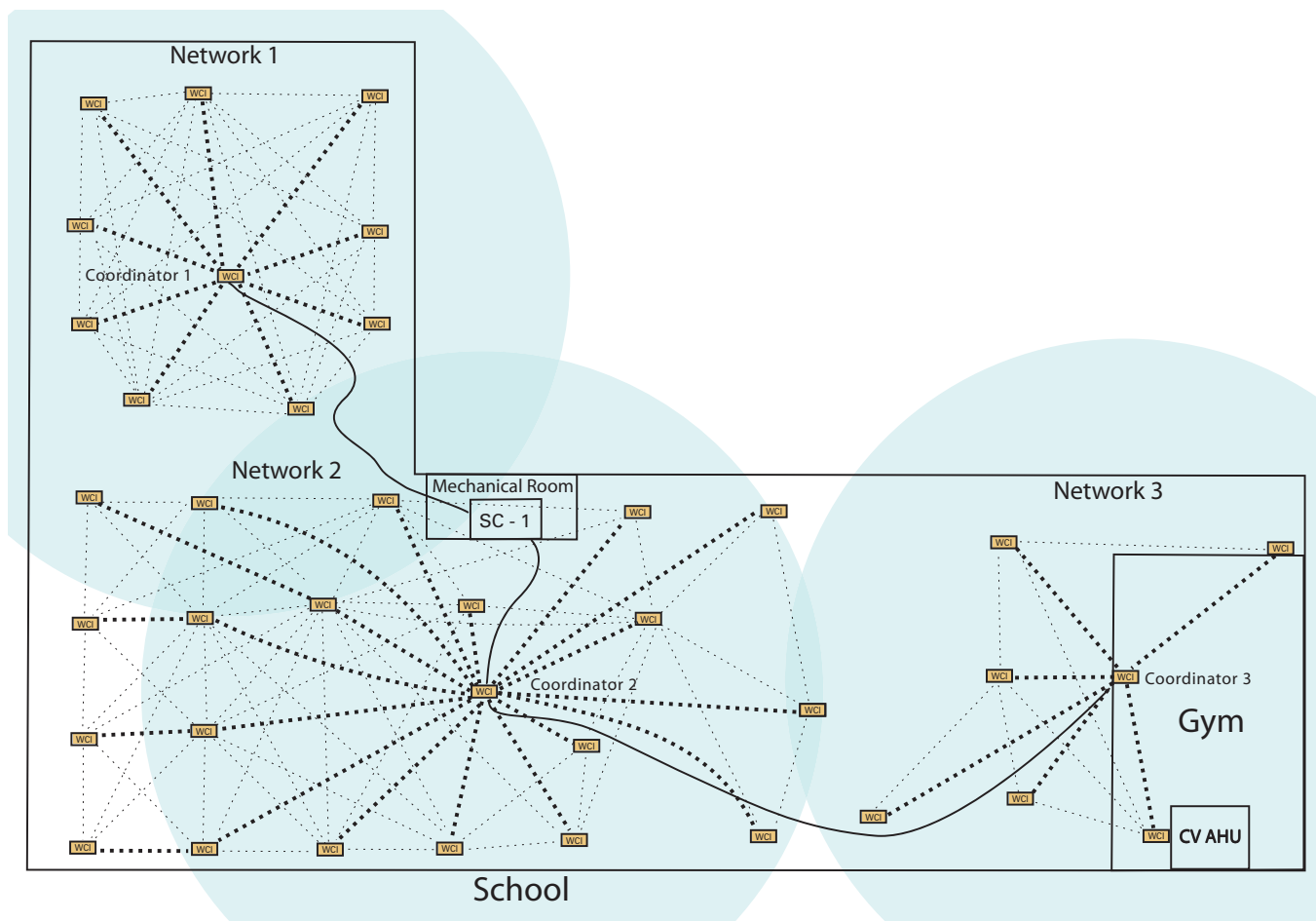
Factors That Decrease Signal Strength in a Network

Create additional circles, as necessary, decreasing the radius for devices that have obstructions between them. For example, buildings with concrete walls and no open ceiling should be drawn with a smaller-sized radius to depict a more limited radio range. Refer to the floor plan and architectural and mechanical specifications to determine these characteristics.

Note: For some installations, testing signal strength may be advisable. Using a sensor demo kit or a sensor/receiver set, apply power to the receiver at the location that you are testing. Walk through the building to each location that is planned for WCI installation and press the Test button on the sensor. Repeat for each WCI that you want to test.

Figure 7 shows the same network example used in Figure 3 but in a building with structural characteristics that limit the radio range to a radius of less than a 200 feet (the smaller sized blue sphere indicates the reduced radio range). Many WCIs on the right side require three hops to reach the coordinator.

Figure 7.   Example of radio range limited by building structure
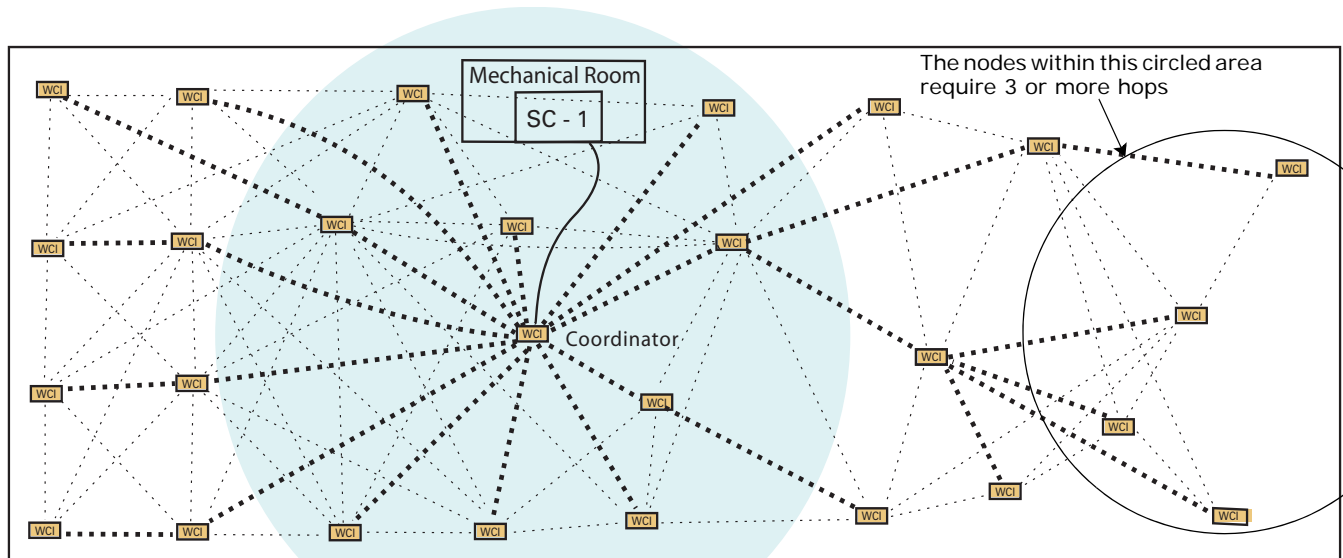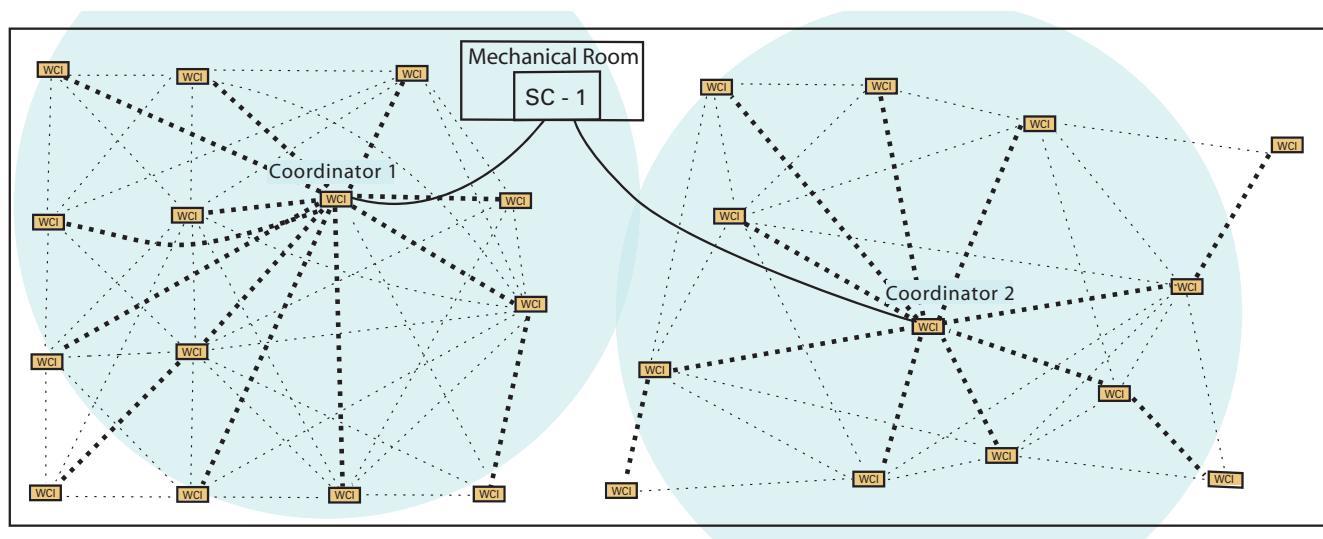

Figure 8 shows a resolution to the multi-hop issue illustrated in Figure 7 by the addition of a network.

Figure 8.   Example of building with structural characteristics that limit radio range—potential multi-hop issue alleviated by additional network

## Use of Repeaters to Overcome Out of Range Problems

Figure 9 illustrates a network node with a single point of failure and a route to the coordinator which requires four hops.

Figure 9. Single point of failure and indirect route
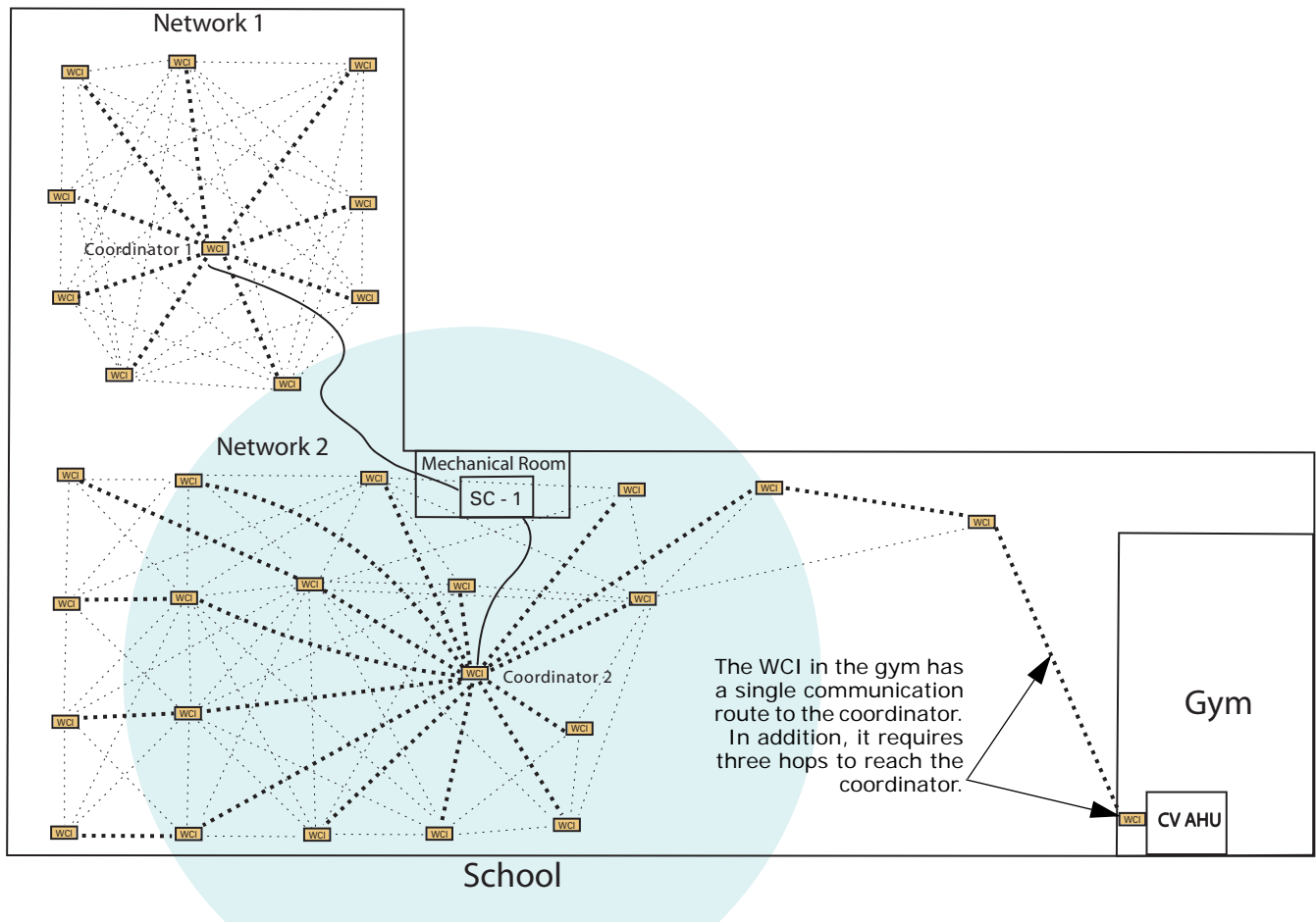
The situation in Figure 9 can be alleviated by a repeater. Figure 10 shows the same network after a repeater has been installed.

Figure 10. Repeater added

The repeater provides redundancy for the WCI in the gym, as well as a more direct route to the coordinator.
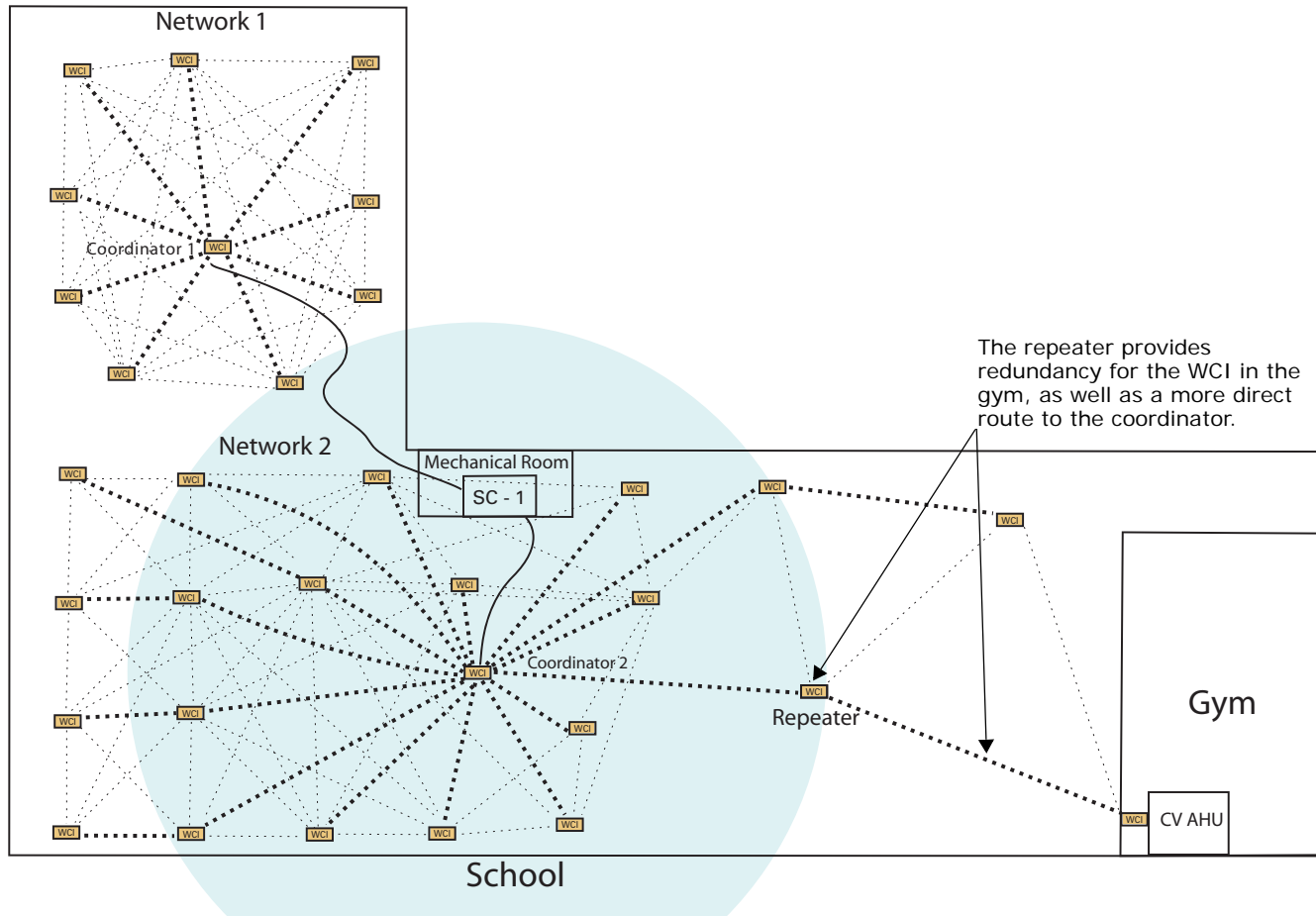
In the example in Figure 11, the repeater has failed. The redundancy that it provided for the WCI in the gym, along with the more direct route to the coordinator 2, no longer exist. However, the three-hop route that existed before the repeater was installed enables communication to continue.

Figure 11. The repeater fails but another WCI provides a back-up link to continue network communication to the gym
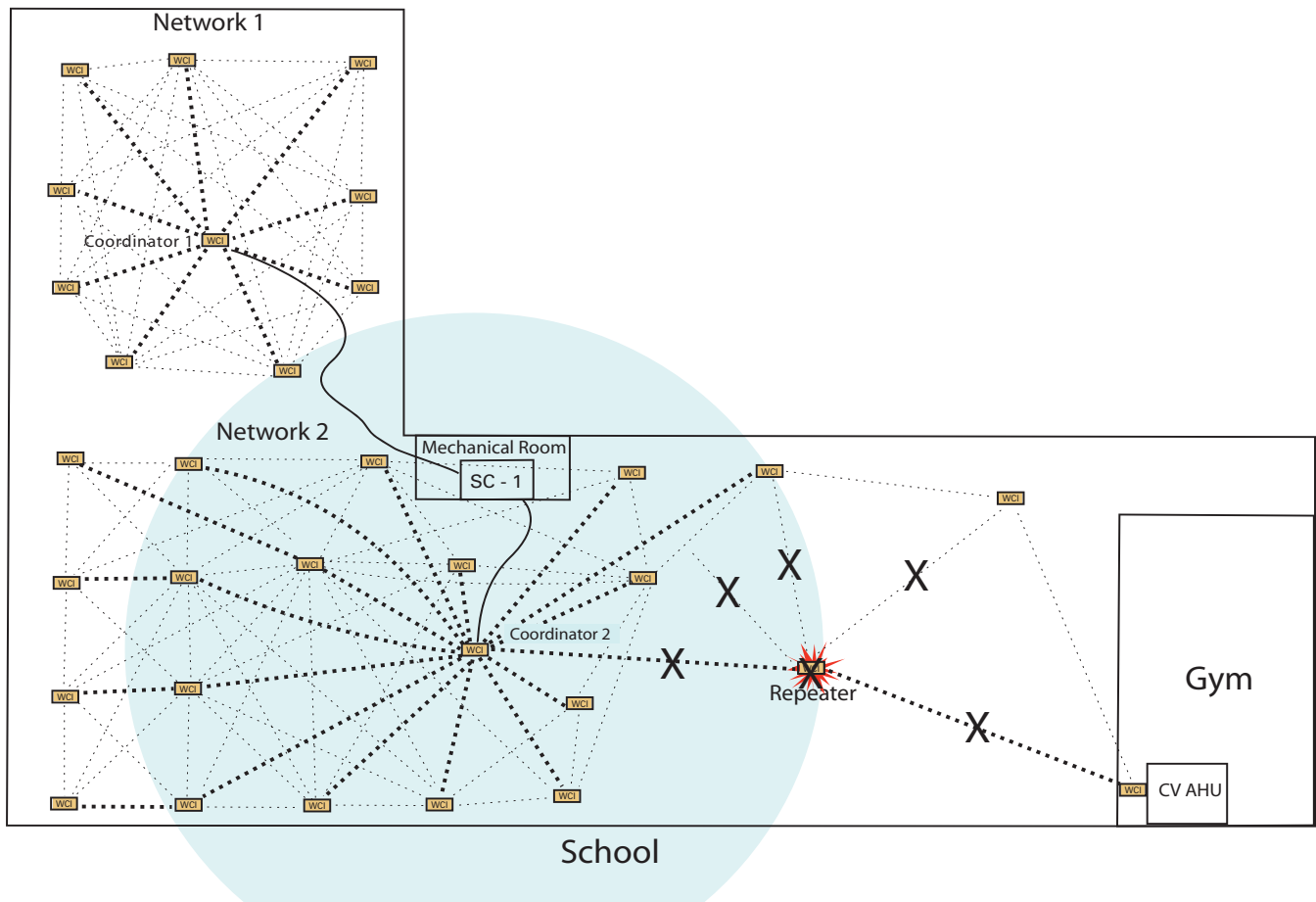
Addressing

This section explains the addressing requirements for Wireless Comm.

WCI Addressing

WCI addressing determines which devices can communicate on a wireless network. WCIs can be installed within communication range of each other but will not have the ability to communicate with each other if they do not have the same network address.

A WCI has two rotary address switches (Figure 12). Address settings are explained in Table 1.

GRP: This address setting determines the Tracer SC group membership of the WCI. The GRP address setting must be the same for all WCIs connected to a specific Tracer SC.

NET: This address setting determines the network membership of the WCI and corresponds to a Tracer SC link. The NET address setting must be the same for all WCIs that are members of a specific network.

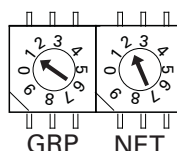**Figure 12. WCI rotary address switches**


Table 1. Address settings

Function/Purpose	GRP	NET
Trane BACnet communication and receiver for sensor	0–8	1–8
Receiver for sensor only	1–9	0
Return to default configuration	0	0
Future use	9	1–8

Figure 13 provides an example of an application with two Tracer SCs. In this example, each Tracer SC communicates with two networks.

The group (GRP) address must be unique for each Tracer SC group. The Tracer SC-1 GRP address is 1 and the Tracer SC-2 GRP address is 2.

The network (NET) address must be unique for the network within a group. One network address in the Tracer SC-1 group is 1 and the other network address is 2. The same network addresses are used for the Tracer SC-2 group.

Figure 13. Address examples for an installation with two groups with two networks
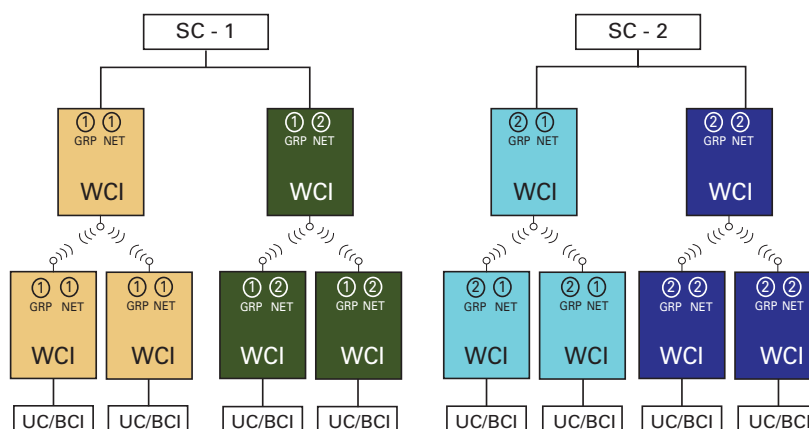
Figure 14 and Figure 15 illustrate WCI addressing for the same type of installation shown in Figure 13, but from a floor plan perspective.

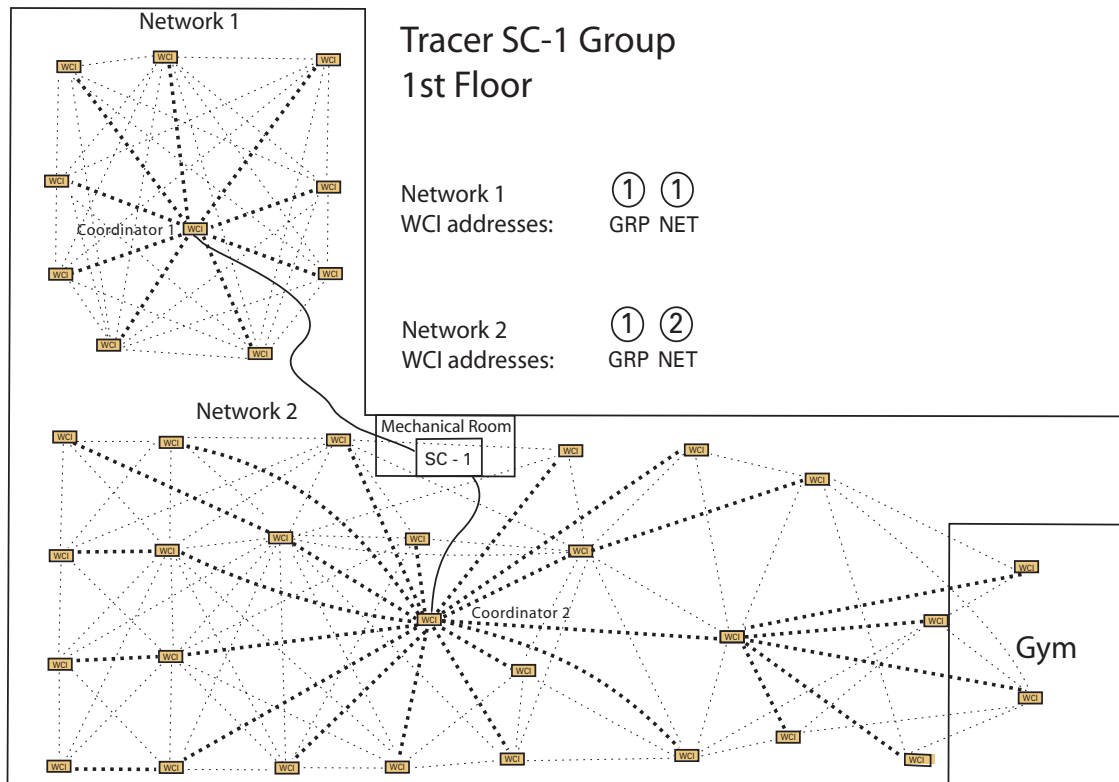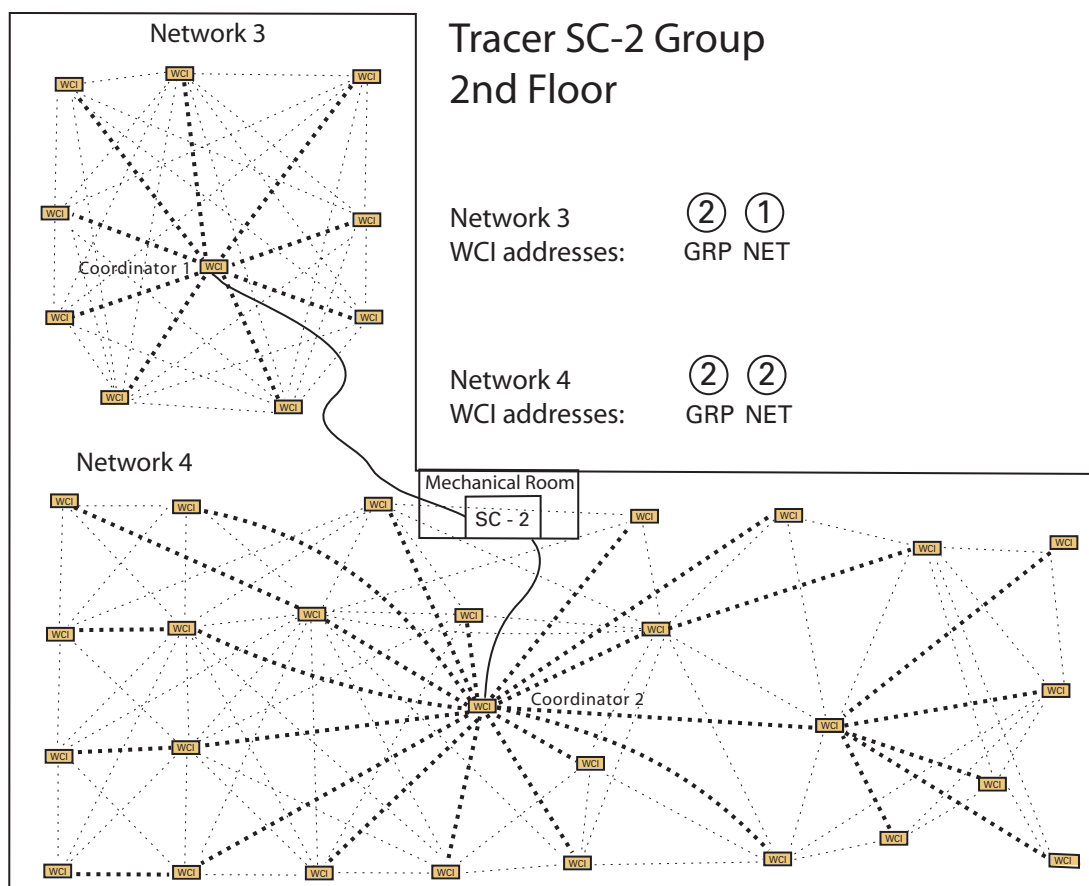**Figure 14. Example of network addressing in two-story building: First floor**

Figure 15. Example of network addressing in two-story building: Second floor

Wireless Zone Sensor Receiver Addressing

A WCI that is installed on a unit controller as a wireless communication interface can also function as a zone sensor receiver. To enable this function, the rotary address switches on the wireless zone sensor and the unit controller must match, as shown in Figure 16. The wireless zone sensor searches for a unit controller that has a matching address and associates with it.

Figure 16. Wireless zone sensor addressing

Note: Be careful to match addresses rather than direction of the arrows.
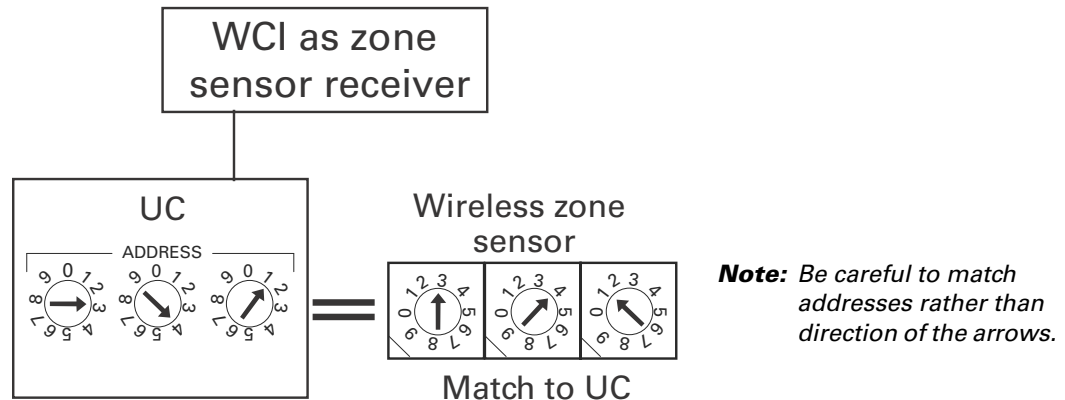
On a Wireless Comm network, the rotary address switches on unit controllers serve the same function as those on the receiver module of our previous generation of wireless sensor/receiver sets. Therefore, to minimize the risk of incorrect associations between sensor and controller, we strongly recommend the use of unique rotary address settings on all devices within radio range.

The values of 1–999 are valid for unit controller addresses. There is no advantage to starting at 1 or to numbering them consecutively. Since 999 possibilities exist, this restriction does not provide a challenge.

Tracer SC Addressing

All Tracer SCs that are connected by BACnet/IP must have a unique rotary address. Network numbers are derived from the SC rotary address as shown in the following table. A Tracer SC can have 2 MS/TP networks and 8 wireless networks.

Link	Network number
MS/TP link1	(SC Rotary * 10) + 1
MS/TP link2	(SC Rotary * 10) + 2
Wireless link 1[a]	(SC Rotary * 10) + 3
Wireless link 2	(SC Rotary * 10) + 4
Wireless link 3	(SC Rotary * 10) + 5
Wireless link 4	(SC Rotary * 10) + 6
Wireless link 5	(SC Rotary * 10) + 7
Wireless link 6	(SC Rotary * 10) + 8
Wireless link 7	(SC Rotary * 10) + 9
Wireless link 8	(SC Rotary * 10)

Note: This scheme limits the Tracer SC to a maximum of 10 distinct BACnet/IP networks. Since the BACnet/IP network is common to all Tracer SCs, it is not considered one of these 10. The BACnet/IP network is typically assigned the network number 1. This scheme also limits the maximum number of WCIs on a Tracer SC to 8.

(a) The wireless link # matches the NET rotary setting on the WCI.

Unit Controller Device IDs

Unit controllers are assigned a device ID by the Tracer SC during installation. The algorithm that calculates the desired unit controller device ID starts with the Tracer SC rotary address. Thus, all unit controllers on all Tracer SCs are guaranteed to be assigned unique device IDs.

Unit controller device IDs are user configurable using Tracer TU. However, currently, during installation, Tracer SC will overwrite device IDs that have been configured with Tracer TU.

The algorithm that calculates device IDs is different for MS/TP and for wireless networks.

MS/TP

LINK1: DeviceId = SC-Rotary * 10000 + 1000 + UC-Rotary

LINK2: DeviceId = SC-Rotary * 10000 + 2000 + UC-Rotary

Wireless

DeviceId = Network-Number * 1000 + UC-Rotary

To prevent an overflow of the unit controller device ID, the Network-Number of wireless networks is limited to 4193 (which is more restrictive than the BACnet limit of 65535).

Note: *This limit is of concern only if you manually configure the network number. You will not be able to install devices if you exceed 4193; the default values will not exceed this value because the Tracer SC rotary address is limited to 419.*

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