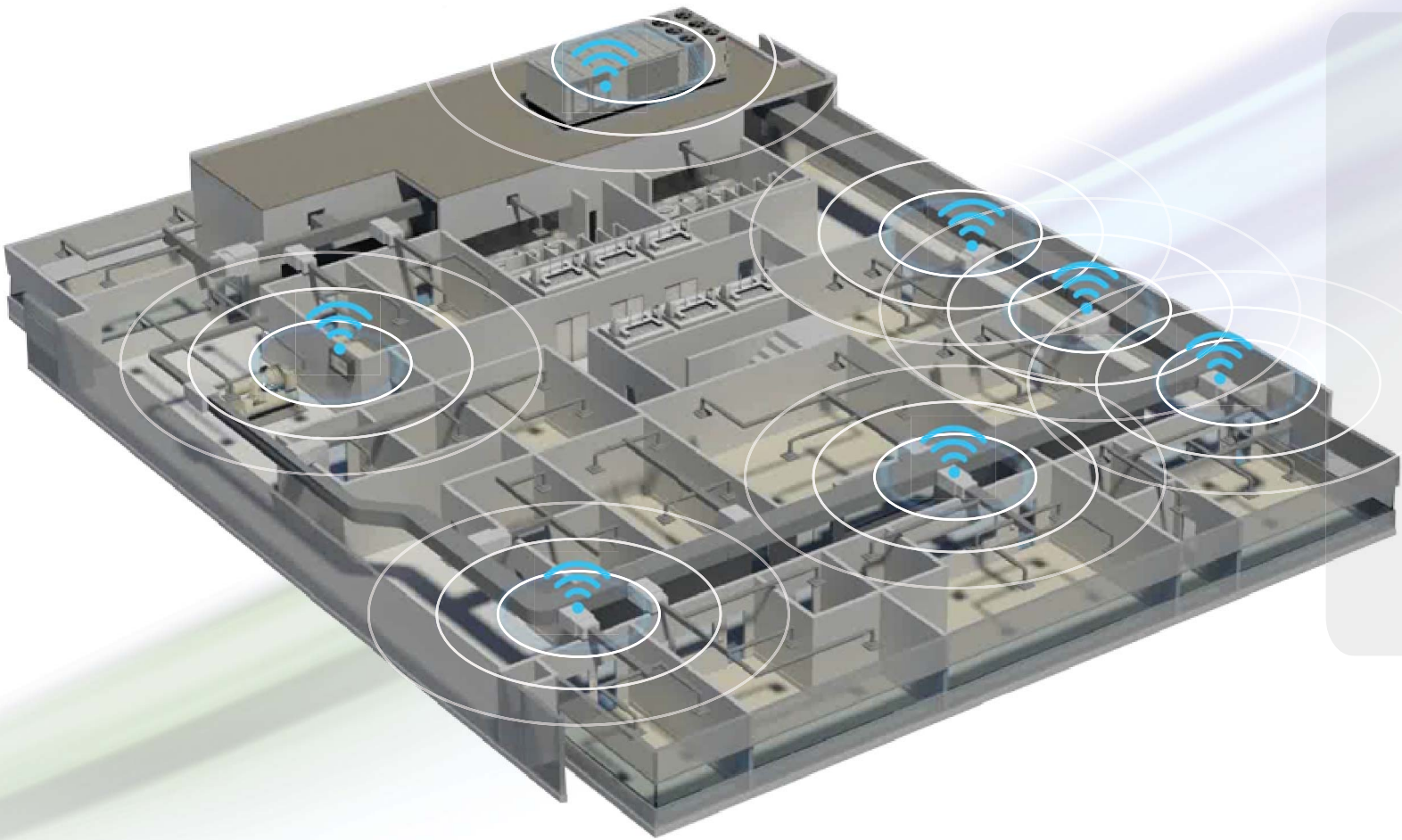




*Trane Engineers Newsletter Live*

# Controls Communication Technology

*with Trane Engineers Jim Kohl and Dan Kollodge*



Trane program number: APP-CMC066-EN  
[www.trane.com/ENL](http://www.trane.com/ENL)







# Agenda

Trane Engineers Newsletter Live Series

## Controls Communication Technology

### Abstract

The marketplace demands open, standard communication protocols to deliver flexible and interoperable control systems for building owners. Recent innovations in the industry have made this even more prevalent. This program discusses BACnet® communication protocol, with emphasis on specifications, various wireless communication options, and where each best applies, and concludes with a comparison of wired versus wireless communication.

**Presenters:** Trane engineers Jim Kohl and Dan Kollodge

### After viewing attendees will be able to:

1. Specify BACnet communications for an interoperable building automation system
2. Identify BTL certified control devices
3. Understand the pros and cons of BACnet MS/TP versus BACnet/IP
4. Properly apply various wireless technologies to where they best fit
5. Explain the benefits of using wireless communication for HVAC control

### Agenda

#### Specifying BACnet

- Device profiles
- BTL certified devices
- BACnet MS/TP versus BACnet/IP

#### Wireless communication options

- Wired versus wireless communication



## *Presenter biographies*

### *Controls Communication Technology*

#### **Jim Kohl | senior product manager | Trane**

Jim has over 35 years of experience in filtration and HVAC, including product management, product design, and applications engineering. In his role as a Trane controls product manager he is primarily responsible for wireless technologies, chiller controls, and rooftop controls. He holds several patents.

Kohl received his MBA from Metropolitan State University in 2002, where he continued on as an adjunct professor within the Marketing department.

#### **Dan Kollodge | systems applications engineer | Trane**

Dan has been with Trane for 14 years. He has worked as an applications engineer for the past ten and was a product development engineer prior to his current position. He is responsible for integrating of BAS equipment and controls into Trane building automation systems and assists Trane offices with BAS design and integration opportunities.

He serves on the ASHRAE SSPC-135 (BACnet) committee. Dan graduated from the University of Minnesota with a BS in Computer Engineering.



# Controls Communication Technology

*Trane Engineers Newsletter Live Series*



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# Learning objectives

1. Specify BACnet® communications for an interoperable building automation system
2. Identify BTL certified control devices
3. Understand the pros and cons of BACnet MS/TP versus BACnet/IP
4. Properly apply various wireless technologies to where they best fit
5. Explain the benefits of using wireless communication for HVAC control

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## Agenda

- Specifying BACnet® Device profiles
  - BTL certified devices
  - BACnet MS/TP versus BACnet/IP
- Wireless communication options
  - Wired versus wireless communication

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## Today's Presenters



**Dan Kollodge**  
Applications Engineer



**Jim Kohl**  
Product Manager

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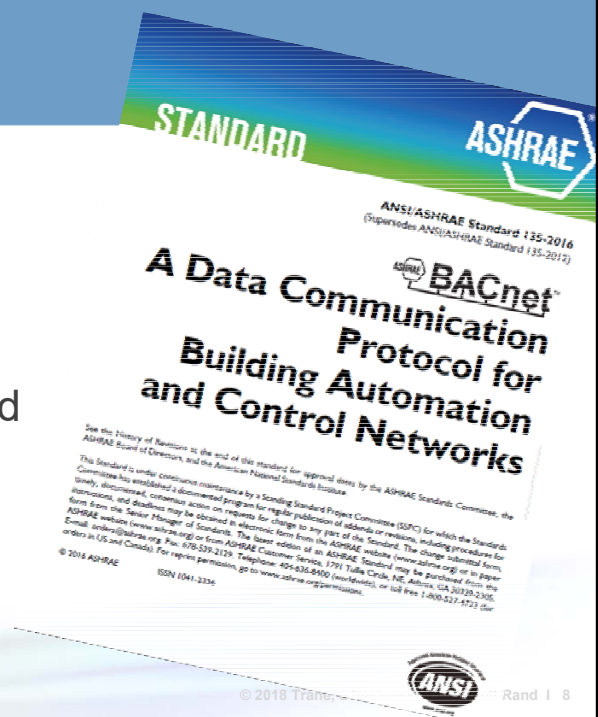
*“What should I write in a specification so that this site will have an interoperable BACnet® automation system?”*

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## The BACnet® Standard

### ANSI®/ASHRAE® Standard 135

- > 1300 pages
- Prescribes how protocol works and how it must be implemented
- Intended to scale from simple devices to enterprise systems



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## Agenda

- **Specifying BACnet®**
  - **Device profiles**
  - BTL certified devices
  - BACnet MS/TP versus BACnet/IP
- Wireless communication options
  - Wired versus wireless communication

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## BACnet® Device Profiles

- “Short hand” method to describe intended use of a device
- Each profile is comprised of five functional groups:
  - Data sharing
  - Alarm and event management
  - Scheduling
  - Trending
  - Device and network management
- Defines minimum set of BACnet functionality supported
  - BACnet Interoperability Building Blocks (BIBBs)

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## Commonly-Used BACnet® Device Profiles

### Equipment

**B-ASC** (Application Specific Controller)

**B-AAC** (Advanced Application Controller)

### Building System

**B-BC** (Building Controller)

### Enterprise Workstation

**B-OWS** (Operator Workstation)

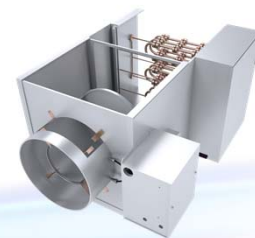
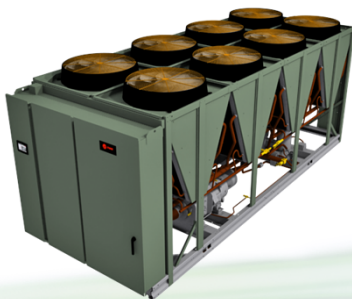
**B-AWS** (Advanced Operator Workstation)

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## B-ASC Device Profile

### Application Specific Controller (B-ASC)

- Focused on a piece of equipment
- Functional areas supported
  - Data sharing
  - Device and network management



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## B-AAC Device Profile

### **Advanced Application Specific Controller (B-AAC)**

- Focused on a piece of equipment
- Functional areas supported
  - Data sharing
  - **Alarm and event management**
  - **Scheduling**
  - Device and network management



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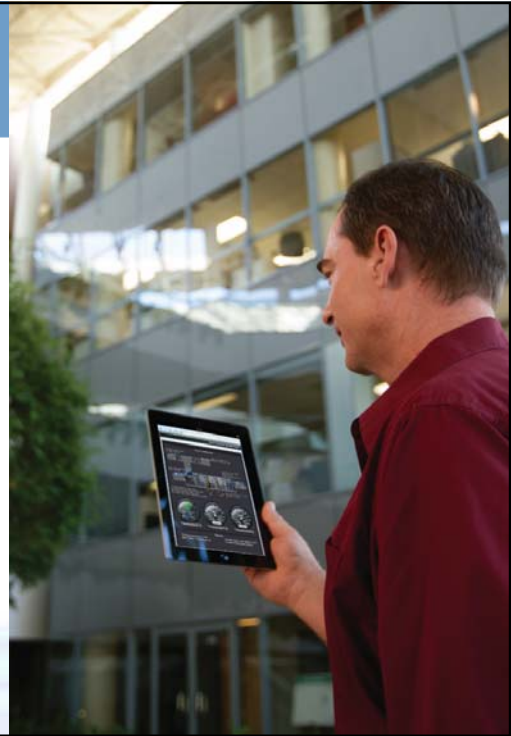
## Alarming

- Change of value event reporting
- **Intrinsic reporting**
- Algorithmic reporting
- Alert reporting

*“I want BACnet<sup>®</sup> alarming.”*

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## Intrinsic Alarming



## Alarming Specification Language

*“All devices that control and/or monitor equipment shall support BACnet® intrinsic reporting.”*

*“All devices that meet the B-ASC device profile requirements shall support BACnet intrinsic reporting.”*

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## B-BC Device Profile

### Building Controller (B-BC)

- Focused on system-level control
- Functional areas supported
  - Data sharing
  - Alarm and event management
  - **Scheduling**
  - **Trending**
  - Device and network management



## B-OWS and B-AWS Device Profile

### Operator Workstation (B-OWS)

### Advanced Operator Workstation (B-AWS)

- Software applications for a PC or server
- Functional areas supported
  - Data sharing
  - Alarm and event management
  - Scheduling
  - Trending
  - Device and network management



## Agenda

- **Specifying BACnet®**
  - Device profiles
  - **BTL certified devices**
  - BACnet MS/TP versus BACnet/IP
- Wireless communication options
  - Wired versus wireless communication

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## BACnet® International

- Industry association that facilitates successful use of BACnet protocol worldwide
  - Sponsors BACnet interoperability testing and certification program
  - Sustains and funds BACnet Testing Laboratories (BTL)
  - Disseminates information about BACnet technology and products
  - Organizes educational events and documentation

[www.BACnetInternational.org](http://www.BACnetInternational.org)

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## BACnet® Testing Laboratories (BTL)

- Certification group within BACnet International
- Certifies testing laboratories
- Manages device certification process
- Maintains directory of BTL certified devices



[www.BACnetlabs.org](http://www.BACnetlabs.org)

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## BACnet® Certified Devices

- Device with BTL certification:
  - Tested by an independent lab
  - Followed a standardized, repeatable test process
  - Verified functionality works as prescribed in BACnet standard
- Device without certification:
  - “Trust me, it works”

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## Beware of Marketing Slang

~~“native BACnet”~~

~~“supports BACnet”~~

~~“BACnet compliant”~~

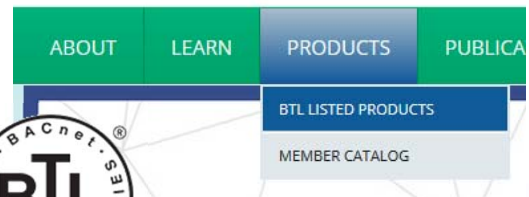
**“Are your devices BTL certified?”**

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## Is a Device BTL Certified?

- Ask “is this device BTL certified?”
- Visit BACnet® International website ([www.BACnetInternational.org](http://www.BACnetInternational.org))
- BTL mark displayed on device

**BACnet**  
International 



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## Agenda

- **Specifying BACnet®**
  - Device profiles
  - BTL certified devices
  - **BACnet MS/TP versus BACnet/IP**
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## BACnet® MS/TP versus BACnet/IP

### BACnet MS/TP

- Master-Slave Token Passing
- RS-485 protocol
- Twisted two- or three-conductor shielded cable with drain wire
- Devices connected in a “daisy chain” configuration
- 76.8 or 38.4 kbit/s baud rate

### BACnet/IP

- Internet Protocol (IP)
- Ethernet cable
- Devices connected with “home run” wiring to an IT switch
- 100 Mbit/s baud rate



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	<b>BACnet® MS/TP</b>	<b>BACnet/IP</b>
Speed		
Device cost		
Wire cost		
Infrastructure cost		
Network reliability		
Security		
IT department support		

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	<b>BACnet® MS/TP</b>	<b>BACnet/IP</b>
Speed		●
Device cost		
Wire cost		
Infrastructure cost		
Network reliability		
Security		
IT department support		

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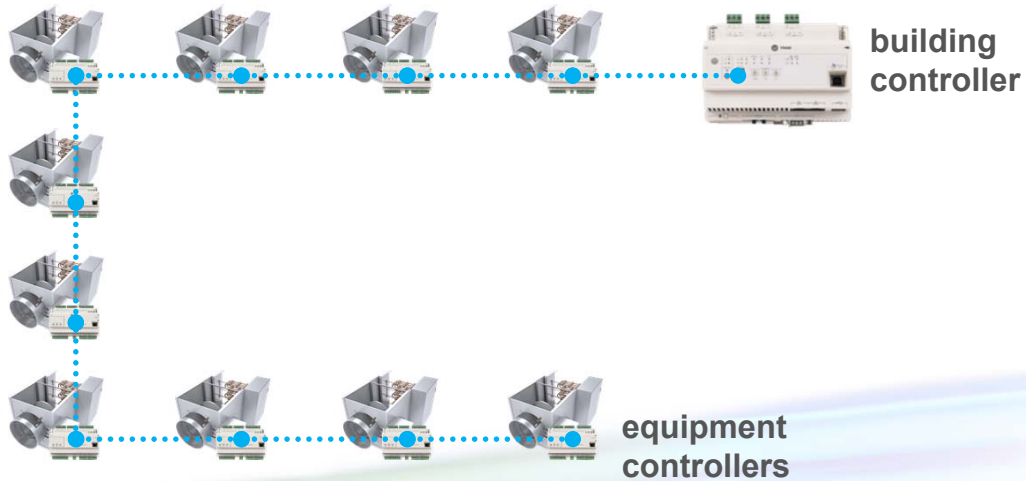
	BACnet® MS/TP	BACnet/IP
Speed		●
Device cost	●	
Wire cost		
Infrastructure cost		
Network reliability		
Security		
IT department support		

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	BACnet® MS/TP	BACnet/IP
Speed		●
Device cost	●	
Wire cost	●	
Infrastructure cost		
Network reliability		
Security		
IT department support		

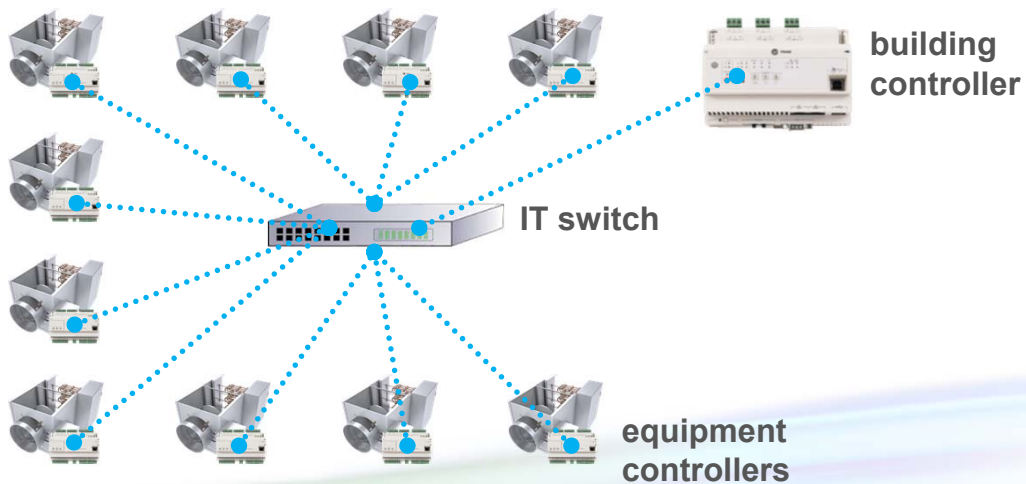
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## BACnet® MS/TP (“Daisy Chain” Wiring)



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## BACnet®/IP (“Home Run” Wiring)



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	BACnet® MS/TP	BACnet/IP
Speed		●
Device cost	●	
Wire cost	●	
Infrastructure cost	●	
Network reliability		
Security		
IT department support		

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	BACnet® MS/TP	BACnet/IP
Speed		●
Device cost	●	
Wire cost	●	
Infrastructure cost	●	
Network reliability	●	●
Security		
IT department support		

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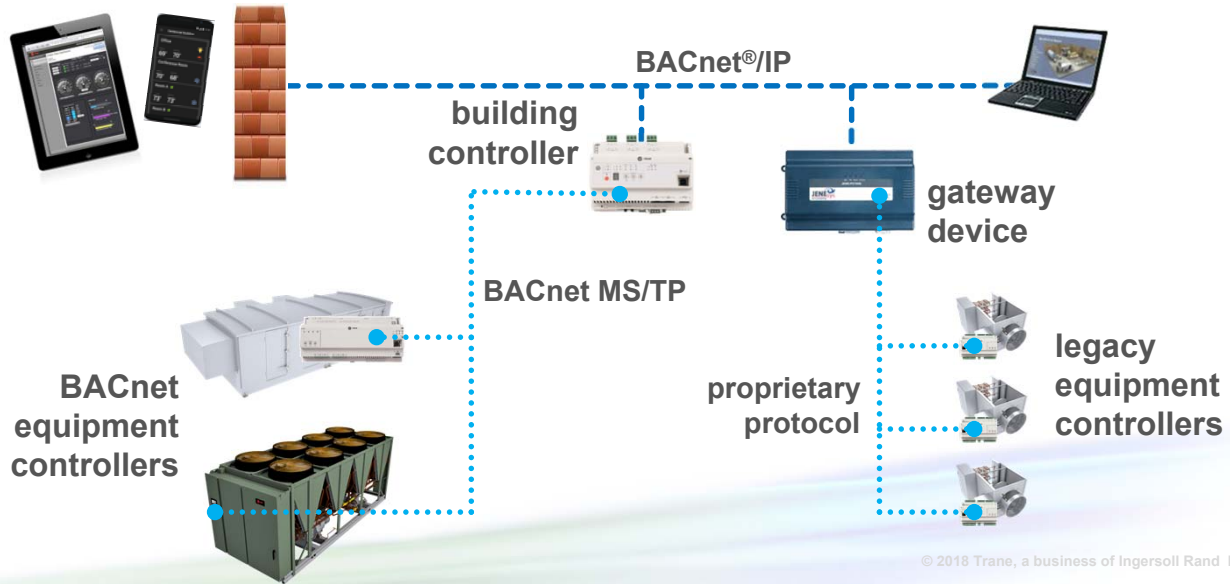
	BACnet® MS/TP	BACnet/IP
Speed		●
Device cost	●	
Wire cost	●	
Infrastructure cost	●	
Network reliability	●	●
Security	●	
IT department support		

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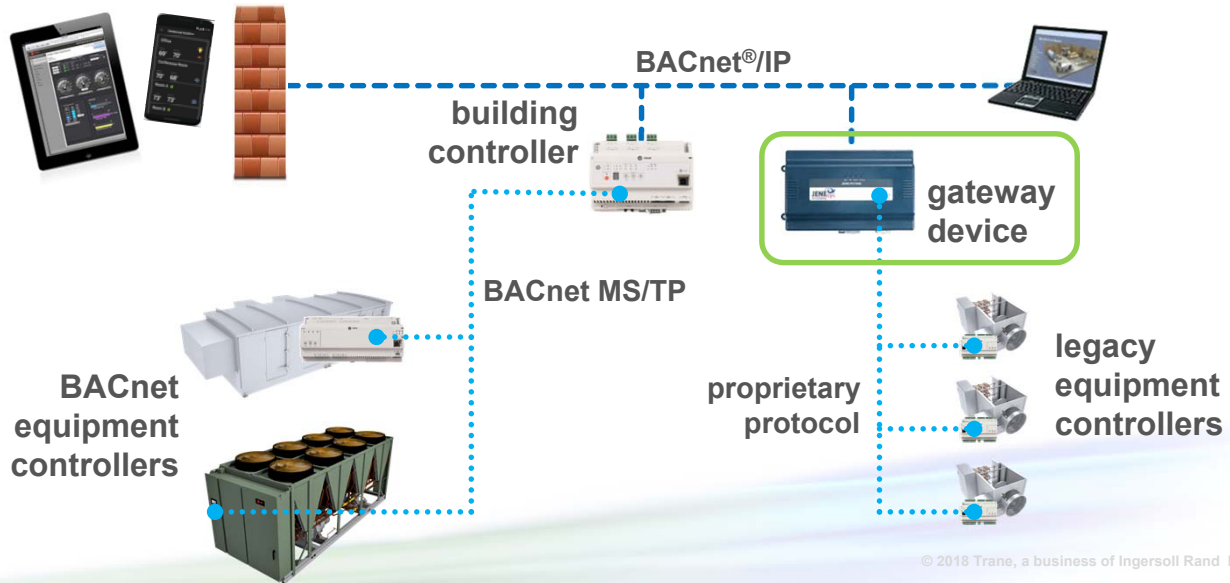
	BACnet® MS/TP	BACnet/IP
Speed		●
Device cost	●	
Wire cost	●	
Infrastructure cost	●	
Network reliability	●	●
Security	●	
IT department support	●	

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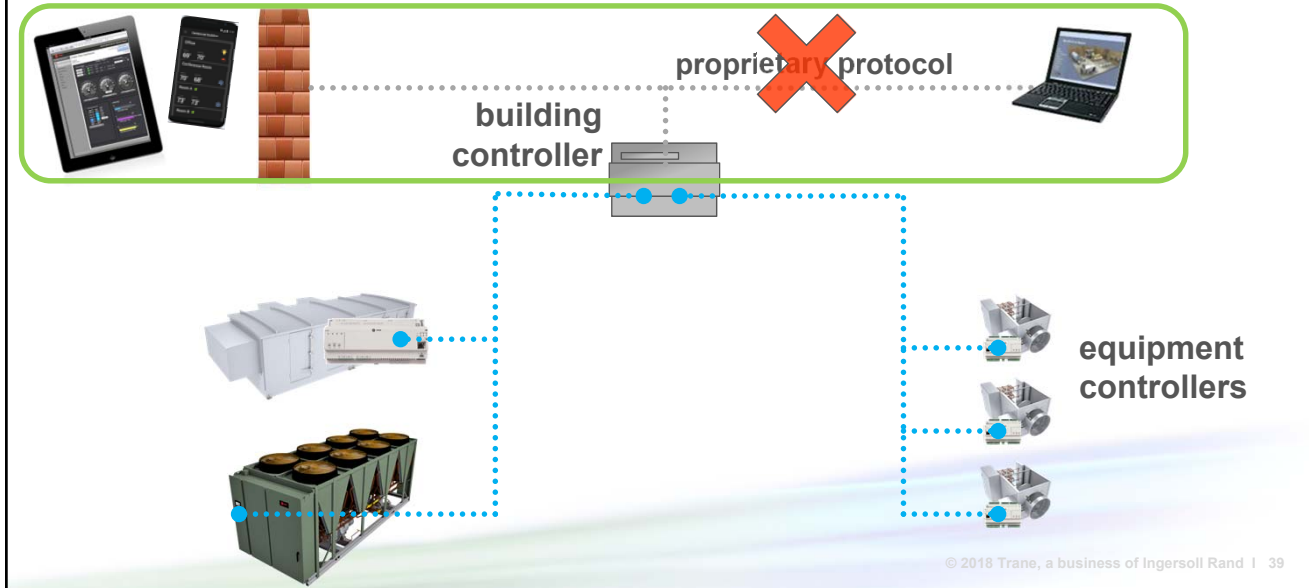
# Retrofit Integration with Gateway Devices



# Avoid Use of Gateways if Possible



## Specify BACnet at ALL Layers of Architecture



## Agenda

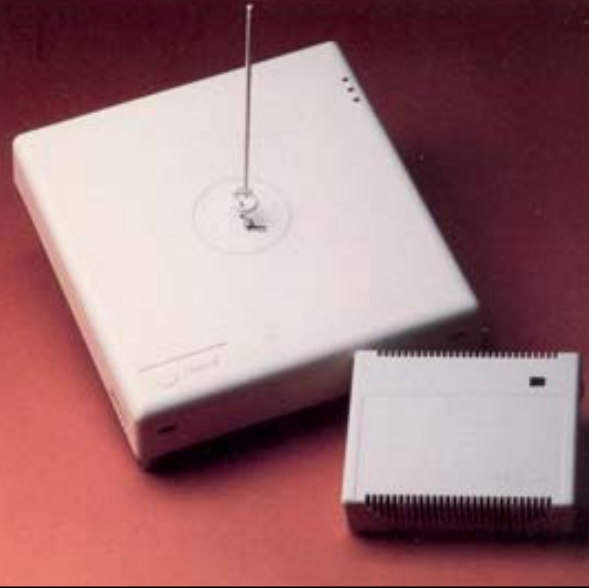
- **Specifying BACnet®**
  - Device profiles
  - BTL certified devices
  - BACnet MS/TP versus BACnet/IP
- **Wireless communication options**
  - Wired versus wireless communication

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## Past Wireless Solutions

- Standards not specifically designed for HVAC controls
- Limited applications
- High maintenance costs
- Limited reliability



## Today's Wireless Solutions

- New standards
- Longer battery life
- Improved reliability
- Easier installation
- Lower installed cost



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	Power Source	Data Rate	Quantity
Sensors			
Equipment controls			
Buildings controls			
Tools			

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	Power Source	Data Rate	Quantity
Sensors	Batteries (years) Power harvesting	Low	Many
Equipment controls			
Buildings controls			
Tools			

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	<b>Power Source</b>	<b>Data Rate</b>	<b>Quantity</b>
Sensors	Batteries (years) Power harvesting	Low	Many
Equipment controls	Line power	Moderate	Many
Buildings controls			
Tools			

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	<b>Power Source</b>	<b>Data Rate</b>	<b>Quantity</b>
Sensors	Batteries (years) Power harvesting	Low	Many
Equipment controls	Line power	Moderate	Many
Buildings controls	Line power	High	Few
Tools			

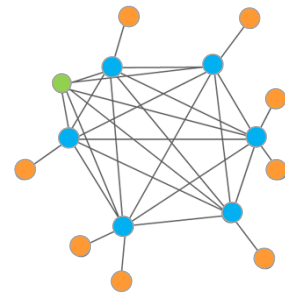
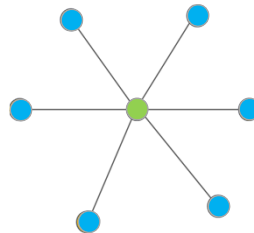
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	Power Source	Data Rate	Quantity
Sensors	Batteries (years) Power harvesting	Low	Many
Equipment controls	Line power	Moderate	Many
Buildings controls	Line power	High	Few
Tools	Batteries (hours)	High	Few

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## Common Wireless Topologies

- Point-to-point
- Star
- Mesh



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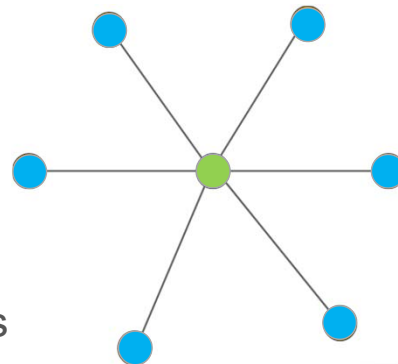
## wireless topologies Point-to-Point

- Direct communication between two devices
- Consumes least amount of power
- No redundancy



## wireless topologies Star

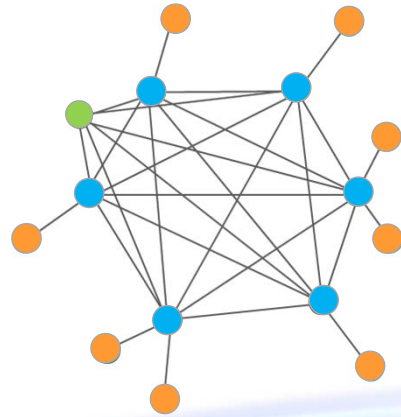
- Centralized routing and access point
- All data must flow through the access point
- No redundancy
- Typically used in Wi-Fi installations



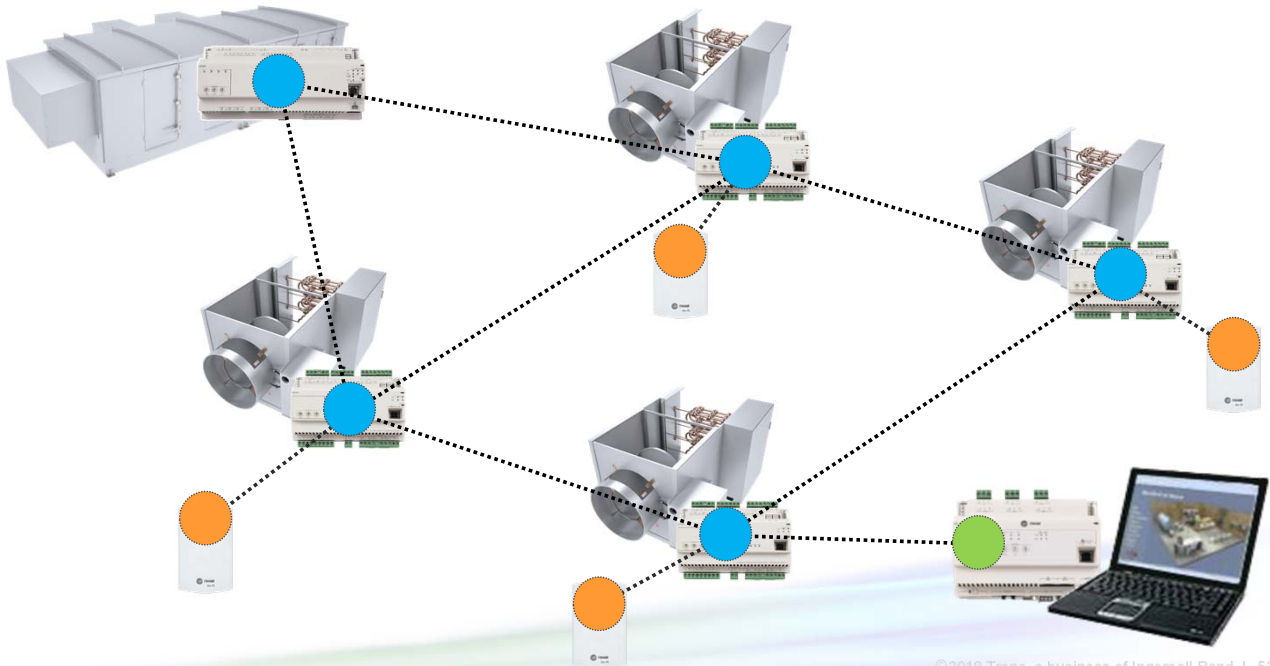
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## wireless topologies Mesh

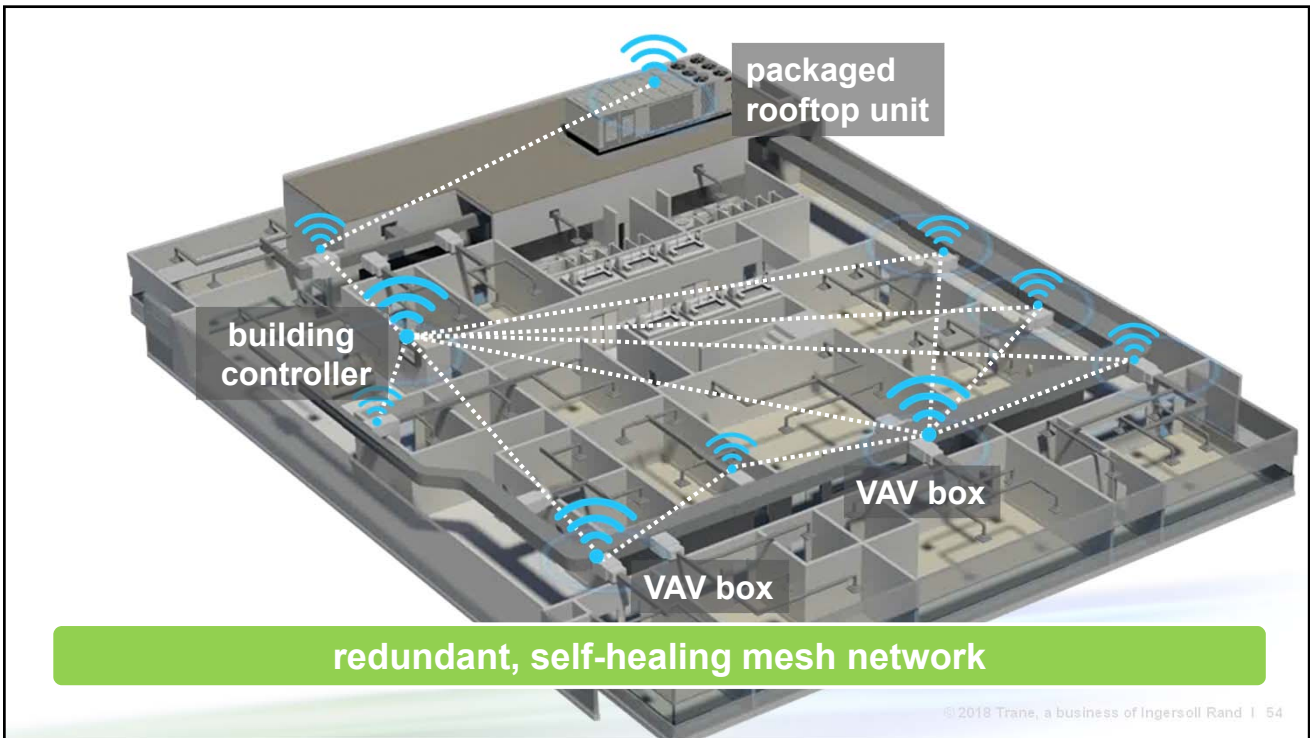
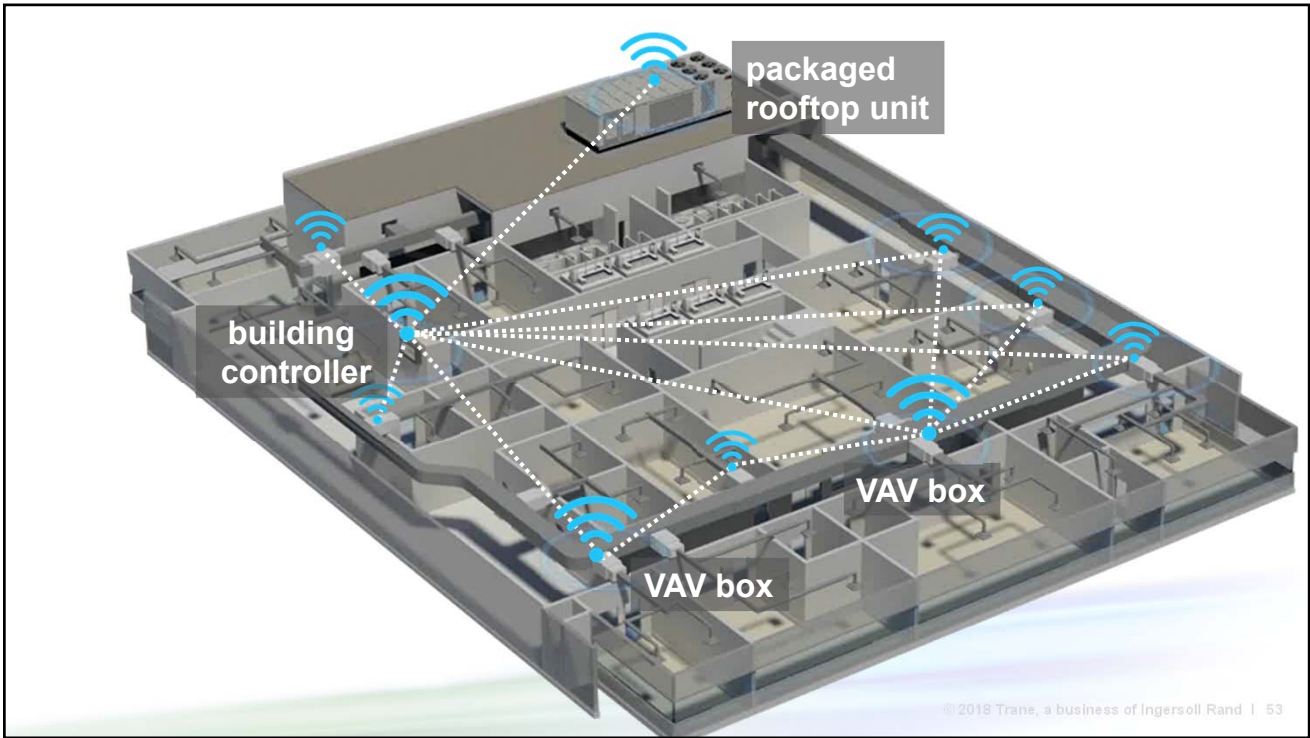
- Full redundancy
- Self-configuring
- Self-healing



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## Common Wireless Technologies

- Wi-Fi®
- Bluetooth®
- EnOcean®
- Z-Wave®
- Zigbee®



Wireless Technology	Typical Range (meters)	Data Rate	Topologies Supported	Power
Wi-Fi® IEEE 802.11 b/g/n	70	600 Mbit/s	Point-to-point Star	Battery (hours)
Bluetooth® IEEE 802.15.1	10	25 Mbit/s	Point-to-point	Battery (days)
EnOcean® ISO/IEC 14543-3-10	30	125 kbps	Point-to-point	Power harvesting Battery (years)
Z-Wave®	30	40 kbps	Mesh	Battery (years)
Zigbee® IEEE 802.15.4	70*	250 kbps	Point-to-point Star Mesh	Battery (years)

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## Wi-Fi®

- Good for high data rate applications
- Can be tied to building WLAN
  - » But security may be a concern for some
  - » May constrain higher priority applications and users
- Limited topologies may compromise reliability
- Power consumption limits application
- Supports BACnet communications

**Best suited for building controllers & high data rate equipment controllers**

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Wireless Technology	Typical Range (meters)	Data Rate	Topologies Supported	Power
Wi-Fi® IEEE 802.11 b/g/n	70	600 Mbit/s	Point-to-point Star	Battery (hours)
Bluetooth® IEEE 802.15.1	10	25 Mbit/s	Point-to-point	Battery (days)
EnOcean® ISO/IEC 14543-3-10	30	125 kbps	Point-to-point	Power harvesting Battery (years)
Z-Wave®	30	40 kbps	Mesh	Battery (years)
Zigbee® IEEE 802.15.4	70*	250 kbps	Point-to-point Star Mesh	Battery (years)

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## Bluetooth®

- Good for high data rate applications
- Limited topologies may compromise reliability
- Does not support standard BACnet communications

Best suited for service tools

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Wireless Technology	Typical Range (meters)	Data Rate	Topologies Supported	Power
Wi-Fi® IEEE 802.11 b/g/n	70	600 Mbit/s	Point-to-point Star	Battery (hours)
Bluetooth® IEEE 802.15.1	10	25 Mbit/s	Point-to-point	Battery (days)
EnOcean® ISO/IEC 14543-3-10	30	125 kbps	Point-to-point	Power harvesting Battery (years)
Z-Wave®	30	40 kbps	Mesh	Battery (years)
Zigbee® IEEE 802.15.4	70*	250 kbps	Point-to-point Star Mesh	Battery (years)

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## EnOcean®

- Good for low power consumption applications
- Limited topologies may compromise reliability
- Data rate limits application
- Does not directly support BACnet communications

Best suited for sensors and end devices

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Wireless Technology	Typical Range (meters)	Data Rate	Topologies Supported	Power
Wi-Fi® IEEE 802.11 b/g/n	70	600 Mbit/s	Point-to-point Star	Battery (hours)
Bluetooth® IEEE 802.15.1	10	25 Mbit/s	Point-to-point	Battery (days)
EnOcean® ISO/IEC 14543-3-10	30	125 kbps	Point-to-point	Power harvesting Battery (years)
Z-Wave®	30	40 kbps	Mesh	Battery (years)
Zigbee® IEEE 802.15.4	70*	250 kbps	Point-to-point Star Mesh	Battery (years)

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## Z-Wave®

- Good for low power consumption applications
- Data rate limits application
- Does not directly support BACnet communications

Best suited for sensors and end devices

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Wireless Technology	Typical Range (meters)	Data Rate	Topologies Supported	Power
Wi-Fi® IEEE 802.11 b/g/n	70	600 Mbit/s	Point-to-point Star	Battery (hours)
Bluetooth® IEEE 802.15.1	10	25 Mbit/s	Point-to-point	Battery (days)
EnOcean® ISO/IEC 14543-3-10	30	125 kbps	Point-to-point	Power harvesting Battery (years)
Z-Wave®	30	40 kbps	Mesh	Battery (years)
Zigbee® IEEE 802.15.4	70*	250 kbps	Point-to-point Star Mesh	Battery (years)

\* In locales where extended range is allowed.

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## Zigbee®

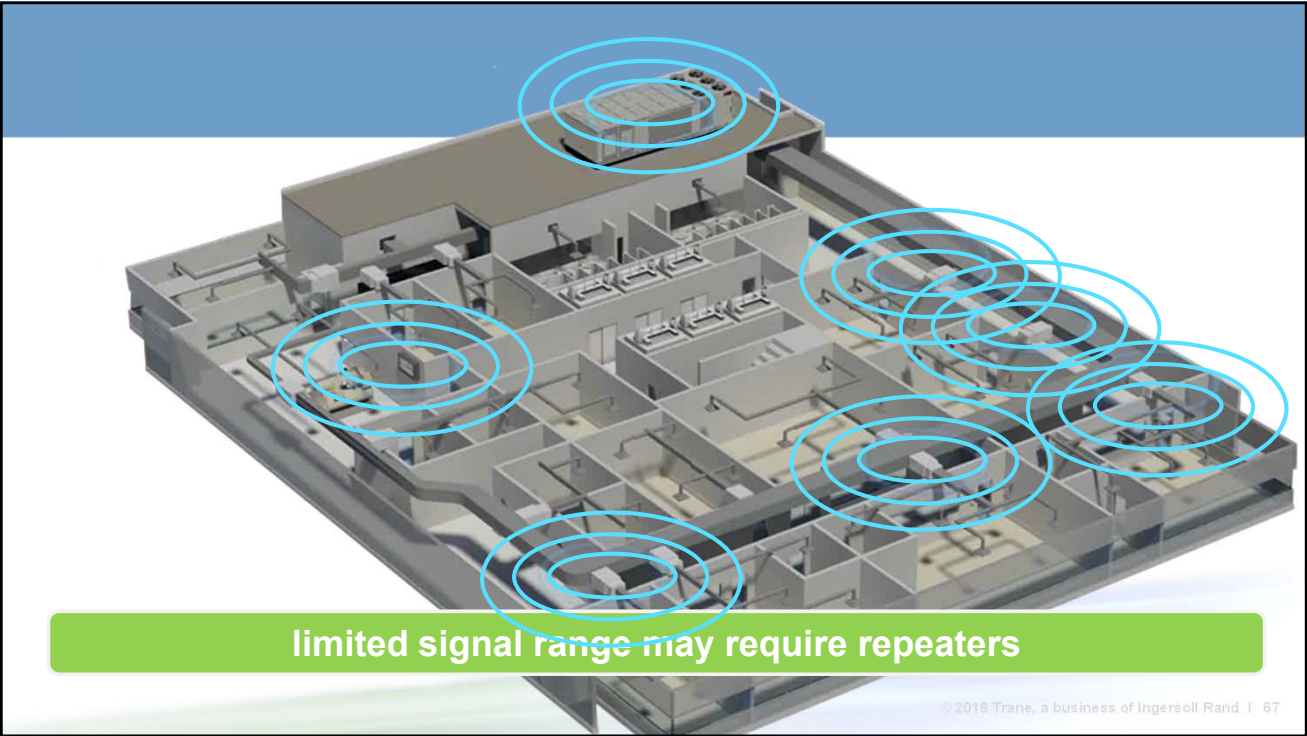
- Good for low power consumption applications
- Moderate data rate expands applications
- Support BACnet communications

Best suited for sensors and equipment controllers

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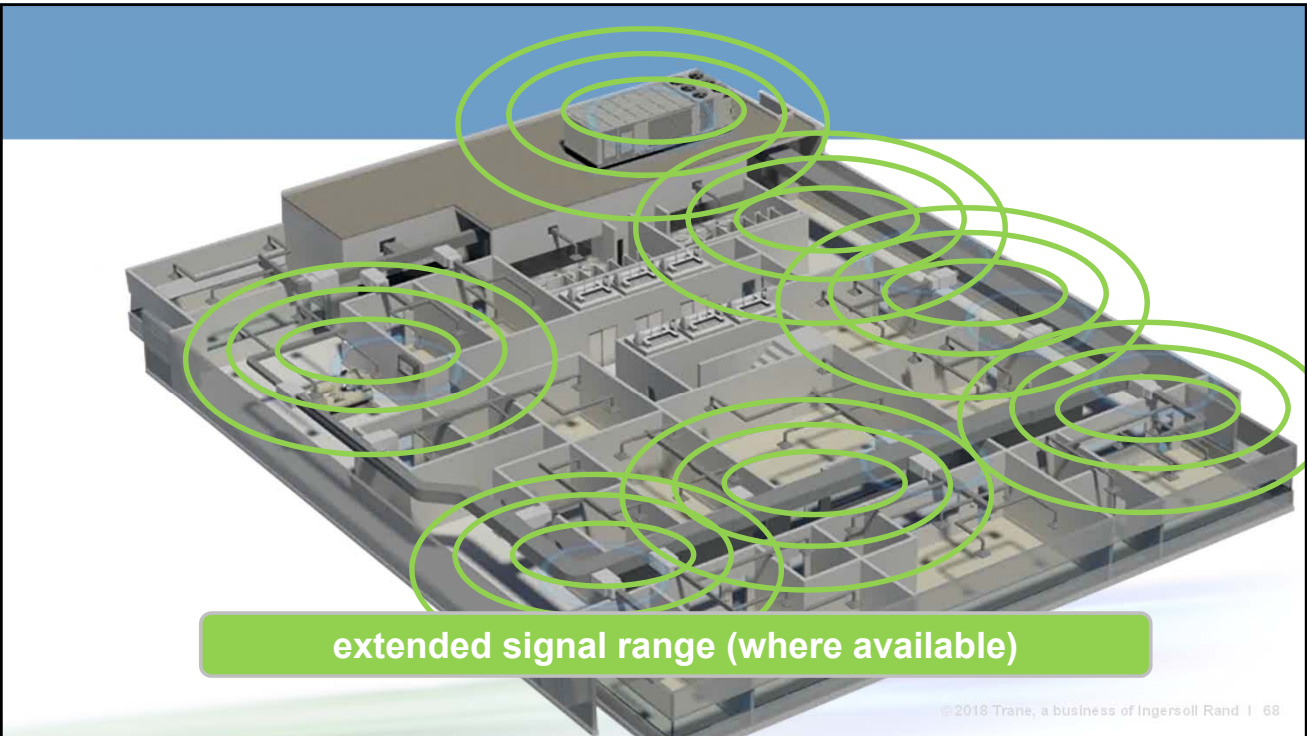
Wireless Technology	Typical Uses
Wi-Fi®	Replaces Ethernet cable (building controllers)
Bluetooth®	Short range, moderate data rate applications (service tools)
EnOcean®	Moderate range, low data rate applications (sensors, lighting)
Z-Wave®	Moderate range, low data rate applications (residential thermostats, lighting)
Zigbee®	Moderate range, moderate data rate applications (commercial buildings, sensors, equipment controls)

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**limited signal range may require repeaters**

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**extended signal range (where available)**

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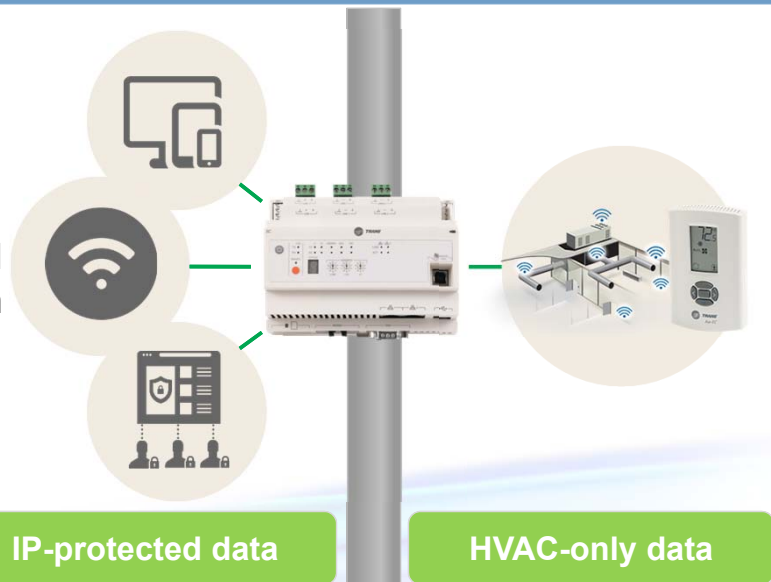
## Coexistence

- Designed to IEEE standards for reliable coexistence
  - Channel management
  - Carrier sense multiple access with collision avoidance
- Proven to reliably coexist in challenging environments
  - Hospitals
  - Stadiums
  - Distribution warehouses



## Security

- AES Standard 128
  - Similar security standards to Wi-Fi
- HVAC communications isolated from confidential and sensitive information



## Agenda

- Specifying BACnet™
  - Device profiles
  - BTL certified devices
  - BACnet MS/TP versus BACnet/IP
- Wireless communication options
  - **Wired versus wireless communication**

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## Advantages of Wired Communications

1. Applicable in extremely “noisy” environments
  - Example: MRI room
2. Reduced security concerns
  - Example: defense industries
3. Easy wiring (fixed location, few devices, close proximity)
  - Example: large equipment located in a mechanical room

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## Advantages of Wireless Communications

### 1. Lower installed cost, faster project completion

- Eliminates need to pull or repair wire
- Avoid penetrating structures and hazardous materials (especially beneficial on historical buildings)



*“Installation of the wireless sensors definitely expedited the installation / construction process, which is a very important benefit when dealing with the small windows of opportunity—spring break, Christmas break, summer break—that we usually have to accomplish projects of this nature.”*

**Director of maintenance for a school district in Kansas City**

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## Advantages of Wireless Communications

### 1. **Lower installed cost, faster project completion**

- Eliminates need to pull or repair wire
- Avoid penetrating structures and hazardous materials
- Often makes control upgrades financially feasible

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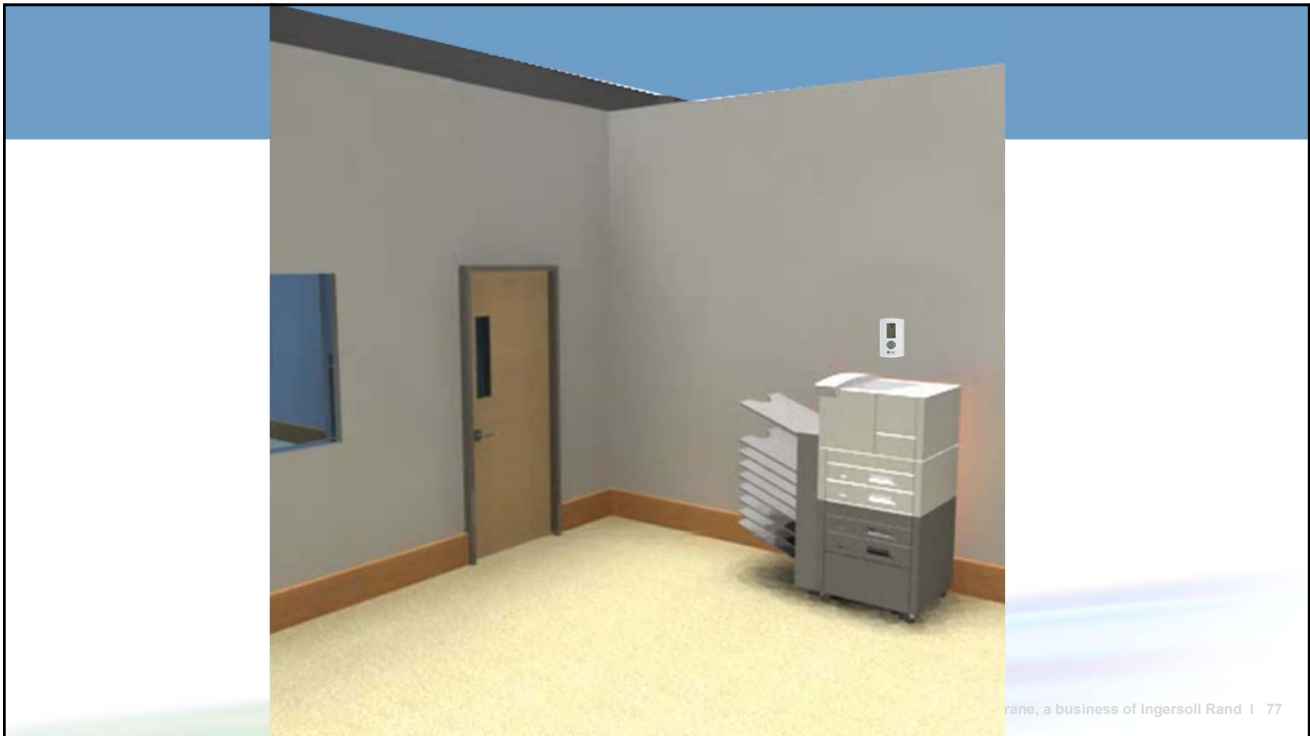
## Advantages of Wireless Communications

### 1. Lower installed cost, faster project completion

### 2. **Easier problem solving**

- Easy to relocate devices for improved sensing accuracy

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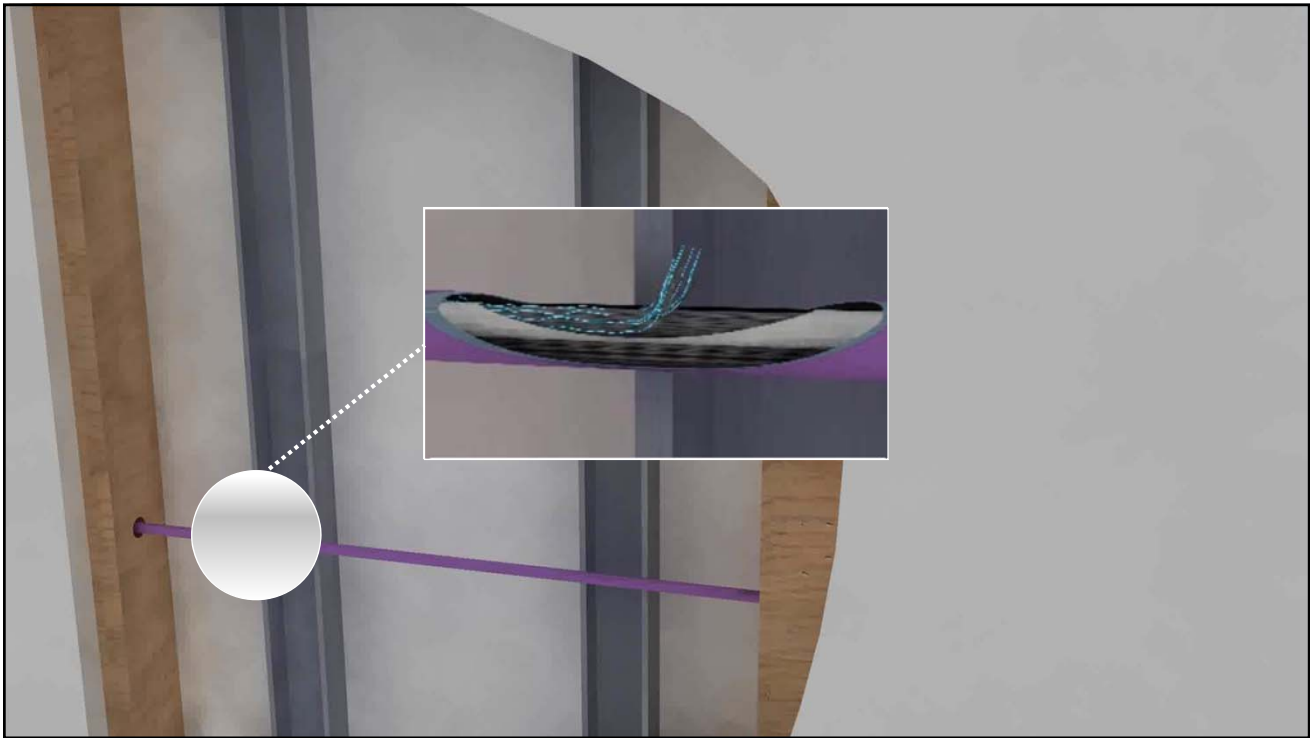


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## Advantages of Wireless Communications

1. Lower installed cost, faster project completion
2. **Easier problem solving**
  - Easy to relocate devices for improved sensing accuracy
  - No damaged communication wire to troubleshoot

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## Advantages of Wireless Communications

1. Lower installed cost, faster project completion
2. Easier problem solving
  - Easy to relocate devices for improved sensing accuracy
  - No damaged communication wire to troubleshoot
3. **Easier to move if space is reconfigured or to provide easier access**

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# Specifying Wireless Communications

- 200-ft design range
- Mesh topology
- IEEE®
- Lifetime batteries (or power harvesting)
- Battery condition indicator and alarming
- Certified, open standard solutions (BACnet, Zigbee)

reliability, security, minimal maintenance, easy to integrate

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# Where to Learn More

The collage features three main items:

- Engineers Newsletter**: Volume 47-1, featuring an article on "Harmonic Distortion in Electrical Systems".
- Applications Engineering Manual**: SYS-APM007-EN, featuring a section on "Rooftop VAV Systems".
- Chilled-Water System Decisions**: A DVD-ROM from the Trane Engineers Newsletter Live Series, with a runtime of 75 minutes.

[www.trane.com/bookstore](http://www.trane.com/bookstore)

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## Continuing Education Courses

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- **NEW!** Demand Response in Commercial Buildings
- **NEW!** High Performance Air Systems
- Acoustics in Outdoor HVAC Systems
- HVAC Myths and Realities
- New Fan Efficiency Regulations and Technology
- Trends in Small Rooftop Systems
- All-Variable Speed Compressors on Chillers
- ASHRAE Standard 62.1, 90.1 and 189.1
- All Variable-Speed Chiller Plant Operation



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Demand-Controlled Ventilation

Please contact your local Trane office for event details and registration or visit [trane.com/ENL](http://trane.com/ENL).

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# Controls Communication Technology

*Trane Engineers Newsletter Live Series*







# Bibliography

May 2018

## **Controls Communication Technology**

### **Industry Resources**

ANSI/ASHRAE Standard 135: BACnet™ - A Communication Protocol for Building Automation and Control Networks. Available from [www.ashrae.org/bookstore](http://www.ashrae.org/bookstore)

BACnet International web site: [www.BACnetInternational.org](http://www.BACnetInternational.org)

BACnet Testing Laboratories (BTL) web site: [www.BACnetlabs.org](http://www.BACnetlabs.org)

ZigBee Alliance web site: [www.zigbee.org](http://www.zigbee.org)

ZigBee Alliance. *ZigBee and Wireless Radio Frequency Coexistence* white paper. Available from <https://www.trane.com/content/dam/Trane/Commercial/global/controls/building-mgmt/Air-Fi/ZigBee%20Wireless%20Whitepaper.pdf>

### **Trane Resources**

Trane. "HVAC System Control" Air Conditioning Clinic. TRG-TRC017-EN. 2018.

Trane Air-Fi® Wireless Communications web site [www.trane.com/Air-Fi](http://www.trane.com/Air-Fi)







**Trane Engineers Newsletter LIVE: Controls Communication Technology  
APP-CMC066-EN QUIZ**

1. The BACnet standard is published by which organization?
  - a. U.S. Department of Energy
  - b. AHRI
  - c. ASHRAE
  
2. TRUE or FALSE: Intrinsic alarming is the functionality in BACnet that allows an alarm that originates at the equipment-level controller to be shared up to the building controller and/or the enterprise workstation.
  
3. Which term is used by BACnet International to identify a device that has been tested by an independent lab in order to verify that the supported BACnet functionality works as expected?
  - a. Native BACnet
  - b. BTL certified
  - c. Supports BACnet
  - d. BACnet compliant
  
4. Which of the following wireless topologies has the capability to self-form and self-heal, so that if a communication path is lost, the device will search for a different path?
  - a. Point-to-point
  - b. Star
  - c. Mesh
  
5. Which of the following are possible advantages of using wireless communications for HVAC control?
  - a. Faster project completion
  - b. Avoids the need to penetrate structure
  - c. Easier to relocate devices for improved sensing or when space usage changes
  - d. All of the above



