BMS BASICS

Continuing Education Credits

- Carrier University is authorized by IACET to offer 0.1 IACET CEUs for this program
- You must be present the entire time
- You will receive an email with a link to take the knowledge check and access your certificate

- The Professional Development Hour (PDH) is a term established by the National Council of Examiners for Engineering and Surveying (NCEES) in their “Continuing Professional Competency Guidelines.” In these guidelines, NCEES defines the relationship between CEUs and PDHs as: 0.1 CEU (1 hour of instruction) = 1 PDH; 1.0 CEU (10 hours of instruction) = 10 PDHs.

ACCREDITED IACET PROVIDER

Carrier

Automated Logic

Objectives

- Define a BMS
- Recognize different types of inputs and outputs
- Review controller types and network topologies
- Discuss BMS protocols and understand how they affect BMS and equipment
- Learn about software and advanced functionality
- Value of data, visualization, and analytics (Live Demo)

Carrier

Automated Logic

Controls – What is a BMS?

A **Building Management System (BMS)** is a computer-based control system installed in buildings that controls and monitors the building's mechanical and electrical equipment

The (insert your preferred acronym here: BMS, BAS, ATC, BACS, EMS, etc.) is typically involved with HVAC and energy but can interface with other systems such as:

- Power
- Lighting
- Shades
- Fire
- Security
- Other (Maintenance Management, Booking, A/V)…

Controls – What Makes up a BMS?

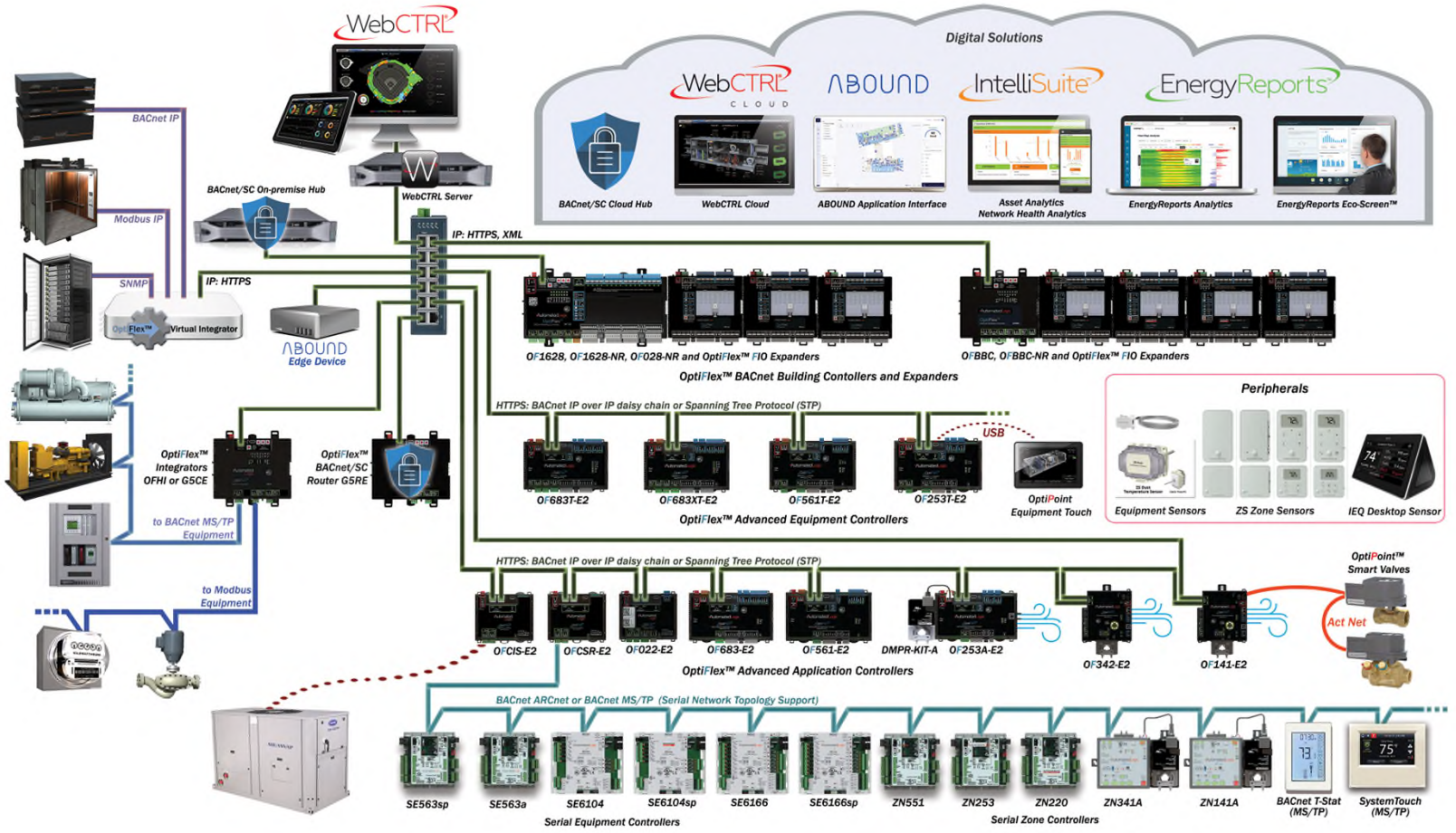
A **Building Management System (BMS)** is composed of both hardware and software

- Input devices such as sensors and switches
- Output devices such as relays and actuators
- Distributed system of hardware (controllers)
- Software (front end/operator workstation)
- Often integrated to other systems
- Lines are blurring

Carrier

Automated Logic

Controls – A More Advanced Network



Carrier

Automated Logic

Controls – What Does a BMS do?

- Occupant comfort
- Energy efficiency
- Remote monitoring
- Facilitates maintenance
- Protects owner investment
- Reporting
- Optimization

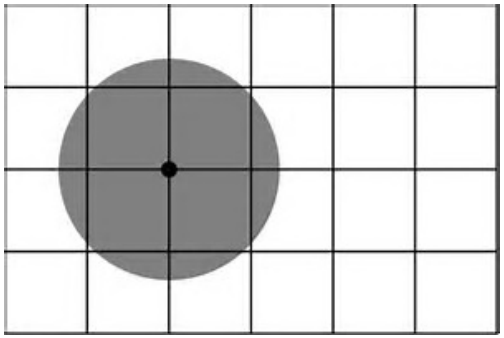
POINTS – INPUTS AND OUTPUTS

Points – a Good Starting Point

A point is simply a digital representation of a value or signal

- Can be real or virtual
- Analog or digital (binary)

Since a BMS utilizes direct digital control (DDC), all information must be converted into digital format which is a series of 1's and 0's



Carrier

Automated Logic

Control Basics – Common Input Point Types

Inputs	
Analog	Digital
Temperature	Status – on/off
Humidity	Status – open/closed
Pressure	Alarm, fault, etc.
Airflow	Leak

Carrier

Automated Logic

Control Basics – Common Input Signals

Inputs	
Analog	Digital
RTD, Thermistor	Dry contact
0-10 VDC	Pulse
4-20 mA	

Smart Sensors

Carrier

Automated Logic

Control Basics – Common Output Point Types

Outputs	
Analog	Digital
Valve Control	Valve Command
Damper Control	Damper Command
Motor Speed Control	Motor Start/Stop

Carrier

Automated Logic

Control Basics – Common Output Signals

Outputs	
Analog	Digital
0-10 VDC	Contact Closure
4-20 mA	Relay
Floating/Triac	

Carrier

Automated Logic

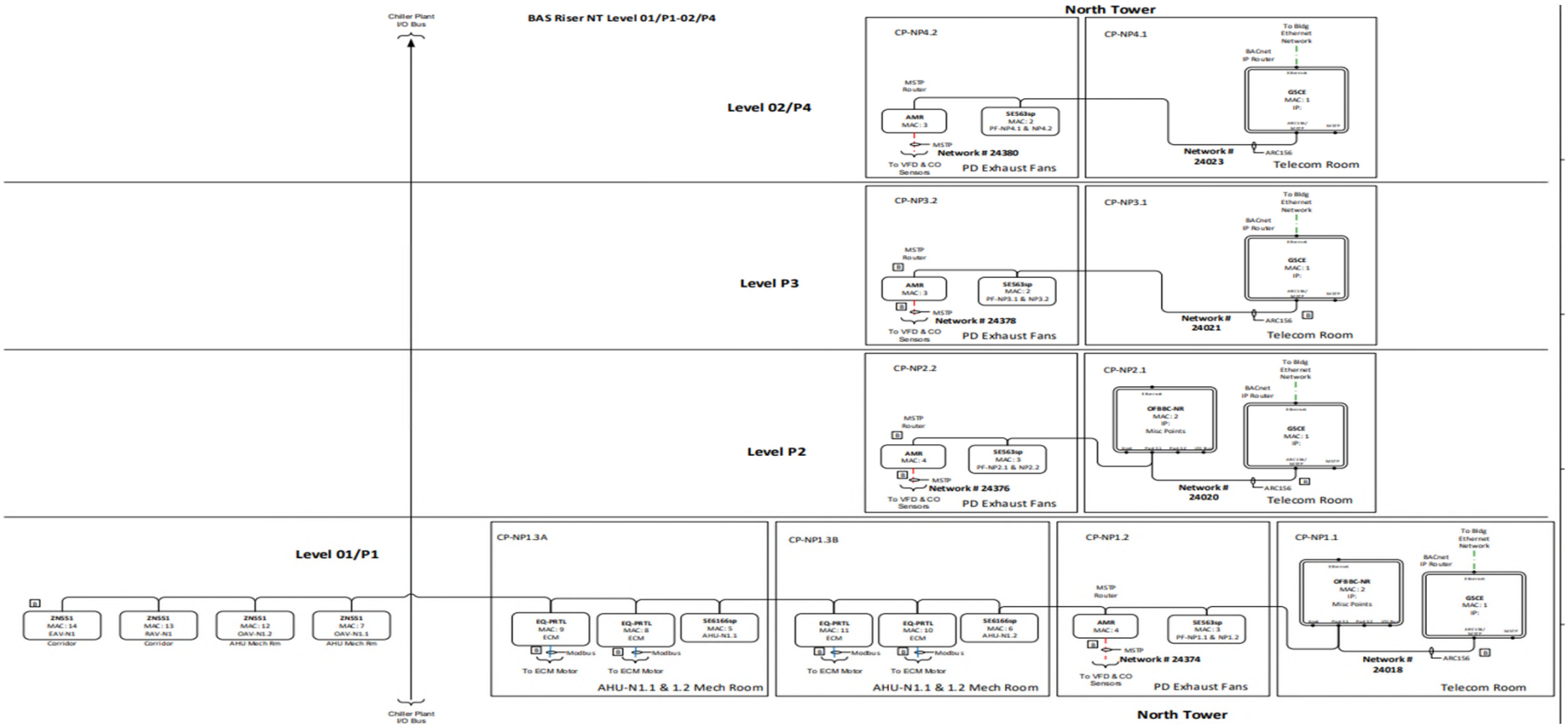
Points and Design Documents

What should you show and why?

Carrier

Automated Logic

Submittal Review – Network Riser



Carrier

Automated Logic

Points and Design Documents

Points List:

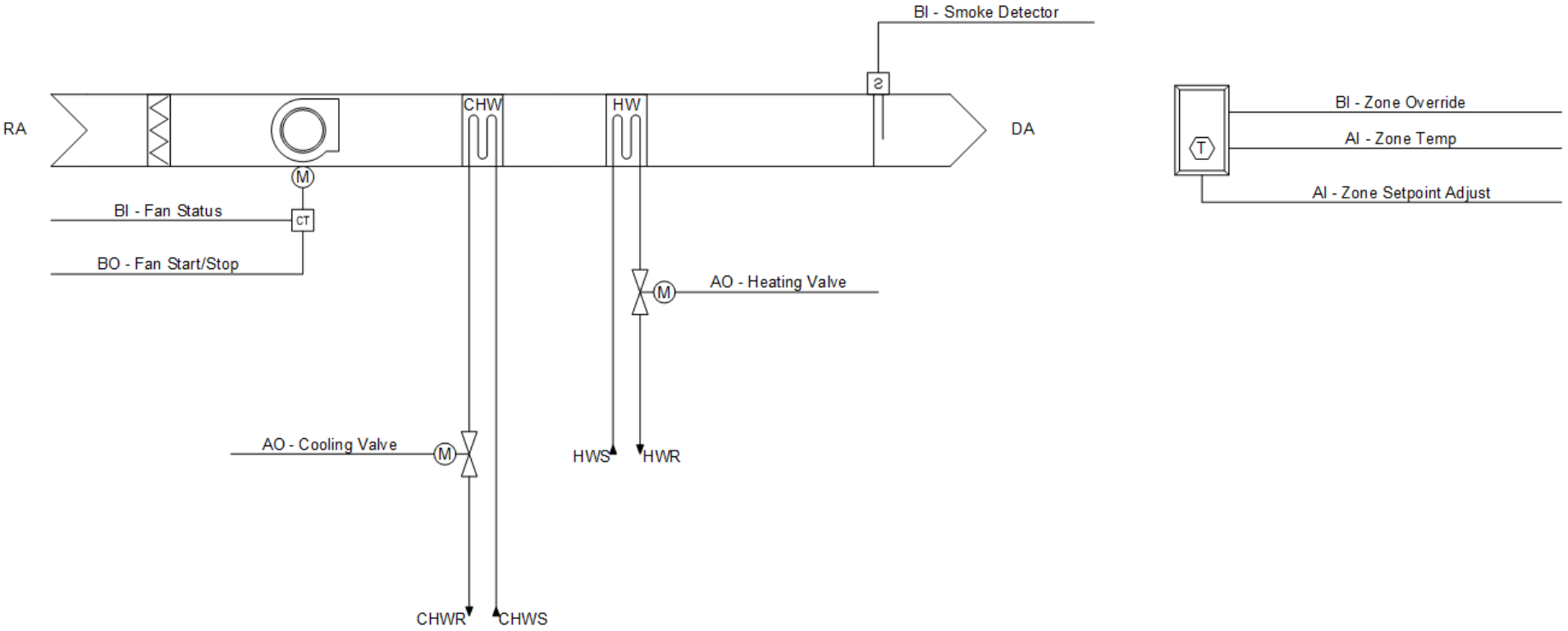
	Hardware Points				Software Points						
Point Name	**AI**	**AO**	**BI**	**BO**	**AV**	**BV**	**Loop**	**Sched**	**Trend**	**Alarm**	**Show On Graphic**
Chilled Water Bypass Valve		x							x		x
Chilled Water Supply Temp Setpoint Reset		x							x		x
Chiller Chilled Water Differential Pressure	x								x		x
Chiller Chilled Water Differential Pressure Setpoint					x				x		x
Chiller Enable				x							x
Chiller Failure						x				x	
Chiller Running in Hand						x				x	
Chiller Runtime Exceeded						x				x	
Chiller Status			x						x		X
Heat Exchanger Isolation Valve Command (Each)				x							X
Heat Exchanger Isolation Valve End Switch Open & Closed Status (Each)			x								X
Heat Exchanger Isolation Valve Failure						x				x	

Carrier

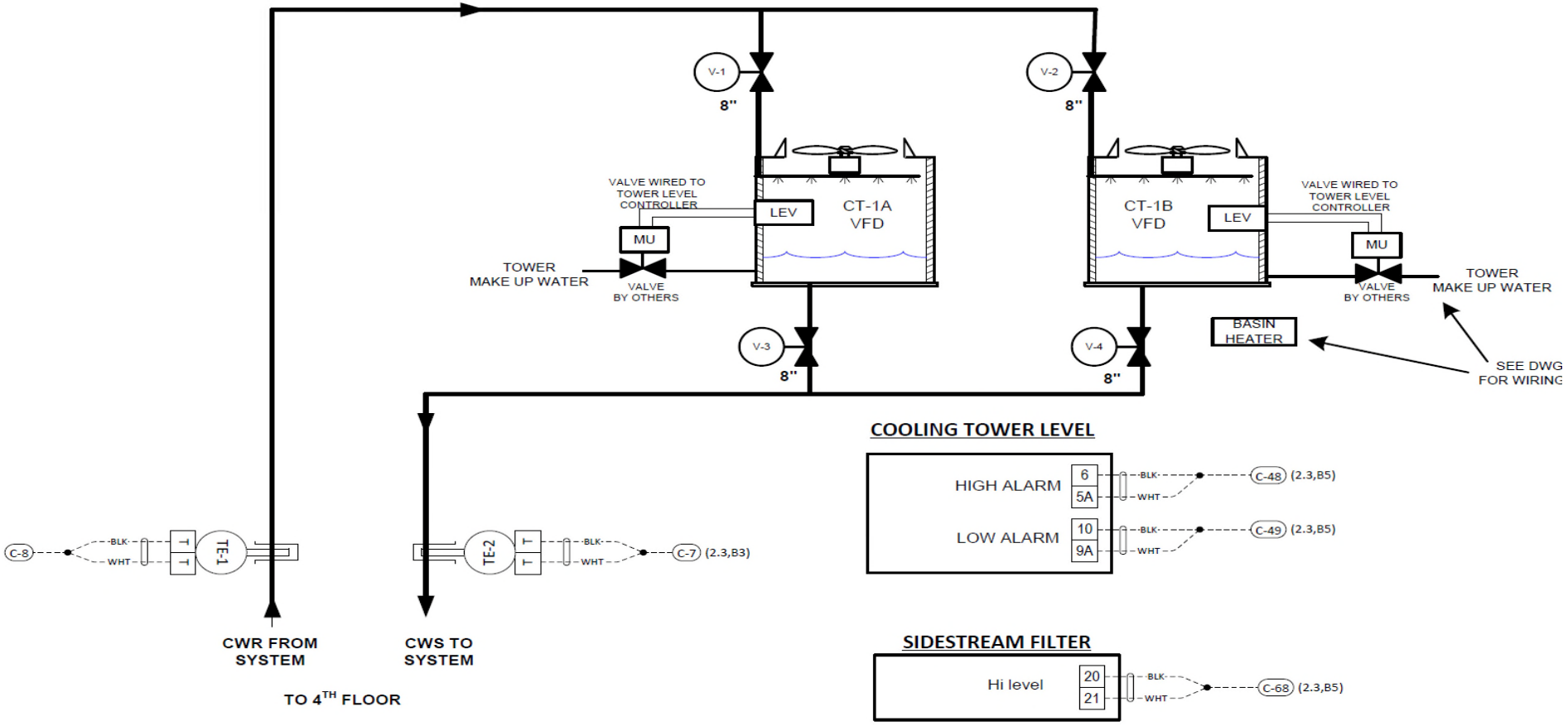
Automated Logic

Points and Design Documents

Control Diagram:



Submittal Review – Flow Diagram



Carrier

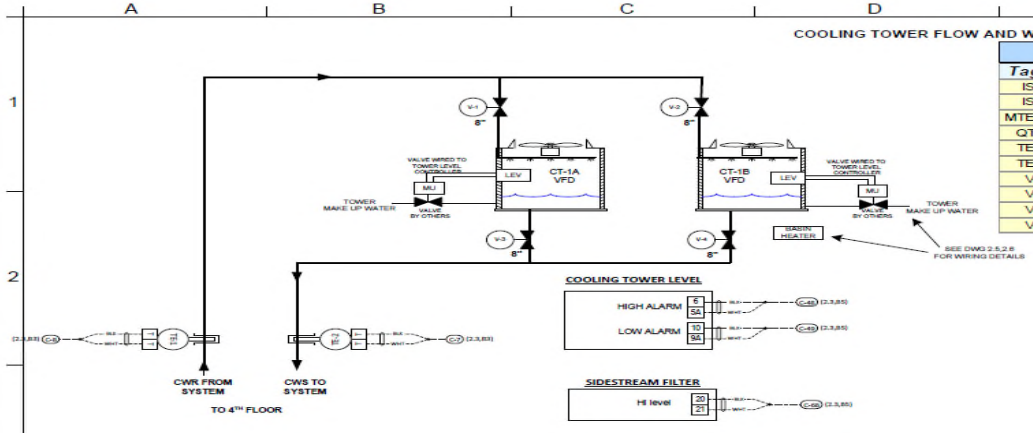
Automated Logic

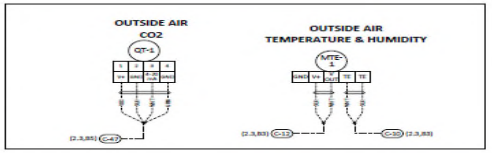
Submittal Review

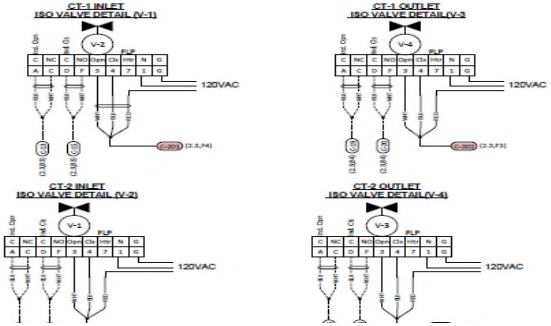
COOLING TOWER FLOW AND WIRING

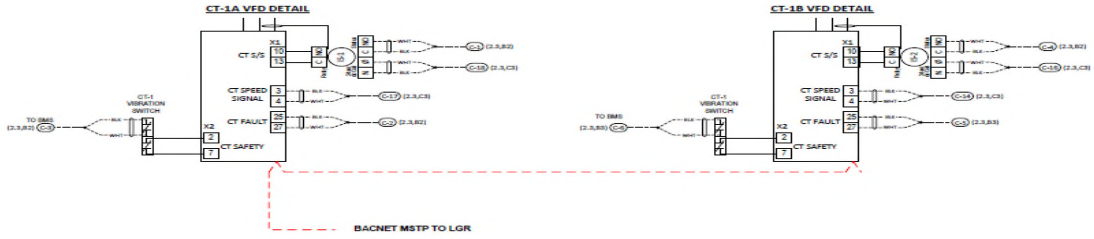
Instrument List

Tag	Manufacturer	Vendor	Part Number	Product Description
IS-1	Veris	Veris	H934	Current Switch for VFD w/Relay, Split Core, Adj. Setpoint
IS-2	Veris	Veris	H934	Current Switch for VFD w/Relay, Split Core, Adj. Setpoint
MTE-1	BAPI	BAPI	ALC/10K-2-H200-O-BB	Humidity, Outside, 2% w/Temperature Sensor, BAPI BOX NEMA 4X
QT-1	AirTest	ALPS	EE82-2C6	Outdoor Air CO2 Sensor, 0-2000 PPM, 4-20mA
TE-1	BAPI	BAPI	ALC/10K-2-I-4"-BB-M304	Immersion 4" Insertion in BAPI BOX NEMA 4X, w/304 Stainless Thermowell
TE-2	BAPI	BAPI	ALC/10K-2-I-4"-BB-M304	Immersion 4" Insertion in BAPI BOX NEMA 4X, w/304 Stainless Thermowell
V-1	Belimo	Belimo	See Valve Schedule	ISO Valve
V-2	Belimo	Belimo	See Valve Schedule	ISO Valve
V-3	Belimo	Belimo	See Valve Schedule	ISO Valve
V-4	Belimo	Belimo	See Valve Schedule	ISO Valve





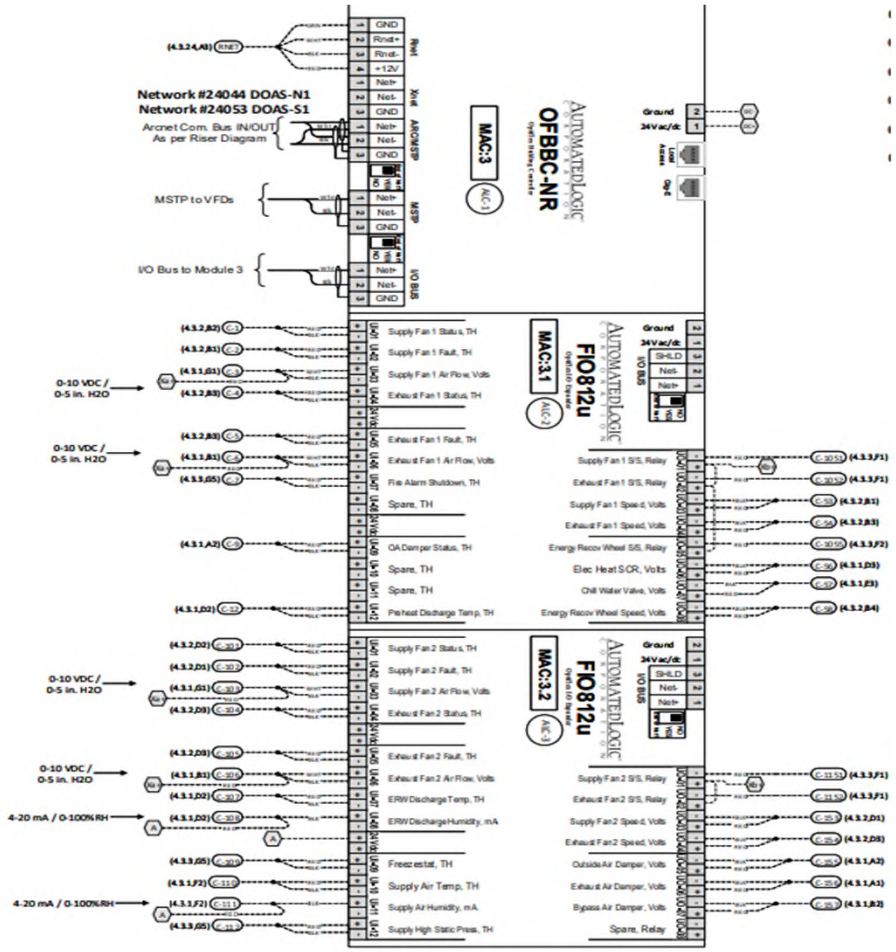




Carrier

Automated Logic

Submittal Review – Wiring Diagram

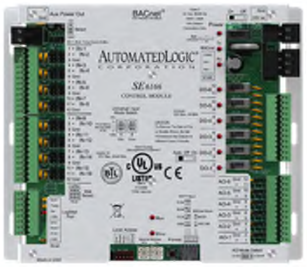


Carrier

Automated Logic

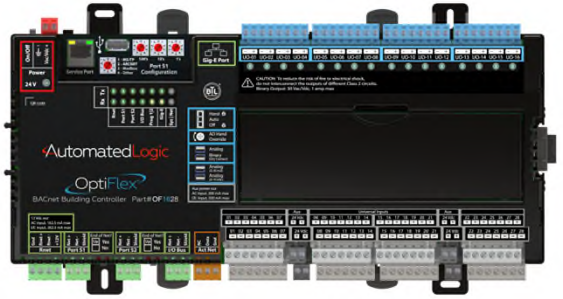
CONTROLLERS

Control Basic - Hardware

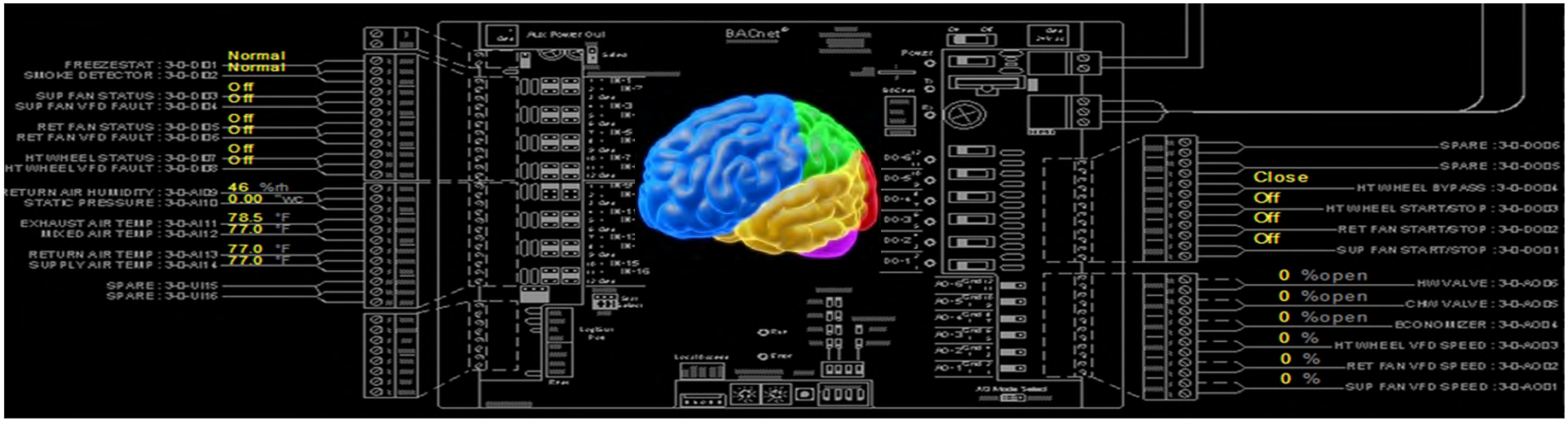


A **controller** resides on the distributed network and provides control of the mechanical equipment

- Connects to I/O
- Contains control program (algorithm)



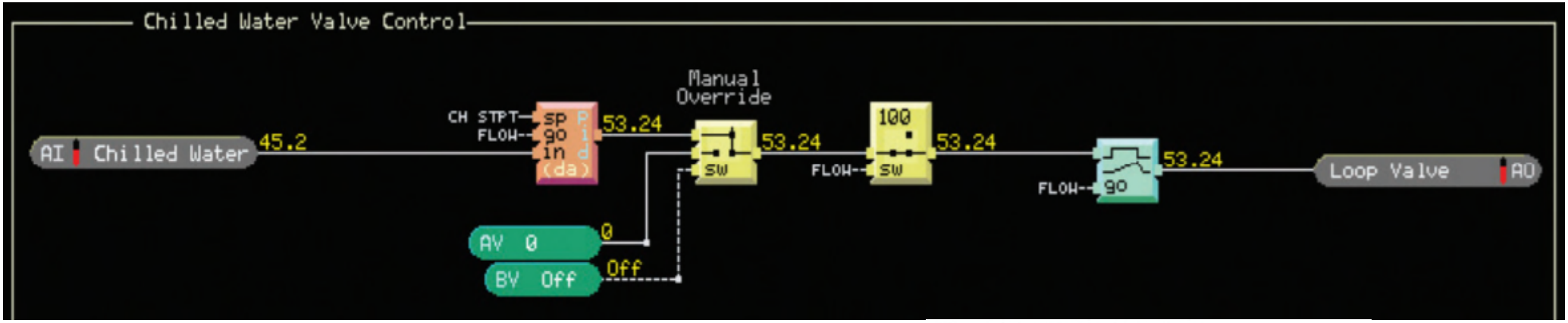
Inputs indicate conditions **Control program drives process** **Outputs drive equipment**



Carrier

Automated Logic

Control Basic - Programming



Programming is either graphical or line based depending on the manufacturer

```
10  A=(TEMP;AI)-(PID;SP)
20  IF A<5 THEN 30 ELSE 80
30  IF A<-5 THEN 40 ELSE 80
40  (PID;PI)=0
50  (PID;PE)=0
60  (PID;RP)=(PID;DP)
70  GOTO 20
80  B=A*(PID;DP)/100
90  IF (PID;DP)>=100 THEN 120 ELSE 100
100 IF (PID;DP)<=0 THEN 120 ELSE 110
110 (PID;PI)=A+(PID;PE)/
2*(PID;IC)+(PID;PI)
120 C=(PID;PI)/100
130 (PIC;PE)=A
140 A=(PIC;RP)+B+C
150 IF A>=0 THEN 170 ELSE 160
160 A=0
170 IF A<=100 THEN 190 ELSE 180
180 A=100
190 IF (SAFETY;BV)==1 THEN 200 ELSE 210
200 A=0
210 (PID;DP)=A
220 SWAIT 1
230 GOTO 10
```

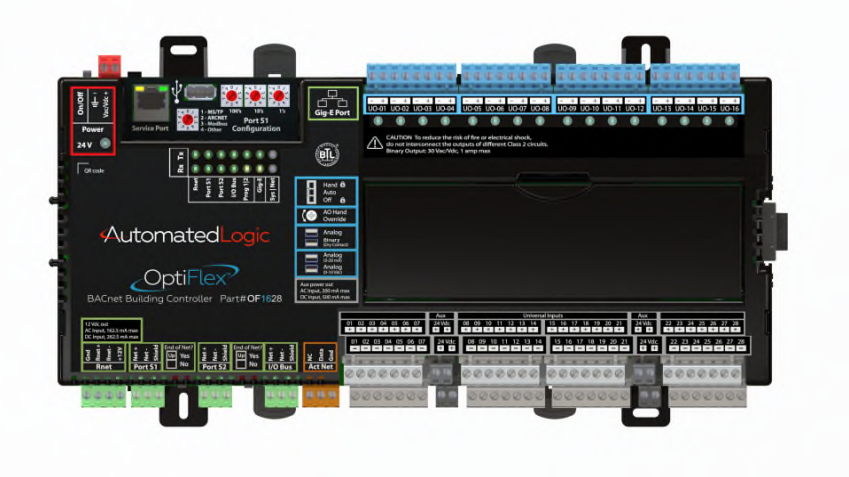
Carrier

Automated Logic

Control Basic - Hardware

In addition to providing the actual control, a DDC controller also provides the following functionality

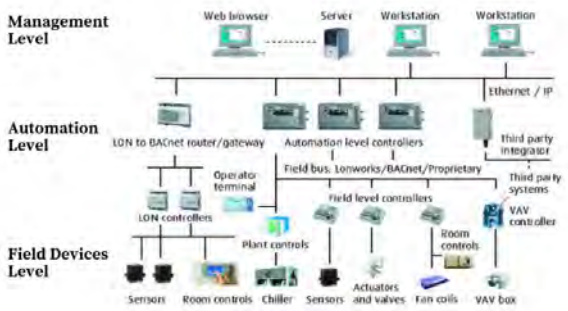
- Data Transfer
- Scheduling
- Alarming
- Trending

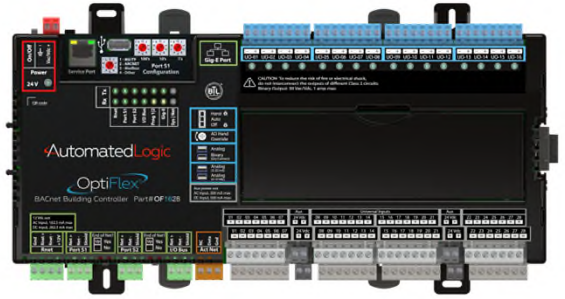


Types of Controllers

Different designations by manufacturer but some common terms are:

- Network / Supervisory
- Field / Equipment/ Terminal
- Modular / Fixed I/O





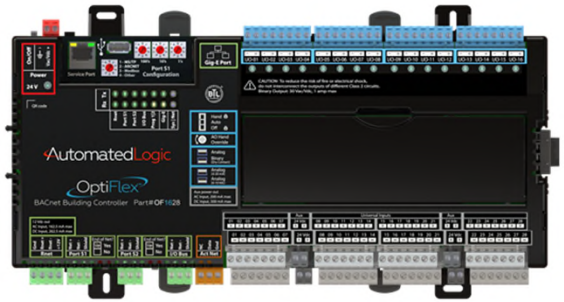
Types of Controllers

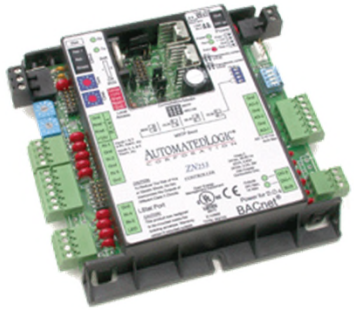
ASHRAE BACnet™

Building Controller
- Global Sequences
- Data Transfer/Management
- Possibly Equipment Control

Advanced Application Controller
- Control of advanced systems/equipment
- Alarming, trending, scheduling

Application Specific Controller
- Control of simpler systems/equipment
- Alarming, trending, scheduling





Carrier

Automated Logic

Controller – Factory vs Field

Factory mounted controls:

- Can be lower initial cost
- Manufacturer expertise
- System integration
- Black box
- Difficult to change in field
- Lower complexity systems?

Field applied controls:

- Higher initial cost
- Customizable
- Does not require integration
- Can be field programmed
- Higher complexity systems?
- More knowledgeable facility staff?

Factory mounted

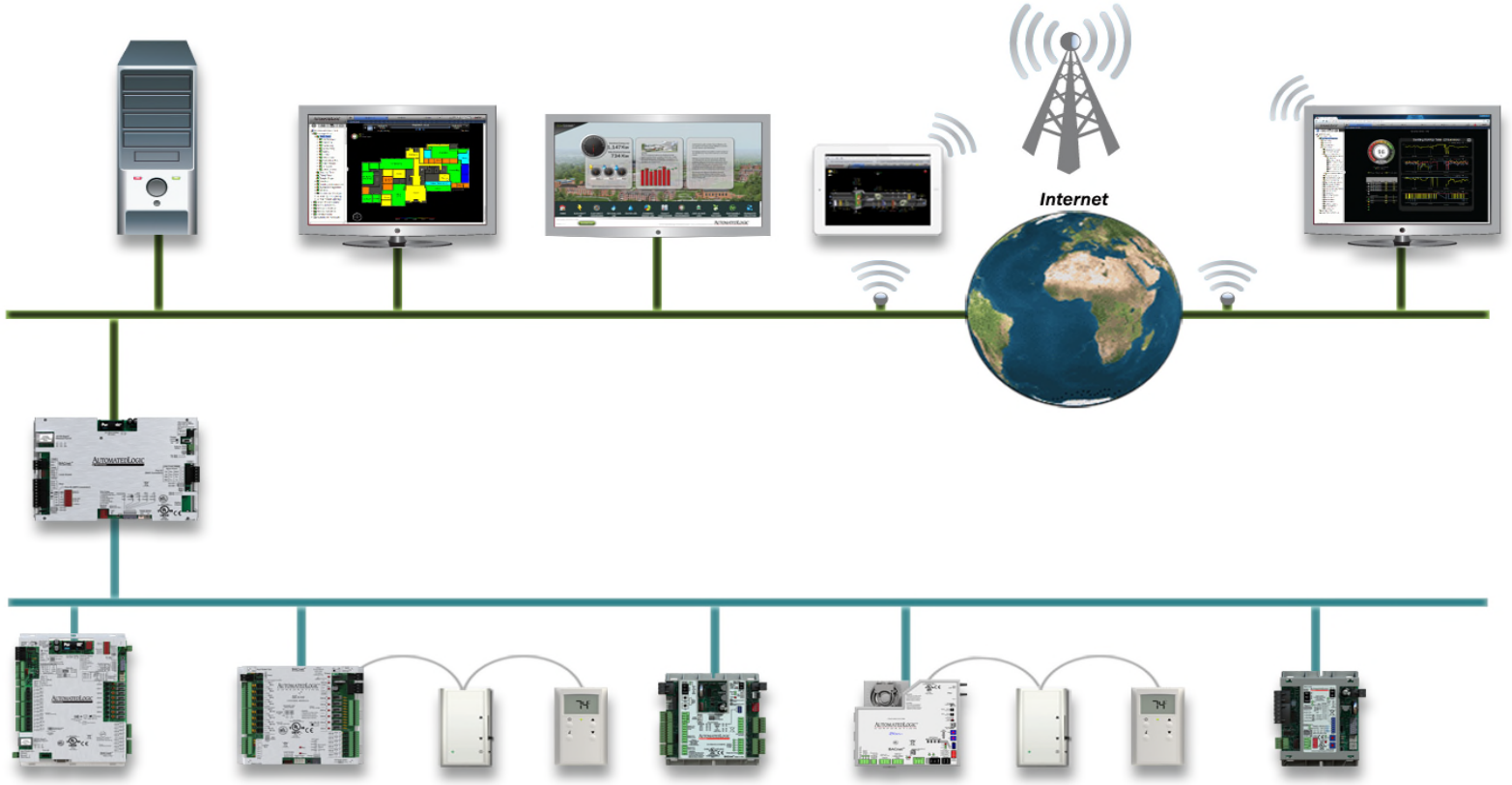
Field Applied

Carrier

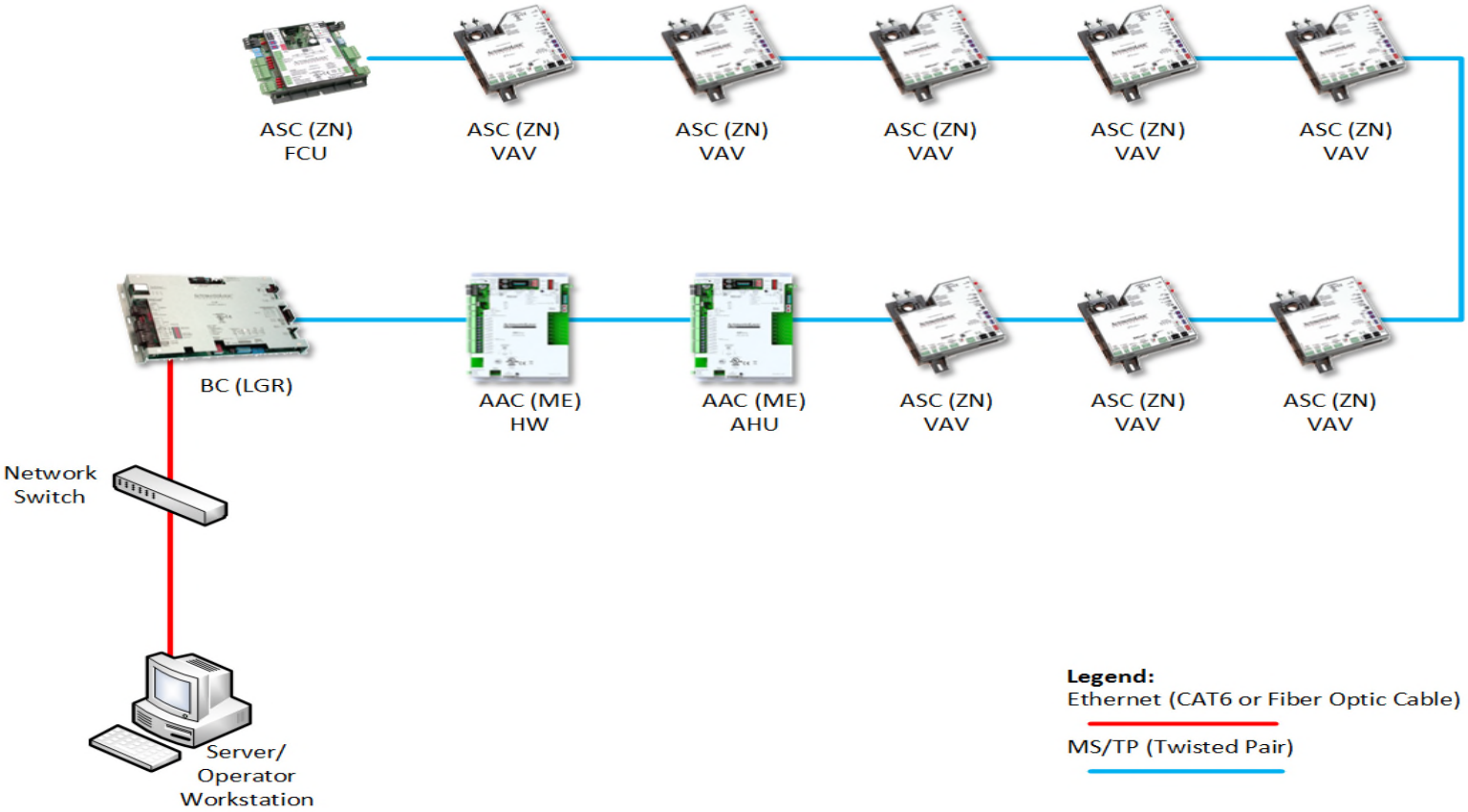
Automated Logic

BMS NETWORK

Controls – A Typical System



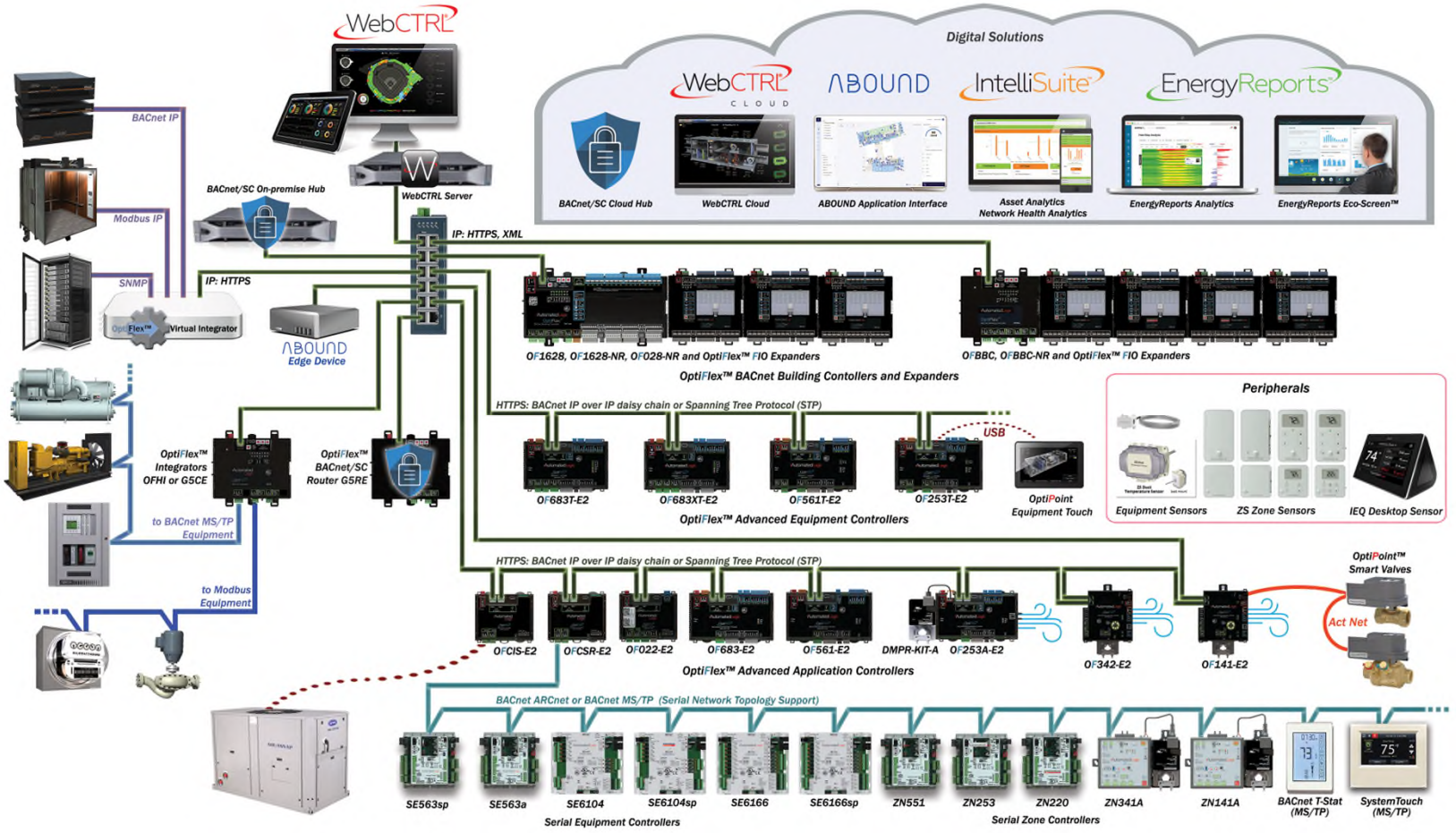
Controls – A Simple Network



Carrier

Automated Logic

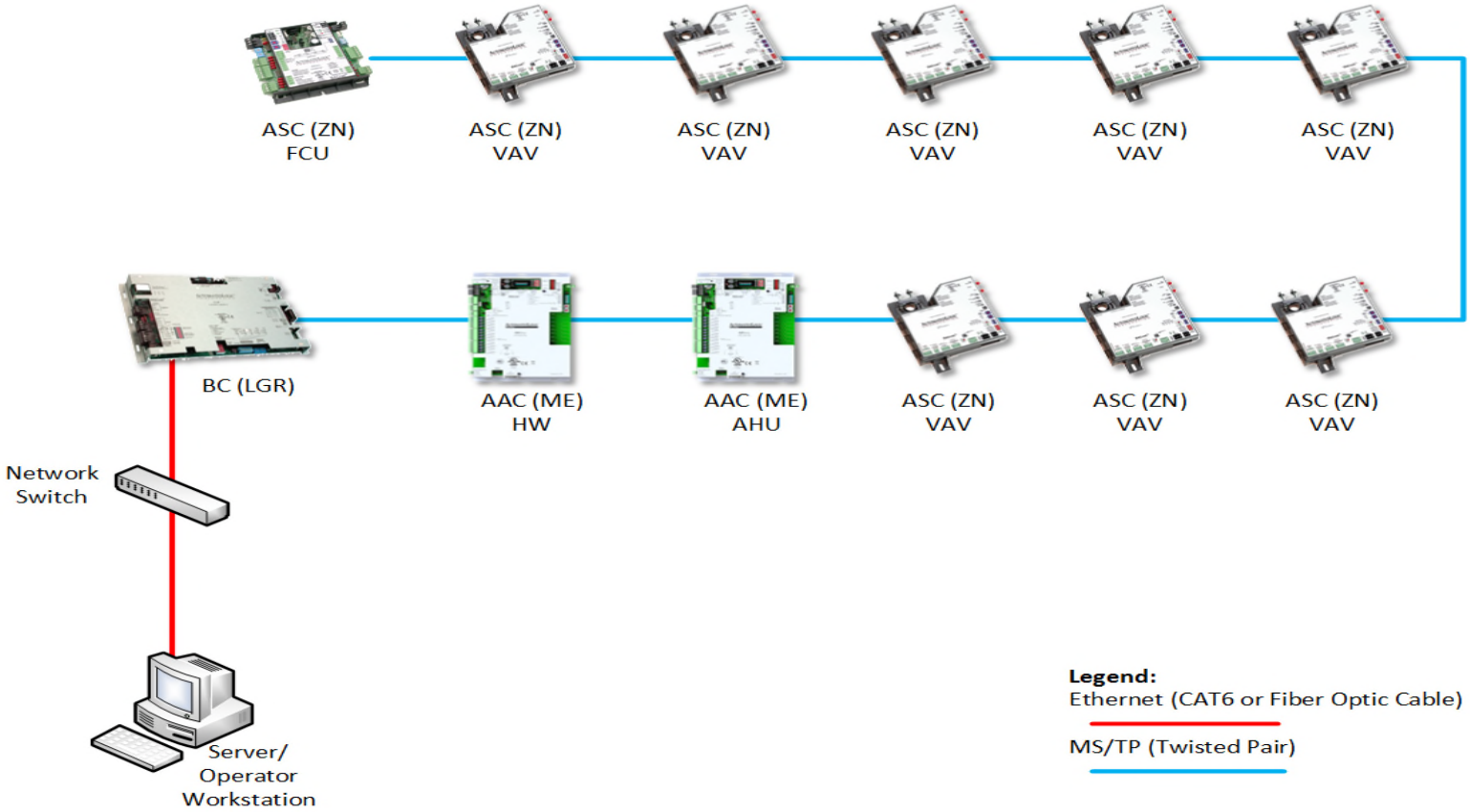
Controls – A More Advanced Network



Carrier

Automated Logic

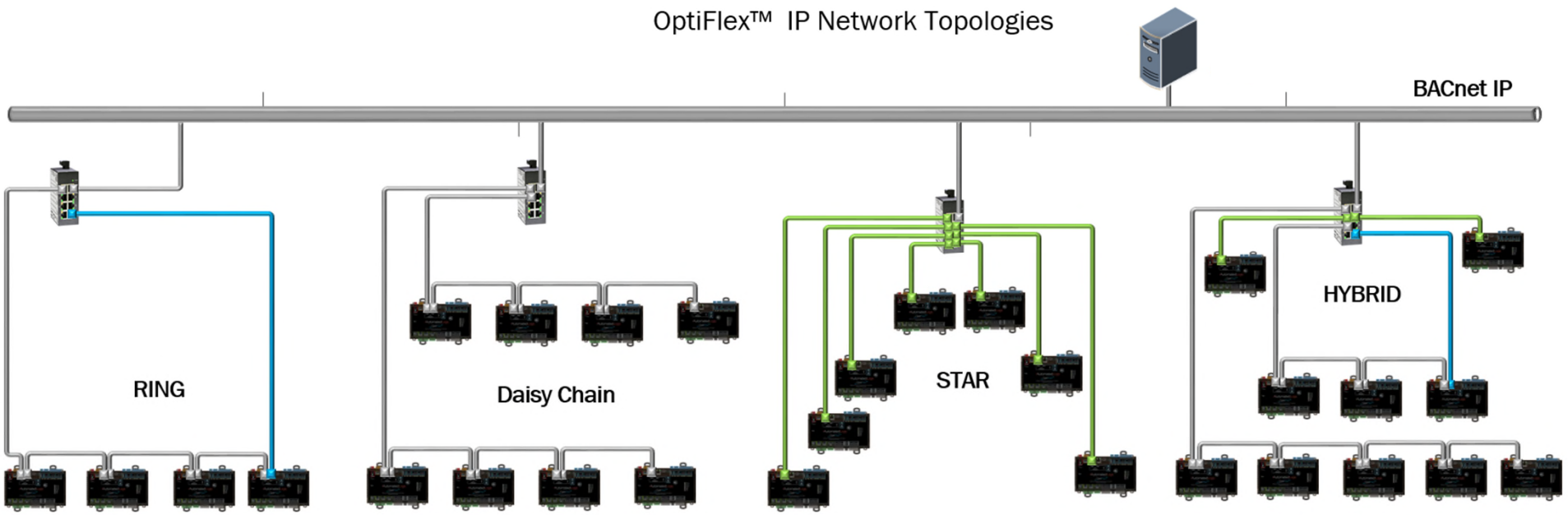
Controls – A Simple Network



Carrier

Automated Logic

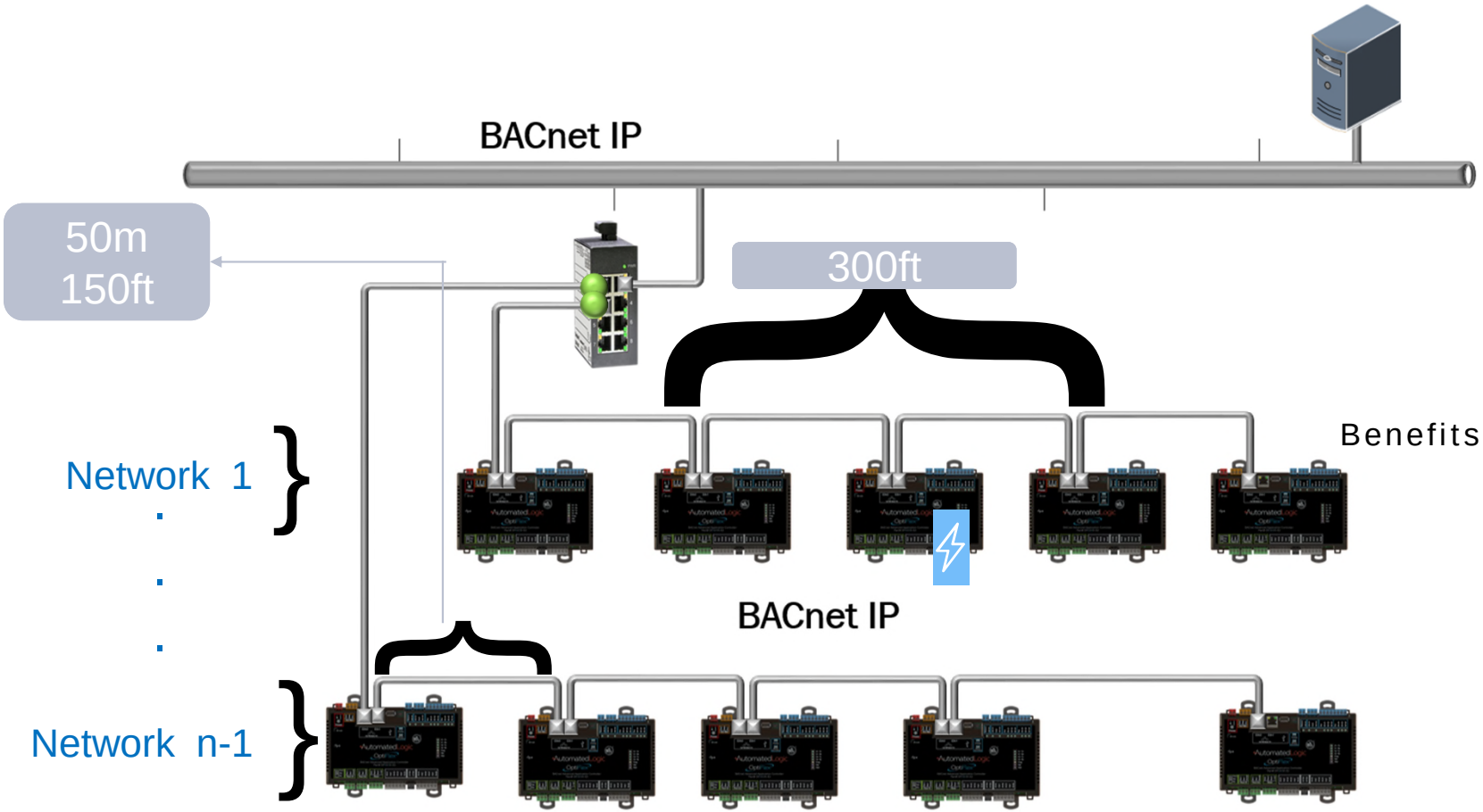
IT and BAS topologies



Carrier

Automated Logic

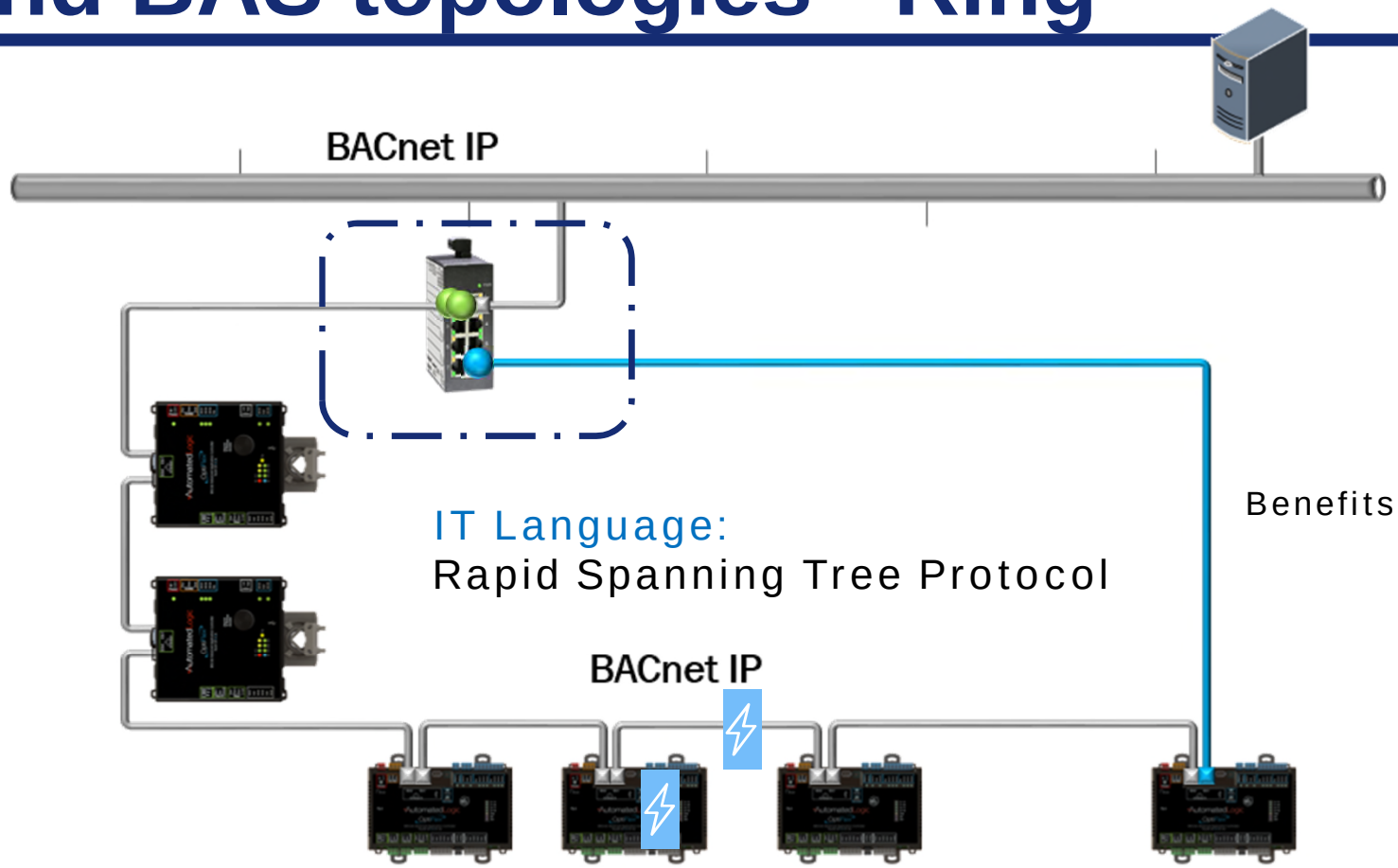
IT and BAS topologies – IP Daisy Chain



Carrier

Automated Logic

IT and BAS topologies - Ring



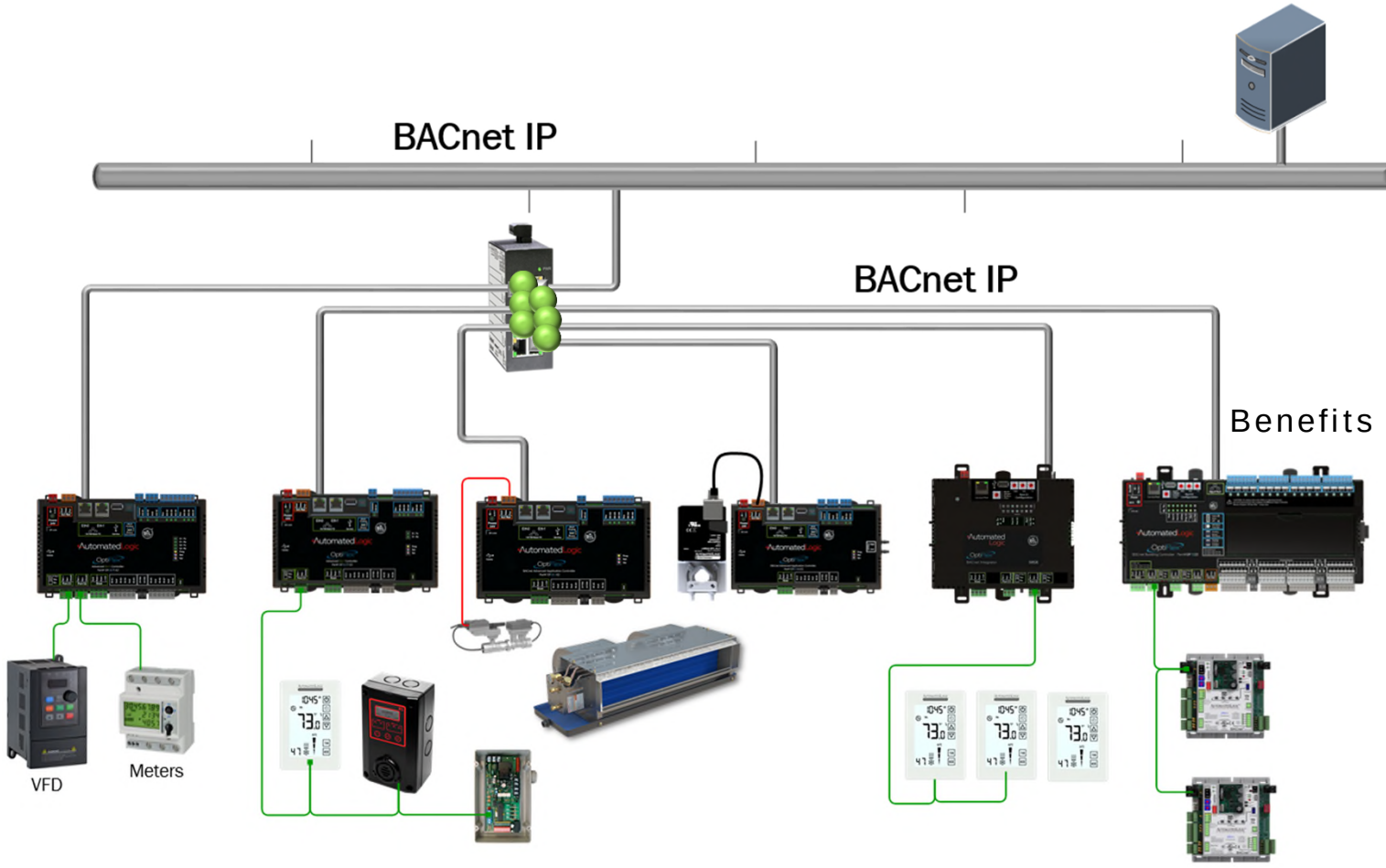
Benefits

- Network Redundancy
- RING Network
- Fail safe
- Prevent single point of failure
- Self Healing

Carrier

Automated Logic

IT and BAS topologies – Star Topology



Benefits

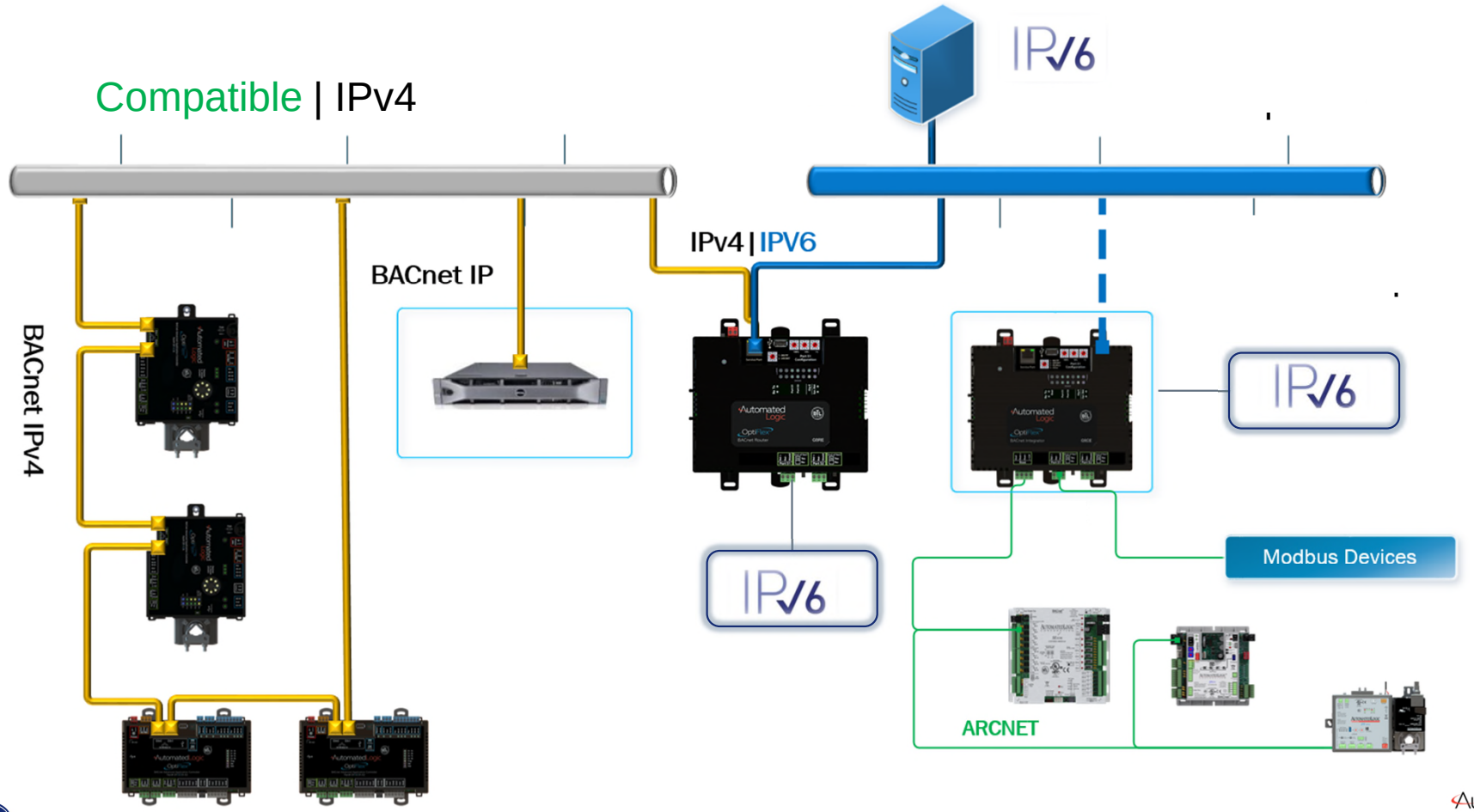
- Low latency
- Less points of failure
- Easy to manage

Carrier

Automated Logic

LATEST BAS TOPOLOGIES

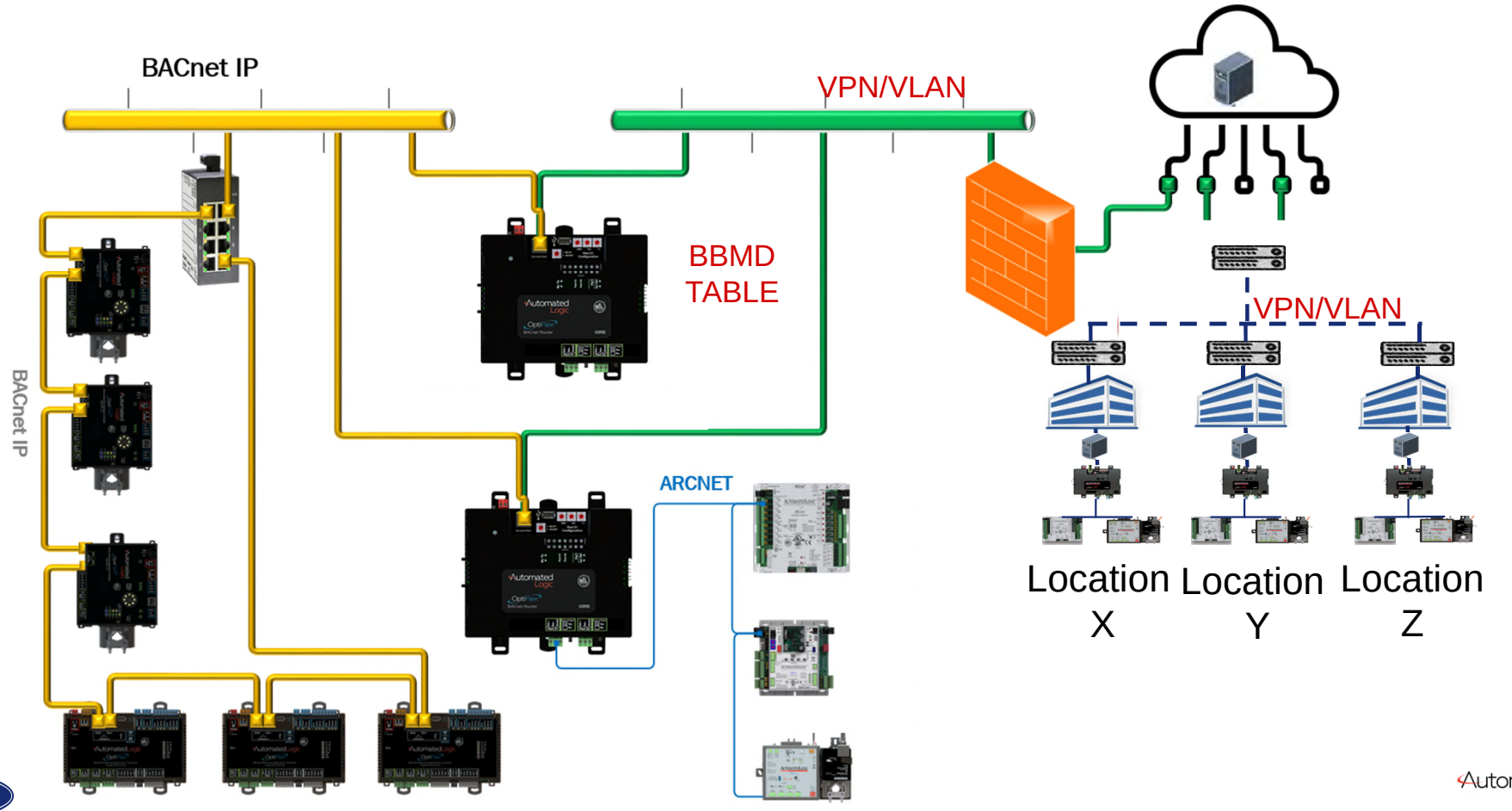
BAS topologies



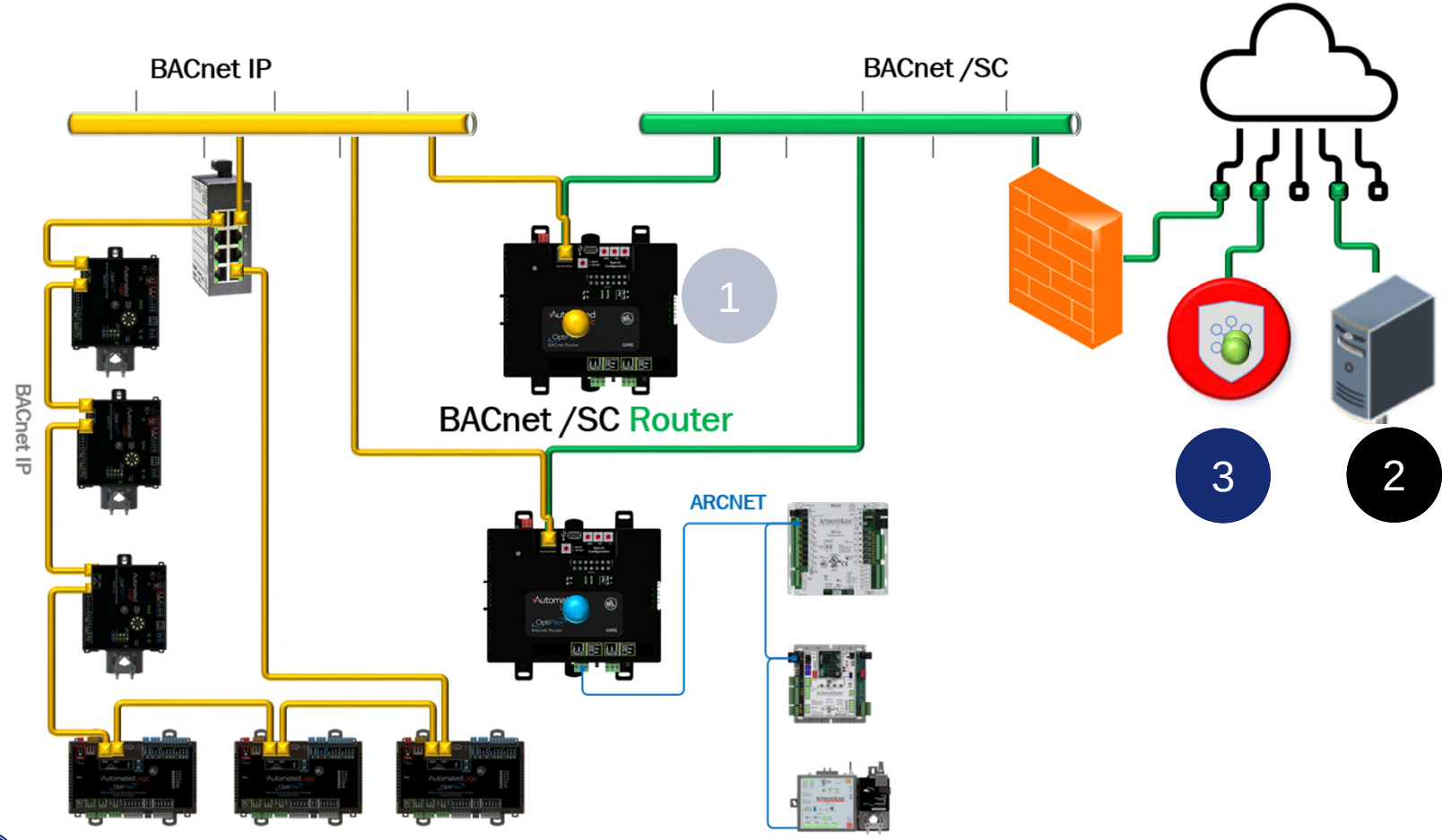
Carrier

Automated Logic

BAS topologies – with Cloud



BAS topologies – with Cloud and BACnet/SC



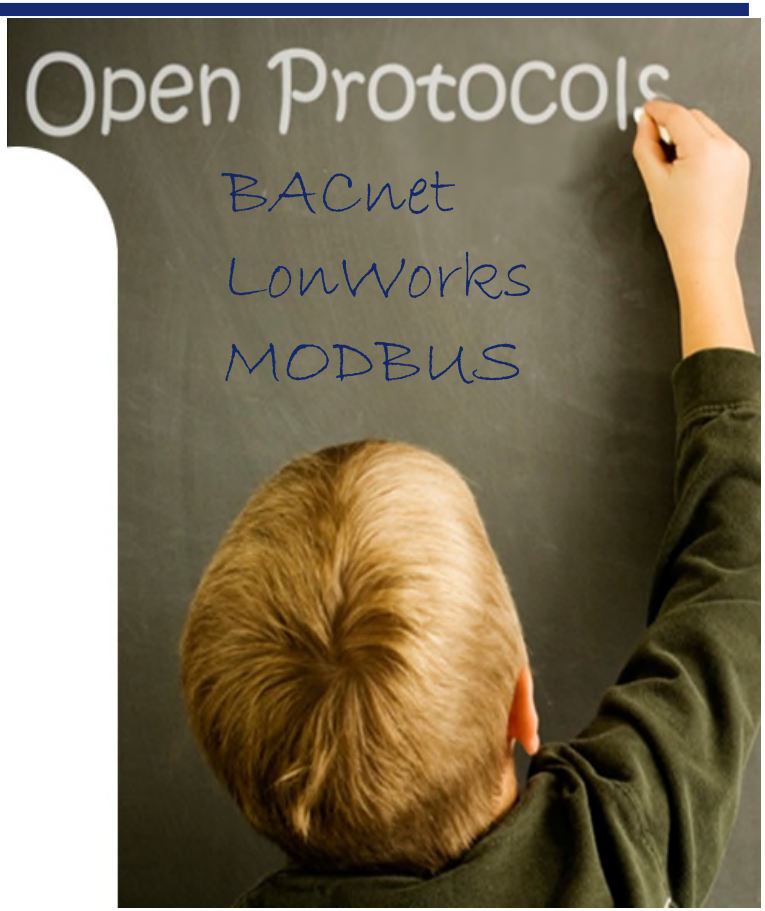
PROTOCOLS

Control Basics - Protocols

A protocol is the language used by controllers to communicate.

Originally were proprietary to each manufacturer.

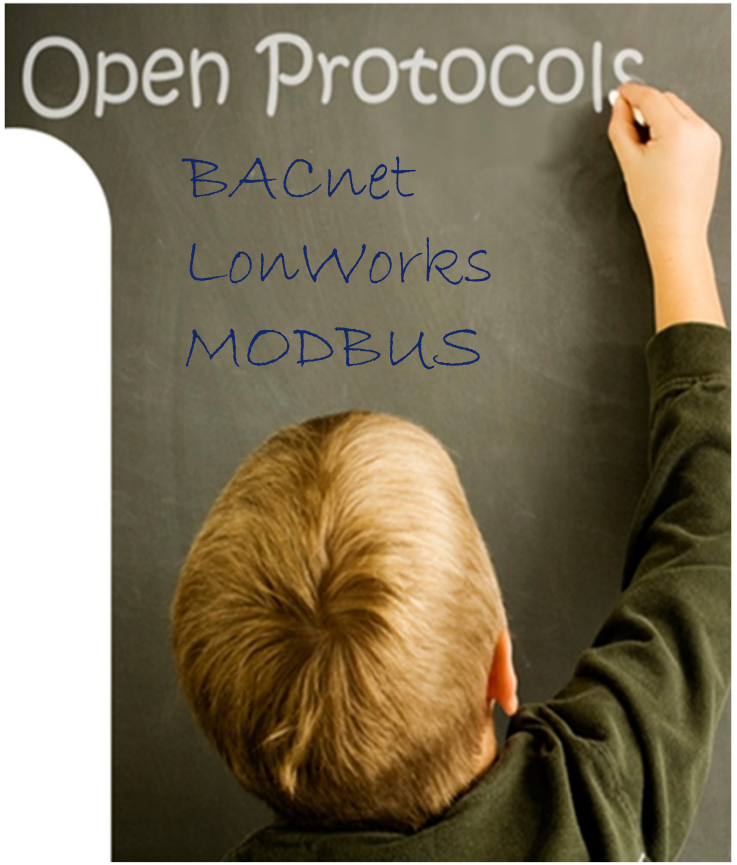
An **open protocol** or open standard is a standard that is publicly available and has various rights to use associated with it and may also have various properties of how it was designed. There is no single definition and interpretations vary with usage.



Control Basics - Protocols

An **open protocol** benefits the owner in numerous ways:

- Protects long-term owner investment
- Provides for numerous options
- Facilitates factory mounted controls
- Enhances operational efficiency (one network)
- Provides for scalability and flexibility
- Lowers cost
- Fosters competition and innovation
- Data!



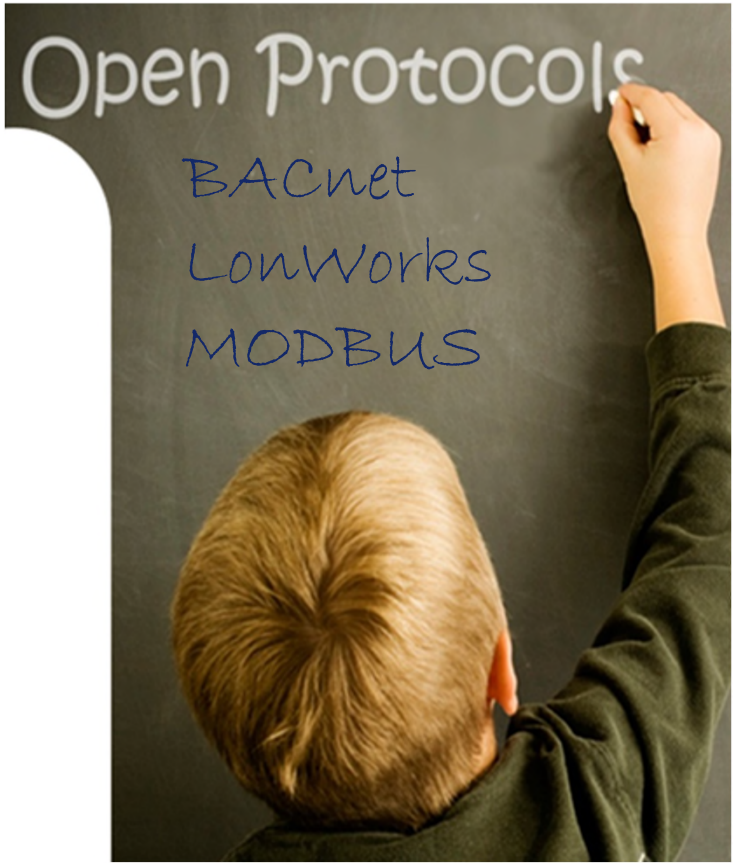
Carrier

Automated Logic

Control Basics - Protocols

When we say open protocol, we typically mean the fact that devices can communicate to each other on the same network.

<u>This does not usually include sharing a common engineering toolset!</u>



Control Basics - BACnet

Objects

Properties

Object_Name	SpaceTemp
Object_Type	analog-input
Present_Value	72.3
Status_Flags	Normal, InService
High_Limit	78.0
Low_Limit	62.0

Analog Input/ Output/Value	Loop	Event Enrollment	Calendar
Binary Input/ Output/Value	Averaging	Notification Class	Device
Multistate Input/Output/ Value	Life Safety Point/Zone	Schedule	File
Trend Log	Program	Group	Command

22.1.1 Protocol Implementation Conformance Statement (PICS)

All devices conforming to the BACnet protocol shall have a Protocol Implementation Conformance Statement (PICS) that identifies all of the portions of BACnet that are implemented. This PICS shall contain all of the information described in 22.1.1.1 and shall be in the format found in Annex A.

BACnet TESTING LABORATORIES BTL™

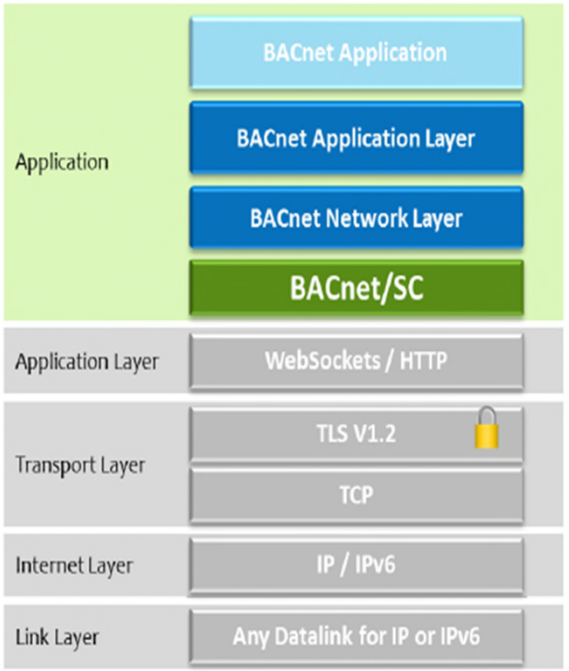
Carrier

Automated Logic

Control Basics - Protocols

Note that this language (protocol) is only part of the story…

- ARCNET
- BACnet MS/TP
- BACnet Ethernet
- BACnet IP
- BACnet Secure Connect (SC)
- TCP/IP
- UDP/IP
- PTP
- HTTP/HTTPS
- Web Services



There are many ways to move the data or language.
Think of these ways as the **medium** you communicate this language in.

Carrier

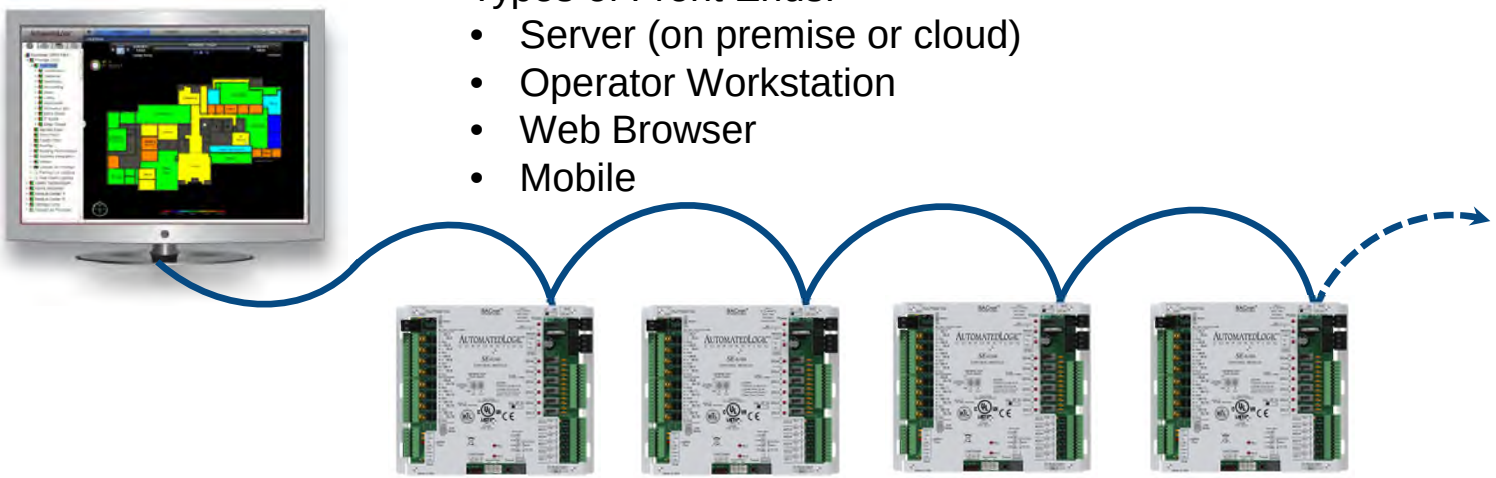
Automated Logic

SOFTWARE

Control Basics - Software

A **front end (UI)** provides the user interface to the system**.** The main function of the front end is monitoring of and access to the system. This is where information is viewed (points, data, etc.) and adjustments (setpoints, schedules, etc.) are made.

It also stores historical information **(trends)** and provides notification of problems **(alarms).**



Types of Front Ends:

- Server (on premise or cloud)
- Operator Workstation
- Web Browser
- Mobile

Controllers are linked to each other and the front end by a network.

Carrier

Automated Logic

Control Basics - Software

Data

The front end also collects and stores system data that is increasingly being used for other applications.

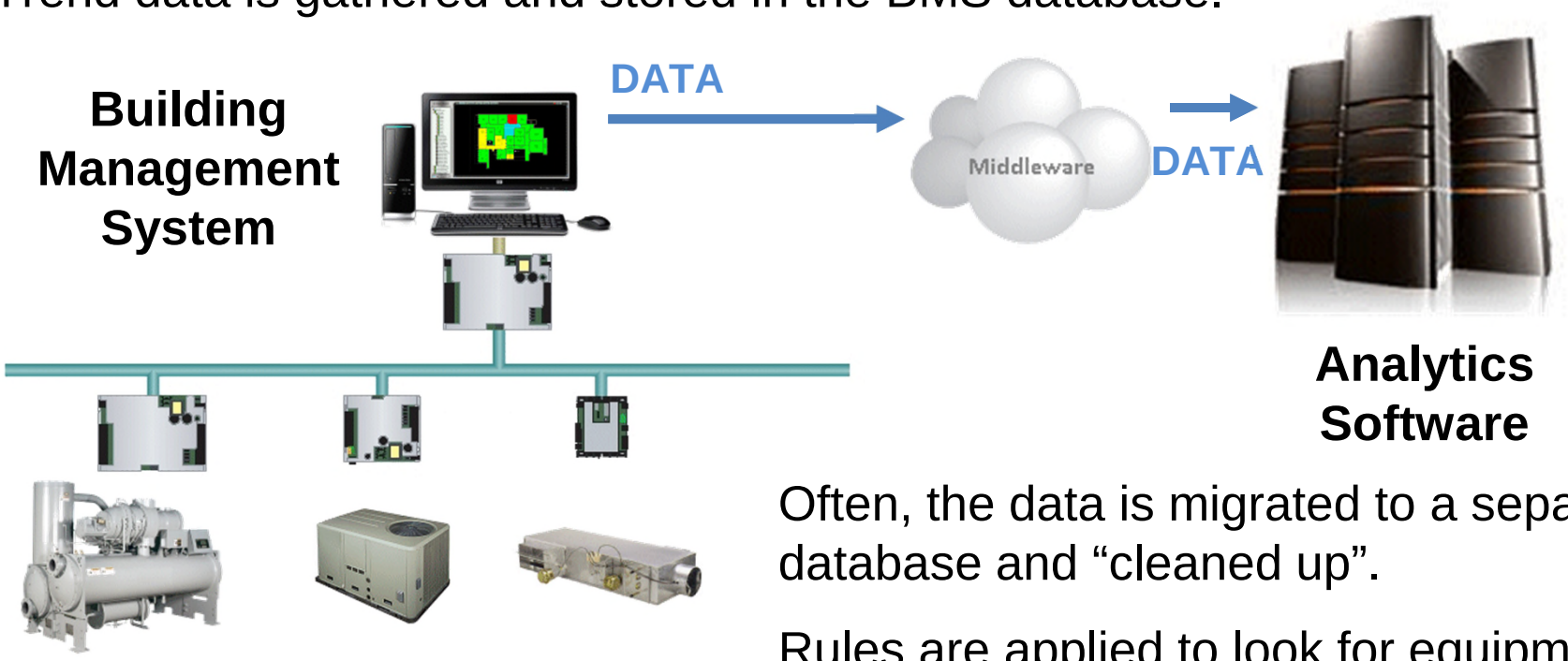
- Energy analysis
- Analytics
- FDD Alarming
- Advanced reporting
- Integration into other systems
- Data visualization

Carrier

Automated Logic

Analytics and the BMS

Trend data is gathered and stored in the BMS database.



Often, the data is migrated to a separate database and “cleaned up”.

Rules are applied to look for equipment issues, energy issues, and other undesirable conditions.

Carrier

Automated Logic

Data Visualization | Dash boards

A tool for viewing and understanding real time data. “Eyeball Analytics”

Carrier

Automated Logic

Data Visualization | Energy Reporting

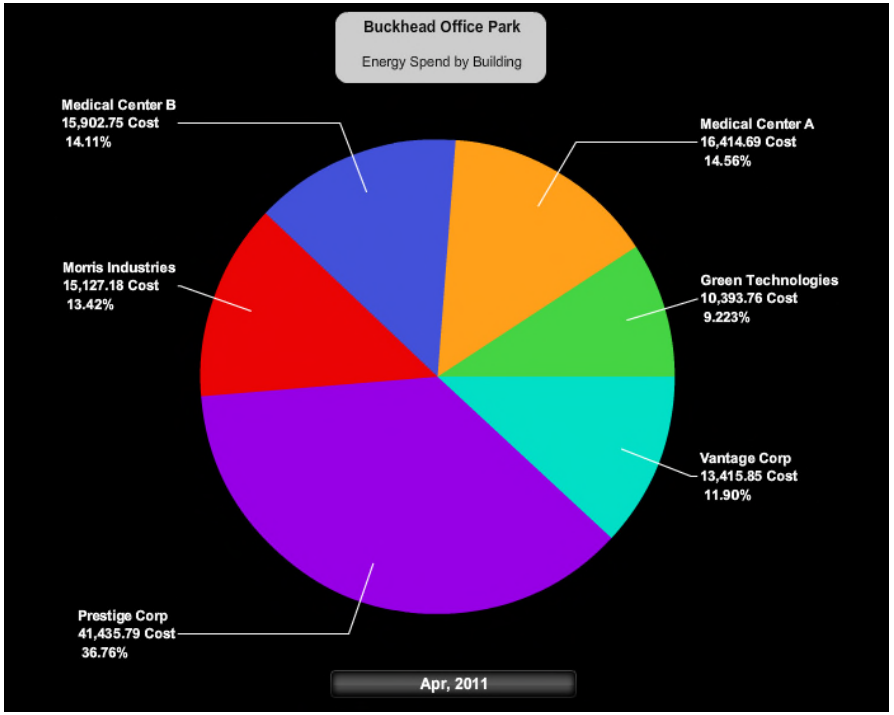
Historical reporting mined from trended and stored meter data.

Often includes building and time period comparisons as well as benchmarking capabilities.

Carrier

Automated Logic

Data Visualization | Financial Reporting



Often as simple as applying a rate to kWh in the data visualization tool. Can become more nuanced as well.

- Demand charges
- Misc charges
- Bill reconciliation
- Automated reporting
- Tenant billing
- Many more examples

Carrier

Automated Logic

Data Visualization | Green Screen | IAQ

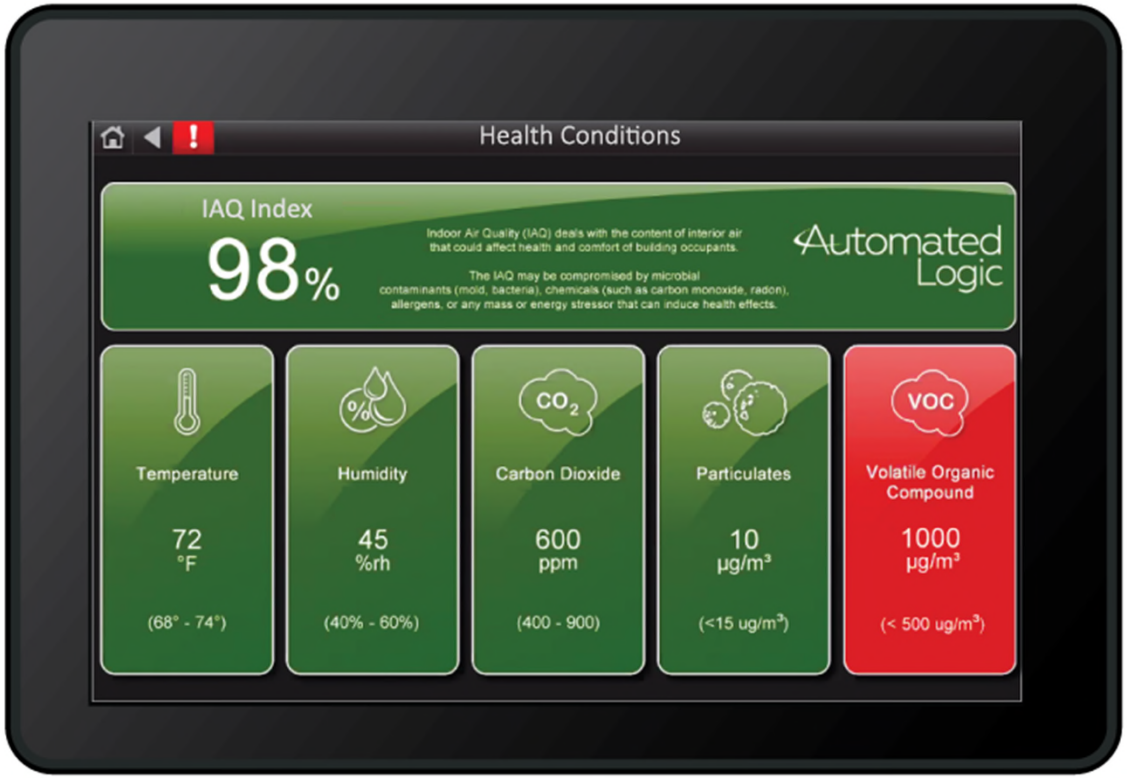
Green screens are typically designed to provide an educational experience for the layperson or building occupant. They are driven by the data in the BAS.

Carrier

Automated Logic

Data Visualization | IAQ

Temperature, humidity, CO2, Particulates, Radon, Formaldehyde

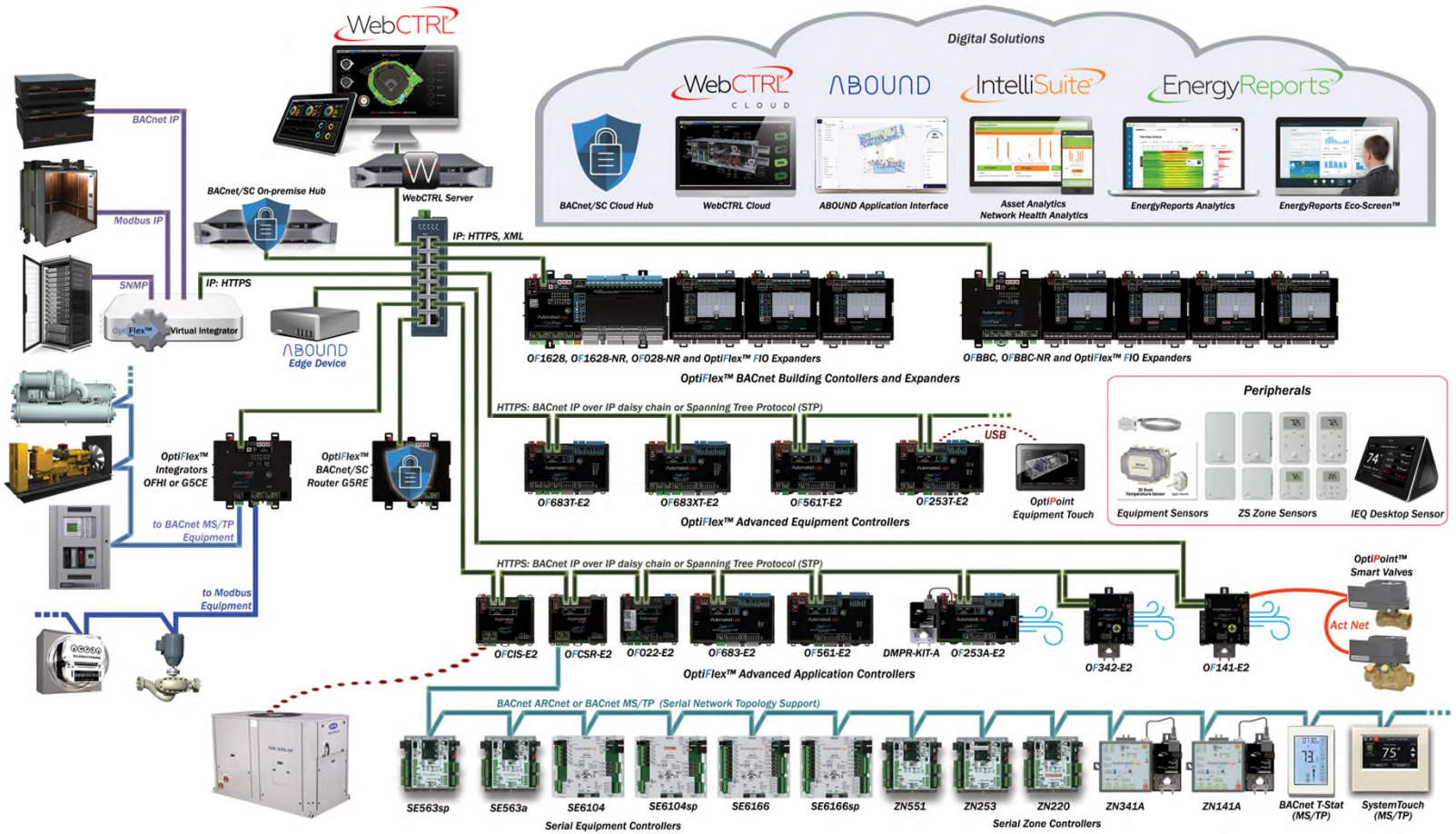


INTERNATIONAL WELL BUILDING INSTITUTE™

Carrier

Automated Logic

BAS - A More Advanced Network



Carrier

Automated Logic

KEY TAKEAWAYS

Key take-a-ways

- A BMS is a digital management system used to maximize occupant comfort and energy efficiency
- Controllers use points to control building equipment
- A BMS connects to building equipment/controllers thorugh a network
- BACnet is a common protocol used by building systems
- BMS software provides graphics, trends, and analytics

Carrier

Automated Logic

Questions?