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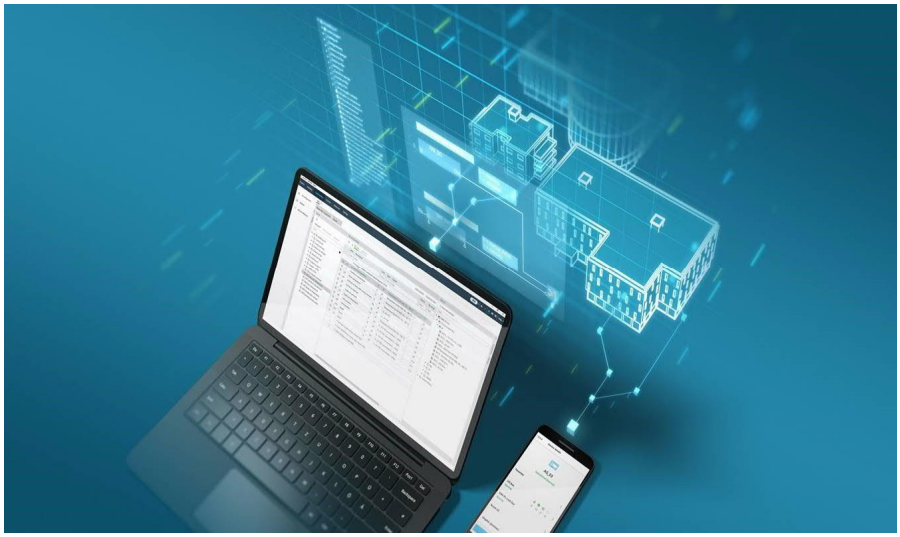

Desigo™

Application Guide for BACnet Networks in Building Automation

Technical Manual

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Smart Infrastructure

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2 About this document

What is the purpose of this document?

This document handles the following topics:

- How to design Desigo projects with regard to IP and BACnet on the network
- What system components do we recommend
- What system settings are required

Who is the target audience for this document?

- Sales (Front and back office)
- Design and commissioning engineers

What does this document cover?

The document focuses on Desigo V6.1.

What Desigo documents are there on the topic of networks?

- *Desigo Technical principles* (CM110664).
- *Ethernet, TCP/IP, MS/TP and BACnet fundamentals* (CM110666)
- *Practical guide on IP networks in building automation and control* (CM110668)
- *Desigo room automation engineering, mounting and installation* (CM111043)
- *Installation guide RXB, RXL* (CM110381)
- *BACnet Protocol information conformance statements (PICS)* (CM110665)

3 Overview

There is a different approach in room automation with regard to flexibility, sizing, use, and reuse versus on primary plants, for example, air handling.

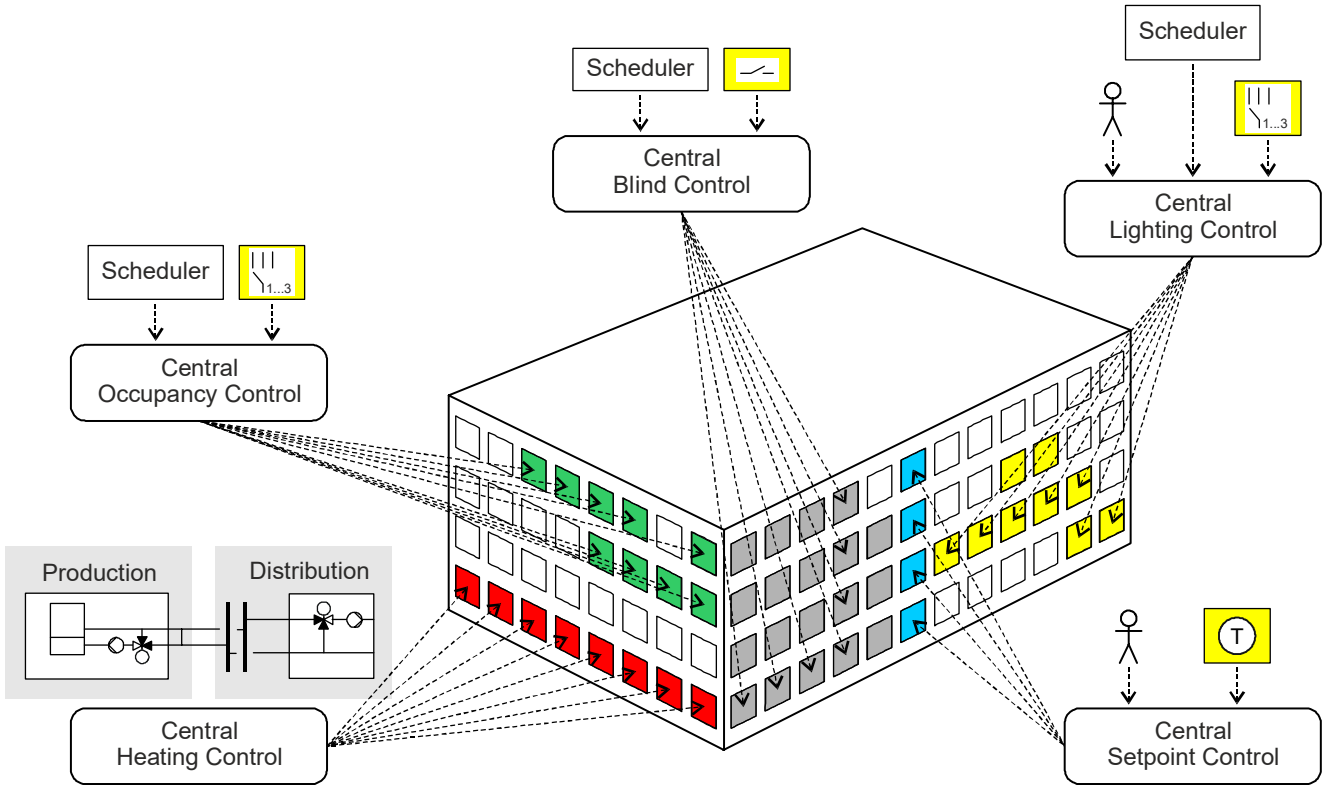
Functions are required here to centrally switch all rooms with a specific room state through the entire floor or switch lighting in rooms at a specified time. The same applies to shading systems that deploy the blinds to a safe position during high winds based on a weather station. Building users are increasingly requiring flexible use of rooms. For example, the rooms are newly rented out, or rooms are increased in size using partitions and designed to the current use.

Building automation and control expects the building automation and control system to do this, or for the room automation to automatically adapt.

On the one hand, central functions can control the room operating mode as well as centralized control of lighting and blinds over multiple room automation stations. Protection, service, or emergency functions can also be implemented over various devices.

On the other hand, flexible room management can be implemented with Desigo room automation and PXC3 or DXR2 room automation stations.

Repurposing can be quite easy using the separation between room and room segment. Coordination takes place in the room between HVAC, lighting, and blinds, set points are calculated, etc., and then sent to the assigned room segments. The physical data points are located in the segment to control aggregates and components.



The entire Desigo system prefers the use of BACnet/IP to avoid expensive gateway solutions. This requires careful planning, sizing, and implementation of BACnet and IP networks.

3.1 General

The first and most costly mistakes are already made during the planning phase. It is not uncommon to submit faulty bids or bids that are not understandable. Planning offices generally fail to provide clear answers to detailed queries since the requisite knowledge on networks is often lacking. Pay close attention to the section on network and communications if a tender is involved.

It is fairly common to forget during initial clarifications to set up the system on an existing network or infrastructure (rack, cabinets, switches, cabling, etc.) at the customer. An appropriate examination can save unnecessary costs.

Provided of course that the customer's infrastructure meets the same requirements for reliability, performance, availability, expandability, IT security, etc. as described in this document. If new networks are unavoidable, it makes sense to consider topics such as digitalization, cloud solutions, scalability, and flexible administration using virtual and easy-to-administer networks.

Building automation and control systems do not play a significant role here.

3.1.1 Functions in a building automation and control system

The goal of a building automation and control system (BAC system) is to achieve and maintain an optimum level of comfort and the lowest possible energy. The classical building automation and control system is divided into three levels (even when using a standardized communication protocol BACnet):

- Management level
- Automation level
- Field level

In a Desigo system, this can be described in greater detail through functions and applications.

Plant scope

Here is where the automation stations are located that take over control of primary plants such as air handling units, heating circuits, and cooling circuits to supply the rooms or heating or refrigeration plants.

The plants are always demand-controlled over the supply chain, in other words, heat or cooling demand occurs in a room that is forwarded to the applicable generation or over the heating or cooling circuit.

Floor scope

This is where rooms and room segments are controlled - energy-efficient HVAC functions, but also lighting and shading systems ensure optimum room conditions.

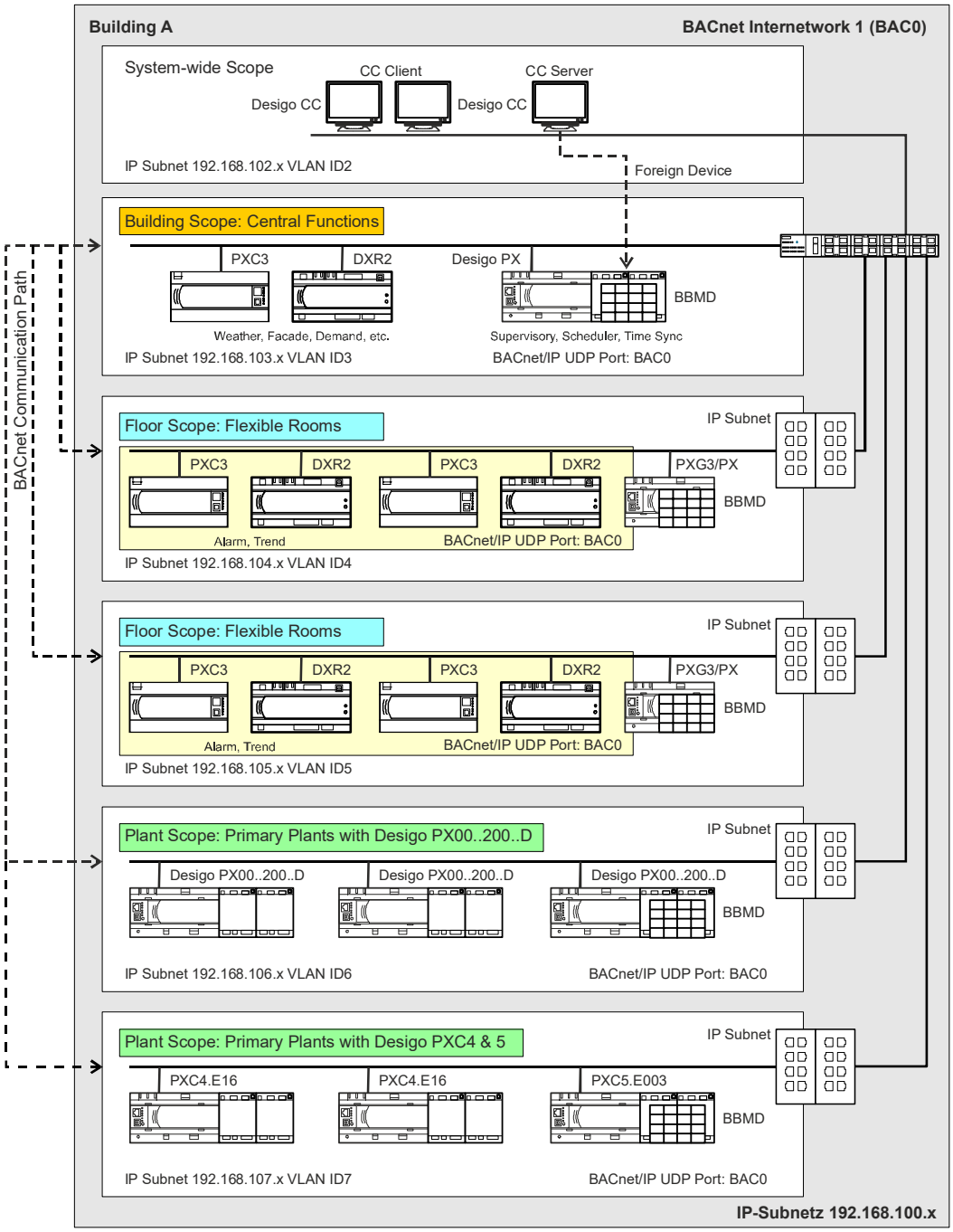
In an HVAC environment, we have radiators, and/or heating/chilled ceilings, but also fan coil units as well as variable air flow systems. On primary plants, hot or chilled water, but also treated air, is provided based on demand and is treated in the room segment by radiators, heated/chilled ceilings, heating or cooling coils. Blinds control can be used in addition to daylight or indirect lighting to heat and cool the room. Lighting control is also integrated to provide optimum lighting, together as well with blinds control.

Central functions specify, from the superposed location (Building Scope), for example, the room operating mode as well as room setpoints for the room or a group of rooms. The room user can also intervene with local room operator units and adapt room conditions to his or her needs.

Building Scope

Superposed central functions, e.g. a weather station, can generate setpoints for assigned rooms based on the outside air temperature. A scheduler can form and distribute a room operating mode for assigned rooms in a building section or floor. Moreover, lighting and blinds components can be deployed to a defined state via protection, service, or emergency functions. Demand signals from the rooms (Floor scope) are evaluated here and compiled and forwarded to the primary plants such as central air handling, heating or cooling circuits (located in the Plant Scope).

The following image illustrates the devices and functions located in different scopes and how the communication paths are defined. It illustrates that the floor scope does not require interaction to another floor scope nor permits and supports interaction; conversely, functions and applications communicate in the building scope with floor and plant scopes. The plant scope processes the information (forced and demand signals) from the building scope.



You can set in detail that a floor scope encompasses a floor or floor segment with a maximum of 250 participants. The floor scope can comprise multiple floors (with a total of max. 250 participants), i.e. the floor scope stands for a zone with a max. 250 IP-capable devices or room automation stations.

Central functions and flexible room management plays an important role in the design of BACnet and IP networks.

Central functions

Central functions are based on the concept of group master and group members.

Room operating modes, room setpoints, and operating modes for lighting or blinds groups are flexibly distributed from a group master over group members whose group membership is typically set during commissioning, but can also be changed later during operation using a management platform, e.g. Desigo CC. Multiple group members can be located on a room automation station by discipline. This includes, for example, lighting groups by floor, building section or building or blinds group by facade or over a facade segment.

Commanding	Designing a system
Distribution/commanding of group masters to group member	Restricted to max. 500 group members

Moreover, the same concept can be used to compile demand signals for chilled water, hot water, or for air handling. Demand occurs in room segments assigned to a group; it is collected, evaluated and transmitted to generation via the applicable group master.

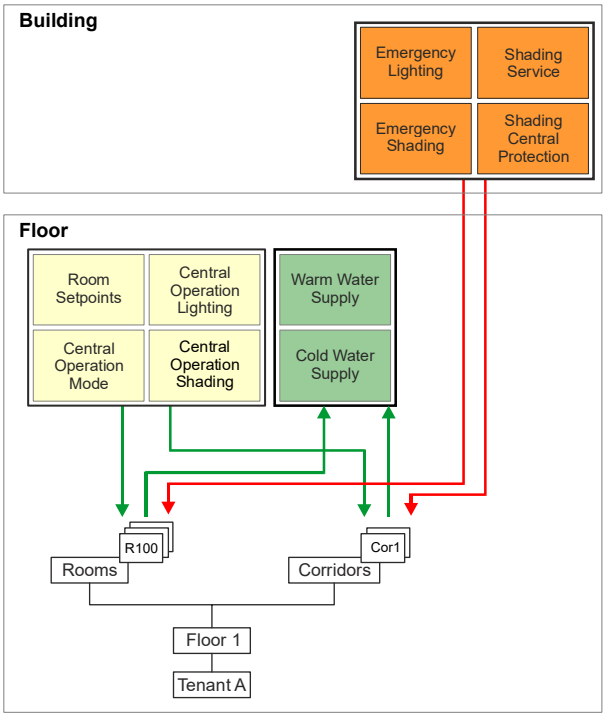
Concentrate data	Designing a system
Collecting data from the group members via the group master	Restricted to max. 250 group members

A group member is not the same as a room segment. A room segment can include multiple group members.

Central functions can be directly designed in an easy-to-understand manner. In a multi-story building, rooms are rented on a floor-by-floor basis to various users. A central function exists by floor for each room operating mode, room setpoints, lighting, and shading. All lighting and shading is switched from a central location for each floor.

Emergency, service, and protection functions act on the entire lighting control and shading systems in the building.

Tenant				
Retail mall Ground floor	Tenant A, 1st floor	Tenant B, 2n floor	Tenant C 3rd floor	Tenant D, 4th floor
Businesses and public areas	Offices and hallways	Offices and hallways	Offices and hallways	Offices and hallways

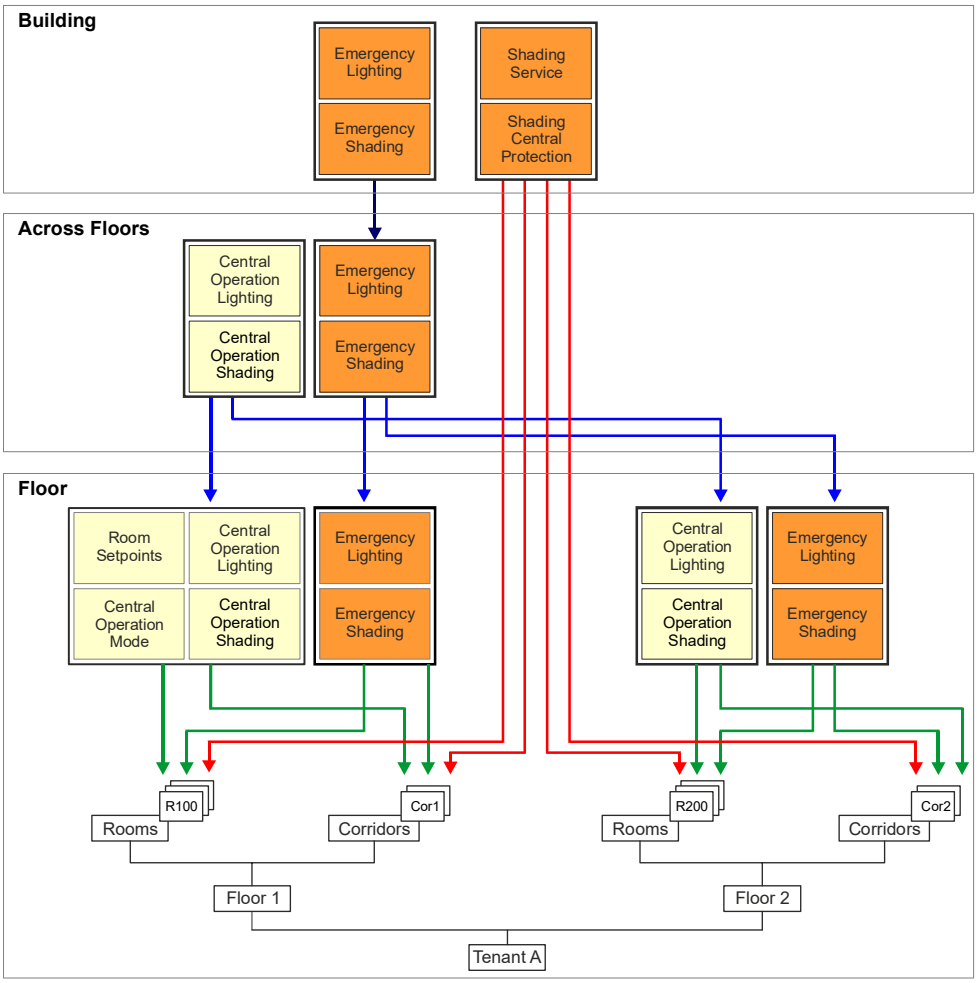


All central functions can be interconnected to meet the advanced requirements on mid-size to large projects.

If a tenant uses, for example, two floors, a central function can individually act on the given floor, that acts for its part on an additional, superposed central function, on both floors. The example of lighting or shading provides a good illustration of this.

Tenant				
Retail mall Ground floor	Tenant A, 2nd floor	Tenant A, 3rd floor	Tenant B, 4th floor	Tenant B, 5th floor
Businesses and public areas	Offices and hallways	Offices and hallways	Offices and hallways	Offices and hallways

For separate IP networks on both floors, the building and cross-floor functions are mapped in the building scope and the floor functions in applicable floor scope.

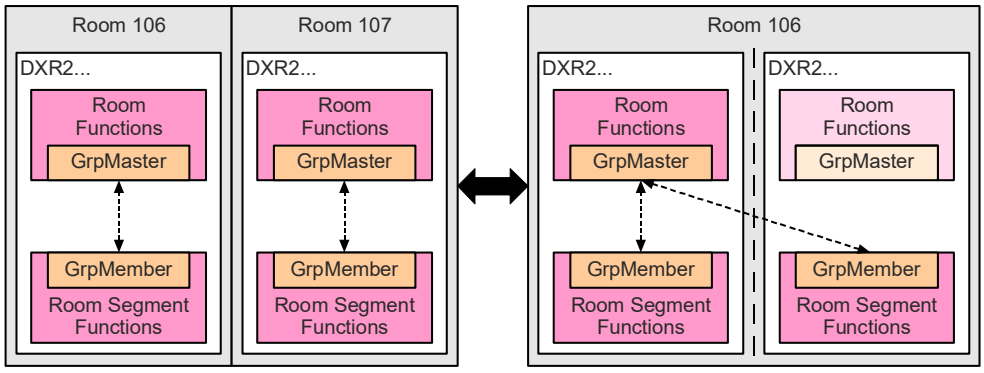


Flexible room management

The functions are divided up: The room coordinates HVAC, lighting, or blinds functions as the shell and generates the resulting operating modes, setpoints, etc.

In the room segment, components and aggregates such as radiators, chilled ceilings, lighting, or blinds actuators are controlled per the operating mode set in the room.

One or more room segments can be assigned a room. The room segment is flexible, since it can be reassigned by the management platform (by the user) under certain circumstances without an engineering tool. The ABT engineering tool is used to regroup in the event that buttons are used for lighting and blinds.



3.2 Networking Ethernet/IP networks

The function and application summarized above are implemented on an automation station or room automation station. These devices must be networked together. Preliminary clarifications must define the number of room automation stations, automation stations for primary plants and superposed functions as well as central functions are required and how they are distributed.

The functions, guidelines and recommended set forth in *Practical Guide on IP Networks in Building Automation and Control Systems* (CM110668) apply to networking the devices.

3.2.1 Scalable Desigo system - System design

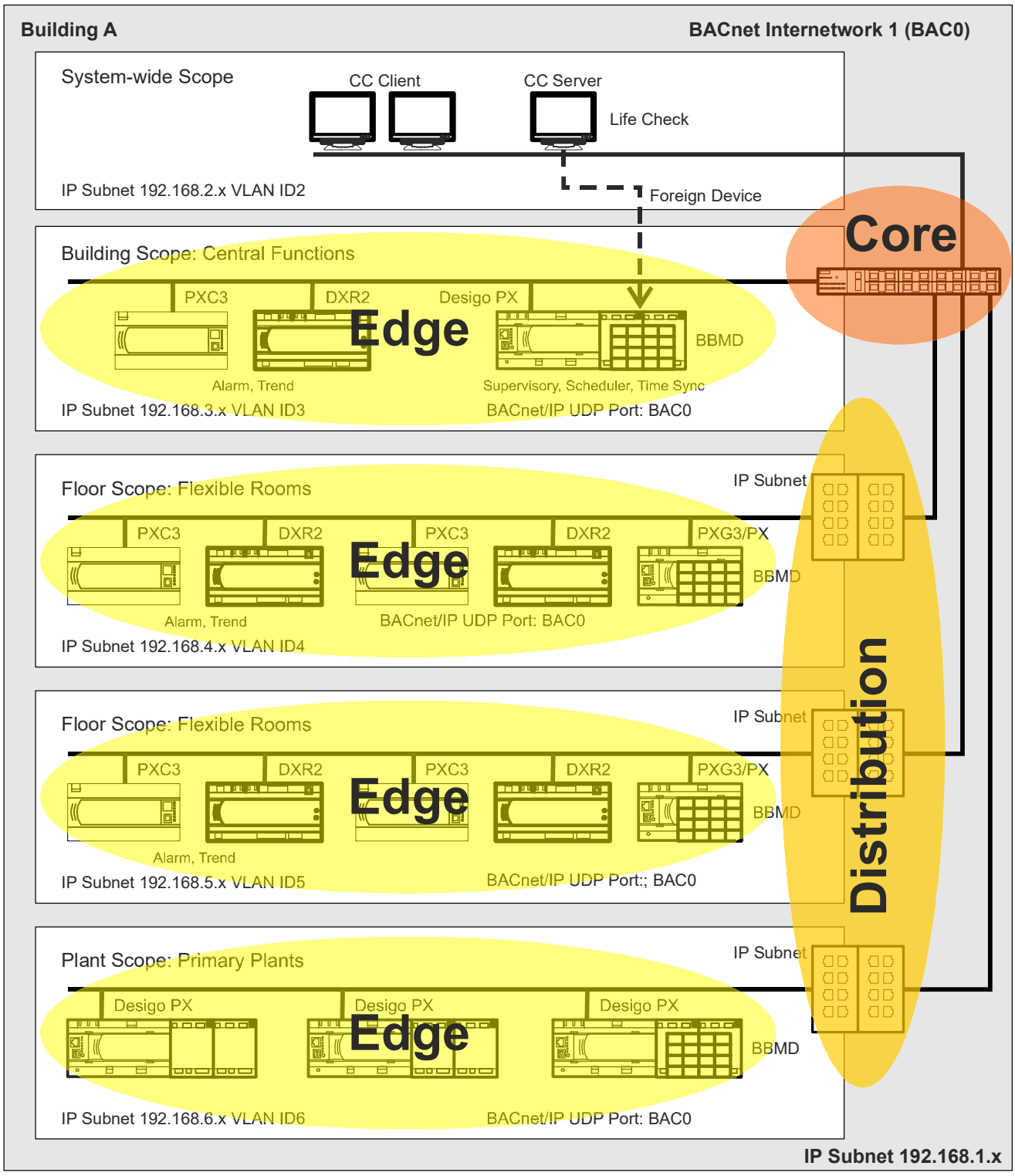
We must take a closer look at various aspects of the scalable Desigo system to properly define the design criteria here and then subdivide them to ultimately derive system limits and system topologies.

Project and network size	Designing a system
Small to mid-size project and networks of a lower complexity One building, up to 200 primary plants, 500 rooms, and just a few central functions Example: School, hotel, small to mid-size commercial unit (office, retail)	Restricted to **max. 500** automation stations The devices must be on a common IP segment. For example, subnet mask 255.255.254.0 = max. 512 IP addresses. For details, see *Overview of IPv4 address space*.
Medium to large project and network of medium complexity Large building complexes, more than 200 primary plants, 500 to 1500 rooms, lots of distributed central functions, multiple, different user groups Example: University, hospital, office building, residential and office complex, shopping mall	Restriction of **max. 250 devices on one IP segment**. Multiple IP segments for plant, building, and floor scopes via layer 2 switches, VLAN and layer 3 switches. BACnet internetwork over multiple IP segments with BBMD.
Large project and network of high complexity Multiple buildings, more than 200 primary plants, 500 to 1500 rooms, lots of distributed central functions, multiple, different user groups Example: University campus, hospital, large residential and office complex, pharmaceutical or automobile companies, industrial parks	Restriction of **max. 250 devices on one IP segment**. Multiple IP segments for plant, building, and floor space via layer 2 switches, VLAN and layer 3 switches. Multiple BACnet internetworks with up to 2,000 devices each, distributed on different BACnet networks with BBMD.

3.2.2 Zones on the IP network

Switches are a decisive element on a network: Core, distribution, and edge switches. Moreover, they are available as managed or unmanaged layer 2 and managed layer 3 switches. An overview follows.

For details, see *Practical guide on IP networks in building automation and control* (CM110668).



Core

These powerful switches form the backbone of a network. The servers and most important devices are connected to the core. Moreover, these switches can take over redundancy and routing tasks (layer 3) and are therefore managed.

Distribution switches

They are located in the riser zones, take over data from core switches and forward them to the various floors in the building.

They are optimally designed as managed layer 2 switches to setup VLANs.

Edge switches

The end devices are connected here. They are located at the end of the network in the control cabinets. They are typically unmanaged layer 2 switches; managed layer 2 switches when setting up VLANs.

Layer 2 and layer 3 switches

Layer 2 switches (Ethernet switches) only take the Ethernet MAC address into account when transmitting a data packet. No additional configuration required.

Layer 3 switches (IP router) use IP addresses to forward data packets. The routing function improves structuring of IP networks and results in lower load caused by broadcast communication.

Managed and unmanaged

Administration is another distinguishing feature of switches. Managed switches have an IP address and can be managed and configured using a web browser or Command Line Interface (CLI).

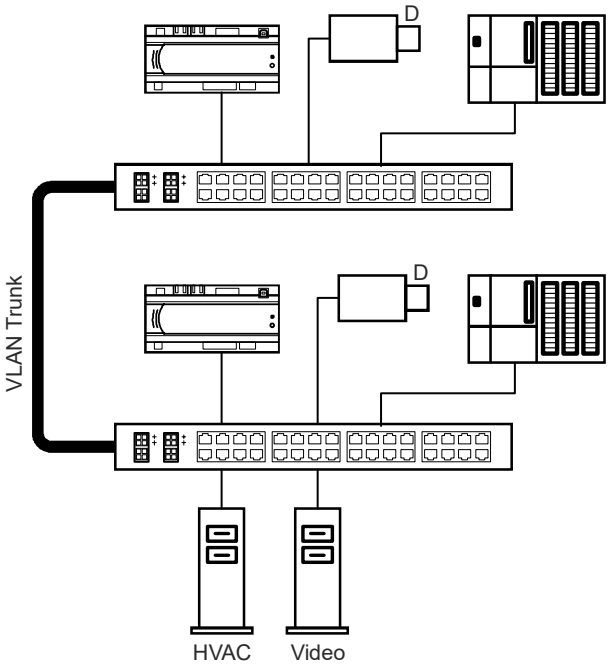
Unmanaged switches are take end devices online on the network. These switches have no additional functionality such as filters, redundancy, or alarm functions.

Managed layer 2 switches support intelligent network management functions, such as port trunking, MAC address-based VLANs and RSTP for ring topologies. Port mirroring for troubleshooting and diagnostics using network analysis tools is an important aspect for using managed layer 2 switches.

Also important, especially on BACnet networks, is support of IEEE802.1X, or more specifically, MAC Authentication (MAB) in general with a whitelist of permitted devices or a complete certificate-based client-server access control and authentication that prevents unauthorized devices from connecting to a network over public access ports. In principle, devices must first be authenticated on the switch before it can communicate with other network elements.

Managed layer 3 switches are multifunction devices that, in addition to layer 2 functions, connect IP subnetworks to one another, i.e. IP packets are transmitted to the correct subnetworks and broadcasts are blocked. Moreover, a layer 3 switch can route VLANs to each other, i.e. VLANs remain autonomous, but it supports a network transition or common interface.

VLANs



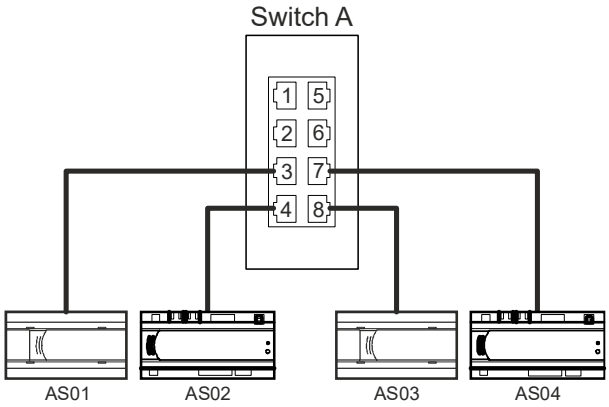
The era of setting up a separate network in building automation and control for each supplier and discipline has passed. Multi-service networks allow each to work undisturbed on VLANs.

Managed layer 2 switches make it possible.

Implement a VLAN to optimize security and communication, if:

- More than 250 devices from the same discipline are planned (concentration of risk).
- Different security zones are required to separate primary plants form secondary plants.
- A high degree of reliability is required.

Port-based VLANs



Port-based VLANs distribute a virtual managed switch to multiple switches. Each VLAN is identified by a VLAN-ID between 1 and 4094 with VLAN-ID 1 reserved as the default VLAN.

The switch's IP address is exclusively reachable via ports that are fixed on this VLAN. In the example above, ports 1 to 4 are assigned to VLAN 1001; ports 5 to 8 to VLAN 1002, in other words, communication can only take place between devices 1 to 4 on the same VLAN. This is referred to as port-based VLANs or often as untagged VLANs, since the Ethernet frames from the switch to the end device no longer have a tag.

Benefits:

- Port-based VLANs reduce the need, especially on smaller installations, for a physical switch on each network.
- The end devices do not need to support VLAN tagging per IEEE 802.1q, since the switch takes over this task.

Tagged VLANs

In contrast to untagged VLANs, tagged VLANs are frame-based rather than port-based. A port is assigned to multiple VLANs rather just a single one. Each frame receives a VLAN tag so that the switch knows to which VLAN an Ethernet frame belongs.

Benefits:

- A single cable suffices to connect both switches.

Disadvantages:

- Each switch (not end devices) must support tagging per IEEE 802.1q as the end device does not recognize the data packet and rejects it, i.e. no communication occurs.

Networking in a star topology

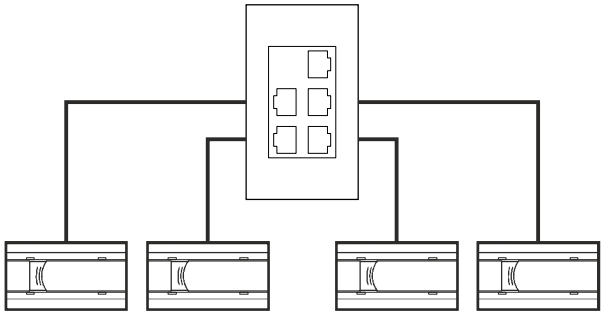
Benefits:

- Less expensive installation
- Low operating costs
- Improved overview

- Easy troubleshooting
- Managed and unmanaged switches can be used
- Very high speed and short latency

Disadvantages:

- High cabling expense
- Communication failure for a defective star point (no redundancy)



Networking in a daisy chain topology (Line topology)

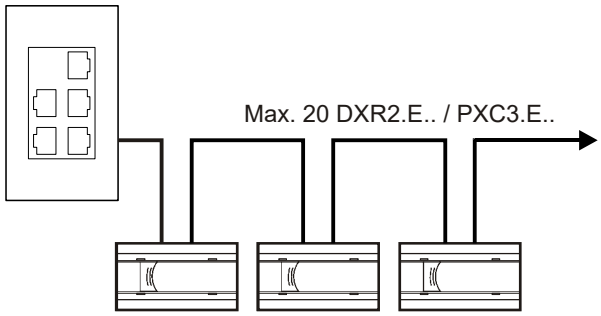
Benefits:

- Inexpensive
- Low cost for cabling
- Fewer switch ports required

Disadvantages:

- The loss of a device interrupts all communications to downstream devices
- Difficult overview and difficult to troubleshoot
- The latency of data transmission increases linearly with the number of downstream connected components; the probably of failure exponentially.

Only suitable where price is decisive or on non-critical system, such as are located in normal office buildings.



Networking in a ring topology

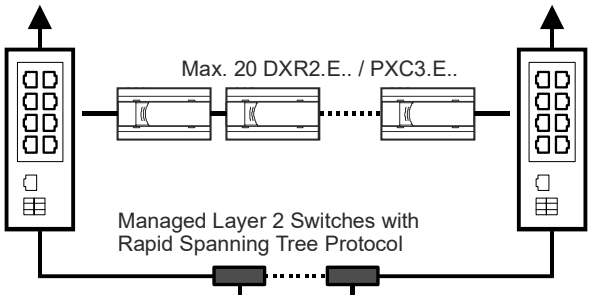
Benefits:

- A stand-by line results in high reliability
- Suitable for all network sizes
- Easy troubleshooting
- High speed with average latency times

Disadvantages:

- High cabling and engineering costs and managed layer 2 switch with RSTP
- Alarming and network management recommended
- Comprehensive expert knowledge required for engineering

In the event of a fault, switching the communication paths on DXR2.E../PXC3.E.. can take between 10 and 30 seconds. IT should monitor switches to notify the superposed system of a failure.



It is not enough to plan and implement the proper network technology to guarantee reliability and availability.

Switches with two voltage inputs are commonly offered to increase availability. Alarm messages can also be sent over hardware relay contacts (for example, in the event a connection or power supply fails, etc.). The switch can also be monitored as an alternative on a suitable management platform such as Desigo CC via the SNMP protocol.

Moreover, provide a separate or redundant power supply on important infrastructure, key automation stations, sensors, or actuators.

Selecting the topology is not always easy. Plant or application requirements are always the decisive factor, however. Special attention should be directed at the network since it forms the backbone of automation communications.

DHCP or fix IP address

The question comes up repeatedly as to whether DHCP should be used on a Desigo project.

For the sake of understanding, the following arguments pro and contra DHCP are listed here.

The Dynamic Host Configuration Protocol (DHCP) is a communications protocol where a DHCP server automatically assigns the network configuration (e.g. IP address, subnet) to a network participant (client). The DHCP server operates as a network service in the background and waits for client queries. The clients can be automatically or dynamically addressed based on the information on the available address pool from its configuration file.

There are three types of address assignment:

- Under manual assignment (static DHCP), the IP addresses are assigned to specific MAC address for an undetermined time on the DHCP server.
- The automatic assignment defined a range of IP address on the DHCP server and automatically assigns new DHCP clients to the MAC address. A table sets the assignment and is permanent. Assignments are not deleted and have the benefit that a participant always receives the same IP address so that the address cannot be assigned to another participant.
- Dynamic assignment is comparable to automatic assignment. The DHCP server does however manage data in its configuration file on how long certain IP address may be assigned to a participant before it is required to register on the server and request an extension. The IP address becomes available if this does not occur and can be assigned to other participants.

The DHCP procedures do have some disadvantages on a Desigo system or BACnet network:

- Access to the automation station is only through the BACnet names.
- Devices covering BBMD functionality, such as QXM7 or assigned Desigo room automation stations always require a fixed IP address.
- It is difficult for the user to access device when addresses change since room automation stations have a web server on board and are operated by ABT SSA for servicing and diagnostics.

For these reasons, Desigo automation stations are assigned a fixed IP address. The advantages clear outweigh the DHCP process, since:

- Automation stations are permanently assigned to a network and always have the same IP address.
- Simply and unique address assignments are important in the Desigo Engineering tools for service, diagnostics, and exchange.
- It permits unique project documentation on all levels.
- The devices can be uniquely assigned for servicing and diagnostics and simplifies operation via ABT SSA (Service and system assistant).

An IP segment can also be divided on a project-by-project bases into a part with static addresses, e.g. automation stations, etc., and a dynamic part (DHCP), e.g. for engineering laptops.

For detailed information, see *Desigo Ethernet, TCP/IP, MS/TP and BACnet* (CM110666) and *Practical guide on IP networks in building automation and control* (CM110668).

3.3 Networking BACnet network

The topics of IP networks and BACnet merge when networking BACnet networks. Standard knowledge of planning and implementation suffice for small to mid-sized projects. Expert knowledge of BACnet (and not necessarily IP networks) is required to plan, size, and implement large and complex BACnet/Desigo projects.

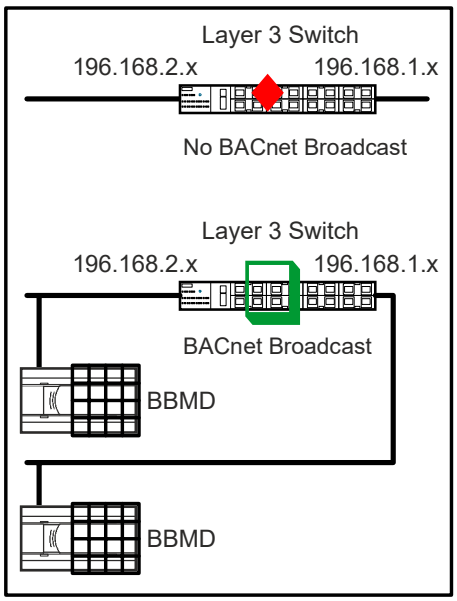
Desigo is based on that standard BACnet communication protocol. Services are required to communicate between BACnet devices. The following can be used to exchange data, for example, to transmit a demand signal from the room and its evaluation and forwarding to the primary plant:

- A Unicast service continuously queries and evaluates the state using a cyclical read (ReadProperty).
- A Unicast service that subscribes to the demand signal (SubscribeCOV) for a specified lifetime and receives an update if the value or its state changes.

This exchange of data between both BACnet devices can be labeled as highly targeted. The communication protocol also supports broadcasts to all BACnet devices. Example:

- A BACnet client determines at start up all pending alarms and events to display them in a current alarm list (GetEventInformation).
- A generic operator unit learns at start up with a broadcast who the other participants are.
- A BACnet object with a broadcast (WhoHas) is searching for another object with a unique name, e.g. B01'Flr1'RS100'HclHwDmd.

(BACnet) broadcasts on a large IP network would take down the entire network.
Layer 3 switches (IP router) block broadcasts to prevent this.



BBMD functionality is available in BACnet to nevertheless allow the use of BACnet broadcasts over multiple IP segments.

A BBMD (BACnet Broadcast Management Device) is set up on each IP segment. The BBMDs recognize one another through a table.

The applicable BBMD recognizes a broadcast triggered in a segment and distributes it as Unicast in a targeted manner to all other BBMDs that are entered in the Broadcast Distribution Table BDT of BBMDs. The broadcast is forward in other segments using their BBMDs.

Only one BBMD per IP segment is permitted. One BBMD must have a fixed IP address and use a UDP port. BBMD is not a separate device, but rather auxiliary functionality on a BACnet device.

In the use cases to date (Desigo PX in multiple IP segments with the same UDP port) a symmetrical BDT is always used. In other words, all BBMDs are entered in the Broadcast Distribution Table and distributed in this manner over the bypass to all other BBMDs in the various IP segments. Mid-sized to large Desigo

projects, especially with Desigo room automation, operate with asymmetrical BDT entries. To this end there is a designated BBMD (Building Scope) that knows all other BBMDs, but where the other BBMDs only know these special BBMD.

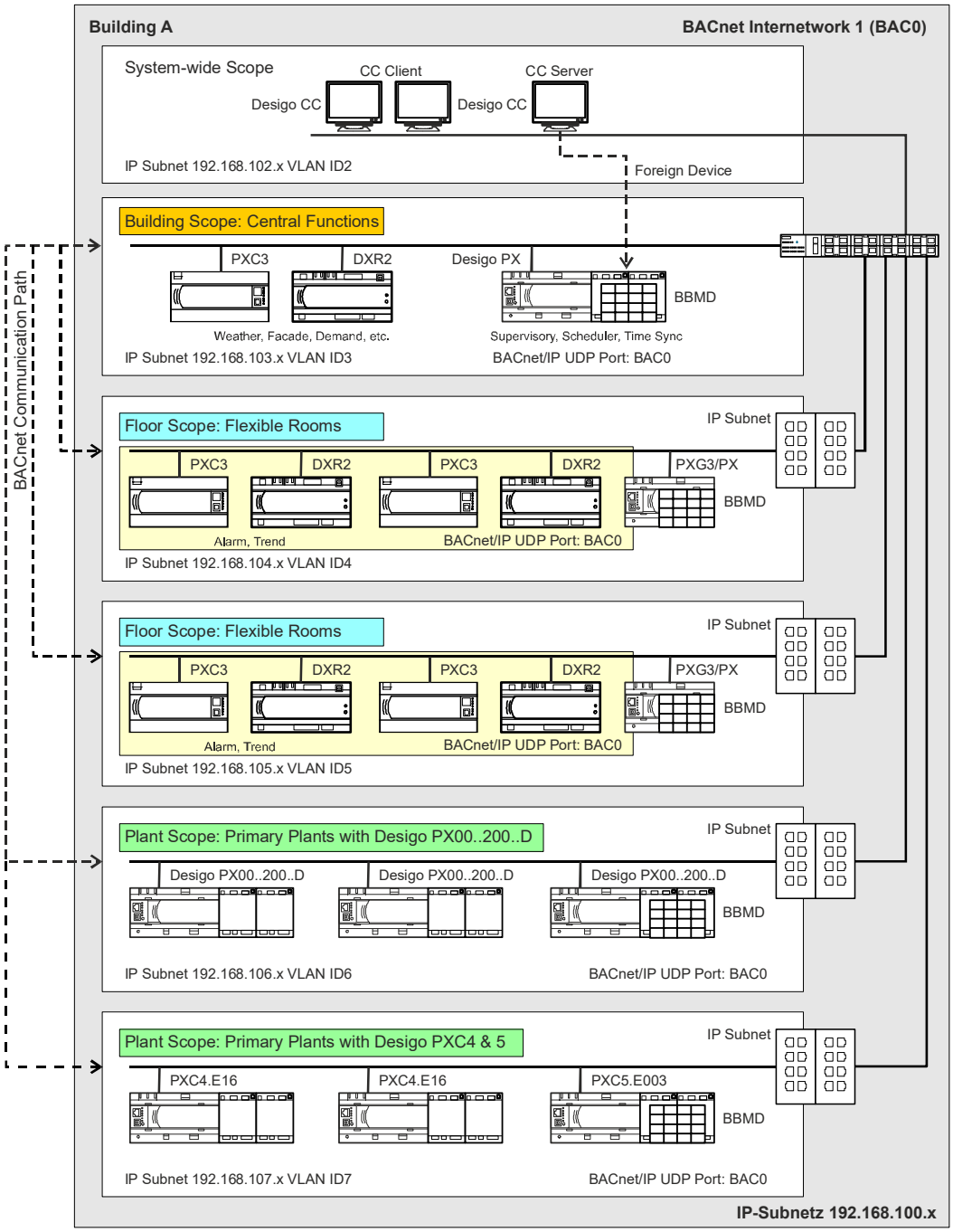
For detailed information, see *Desigo Ethernet, TCP/IP, MSTP and BACnet* (CM110666) and the following sections and practical examples.

In the Desigo system, the PXG3.L and PXG3.M as well as all PXC... automation stations support BBMD functionality, with PXG3 device operating at significantly higher performance levels. Use a PXG3 in the Building Scope when planning highly complex large projects and networks.

Local and global broadcasts are used on a Desigo room automation project with PXC3 and DXR2 components.

- The interaction between room and room segment are based on local broadcasts.
- Central functions use global broadcasts.

The following graphic shows the interaction on one BACnet internetwork with different IP networks.

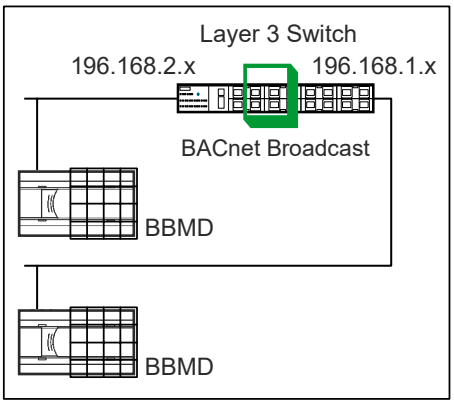


A broadcast is sent when starting up a BACnet client, for example, Desigo CC. This is necessary since this BACnet participant is located in a remote IP segment and must registered on the network as a third-party device.

Its broadcast is recognized on the BBMD for the new network, packed, and sent to all participants entered in the BBMD.

BBMDs in other IP segments recognize this and send the Unicast as broadcast to all participants in its segment.

Flexible room management uses, in other words, communication in one room over multiple room segments, local broadcasts. Lots of devices on an IP network cause lots of broadcasts.



As result, large, complex projects must:

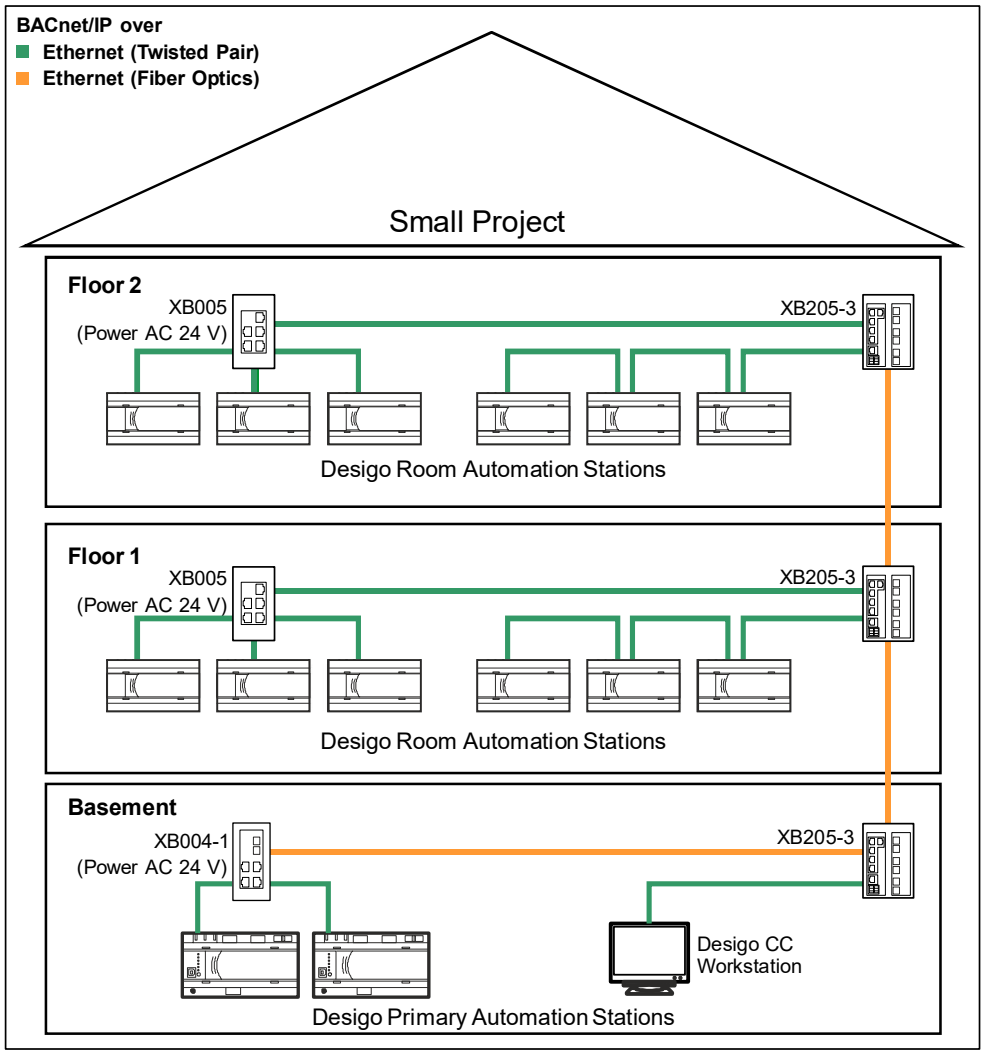
- Supply BACnet devices over layer 3 switches in its own IP segment (VLAN).
- Compile BACnet devices from the building, floor and plant scope, each on their own IP segments.
- Configure asymmetrical BDTs.
- Use a powerful PXG3 for BBMD functionality in the building scope.

3.4 Merging BACnet/IP networks

The following illustrates, based on this fundamentals, how to structure a small, mid-size, or large, up to a multi-discipline project.

Small to mid-sized project

Up to 500 automation stations.



Siemens SCALANCE Distribution Switches (XB205-3) are equipped as a managed layer 2 switches:

- Connects over various floors
- Can further expand the project
- Support the expansion per VLAN and ring topology
- Offers port mirroring (network analysis)

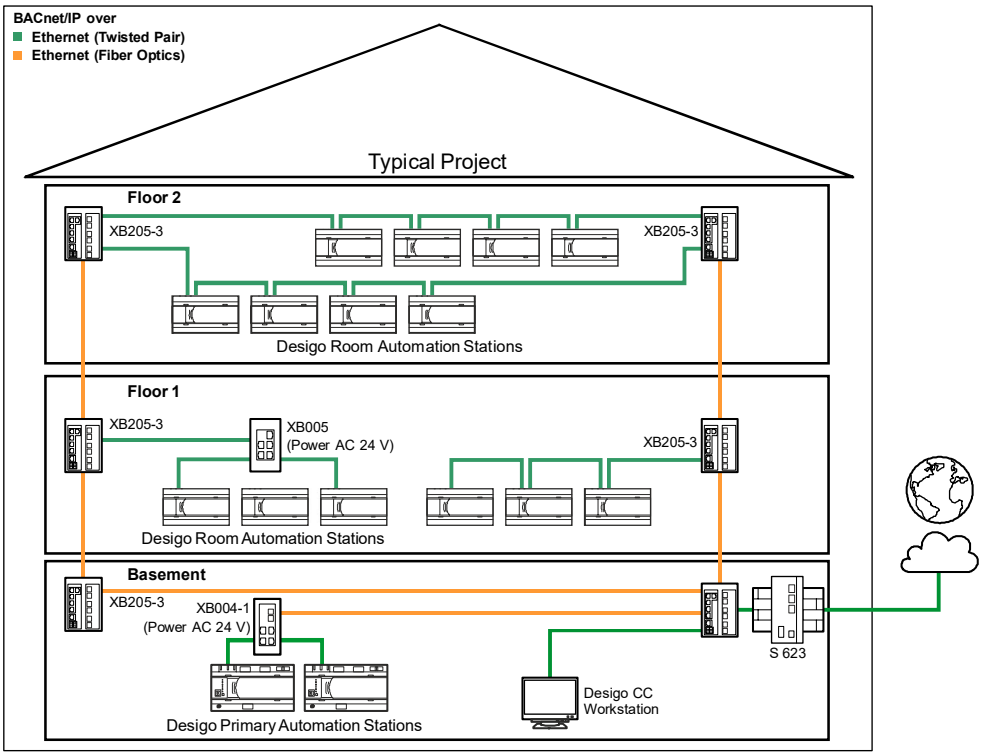
The Siemens SCALANCE Edge Switch (XB005) distributes on a floor as an unmanaged layer 2 switch:

- Important Desigo room automation stations are installed in a star topology (central functions, important rooms)
- A few, critical automation stations can be connected in a daisy chain topology

Fiber optics network the distribution switches over longer distances. The distribution and networking on the floors up to the edge swtiches over copper cables.

Mid-size to large project

The next example also illustrates a clearly structured network. The distribution switches are networks in ring technology, improving network availability and reliability.
An independent IP network is set up together with a layer 3 core switch to which the most important network components are connected.



On the actual floors, up to 20 Desigo room automation stations are network over a daisy chain. The entire network continues operated, even if a device fails.

Copper cabling can still be used to reach individual edge switches. And from there distributed (depending on the application) in a star or daisy chain topology.

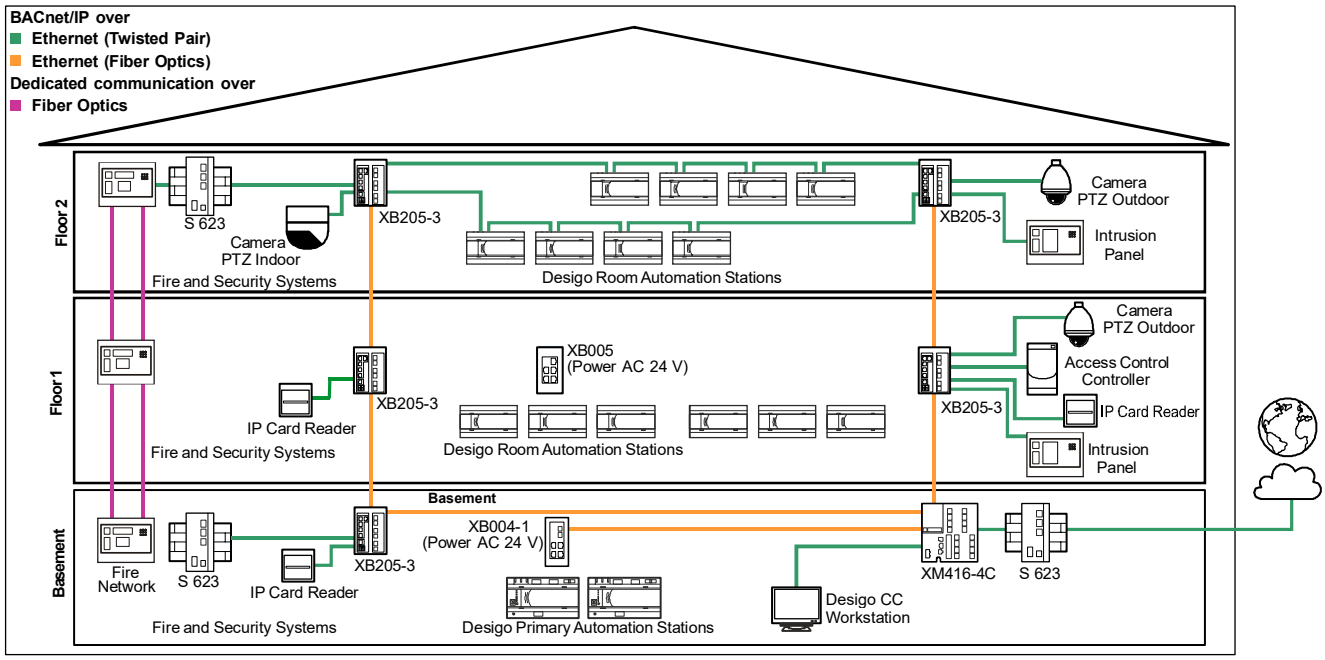
The distribution switches are equipped as managed layer 2 switches; the edge switches as unmanaged.

This topology illustrates that you can expand in the future using layer 2 switches. Separate VLANs can be configured for each floor to separate disciplines (HVAC, room automation, video, fire detection systems). Ring cabling of distribution switches meet customer requirements for reliability. Important Desigo room automations for central functions and important room are cabled in a star topology to the edge switch.

Large project

The following illustrates a large project with various disciplines. Emphasis is also placed here on speed, availability, a structure cabling concept, and standardized connection technology. Advanced availability and redundancy is achieved by using an additional core switch.

Glass fiber optics can cable network components across building over long distances, over EMC risky areas, and where there is a risk of potential drift.



Examples for industrial switches are:

- Siemens SCALANCE XB-000 range: Unmanaged switches with electric and/or optical ports for setting up small networks, AC/DC 24 V, used in edge or distribution areas.
- Siemens SCALANCE XB-200 range: Manageable layer 2 IE switches with a console port, diagnostic LED and redundant power supply for use as a distribution switch, supports ring technology RSTP, VLAN, port mirroring for troubleshooting and diagnostics, configuration with Step7/TIA, Web or Command Line Interface (CLI), SNMP.
- Siemens SCALANCE XM-400 Range: Managed Layer 3 IE Switch with auxiliary routing functions between IP subnetworks.

For details, see:

https://mall.industry.siemens.com/mall/de/WW/Catalog/Products/9300002?tree=CatalogTree

We refer here again to topics IT security and IT basic protection.

The increasing use of Ethernet connections up to the field level means that the associated security issues are also increasing in importance. Open communications and increased networking of different systems and disciplines not only present enormous possibilities, but also considerable risks. The appropriate measures must be undertake to fully protect building automation and control under the aspect of security.

As also depicted in the graphic above, you can achieve security segmentation of an important and security-relevant discipline (e.g. fire or intrusion) via the security module Scalance S623 or Sinema Remote Control. Cell protection with a firewall can protect against unauthorized access and data transmission via VPN against manipulation or spying.

For details, see:

https://mall.industry.siemens.com/mall/de/WW/Catalog/Products/10224584?tree=CatalogTree

https://mall.industry.siemens.com/mall/de/WW/Catalog/Products/10263934?tree=CatalogTree

You must ensure that the IP network is secure since the BACnet protocol transmit unencrypted.

Risk factors:

- Unprotected network sockets
- Unprotected WLAN networks
- Unprotected system and hardware
- Physical access to equipment rooms, control panels, and operator units
- Access rights on the network and in the Desigo system

The elements of infrastructure, IT systems, networks, and applications must be discussed under the aspects of security and appropriate measures need to be developed. Customer, domestic, or industry guidelines and directives must be observed under all circumstances.

For additional details, see *IT security on installations with Desigo* (CM110663) and *Practical Guide on IP Networks in Building Automation and Control Systems* (CM110668).

4 BACnet/IP networks

4.1 Checklist for designing BACnet/IP networks

Small to mid-sized project

Consider the following questions for detailed planning when designing a small to mid-sized project with a low level of network complexity:

Question	Designing the BACnet network	Designing the IP network
Is the number of Desigo room automation stations < 500?	One BACnet network	Small to mid-size project and networks of a lower complexity
Does the number of primary plants, implemented with Desigo PXC, < 200?	One BACnet network	
Are only HVAC and Desigo room automation planned on this project?		
Is only one building or building section automated on this project?		
Are BACnet third-party devices used?	Own BACnet network	
Does data exchange need to be implemented between BACnet third-party devices and Desigo units (PXC)?	Same UDP port	
Do you anticipate commanding more than 500 group member on central functions (emergency, service, or protection functions or operating modes and set points for lighting, blinds, HVAC, fire and wind, etc.)?	No → OK	
	The central functions need to be divided up for more than 500 group members. A group member is not the same as a room segment. A room segment can include lots of group members.	
Do you anticipate more than 250 group members on central functions that supply demand signals to supply systems? A cooling or heating valve sends out a demand signal. A room segment can send out multiple demand signals.	No → OK	
	The central functions need to be divided up for more than 250 group members. A group member is not the same as a room segment. A room segment can include lots of group members.	
Superposed, it is used to monitor devices and schedule a monitoring device. Is there more than 500 BACnet references or more than 50 scheduler programs with a maximum of 5 references?	No → OK	

Question	Designing the BACnet network	Designing the IP network
	For more than 500 BACnet references, i.e. more than 50 scheduler programs with a maximum each of 5 references and 250 BACnet references to the Desigo room automation stations, requires an additional PXC. Recommendation: We recommend, when managing the project with BOS, using a monitoring device for scheduling or checking whether the scheduler program for the floor scope can be implemented using another PXC. Moreover, an additional PXC00-E.D is preferable for monitoring Desigo room automation stations. Reason: All references, etc., are deleted if BOS checks out a monitoring device and scheduler without Desigo room automation stations and the CFC data is generated from the XWP Point Configurator.	
Should the IP network be redesigned and implemented?		Definition of subnetwork and IP addresses
Can the existing infrastructure be extended?		Clarify with IT
Are equipment rooms, control panels, distributors distributed over multiple floors?		Use of unmanaged layer 2 switches
What is the distance between control panels?		Copper cable or glass fiber optics, clarify the distances
Is network diagnostics and troubleshooting required?		Managed layer 2 switches including configuration for port mirroring
Is reliability and redundancy required?		Managed layer 2 switches, RSTP
Is monitoring for faults/failures required?		SNMP or hardware contact
Is remote access required?		Use of security modules for firewall and VPN
Is IT security required?		Based on local and industry guidelines

Mid-sized project

Consider the following questions for detailed planning when designing a mid-sized project with a medium level of network complexity:

Question	Designing the BACnet network	Designing the IP network
Is the number of Desigo room automation stations between 500 and 2500?		Medium to large project and network of medium complexity
Does the number of primary plants, implemented with Desigo PXC, > 200?		
Are BACnet third-party devices used?	Own BACnet network	
Does data exchange need to be implemented between BACnet third-party devices and Desigo units (PXC)?	Same UDP port	Mounting managed layer 2 switches, configuration of VLAN, and eventually port mirroring
Are equipment rooms, control panels, distributors distributed over multiple building sections or floors?	Mounting BBMD	
Are the units to control the primary plants centrally located in an equipment room?	Plant scope The same UDP port for the Desigo system	Plant scope on its own VLAN

Question	Designing the BACnet network	Designing the IP network
Are the control units for the primary plants decentralized on individual floors together with Desigo room automation stations?	Floor scope The same UDP port for the Desigo system	Floor scope with room automation on its own VLAN
Are BACnet/Desigo devices together on a separate BACnet network for building, plant,, and floor scope?		Managed layer 2 switches, configuration of VLAN, and eventually port mirroring
Are there Desigo room automation stations with central functions?		Unmanaged layer 2 switch cabled in a star topology
Are there Desigo room automation stations that automate important and critical rooms?		
Are the no more than 20 Desigo room automation stations on the floor?		Cabling using daisy chain technology, originated at a distribution switch
You must distinguish between important and less important room automation stations if there are more than 20 Desigo room automation units on the floor. Starting at the distribution switch, the cabling is either in a star topology or with a max. of 20 units as daisy chain.		
Are different IP networks and different UDP ports configured?	One BBMD per IP segment is required with an asymmetrical BDT. FDT must also be possible if there is a Desigo CC management platform or other BAC clients.	Layer 3 switch

Large project

Consider the following questions for detailed planning when designing a large project with a high level of network complexity:

Question	Designing the BACnet network	Designing the IP network
Are other disciplines (fire, intrusion, video) planned on the project in addition to HVAC and Desigo room automation?		Large project and network of high complexity
Is the number of Desigo room automation stations between 500 and 15,000?		
Does the number of primary plants, implemented with Desigo PXC, > 200?		
Does building automation and control extend to multiple properties, buildings, and building sections?	Multiple BACnet internetworks, eventually with multiple BACnet networks. See as well: Special case: BACnet referencing over different IP networks [→ 44]	
Do numerous properties and buildings required a clearly structure IP network?		Layer 3 switches for implementing multiple IP segments
Is IT security required?		Implementation of relevant topics on local or industry guidelines

4.2 Designing BACnet/IP networks

The following examples demonstrates network planning and configuring of a BACnet network up to commissioning in the real world.

The examples illustrate the required clarifications and planning steps, the selection and configuration of hardware components involved in implementing small to mid-sized, up to large Desigo projects.

We rely on products from the Siemens portfolio in the examples. The network components must meet the same requirements and function if you can use existing IT infrastructure to implement the project.

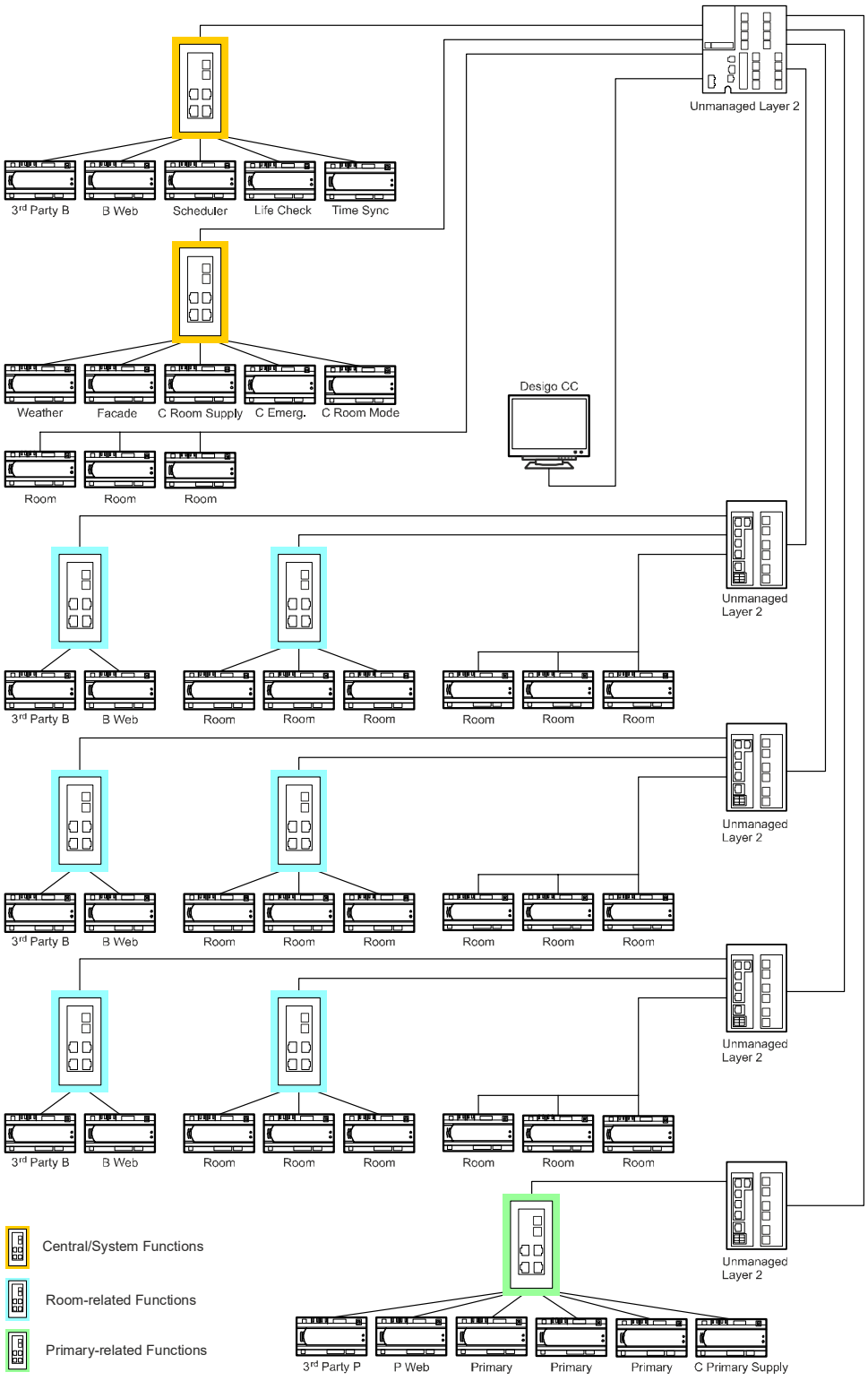
4.2.1 Network for a small to mid-sized project

Example for planning and implementing a project:

Project Description

- New office building with room automation for 136 rooms over 4 floors as well as preparing the appropriate primary plants.
- Each floor is leased by another tenant and has its own occupancy and use, i.e. the room operating mode as well as associated room setpoints, lighting per floor with central operation, and emergency function over all floors.
- Blinds control for each facade, including protection, service, and emergency function over all floors, a central weather station, demand-control of primary plants.
- Schedulers together with a calendar for room operating modes and lighting for each floor, superposed functions on a monitoring device.
- Primary plants for air handling, heat generation and distribution as well as central distribution of refrigeration on equipment rooms.
- Primary plants and general: 5 PXC100-E.D und 1 PXC00-E.D
- Desigo room automation: 121 DXR2 or PXC3.E…
- Network infrastructure: Visualization and monitoring in the event of failure

Functional display of an example topology



Planning and implementation, IP network

Core level

A core switch is not needed since everything is located on one IP segment.

Distribution level

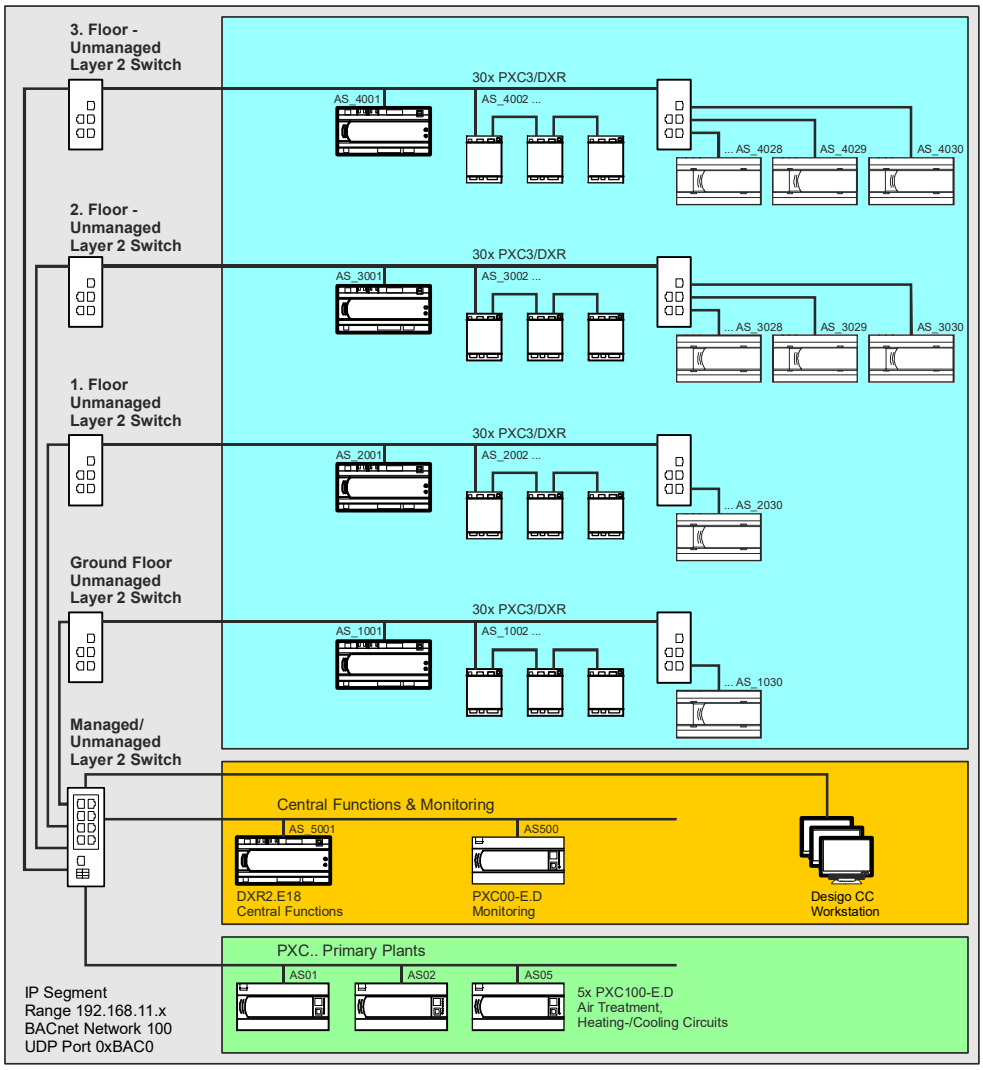
In the distribution level, in the riser zones, i.e. floor distributors:

- Unmanaged layer 2 switches are planned that are connected with copper cable.
- A managed layer 2 switch is planned for network diagnostics and troubleshooting where a management platform is connected. An unmanaged layer 2 switch can be used as well if the customer has no special requirements.

Edge level

Only unmanaged layer 2 switches are planned as edge switches. The following applies:

- Important rooms / Desigo room automation stations are implemented in a star topology on a distribution switch or remote edge switch.
- Unimportant rooms / Desigo room automation stations (max. 20) are networked in a line topology (daisy chain).
- Central functions / Desigo room automation stations are implemented using star cabling on the layer 2 switch (e.g. AS4001).
- PXC··· for the primary plants and superposed functions in the equipment room are implemented in star cabling on a layer 2 switch.



IP/VLAN overview

Network designation	Network	Address range
Building automation and control	192.168.11.0/24	192.168.11.2···.192.168.11.254
Requires more than 200 IP addresses		
Building automation and control	192.168.11.0/23	Max. 510 usable IP addresses

Planning and implementation, BACnet network

A BACnet internetwork is built using a BACnet network. All Desigo devices communicate on the same UDP port, e.g. 0xBAC0.

Local and global broadcasts are not critical for this amount of devices, rooms, and plants, i.e. BBMD configuration is not required.

Each Desigo PXC... automation station should have FDT functionality for maintenance and diagnostics and remote access.

Planning and implementation, HVAC and room automation

Plant scope:

- Desigo PXC···E.D to control primary plants.

Building scope:

- Desigo PXC00-E.D for superposed functions, e.g. scheduler for occupancy and use times by floor and monitoring Desigo room automation stations.
- Desigo DXR2.E18/PXC3.E··· for central functions over multiple floors.

Floor scope:

- Desigo DXR2.E18/PXC3.E··· for central functions.
- Desigo DXR2.E../PXC3.E... for room and room segments / HVAC, lighting, and blinds.

If project implementation permits (from a cost standpoint), we recommend distributing monitoring of Desigo room automation stations or schedulers for the floors over different monitoring units (PXC00-E.D).

Planning and implementation of central functions

Central function	1st floor Tenant A	Floor 1 Tenant B	Floor 2 Tenant C	Floor 3 Tenant D	The entire building, across floors
Hardware	AS1001	AS2001	AS3001	AS4001	AS5001
Central weather station					CenWthStn
Central setpoint generation via seasonal compensation					CenSsn
Central operating mode determination	CenOp_EG	CenOp_1OG	CenOp_2OG	CenOp_3OG	
AS500 Scheduler for room operating mode	SchedOp0 Scheduler, room operating mode ground floor	SchedOp1 Scheduler, room operating mode 2nd floor	SchedOp2 Scheduler, room operating mode 3rd floor	SchedOp3 Scheduler, room operating mode 4th floor	
Central operation lighting	CenOpLgt_EG	CenOpLgt_1OG	CenOpLgt_2OG	CenOpLgt_3OG	
AS500 Scheduler for lighting, building occupancy	SchedLg0 Scheduler, lighting occupancy, ground floor	SchedLg1 Scheduler, lighting, building occupancy, 2nd floor	SchedLg2 Scheduler, lighting, building occupancy, 3rd floor	SchedLg3 Scheduler, lighting, building occupancy, 4th floor	
AS500 Scheduler for lighting, system operation	SchedLg6 Scheduler, lighting system operation. First floor	SchedLg7 Scheduler, lighting system operation. 2nd floor	SchedLg8 Scheduler, lighting system operation. 3rd floor	SchedLg9 Scheduler, lighting system operation. 4th floor	
Central emergency function lighting	CenEmgLgt_EG	CenEmgLgt_1OG	CenEmgLgt_2OG	CenEmgLgt_2OG	
Central emergency lighting (overall)					CenEmgLgt
Central shading operation	CenOpShd_EG	CenOpShd_1OG	CenOpShd_2OG	CenOpShd_3OG	

Central function	1st floor Tenant A	Floor 1 Tenant B	Floor 2 Tenant C	Floor 3 Tenant D	The entire building, across floors
AS500 Scheduler for shading, building occupancy	SchedSh0 Scheduler, shading, occupancy, ground floor	SchedSh1 Scheduler, shading, occupancy, 2nd floor	SchedSh2 Scheduler, shading, occupancy, 3rd floor	SchedSh3 Scheduler, shading, occupancy, 4th floor	
AS500 Scheduler for shading, system operation	SchedSh6 Scheduler, shading system operation. Ground floor	SchedSh7 Scheduler, shading system operation. 2nd floor	SchedSh8 Scheduler, shading system operation. 3rd floor	SchedSh9 Scheduler, shading system operation. 4th floor	
Central emergency shading (overall)					CenEmgShd
Central protection function shading					CenPrtShd
Central service function Blinds	CenSrvShd_EG	CenSrvShd_1OG	CenSrvShd_2OG	CenSrvShd_3OG	
Central facade shading west					CenFcdShd_W
Central facade shading south					CenFcdShd_S
Central facade shading east					CenFcdShd_E
Hot water supply chain					SplyHw
Supply chain chilled water					SplyChw

Recommendation: Network components

- Siemens SCALANCE XB005 - as the edge switch for cabling PXC and Desigo room automation stations.
- Siemens SCALANCE XB005 - At the distribution level in the riser zones.
- Siemens SCALANCE XB205 - At the distribution level with port mirroring for diagnostics.

IT security and IT basic protection

The elements of infrastructure, IT systems, networks, and applications must be discussed under the aspects of security and appropriate measures need to be developed. Customer, domestic, or industry guidelines and directives must be observed under all circumstances.

For additional details, see *IT security on installations with Desigo* (CM110663) and *Practical Guide on IP Networks in Building Automation and Control Systems* (CM110668).

Summary

The following tables show how to depict all devices and network components in a small project.

Plant category	Number of IP devices
PXC primary plants	5
PXC3/DXR2 individual room control & central functions	121
PXC00-E.D system controller, building scope	1
Reserves 5%	6
Amount	133

Network components	Type Siemens	Layer	Managed	No.
Edge switch per floor	XB005	2	No	9
Distribution switch in the equipment rooms	XB200	1	Yes	1

Description	2nd floor DXR2	3rd floor DXR2	4th floor DXR2	5th floor DXR2	Primary plant	System level
VLAN	VLAN 01	VLAN 01	VLAN 01	VLAN 01	VLAN 01	VLAN 01
UDP port	BAC0	BAC0	BAC0	BAC0	BAC0	BAC0
Subnet mask	255.255.255.0	255.255.255.0	255.255.255.0	255.255.255.0	255.255.255.0	255.255.255.0
Default gateway	192.168.11.254	192.168.11.254	192.168.11.254	192.168.11.254	192.168.11.254	192.168.11.254
Engineering notebook XWP/ABT						192.168.11.251
Number of DXR2	30	30	30	30		
Reserve IP addresses	220	220	220	220		
IP address range for DXR2 from…	192.168.11.11	192.168.11.51	192.168.11.101	192.168.11.151		
IP address range for DXR2 …to	192.168.11.50	192.168.11.100	192.168.11.150	192.168.11.200		
Central functions floor (DXR2…)	192.168.11.50	192.168.11.100	192.168.11.150	192.168.11.200		
Central functions for the overall building (PXC3/DXR2)						192.168.11.201
System controller monitoring floors (PXC00-E.D)						192.168.11.202
Number of PXC					5	
Reserve IP addresses					249	
IP address range PXC primary plants from…					192.168.11.203	
IP address range PXC primary plants …to					192.168.11.210	
IP address range Mgmt'stations Desigo CC from…						192.168.11.211
IP address range Mgmt'stations Desigo CC f…to						192.168.11.215

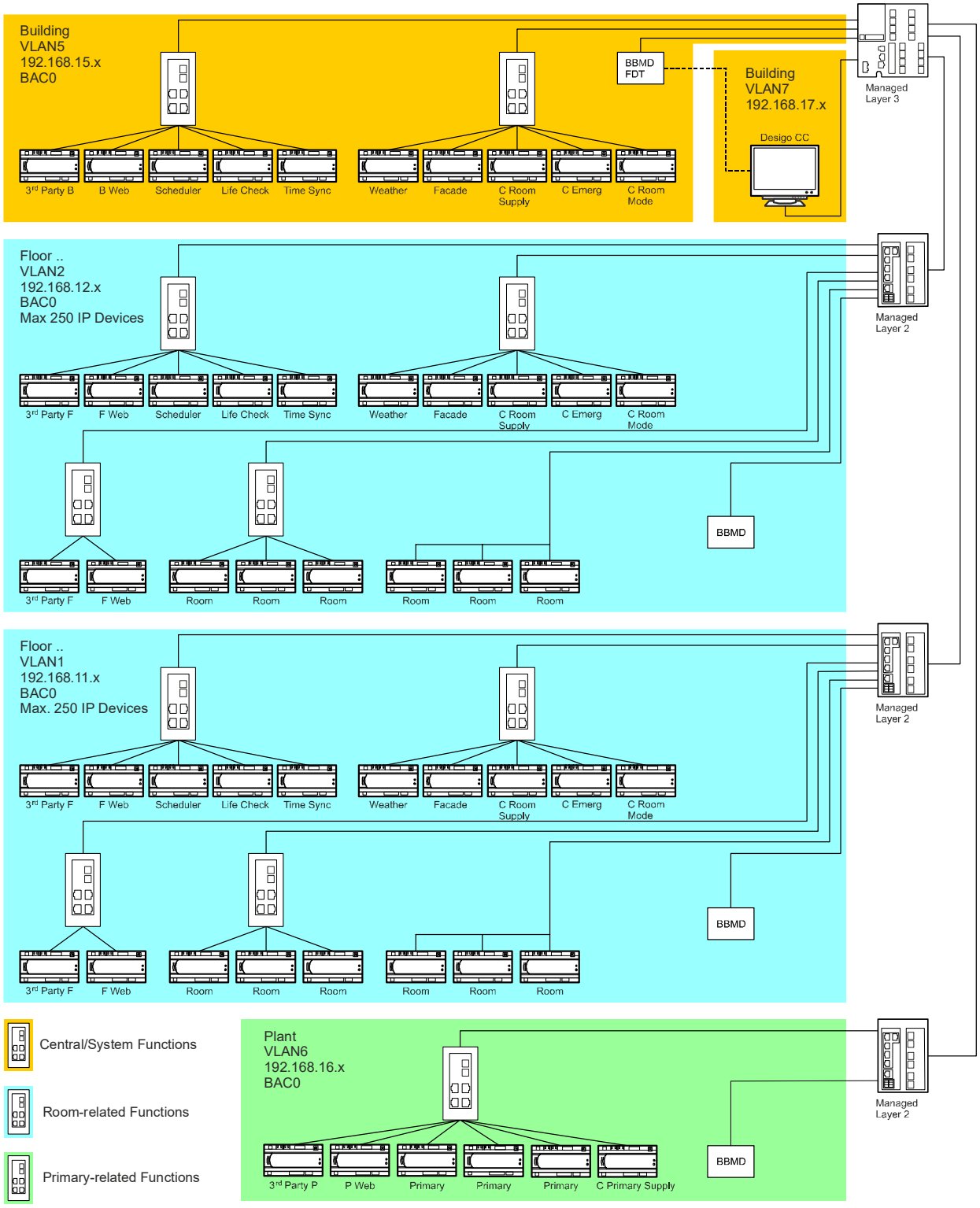
4.2.2 Network for mid-sized to large project structured with centralized primary plants

Example for planning and implementing a project:

Demand

- New office building with room automation for 424 rooms over 4 floors as well as preparing the appropriate primary plants.
- Each floor is leased by another tenant and has its own occupancy and use, i.e. the room operating mode as well as associated room setpoints, lighting per floor with central operation, and emergency function.
- Blinds control for each facade including protection, service, and emergency function.
- Central weather station, demand-controlled control of primary plants.
- Schedulers together with a calendar for room operating modes and lighting for each floor, superposed functions on a monitoring device.
- Primary plants for air handling, heat generation and distribution as well as central distribution of refrigeration in an equipment room.
- Primary plants and general: 5 PXC100-E.D und 5 PXC00-E.D
- Desigo room automation: 402 PXC3.E…/DXR2
- Visualization, operating and monitoring Desigo CC
- Monitoring network components via SNMP

Functional display of an example topology



Planning and implementation, IP network

Core level

Core Switch (Managed Layer 3) as the network core, interface for remote maintenance, and office network as well as building additional IP segments or as a redundant backbone.

Distribution level

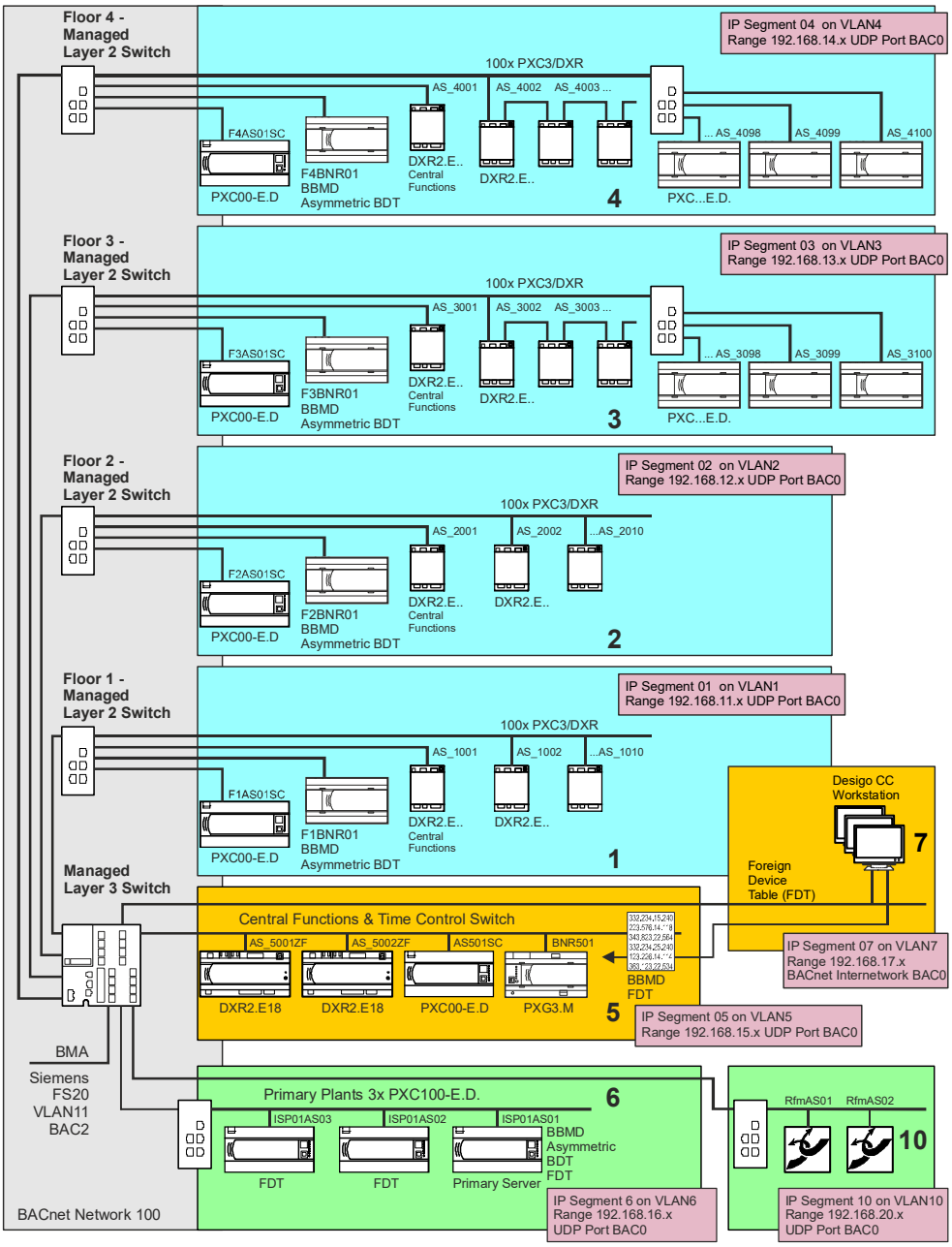
Managed layer 2 switches are planned on the distribution level, in the riser zones, i.e. floor distributors that:

- Are connected with copper cabling.
- Ensure that Desigo room automation stations from the given floor are located on its own VLAN and therefore isolated from other Desigo room automation stations on other floors for the purposes of local BACnet broadcasts.
- You can configure port mirroring of each VLAN for network diagnostics and troubleshooting.

Edge level

Only unmanaged layer 2 switches are planned as edge switches. The following applies:

- Important rooms / Desigo room automation stations are implemented in a star topology on a distribution switch or remote edge switch.
- Unimportant rooms / Desigo room automation stations (max. 20) are networked in a line topology (daisy chain).
- Central functions / Desigo room automation stations are implemented using star cabling on a layer 2 switch.
- PXC··· for the primary plants and superposed functions in the equipment room are connected in star cabling on a layer 2 switch.



IP/VLAN overview

Network designation	VLAN ID	Subnet	Address range	Default gateway
BA_TRA_01	1	255.255.255.0	192.168.11.1 -- 254	192.168.11.254
BA_TRA_02	2	255.255.255.0	192.168.12.1 -- 254	192.168.12.254
BA_TRA_03	3	255.255.255.0	192.168.13.1 -- 254	192.168.13.254
BA_TRA_04	4	255.255.255.0	192.168.14.1 -- 254	192.168.14.254
BA_Mgmt	5	255.255.255.0	192.168.15.1 -- 254	192.168.15.254
BA_Hvac	6	255.255.255.0	192.168.16.1 -- 254	192.168.16.254
BA_CC_BuB	7	255.255.255.0	192.168.17.1 -- 254	192.168.17.254
BA_Rfm	10	255.255.255.0	192.168.20.1 -- 254	192.168.20.254
DMS_FS20	11	255.255.255.0	192.168.21.1 -- 254	192.168.21.254

An IP segment can also be divided on a project-by-project bases into a part with static addresses, e.g. automation stations, etc., and a dynamic part (DHCP), e.g. for engineering laptops.

As an alternative, you can also work in general with DHCP. You must ensure, however, that the stations always have the same IP address. This applies to:

- BACnet device that assume BBMD functionality.
- Room automation stations with an on-board web server and are operated with ABT SSA for servicing and diagnostics.
- Room operator units, such as QMX7.

Planning and implementation, BACnet network

Each Desigo PXC... automation station should have FDT functionality for maintenance and diagnostics and remote access.

A BACnet internetwork must be set up. Each IP segment becomes a BACnet network.

A BBMD must be used in each IP segment in order for BACnet and IP networks to interact. This permits isolating local broadcasts from the flexible room management (room/room segment). Global broadcasts, originating from central functions, are managed on the BACnet device that assumes the BBMD functionality by asymmetrical BDT entries (Broadcast Distribution Table).

Set up the device accordingly in the XWP network configurator. The following is a overview of the BACnet configuration:

Device name	BNR501	ISP01AS01	F1BNR01	F2BNR01	F3BNR01	F4BNR01
Device Type	PXG3.M	PXC100-E.D	PXG3.M	PXG3.M	PXG3.M	PXG3.M
IP address	192.168.15.250	192.168.16.250	192.168.11.250	192.168.12.250	192.168.13.250	192.168.14.250
BACnet Network no.	NET100	NET100	NET01	NET02	NET03	NET04
UDP Port	BAC0	BAC0	BAC0	BAC0	BAC0	BAC0
IP segment	05	06	01	02	03	04
BBMD	true	true	true	true	true	true
BDT						
IP address	192.168.15.250	192.168.16.1	192.168.11.250	192.168.12.250	192.168.13.250	192.168.14.250
	192.168.11.250	192.168.15.250	192.168.15.250	192.168.15.250	192.168.15.250	192.168.15.250
	192.168.12.250	-	-	-	-	-

	192.168.13.250	-	-	-	-	-
	192.168.14.250	-	-	-	-	-
	192.168.16.1	.-	-	-	-	-
Function	For system monitoring of the system level (Timesync) Time switch catalogs global BBMD (is the node for all broadcast messages between VLAN 01-07 or between ERR from floors and primary plants) Primary server	Main HVAC plant	BBMD in VLAN 1	BBMD in VLAN 2	BBMD in VLAN 3	BBMD in VLAN 4

How and why asymmetrical BDT entries?

Local broadcasts that use the flexible room management to locate and address room segments from the room, are routed to an own VLAN or BACnet network to a defined UDP port (0xBAC0). Local broadcasts are thus encapsulated and no longer forwarded to other networks.

BACnet Broadcast Management Devices (through the BDT) must, however, be defined for global BACnet broadcasts (originating, among others, from central functions) to operate successfully on the different IP segments and BACnet networks.

From the project topology described above, a PXG3.M (BNR501) must for performance reasons in building scope:

- Support the BBMD function on the first port.
- Enter its own IP address in the BDT to 0xBAC0 (first port).
- Enter all other IP address for the BBMDs in the other IP segments that also communicated on UDP port 0xBAC0.

A BBMD must be defined for each of the other IP segments.

The BDT is also enabled in FxBNR01 to BAC0. In the BDT is the own IP address and address for BNR501. For performance reasons, we recommend using a PXG3 (BNR) on the floor scope on a midsize to large project.

The Desigo CC management platform registers as a third-party device in BNR501. The broadcast can be triggered here and forward via the asymmetrical BBMD entries to all other participants in the various IP segments.

The project example illustrated above relies on Desigo room automation stations that support Desigo Version 6.1. In the event that Desigo room automation stations, version 6.0 are used for various reasons (project progress):

- Desigo room automation stations in the floor scope must be placed on another UDP port to isolate local broadcasts (room/room segment).
- The routing functionality must be configured for the BACnet router.

Planning and implementation, HVAC and room automation

Plant scope:

- Desigo PXC···E.D to control primary plants.

Building scope:

- Desigo PXC00-E.D for superposed functions, e.g. scheduler for occupancy and use times by floor.
- Desigo DXR2.E18 for central functions over multiple floors.

Floor scope:

- Desigo PXC00-E.D for monitoring Desigo room automation stations.
- Desigo DXR2.E18/PXC3.E.. for central functions within the floor scope.
- Desigo DXR2.E../PXC3.E.. for room and room segments / HVAC, lighting, and blinds.

You can operate with cascading group master functions if lighting and blinds exceed a maximum of 500 commandable group members. This could, for example, be used for emergency control of blinds actuators over multiple facades over lighting over multiple floors.

Notes on project implementation

In the project example above was generously planned (since it is a midsized to large project) and one PXC00-E.D was assigned to each floor scope as well. It assumes monitoring of Desigo room automation stations. The PXC00-E.D in the building scope is used for scheduling and superposed functions for various floors as well as central functions for room operating mode, lighting, and blinds.

Depending on building design, air handling may be decentralized on various floors. A PXC100-E.D each is used in the floor scope to this end. It takes over scheduling and superposed functions for the floor / floor scope. The PXC00-E.D monitoring unit is used in the building scope to monitor Desigo room automation stations.

Planning and implementation of central functions

Central function	Ground floor	Floor 1	Floor 2	Floor 3	Entire building
Hardware	AS1001	AS2001	AS3001	AS4001	AS5001ZF
Central weather station					CenWthStn
Central setpoint generation via seasonal compensation for North, East, South, West					CenSsnN CenSsnE CenSsnS CenSsnW
Central operating mode determination	CenOp_EG	CenOp_1OG	CenOp_2OG	CenOp_3OG	
AS501SC Scheduler for room operating mode	SchedOp0 Scheduler, room operating mode ground floor	SchedOp1 Scheduler, room operating mode 2nd floor	SchedOp2 Scheduler, room operating mode 3rd floor	SchedOp3 Scheduler, room operating mode 4th floor	
Central operation lighting	CenOpLgt_EG	CenOpLgt_1OG	CenOpLgt_2OG	CenOpLgt_3OG	
AS501SC Scheduler for lighting, building occupancy	SchedLg0 Scheduler, lighting occupancy, ground floor	SchedLg1 Scheduler, lighting, building occupancy, 2nd floor	SchedLg2 Scheduler, lighting, building occupancy, 3rd floor	SchedLg3 Scheduler, lighting, building occupancy, 4th floor	
AS501SC Scheduler for lighting, system operation	SchedLg6 Scheduler, lighting system operation Ground Floor.	SchedLg7 Scheduler, lighting system operation 2nd floor.	SchedLg8 Scheduler, lighting system operation 3rd floor.	SchedLg9 Scheduler, lighting system operation 4th floor.	
Central emergency function lighting	CenEmgLgt_EG	CenEmgLgt_1OG	CenEmgLgt_2OG	CenEmgLgt_2OG	
Central emergency lighting (overall)					CenEmgLgt
Zentrale Bedienung Jalousie	CenOpShd_EG	CenOpShd_1OG	CenOpShd_2OG	CenOpShd_3OG	
AS501SC Scheduler for shading, building occupancy	SchedSh0 Scheduler, shading, occupancy, ground floor	SchedSh1 Scheduler, shading, occupancy, 2nd floor	SchedSh2 Scheduler, shading, occupancy, 3rd floor	SchedSh3 Scheduler, shading, occupancy, 4th floor	

Central function	Ground floor	Floor 1	Floor 2	Floor 3	Entire building
AS501SC Scheduler for shading, system operation	SchedSh6 Scheduler, shading system operation ground floor.	SchedSh7 Scheduler, shading system operation 2nd floor.	SchedSh8 Scheduler, shading system operation 3rd floor.	SchedSh9 Scheduler, shading system operation 4th floor.	
Central emergency shading (overall)					CenEmgShd
Central protection function shading					CenPrtShd
Central service function shading	CenSrvShd_EG	CenSrvShd_1OG	CenSrvShd_2OG	CenSrvShd_3OG	
Central facade shading west					CenFcdShd_W
Central facade shading south					CenFcdShd_S
Central facade shading east					CenFcdShd_E
Hot water supply chain	SplyHw	SplyHw	SplyHw	SplyHw	SplyHw (Total)
Supply chain chilled water	SplyChw	SplyChw	SplyChw	SplyChw	SplyChw (Total)
Supply chain ventilation	SplyAir	SplyAir	SplyAir	SplyAir	SplyAir (Total)

Recommendation: Network components

- Siemens SCALANCE XB005 - as the edge switch for cabling PXC and Desigo room automation stations.
- Siemens SCALANCE XB205 - At the distribution level in the riser zones for setting up VLANs and port mirroring for diagnostics.
- Siemens SCALANCE XM405 - As core switch for possible IP routing.

SCALANCE switches from the product family X-200 or X-400 support SNMP and can be monitored on Desigo CC.

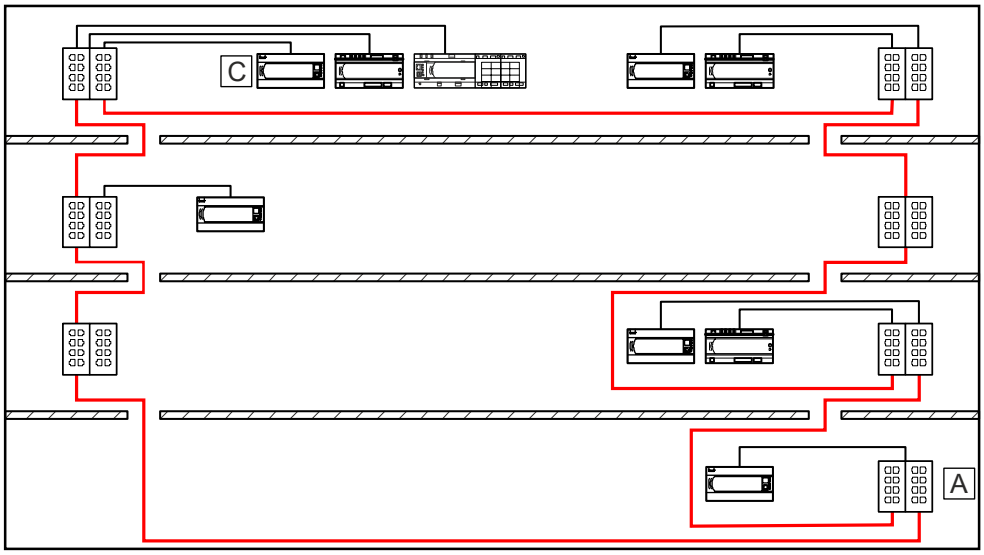
IT security and IT basic protection

The elements of infrastructure, IT systems, networks, and applications must be discussed under the aspects of security and appropriate measures need to be developed. Customer, domestic, or industry guidelines and directives must be observed under all circumstances.

For additional details, see *IT security on installations with Desigo* (CM110663) and *Practical Guide on IP Networks in Building Automation and Control Systems* (CM110668).

Reliability and redundancy

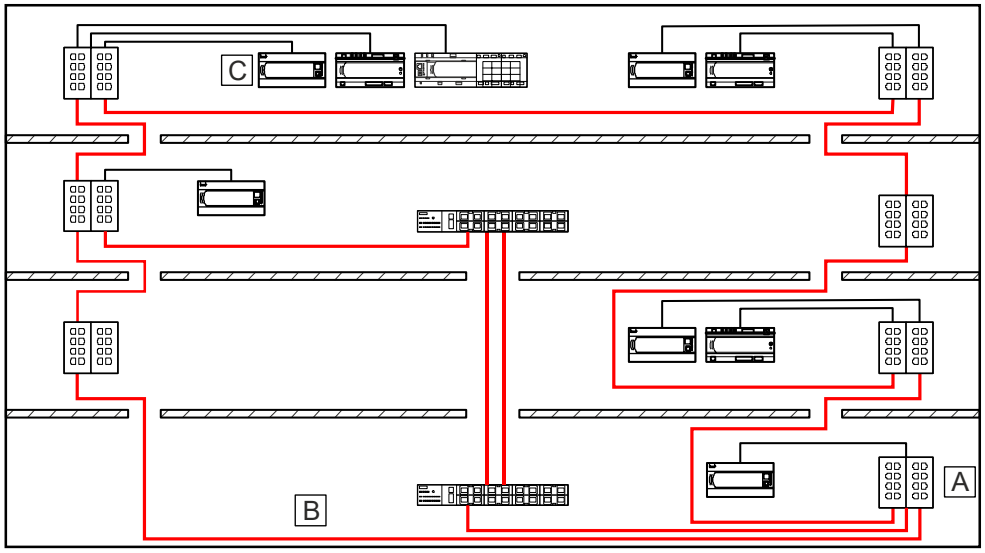
Distribution switches can be cabled on the floor distributors from the core switch in a Gbit ring as backbone if the customer requires extended availability. To this end, special network components must be planned on midsized to highly complex networks with basic cabling of fiber optics and copper cable.



A – Distribution Switch B – Core Switch C – Edge Switch

Fiber Optics Twisted Pair

Yet another level for increasing reliability and redundancy is to employ two core switches at different locations.



Cabling of distribution switches and Desigo room automation stations

The distribution switches can be cabled in a ring, if RSTP capable, which offer high reliability. The important Desigo room automation stations (important rooms, central functions) are connected directly to the distribution switch. Less critical Desigo room automation stations are cabled to either remote edge switches or over daisy chain technology.

Desigo PXC3.E.../DXR2 room automation stations support cabling based on daisy chain topology. The max. number is 20 devices and in the event of a failed automation station, all other stations are no longer reachable.

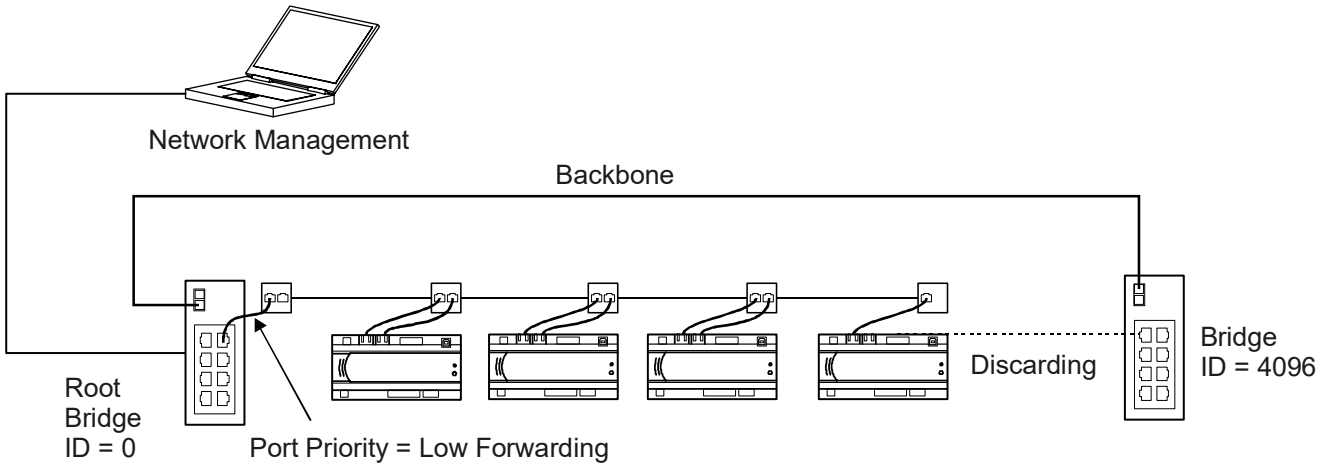
Desigo room automation stations can be cabled as ring topology if higher reliability is required.

This requires support for layer 2 switches RSTP (Rapid Spanning Tree Protocol) as well as SNMP monitoring and that any loss of superposed systems is reported.

In the event of a fault, switching the communication paths can take between 10 and 30 seconds.

DXR2/PXG3 automation stations route the RSTP protocol for the switches. It does not actually process the RSTP protocol.

For details, see Section 3.3.5 in *Practical guide on IP networks in building automation and control* (CM110668).



Summary

The following tables show how to depict all devices and network components in a midsized to large project.

Plant category	Number of IP devices
PXC primary plants	3
DXR2/PXC3 individual room control & central functions	400
PXC00-E.D system controller, floor scope	4
DXR2 for central functions, building scope	2
PXC00-E.D system controller, building scope	1
PXG3.M for BBMD functionality	5
Reserves 5%	21
Amount	436

Network components	Type Siemens	Layer	Managed	No.
Edge switch on the floors	XB-005	2	No	16
Distribution switch per floor	XB-200	2	Yes	6
Core switch in the equipment rooms	XM 400	3	Yes	1

Description	Ground floor DXR2	2nd floor DXR2	3rd floor DXR2	4th floor DXR2	BA Mgmt DXR2	Primary plants	System level	Refrigeration machines BACnet 3rd	Sinteso FS20 BMA
VLAN	VLAN 01	VLAN 02	VLAN 03	VLAN 04	VLAN 05	VLAN 06	VLAN 07	VLAN 10	VLAN 11
UDP port	BAC0	BAC0	BAC0	BAC0	BAC0	BAC0	BAC0	BAC0	BAC2
Subnet mask	255.255.255.0	255.255.255.0	255.255.255.0	255.255.255.0	255.255.255.0	255.255.255.0	255.255.255.0	255.255.255.0	255.255.255.0
Default gateway	192.168.11.254	192.168.12.254	192.168.13.254	192.168.14.254	192.168.15.254	192.168.16.254	192.168.17.254	192.168.20.254	192.168.21.254
Engineering notebook XWP/ABT	192.168.11.251	192.168.12.251	192.168.13.251	192.168.14.251	192.168.15.251	192.168.16.251	192.168.17.251	192.168.20.251	192.168.21.251
Number of DXR2/PXC3 and PXC00-E.D	101	101	101	101	3				

Description	Ground floor DXR2	2nd floor DXR2	3rd floor DXR2	4th floor DXR2	BA Mgmt DXR2	Primary plants	System level	Refrigeration machines BACnet 3rd	Sinteso FS20 BMA
Reserve IP addresses	149	149	149	149	247				
IP address range for DXR2 from…	192.168.11.1	192.168.12.1	192.168.13.1	192.168.14.1	192.168.15.1				
IP address range for DXR2 …to	192.168.11.200	192.168.12.200	192.168.13.200	192.168.14.200	192.168.15.50				
PXC00-E.D monitoring, floor scope	192.168.11.201	192.168.12.201	192.168.13.201	192.168.14.201					
Central functions, floor scope	192.168.11.1	192.168.12.1	192.168.13.1	192.168.14.1					
Central functions, superposed, building scope					192.168.15.1…2				
PXG3.M, BBMD in the floor scope	192.168.11.250	192.168.12.250	192.168.13.250	192.168.14.250					
PXG3.M, central BBMD in the building scope					192.168.15.250				
PXC00-E.D scheduler for floor scope					192.168.15.51				
Number of PXC, FS20, BACnet3rd						3	1	2	10
Reserve IP addresses						251	253	248	240
IP address range from…						192.168.16.1	192.168.17.1	192.168.20.1	192.168.21.1
IP address range …to						192.168.16.249	192.168.17.249	192.168.20.249	192.168.21.249

Description	Ground floor DXR2	2nd floor DXR2	3rd floor DXR2	4th floor DXR2	BA Mgmt DXR2	Primary plants	System level	Refrigeration machines BACnet 3rd	Sinteso FS20 BMA
PXC BBMD						192.168.16.1			
IP address range Mgmt'stations Desigo CC from···							192.168.17.11		
IP address range Mgmt'stations Desigo CC ...to							192.168.17.13		
Mgmt'station Desigo CC, entry in FDT							192.168.15.250		

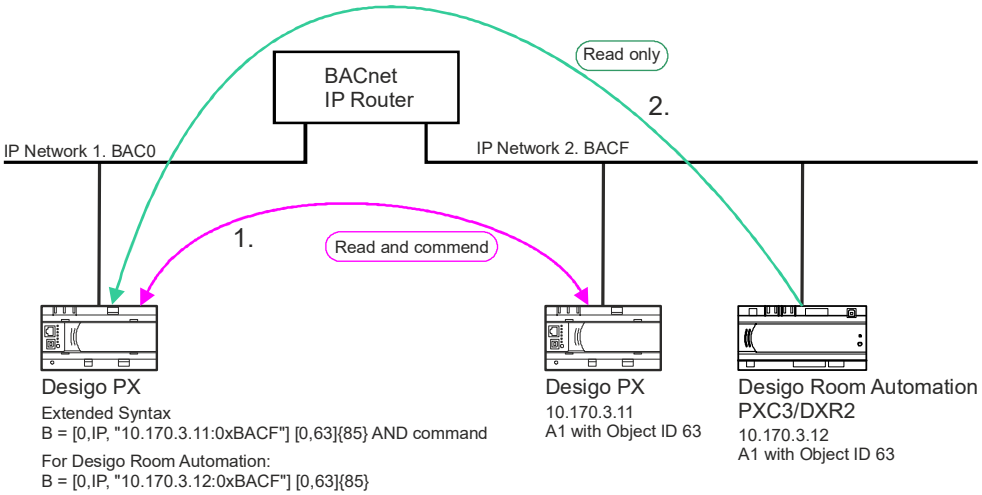
4.3 BACnet referencing over different IP networks

A common exception is the necessity to provide an individual data point to multiple locations in the building. One example is a weather station where the value is required on all BACnet networks. A coupling of BACnet networks via BBMDs for just this one data point is possible, but costly.

As a consequence, Desigo V6.1 was extended with the functionality of BACnet referencing to connect point-to-point between different IP networks / UDP ports.

No BBMD configuration is required for this functionality since it is a point-to-point connection (Unicast).

The following topology is thus also supported:



1. Desigo PX has **read and write** access to only one Desigo PX on another IP network (also on another UDP port).
2. Desigo PX has **read only** access to only one Desigo room automation station on another IP network.

Restriction

In Desigo V6.1, the PXC3/DXR2 Desigo room automation stations cannot read data points from other IP networks.

Syntax

B=[BACnet Network number (0=own network), Communication path (IP)"Station Address"] [Objecttype,Object ID]{Property ID}

Example: B=[0,IP,"10.170.3.11:0xBACF"][0,63]{85}

For details, see *Appendix C* in *Ethernet, TCP/IP, MS/TP and BACnet* (CM10666).

4.4 Diagnostics and troubleshooting BACnet/IP networks

General procedure for diagnostics and troubleshooting

BACnet on IP involves the use of a large number of components and this results in a certain degree of complexity and a corresponding vulnerability to errors.

If a problem arises in the system, it must be located in a step-by-step procedure. Always start you analysis at the lowest system. Only continue to the next higher system once you are sure that the system is operating correctly. A sketch of the topology is extremely helpful when attempting to locate problems. Create a sketch if none exists.

The following questions can help to troubleshoot communication problems.

Faults	Possible causes & troubleshooting
Is the link signal available on the IP components? With switches, the link signal is indicated by a continuous or flashing LED. In all devices in the Desigo system, the Service LED is continuously ON if no link signal is detected.	● Is the extension module (PXC modular) plugged in firmly? ● Are all connectors firmly in their sockets? ● Is there supply voltage for the switches? ● Were the RX and TX connections mixed up on fiber optics? ● Is the setting for the switch/router port correct?
Are VLAN switches used on the network?	● Are all BACnet devices configured on the same VLAN? ● A number of managed switches offer information on their own web interface on connected devices. This includes, for example, port speed, VLAN association, and packet statistics. The latter can also provide references on insufficient cabling.
Diagnostics via wireshark is not possible.	No port mirroring configured on the managed switches ● Use of hub or configured switch ● Consultation with customer IT on the use of wireshark
Wireshark does not have the proper BACnet services.	Layer 2 switch is used, but without port mirroring Use a hub or configure a corresponding layer 2 switch via the web interface
No communication between the BACnet client and the various BACnet devices.	Is a firewall available? Consultation with IT, cannot be discovered using the diagnostics tool. Firewall, UDP port configuration is not entered
The BACnet clients cannot access the different BACnet devices on the various VLANs.	BBMD in multiple IP segments BACnet devices do not have a unique instance number BACnet devices do not have a fixed IP address (if configured as BBMD) BBMD used, but all BACnet networks are the same UDP port?
Have you considered notes from technical documentation?	● *Desigo Ethernet, TCP/IP, MS/TP and BACnet fundamentals* (CM110666)
Communication, speed on the Desigo network	Compliance with system topology, regarding: ● Number of devices on a BACnet network. ● Max. number of 500 commanded group members. No more than 500 addresses can be managed. ● Max. number of 250 group members. The interface performance when acquiring data is limited, in other words, only a limited number of telegrams can be processes in brief period.

5 BACnet networks with MS/TP trunks

5.1 Designing BACnet networks with MS/TP trunks

MS/TP is Master-Slave/Token-Passing and stands for the BACnet data link protocol with services based on EIA-485 as the physical layer. It permits simple cabling on site with 3 wires up to a max. cable length of 1200 meters.

The logical principle behind MS/TP is the token passing, i.e. a token is transmitted in the system from one device to another over the EIA-485 bus. A device can only communicate after receive this token. MS/TP distinguishes between two types of devices:

- Master devices
- Slave devices

A BACnet slave can be read/written, but never receives the token. The disadvantage of slave devices is that slave devices cannot actually send out messages and always requires a master on the network to establish communications. On the other hand, it has the advantage of the transferring less tokens the more slaves that exist on the EIA-485 bus, which then accelerates overall communication. Overall, however, the disadvantages outweigh the advantages so that most MS/TP devices are set up as master devices.

Each mast on the network periodically outputs a poll for the next master, i.e. it checks its successor ability to forward the token. Each master sends out a query between the own address and the next known master address. For example, if the current address of the master device is 12 and the next known master address thus far is 22, the addresses 13...21 is polled periodically in ascending order to see whether a new mast device was added to the network with an address in this range. Unused gaps in addresses should be avoided since the system must wait for a timeout error to determine that there is no corresponding master under the queried address and this would negatively impact performance of a BACnet MS/TP system.

BACnet MS/TP has less bandwidth than BACnet/IP. MS/TP networks typically operated at 76.8 kBit/s, while IP networks operate at 100..1000 kBit/s.

All MS/TP devices must have the same baud rate in general with the slowest MS/TP device specifying the setting limit. You must ensure that no single MS/TP device slows down the system to achieve solid performance.

Even if MS/TP cannot be used as a general BACnet backbone, MS/TP devices still represent the correct choice for lots of applications due to the following benefits:

- Simple, cost-effective cabling based on proven EIA-485 technology
- MS/TP generally supports cable lengths of max. 1200m without additional network devices, thus supporting distributed control
- BACnet MS/TP is officially supported in the BACnet standard resulting in a seamless BACnet system at all levels
- BACnet MS/TP devices are cost-efficient on applications that do not require fast update rates (such as VAV and heat pump controllers) and where BACnet/IP devices cannot be used for cost reasons.

It is nevertheless important to correctly use and install the MS/TP networks to take advantage of the benefits. The following outlines aspects that are important for achieving optimum system performance.

5.2 MS/TP cabling and topology

Physically, an MS/TP bus is a line topology, even if it is logically a ring (due to the token passing principle). The following applies:

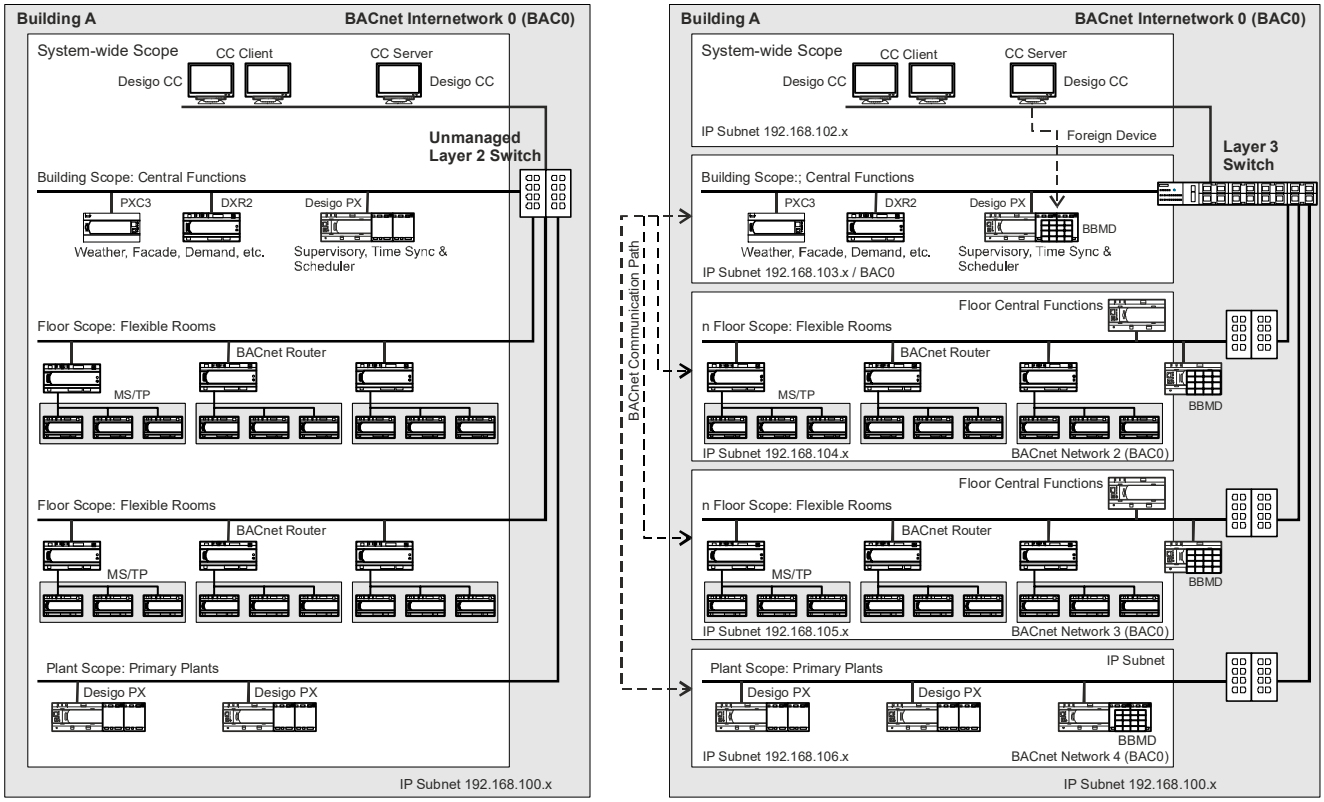
- The MS/TP network may only be implemented within a building.
- BACnet MS/TP networks may only be wired in a line topology. T connections/branches are prohibited. Stub lines are one exception (up to a maximum of 30 meters).
- In the Desigo system there are actually no pure BACnet /MS/TP networks. BACnet/IP is always used as the backbone.

For details, see *Desigo Ethernet, TCP/IP, MSTP and BACnet* (CM110666) and *Desigo room automation engineering, mounting and installation* (CM111043, section 10 *Network topology*).

As a rule a BACnet MS/TP-IP router to the IP network is always required when setting up a Desigo project with BACnet MS/TP devices. Since both the PXC··· for primary plants (in plant scope) and the central functions (in the building scope) as well as Desigo CC as a BACnet-capable management platform only communicated over BACnet/IP.

On smaller to mid-sized projects with low complexity, all BACnet/IP devices use the same UPD port; the BACnet-MS/TP-IP router only connects to the BACnet MS/TP networks.

On mid-sized to large projects at medium to high complexity, the BACnet MS/TP-IP router also takes over the BBMD functionality.



The following diagram illustrates which devices and functions are located in what scope and how the communication paths are defined. The floor scope does not require/support any interaction with another floor scope. Conversely, functions and applications in the building scope do communicate with the floor and plant scope. The plant scope processes the information (forced and demand signals) from the building scope.

You can determine that a floor can be a floor or floor segment, i.e. a MS/TP trunk with max. 64 participants (e.g. max. 64 DXR2.M). The MS/TP trunk can, however, also encompass multiple floors with max. 64 participants, in other words, a floor represents a zone with max. 64 BACnet MS/TP-capable devices/room automation stations. The following also applies to the MS/TP trunk: There are no central functions with group master function and rooms/room segments can only communicate within the trunk.

An IP network can include a max. 8 BACnet MS/TP-IP router and max. 250 DXR2.M devices. A separate device is needed per IP network that takes over the BBMD functionality. Devices implementing central functions can only communicated via BACnet/IP.

Different BACnet networks are interconnected to one BACnet internetwork that can include a max. 50 BACnet MS/TP-IP routers or max. 2500 DXR2.M devices.

This is a good point to refer once again to the two system limits to complete the concept:

Command process	Designing a system
Distribution/commanding of group masters to group member	Restricted to max. 500 group members

Collect data	Designing a system
Collecting data from the group members via the group master	Restricted to max. 250 group members

5.3 Checklist for designing BACnet networks with MS/TP trunks

Small to mid-sized project

Consider the following questions for detailed planning when designing a small to mid-sized project with a low level of network complexity:

Question	Designing the BACnet network	Designing the IP network
Is the number of Desigo room automation stations < 500?	One BACnet network	Small to mid-size project and networks of a lower complexity
Does the number of primary plants, implemented with Desigo PXC, < 200?	One BACnet network	
Are only HVAC and Desigo room automation stations planned on this project?	For lighting and blinds controls, see Section *Network topology* in the manual *Desigo room automation engineering, mounting and installation* (CM111043)	
Is the number of Desigo room automation stations on a flow (MS/TP segment) > 64?	Segments over multiple BACnet MS/TP IP routers	
Are multiple BACnet MS/TP IP routers used?	An IP network can include a max. 8 BACnet MS/TP IP routers and max. 250 DXR2.M devices.	
Are BACnet third-party devices used?	Own UDP port	
Does data exchange need to be implemented between BACnet third-party devices and Desigo units (PXC)?	Same UDP port	
Do you anticipate commanding more than 500 group member on central functions (emergency, service, or protection functions or operating modes and set points for lighting, blinds, HVAC, fire and wind, etc.)?	No → OK	
	The central functions need to be divided up for more than 500 group members. A group member is not the same as a room segment. A room segment can include lots of group members.	
Do you anticipate more than 250 group members on central functions that supply demand signals to supply plants? A cooling or heating valve sends out a demand signal. A room segment can send out multiple demand signals.	No → OK	

Question	Designing the BACnet network	Designing the IP network
	The central functions need to be divided up for more than 250 group members. A group member is not the same as a room segment. A room segment can include lots of group members.	
Superposed, it is used to monitor devices and schedule a monitoring device. Are there more than 500 BACnet references or more than 50 scheduler programs with a maximum of 5 references?	No → OK	
	Plan for another PXC for more than 500 BACnet references, i.e. more than 50 scheduler programs with a maximum each of 5 references and 250 BACnet references to the Desigo room automation stations. Recommendation: We recommend, when managing the project with BOS, using a monitoring device for scheduling or checking whether the scheduler program for the floor scope can be implemented using another PXC. Moreover, an additional PXC00-E.D is preferable for monitoring Desigo room automation stations. Reason: All references, etc., are deleted if BOS checks out a monitoring device and scheduler without Desigo room automation stations and the CFC data is generated from the XWP Point Configurator.	
Can an existing cable be used to network BACnet MS/TP devices?		Note the topology, cable types, max. cable length, outgoing lines and terminating resistances, line topology with stub lines MS/TP does not support a star topology
Should the IP network be redesigned and implemented?		Definition of subnetwork and IP addresses
Can the existing infrastructure be extended?		Clarify with IT
Are equipment rooms, control panels, distributors distributed over multiple floors?		Use of unmanaged layer 2 switches
What is the distance between control panels?		Clarify the distances (Ethernet sections over copper may only be ca. 90 meters long)
Are network diagnostics and troubleshooting required?		Managed layer 2 switches including configuration for port mirroring
Are reliability and redundancy required?		Managed layer 2 switches, RSTP
Is monitoring for faults/failures required?		SNMP or hardware contact
Is remote access required?		Use of security modules for firewall and VPN
Is IT security required?		Based on local and industry guidelines

Mid-sized project

Consider the following questions for detailed planning when designing a mid-sized project with a medium level of network complexity:

Question	Designing the BACnet network	Designing the IP network
Is the number of Desigo room automation stations between 500 and 2500?		Medium to large project and network of medium complexity
Does the number of primary plants, implemented with Desigo PXC, < 200?		
Are BACnet third-party devices used?	Own UDP port	
Is data exchange to Desigo devices (PXC) required?	Same UDP port	
Are equipment rooms, control panels, distributors distributed over multiple building sections or floors?		
Are the devices to control the primary plants centrally located in an equipment room?	Plant scope BACnet network	Plant scope on its own VLAN
Are the control units for the primary plants decentralized on different floors together with Desigo room automation stations?	Floor scope Own BACnet network	Floor scope on its own VLAN
Are BACnet/Desigo devices together on a separate BACnet network for building, plant, and floor scope?		Managed layer 2 switches, configuration of VLAN, and eventually port mirroring
Are different IP networks configured?	One BBMD per IP segment is required with an asymmetrical BDT. FDT must also be possible if there is a Desigo CC management platform or other BAC clients for operation.	

Large project

Consider the following questions for detailed planning when designing a large project with a high level of network complexity:

Question	Designing the BACnet network	Designing the IP network
Are other disciplines (fire, intrusion, video) planned on the project in addition to HVAC and Desigo room automation?		Large project and network of high complexity
Is the number of Desigo room automation stations between 500 and 15,000?		
Does the number of primary plants, implemented with Desigo PXC, < 200?		
Does building automation and control extend to multiple properties, buildings, and building sections?	Multiple BACnet internetworks, eventually with multiple BACnet networks	
Are there multiple properties or building requiring a clearly structured IP network?		Layer 3 switches for implementing multiple IP segments
Is IT security required?		Based on local and industry guidelines

5.4 Application examples

The following examples demonstrates network planning and configuring of a BACnet network up to commissioning in the real world.

The examples illustrate the required clarifications and planning steps, the selection and configuration of hardware components involved in implementing small to mid-sized, up to large Desigo projects.

We rely on products from the Siemens portfolio in the examples. The network components must meet the same requirements and function if you can use existing IT infrastructure to implement the project.

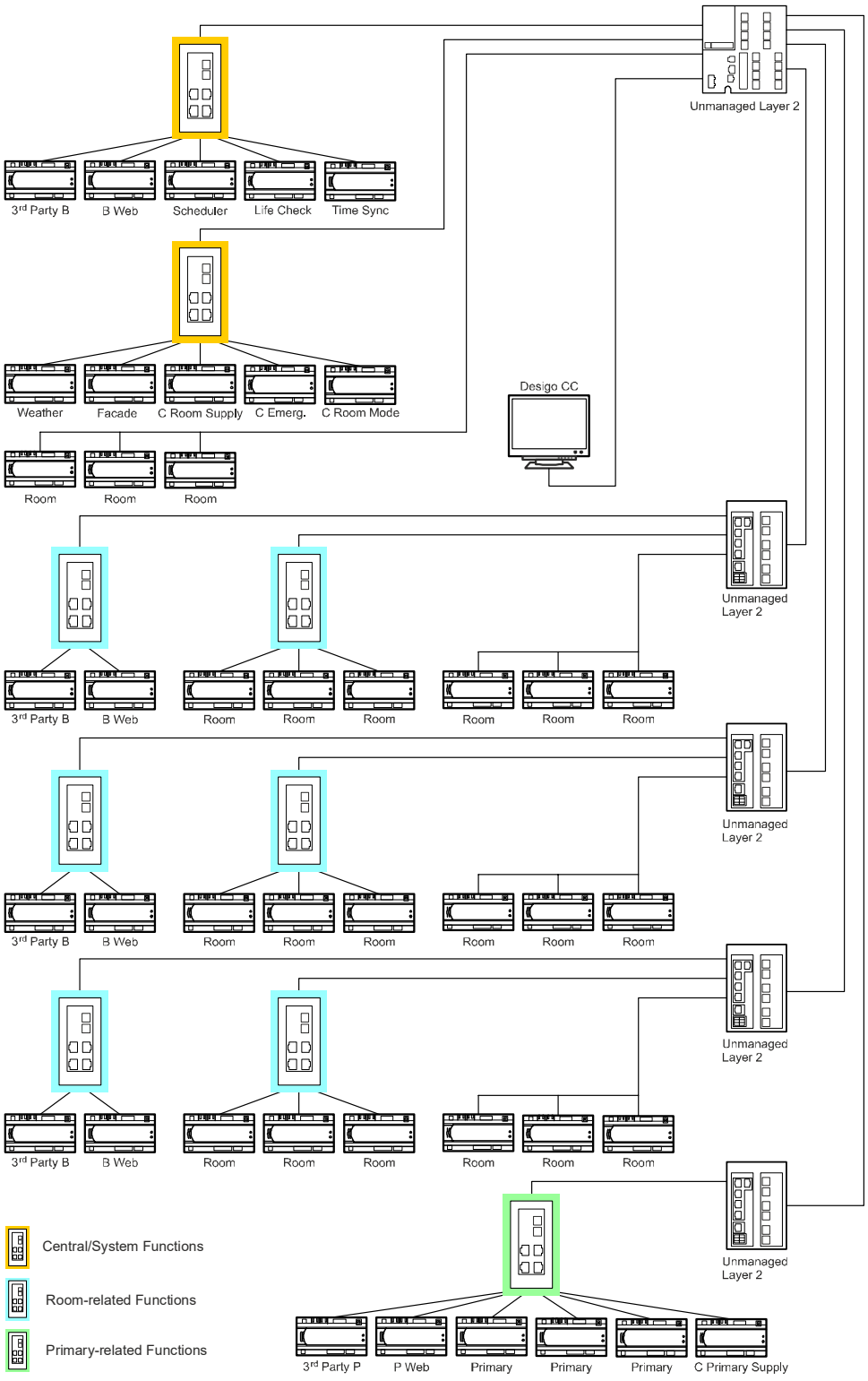
5.4.1 Network for a small to mid-sized project

Example for planning and implementing a project.

Project Description

- New office building with room automation for 136 rooms over 4 floors as well as preparing the appropriate primary plants.
- Each floor is leased by another tenant and has its own occupancy and use, i.e. the room operating mode as well as associated room setpoints, lighting per floor with central operation, and emergency function over all floors.
- Blinds control for each facade, including protection, service, and emergency function over all floors, a central weather station, demand-control of primary plants.
- Schedulers together with a calendar for room operating modes and lighting for each floor, superposed functions on a monitoring device.
- Primary plants for air handling, heat generation and distribution as well as central distribution of refrigeration on equipment rooms.
- Primary plants and general: 5 PXC100-E.D und 1 PXC00-E.D
- Desigo room automation stations: 120 DXR2.M and 1 DXR2.E18
- Network infrastructure: Visualization and monitoring in the event of failure

Functional display of an example topology



Planning and implementation, IP network

Core level

A core switch is not needed since everything is located on one IP segment.

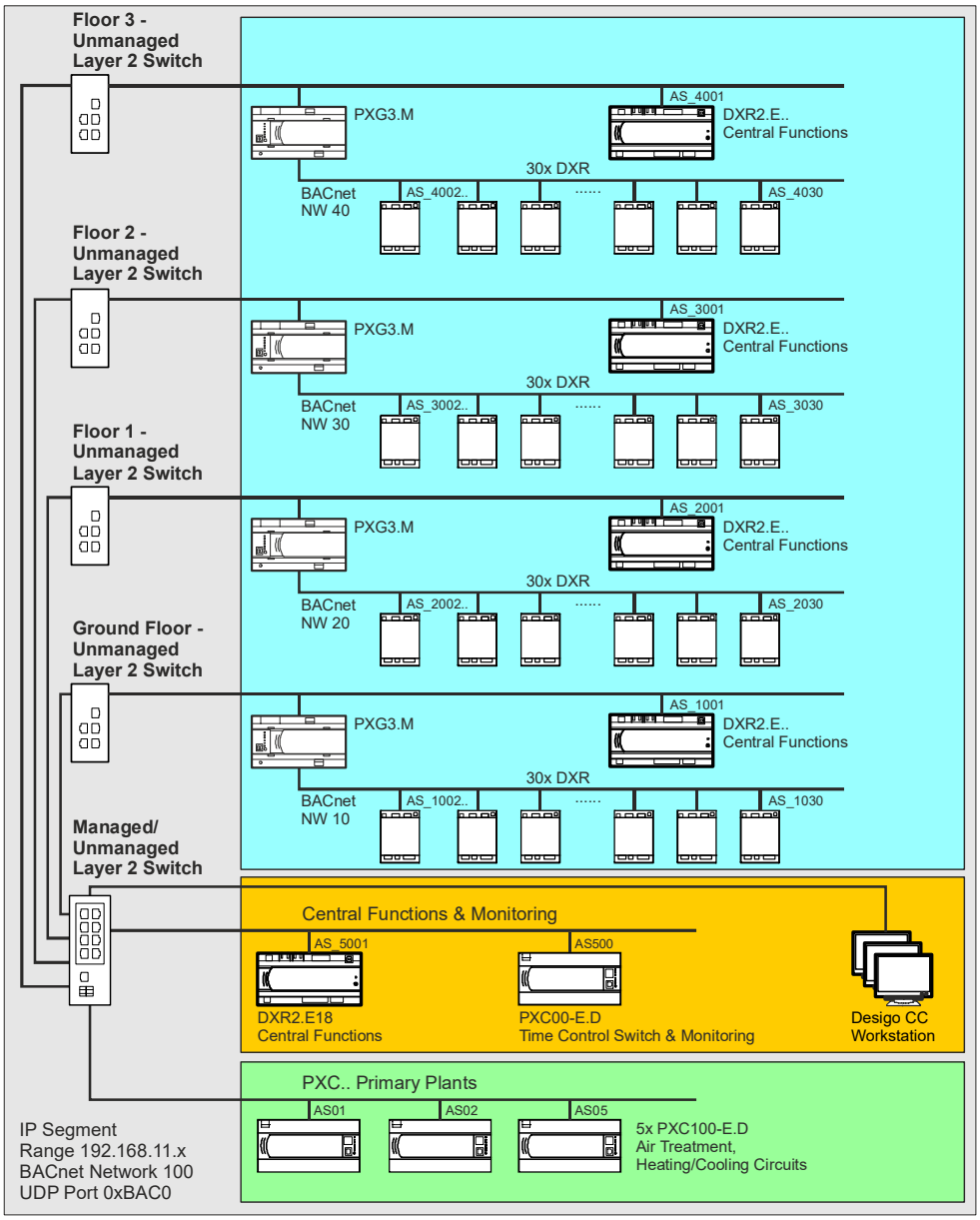
Distribution level

In the distribution level, in the riser zones, i.e. floor distributors:

- Unmanaged layer 2 switches are planned that are connected with copper cable
- A managed layer 2 switch is planned for network diagnostics and troubleshooting where a management platform is connected. An unmanaged layer 2 switch can be used as well if the customer has no special requirements.

BACnet MS/TP networks can have a max. cable length depending on the set baud rate. If the overall length is, however, exceeded, a new BACnet network must be created and connected via a BACnet MS/TP IP router to BACnet/IP over the Ethernet.

The rules apply again for BACnet/IP networks, i.e. the Ethernet network must be installed as an unmanaged layer 2 switch. Of course, a PXC.. can integrated in the given zones to control primary plants, depending on building planning.



IP/VLAN overview

Network designation	Network	Address range
Building automation and control	192.168.11.0/24	192.168.11.2⋯.192.168.11.254

Planning and implementation, BACnet networks

A BACnet internetwork is built using a multiple BACnet networks. All BACnet/IP capable Desigo devices communicate on the same UDP port, e.g. 0xBAC0.

The BACnet MS/TP IP router connects the BACnet/IP network to the different BACnet MS/TP networks on the floors. Note that each network must receive a unique network number.

Local and global broadcasts are not critical for this amount of devices, rooms, and plants, i.e. BBMD configuration is not required.

Each Desigo PXC.. automation station should have FDT functionality for maintenance and diagnostics and remote access.

Planning and implementation, HVAC and room automation

Plant scope:

- Desigo PXC···E.D to control primary plants.

Building scope:

- Desigo PXC00-E.D for superposed functions, e.g. scheduler for occupancy and use times by floor and monitoring Desigo room automation stations.
- Desigo DXR2.E18 for central functions over multiple floors.

Floor scope:

- Desigo DXR2.E exclusively for central functions.
- Desigo DXR2.M.. for rooms with HVAC, lighting, and blinds, or room segments with HVAC.
- PXG3.M BACnet-MS/TP IP router.

If project implementation permits (from a cost standpoint), we recommend distributing monitoring of Desigo room automation stations or schedulers for the floors over different monitoring units (PXC00-E.D).

Planning and implementation of central functions

Central function	1st floor Tenant A	Floor 1 Tenant B	Floor 2 Tenant C	Floor 3 Tenant D	The entire building, across floors
Hardware	AS1001	AS2001	AS3001	AS4001	AS5001
Central weather station					CenWthStn
Central setpoint generation via seasonal compensation					CenSsn
Central operating mode determination	CenOp_EG	CenOp_1OG	CenOp_2OG	CenOp_3OG	
AS500 Scheduler for room operating mode	SchedOp0 Scheduler, room operating mode ground floor	SchedOp1 Scheduler, room operating mode 2nd floor	SchedOp2 Scheduler, room operating mode 3rd floor	SchedOp3 Scheduler, room operating mode 4th floor	
Central operation lighting	CenOpLgt_EG	CenOpLgt_1OG	CenOpLgt_2OG	CenOpLgt_3OG	
AS500 Scheduler for lighting, building occupancy	SchedLg0 Scheduler, lighting occupancy, ground floor	SchedLg1 Scheduler, lighting, building occupancy, 2nd floor	SchedLg2 Scheduler, lighting, building occupancy, 3rd floor	SchedLg3 Scheduler, lighting, building occupancy, 4th floor	
AS500 Scheduler for lighting, system operation	SchedLg6 Scheduler, lighting system operation Ground Floor.	SchedLg7 Scheduler, lighting system operation 2nd floor.	SchedLg8 Scheduler, lighting system operation 3rd floor.	SchedLg9 Scheduler, lighting system operation 4th floor.	
Central emergency function lighting	CenEmgLgt_EG	CenEmgLgt_1OG	CenEmgLgt_2OG	CenEmgLgt_2OG	
Central emergency lighting (overall)					CenEmgLgt
Central shading operation	CenOpShd_EG	CenOpShd_1OG	CenOpShd_2OG	CenOpShd_3OG	

Central function	1st floor Tenant A	Floor 1 Tenant B	Floor 2 Tenant C	Floor 3 Tenant D	The entire building, across floors
AS500 Scheduler for shading, building occupancy	SchedSh0 Scheduler, shading, occupancy, ground floor	SchedSh1 Scheduler, shading, occupancy, 1st floor	SchedSh2 Scheduler, shading, occupancy, 2nd floor	SchedSh3 Scheduler, shading, occupancy, 3rd floor	
AS500 Scheduler for shading, system operation	SchedSh6 Scheduler, shading system operation ground floor.	SchedSh7 Scheduler, shading system operation 1st floor.	SchedSh8 Scheduler, shading system operation 2nd floor.	SchedSh9 Scheduler, shading system operation 3rd floor.	
Central emergency shading (overall)					CenEmgShd
Central protection function shading					CenPrtShd
Central service function shading	CenSrvShd_EG	CenSrvShd_1OG	CenSrvShd_2OG	CenSrvShd_3OG	
Central facade shading west					CenFcdShd_W
Central facade shading south					CenFcdShd_S
Central facade shading east					CenFcdShd_E
Hot water supply chain					SplyHw
Supply chain chilled water					SplyChw

Recommendation: Network components

- Siemens SCALANCE XB005 – Optional, as edge switch for cabling the BACnet-MS/TP IP router PXG3.M in the event the maximum cable length for the BACnet-MS/TP network is exceeded.
- Siemens SCALANCE XB005 - At the distribution level in the riser zones.
- Siemens SCALANCE XB205 - At the distribution level with port mirroring for diagnostics.

IT security and IT basic protection

The elements of infrastructure, IT systems, networks, and applications must be discussed under the aspects of security and appropriate measures need to be developed. Customer, domestic, or industry guidelines and directives must be observed under all circumstances.

For additional details, see *IT security on installations with Desigo* (CM110663) and *Practical Guide on IP Networks in Building Automation and Control Systems* (CM110668).

Summary

The following tables show how to depict all devices and network components in a small project.

Plant category	Number of IP devices	Number of MS/TP devices
PXC primary plants	5	
DXR2 individual room control & central functions	1	120
PXC00-E.D system controller, building scope	1	
PXG3.M BACnet-MS/TP IP router	4	
Reserves 5%	1	6
Amount	12	126

Network components	Type Siemens	Layer	Managed	No.
Edge switch per floor	XB005	2	No	4
Distribution switch in the equipment rooms	XB200	1	Yes	1

Description	2nd floor DXR2	3rd floor DXR2	4th floor DXR2	5th floor DXR2	Primary plant	System level
VLAN	VLAN 01	VLAN 01	VLAN 01	VLAN 01	VLAN 01	VLAN 01
UDP port	BAC0	BAC0	BAC0	BAC0	BAC0	BAC0
Subnet mask	255.255.255.0	255.255.255.0	255.255.255.0	255.255.255.0	255.255.255.0	255.255.255.0
Default gateway	192.168.11.254	192.168.11.254	192.168.11.254	192.168.11.254	192.168.11.254	192.168.11.254
Engineering notebook XWP/ABT						192.168.11.250
Number of DXR2	30	30	30	30		
MS/TP segment/ BACnet network number	1	2	3	4		
Baud rate (kBit/s)	115200	115200	115200	115200		
PXG3.M, MS/TP start address	0	0	0	0		
MS/TP addressing, Max.Master / Max.Info	30/50	30/50	30/50	30/50		
SNMP, read community	enabled, public	enabled, public	enabled, public	enabled, public		
IP address PXG3.M router	192.168.11.10	192.168.11.20	192.168.11.30	192.168.11.40		
Central functions for the overall building (DXR2.E18)						192.168.11.200
System controller monitoring floors (PXC00-E.D)						192.168.11.201
Number of PXC					5	
IP address range PXC primary plants from…					192.168.11.100	
IP address range PXC primary plants …to					192.168.11.199	
IP address range Mgmt'stations Desigo CC from…						192.168.11.210
IP address range Mgmt'stations Desigo CC f…to						192.168.11.215

5.4.2 Network for mid-sized to large BACnet MS/TP project structured with centralized primary plants

Example for planning and implementing a project.

Demand

- New office building with room automation for 424 rooms over 4 floors as well as preparing the appropriate primary plants.
- Each floor is leased by another tenant and has its own occupancy and use, i.e. the room operating mode as well as associated room setpoints, lighting per floor with central operation, and emergency function.
- Blinds control for each facade including protection, service, and emergency function.
- Central weather station, demand-controlled control of primary plants.
- Schedulers together with a calendar for room operating modes and lighting for each floor, superposed functions on a monitoring device.
- Primary plants for air handling, heat generation and distribution as well as central distribution of refrigeration in an equipment room.
- Primary plants and general: 5 PXC100-E.D und 5 PXC00-E.D
- Desigo room automation: 406 DXR2…
- Visualization, operating and monitoring Desigo CC
- Monitoring network components via SNMP

Planning and implementation, IP network

Core level

Core Switch (Managed Layer 3) as the network core, interface for remote maintenance, and office network as well as building additional IP segments or as a redundant backbone.

Distribution level

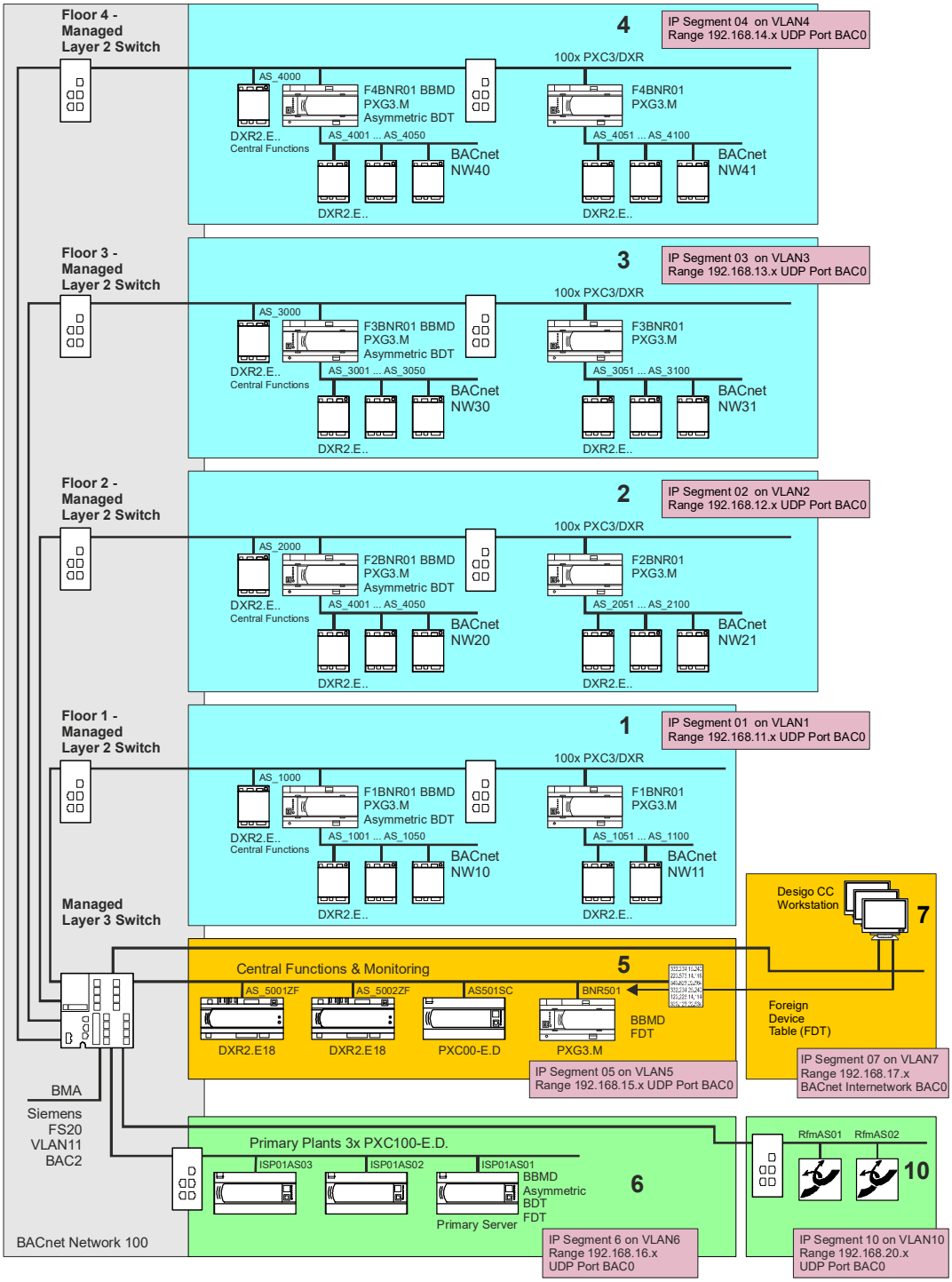
Managed layer 2 switches are planned on the distribution level, in the riser zones, i.e. floor distributors that:

- Are connected with copper cabling.
- Ensure that Desigo room automation stations from the given floor are located on its own VLAN and therefore isolated from other Desigo room automation stations on other floors for the purposes of local BACnet broadcasts.
- You can configure port mirroring of each VLAN for network diagnostics and troubleshooting.

Edge level

Only unmanaged layer 2 switches are planned as edge switches. BACnet MS/TP networks can have a max. cable length depending on the set baud rate. If the overall length is, however, exceeded, a new BACnet network must be created and connected via a BACnet MS/TP IP router to BACnet/IP over the Ethernet.

The rules apply again for BACnet/IP networks, i.e. the Ethernet network must be installed as an unmanaged layer 2 switch. A PXC.. can integrated in the given zones to control primary plants, depending on building planning.



IP/VLAN overview

Network designation	VLAN ID	Subnet	Address range	Default gateway
BA_TRA_01	1	255.255.255.0	192.168.11.1 -- 254	192.168.11.254
BA_TRA_02	2	255.255.255.0	192.168.12.1 -- 254	192.168.12.254
BA_TRA_03	3	255.255.255.0	192.168.13.1 -- 254	192.168.13.254
BA_TRA_04	4	255.255.255.0	192.168.14.1 -- 254	192.168.14.254
BA_Mgmt	5	255.255.255.0	192.168.15.1 -- 254	192.168.15.254

Network designation	VLAN ID	Subnet	Address range	Default gateway
BA_Hvac	6	255.255.255.0	192.168.16.1 -- 254	192.168.16.254
BA_CC_BuB	7	255.255.255.0	192.168.17.1 -- 254	192.168.17.254
BA_Rfm	10	255.255.255.0	192.168.20.1 -- 254	192.168.20.254
DMS_FS20	11	255.255.255.0	192.168.21.1 -- 254	192.168.21.254

An IP segment can also be divided on a project-by-project bases into a part with static addresses, e.g. automation stations, etc., and a dynamic part (DHCP), e.g. for engineering laptops.

As an alternative, you can also work in general with DHCP. You must ensure, however, that the stations always have the same IP address. This applies to:

- BACnet device that assume BBMD functionality.
- Room automation stations with an on-board web server and are operated with ABT SSA for servicing and diagnostics.

Planning and implementation, BACnet network

Each Desigo PXC.. automation station should have FDT functionality for maintenance and diagnostics and remote access.

A BACnet internetwork is built using a multiple BACnet networks. The IP segment as well as each MS/TP segment forms a BACnet network. A BBMD must be used in each IP segment in order for BACnet and IP networks to interact. This permits isolating local broadcasts from the flexible room management (room/room segment). Global broadcasts, originating from central functions, are managed on the BACnet device that assumes the BBMD functionality by asymmetrical BDT entries (Broadcast Distribution Table).

Set up the device accordingly in the XWP network configurator. The following table provide an overview of the BACnet configuration:

Device name	BNR501	ISP01AS01	F1BNR01	F2BNR01	F3BNR01	F4BNR01
Device Type	PXG3.M	PXC100-E.D	PXG3.M	PXG3.M	PXG3.M	PXG3.M
IP address	192.168.15.250	192.168.16.1	192.168.11.10	192.168.12.20	192.168.13.30	192.168.14.40
BACnet Network no.	NET100	NET100	NET01	NET02	NET03	NET04
UDP port	BAC0	BAC0	BAC0	BAC0	BAC0	BAC0
IP segment	05	06	01	02	03	04
BBMD	true	true	true	true	true	true
BDT						
IP address	192.168.15.250	192.168.16.1	192.168.11.250	192.168.12.250	192.168.13.250	192.168.14.250
	192.168.11.10	192.168.15.250	192.168.15.250	192.168.15.250	192.168.15.250	192.168.15.250
	192.168.12.20	-	-	-	-	-
	192.168.13.30	-	-	-	-	-
	192.168.14.40					
	192.168.16.1	-	-	-	-	-
Function	Central BBMD (is the node for all broadcast messages between VLAN 01-07	Main HVAC plant BBMD	BBMD for VLAN01 BACnet MS/TP IP router to the DXR on the 1st floor	BBMD for VLAN02 BACnet MS/TP IP router to the DXR on the 2nd floor	BBMD for VLAN03 BACnet MS/TP IP router to the DXR on the 2rd floor	BBMD for VLAN04 BACnet MS/TP IP router to the DXR on the 4th floor

How and why asymmetrical BDT entries?

Local broadcasts that use the flexible room management to locate and address room segments from the room, are routed to an own VLAN or BACnet network to a defined UDP port (0xBAC0). Local broadcasts are thus encapsulated and no longer forwarded to other networks.

BACnet Broadcast Management Devices (through the BDT) must, however, be defined for global BACnet broadcasts (originating, among others, from central functions) to operate successfully on the different IP segments and BACnet networks.

From the project topology above, a PXG3.M (BNR501) must be in the building scope for performance reasons:

- Support the BBMD function on the first port.
- Enter its own IP address in the BDT to 0xBAC0 (1.Port).
- Enter all other IP address for the BBMDs in the other IP segments that also communicated on UDP port 0xBAC0.

A BBMD must be defined for any other IP segments, i.e. the BDT is also enabled on the PXG3 to BAC0. In the BDT is the own IP address and address for BNR501.

The Desigo CC management platform registers as a third-party device in BNR501. The broadcast can be triggered here and forward via the asymmetrical BBMD entries to all other participants in the various IP segments.

As an alternative, you can of course work with DHCP. Important is that all devices that support BBMD functionality must receive a fixed IP address.

Planning and implementation, HVAC and room automation

Plant scope:

- Desigo PXC···E.D to control primary plants.

Building scope:

- Desigo PXC00-E.D and DXR2.E18 for superposed functions, e.g. scheduler for occupancy and use times by floor and central functions across floors.
- PXG3.M BACnet MS/TP IP router as central BBMD for structuring the BACnet networks.

Floor scope:

- Desigo DXR2.E18 exclusively for central functions.
- Desigo DXR2.M.. for rooms with HVAC, lighting, and blinds, or room segments with HVAC.
- PXG3.M BACnet-MS/TP IP router.

You can operate with cascading group master functions if lighting and blinds exceed a maximum of 500 commandable group members. This can, for example, be used for emergency control of blinds actuators over multiple facades over lighting over multiple floors.

Notes on project implementation

In the project example above was generously planned (since it is a midsized to large project) and one PXC00-E.D was assigned to each floor scope as well. It assumes monitoring of Desigo room automation stations. The PXC00-E.D in the building scope is used for scheduling and superposed functions for various floors as well as central functions for room operating mode, lighting, and blinds.

Depending on the building plan, air handing may not be centralized, but rather distributed decentralized on each floor. A PXC100-E.D each is used in the floor scope to this end. It takes over scheduling and superposed functions for the floor / floor scope. The PXC00-E.D monitoring unit is used in the building scope to monitor Desigo room automation stations.

Planning and implementation of central functions

Central function	Ground floor	Floor 1	Floor 2	Floor 3	Entire building
Hardware	AS_1000	AS_2000	AS_3000	AS_4000	AS_5001ZF AS_5002ZF
Central weather station					CenWthStn
Central setpoint generation via seasonal compensation for North, East, South, West					CenSsnN CenSsnE CenSsnS CenSsnW
Central operating mode determination	CenOp_EG	CenOp_1OG	CenOp_2OG	CenOp_3OG	

Central function	Ground floor	Floor 1	Floor 2	Floor 3	Entire building
AS501SC Scheduler for room operating mode	SchedOp0 Scheduler, room operating mode ground floor	SchedOp1 Scheduler, room operating mode 2nd floor	SchedOp2 Scheduler, room operating mode 3rd floor	SchedOp3 Scheduler, room operating mode 4th floor	
Central operation lighting	CenOpLgt_EG	CenOpLgt_1OG	CenOpLgt_2OG	CenOpLgt_3OG	
AS501SC Scheduler for lighting, building occupancy	SchedLg0 Scheduler, lighting occupancy, ground floor	SchedLg1 Scheduler, lighting, building occupancy, 2nd floor	SchedLg2 Scheduler, lighting, building occupancy, 3rd floor	SchedLg3 Scheduler, lighting, building occupancy, 4th floor	
AS501SC Scheduler for lighting, system operation	SchedLg6 Scheduler, lighting system operation Ground Floor.	SchedLg7 Scheduler, lighting system operation 2nd floor.	SchedLg8 Scheduler, lighting system operation 3rd floor.	SchedLg9 Scheduler, lighting system operation 4th floor.	
Central emergency function lighting	CenEmgLgt_EG	CenEmgLgt_1OG	CenEmgLgt_2OG	CenEmgLgt_2OG	
Central emergency lighting (overall)					CenEmgLgt
Central blinds operation	CenOpShd_EG	CenOpShd_1OG	CenOpShd_2OG	CenOpShd_3OG	
AS501SC Scheduler for blinds, building occupancy	SchedSh0 Scheduler, blinds, occupancy, ground floor	SchedSh1 Scheduler, blinds, occupancy, 1st floor	SchedSh2 Scheduler, blinds, occupancy, 2nd floor	SchedSh3 Scheduler, blinds, occupancy, 3rd floor	
AS501SC Scheduler for blinds, system operation	SchedSh6 Scheduler, shading system operation ground floor.	SchedSh7 Scheduler, shading system operation 1st floor.	SchedSh8 Scheduler, shading system operation 2nd floor.	SchedSh9 Scheduler, shading system operation 3rd floor.	
Central emergency shading (overall)					CenEmgShd
Central protection function shading					CenPrtShd
Central service function shading	CenSrvShd_EG	CenSrvShd_1OG	CenSrvShd_2OG	CenSrvShd_3OG	
Central facade shading west					CenFcdShd_W
Central facade shading south					CenFcdShd_S
Central facade shading east					CenFcdShd_E
Hot water supply chain	SplyHw	SplyHw	SplyHw	SplyHw	SplyHw (Total)
Supply chain chilled water	SplyChw	SplyChw	SplyChw	SplyChw	SplyChw (Total)
Supply chain ventilation	SplyAir	SplyAir	SplyAir	SplyAir	SplyAir (Total)

Recommendation: Network components

- Siemens SCALANCE XB005 - as the edge switch for cabling PXC and Desigo room automation stations.
- Siemens SCALANCE XB205 - At the distribution level in the riser zones for setting up VLANs and port mirroring for diagnostics.
- Siemens SCALANCE XM405 - As core switch for possible IP routing.

Siemens SCALANCE switches from the product family X-200 or X-400 support SNMP and can be monitored on Desigo CC.

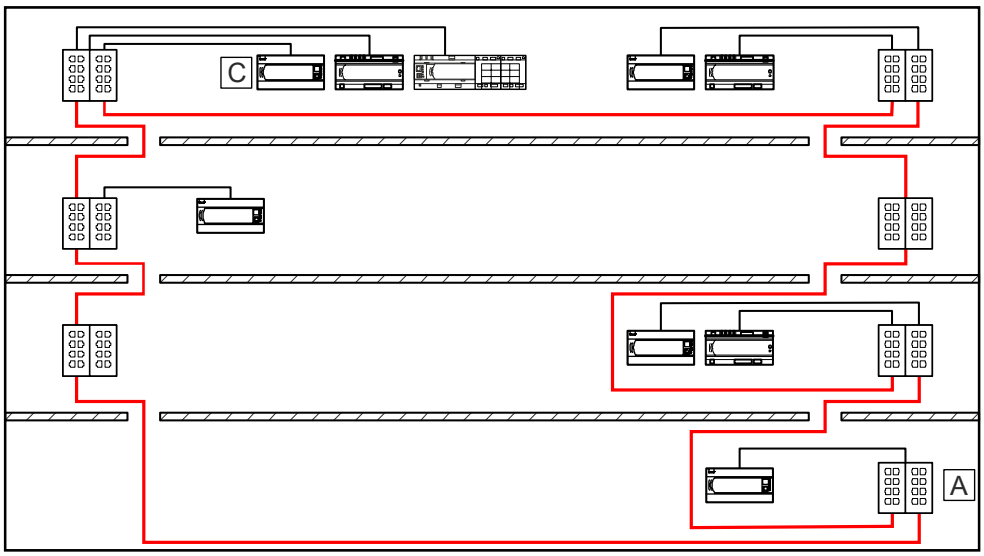
IT security and IT basic protection

The elements of infrastructure, IT systems, networks, and applications must be discussed under the aspects of security and appropriate measures need to be developed. Customer, domestic, or industry guidelines and directives must be observed under all circumstances.

For additional details, see *IT security on installations with Desigo* (CM110663) and *Practical Guide on IP Networks in Building Automation and Control Systems* (CM110668).

Reliability and redundancy

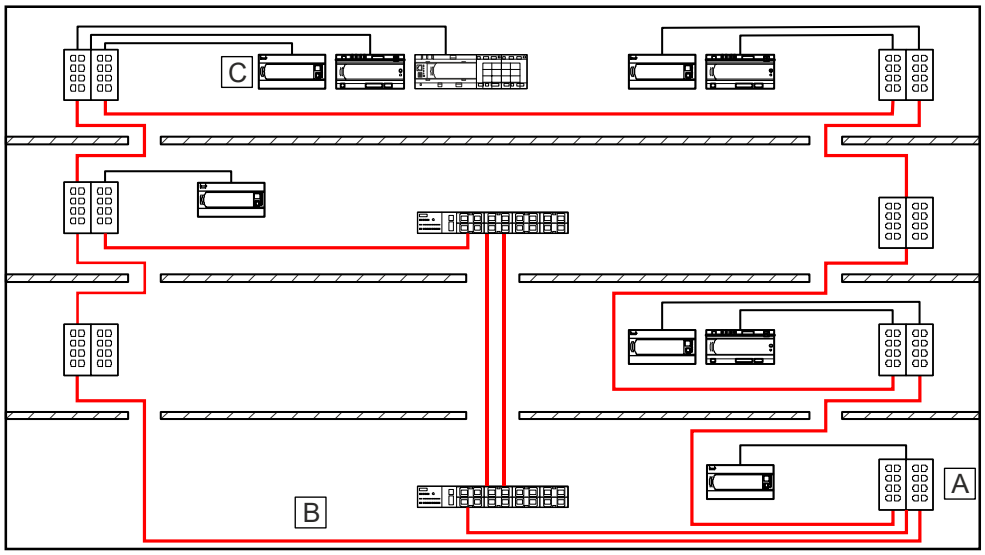
Distribution switches can be cabled on the floor distributors from the core switch in a Gbit ring as backbone if the customer requires extended availability. To this end, special network components must be planned on midsized to highly complex networks with basic cabling of fiber optics and copper cable.



A – Distribution Switch B – Core Switch C – Edge Switch

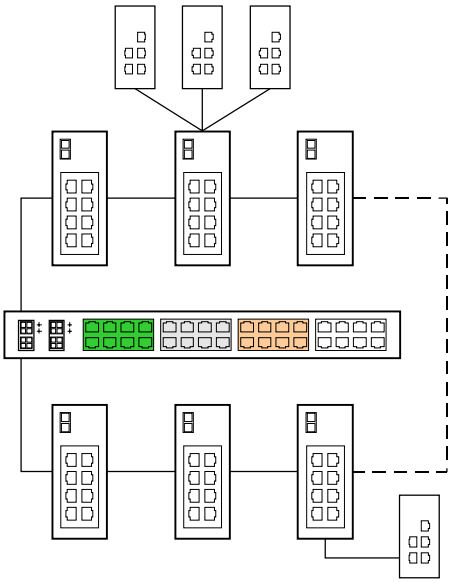
Fiber Optics Twisted Pair

Yet another level for increasing reliability and redundancy is to employ two core switches at different locations.



Cabling the distribution switches

The distribution switches can be cabled in RSTP, increasing reliability. The BACnet MS/TP IP routers are either connected directly to the distribution switch or on remote edge switches.



Benefits

- The backbone is executed redundantly as ring.
- The smaller, e.g. unmanaged switches are connected in a star topology based on importance or price pressure.
- Cost savings during installation.
- Compromises are possible, e.g. more important devices can be planned directly on the ring switch.

Disadvantages

- Distribution switches typically support SNMP; a failure can be reported via the Desigo CC management platform. This would go unnoticed in this topology.
- The probability of failure increases for switches connected in a star topology.

For details, see Section 3.3.5 in *Practical guide on IP networks in building automation and control* (CM110668).

Summary

The following tables show how to depict all devices and network components in a midsized to large project.

Plant category	Number of IP devices	Number of MS/TP devices
PXC primary plants	3	
DXR2 individual room control		400
PXC00-E.D system controller, floor scope	4	
PXC00-E.D system controller, building scope	1	
DXR2.E18 for central functions, floor scope	4	
DXR2.E18 for central functions, building scope	2	
PXG3.M as BBMD, routing to by BACnet MS/TP	8	
PXG3.M, as central BBMD, building scope	1	
Reserves 5%	1	20
Amount	24	420

Network components	Type Siemens	Layer	Managed	No.
Edge switch on the floors	XB-005	2	No	4
Distribution switch per floor	XB-200	2	Yes	6
Core switch in the equipment rooms	XM 400	3	Yes	1

Description	Ground floor DXR2	2nd floor DXR2	3rd floor DXR2	4th floor DXR2	BA Mgmt DXR2	Primary plants	System level	Refrigeration machines BACnet 3rd	Sinteso FS20 BMA
VLAN	VLAN 01	VLAN 02	VLAN 03	VLAN 04	VLAN 05	VLAN 06	VLAN 07	VLAN 10	VLAN 11
UDP port	BAC0	BAC0	BAC0	BAC0	BAC0	BAC0	BAC0	BAC0	BAC2
Subnet mask	255.255.255.0	255.255.255.0	255.255.255.0	255.255.255.0	255.255.255.0	255.255.255.0	255.255.255.0	255.255.255.0	255.255.255.0
Default gateway	192.168.11.254	192.168.12.254	192.168.13.254	192.168.14.254	192.168.15.254	192.168.16.254	192.168.17.254	192.168.20.254	192.168.21.254
Engineering notebook XWP/ABT	192.168.11.251	192.168.12.251	192.168.13.251	192.168.14.251	192.168.15.251	192.168.16.251	192.168.17.251	192.168.20.251	192.168.21.251
IP address range PXG3.M router from…	192.168.11.10	192.168.11.20	192.168.11.30	192.168.11.40					
IP address range PXG3.M router ... to	192.168.11.19	192.168.11.29	192.168.11.39	192.168.11.49					
IP address range for DXR2.E18 (central function) from…	192.168.11.1	192.168.12.1	192.168.13.1	192.168.14.1	192.168.15.1				
IP address range for DXR2.E18 (central function) to…	192.168.11.9	192.168.12.9	192.168.13.9	192.168.14.9	192.168.15.9				
PXG3.M as BBMD, routing to MS/TP	192.168.11.10	192.168.11.20	192.168.11.30	192.168.11.40					
PXG3.M, central BBMD in the building scope					192.168.15.250				
Number of DXR2/PXC3	101	101	101	101	2				
MS/TP segment / BACnet network number from...	10	20	30	40					
MS/TP segment / BACnet network number ... to	19	29	39	49					
Baud rate (kBit/s)	115200	115200	115200	115200					

Description	Ground floor DXR2	2nd floor DXR2	3rd floor DXR2	4th floor DXR2	BA Mgmt DXR2	Primary plants	System level	Refrigeration machines BACnet 3rd	Sinteso FS20 BMA
PXG3.M, MS/TP start address	0	0	0	0					
MS/TP addressing, Max.Master / Max.Info	100/50	100/50	100/50	100/50					
SNMP, read community	enabled, public	enabled, public	enabled, public	enabled, public					
Central functions, floor scope	192.168.11.1	192.168.12.1	192.168.13.1	192.168.14.1					
Central functions, superposed, building scope					192.168.15.1…2				
Number of PXC, FS20, BACnet3rd						3	1	2	10
Reserve IP addresses						251	253	248	240
IP address range from…						192.168.16.1	192.168.17.1	192.168.20.1	192.168.21.1
IP address range ...to						192.168.16.249	192.168.17.249	192.168.20.249	192.168.21.249
PXC BBMD						192.168.16.1			
IP address range Mgmt'stations Desigo CC from…							192.168.17.11		
IP address range Mgmt'stations Desigo CC ...to							192.168.17.13		
Mgmt'station Desigo CC, entry in FDT							192.168.15.250		

5.5 Diagnostics and troubleshooting in BACnet networks with MS/TP trunks

Typical faults and their solution

BACnet on MS/TP involves the use of a large number of components and this results in a certain degree of complexity and a corresponding vulnerability to errors.

If a problem arises in the system, it must be located in a step-by-step procedure. Always start you analysis at the lowest system. Only continue to the next higher system once you are sure that the system is

operating correctly. A sketch of the topology is extremely helpful when attempting to locate problems. Create a sketch if none exists.

BACnet MS/TP devices are introduced to the Desigo system over the BACnet MS/TP IP router to the Ethernet. In other words, you consider topics from the BACnet/IP world and include it in your analysis when troubleshooting problems.

The following questions can help to troubleshoot communication problems.

Faults	Possible causes & troubleshooting
Check cabling prior to commissioning	● 3-wire cabling wherever possible. Is the common reference signal wiring only grounded on one end with the PTC thermistor (TRF250-120)? ● Are the wires + and - for the EIA-485 bus correctly terminated with 120 Ohm resistance at both physical ends of the wires? ● Note that some MS/TO devices have integrated resistance. Make sure they are disabled (unless the corresponding device is in fact at the end of the EIA-485 bus). ● Make sure in a mixed operation of 2 and 3-wire environment, that the cable shield is not used as a common reference signal wire for 3-wire devices. ● MS/TP does not support a star topology Split up the cabling and eventually network it over multiple trunks and routers. ● Check in a mixed operation with 2 and 3-wire environment that the cable shield is not connected.
No communication to the BACnet MS/TP devices.	● Is the entered baud rate incorrect? The same transmission rate must be configured on all MS/TP devices on the same EIA-485 bus, with the slowest of the devices specifying the value. ● Max. 115 kBaud, but the baud rate must be set back to 76.8 kBaud at cable lengths in excess of ~750 m. ● The devices are incorrectly configured (no master) or no slave proxy is set for the slave. ● Check the terminating resistances and terminals or cabling. ● The network is not or incorrectly configured. Check the settings on the BACnet routers PXG3.M and on the DXR2.M... devices.
New BACnet MS/TP devices are not recognized.	● The MAX_MASTER value must be set to the highest available MS/TP address (max. number of devices). ● Max. number of 64 MS/TP Desigo room automation devices is exceeded.
The network does not recognize the BACnet MS/TP devices at the end of the trunk.	● Check whether the wiring between the last visible and next device is OK.
Communication is not reliable.	● Baud rates are not optimally set and should not be less than 76,800 baud. ● Check the cable shielding and terminating resistances. ● Terminating resistances are missing or installed in the wrong location. ● Wrong cable, incorrect polarity or the cable is grounded. ● A MS/TP third-party device on the trunk. ● Cable length exceeded. Install a repeater in the middle of the trunk.

Faults	Possible causes & troubleshooting
Communication is slow.	● A master device normally holds the token for only a few milliseconds, with the forwarding to the next device taking up to 250 ms. In other words, a high number of devices causes a high cycle which requires a very conservative (long) timeout value. You must configure the following timeouts if MS/TP devices participate in the communication: – APDU timeout: 6000 ms – APDU segment timeout: 5000 ms – Max Info frames: 50 ● Operation on the Desigo CC management platform requires, where there are lots of BACnet MS/TP devices, reading the functions sequentially by discipline. This requires training course and operator instructions.
Communication no longer restarts after a power outage or communication no longer starts after a power outage on the BACnet/IP router.	● Communication – Data traffic is too high or way too high. In other words, reduce or cease the following: – Room segment communication – No lighting or blinds application – Max. one Desigo CC management platform – Max. 5 trends per room – Max. 3 alarms per room – No central functions for gathering, i.e. for the hot water supply chain, chilled water, air
BACnet networks	● PXG3.M runs automatic network checks, and indicates errors with an illuminated Info-LED. ● PXG3.M operates on large projects as BBMD. These devices must have a fixed IP address and not DHCP. ● Only one PXG3.M with BBMD functionality permitted per BACnet network.
Have you considered notes from technical documentation?	● *Desigo Ethernet, TCP/IP, MS/TP and BACnet fundamentals* (CM110666) ● *Desigo room automation engineering, mounting and installation* (CM111043, Section *Network topology*)

6 Product for network infrastructure

How can we use Siemens SCALANCE products? This is only general information and not a product catalog.

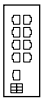
Siemens SCALANCE Switches

Siemens SCALANCE XB-000 series:

- Unmanaged layer-2 switches
- AC & DC 24 V voltage supply
- Main application: Edge & distribution level

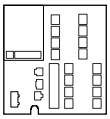
Siemens SCALANCE XB-200 series:

- Managed layer-2 switches
- Support ring topology & virtual networks (VLAN)
- Port mirroring for service
- Main application: Distribution level



Siemens SCALANCE XB-400 series:

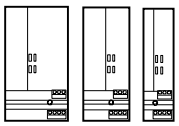
- Managed layer 3 switches (key plug required)
- Auxiliary router functionality
- Main application: Core level



SITOP power supply

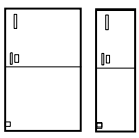
SITOP lite:

- 120/230 V AC
- 24 V / 2.5 A, 5 A, 10 A
- CE, cULus



SITOP Simatic design:

- 120/230 V AC
- 24 V / 3 A, 8 A
- CE, cULus



7 Glossary

Term	Definition
AS or PXC	Automation station for control of primary plants: PXC50/100/200-E.D
Group master	Group master in Desigo room automation to distribute operating modes, setpoints, or coordination signals to assigned group members.
Group member	Group member – logistical merger of HVAC, lighting, or shading functions.
BAC system	Building automation and control system
CLI	Command line interface, often referred to as console or terminal, is input pane to control software, typically (but not necessarily) text based.
SNMP	(Simple Network Management Protocol) A protocol developed by the Internet Engineering Task Force (IETF) to monitor and control network elements, including printers, switches, or computer, from a centralized location.
Latency time	Delay time, i.e. time interval from end of an event or command to the start of the reaction to this event. Network latency exists on communication networks. On Ethernet networks, this latency is caused by runtimes on the transmission medium and Ethernet switching. The latency time describes the time period that passed until bit received on the switch port leaves the destination port. The period is indicated in microseconds and is based on the switching method.
STEP7/TIA	Engineering tool for programming and commissioning automation stations and room automation stations.
BBMD	(BACnet Broadcast Management Device) Is used to distribute BACnet broadcasts over multiple IP segments.
Symmetrical BDT	(BACnet Distribution Table) Symmetrical means that all BBMDs are entered in the BDT, the BBMDs recognize one another and the unicast is distributed to all devices entered in the table.
Asymmetrical BDT	(BACnet Distribution Table) Asymmetrical means that the BACnet broadcast originating from a BACnet client on one IP segment travel in only one direction and are can be distributed to all other IP segments. No broadcasts are distributed from the queried IP segment to other IP segment so that broadcast data traffic on BACnet networks, distributed over multiple IP segments, can be controlled and kept to a minimum.

Overview of IPv4 address room

Allgemein gilt: $\text{Anzahl der IPv4-Adressen} = 2^{(32-\text{Länge der Netzadresse})}$

Notation	Adressen	Nutzbare Host-Adressen	Subnetzmaske dezimal	Subnetzmaske binär	Kommentar
/0	4.294.967.296	– [Anm. 1]	0.0.0.0	00000000.00000000.00000000.00000000	Vollständiger IPv4-Adressraum
/1	2.147.483.648	–	128.0.0.0	10000000.00000000.00000000.00000000	
/2	1.073.741.824	–	192.0.0.0	11000000.00000000.00000000.00000000	
/3	536.870.912	–	224.0.0.0	11100000.00000000.00000000.00000000	
/4	268.435.456	–	240.0.0.0	11110000.00000000.00000000.00000000	
/5	134.217.728	–	248.0.0.0	11111000.00000000.00000000.00000000	
/6	67.108.864	–	252.0.0.0	11111100.00000000.00000000.00000000	
/7	33.554.432	–	254.0.0.0	11111110.00000000.00000000.00000000	
/8	16.777.216	16.777.214	255.0.0.0	11111111.00000000.00000000.00000000	„Class A“-Größe
/9	8.388.608	8.388.606	255.128.0.0	11111111.10000000.00000000.00000000	
/10	4.194.304	4.194.302	255.192.0.0	11111111.11000000.00000000.00000000	
/11	2.097.152	2.097.150	255.224.0.0	11111111.11100000.00000000.00000000	
/12	1.048.576	1.048.574	255.240.0.0	11111111.11110000.00000000.00000000	
/13	524.288	524.286	255.248.0.0	11111111.11111000.00000000.00000000	
/14	262.144	262.142	255.252.0.0	11111111.11111100.00000000.00000000	
/15	131.072	131.070	255.254.0.0	11111111.11111110.00000000.00000000	
/16	65.536	65.534	255.255.0.0	11111111.11111111.00000000.00000000	„Class B“-Größe
/17	32.768	32.766	255.255.128.0	11111111.11111111.10000000.00000000	
/18	16.384	16.382	255.255.192.0	11111111.11111111.11000000.00000000	
/19	8.192	8.190	255.255.224.0	11111111.11111111.11100000.00000000	
/20	4.096	4.094	255.255.240.0	11111111.11111111.11110000.00000000	
/21	2.048	2.046	255.255.248.0	11111111.11111111.11111000.00000000	
/22	1.024	1.022	255.255.252.0	11111111.11111111.11111100.00000000	
/23	512	510	255.255.254.0	11111111.11111111.11111110.00000000	
/24	256	254	255.255.255.0	11111111.11111111.11111111.00000000	„Class C“-Größe
/25	128	126	255.255.255.128	11111111.11111111.11111111.10000000	
/26	64	62	255.255.255.192	11111111.11111111.11111111.11000000	
/27	32	30	255.255.255.224	11111111.11111111.11111111.11100000	
/28	16	14	255.255.255.240	11111111.11111111.11111111.11110000	
/29	8	6	255.255.255.248	11111111.11111111.11111111.11111000	
/30	4	2	255.255.255.252	11111111.11111111.11111111.11111100	Verbindungsnetz zwischen zwei Routern
/31	2	0 (2) [Anm. 2]	255.255.255.254	11111111.11111111.11111111.11111110	
/32	1	0 (1) [Anm. 2]	255.255.255.255	11111111.11111111.11111111.11111111	einzelner Host

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