

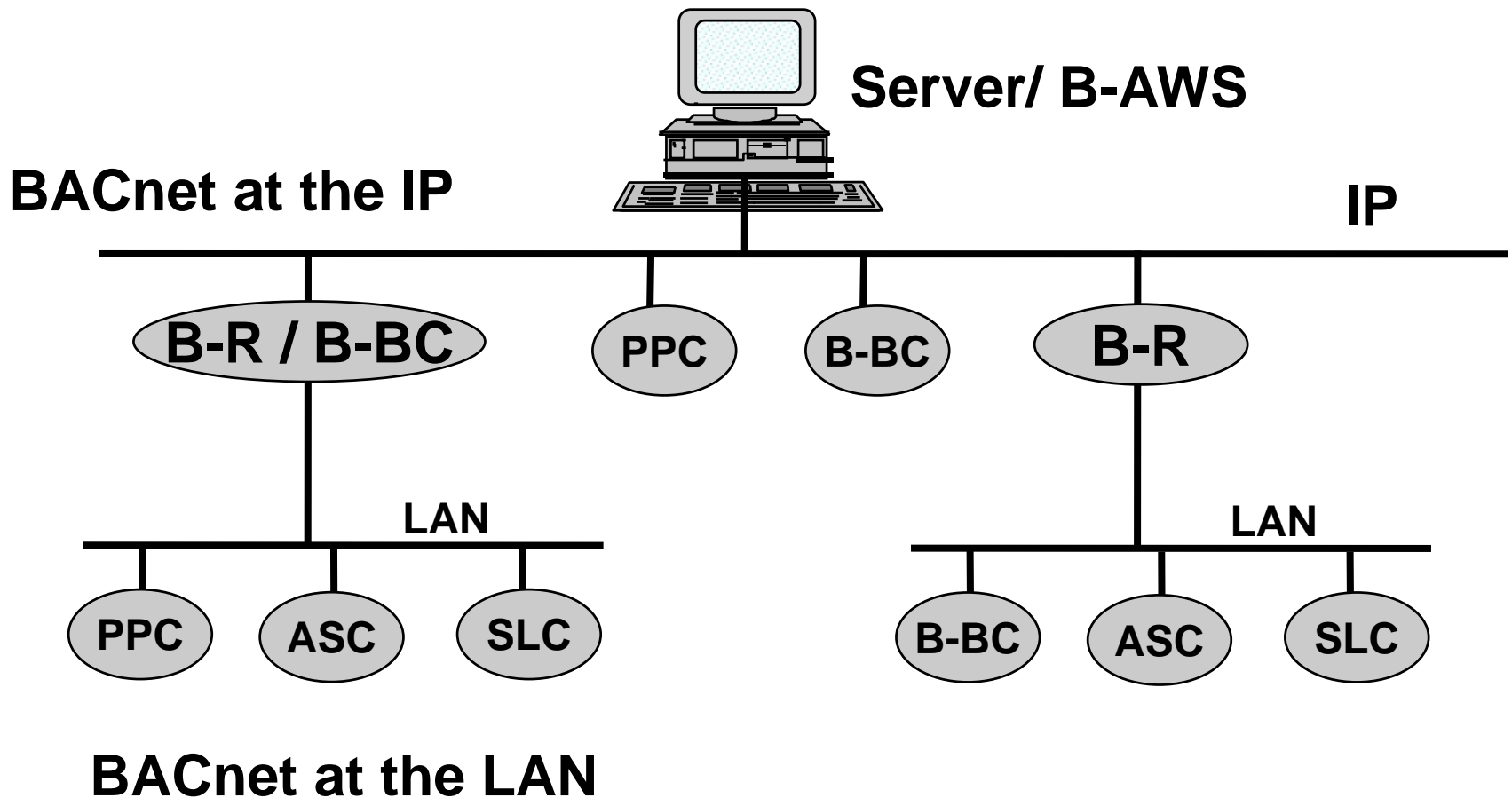
System Architecture For ASHRAE-135 (BACnet) Systems

Objectives

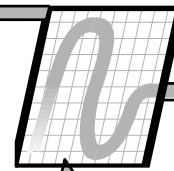


- Describe the system architectures based on BACnet at all levels.
- Describe the basics of the BACnet protocol.
 - Objects
 - Properties
 - Services
 - BIBBS
 - PICS
- Describe key issues in developing an Open System specification based on BACnet

BACnet Architecture



Terminology



- B-R: BACnet Router
- B-BC: BACnet Building Controller
- SLC: Supervisory Logic Controller
 - B-BC or B-AAC (Advanced Application Controller)
- PPC: Programmable Process Controller
 - B-AAC or B-BC
- ASC: Application Specific Controller
 - B-ASC (Application Specific Controller)
 - B-SA (Smart Actuator), B-SS (Smart Sensor)
- B-AWS: Advanced Workstation (avoid B-OWS)

Network Technology



- BACnet is ANSI/ASHRAE 135
- Top level (LAN) generally IP – suitable for Primary Control
 - Old technology: Ethernet, Arcnet, PTP
- Second level is generally MS/TP - Secondary Control
 - 38.4 kbps or 76.8 kbps
 - Master – Slave (not necessarily peer-to-peer)
 - Others : Arcnet, Ethernet, PTP, Others.
- MS/TP has various options
 - Often are issues with mixing devices from multiple vendors
 - What about VFDs?

BACnet Objects



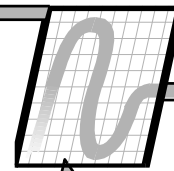
- BACnet defines standard objects
- These correspond to functional elements in the DDC system, e.g.:
 - Analog Input Object
 - Binary Output Object
 - Schedule Object
 - (PID) Loop Object
 - Trend Object
 - Device Object
 - “proprietary” Object
 - 30+ others

BACnet Properties



- Different Objects have different properties:
 - Present Value
 - Object Identifier
 - Status Flags
 - “proprietary” Properties
 - Many others
- Properties may be
 - Writeable (via BACnet services)
 - Read-only (not writeable via BACnet services)
 - Written via some closed, proprietary method
 - Optional (not implemented in a vendor's object)
 - Few requirements to **actually use** Properties

Analog Value Object



Object_Identifier	Number that IDs this for BACnet
Object_Name	A meaningful name
Present_Value	The actual analog value
Status_Flags	Various error and override flags
Out_Of_Service	Used during commissioning
Units	What are engineering units?
Priority_Array (O)	For overrides, what Priority
COV_Increment (O)	For COV
High_Limit (O)	For Alarms
Low_Limit (O)	For Alarms
(and many more)	

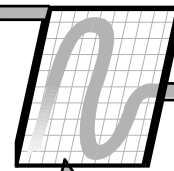
(O) is Optional Property

BACnet Services



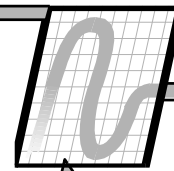
- Services are how devices communicate
- Services range from simple to complex:
 - Read Property
 - Read Trend Log
 - Subscribe COV notification
 - “proprietary” services
 - Many others
- Uses Client – Server model (Example: Read Property)
 - Device A (client): I know how to read your data
 - Device B (server): I'll let you read my data
 - Data exchange requires pairing up A and B devices!

BACnet BIBBs



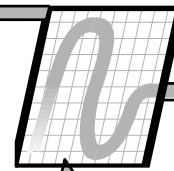
- BIBBs: BACnet Interoperability Building Blocks
 - Grouping of Services into useful chunks
 - Uses Client (A) – Server (B) model
 - DS-RP-B: I support Reading Properties
 - DS-RP-A: I support having my Properties Read
- Defined in Annex L of the BACnet spec
- Uses strange (but standard) naming:
 - DM-OCD-A = DeviceManagement, ObjectCreationDeletion, Client
 - DS-WP-B = DataSharing, WriteProperty, Server

Device Profiles



- BACnet defines standard hardware devices
- Specifies a minimum set of BIBBs for a device
 - B-BC: Building Controller
 - B-AAC: Advanced Application Controller
 - B-ASC: Application Specific Controller
 - B-SA, B-SS: Smart Actuator, Smart Sensor
 - B-AWS: Advanced Workstation
 - B-OWS: Operator Workstation (avoid)
 - B-OD: Operator Display – local display in the field

BACnet PICS



- Protocol Implementation Conformance Statement
- Describes how a given device supports BACnet
- Is it BTL listed as a BACnet type of device
 - Which one? (B-BC, B-ASC, etc..)
 - Generally, want to require BTL listed devices
- What media does it use?
- What objects and services can it **support**?
- Describes **capability**: a given device -- on **your** project -- may **not** implement that capability

BACnet describes *Capability*



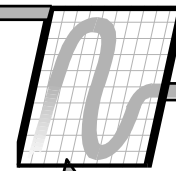
- ASHRAE 135–2012 is 1056 pages
- Clause 22.1.5: Minimum Device Requirements
 - **Have a Device Object**
 - **Have a Device ID that can range from 0 - 4194302**
 - **Execute Read Property Service**
 - Unless it's an MS/TP Slave: Execute Who-Has and Who-Is
 - If it executes WritePropertyMultiple, AddListElement, or RemoveListElement: Execute WriteProperty
 - Allow WriteProperty to modify any properties that can be modified by AddListElement or RemoveListElement
 - If the device contains any properties required to be Writeable: Execute WriteProperty
- Most else is “If you do <x>, you must do.....”

BACnet describes *Capability*

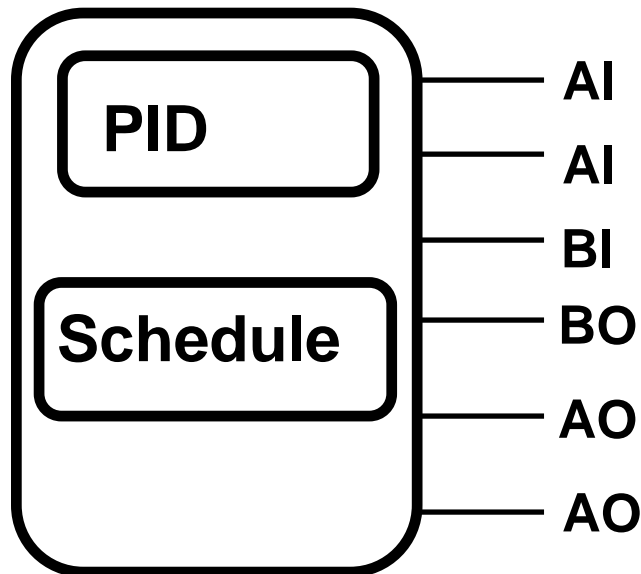


- Analog Output Object ***must*** be Writeable
 - e.g. other vendors can use BACnet to change the value.
- Analog Value Object ***may*** be Writeable
- BTL Implementation Guideline says:
 - If you can't provide a Writeable AO for a hardware Output, provide an AV instead
- In this case, BTL recommends using something other than an Analog Output Object for a Hardware Analog Output
- ***There's no requirement to use the AO Object – even for a real hardware Analog Output!***

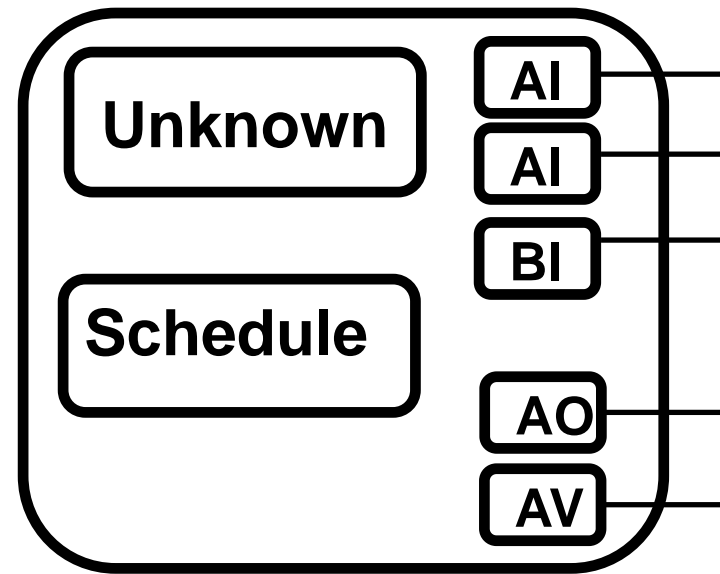
BACnet vs Reality



Physical Device

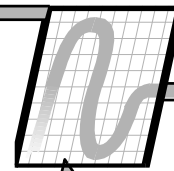


As it appears in BACnet

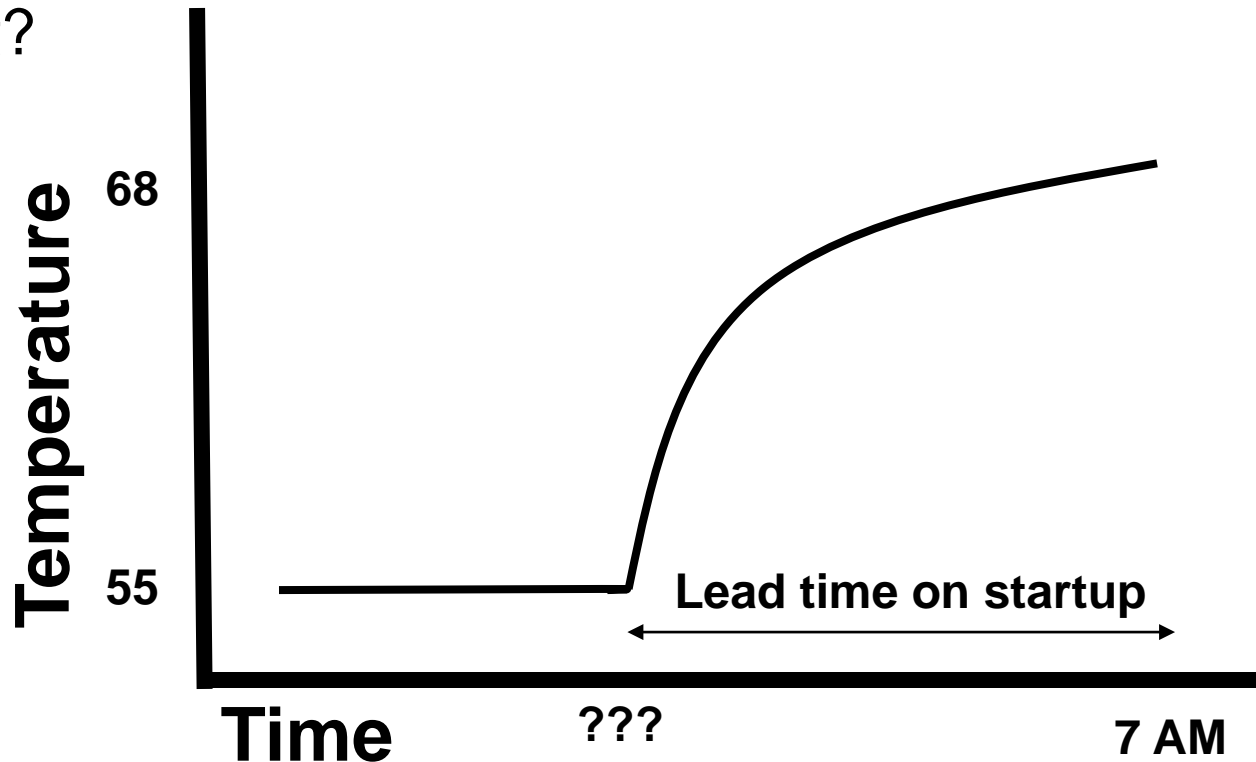


Not likely, but there's nothing in ASHRAE-135 that prevents this

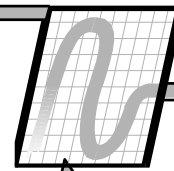
Devil in the Details: Optimum Start



- It's January in Madison. At 4 AM, it's -20 F outside and 55 F inside. By 7 AM it needs to be 68 F inside for occupied conditions. When do you need to turn on the heat?

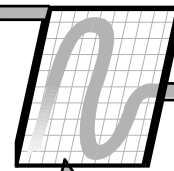


Devil in the Details: Optimum Start



- This is a ***hard problem***: You need to know a lot about system capacity, outdoor conditions, building dynamics.
- Usually, the AHU controller computes the necessary lead time (say today's value is 93 minutes, AHU should start at 5:27 AM)
- Then, the AHU has to know either:
 - Occupancy time and current time (i.e. the scheduler is in the AHU) --- OR ---
 - Time until occupancy from schedule device (i.e. "Occupancy in 90 minutes".... ".... in 85 minutes....") – i.e. advance notice of impending occupancy
- The AHU can then start with enough lead time.

ASHRAE-135 can't do this



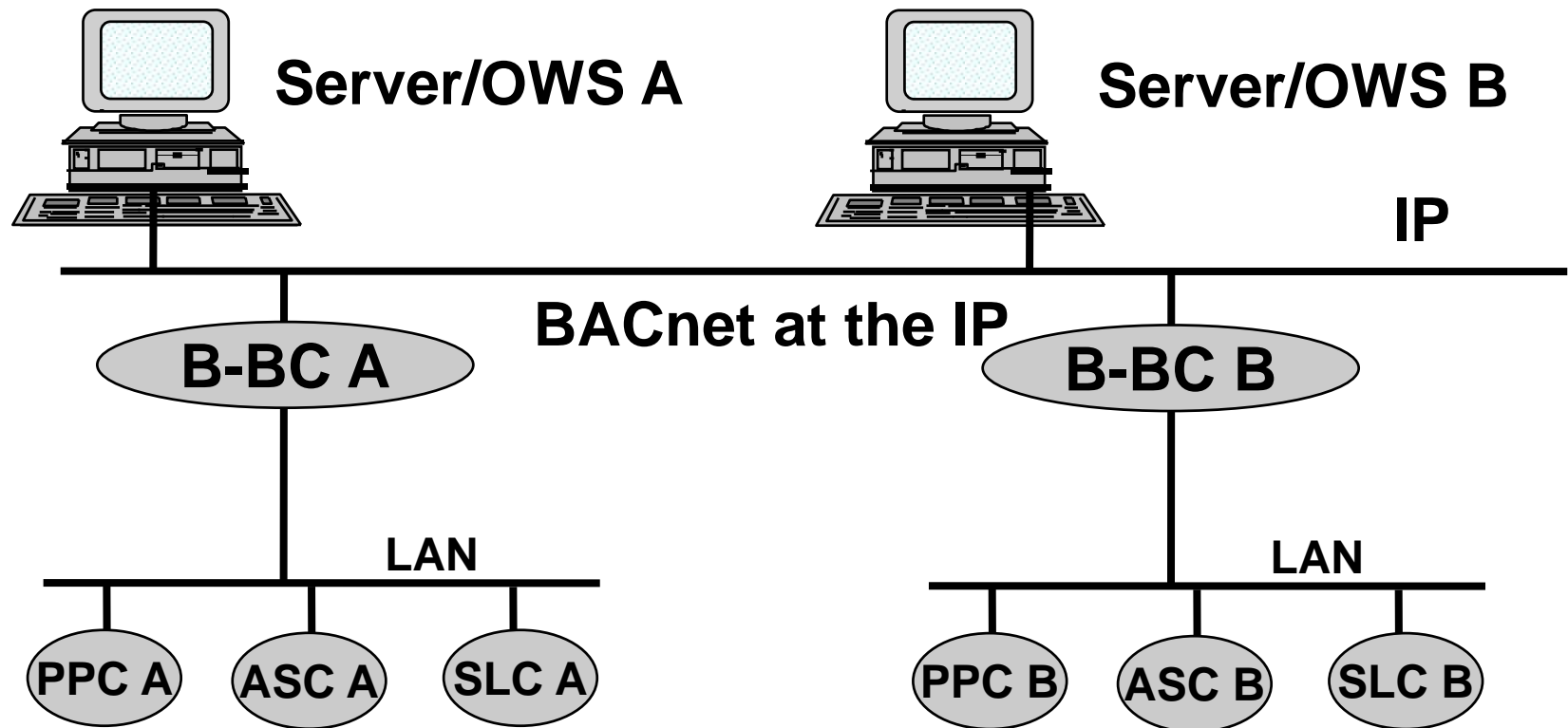
- Can put schedule functionality in AHU program, but then you're not using a BACnet Schedule Object – and probably can't manipulate schedule via BACnet.
- BACnet scheduler object can't compute lead time
- BACnet schedule object doesn't provide a countdown timer output (advance notice), only “go occupied **NOW**”
- You can't easily do Optimum Start using BACnet to schedule the AHU.
- BACnet **vendors** can do Optimum Start – but not using BACnet Schedule Objects for scheduling.

Key Interoperability Issues

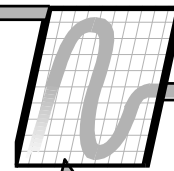


- If we mix multiple vendors into a single overall system, just what interoperability can we expect?
 - Data flow from one system to another?
 - Time Schedules?
 - Trend log retrieval?
 - Alarm message generation?
 - Alarm acknowledgement?
 - Adjustment of parameters?

Multi-Vendor BACnet

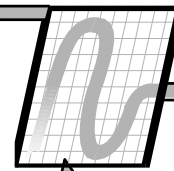


Some Questions



- Can data flow from B-BC A to B-BC B? Vice versa?
- What is the relationship between OWS A and B-BC B and the sub-ordinate controllers?

Data Exchange



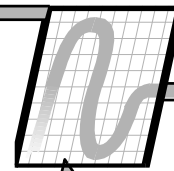
- Data exchange between devices can be specified.
- Issues to be addressed include:
 - Most data exchange must occur at the B-BC level: B-AACs typically cannot talk to each other
 - Can create problems when replacing devices
 - BACnet doesn't require the application engineer to necessarily expose data as BACnet objects or properties when the device is programmed.
 - Many vendors use proprietary objects, this may create data exchange issues.
 - Analog values may not be writeable.

Schedules, Alarms, Trends



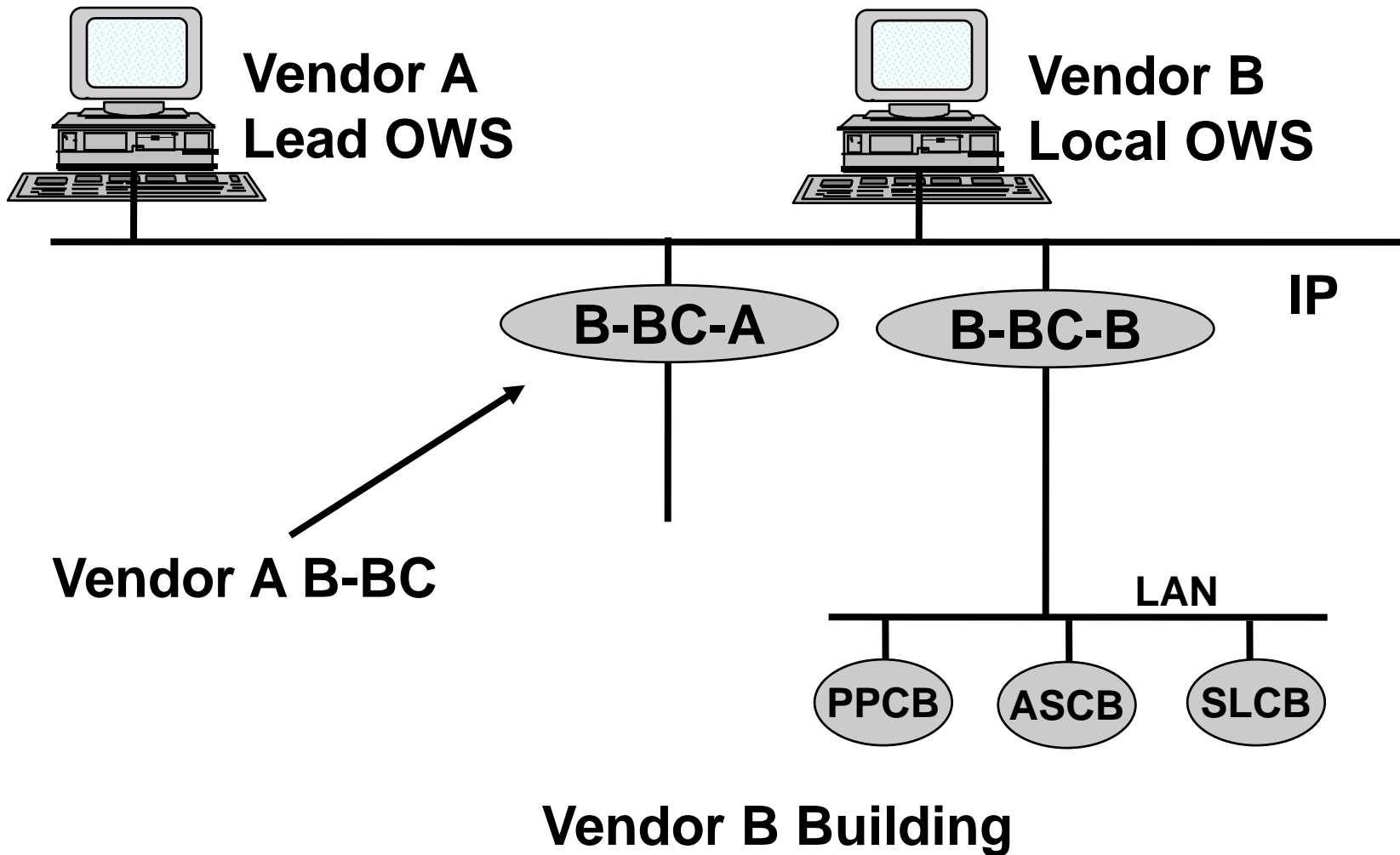
- Higher order functions is where we need to spend more time ensuring interoperability.
 - Time Schedules
 - Trend log retrieval
 - Alarm processing
 - Engineering tasks (pretty much hopeless)
- BIBBs provide a high degree of interoperability
 - Vendor support (Winter 2017) is not 100%
 - And recall, there's no requirement to **use** BIBBs
- If not, we have to apply hardware based solutions.

Spec requirements:



- Easy to get with minimal pain:
 - Require BTL listed devices
 - Require front end be a B-AWS
- Probably can get at a cost:
 - Require Writeable Object/Properties **where needed**
- Will push vendors and cost more:
 - Require Commandable Object/Properties **where needed** for overrides
 - Require support for configuration of schedules, trends, and alarms from a B-AWS
 - If not, need additional hardware to make this work.

Architecture

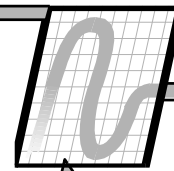


Hardware Solutions



- Assuming you can't get Scheduling, Alarming, Trending, Overrides working between Vendor A and Vendor B:
- The Lead Vendor is Vendor A
- He installs one of his B-BC's (B-BC-A) in Vendor B's building.

Hardware Solutions



- Time schedules for the existing building will reside in the new B-BC A.
 - Binary occupancy commands shall pass from the new B-BC A to the existing B-BC B and on to the field bus controllers.
- Alarm conditions in the existing controllers shall pass as simple binary data points from the existing B-BC B to the new B-BC A.
 - Upon arrival at the new B-BC A, the message is assigned and forwarded to the OWS for vendor A.

Hardware Solutions



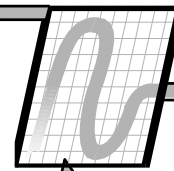
- Binary and analog data to be trended shall pass from the existing field bus controllers over the IP to the Vendor A B-BC for data storage.
- The OWS for vendor A can extract the trend logs from the new B-BC A.

Other Issues With BACnet



- Data flow from across IT subnets
- Address schemes and avoiding conflicts
 - BACnet lacks a standard tool for network management
 - Vendor A builds a system independent of Vendor B
 - This can (and often does) create conflicts
- Defining what an operator from Vendor A's OWS can do to applications in Vendor B's controllers
 - Most devices require proprietary engineering tools
- Generally will need OWSes from each vendor

Summary



- Multi-vendor installations, whether based on LonWorks or BACnet bring to the table a need to design and specify at a much deeper level than with single vendor solutions.
- You need to jump in with both feet or stay out of the water!