Basics of BACnet

- History of BACnet

- BACnet Architecture

- Routers

- Gateways

- Objects

- Properties

- Services

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Why a Standard Protocol?

- Interoperability

- Competitive system expansion

- End "lock in" fear

- Integrating building services requires communication standards

- Reduce training cost by using a single operator interface

- Enable development of new technology

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Why a Standard Protocol?

- Share data among different vendor's systems for a more sensible and integrated approach to facilities management

- Access all systems from a common interface to permit common graphics, event and alarm enunciation, and data logging

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History of BACnet

- Committee began in June, 1987

- Consensus using working groups

- ASHRAE/ANSI standard 135-1995

- ISO 16484-5 in 2003

- Design Goals
  - Interoperability
  - Efficiency
  - Flexibility
  - Extensibility
  - Reliability
  - Stability
  - Simplicity

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BACnet Applications

- HVAC Controls

- Lighting Controls

- Security (access control)

- Fire detection/suppression systems

- Smart Elevators

- Fault detection and diagnostic systems

BACnet Architecture

BACnet Layers   OSI

BACnet Application Layer (APDU)								Application
BACnet Network Layer (NPDU)								Network
ISO 8802-2		MS/TP	PTP	BVLC	BVLC	LonTalk	ZigBee	Data Link
Ethernet	ARCNET	EIA-485	EIA-232	UDP/IP4	UDP/IP6		802.15.4	Physical

LAN options with BACnet

Pros? Cons?

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LAN: PTP

- Only choice for modem

- Special design for point to point applications

- Accommodates modern modem standards (V.32bis, V.42)

- Point to point only

- Limited speed (9.6K to 56Kbps)

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LAN: LonTalk

- Variety of media (UTP, coax, RF, IR, fiber)

- Scalable speed (32K to 1.25Mbps)

- Non-deterministic

- Distance limitations

- Sole source chip

- Special development tools

- Application size limited

- Very few BACnet vendors using LonTalk

LAN: ARCNET

Pros

- ANSI Standard

- Deterministic response

- Scalable speed

- Variety of media (UTP, coax, fiber)

- Very fast (156k-7.5Mbps)

- No special development tools

- High performance for medium cost

Cons

- Sole source chip

- Too costly for low end unitary controllers

- Distance limitations for some media

- Very few BACnet vendors using ARCNET

LAN: BACnet MS/TP

- ANSI standard

- Low cost

- Can be implemented in a single chip microcontroller

- Deterministic response

- Long distance (1500 m)

- Single media (EIA-485)

- Limited speed (9.6K to 115Kbps)

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LAN: Ethernet

Pros

- International standard
- Already in most buildings
- Variety of media (UTP, fiber, wireless)
- Very fast (10/100/1000 or more Mbps)
- Easy to interface to PCs
- No special development tools
- Power included (PoE)

Cons

- High cost
- Distance limitations
- non-deterministic

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LAN: BACnet/IP

- International standard

- Already in most buildings

- Variety of media (UTP, fiber, wireless)

- Very fast (10/100/1000 or more Mbps)

- Easy to interface to PCs

- No special development tools

- Power included (PoE)

- High cost

- Distance limitations

- Non-deterministic

- Additional software stack required (UDP/IP)

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LAN: BACnet/IPv6

- International standard

- New to BACnet (2015)

- Variety of media (UTP, fiber, wireless)

- Standard meshing and messaging built on standard wireless layer (IEEE 802.15.4)

- Uses VMAC for address

- Can use Ethernet, WiFi, 6lowPAN, 6loBAC

- Additional software stack required (UDP/IPv6)
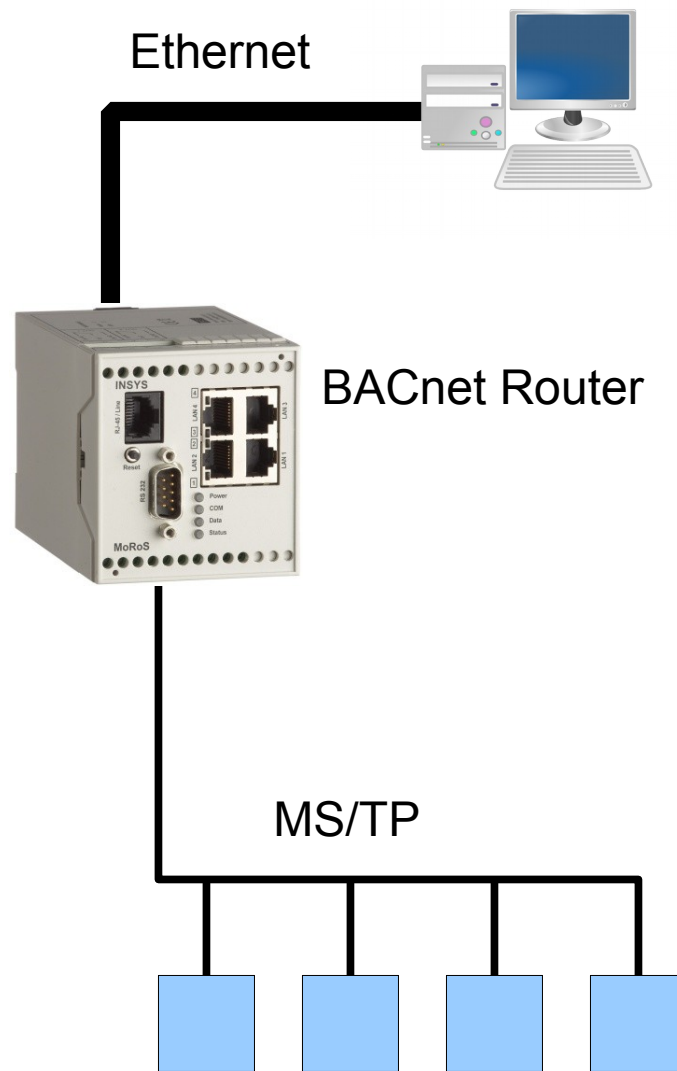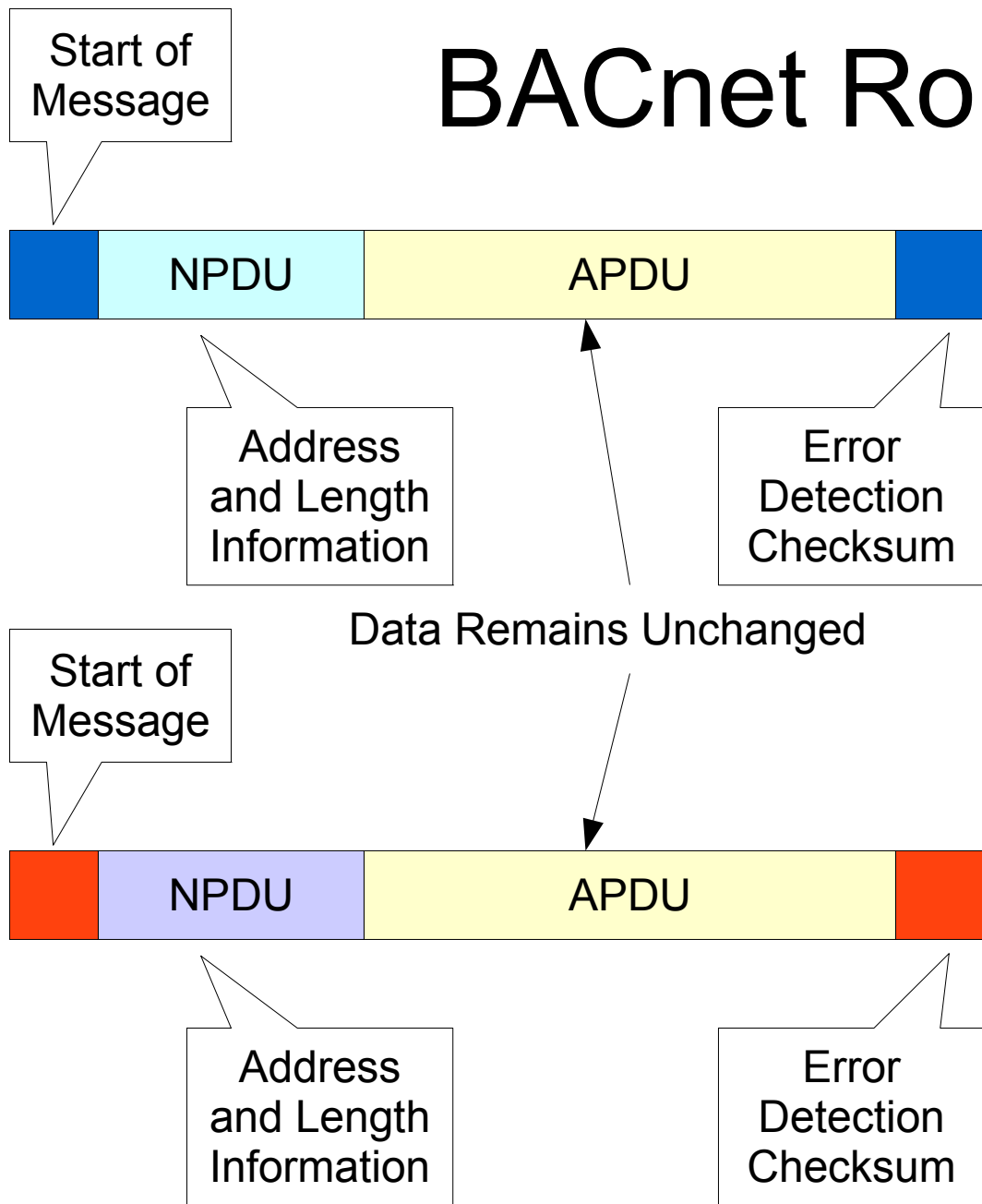
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LAN: ZigBee

- Low cost, low power wireless

- Standard meshing and messaging built on standard wireless layer (IEEE 802.15.4)

- Limited speeds

- Limited broadcasting
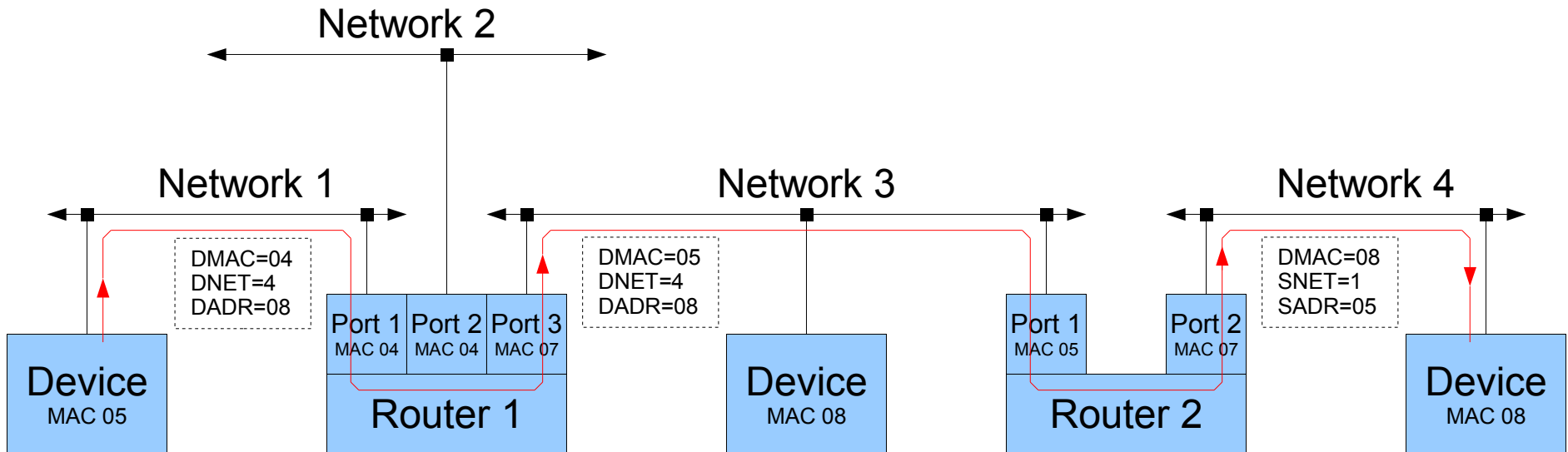
- Nodes may sleep

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Internetworking

Required whenever two dissimilar LAN technologies need be coupled

- Performance constraints (bandwidth)

- Cost constraints

- Isolate message traffic

- Remote access

- Utilize existing infrastructure

- Connect multiple isolated applications

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BACnet Routers

Start of Message

NPDU | APDU

Address and Length Information

Error Detection Checksum

Data Remains Unchanged

Start of Message

NPDU | APDU

Address and Length Information

Error Detection Checksum

Ethernet

BACnet Router

MS/TP

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BACnet Routers

Network 2

Network 1

Network 3

Network 4

DMAC=04
DNET=4
DADR=08

DMAC=05
DNET=4
DADR=08

DMAC=08
SNET=1
SADR=05

Device
MAC 05

| Port 1 | Port 2 | Port 3 |
| MAC 04 | MAC 04 | MAC 07 |

Router 1

Device
MAC 08

| Port 1 | Port 2 |
| MAC 05 | MAC 07 |

Router 2

Device
MAC 08

Routing Table	
Net	Send To
1	Attached, port 1
2	Attached, port 2
3	Attached, port 3
4	Net 3, MAC 5

Routing Table	
Net	Send To
1	Net 3, MAC 7
2	Net 3, MAC 7
3	Attached, port 1
4	Attached, port 2

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BACnet Gateway

	NPDU	APDU	

Ethernet

BACnet Gateway

Modbus RTU
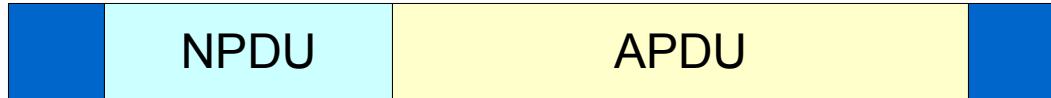
BAConfig Modbus to BACnet Gateway Configuration Tool v1.01

Modbus Register to BACnet Object Mappings

Object: 1

Object Name: Analog Input 1

☑ Enable Map   ☐ Group

☐ Default to Out of Service
☐ Write Modbus on Power Up
☐ Default on Modbus Comm Fail

Slave ID: 1

Register Type: Holding Register

Register #: 503

Register Format: Unsigned 16-bit

Slope: 0.000000   Intercept: 0.000000   Default Value: 0.000000   Mask: 0000   Fill: 0000   Poll Rate (Sec): 2

Reference String: System Pressure Transducer
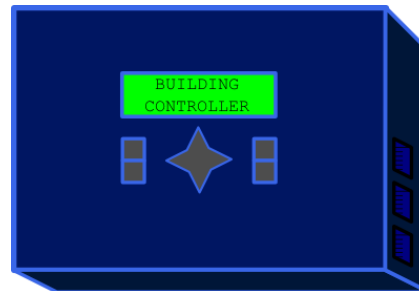
Read   Write

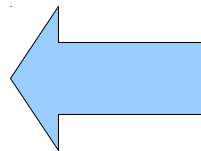Gateway Configuration tool from Control Solutions, Inc

Modbus RTU Packet
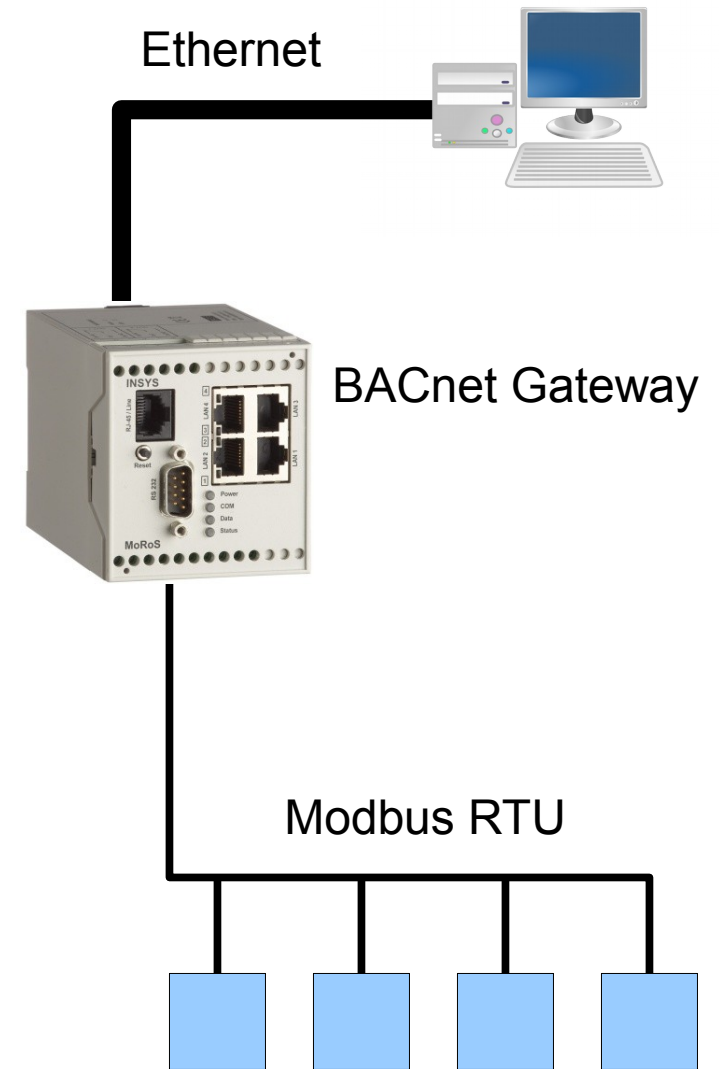
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BACnet Objects

- Objects represent physical inputs, outputs, and software processes.

IF level > 50 THEN

BUILDING CONTROLLER

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BACnet Objects

- Objects are evaluated and controlled by their properties

- Property Name, Value
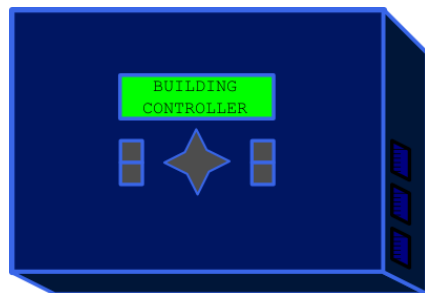
Object_Name	"Lighting Area 1"
Object_Type	BINARY_OUTPUT
Present_Value	Active
Status_Flags	Normal, In-Service
Out_Of_Service	False
Inactive_Text	"Off"
Active_Text	"On"

BUILDING CONTROLLER

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BACnet Objects

accumulator	binary-output	file	multi-state-output	trend-log
analog-input	binary-value	group	multi-state-value	load-control
analog-output	calendar	life-safety-point	notification-class	structured-view
analog-value	command	life-safety-zone	program	access-door
averaging	device	loop	pulse-converter	binary-input
access-credential	event-enrollment	multi-state-input	schedule	event-log
access-zone	access-rights	access-point	access-user	credential-data-input
characterstring-value	bitstring-value	trend-log-multiple	global-group	characterstring-value
date-pattern-value	date-value	datetime-pattern-value	datetime-value	integer-value
large-analog-value	octetstring-value	positive-integer-value	time-pattern-value	time-value
channel	staged-value	timer-value	lighting-output	binary-lighting-output
notification-forwarder	alert-enrollment	network-port	elevator	

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BACnet Objects

Required and Optional Properties

Object_Name	"Lighting Area 1"
Object_Type	BINARY_OUTPUT
Present_Value	Active
Status_Flags	Normal, In-Service
Out_Of_Service	False
Inactive_Text	"Off"
Active_Text	"On"

Required

Optional

Other properties...

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Binary Output Object

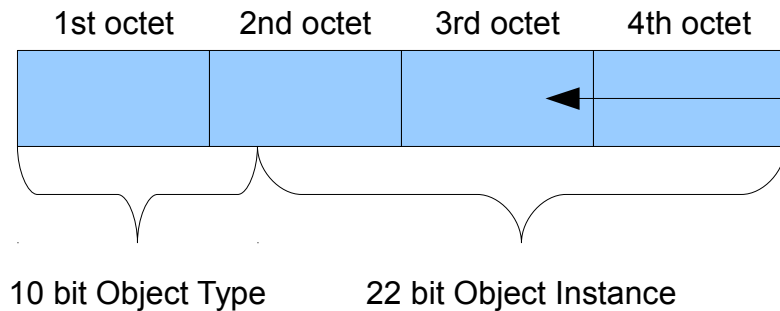| Property Identifier	Property Datatype	Conformance Code
Object_Identifier	BACnetObjectIdentifier	R
Object_Name	CharacterString	R
Object_Type	BACnetObjectType	R
Present_Value	BACnetBinaryPV	W
Description	CharacterString	O
Device_Type	CharacterString	O
Status_Flags	BACnetStatusFlags	R
Event_State	BACnetEventState	R
Reliability	BACnetReliability	O
Out_Of_Service	BOOLEAN	R
Polarity	BACnetPolarity	R
Inactive_Text	CharacterString	O[1]
Active_Text	CharacterString	O[1]
Change_Of_State_Time	BACnetDateTime	O[2]
Change_Of_State_Count	Unsigned	O[2]
Time_Of_State_Count_Reset	BACnetDateTime	O[2]
Elapsed_Active_Time	Unsigned32	O[3]
Time_Of_Active_Time_Reset	BACnetDateTime	O[3]
Minimum_Off_Time	Unsigned32	O
Minimum_On_Time	Unsigned32	O
Priority_Array	BACnetPriorityArray	R
Relinquish_Default	BACnetBinaryPV	R
Time_Delay	Unsigned	O[4]
Notification_Class	Unsigned	O[4]
Feedback_Value	BACnetBinaryPV	O[4]
Event_Enable	BACnetEventTransitionBits	O[4]
Acked_Transitions	BACnetEventTransitionBits	O[4]
Notify_Type	BACnetNotifyType	O[4]
Event_Time_Stamps	BACnetARRAY[3] of BACnetTimeStamp	O[4]
Profile_Name	CharacterString	O

Conformance Codes:
R   required, readable
W   required, writable
O   optional

Out_Of_Service decouples the physical output from the Present_Value.

Properties required because Present_Value is *commandable*

Properties required for intrinsic reporting

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Object Identifiers

1st octet	2nd octet	3rd octet	4th octet

10 bit Object Type   22 bit Object Instance

Object instances can range from 0 to 4194303, but 4194303 is reserved for unconfigured devices.

analog-input	(0),
analog-output	(1),
analog-value	(2),
binary-input	(3),
binary-output	(4),
binary-value	(5),
calendar	(6),
command	(7),
device	(8),
event-enrollment	(9),
file	(10),
group	(11),
loop	(12),
multi-state-input	(13),
multi-state-output	(14),
notification-class	(15),
program	(16),
schedule	(17),
...	

Object types can be any of the BACnet standard types, or non-standard types from 128 to 1023

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Property Identifiers

accepted-modes	(175),	configuration-files	(154),	
acked-transitions	(0),	controlled-variable-reference	(19),	
ack-required	(1),	controlled-variable-units	(20),	
action	(2),	controlled-variable-value	(21),	
action-text	(3),	count	(177),	
active-text	(4),	count-before-change	(178),	
active-vt-sessions	(5),	count-change-time	(179),	
active-cov-subscriptions	(152),	cov-increment	(22),	
adjust-value	(176),	cov-period	(180),	
alarm-value	(6),	cov-resubscription-interval	(128),	
alarm-values	(7),	database-revision	(155),	
all	(8),	date-list	(23),	
all-writes-successful	(9),	daylight-savings-status	(24),	
apdu-segment-timeout	(10),	deadband	(25),	
apdu-timeout	(11),	derivative-constant	(26),	
application-software-version	(12),	derivative-constant-units	(27),	
archive	(13),	description	(28),	
attempted-samples	(124),	description-of-halt	(29),	
auto-slave-discovery	(169),	device-address-binding	(30),	
average-value	(125),	device-type	(31),	
backup-failure-timeout	(153),	direct-reading	(156),	
bias	(14),	effective-period	(32),	
buffer-size	(126),	elapsed-active-time	(33),	
change-of-state-count	(15),	error-limit	(34),	
change-of-state-time	(16),	event-enable	(35),	
client-cov-increment	(127),	event-state	(36),	
		...		

Property identifiers are specified for each standard object.

Non-standard property identifiers in the range of 512 to 4194303 allows each vendor to define their own properties.

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BACnet Services

- Service == Message
- Services allow Devices to do something
- Must implement at least ReadProperty

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BACnet Confirmed Services

- Confirmed == Unicast, Acknowledged

AcknowledgeAlarm	AtomicWriteFile	WritePropertyMultiple
COV-Notification	AddListElement	PrivateTransfer
EventNotification	RemoveListElement	TextMessage
GetAlarmSummary	CreateObject	ReinitializeDevice
GetEnrollmentSummary	DeleteObject	VTOpen
SubscribeCOV	ReadProperty	VTClose
SubscribeCOVProperty	ReadPropertyMultiple	VTData
LifeSafetyOperation	ReadRange	Authenticate
AtomicReadFile	WriteProperty	ReqestKey
ReadPropertyConditional	DeviceCommunicationControl	

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BACnet Unconfirmed Services

- Unconfirmed == Broadcast (usually)

I-Am	TextMessage
I-Have	TimeSynchronization
COV-Notification	WhoHas
EventNotification	WhoIs
PrivateTransfer	UTC TimeSynchronization
WriteGroup	

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