

ISO 16484-5:2012-08 (E)

Building automation and control systems - Part 5: Data communication protocol

Contents	Page
FOREWORD	vii
1 PURPOSE.....	1
2 SCOPE.....	1
3 DEFINITIONS	1
3.1 Terms Adopted from International Standards	1
3.2 Terms Defined for this Standard	2
3.3 Abbreviations and Acronyms Used in this Standard.....	6
4 BACnet PROTOCOL ARCHITECTURE.....	9
4.1 The BACnet Collapsed Architecture.....	10
4.2 BACnet Network Topology	12
4.3 Security	14
5 THE APPLICATION LAYER	15
5.1 The Application Layer Model.....	15
5.2 Segmentation of BACnet Messages	19
5.3 Transmission of BACnet APDUs.....	20
5.4 Application Protocol State Machines	24
5.5 Application Protocol Time Sequence Diagrams	41
5.6 Application Layer Service Conventions.....	50
6 THE NETWORK LAYER	52
6.1 Network Layer Service Specification.....	52
6.2 Network Layer PDU Structure	54
6.3 Messages for Multiple Recipients	59
6.4 Network Layer Protocol Messages.....	60
6.5 Network Layer Procedures.....	63
6.6 BACnet Routers	65
6.7 Point-To-Point Half-Routers	70
7 DATA LINK/PHYSICAL LAYERS: ISO 8802-3 ("Ethernet") LAN.....	75
7.1 The Use of ISO 8802-2 Logical Link Control (LLC).....	75
7.2 Parameters Required by the LLC Primitives.....	75
7.3 Parameters Required by the MAC Primitives	75
7.4 Physical Media	75
8 DATA LINK/PHYSICAL LAYERS: ARCNET LAN.....	77
8.1 The Use of ISO 8802-2 Logical Link Control (LLC).....	77
8.2 Parameters Required by the LLC Primitives.....	77
8.3 Mapping the LLC Services to the ARCNET MAC Layer	77
8.4 Parameters Required by the MAC Primitives	77
8.5 Physical Media	77
9 DATA LINK/PHYSICAL LAYERS: MASTER-SLAVE/TOKEN PASSING (MS/TP) LAN.....	79
9.1 Service Specification.....	79
9.2 Physical Layer.....	81
9.3 MS/TP Frame Format.....	92
9.4 Overview of the MS/TP Network.....	93
9.5 MS/TP Medium Access Control	94
9.6 Cyclic Redundancy Check (CRC).....	111
9.7 Interfacing MS/TP LANs with Other BACnet LANs	112
9.8 Responding BACnet User Processing of Messages from MS/TP	112
9.9 Repeaters	112
10 DATA LINK/PHYSICAL LAYERS: POINT-TO-POINT (PTP).....	114
10.1 Overview	114
10.2 Service Specification.....	114
10.3 Point-to-Point Frame Format.....	119
10.4 PTP Medium Access Control Protocol.....	121
11 DATA LINK/PHYSICAL LAYERS: EIA/CEA-709.1 ("LonTalk") LAN	142
11.1 The Use of ISO 8802-2 Logical Link Control (LLC).....	142
11.2 Parameters Required by the LLC Primitives.....	142

11.3	Mapping the LLC Services to the LonTalk Application Layer	142
11.4	Parameters Required by the Application Layer Primitives	142
11.5	Physical Media	143
12	MODELING CONTROL DEVICES AS A COLLECTION OF OBJECTS	144
12.1	Accumulator Object Type	148
12.2	Analog Input Object Type	156
12.3	Analog Output Object Type	161
12.4	Analog Value Object Type	166
12.5	Averaging Object Type	171
12.6	Binary Input Object Type	174
12.7	Binary Output Object Type	179
12.8	Binary Value Object Type	185
12.9	Calendar Object Type	190
12.10	Command Object Type	192
12.11	Device Object Type	196
12.12	Event Enrollment Object Type	205
12.13	File Object Type	211
12.14	Group Object Type	214
12.15	Life Safety Point Object Type	216
12.16	Life Safety Zone Object Type	223
12.17	Loop Object Type	230
12.18	Multi-state Input Object Type	237
12.19	Multi-state Output Object Type	242
12.20	Multi-state Value Object Type	246
12.21	Notification Class Object Type	251
12.22	Program Object Type	254
12.23	Pulse Converter Object Type	259
12.24	Schedule Object Type	266
12.25	Trend Log Object Type	271
12.26	Access Door Object Type	279
12.27	Event Log Object Type	286
12.28	Load Control Object Type	292
12.29	Structured View Object Type	301
12.30	Trend Log Multiple Object Type	304
12.31	Access Point Object Type	312
12.32	Access Zone Object Type	327
12.33	Access User Object Type	335
12.34	Access Rights Object Type	338
12.35	Access Credential Object Type	343
12.36	Credential Data Input Object Type	351
12.37	CharacterString Value Object Type	355
12.38	DateTime Value Object Type	360
12.39	Large Analog Value Object Type	363
12.40	BitString Value Object Type	368
12.41	OctetString Value Object Type	372
12.42	Time Value Object Type	374
12.43	Integer Value Object Type	377
12.44	Positive Integer Value Object Type	382
12.45	Date Value Object Type	387
12.46	DateTime Pattern Value Object Type	390
12.47	Time Pattern Value Object Type	393
12.48	Date Pattern Value Object Type	396
12.49	Network Security Object Type	399
12.50	Global Group Object Type	402
13	ALARM AND EVENT SERVICES	408
13.1	Change of Value Reporting	409
13.2	Intrinsic Reporting	412

13.3	Algorithmic Change Reporting	419
13.4	Alarm and Event Occurrence and Notification	430
13.5	AcknowledgeAlarm Service.....	432
13.6	ConfirmedCOVNotification Service	434
13.7	UnconfirmedCOVNotification Service	435
13.8	ConfirmedEventNotification Service	437
13.9	UnconfirmedEventNotification Service	440
13.10	GetAlarmSummary Service	442
13.11	GetEnrollmentSummary Service.....	444
13.12	GetEventInformation Service.....	447
13.13	LifeSafetyOperation Service	449
13.14	SubscribeCOV Service.....	451
13.15	SubscribeCOVProperty Service	454
14	FILE ACCESS SERVICES	457
14.1	AtomicReadFile Service.....	458
14.2	AtomicWriteFile Service.....	461
15	OBJECT ACCESS SERVICES	464
15.1	AddListElement Service.....	464
15.2	RemoveListElement Service	466
15.3	CreateObject Service.....	468
15.4	DeleteObject Service.....	471
15.5	ReadProperty Service	472
15.6	Deleted Clause.....	474
15.7	ReadPropertyMultiple Service	475
15.8	ReadRange Service	478
15.9	WriteProperty Service	482
15.10	WritePropertyMultiple Service	484
16	REMOTE DEVICE MANAGEMENT SERVICES	487
16.1	DeviceCommunicationControl Service.....	487
16.2	ConfirmedPrivateTransfer Service	489
16.3	UnconfirmedPrivateTransfer Service	491
16.4	ReinitializeDevice Service	492
16.5	ConfirmedTextMessage Service	494
16.6	UnconfirmedTextMessage Service	496
16.7	TimeSynchronization Service	497
16.8	UTCTimeSynchronization Service	498
16.9	Who-Has and I-Have Services	499
16.10	Who-Is and I-Am Services	501
17	VIRTUAL TERMINAL SERVICES.....	503
17.1	Virtual Terminal Model.....	503
17.2	VT-Open Service.....	507
17.3	VT-Close Service	509
17.4	VT-Data Service.....	510
17.5	Default-terminal Characteristics.....	512
18	ERROR, REJECT, and ABORT CODES.....	516
18.1	Error Class - DEVICE.....	516
18.2	Error Class - OBJECT.....	516
18.3	Error Class - PROPERTY	517
18.4	Error Class - RESOURCES	518
18.5	Error Class - SECURITY	518
18.6	Error Class - SERVICES.....	520
18.7	Error Class - COMMUNICATION.....	521
18.8	Error Class - VT.....	523
18.9	Reject Reason.....	524
18.10	Abort Reason.....	524
18.11	Confirmed Service Common Errors.....	525
19	BACnet PROCEDURES	526

19.1	Backup and Restore.....	526
19.2	Command Prioritization	530
19.3	Device Restart Procedure	533
20	ENCODING BACnet PROTOCOL DATA UNITS	535
20.1	Encoding the Fixed Part of BACnet APDUs.....	535
20.2	Encoding the Variable Part of BACnet APDUs.....	546
21	FORMAL DESCRIPTION OF APPLICATION PROTOCOL DATA UNITS	559
22	CONFORMANCE AND INTEROPERABILITY	629
22.1	Conformance to BACnet.....	629
22.2	BACnet Interoperability	630
23	EXTENDING BACnet TO ACCOMMODATE VENDOR PROPRIETARY INFORMATION	632
23.1	Extending Enumeration Values.....	632
23.2	Using the PrivateTransfer Services to Invoke Non-Standardized Services.....	633
23.3	Adding Proprietary Properties to a Standardized Object.....	633
23.4	Adding Proprietary Object Types to BACnet.....	634
23.5	Restrictions on Extending BACnet	634
24	NETWORK SECURITY	635
24.1	Overview	635
24.2	Security Wrapper.....	639
24.3	Security Messages.....	643
24.4	Securing an APDU	658
24.5	Securing an NPDU	660
24.6	Securing a BVLL	660
24.7	Securing Messages	662
24.8	Network Security Network Trust Levels.....	664
24.9	Network Security Policies	665
24.10	Network Security.....	665
24.11	End-to-End Security	666
24.12	Wrapping and Unwrapping Secure Messages	667
24.13	Authenticating Messages.....	669
24.14	User Authentication.....	671
24.15	Time Synchronization Requirements	672
24.16	Integrating the Security Layer into the BACnet Stack	673
24.17	BACnet Security In A NAT Environment	680
24.18	BACnet Security Proxy.....	680
24.19	Deploying Secure Device on Non-Security Aware Networks.....	681
24.20	Deploying Secure Single Network Installations.....	681
24.21	Security Keys	681
24.22	Key Server.....	683
25	REFERENCES	687
	ANNEX A - PROTOCOL IMPLEMENTATION CONFORMANCE STATEMENT (NORMATIVE)	690
	ANNEX B - GUIDE TO SPECIFYING BACnet DEVICES (INFORMATIVE).....	693
	ANNEX C - FORMAL DESCRIPTION OF OBJECT TYPE STRUCTURES (INFORMATIVE).....	694
	ANNEX D - EXAMPLES OF STANDARD OBJECT TYPES (INFORMATIVE).....	719
	ANNEX E - EXAMPLES OF BACnet APPLICATION SERVICES (INFORMATIVE).....	754
	E.1 Alarm and Event Services	754
	E.2 File Access Services.....	758
	E.3 Object Access Services	760
	E.4 Remote Device Management Services	765
	E.5 Virtual Terminal Services.....	769
	ANNEX F - EXAMPLES OF APDU ENCODING (INFORMATIVE)	771
	F.1 Example Encodings for Alarm and Event Services.....	771
	F.2 Example Encodings for File Access Services.....	780
	F.3 Example Encodings for Object Access Services	782
	F.4 Example Encodings for Remote Device Management Services.....	791
	F.5 Example Encodings for Virtual Terminal Services	795
	ANNEX G - CALCULATION OF CRC (INFORMATIVE).....	798

G.1 Calculation of the Header CRC	798
G.2 Calculation of the Data CRC	804
ANNEX H - COMBINING BACnet NETWORKS WITH NON-BACnet NETWORKS (NORMATIVE)	809
H.1 Mapping Non-BACnet Networks onto BACnet Routers	809
H.2 Multiple "Virtual" BACnet Devices in a Single Physical Device	809
H.3 Using BACnet with the DARPA Internet Protocols	809
H.4 Using BACnet with the IPX Protocol	810
H.5 Using BACnet with EIB/KNX	812
H.6 Using BACnet with the BACnet/WS Web Services Interface (Annex N)	823
H.7 Virtual MAC Addressing	825
ANNEX I - COMMANDABLE PROPERTIES WITH MINIMUM ON AND OFF TIMES (INFORMATIVE)	826
ANNEX J - BACnet/IP (NORMATIVE)	828
J.1 General	828
J.2 BACnet Virtual Link Layer	828
J.3 BACnet/IP Directed Messages	832
J.4 BACnet/IP Broadcast Messages	832
J.5 Addition of Foreign B/IP Devices to an Existing B/IP Network	834
J.6 Routing Between B/IP and non-B/IP BACnet Networks	836
J.7 Routing Between Two B/IP BACnet Networks	837
J.8 Use of IP Multicast within BACnet/IP	842
J.9 Sources for Internet Information	843
ANNEX K - BACnet INTEROPERABILITY BUILDING BLOCKS (BIBBs) (NORMATIVE)	844
K.1 Data Sharing BIBBs	844
K.2 Alarm and Event Management BIBBs	851
K.3 Scheduling BIBBs	857
K.4 Trending BIBBs	860
K.5 Device and Network Management BIBBs	864
ANNEX L - DESCRIPTIONS AND PROFILES OF STANDARDIZED BACnet DEVICES (NORMATIVE)	872
L.1 Operator Interfaces	872
L.2 BACnet Building Controller (B-BC)	874
L.3 BACnet Advanced Application Controller (B-AAC)	874
L.4 BACnet Application Specific Controller (B-ASC)	875
L.5 BACnet Smart Actuator (B-SA)	875
L.6 BACnet Smart Sensor (B-SS)	876
L.7 Profiles of the Standard BACnet Devices	877
ANNEX M - GUIDE TO EVENT NOTIFICATION PRIORITY ASSIGNMENTS (INFORMATIVE)	878
ANNEX N - BACnet/WS WEB SERVICES INTERFACE (NORMATIVE)	882
N.1 Data Model	882
N.2 Paths	883
N.3 Normalized Points	883
N.4 Reference Nodes	884
N.5 Localization	884
N.6 Security	884
N.7 Sessions	885
N.8 Attributes	885
N.9 Standard Nodes	891
N.10 Encodings	892
N.11 Service Options	893
N.12 Services	896
N.13 Errors	914
N.14 Extending BACnet/WS	915
ANNEX O - BACnet OVER ZigBee AS A DATA LINK LAYER (NORMATIVE)	916
O.1 General	916
O.2 ZigBee Overview	916
O.3 Definitions	917
O.4 Unicast Addressing	917
O.5 Broadcast Addressing	917

O.6 BACnet/ZigBee Data Link Layer (BZLL).....	918
O.7 Maximum Payload Size	921
O.8 Vendor Specific Commands	921
ANNEX P - BACnet ENCODING OF STANDARD AUTHENTICATION FACTOR FORMATS (NORMATIVE)	922
ANNEX Q - XML DATA FORMATS (NORMATIVE)	928
Q.1 Introduction.....	928
Q.2 Document Structure	931
Q.3 Expressing BACnet Datatypes in XML.....	932
Q.4 Expressing BACnet Objects and Properties in XML.....	966
Q.5 Definitions, Types, Instances, and Inheritance	966
Q.7 Extensibility	973
ANNEX R - MAPPING NETWORK LAYER ERRORS (NORMATIVE)	976
ANNEX S - EXAMPLES OF SECURE BACnet MESSAGES (INFORMATIVE).....	978
HISTORY OF REVISIONS	993