



# ADDENDA

**ANSI/ASHRAE Addendum bh to  
ANSI/ASHRAE Standard 135-2012**



# Data Communication Protocol for Building Automation and Control Networks

Approved by ASHRAE on February 29, 2016, and by the American National Standards Institute on March 1, 2016.

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**[This foreword and the “rationales” on the following pages are not part of this standard. They are merely informative and do not contain requirements necessary for conformance to the standard.]**

## **FOREWORD**

The purpose of this addendum is to present a proposed change for public review. These modifications are the result of change proposals made pursuant to the ASHRAE continuous maintenance procedures and of deliberations within Standing Standard Project Committee 135. The proposed changes are summarized below.

**135-2012*bh*-1. Correct Application State Machine Failover, p. 2**

**135-2012*bh*-2. Increase Segmentation Window Size for MS/TP, p. 4**

In the following document, language to be added to existing clauses of ANSI/ASHRAE 135-2012 and Addenda is indicated through the use of *italics*, while deletions are indicated by ~~strikethrough~~. Where entirely new subclauses are proposed to be added, plain type is used throughout. Only this new and deleted text is open to comment as this time. All other material in this addendum is provided for context only and is not open for public review comment except as it relates to the proposed changes.

### 135-2012bh-1. Correct Application State Machine Failover.

#### Rationale

During testing of the performance of MS/TP connected via a router to an IP network, it was found that delays in message delivery (i.e., the message was waiting at the router for the token to arrive) could cause undesirable side-effects which resulted in a degradation of performance far beyond that due directly to the message delay. These side-effects were in two cases which will be explained below. The corrections to the Application Layer communication state machine for BACnet communications are intended to eliminate the side-effects and restore expected operation.

#### Case 1 associated with the correction in Clause 5.4.2.2 Function DuplicateInWindow

This case can happen if Confirmed Request PDUs which are segments of a larger message are delayed sufficiently in transport (i.e., buffered in a router and waiting for the MS/TP token to arrive) to cause the sender to time out and begin retransmission of the message segment(s). When the original segment(s) arrive at the destination device, they will cause the destination device to expect the next segmentation window group to start arriving and will change InitialSequenceNumber (i.e., when in the 5.4.5.2 SEGMENTED\_REQUEST state will take the LastSegmentOfGroupReceived transition). After this is done, the retransmitted message segment(s) will arrive at the destination device and will contain sequence-number(s) belonging to the previous segmentation window group. Since the sequence-number(s) belong to the previous segmentation window group, the function DuplicateInWindow will not recognize the message segment(s) as duplicates causing the destination device to treat them as out of order (i.e., the 5.4.5.2 SEGMENTED\_REQUEST state will take the SegmentReceivedOutOfOrder transition). The result is that the destination device sends one or more BACnet-SegmentACK-PDUs with 'negative-ACK' = TRUE to the requesting device when there is no reason to do so.

The correction is to modify the DuplicateInWindow function to recognize sequence-number(s) belonging to the previous segmentation window group as duplicates during the time immediately after a new segmentation window group has been started. The start of a new segmentation window group is indicated by firstSeqNumber and lastSequenceNumber being equal (i.e., local variable receivedCount is zero). Sequence-number(s) belonging to the previous segmentation window group are indicated by a seqA value less than or equal to firstSeqNumber (modulo 256) within the span of ActualWindowSize.

This case no longer exists after message segment(s) inside the new segmentation window group start arriving since all previous segmentation window group retries should be purged from the transport devices at that time.

#### Case 2 associated with the correction in Clause 5.4.5.1 IDLE (server).

This case can happen when Confirmed Request PDUs which are the last segment(s) of a larger message are delayed sufficiently in transport (i.e., buffered in a router and waiting for the MS/TP token to arrive) to cause the requester to time out and begin retransmission of the message segment(s). When the original segment(s) arrive at the destination device, they will cause the destination device to accept the completed larger message and transmit a SegmentACK-PDU before processing the larger message (i.e., the 5.4.5.2 SEGMENTED\_REQUEST state will take the LastSegmentOfMessageReceived transition). When the destination device completes the processing of the larger message and places a response in its data link output queue (i.e., the response is waiting for the token to arrive) it will then transition to the IDLE state. If message segment retries remaining from the request message arrive after that time, they will be immediately answered with an Abort PDU (i.e., the 5.4.5.1 IDLE state will take the UnexpectedPDU\_Received transition) even if the response to the larger message is still waiting in the data link output queue. The Abort PDU will cause the requesting device to treat the larger message as being aborted even though the larger message was successful and a response is waiting (i.e., the 5.4.4.3 AWAIT\_CONFIRMATION state will take the AbortPDU\_Received transition).

The correction is to prevent the Abort PDU(s) sent in response to unexpected confirmed request segments from preceding the larger message response so that the requesting device receives the larger message response before the Abort PDU(s) and processes it. This is done by issuing an N-RELEASE.request to the network layer before issuing the Abort PDU N-UNITDATA.request. This causes the data link to release (i.e., the MS/TP data link sends a reply postpone frame to the router) before the Abort PDU(s) arrive at the data link. Since the data link has been released, the Abort PDU(s) will be placed in the output queue after the larger message response that may still be waiting (i.e., the token has not yet arrived at this device). Thus the expected message order is preserved and the requesting device can process the larger message response.

[Change **Clause 5.4.2.2**, p. 27]

#### **5.4.2.2 Function DuplicateInWindow**

The function "DuplicateInWindow" determines whether a value, seqA, is within the range firstSeqNumber through lastSequenceNumber, modulo 256, *or if called at the start of a new Window and no new message segments have been received yet, it determines if the value seqA is within the range of the previous Window*. All computations and comparisons are modulo 256 operations on unsigned eight-bit quantities.

function DuplicateInWindow(seqA, firstSeqNumber, lastSequenceNumber)

- (1) Set local variable receivedCount to ~~lastSeqNumber~~ *lastSequenceNumber* minus firstSeqNumber, modulo 256.
- (2) If receivedCount is greater than ActualWindowSize, then return FALSE.
- (3) If seqA minus firstSeqNumber, modulo 256, is less than or equal to receivedCount, then return TRUE.
- (4) *If receivedCount is zero and firstSeqNumber minus seqA, modulo 256, is less than or equal to ActualWindowSize, then return TRUE.*
- (45) Else return FALSE.

[Change **Clause 5.4.5.1**, p. 36]

#### **5.4.5.1 IDLE**

In the IDLE state, the device waits for a PDU from the network layer.

SecurityError\_Received

If a security error is received via an N-REPORT.indication from the network layer,

then enter the IDLE state.

...

AbortPDU\_Received

If a BACnet-Abort-PDU whose 'server' parameter is FALSE is received from the network layer,

then enter the IDLE state.

UnexpectedPDU\_Received

If an unexpected PDU (BACnet-Confirmed-Request-PDU with 'segmented-message' = TRUE and 'sequence-number' not equal to zero or BACnet-SegmentACK-PDU with 'server' = FALSE) is received from the network layer,

*then issue an N-RELEASE.request to the network layer entity specifying the source\_address value of the segment for the destination\_address parameter (to prevent the following abort response from being transmitted ahead of other response message frames that may be queued); then issue an N-UNITDATA.request with 'data\_expecting\_reply' = FALSE to transmit a BACnet-Abort-PDU with 'server' = TRUE and 'abort-reason' = INVALID\_APDU\_IN\_THIS\_STATE; and enter the IDLE state.*

## 135-2012bh-2. Increase Segmentation Window Size for MS/TP.

### Rationale

Limiting the segmentation window size to one for all MS/TP devices unnecessarily restricts performance, especially when a router exists between the MS/TP device and the other node. If the MS/TP device has limited resources and needs a segmentation window size of one, it can continue to use a proposed/actual window size of one. If it can handle a larger segmentation window size, then it should be allowed to improve its performance. Thus the proposed change is backward compatible.

Performance is restricted (with the current standard) in that only one frame of a segmented message can generally be sent each time the token goes around the loop when a router is involved. If, for example, the router receives a message segment from an Ethernet port, it generally cannot get the next message segment until after it has passed the token due to the delays involved with processing each segment Ack at the sending node. However, if the sending node was allowed to send multiple message segments to the router (i.e., a segmentation window size greater than one), the router could then send multiple frames within the limits of its `Nmax_info_frames` value before passing the token, thus greatly improving performance for large messages.

Alternate approaches to reducing this problem such as making message segments unconfirmed are undesirable because they would affect all Data Link types (not just MS/TP), could cause incompatibilities with existing implementations that assume segments can be responded to at will, and could affect performance on installations that have significant errors (since a segment can't be NAKed immediately). The proposed change makes MS/TP behave more like other commonly used Data Link types and eliminates some special requirements for MS/TP that affect other communication layers.

[Change **Clause 4.1**, p. 12]

The data link layer organizes the data into frames or packets, regulates access to the medium, provides addressing, and handles some error recovery and flow control. These are all functions that are required in a BAC protocol. The conclusion is that the data link layer is needed. *For the purposes of BACnet, a data link layer entity may ignore any service request primitive that is not defined for the particular data link type.*

[Change **Clause 5.4.4.4**, p. 33]

#### 5.4.4.4 SEGMENTED\_CONF

...

##### NewSegmentReceived

If a BACnet-ComplexACK-PDU that has sufficient security parameters is received from the network layer whose 'segmented-message' parameter is TRUE; whose 'more-follows' parameter is TRUE; whose 'sequence-number' parameter is equal to `LastSequenceNumber` plus 1, modulo 256; and whose 'sequence-number' parameter is not equal to `InitialSequenceNumber` plus `ActualWindowSize`, modulo 256,

then save the BACnet-ComplexACK-PDU segment; increment `LastSequenceNumber`, modulo 256; restart `SegmentTimer`; *issue a N-RELEASE.request to the network layer entity specifying the source\_address value of the segment for the destination\_address parameter (in case the data link layer is waiting for a reply)*; and enter the SEGMENTED\_CONF state to receive additional segments.

...

[Change **Clause 5.4.5.2**, p. 37]

#### 5.4.5.2 SEGMENTED\_REQUEST

...

##### NewSegmentReceived

If a BACnet-Confirmed-Request-PDU that is secured with the same settings as the original PDU is received from the network layer whose 'segmented-message' parameter is TRUE; whose 'more-follows' parameter is TRUE; whose 'sequence-number' parameter is equal to `LastSequenceNumber` plus 1, modulo 256; and whose 'sequence-number' parameter is not equal to `InitialSequenceNumber` plus `ActualWindowSize`, modulo 256,

then save the BACnet-Confirmed-Request-PDU segment; increment `LastSequenceNumber`, modulo 256; restart `SegmentTimer`; *issue a N-RELEASE.request to the network layer entity specifying the source\_address value of the*

*segment for the destination\_address parameter (in case the data link layer is waiting for a reply); and enter the SEGMENTED\_REQUEST state to receive the remaining segments.*

...

[Change **Clause 6.1**, p. 53]

### **6.1 Network Layer Service Specification**

Conceptually, the BACnet network layer provides an unacknowledged connectionless form of data unit transfer service to the application layer. The primitives associated with the interaction are the N-UNITDATA request and indication, *the N-RELEASE request*, and the N-REPORT indication. These primitives provide parameters as follows:

```
N-UNITDATA.request (  
    destination_address,  
    data,  
    network_priority,  
    data_expecting_reply  
    security_parameters  
)
```

```
N-UNITDATA.indication (  
    source_address,  
    destination_address,  
    data,  
    network_priority,  
    data_expecting_reply,  
    security_parameters  
)
```

```
N-RELEASE.request (  
    destination_address  
)
```

...

Upon receipt of an N-UNITDATA.request primitive from the application layer, the network layer shall attempt to send an NSDU using the procedures described in this clause. Upon receipt of an NSDU from a peer network entity, a network entity shall either 1) send the NSDU to its destination on a directly connected network, 2) send the NSDU to the next BACnet router en route to its destination, and/or 3) if the destination address matches that of one of its own application entities, issue an N-UNITDATA.indication primitive to the appropriate entity in its own application layer to signal the arrival of the NSDU.

*Upon receipt of an N-RELEASE.request primitive from the application layer, the network entity shall attempt to issue a DL-RELEASE.request primitive to the data link entity specified by the destination\_address parameter of the N-RELEASE.request. If there is only one data link entity available, then the destination\_address may be ignored.*

[Change **Clause 6.5.4**, p.66]

### **6.5.4 Network Layer Procedures for the Receipt of Remote Traffic**

Upon receipt of an NPDU from the data link layer ... SA of the incoming NPDU.

*If the NPCI control octet indicates the presence of a DNET field, the NE resides in a BACnet router, the NPDU is to be routed to a different device, and the NPDU requires a reply (conveyed by the 'data\_expecting\_reply' parameter of the DL-UNITDATA indication primitive), then a DL-RELEASE request shall be issued to the data link layer entity specified by the source\_address value of the DL-UNITDATA indication.*

Three possibilities exist: either the router is directly connected ...

[Add new **Clause 9.1.4**, p. 81]

### **9.1.4 DL-RELEASE.request**

#### 9.1.4.1 Function

This primitive is the service request primitive for releasing a Master Node State Machine from the ANSWER\_DATA\_REQUEST state when no reply is available from the higher layers.

#### 9.1.4.2 Semantics of the Service Primitive

The primitive shall not provide any parameters as follows:

DL-RELEASE.request()

#### 9.1.4.3 When Generated

This primitive is generated from the network layer to the MS/TP entity to indicate that no reply is available from the higher layers.

#### 9.1.4.4 Effect on Receipt

Receipt of this primitive causes the MS/TP Master Node State Machine to leave the ANSWER\_DATA\_REQUEST state. If a Master Node State Machine is not in the ANSWER\_DATA\_REQUEST state or a Slave Node State Machine is present, then this primitive shall be ignored.

[Change **Clause 9.5.6**, p. 102]

### 9.5.6 Master Node Finite State Machine

...

A master node that supports segmentation shall ~~not use a segmentation window size greater than one.~~ *respond to each BACnet Data Expecting Reply frame with either a Reply Postponed frame or a data frame. This response releases the MS/TP Master Node State Machine that is holding the token from the WAIT\_FOR\_REPLY state and allows it to send the next MS/TP frame.*

[Change **Clause 9.5.6.9**, p. 109]

#### 9.5.6.9 ANSWER\_DATA\_REQUEST

...

DeferredReply

If no reply will be available from the higher layers within  $T_{reply\_delay}$  after the reception of the final octet of the requesting frame (the mechanism used to determine this is a local matter), *or after a DL-RELEASE.request is received,*

then an immediate reply is not possible. Any reply shall wait until this node receives the token. Call SendFrame to transmit a Reply Postponed frame, and enter the IDLE state.

[Change **Clause 9.7.1**, p. 112]

### 9.7.1 Routing of Messages from MS/TP

When a network entity with routing capability receives from a directly connected MS/TP data link an NPDU whose 'data\_expecting\_reply' parameter is TRUE and the NPDU is to be routed to another ~~network~~ *device* according to the procedures of Clause 6, the network entity shall direct the MS/TP data link to transmit a Reply Postponed frame *by issuing a DL-RELEASE.request* before attempting to route the NPDU. This allows the routing node to leave the ANSWER\_DATA\_REQUEST state and the sending node to leave the WAIT\_FOR\_REPLY state before the potentially lengthy process of routing the NPDU is begun.



[Add a new entry to **History of Revisions**, p. 1027]

**(This History of Revisions is not part of this standard. It is merely informative and does not contain requirements necessary for conformance to the standard.)**

### HISTORY OF REVISIONS

...	...	...
1	18	<b>Addendum bh to ANSI/ASHRAE 135-2012</b> Approved by ASHRAE on February 29, 2016, and by the American National Standards Institute March 1, 2016.  <ol style="list-style-type: none"><li>1. Correct Application State Machine Failover</li><li>2. Increase Segmentation Window Size for MS/TP</li></ol>

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