

IPv6 over MS/TP Networks

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Kerry Lynn, Editor <kerlyn@ieee.org>

Jerry Martocci <jerald.p.martocci@jci.com>

Carl Neilson <cneilson@deltaccontrols.com>

Stuart Donaldson <stuart.donaldson@honeywell.com>

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Motivation

Develop a low-cost **wired** IPv6 solution for commercial building control applications

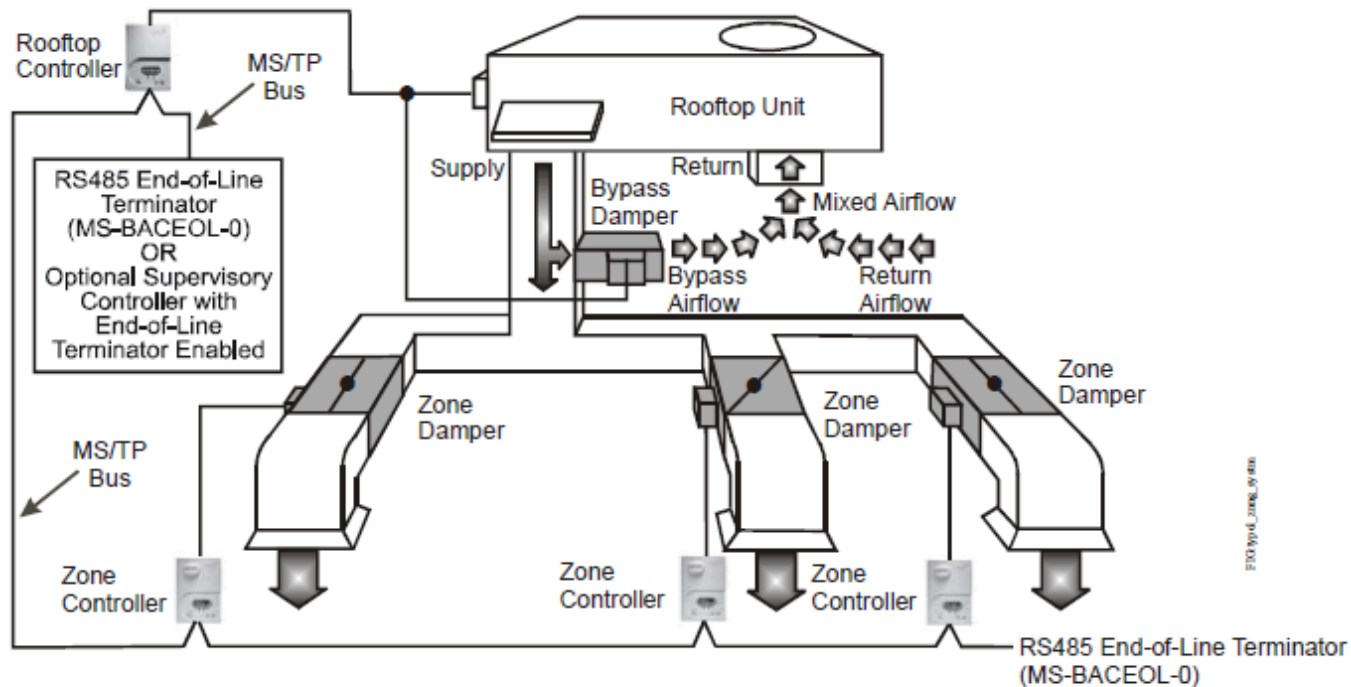


Figure 1: Typical Zoning Control System Installed on a Single MS/TP Bus

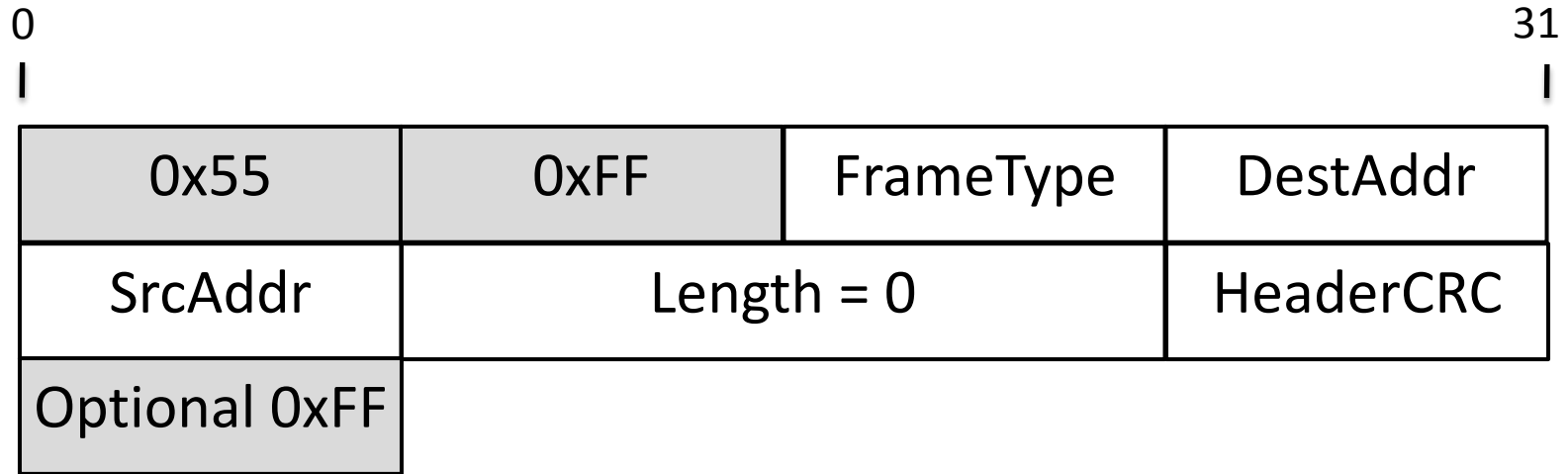
Background

- **BACnet** is the ISO/ANSI/ASHRAE [Standard 135-2012] data communication protocol for Building Automation and Control networks
- **MS/TP** (Master-Slave/Token-Passing) is a widely used data link defined in BACnet
 - Based on RS-485 single twisted pair PHY; supports data rates up to 115.2 kpbs and 1 km diameter
 - Contention-less MAC (token passing bus)
 - Consider it a wired alternative to IEEE 802.15.4

Technical Approach

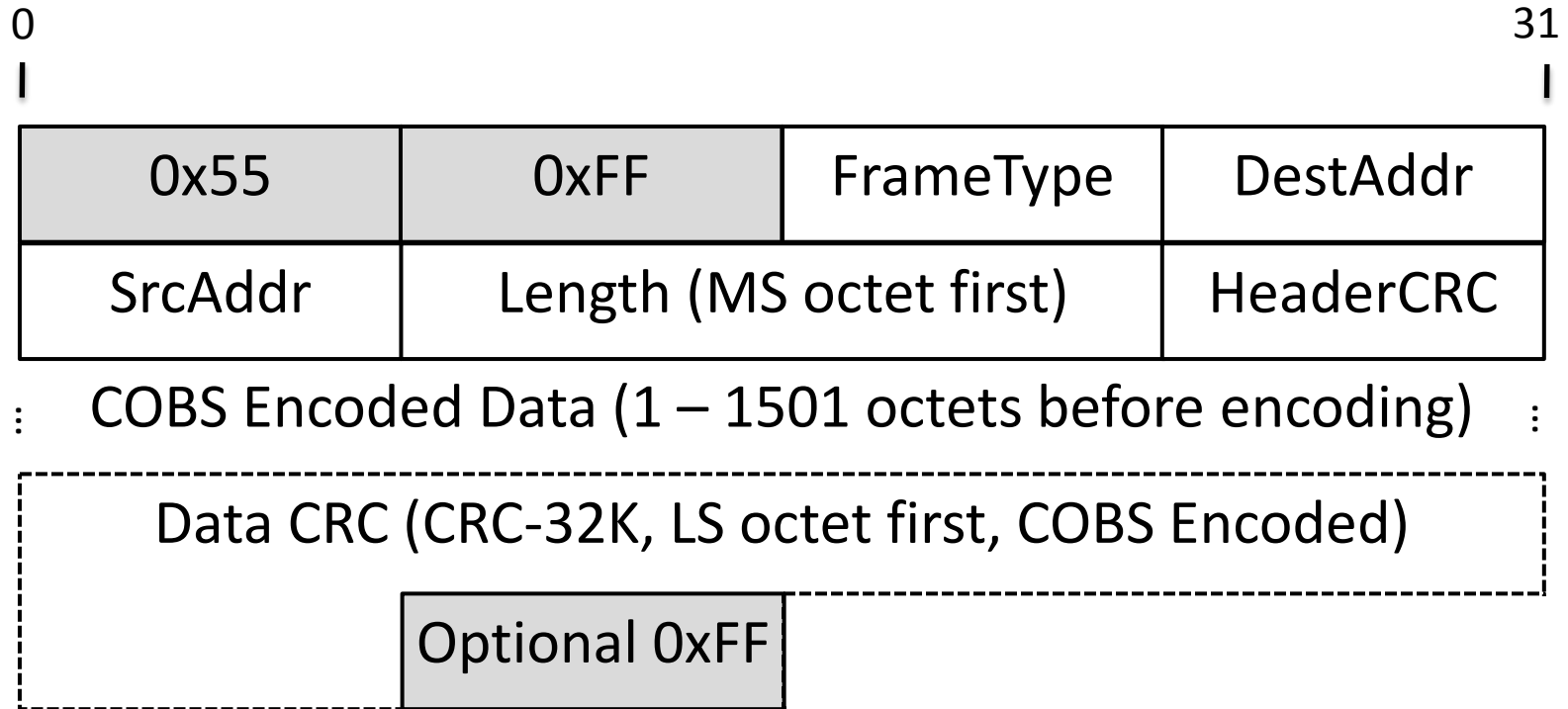
- Leverage elements of 6LoWPAN [RFC 4944]
- Minimize changes to existing MS/TP specification [BACnet Clause 9]
- Goal: co-existence with legacy MS/TP nodes
 - No changes to frame header format, control frames, or MS/TP Master Node state machine
- MS/TP Extended Frames proposal includes:
 - New frame type for IPv6 (LoBAC) Encapsulation
 - Larger MSDU (1500+ octets)
 - 32-bit FCS (CRC-32K)
 - COBS (Consistent Overhead Byte Stuffing) encoding

MS/TP Control Frame Format



- Frame Type:
- 0 = Token
 - 1 = Poll for Master
 - 2 = Reply to Poll for Master
- Destination Address: 0 – 127
- Source Address: 0 – 127

MS/TP Encoded Data Frame Format



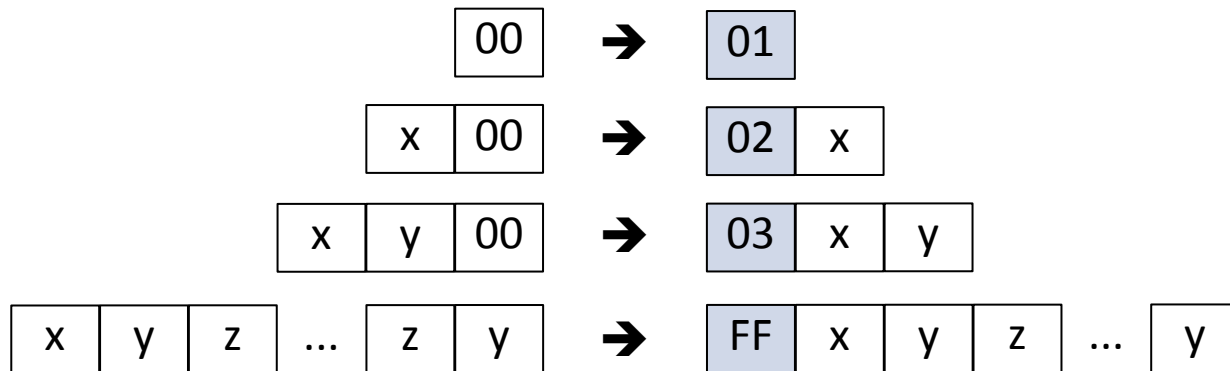
Frame Type: 34 = IPv6 (LoBAC) Encapsulation

Destination Address: 0 – 127 or 255 (all nodes)

Source Address: 0 – 127

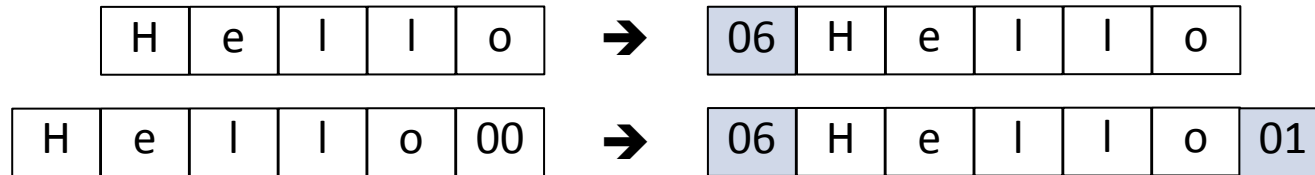
COBS Encoding Basics

Code	Followed By	Meaning
0x00	(not applicable)	(not allowed)
0x01	nothing	A single zero byte
0x02	one data byte	The single data byte, followed by a zero byte
n	$(n - 1)$ data bytes	The $(n - 1)$ data bytes, followed by a zero byte
0xFE	253 data bytes	The 253 data bytes, followed by a zero byte
0xFF	254 data bytes	The 254 data bytes, not followed by a zero byte



COBS Encoding in Detail

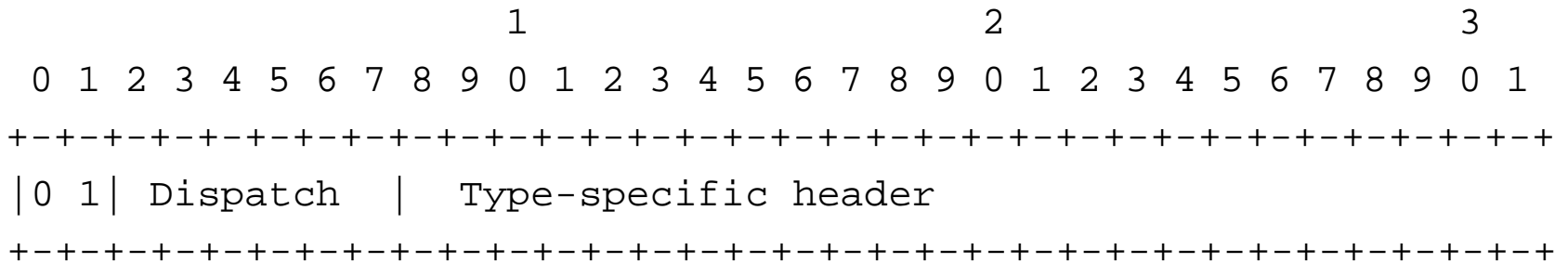
- "Phantom zero" is appended to input to resolve ambiguity in final code block:



- An arbitrary octet (e.g. 0x55) may be removed by XOR-ing it over the COBS encoder **output** stream
- COBS overhead:
 - At least one octet per encoded field
 - At most one octet in 255 (6 octets in 1501; $\approx 0.4\%$)

LoBAC Encapsulation

- Uses 6LoWPAN Dispatch Header [RFC 4944]:



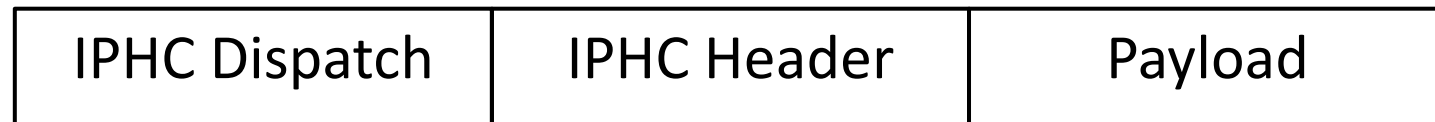
Pattern	Header Type
00 XXXXXX	NALP – Not a LoWPAN (LoBAC) frame
01 000000	ESC – Additional Dispatch octet follows
01 000001	IPv6 – Uncompressed IPv6 header
...	Reserved by RFC 4944
01 1XXXXX	LOWPAN_IPHC – Compressed IPv6 header

LoBAC Encapsulation (cont.)

- No mesh, broadcast, or fragmentation headers
 - Two options remain:



A LoBAC encapsulated IPv6 datagram



A LoBAC encapsulated LOWPAN_IPHC
[RFC 6282] compressed datagram

IPHC Compression [RFC 6282]

- Assumes some 6LBR-like behavior, e.g. 6LoWPAN Context Option (6CO, [RFC 6775])
- Uses 6LoWPAN short address format, formed by appending 8-bit MS/TP address to the octet 0x00
 - For example, an MS/TP node with a MAC address of 0x4F results in the following IPHC short address:

```
| 0 | 1 |  
| 0 | 5 |  
+-----+  
| 0000000001001111 |  
+-----+
```

Stateless Address Auto-Configuration

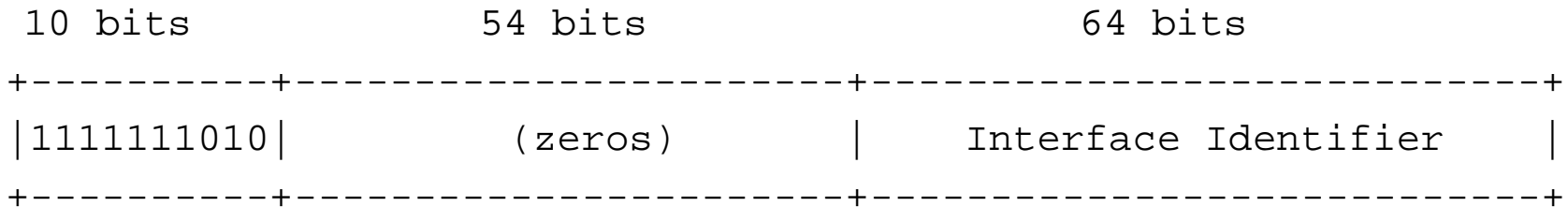
- Typically, 8-bit MAC address is appended to the seven octets 0x00, 0x00, 0x00, 0xFF, 0xFE, 0x00
 - For example, an MS/TP node with a MAC address of 0x4F results in the following Interface ID:

```
| 0           1 | 1           3 | 3           4 | 4           6 |
| 0           5 | 6           1 | 2           7 | 8           3 |
+-----+-----+-----+-----+
| 0000000000000000 | 0000000011111111 | 1111111000000000 | 0000000001001111 |
+-----+-----+-----+-----+
```

- A privacy address **may** be used for the Interface Identifier
 - In this case there **must** be a way to map the IID to an 8-bit MAC address (e.g. ARO in NS [RFC 6775])

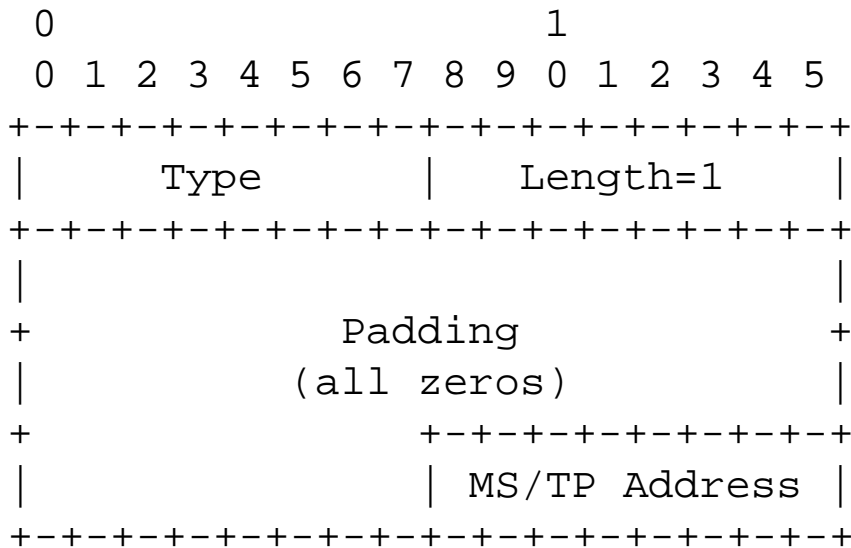
IPv6 Link Local Address

- The IPv6 link-local address [RFC 4291] for an MS/TP interface is formed by appending the Interface Identifier (defined in previous slide) to the prefix FE80::/64:



Unicast Address Mapping

- The Source/Target Link-Layer Address option has the following form when the link layer is MS/TP and the addresses are 8-bit MS/TP MAC addresses:



Option fields:

Type:

- 1 = Source Link-layer address
- 2 = Target Link-layer address

Length:

The value of this field is
1 for 8-bit MS/TP addresses

MS/TP Address:

The 8-bit MAC address in
canonical bit order

Multicast Address Mapping

- MS/TP only supports link-local broadcast
- Uses 6LoWPAN short address format, formed by appending 0xFF to the octet 0x00
 - All IPv6 multicasts on the MS/TP link map to the following IPhc short destination address:

```
| 0                               1 |  
| 0                               5 |  
+-----+  
| 0000000011111111 |  
+-----+
```

Thank You

- Questions?