IPv6 over MS/TP Networks

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Motivation

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

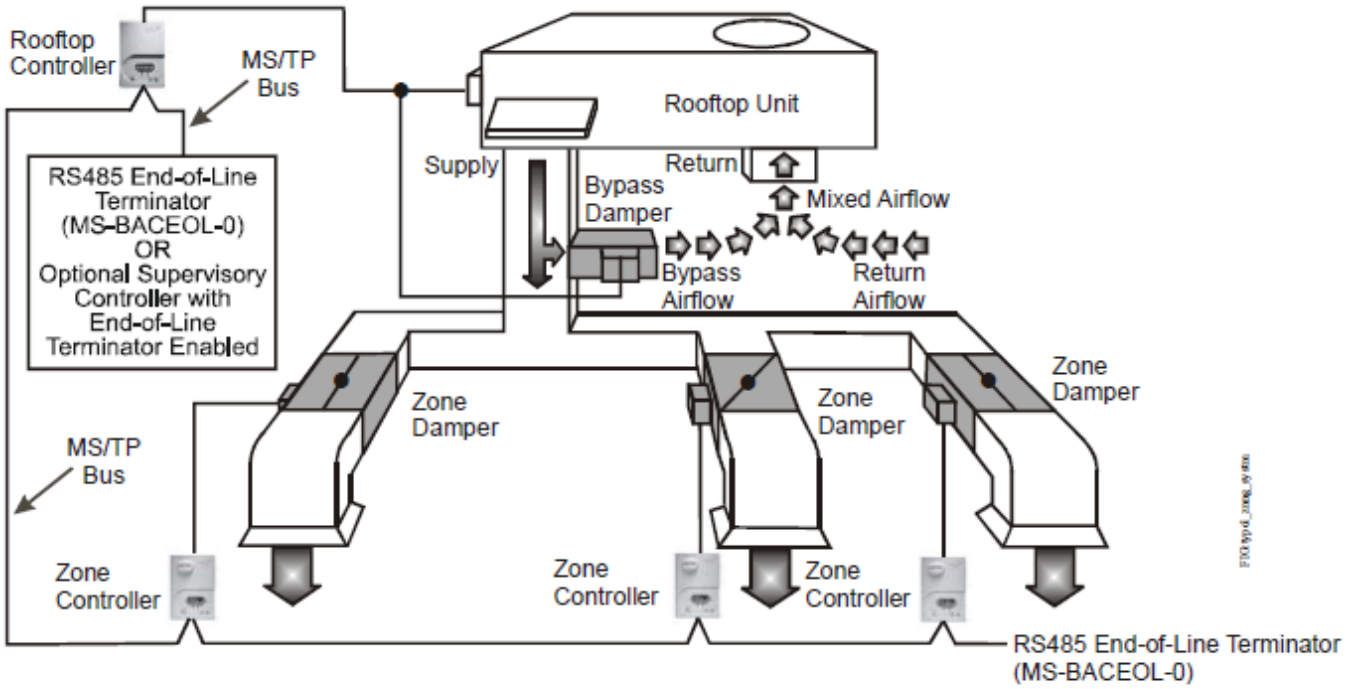


Figure 1: Typical Zoning Control System Installed on a Single MS/TP Bus

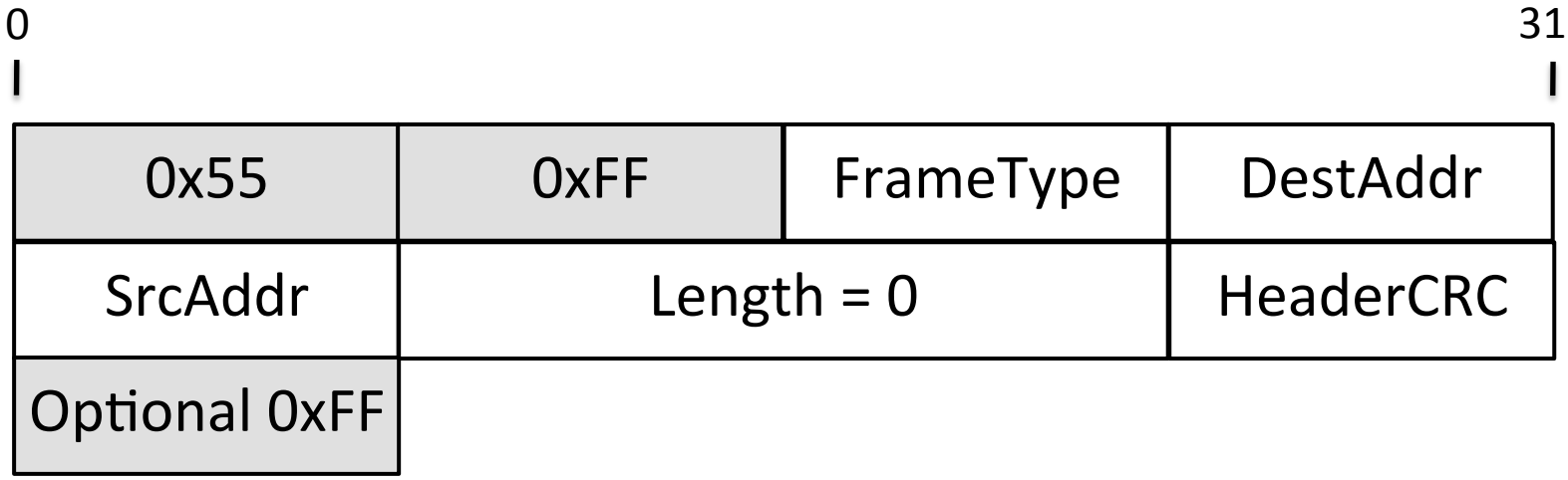
Background

- **BACnet** is the ISO/ANSI/ASHRAE [Standard 135-2010] 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

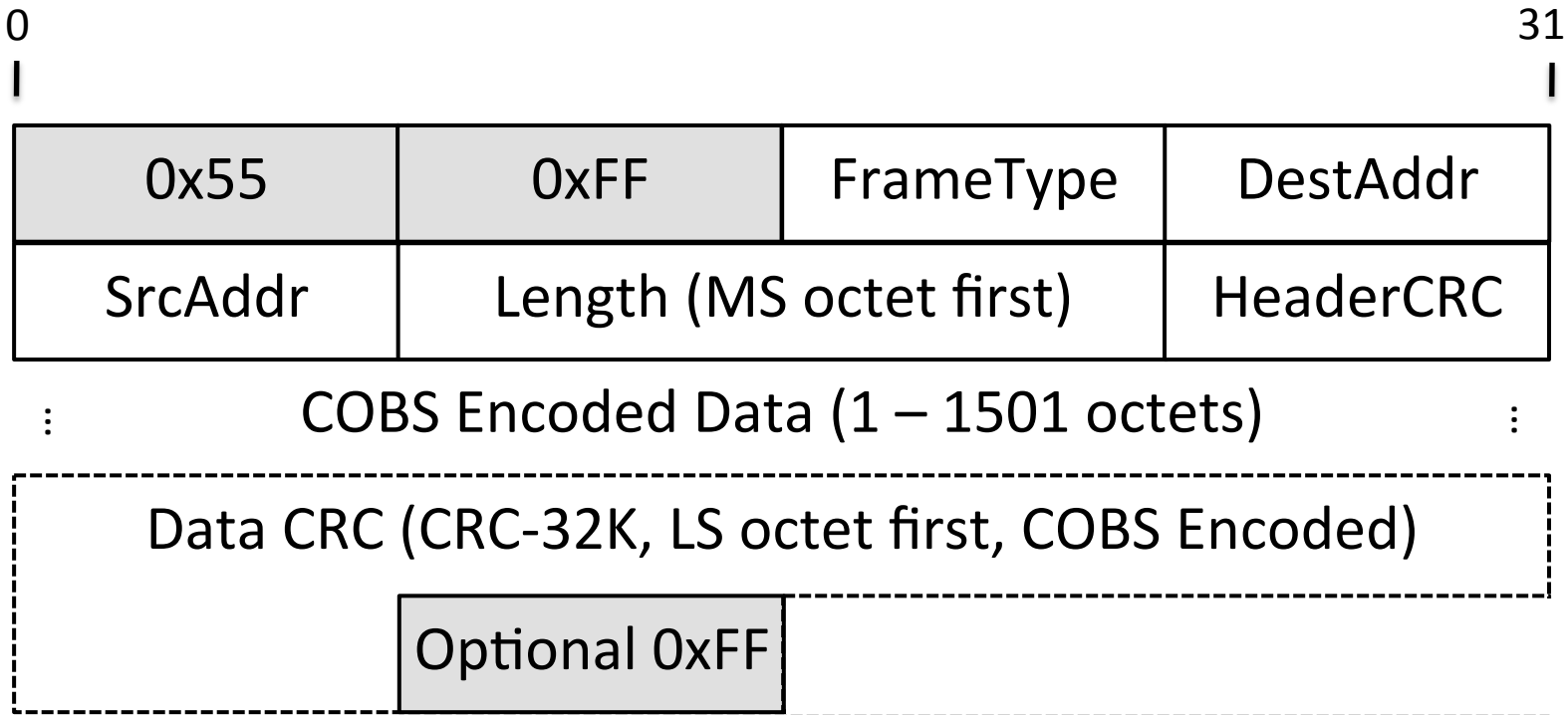
- Leverage elements of 6LoWPAN [RFC 4944]
- Minimize changes to existing MS/TP specification [BACnet Clause 9]
- Goal: co-existence with legacy MS/TP nodes
  - No changes to frame header format, control frames, or MS/TP Master Node state machine
- MS/TP Extended Frames proposal includes:
  - New frame 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

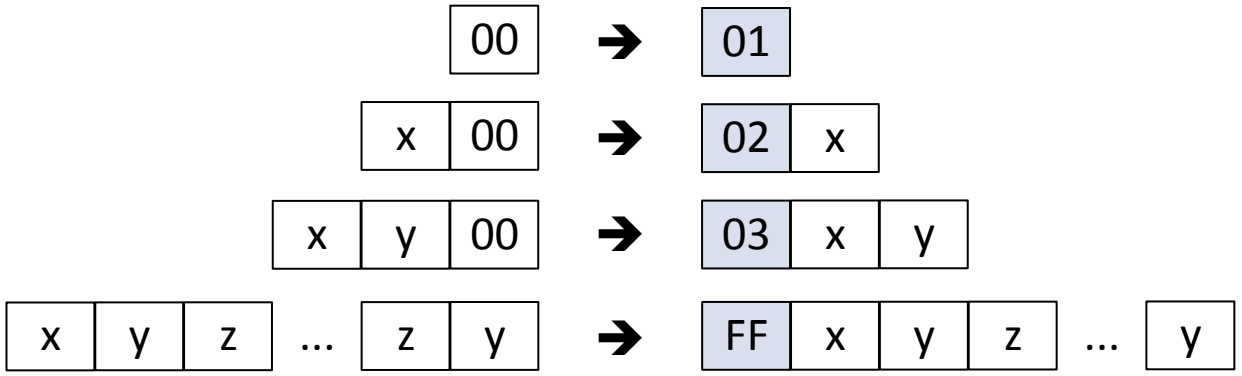
MS/TP Extended Data Frame Format



Frame Type: 127 = IPv6 (LoBAC) Encapsulation
Destination Address: 0 – 127, 255 (all nodes)
Source Address: 0 – 127

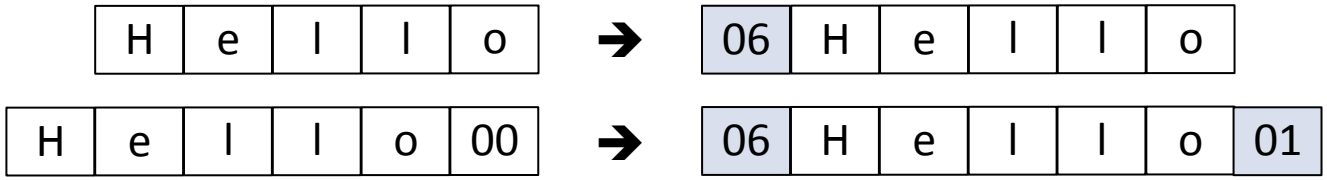
COBS Encoding Basics

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

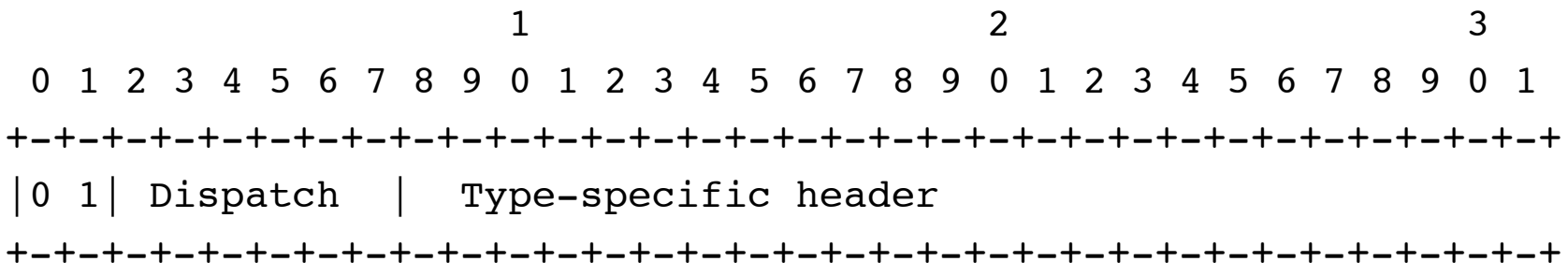
- "Phantom zero" is appended to input to resolve ambiguity in final code block:



- An arbitrary octet (e.g. 0x55) may be removed by XOR-ing it over the COBS output stream
- COBS overhead:
  - At least, one octet
  - At most, one octet in 255 (6 octets in 1501; ≈ 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.)

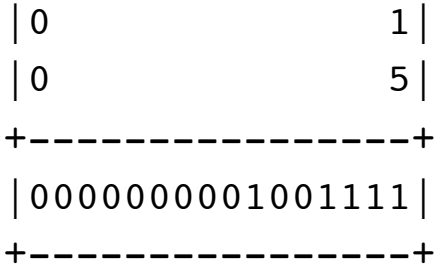
- No mesh, broadcast, or fragmentation headers
  - Two options remain:

A LoBAC encapsulated IPv6 datagram

A LoBAC encapsulated LOWPAN_IPHC
[RFC 6282] compressed datagram

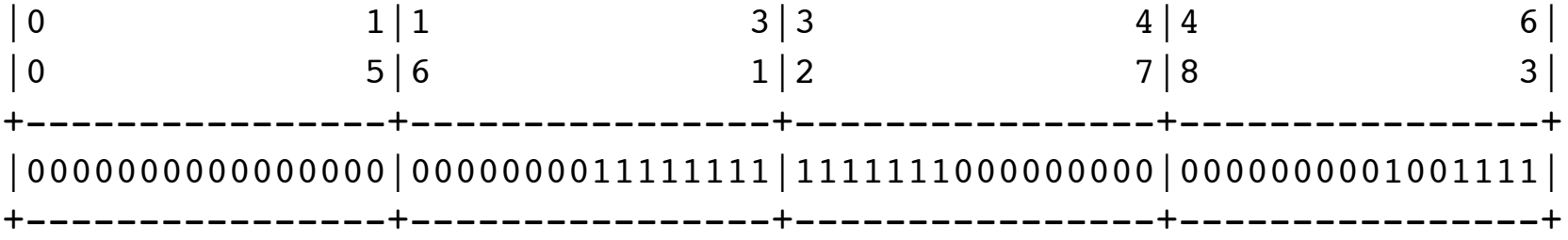
IPHC Compression [RFC 6282]

- Assumes some 6LBR-like behavior, e.g. context distribution
- 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:



Stateless Address Auto-Configuration

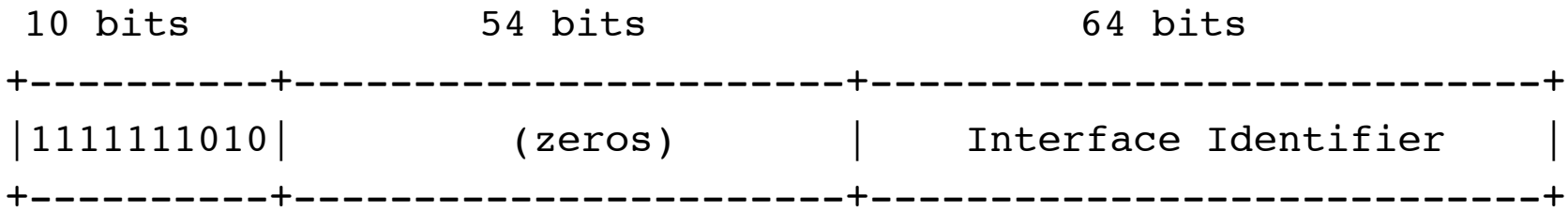
- Typically, 8-bit MAC address is appended to the seven octets 0x00, 0x00, 0x00, 0xFF, 0xFE, 0x00
  - For example, an MS/TP node with a MAC address of 0x4F results in the following Interface ID:



- An EUI-64 **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. registration or DAD)

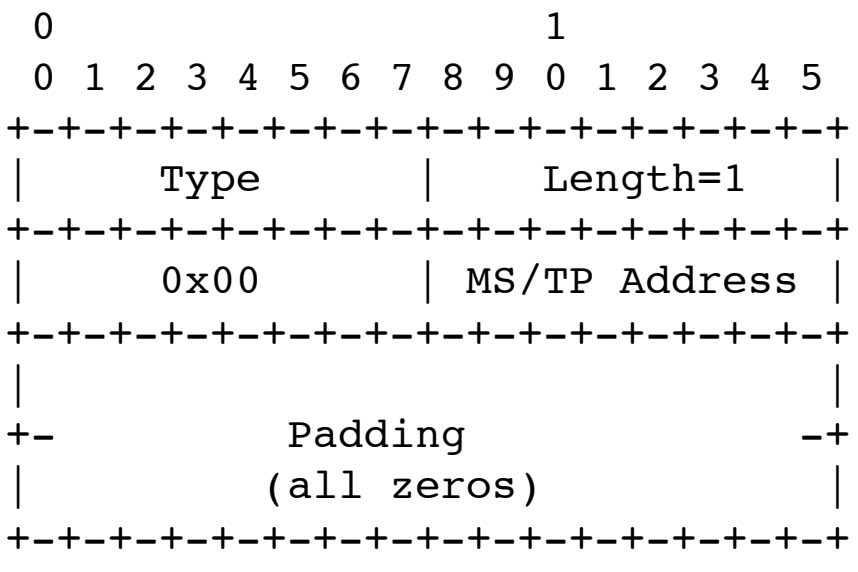
IPv6 Link Local Address

- 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:

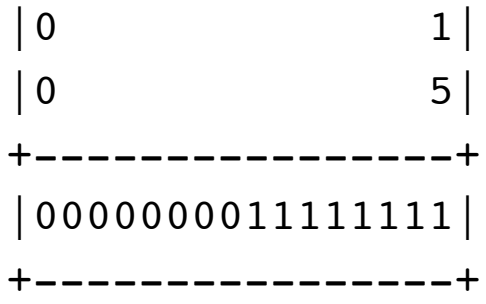
Type:
1 = Source Link-layer address
2 = Target Link-layer address

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:



Thank You

- Questions?