HDLC and GFP encapsulation techniques for EFM copper

Describes HDLC and GFP as possible encapsulation techniques for EFM copper

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Agenda

- This presentation studies two possible encapsulation techniques for EFM: HDLC and GFP. For both a specific solution adjusted for Ethernet transport over copper is presented
- The goal of this presentation is to assist selection of the appropriate encapsulation technique for EFM copper

Main objectives

- Both techniques are international standards, intended for packet mode transmission, byte-oriented, flexible and efficient. Both can provide a good solution for EFM encapsulation
- For GFP a simplified solution accommodating specifics of Ethernet traffic over copper is presented
- For HDLC it is shown that several simple enhancements and proper selection of system parameters can reduce many concerns about the impact of the statistical overhead
- Main features of both techniques are provided

GFP: brief introduction

- GFP = General Framing Procedure

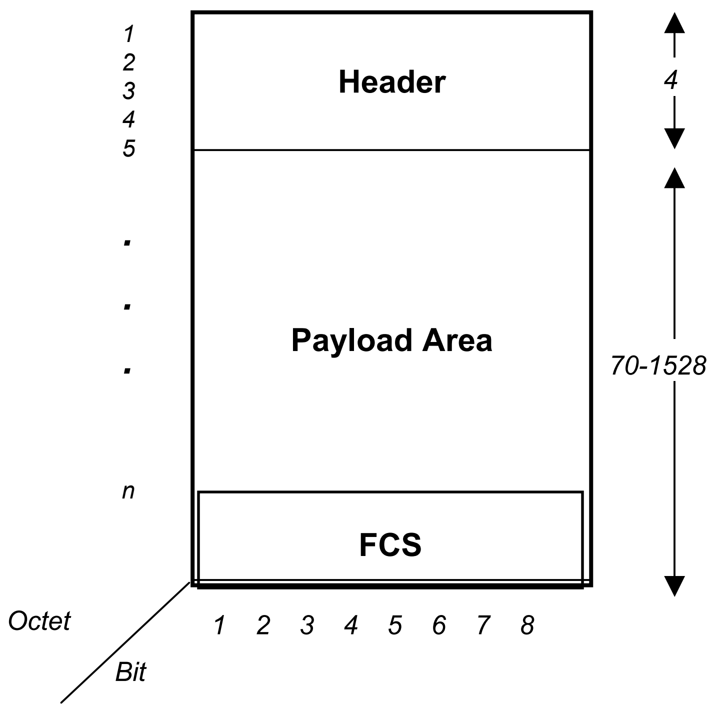
  - Recently standardized by ANSI and ITU as a generic adaptation protocol for multi-service broadband applications.

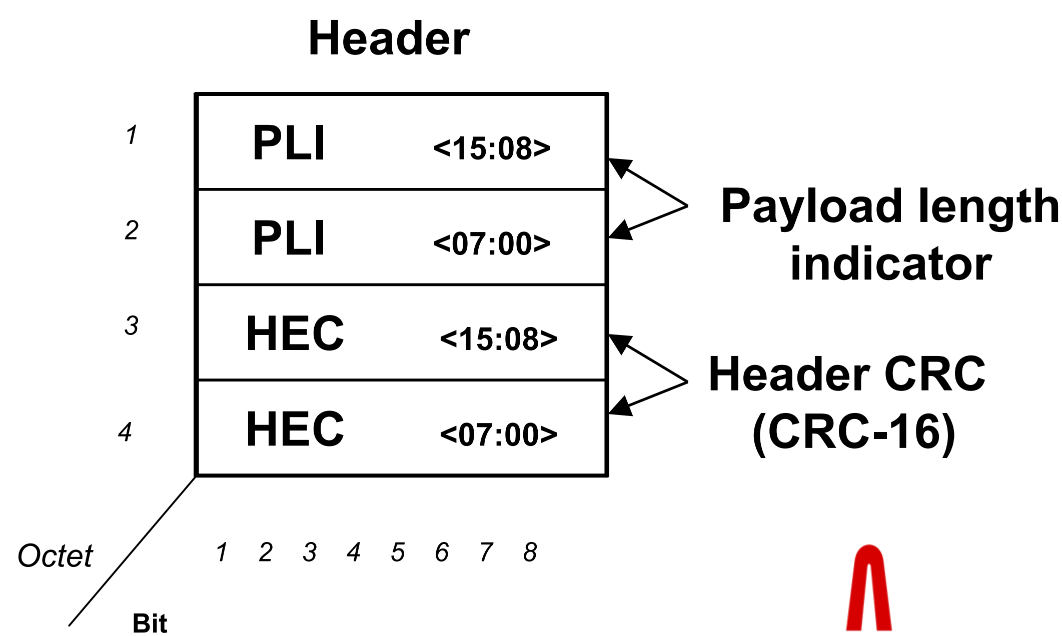
  - Specifically build to operate in packet mode (Frame-Mapped GFP), particularly in Ethernet applications

  - Low fixed overhead (6 bytes per frame) and no statistical overhead

GFP for EFM: scope

- 4-byte header for frame delineation
  Up to 1528-byte payload
  2-byte FCS (CRC-16)
  4-byte IDLE frame for inter-frame gaps (PLI=0x00)





GFP for EFM: header and FCS

- **Header:**
  - Scrambling of the header may not be used since there is a separate scrambling in EFM PMA

  - ISO/ITU CRC-16 used. Single error correction in the header may be skipped as ineffective (multiple errors are more probable)

  - Since the maximum length of the frame is 1528 bytes, 11 bits is sufficient for PLI. Therefore, five MSB may be used to increase protection of frame delimiter and for management purposes

- **FCS**
  A standard ISO/ITU CRC-16 attached after the Ethernet data payload to provide sufficient MTTFPA, [1]

GFP for EFM: payload

- **Payload:**

  - Loop Aggregation Header (LAH, 3-4 bytes) may be be added to the Ethernet frame

  - Standard G.gfp scrambler shall be used to improve frame delineation

  - Since GFP overhead, including LAH and FCS, doesn’t exceed 10 bytes, it is suggested to keep original Preamble and SFD fields transmitted over the line, [1]

Synchronization issues

- Getting to the sync state by searching for a quad of octets with proper HEC count
- Verifying the sync state by CRC-16 check following by a valid header (IDLE or of the next frame) after the PLI count
- Notification of non-sync state by meeting an invalid header after the PLI count. Initiates a new search
- A 4-byte header seems to be a reliable delimiter, [1]

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GFP: pros and cons

- Pros
  - packet/byte-oriented format
  - low and fixed overhead (less than IPG in total) allows to keep the same line bit rate as over MII
  - simple, fast and reliable re-synchronization
  - growing field experience
  - international standard

- Cons
  - a full buffering of the sent frame in TPS-TC is required to obtain the frame length (PLI value)

HDLC: brief introduction

- HDLC

  - Standardized by ITU, IETF an other groups as basis for several widely used protocols for broadband applications

  - Specifically build to operate in packet mode, very simple implementation

  - Low fixed overhead (6 bytes per frame) but high statistical overhead, which is the main concern to use HDLC for EFM

Impact of statistical overhead

- Statistical overhead cause expansion of frames depending on their content. If expansion exceeds the idle period between the frames, several next frames will be delayed. If the number of delayed frames will be too big, a violation of service bit rate may be reported, which is undesirable

- However, if the number of delayed frames is almost always limited so that the total time occupied by the delayed frames is short relatively to the time of bit rate evaluation, no violation will be registered

How to eliminate the impact?

- To ensure that overhead explosion will not impact system performance more than once in predefined time, sufficient idle periods should be established between frames.

  This may be done by appropriate selection the line bit rate, which is key issue to provide the predefined low probability of service bit rate violation caused by statistical overhead

- To exclude frequent overhead explosion, it is proposed to use scrambling of Ethernet data prior to HDLC encoding

The criterion

- a. The probability that the service bit rate will get below the nominal value shall not exceed the predefined threshold,

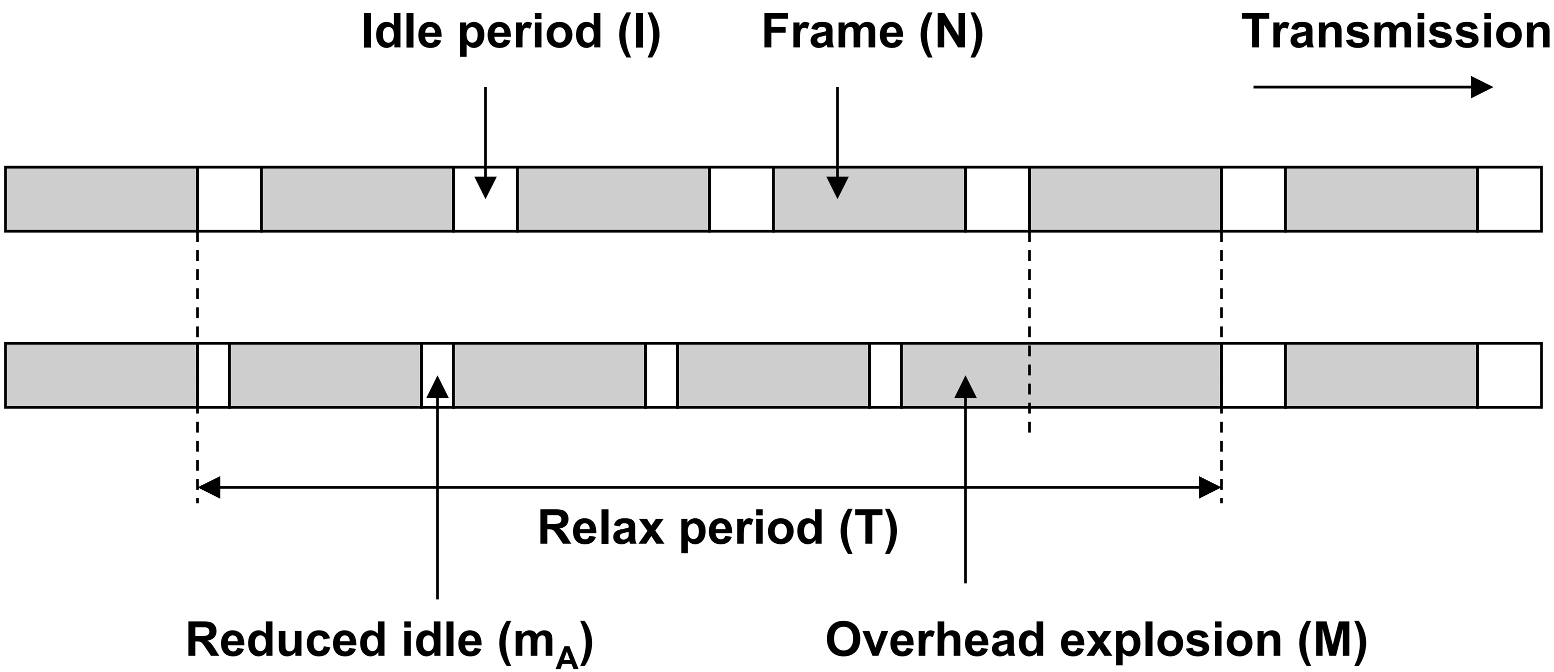
  and

  b. If the service bit rate gets below the nominal value, the duration of this event shall not exceed the predefined value

- Referring to the xDSL bit error probability of 10^{-11}, which corresponds with frame error probability of $4 \cdot 10^{-9}$, select the worst case probability of instant service bit rate violation of 10^{-14}.

  Select number of frames T =10 as the maximum duration of the event (Relax period)

How does it work?



$$T \approx \frac{M - m_A}{I - m_A}$$ [frames]

$$I > O_F + m_A + \frac{M - m_A}{T_{\max}}$$ [bytes]

O_F – is the applied fixed overhead

Parameters

- Use the following parameters to specify the necessary number of idle octets (*I*):
  - The maximum explosion *M* to be accommodated is one appearing with probability of $< 10^{-14}$
  - The reduced idle period should accommodate the overhead appearing with probability of $<10^{-3}$ (99.9% worst case)
  - The relax period is less than 10 frames (Tmax=10)

- If the required value of *I* exceeds the original idle period I_0, the line bit rate must be increased by:

$$q \geq \max_{N}\left(1 + \frac{I(N) + O_F - I_0}{N}\right)$$

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Results of calculation

Parameter	N , bytes in the frame					
	64	128	256	512	1024	1518
10^{-14} (*M*)	12	15	20	27	38	46
10^{-3} (m_A, 99.9%)	4	5	8	11	18	24
I(N)+O_F (O_F=6+LAH=9)	14	15	19	22	29	36

- **The results of calculation show that *I* exceeds the IPG (12 bytes) and for N>256 it exceeds IPG+SFD+Preamble (20 bytes total) - the line bit rate shall be increased.**

- If IPG/SFD/Preamble is removed (I_0=20):

q > 1+ (36-20)/1518 = 0.0105 (1.05%)

- If IPG/SFD/Preamble is not removed (I_0=12):

q > 1+ (14-12)/64 = 0.0313 (3.13%)

Summary

- The following operations are required to provide in the WORST CASE service bit rate violations with probability less than 10-14, and with duration, if violation occurs, only slightly longer than 10 frames:
  - scramble the incoming data
  - remove Preamble and SFD
  - provide line bit rate at least 1.05% higher than MII
- By increasing the line bit rate slightly more (~ 0.5%), the probability of the service bit rate violation may be reduced by another several orders

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HDLC: pros and cons

- Pros
  - packet/byte-oriented format
  - simple, very fast and reliable re-synchronization
  - very simple implementation
  - great field experience
  - international standard

- Cons
  - high statistical overhead doesn't allow to keep the same line bit rate as over MII: a line bit rate increase of at least 1.05% is required

Conclusions

- **Both HDLC and GFP are good choices for EFM copper encapsulation technique**
- **GFP can operate with the same line bit rate as MII, but requires frame buffering in TPS-TC**
- **HDLC is very simple in implementation, but requires to increase the line bit rate relatively to MII by at least 1.05%**

References

- [1] V. Oksman "Requirements for EFM encapsulation technique, Kauai, May 2002