光波長ネットワークの活用と今後の展望
－ＩＰを用いた非圧縮ＨＤＴＶ伝送－

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あらまし エンドーエンドでの全光波長パスの提供は、現時点では難しいが、数年の内に現実のものとなり得る。その様な全光ネットワークがエンドユーザに提供出来る通信機能は、現在の常識を覆すものとなる。つまり、ユーザが自由に速度、フォーマット、プロトコルを光波長パスを設定する毎にネットワーク提供者の力を借りずに変更できるのである。その第一歩としての当社が関与している光波長ネットワークの活用の一例として、ＩＰを用いた非圧縮ＨＤＴＶ伝送方式を紹介する。

キーワード IPｵｰﾊﾞ光、HDTVｵｰﾊﾞIP、波長ﾈｯﾄﾜｰｸ

Applications and Future Directions of λ Network
—Un-compressed HDTV Transmission in IP based Network—

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Abstract Currently, there are still some technical obstacles to provide a true end-to-end lambda path. Those obstacles such as optical 2R/3R and lambda exchanges in optical domain could be overcome in a few years. Once we can reach that point, all common senses in the current communication network will become wrong. These common senses include the limitations of transmission speed, format and protocol. Users and network providers will be freed from those limitations. For the first step toward such lambda network, we show that HDTV signals could be transmitted over a long distance without any compression, and we introduce a new method to map un-compressed HDTV signals onto IP packets.

Keyword IP over Optics, HDTV over IP, Lambda Network

1. Abstract

This documentation describes the packetization method of SMPTE 292M over IP[1]. SMPTE 292M[2] is a definition of the serial digital interface for uncompressed HDTV. SMPTE 292M is transmitted in IP datagram and the IP datagram runs on PPP over SONET/SDH[3]. This method will create one of applications based on the IP over Optics.

2. Introduction

SMPTE 292M, Bit-Serial Digital Interface, is a standard definition for uncompressed HDTV. SMPTE 292M defines the source format data, data format, and serial data format at data rate of 1.485Gbps.

This document specifies the way of SMPTE 292M encapsulation over IP. As IP is a world wide defacto standard protocol, it is easy to adapt to existing links, such as SONET/SDH. In addition, SMPTE 292M will become accessible by hosts.

SMPTE sender/receiver and a network provider might use different clocks. This specification describes a method to resolve the difference of clocks by use of the encapsulation scheme of the time information (time stamp).

3. Packet Payload

One packet payload is fixed at 240 bytes in our system. One SMPTE(HDTV) frame with the time stamp is mapped onto 6 packet payloads. The fields consist of 6 Payloads. The sequence number of payloads in an IP packet is indicated by LEG field. (See 5.1). Information of an HDTV frame is fragmented into one payload size, and mapped onto 6 payloads in order.

The time stamp is only used for the reconstruction of the HDTV frame. The time stamp is encapsulated in the first payload. The second to sixth payloads do not have the field for the time stamp.

The field of packet payloads depends on the use of Read Solomon Code.

When Read Solomon code is not utilized, the fields of payloads are following.

TS: Time Stamp 4 bytes
VIDEO DATA in Payload1 :HDTV data 236 bytes
VIDEO DATA in Payload2-6:HDTV data 240 bytes

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 0 1 2 3 4 5 6 7 0 1 2 3 4 5 6 7 0 1 2 3 4 5 6 7
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                               TS                              |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                                                               |
|                                                               |
|                                                               |
|                          VIDEO DATA                           |
|                                                               |
|                                                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ 60
```

Payload1

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 0 1 2 3 4 5 6 7 0 1 2 3 4 5 6 7 0 1 2 3 4 5 6 7
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                                                               |
|                                                               |
|                                                               |
|                                                               |
|                                                               |
|                          VIDEO DATA                           |
|                                                               |
|                                                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ 60
```

Payload2

.

.

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 0 1 2 3 4 5 6 7 0 1 2 3 4 5 6 7 0 1 2 3 4 5 6 7
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                                                               |
|                                                               |
|                                                               |
```

```
 |                                                               |
 |                                                               |
 |                          VIDEO DATA                           |
 |                                                               |
 |                                                               |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ 60
                              Payload6
```

When Read Solomon Code is utilezed, the fields of Payloads are follwoing.

TS: Time Stamp 4 bytes

VIDEO DATA in Payload1 :HDTV data 220 bytes(Read Solomon Code:16 bytes)

VIDEO DATA in Payload2-6:HDTV data 224 bytes(Read Solomon Code:16 bytes)

```
  0               1               2               3
  0 1 2 3 4 5 6 7 0 1 2 3 4 5 6 7 0 1 2 3 4 5 6 7 0 1 2 3 4 5 6 7
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |                              TS                               |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |                                                               |
 |                          VIDEO DATA                           |
 |                                                               |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ 56
 |                                                               |
 |                      READ SOLOMON CODE                        |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ 60
                              Payload1
```

```
  0               1               2               3
  0 1 2 3 4 5 6 7 0 1 2 3 4 5 6 7 0 1 2 3 4 5 6 7 0 1 2 3 4 5 6 7
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |                                                               |
 |                                                               |
 |                                                               |
 |                          VIDEO DATA                           |
 |                                                               |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ 56
 |                                                               |
 |                      READ SOLOMON CODE                        |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ 60
                              Payload2
                                 .
                                 .
                                 .
```

```
 0               1               2               3
 0 1 2 3 4 5 6 7 0 1 2 3 4 5 6 7 0 1 2 3 4 5 6 7 0 1 2 3 4 5 6 7
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                                                               |
|                                                               |
|                                                               |
|                          VIDEO DATA                           |
|                                                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ 56
|                                                               |
|                      READ SOLOMON CODE                        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ 60
```

Payload6

4. Time Stamp

SMPTE sender/receiver and a network provider might use different clocks. For instance, broadcasters use their own clock for synchronizing SMPTE 292M. This clock will be different from the clock used in SDH/SONET. Therefore, it is necessary that each clock is treated independently. For IP packet transfers, the network clock is utilized. For synchronizing SMPTE 292M, the clock information utilized by a sender of SMPTE 292M. This clock information is encapsulated in the packet payload. The SMPTE receiver must use the encapsulated clock information.

5. IP Packetization

A conventional IP header is utilized for the delivery of SMPTE 292M.

5.1. SMPTE 292M Frame Encapsulation Header

```
 0               1               2               3
 0 1 2 3 4 5 6 7 0 1 2 3 4 5 6 7 0 1 2 3 4 5 6 7 0 1 2 3 4 5 6 7
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|H|I |R| V  | SR |H|I |R| V  | SR |H| I|R| V  | SR |H|I |R| V | SR |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| LEG |  N/A  | LEG |  N/A  | LEG |  N/A  | LEG |  N/A  |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|A|   N/A     |A|   N/A     |A|   N/A     |A|   N/A     |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|     S-No      |     S-No      |     S-No      |     S-No      |
+- - - - - - - -+- - - - - - - -+- - - - - - - -+- - - - - - - -+-+- - - - - - -
|               |               |               |               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|    RSADR      |    RSADR      |    RSADR      |    RSADR      |
+- - - - - - - -+- - - - - - - -+- - - - - - - -+- - - - - - - --+- - - - - - - +
|               |               |               |               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

H: 1bit

This field indicates the payload format.

H field is set to 0 for the delivery of SDTV

H field is set to 1 for the delivery of SMPTE 292M

I: 1 bit

I field is used for Interleaving.

I field is set to 1 for Interleaving.

I field is set to 0 for no Interleaving.

R: 1 bit

R field determines the function of Read Solomon
R field is set to 1 for Read Solomon Code
R field is set to 0 for no use of Read Solomon Code.

V: 10 bits
V field indicates the video interface number to be used.

SR: 3 bits
SR field indicates transfer rate of the IP datagram to be sent. 000:1.485Gbps 001:270Mbps

LEG: 3bits
LEG field has the information of the Payload data length. 001:Payload1 010:Payload2 .... 110:Payload6

S-No:
S-No field contains serial number of IP datagram.
The number is used for Interleaving.

RSADR:
RSADR indicates Address of RAM for Read Solomon.

The way of mapping the address depends whether Read Solomon Code is utilized or not. Based on the use of Read Solomon Code, senders determine the mapping of the address used for Interleaving.

5.2. Error Correction Scheme and Interleaving

Burst errors may occur in IP packet transfers. Interleaving and Read Solomon are introduced to alleviate the effects caused by burst errors.

16 byte-lengths of Read Solomon Code enables correcting 8 byte-errors. R field allows the use of Read Solomon code. The polynomial expression of the Read Solomon code in order to detect errors is following.

$$G(x)= X^8 + X^4 + X^3 + X^2 + 1$$

Interleaving is a way to correlate the relative positions of the bits with respect of the code words. The I field (See 5.1) allows the utilization of the interleaving.

6. SONET/SDH Considerations

6.1. SMPTE 292M over IP over SONET/SDH

IP over SONET/SDH transfer is compliant with "PPP over SONET/SDH","PPP in HDLC-Like Framing"[6] and "The point to point protocol"[7].

6.2. Mapping specification

The followings define specifications of SONET/SDH for the transfer of SMPTE 292M.

SDH input/output interface :
STM-16 VC4-16C(Compliant with G.958 2.4Gbps)
VIDEO input/output interface:
HD-SDI(Compliant with SMPTE 292M, 1.485Gbps)
Error correcting code: Read Solomon code

7. Network Model

A Network Model of IP over SDH for SMPTE 292M is discussed here. One of the most important goals for transmitting SMPTE 292M is survivability. The survivability depends on network architectures and devices that control the networks. In this section, a network model for the delivery of SMPTE 292M is considered. The model is following.

7.1. Ring Connection Model

A ring architecture has endurance to interruption since the multiple paths are provided. Two bi-directional fibers allow a ring network to send SMPTE 292M with redundancy. Both of fibers are active and send data to two directions. Nodes receive the same HDTV signals via two directions. Even if one active line is disconnected, as another line is active, the node connected to the destination. A malfunction line can be bypassed. Therefore, the network has a better survivability.

IP over SDH Network

```
  +---------------+                                                +---------------+
  |               |------------------------------------------------|               |
  |  NODE         |-  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -|  NODE         |
  |               |                                                |               |
  |               |                                                |               |
  +---------------+                                                +---------------+
     |  |                                                                |  |
     |                                                                   |
     |  |                                                                |  |
     |                                                                   |
     |  |                                                                |  |
  +---------------+                                                +---------------+
  |               |                                                |               |
  |  NODE         |                                                |  NODE         |
  |               |------------------------------------------------|               |
  |               |-  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -|               |
  +---------------+                                                +---------------+
```

---------an active fiber

\- - - an active fiver (opposite direction)

8. Conclusion

This document addresses a new method of mapping scheme of HDTV signals onto IP packets, which are mapped onto SDH/SONET payloads. The significance of this method enables a network to convey uncompressed HDTV signals. Such network will be the first step of the lambda network, in which users and network providers can be freed from various limitations based on the current common sense.

9. Reference

[1] IETF RFC 791 "INTERNET PROTOCOL"

[2] Society of Motion Picture and Television Engineers, Bit-Serial Digital Interface for High-Definition Television Systems . SMPTE 292M 1998.

[3] IETF RFC2615 "PPP over SONET/SDH"

[4] ISO/IEC International Standard 13818-2; "Generic coding of moving pictures and associated audio information: Video", 1996.

[5] IETF RFC 2119, "Key words for use in RFCs to Indicate Requirement Levels".

[6] IETF RFC 1662, "PPP in HDLC-like Framing" M Simpson

[7] IETF RFC 1132 "The point-to-point protocol"