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SERIES G: TRANSMISSION SYSTEMS AND MEDIA, DIGITAL SYSTEMS AND NETWORKS

OTN transport of CPRI signals

ITU-T G-series Recommendations – Supplement 56

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Supplement 56 to ITU-T G-series Recommendations

OTN transport of CPRI signals

Summary

The nature of common public radio interface (CPRI) signals is such that they require special consideration when carried as a client signal over the ITU-T G.709 optical transport network (OTN). One consideration is the stringent frequency accuracy requirements for CPRI. Another consideration is that the native line coding of the CPRI signals can be transcoded into a more bandwidth efficient coding, which allows the carriage of additional CPRI client signals in some important applications. Supplement 56 to ITU-T G-series Recommendations describes alternatives for mapping and multiplexing CPRI client signals into the OTN. This Supplement relates to Recommendations ITU-T G.872, ITU-T G.709/Y.1331, ITU-T G.798 and ITU-T G.959.1.

History

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The World Telecommunication Standardization Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

The approval of ITU-T Recommendations is covered by the procedure laid down in WTSA Resolution 1.

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Supplement 56 to ITU-T G-series Recommendations

OTN transport of CPRI signals

1 Scope

This Supplement describes alternatives for mapping and multiplexing common public radio interface (CPRI) client signals into the optical transport network (OTN). Other viable means of carrying CPRI over OTN are known to exist and this Supplement is intended to give examples only. It is not intended to provide an exhaustive list of alternatives. The alternatives in this Supplement are for various applications and requirements. Some are based on new methods and others are to explain how to use standardized tools for carrying CPRI over OTN. The mappings in this Supplement include direct mappings for native CPRI client signals and mappings that apply transcoding in order to gain bandwidth efficiency. This Supplement relates to [ITU-T G.872], [ITU-T G.709], [ITU-T G.798] and [ITU-T G.959.1].

2 References

[ITU-T G.709]	Recommendation ITU-T G.709/Y.1331 (2012), *Interfaces for the optical transport network*.
[ITU-T G.798]	Recommendation ITU-T G.798 (2012), *Characteristics of optical transport network hierarchy equipment functional blocks.*
[ITU-T G.806]	Recommendation ITU-T G.806 (2012), *Characteristics of transport equipment – Description methodology and generic functionality*.
[ITU-T G.872]	Recommendation ITU-T G.872 (2012), *Architecture of optical transport networks.*
[ITU-T G.959.1]	Recommendation ITU-T G.959.1 (2016), *Optical transport network physical layer interfaces*.
ITU-T G.7041]	Recommendation ITU-T G.7041/Y.1303 (2016), *Generic framing procedure.*
[CPRI]	CPRI Specification V7.0 (2015), *Common public radio interface (CPRI), interface specification*. <http://www.cpri.info/downloads/CPRI_v_7_0_2015-10-09.pdf>

3 Definitions

None.

4 Abbreviations and acronyms

This Supplement uses the following abbreviations and acronyms:

AIS	Alarm Indication Signal
AMP	Asynchronous Mapping Procedure
BaFN	Basic Frame Number
BFP	Basic Frame Pointer
CBR	Constant Bit Rate
CID	Channel ID
CPRI	Common Public Radio Interface

CSF	Client Signal Fail
FEC	Forward Error Correction
GFP-T	Transparent Generic Framing Procedure
GMP	Generic Mapping Procedure
HO	High Order
LO	Low Order
NE	Network Element
ODU	Optical channel Data Unit
ODUk	Optical channel Data Unit-k
ODU2r	overclocked Optical channel Data Unit-2
OMFI	OPU2r Multiframe Identifier
OPU	Optical channel Payload Unit
OPUk	Optical channel Payload Unit-k
OTN	Optical Transport Network
PCS	Physical Coding Sublayer
PSI	Payload Structure Identifier
PT	Payload Type
RE	Remote Equipment
RRH	Remote Radio Head
UIpp	Unit Intervals peak-to-peak
UPI	User Payload Identifier

5 Conventions

Transmission order: The order of transmission of information in all the figures in this Supplement is first from left to right and then from top to bottom. Within each byte, the most significant bit is transmitted first. The most significant bit (bit 1) is illustrated at the left in all the figures.

6 Introduction

This Supplement first describes methods for mapping CPRI client signals into the OTN that make use of existing ITU-T Recommendations. CPRI signals are treated as a normal constant bit rate (CBR) client for the ITU-T G.709 OTN, but stringent frequency and clock tolerance requirements are specified for CPRI clients. Second, this Supplement describes a method that uses a combination of transcoding and multiplexing (interleaving) of multiple CPRI clients into an overclocked optical channel data unit-2 (ODU2), called the ODU2r, in order to optimize transport bandwidth efficiency in some important CPRI applications.

Note that OTN transport of CPRI is intended for use within an administrative domain. Users of this Supplement should not assume that the required performance for the CPRI client is met. It is the responsibility of the network operator to determine if the required performance can be met. For example, the OTN network should also be designed in order to meet the applicable symmetry requirements. Considerations for maintaining adequate frequency accuracy for CPRI clients are addressed in the respective clauses.

The definition of CPRI replacement signals during fault conditions is for further study for all mappings.

7 Mappings based on normative methods

This clause describes methods for mapping CPRI client signals into ITU-T G.709 payloads using techniques that are currently defined for use with other client signal mappings in [ITU-T G.709]. The descriptions also describe special considerations that may be needed.

NOTE – It is the responsibility of the network operator to determine if the required performance can be met. The noise generated by the OTN would have to be handled by the CPRI system in order to meet the application requirements. This is considered as a complex task according to the current OTN specification.

7.1 Single CPRI signal mapping into ODUk (k = 0, 1, flex(CBR))

CPRI CBR signals ([CPRI] options 1 to 10) may be transported over an optical channel data unit-k (ODUk) connection. These CBR signals are mapped into a low order (LO) optical channel payload unit-k (OPUk) via the generic mapping procedure (GMP) as specified in clause 17.7 of [ITU-T G.709] for [CPRI] options 1 to 3 and via the bit-synchronous mapping procedure as specified in clause 17.9 of [ITU-T G.709] for [CPRI] options 4 to 10.

Two [CPRI] signals (options 1 and 2) are transported via OPU0, one [CPRI] signal (option 3) is transported via OPU1 and the remaining [CPRI] signals (options 4 to 10) are transported via OPUflex. The GMP C_m and C_n (n = 1) values associated with the [CPRI] options 1 to 3 signals are presented in Tables 7-1a, 7-1b, 7-2a and 7-2b.

The use of the "experimental mapping" payload type (code 0x01) is suggested.

Further details are provided below:

Simulation analyses were done for the transport of [CPRI] option 2, option 3 and option 4 clients over OTN for the following four cases:

a) Option 2 client signal → ODU0 → ODU2 → OTU2 → ODU2 → ODU0 → option 2 client signal

b) Option 3 client signal → ODU1 → ODU2 → OTU2 → ODU2 → ODU1 → option 3 client signal

c) Option 3 client signal → ODU1 → OTU1 → ODU1 → option 3

d) Option 4 client signal → ODU2 → OTU2 → ODU2 → option 4

As described by this Supplement, the mappings of the [CPRI] option 2 client to ODU0 and the [CPRI] option 3 client to ODU1 are via GMP. The [CPRI] option 4 client is mapped to ODUflex, and the ODUflex is mapped to ODU2 via GMP. Finally, in a) the ODU0 is mapped to ODU2 via GMP and in b) the ODU1 is mapped to ODU2 via asynchronous mapping procedure (AMP). Cases a) and b) have a single mapping of the CPRI client to OTN and one level of OTN multiplexing. Cases c) and d) have a single mapping to OTN and no OTN multiplexing.

Simulations were run for no use of additional phase information for the CPRI client to LO ODU mapper (i.e., C_n with n = 8) and 1 UI of additional phase information for the CPRI client to LO ODU mapper (i.e., C_n with n = 1). The desynchronizer bandwidth for the high order (HO) ODU to LO ODU demappers was 300 Hz.

The simulation results indicated that, for CPRI client desynchronizer bandwidth in the range 100 to 300 Hz (current OTN client desynchronizers are 300 Hz or, in a few cases, 100 Hz or 200 Hz) RMS frequency offset ranges from approximately 113 ppb to 190 ppb for transport of [CPRI] option 2 for case a) and 156 ppb to 317 ppb for transport of [CPRI] option 3 for case b). In addition, for the same range of desynchronizer bandwidths, RMS frequency offset ranges from approximately

29 ppb to 116 ppb for [CPRI] option 3 for case c) and 32 ppb to 130 ppb for [CPRI] option 4 for case d).

The simulation results also indicated that, for CPRI client desynchronizer bandwidth in the range 100 to 300 Hz, peak-to-peak jitter ranges from approximately 6.9 to 14.2 unit intervals peak-to-peak (UIpp) for transport of [CPRI] option 2 for case a) and 6.7 to 14.1 UIpp for transport of [CPRI] option 3 for case b). In addition, for the same range of desynchronizer bandwidths, peak-to-peak jitter ranges from approximately 0.8 to 7.2 UIpp for [CPRI] option 3 for case c) and 0.76 to 7.2 UIpp for [CPRI] option 4 for case d).

In order to allow compatibility with OTN transport, CPRI remote equipment (RE) would need to be designed to tolerate and filter properly at least the noise added by the OTN transport, which is not currently budgeted by CPRI. Additional sources of noise may also exist. The OTN network should also be designed in order to meet the applicable CPRI stringent symmetry requirements; this is something that has not been studied. Interworking between OTN and the CPRI RE, in terms of jitter and wander, is still unknown and has to be considered.

The CPRI replacement signal is for further study.

Table 7-1a – C_m (m = 8) for su1.238G clients into OPU0

[CPRI] client signal	Nominal bit rate (kbit/s)	Bit rate tolerance (ppm)	Floor $C_{8,min}$	Minimum c_8	Nominal c_8	Maximum c_8	Ceiling $C_{8,max}$
Option 1	614 400	±100	7552	7552.674	7 553.580	7554.487	7555
Option 2	1 228 800	±100	15105	15105.348	15107.160	15108.973	15109

Table 7-1b – C_n (n = 8 or 1) for su1.238G clients into OPU0

[CPRI] client signal	Nominal bit rate (kbit/s)	Bit rate tolerance (ppm)	Floor $C_{8,min}$	Minimum c_8	Nominal c_8	Maximum c_8	Ceiling $C_{8,max}$
–	–	–	–	–	–	–	–
			Floor $C_{1,min}$	Minimum C_1	Nominal C_1	Maximum C_1	Ceiling $C_{1,max}$
Option 1	614 400	±100	60421	60421.391	60 428.642	60435.894	60436
Option 2	1 228 800	±100	120 854	120 854.867	120 857.284	120 859.701	120 860

Table 7-2a – C_m (m = 16) for supra-1.238 to su2.488G clients into OPU1

[CPRI] client signal	Nominal bit rate (kbit/s)	Bit rate tolerance (ppm)	Floor $C_{16,min}$	Minimum c_{16}	Nominal c_{16}	Maximum c_{16}	Ceiling $C_{16,max}$
Option 3	2 457 600	±100	7 521	7521.073	7521.975	7522.878	7523

Table 7-2b – C_n (n = 8 or 1) for supra-1.238 to su2.488G clients into OPU1

<table>
<tr><th>[CPRI] client signal</th><th>Nominal bit rate (kbit/s)</th><th>Bit rate tolerance (ppm)</th><th>Floor $C_{8,min}$</th><th>Minimum c_8</th><th>Nominal c_8</th><th>Maximum c_8</th><th>Ceiling $C_{8,max}$</th></tr>
<tr><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td></tr>
<tr><td colspan="8"></td></tr>
<tr><td colspan="3"></td><td>Floor $C_{1,min}$</td><td>Minimum c_1</td><td>Nominal c_1</td><td>Maximum c_1</td><td>Ceiling $C_{1,max}$</td></tr>
<tr><td>Option 3</td><td>2 457 600</td><td>±100</td><td>241685</td><td>241685.563</td><td>241714.568</td><td>241743.574</td><td>241744</td></tr>
</table>

Table 7-3 shows supra-2.488G CBR clients.

Table 7-3 – supra-2.488G CBR clients

[CPRI] client signal	Nominal bit rate (kbit/s)	Bit-rate tolerance (ppm)
Option 4	3 072 000	±0.002
Option 5	4 915 200	±0.002
Option 6	6 144 000	±0.002
Option 7	9 830 400	±0.002
Option 8	10 137 600	±0.002
Option 9	12 165 120	±0.002
Option 10	24 330 240	±0.002

Table 7-4 shows the replacement signal for CPRI clients.

Table 7-4 – Replacement signal for CPRI clients

[CPRI] client signal	Replacement signal	Bit-rate tolerance (ppm)
Option 1	Link fault	±100
Option 2	Link fault	±100
Option 3	Link fault	±100
Option 4	Link fault	±100
Option 5	Link fault	±100
Option 6	Link fault	±100
Option 7	Link fault	±100
Option 8	TBD	±100
Option 9	TBD	±100
Option 10	TBD	±100

Table 7-5 shows the number of tributary slots required for ODUj into HO OPUk and OPUCn.

Table 7-5 – Number of tributary slots required for ODUj into HO OPUk and OPUCn

LO ODU – [CPRI]	# 2.5G tributary slots		# 1.25G tributary slots				# 5G tributary slots
	OPU2	**OPU3**	**OPU1**	**OPU2**	**OPU3**	**OPU4**	**OPUCn**
ODUflex(CBR)							
– ODUflex(option 4)	–	–	–	3	3	3	1
– ODUflex(option 5)	–	–	–	4	4	4	1
– ODUflex(option 6)	–	–	–	5	5	5	2
– ODUflex(option 7)	–	–	–	8	8	8	2
– ODUflex(option 8)	–	–	–	–	9	8	2
– ODUflex(option 9)	–	–	–	–	10	10	3
– ODUflex(option 10)	–	–	–	–	20	19	5

Table 7-6 shows C_m and C_n (n = 8) for ODUj into ODTU2.M.

Table 7-6 – C_m and C_n (n = 8) for ODUj into ODTU2.M

ODUj signal – [CPRI]	M	m = 8×M	Floor $C_{m,min}$	Minimum C_m	Nominal C_m	Maximum C_m	Ceiling $C_{m,max}$
ODUflex(CBR)	ODUflex(CBR) dependent						
– ODUflex(option 4)	3	24	12 534	12 534.900	12 536.404	12 537.909	12 538
– ODUflex(option 5)	4	32	15 041	15 041.880	15 043.685	15 045.490	15 046
– ODUflex(option 6)	5	40	15 041	15 041.880	15 043.685	15 045.490	15 046
– ODUflex(option 7)	8	64	15 041	15 041.880	15 043.685	15 045.490	15 046
			Floor $C_{8,min}$	**Minimum C_8**	**Nominal C_8**	**Maximum C_8**	**Ceiling $C_{8,max}$**
ODUflex(CBR)	ODUflex(CBR) dependent						
– ODUflex(option 4)	3	24	37 604	37 604.700	37 609.213	37 613.726	38 614
– ODUflex(option 5)	4	32	60 167	60 167.519	60 174.740	60 181.961	60 182
– ODUflex(option 6)	5	40	75 209	75 209.399	75 218.425	75 227.452	75 228
– ODUflex(option 7)	8	64	120 335	120 335.039	120 349.48	120 363.923	120 364

Table 7-7 shows C_m and C_n (n = 8) for ODUj into ODTU3.M.

Table 7-7 – C_m and C_n (n = 8) for ODUj into ODTU3.M

ODUj signal – [CPRI]	M	m = 8×M	Floor $C_{m,min}$	Minimum C_m	Nominal C_m	Maximum C_m	Ceiling $C_{m,max}$
ODUflex(CBR)	ODUflex(CBR) dependent						
– ODUflex(option 4)	3	24	12 482	12 482.010	12 483.508	12 485.006	12 486
– ODUflex(option 5)	4	32	14 978	14 978.412	14 980.210	14 982.007	14 983
– ODUflex(option 6)	5	40	14 978	14 978.412	14 980.210	14 982.007	14 983
– ODUflex(option 7)	8	64	14 978	14 978.412	14 980.210	14 982.007	14 983
– ODUflex(option 8)	9	72	13 730	13 730.211	13 731.859	13 733.507	13 764
– ODUflex(option 9)	10	80	14 828	14 828.628	14 830.407	14 832.187	14 833
– ODUflex(option 10)	20	160	14828	14828.628	14830.407	14832.187	14833
			Floor $C_{8,min}$	**Minimum C_8**	**Nominal C_8**	**Maximum C_8**	**Ceiling $C_{8,max}$**
ODUflex(CBR)	ODUflex(CBR) dependent						
– ODUflex(option 4)	3	24	37 446	37 446.030	37 450.524	37 455.018	37 456
– ODUflex(option 5)	4	32	59 913	59 913.648	59 920.838	59 928.029	59 929
– ODUflex(option 6)	5	40	74 892	74 892.060	74 901.048	74 910.036	74 911
– ODUflex(option 7)	8	64	119 827	119 827.296	119 841.677	119 856.058	119 857
– ODUflex(option 8)	9	72	123 571	123 571.899	123 586.729	123 601.560	123 602
– ODUflex(option 9)	10	80	148 286	148 286.279	148 304.075	148 321.872	148 322
– ODUflex(option 10)	20	160	296572	296572.557	296608.149	296643.743	296644

Table 7-8 shows C_m and C_n (n = 8) for ODUj into ODTU4.M.

Table 7-8 – C_m and C_n (n = 8) for ODUj into ODTU4.M

ODUj signal – [CPRI]	M	m = 8×M	Floor $C_{m,min}$	Minimum C_m	Nominal C_m	Maximum C_m	Ceiling $C_{m,max}$
ODUflex(CBR)	ODUflex(CBR) dependent						
– ODUflex(option 4)	3	24	12 006	12 006.001	12 007.442	12 008.883	12 009
– ODUflex(option 5)	4	32	14 407	14 407.201	14 408.930	14 410.659	14 411
– ODUflex(option 6)	5	40	14 407	14 407.201	14 408.930	14 410.659	14 411
– ODUflex(option 7)	8	64	14 407	14 407.201	14 408.930	14 410.659	14 411
– ODUflex(option 8)	8	64	14 857	14 857.426	14 859.209	14 860.993	14 861
– ODUflex(option 9)	10	80	14 263	14 263.129	14 264.841	14 266.553	14 267
– ODUflex(option 10)	19	152	15013	15013.820	15015.622	15017.424	15018
			Floor $C_{8,min}$	**Minimum C_8**	**Nominal C_8**	**Maximum C_8**	**Ceiling $C_{8,max}$**
ODUflex(CBR)	ODUflex(CBR) dependent						
– ODUflex(option 4)	3	24	36 018	36 018.003	36 022.326	36 026.649	36 027
– ODUflex(option 5)	4	32	57 628	57 628.805	57 635.722	57 642.638	57 643
– ODUflex(option 6)	5	40	72 036	72 036.007	72 044.652	72 053.297	72 054
– ODUflex(option 7)	8	64	115 257	115 257.611	115 271.443	115 285.276	115 286
– ODUflex(option 8)	8	64	118 859	118 859.411	118 873.676	118 887.941	118 888
– ODUflex(option 9)	10	80	142 631	142 631.293	142 648.411	142 665.529	142 666
– ODUflex(option 10)	19	152	285262	285262.587	285296.822	285331.058	285332

Table 7-9 shows C_m and C_n (n=8) for ODUj into ODTUCn.M.

Table 7-9 – C_m and C_n (n=8) for ODUj into ODTUCn.M

ODUj signal	M	m=128× M	Floor $C_{m,min}$	Minimum c_m	Nominal c_m	Maximum c_m	Ceiling $C_{m,max}$
ODUflex(CBR)	ODUflex(CBR) dependent						
– ODUflex(CPRI 4)	1	128	560	560.302	560.369	560.437	561
– ODUflex(CPRI 5)	1	128	896	896.483	896.591	896.699	897
– ODUflex(CPRI 6)	2	256	560	560.302	560.369	560.437	561
– ODUflex(CPRI 7)	2	256	896	896.483	896.591	896.699	897
– ODUflex(CPRI 8)	2	256	924	924.498	924.609	924.720	925
– ODUflex(CPRI 9)	3	384	739	739.599	739.688	739.776	740
– ODUflex(CPRI 10)	5	640	887	887.519	887.625	887.732	888
			Floor $C_{8,min}$	**Minimum c_8**	**Nominal c_8**	**Maximum c_8**	**Ceiling $C_{8,max}$**
ODUflex(CBR)	ODUflex(CBR) dependent						
– ODUflex(CPRI 4)	1	128	8964	8964.833	8965.909	8966.985	8967
– ODUflex(CPRI 5)	1	128	14343	14343.734	14345.455	14347.176	14348
– ODUflex(CPRI 6)	2	256	17929	17929.667	17931.819	17933.971	17934
– ODUflex(CPRI 7)	2	256	28687	28687.467	28690.910	28694.353	28695
– ODUflex(CPRI 8)	2	256	29583	29583.950	29587.501	29591.051	29592
– ODUflex(CPRI 9)	3	384	35500	35500.740	35505.001	35509.262	35510
– ODUflex(CPRI 10)	5	640	71001	71001.481	71010.002	71018.523	71019

7.2 Multiple CPRI client signal mapping using GFP-T

Transparent generic framing procedure (GFP-T), as defined in clause 8 of [ITU-T G.7041], can be used to carry CPRI clients. The GFP multiplexing facility described in clause 6.1.2.1.3.2 of [ITU-T G.7041] provides a means to carry multiple CPRI clients of the same rate within an OPUk or an OPUflex(GFP) carrier. These two facilities can be combined to yield a method to map multiple CPRI clients (Options 1 to 6) into an ODU2 carrier stream as per clause 17.4 of [ITU-T G.709]. The CPRI clients being mapped are synchronous to each other. The ODU2/OTU2 clock is made to be synchronous to the CPRI clients. The selection of which CPRI client provides a reference clock to the OTU2 clock is outside the scope of this document. Figure 7-1 shows the mapping of synchronous CPRI clients into a synchronous OTU2.

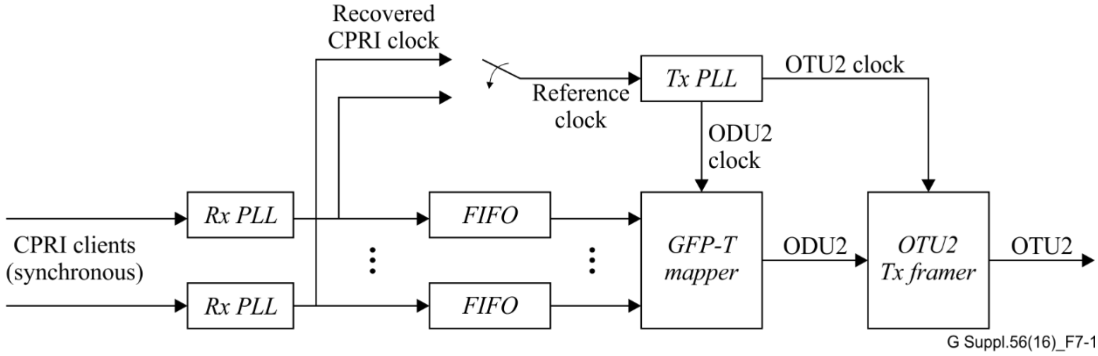

Figure 7-1 – Mapping of synchronous CPRI clients into a synchronous OTU2

The relationship between the OTU2 bit rate and the CPRI client bit rate is given by:

$$CPRI\_BitRate = k * OTU2\_BitRate * (79/1377)$$

The value of the scaler 'k' for CPRI options 1 to 6 are shown in Table 7-10.

Table 7-10 – Scaler 'k' of CRPI options 1 to 6

CPRI client	k
Option 1 (614.4 Mbps)	1
Option 2 (1228.8 Mbps)	2
Option 3 (2457.6 Mbps)	4
Option 4 (3072.0 Mbps)	5
Option 5 (4915.2 Mbps)	8
Option 6 (6144.0 Mbps)	10

The mapping of the CPRI signal into GFP-T is performed as specified in [ITU-T G.7041] with the following parameters:

– each GFP-T frame contains data from a single CPRI signal
– when more than one CPRI clients are multiplexed, each CPRI signal is identified by a unique Channel ID (CID) in the GFP extension header for a linear frame, see clause 6.1.2.1.3.2 of [ITU-T G.7041]
– the GFP frame pFCS is not used.

Since this is a new client for GFP, it requires a new user payload identifier (UPI) code point from Table 6-3 of [ITU-T G.7041]. Using 0xEC is suggested.

During a signal fail condition of the incoming CPRI client signal (e.g., in the case of a loss of input signal), either:

– this failed incoming CPRI signal may be replaced by a stream of 10B blocks each carrying a link fault indication as specified in clause 17.7.1.1 of [ITU-T G.709], which stream is then applied at the GFP-T mapper, or
– the GFP-T signal may be replaced by a stream of GFP client signal fail (CSF) and GFP-idle frames as specified in [ITU-T G.7041].

During either a signal fail condition of the incoming ODU2 signal (e.g., in the case of an ODU-AIS, ODU-LCK, ODU-OCI condition), or incoming CSF frames as specified in [ITU-T G.7041], the GFP-T de-mapper process generates a stream of 10B blocks. Each 10B block carries a link fault indication as a replacement signal for the lost CPRI signal. The link fault character stream is then processed by the GFP-T mapper process in the same manner as if it were the received 8B/10B data stream, mapping it into GFP-T superblocks for transmission.

It is recommended that the single error correction options specified in [ITU-T G.7041] be used for both the extension header and the GFP-T superblocks.

As an example, with S=3 superblocks per GFP-T frame, the maximum number of CPRI clients that can be mapped into an OPU2 is shown in Table 7-11:

Table 7-11 – The number of CPRI clients that can be mapped into an OPU2 using GFP-T

CPRI rate (Mbps)	Max CPRI clients in an OPU2
614.4 (option 1)	18
1228.8 (option 2)	9
2457.6 (option 3)	4
3072.0 (option 4)	3
4915.2 (option 5)	2
6144.0 (option 6)	1

8 Multiple CPRI option 3, 4 or 5 signal mapping into ODU2r

Six [CPRI] option 3 signals, three [CPRI] option 4 signals or three [CPRI] option 5 signals into an OPUk (k = 2r), which has a somewhat higher rate than ODU2, can be multiplexed and mapped using the following method. Transporting these signals over more than a single OTU2r link is for further study.

8.1 OPU2r overhead description

The OPU2r overhead includes the payload structure identifier (PSI) including the payload type (PT), the OPU2r multiframe identifier (OMFI) and client mapping specific overhead. The OPU2r PSI, PT and OMFI overhead locations are shown in Figure 8-1.

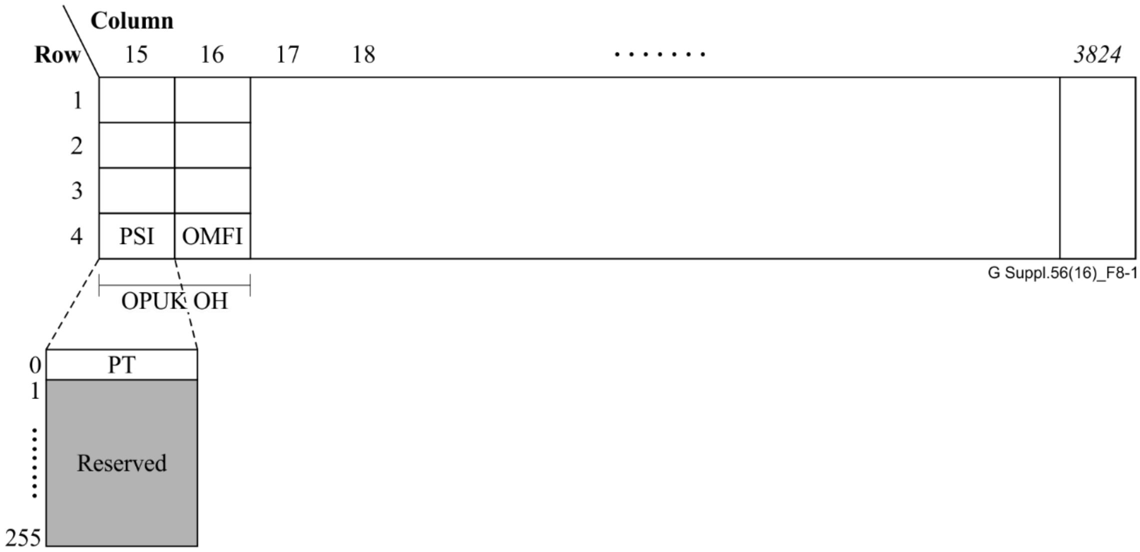

Figure 8-1 – OPU2r overhead

8.1.1 OPU2r overhead definition

8.1.1.1 OPU2r payload structure identifier (PSI)

A one-byte PT signal is defined in the PSI[0] byte of the payload structure identifier to indicate the composition of the OPU2r signal. The code points are defined in Table 8-1. The remaining 255 PSI bytes are reserved.

Table 8-1 – Payload type code points for OPU2r

MSB 1234	LSB 5678	Hex code	Interpretation [CPRI]
1000	0000	80	Option 3 multiplexing structure
1000	0001	81	Option 4 multiplexing structure
1000	0010	82	Option 5 multiplexing structure
NOTE – These three code values are from the reserved codes for proprietary use. Refer to Annex A of [ITU-T G.806] for more information on the use of these codes.			

8.1.1.2 OPU2r mapping specific overhead

An OPU2r multiframe identifier (OMFI) byte is defined in row 4, column 16 of the OPU2r overhead, see Figure 8-2. The value of bits 7 to 8 of the OMFI byte will be incremented each OPU2r frame to provide a 3-frame multiframe for the multiplexing of CPRI signals into the OPU2r.

NOTE – It is an option to align the OMFI = 0 position with MFAS = 0 position every 768 (the least common multiple of 3 and 256) frame periods.

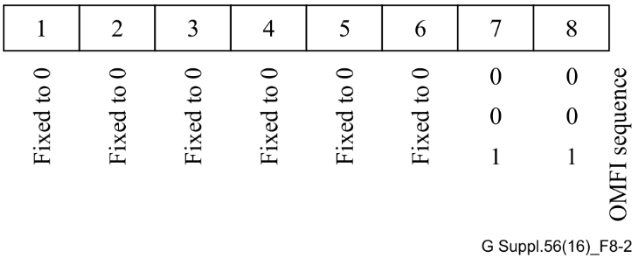

Figure 8-2 – OPU2r multiframe identifier (OMFI) overhead

8.1.1.3 BFP and BaFN overhead

The OPU2r overhead bytes in rows 1-3, column 16 are used to carry the CPRI basic frame pointer (BFP) of the first CPRI basic frame of each channel in the OPU2r payload. The BFP is the offset between the OPU2r payload start and the start of the CPRI basic frame for each signal.

The OPU2r overhead bytes in rows 1-3, column 15 are used to indicate the CPRI basic frame number (BaFN) of the first CPRI basic frame of each channel in the OPU2r payload.

The BFP and BaFN are shown in Figures 8-3 and 8-4.

For each CPRI signal, the corresponding BFP is set to the number of bytes mapped into the OPU2r frame for which OMFI = 0x00, prior to a CPRI basic frame start byte [CPRI]. The BFP range is shown in Table 8-2.

Table 8-2 – BFP range

[CPRI] signal type	BFP range
Option 3	0x00 to 0x3F
Option 4	0x00 to 0x7F
Option 5	0x00 to 0x7F
NOTE – The BFP range for option 4 is computed after augmenting as described in clause Y.2.2 of [CPRI].	

For each CPRI signal, the corresponding BaFN is set to the CPRI basic frame number, within the CPRI hyperframe (0x00 to 0xFF) [CPRI], of the first CPRI basic frame that starts in the OPU2r frame for which OMFI = 0x00.

NOTE – If the BaFN for a CPRI channel in OMFI cycle t was BaFN(t), then the BaFN in cycle t+1 is: BaFN(t+1) = Mod256[BaFN(t)+119].

8.2 OPU2r payload mappings

8.2.1 Mapping of six [CPRI] option 3 signals into OPU2r

Six [CPRI] option 3 signals are byte interleaved. In the OPU2r frame carrying OMFI = 0x00, the first OPU2r payload byte corresponds to a byte of the first CPRI signal, the second OPU2r payload byte corresponds to a byte of the second CPRI signal, and so on (see Figure 8-3).

The BFPi and BaFNi associated with CPRI signals 1 to 3 are located in row 15 and 16 of the OPU2r frame carrying OMFI = 0x00. The BFPi and BaFNi associated with CPRI signals 4 to 6 are located in row 15 and 16 of the OPU2r frame carrying OMFI = 0x01(see Figure 8-3).

	15	16	17	18	19	20	21	22	23	24	....	38	39	40	41	....	3823	3824
1	BaFN1	BFP1	CH1	CH2	CH3	CH4	CH5	CH6	CH1	CH2		CH4	CH5	CH6	CH1		CH3	CH4
2	BaFN2	BFP2	CH5	CH6	CH1	CH2	CH3	CH4	CH5	CH6								
3	BaFN3	BFP3																
4	PSI	0x00															CH3	CH4
1	BaFN4	BFP4	CH5	CH6	CH1	CH2	CH3	CH4	CH5	CH6								
2	BaFN5	BFP5																
3	BaFN6	BFP6																
4	PSI	0x01															CH1	CH2
1	RES	RES	CH3	CH4	CH5	CH6	CH1	CH2	CH3	CH4								
2	RES	RES																
3	RES	RES																
4	PSI	0x02															CH5	CH6

Figure 8-3 – Mapping of six [CPRI] option 3 signals into the OPU2r payload

8.2.2 Mapping of three [CPRI] option 4 signals into OPU2r

The [CPRI] option 4 signals are augmented by adding padding bytes to match the signal rate of [CPRI] option 5. Padding is implemented by inserting three pad bytes after every five data bytes. The value inserted in the padding bytes shall be 0x00. Padding bytes are ignored and discarded by the receiver.

Three [CPRI] option 4 signals are byte interleaved. In the OPU2r frame carrying OMFI = 0x00, the first OPU2r payload byte corresponds to a byte of the first CPRI signal, the second OPU2r payload byte corresponds to a byte of the second CPRI signal and so on (see Figure 8-4).

The BFPi and BaFNi associated with CPRI signals 1 to 3 are located in row 15 and 16 of the OPU2r frame carrying OMFI = 0x00 (see Figure 8-4).

8.2.3 Mapping of three [CPRI] option 5 signals into OPU2r

Three [CPRI] option 5 signals are byte interleaved. In the OPU2r frame carrying OMFI = 0x00, the first OPU2r payload byte corresponds to a byte of the first CPRI signal, the second OPU2r payload byte corresponds to a byte of the second CPRI signal and so on (see Figure 8-4).

The BFPi and BaFNi associated with CPRI signals 1 to 3 are located in row 15 and 16 of the OPU2r frame carrying OMFI = 0x00 (see Figure 8-4).

	15	16	17	18	19	20	21	22	23	24	………	38	39	40	41	……………………………	3823	3824
1	BaFN1	BFP1	CH1	CH2	CH3	CH1	CH2	CH3	CH1	CH2		CH1	CH2	CH3	CH1		CH3	CH1
2	BaFN2	BFP2	CH2	CH3	CH1	CH2	CH3	CH1	CH2	CH3								
3	BaFN3	BFP3																
4	PSI	0x00															CH3	CH1
1	RES	RES	CH2	CH3	CH1	CH2	CH3	CH1	CH2	CH3								
2	RES	RES																
3	RES	RES																
4	PSI	0x01															CH1	CH2
1	RES	RES	CH3	CH1	CH2	CH3	CH1	CH2	CH3	CH1								
2	RES	RES																
3	RES	RES																
4	PSI	0x02															CH2	CH3

Figure 8-4 – Mapping of three [CPRI] option 4 (after padding) or 5 signals into the OPU2r payload

8.3 PCS receiver

The CPRI signal physical coding sublayer (PCS) is terminated and the 8-bit codes are recovered as specified by IEEE 802.3.

The K28.5 control character that indicates the beginning of the CPRI hyperframe is replaced by 0x00. The contents of this byte are ignored on reconstruction of the CPRI signal.

8.3.1 NE at RRH site remote management channel

The network element (NE) at the remote radio head (RRH) site can be managed through the GCC0, GCC1 and/or GCC2 overhead. Protocols for these management channels are outside of the scope of this Supplement.

8.3.1.1 CPRI channel AIS signal

The CPRI channel alarm indication signal (AIS) is specified as all "1"s in the entire CPRI channel, including its BFP and BaFN overheads.

Under CPRI signal fail conditions as defined in [CPRI], the CPRI channel is filled with CPRI channel AIS.

8.3.1.2 Replacement signal

Under ODU2r signal fail conditions, or if the OMFI, BFP or BaFN are inconsistent, the egress CPRI signal should be replaced by the link fault signal.

8.4 OTU2r structure

The OTU2r frame structure is an OTUk (k = 2r) frame structure, which may or may not include the forward error correction (FEC) area.

8.5 Bit rates and tolerances

The bit rates and tolerances are defined in Table 8-3.

Table 8-3 – OTU2r/ODU2r/OPU2r rates and tolerances

Signal type	Nominal bit rate	Tolerance
OTU2r	255/238 × 128 × 24 × 3 840 kbit/s	±100 ppm
OTU2r no FEC	239/238 × 128 × 24 × 3 840 kbit/s	±100 ppm
ODU2r	239/238 × 128 × 24 × 3 840 kbit/s	±100 ppm
OPU2r	128 × 24 × 3 840 kbit/s	±100 ppm

NOTE 1 – The nominal OTU2r rate is approximately 12 639 085.714 kbit/s.

NOTE 2 – The nominal OTU2r without FEC and ODU2r rates are approximately 11 846 045.042 kbit/s.

NOTE 3 – The nominal OPU2r rate is 11 796 480 kbit/s.

NOTE 4 – Due to the BMP mapping, the OTU2r/ODU2r inherits the clock accuracy of the CPRI client signals at the ODU2r source.

The OTU2r/ODU2r/OPU2r frame period is approximately 10.330 μs.

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