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(54) Title: METHOD AND APPARATUS FOR REDUCING THE DATA RATE OF AUTOMATIC PROTECTION SWITCHING PROTOCOL DATA FOR PROCESSING IT WITHIN AN OPTICAL TRANSMISSION NETWORK SWITCH SYSTEM

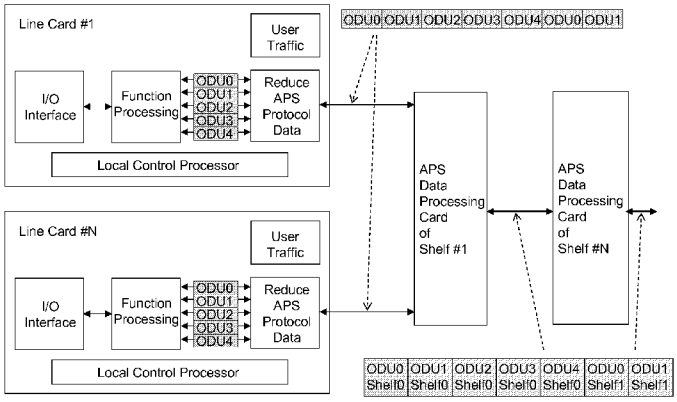

Fig. 8 APS Frame Structure in an OTN Switch

(57) Abstract: It is provided a method to reduce the data rate of Automatic Protection Switching protocol data for processing it within an Optical Transmission Network switch system. Changes in the raw data are identified and reported e.g. by a message inserted into a system internal data channel. Alternatively once in a predefined period of time a sample of the raw data is taken and is inserted into the system internal data channel. Figure 8

Method and Apparatus for Reducing the Data Rate of Automatic Protection Switching Protocol Data for Processing it within an Optical Transmission Network Switch System

Technical Field

Embodiments of the present invention relate generally to Optical Transmission Network switch systems and more particularly to Automatic Protection Switching of transmission lines between said switch systems. The invention relates to a method for processing Automatic Protection Switching protocol data within an Optical Transmission Network switch system.

Background

Up-to-date high speed data networks exhibit switches capable to handle traffic streams up to many Terabits/sec interconnected by optical fiber links with transmission capacities up to several Terabits/sec per fiber.

The International Telecommunication Union (ITU) is in charge of the standardization of information and communication technologies. Its Recommendation G.709 "Interfaces for the Optical Transport Network (OTN)" describes a means of communicating data over an optical network. The G.709 Optical channel Transport Unit OTUk signal is positioned as a server layer signal for various client signals, e.g. SDH (Synchronous Digital Hierarchy)/SONET (Synchronous Optical Network), ATM

(Asynchronous Transfer Mode), IP (Internet Protocol), Ethernet, Fiber Channel and OTN ODUk (Optical channel Data Unit Type k, where k=0, 1, 2, 2e, 3, 3e2, 4 or flex). The ITU-T Recommendation G.709 defines a standardized method for a transparent transport of services over optical wavelengths in DWDM (Dense Wavelength Division Multiplexing) systems. It defines an Optical Transport Network (OTN) as a set of Optical Network Elements which are connected by optical fiber links. An OTN may provide functionalities of transport, multiplexing, switching, management, supervision and survivability of optical channels carrying client signals.

Amongst the functionalities of management, supervision and survivability of optical channels an important function of an OTN may be the protection switching function, i.e. the capability of communication networks to switch over in case of a failure to redundantly held available resources. In case that a communication link is failing the concerned traffic may be transmitted over a protection channel which has been held available for such a case. In order to control this switch over and especially in order to coordinate the switching process between both ends of the communication link a communication channel between both ends of the link is necessary. For OTNs the ITU has defined in its recommendation G.709 and in more detail in its recommendation G.873.1 "Optical Transport Network (OTN): Linear protection" an Automatic Protection Switching and Protection Communication Channel (APS/PCC) which may be used to exchange end-to-end command and state, protection type, requested channel and bridged channel per protection group.

The Automatic Protection Switching (APS) data consist of four data bytes which are transmitted once in every OTN frame each OTN frame comprising 16320 bytes, the frame structure being the same for every OTN line rate. 15232 bytes out of the 16320 bytes of an OTN frame are payload bytes, 1024 bytes are forward error correction bytes and 64 bytes are overhead bytes. The line data rate in the OTN ranges from about 1.33 Gbit/sec in the lowest OTN hierarchy level up to about 112 Gbit/sec in the highest OTN hierarchy level. Since 4 out of the 16320 bytes per OTN frame are APS bytes, the data rates of the APS data streams in an OTN ranges from about 326 kbit/sec to about 27 Mbit/sec. Low hierarchy signals may be multiplexed together, so that a given payload data rate always mates with a corresponding APS data rate r_{APS} = payload data rate * 4 / 15232. This results in that e.g. in an optical switch capable to handle 96 Tbit/sec system 23 Gbit/sec APS data must be handled and processed in the switch.

The APS data may also be structured in various formats, depending on the multiplexing structure of the received line signal. In order to cope with the high performance requirements it might be desirable to implement the processing resources for the APS data e.g. in hardware in such a way that they are prepared to process only one single APS data rate. In this case it would be necessary to implement processing resources which are prepared to process every type of APS data in its maximal number of instances. This suggests to transport the APS data stream from the line receiver to a more central processing platform in parallel data streams, one stream per APS data rate. With five supported hierarchy levels in a 96 Tbit/sec switching system this results in five data

streams of about 5 x 23 Gbit/sec = 115 Gbit/sec. This data stream may be routed to a central APS data processing platform, which may consist e.g. of a pool of conveniently interconnected processor cards.

High speed interconnections requiring high speed ports with e.g. 10 Gbit/sec result in complex cabling issues and difficult hardware design. Besides this the sheer data rate poses extreme requirements to the associated data processing platform and its hardware.

Thus there may be a need to improve APS data handling in Optical Transport Networks.

Summary

As already indicated above all APS data of all OTN hierarchy levels have the same structure: Four bytes per OTN frame. The higher the hierarchy level, the faster one frame is transmitted, and the shorter the frame period. It ranges from about 98 μsec in the lowest hierarchy level down to about 1.17 μsec in the highest hierarchy level.

The requirement for protection switching is that the switch completion time for a failure of a single span shall be less than 50 mec, according to the ITU recommendation G.841, valid for SONET/SDH protection switching, one of the possible payloads of OTNs.

According to the invention the APS data rate may be reduced by sampling and reporting not every APS four-byte-data-set, but only e.g. one data set per one millisecond.

This data rate should be enough for recognizing and completing protection switching; the APS data repetition rate of 1.17 µsec to 98 µsec given in the APS raw data improves the time resolution of the APS data only by fractions of a millisecond for the one-millisecond-example.

According to the invention a preprocessing of the APS data may also be supervising the APS data for changes, i.e. determining whether one or more bits have changed in the APS data compared to the APS data in the previous frame. Identified changes may be reported e.g. in a message oriented format. In order to avoid instabilities due to bit errors caused by interferences, a change may be considered valid only if the data is stable for e.g. three successive frames, i.e. the APS bit pattern remains unchanged for e.g. three frames.

Both methods may also be combined such that the data rate is reduced according to the first method and evaluated according to the second method.

Brief Description of the Drawings

Figure 1 shows the layers in the OTN hierarchy as defined by the ITU recommendation G.709.

Figure 2 shows a table with data rates of respective OTN hierarchy levels according to the ITU recommendation G.709.

Figure 3 shows the frame structure of OTN frames comprising overhead area, payload area and error correction area.

Figure 4 shows in more detail the overhead area and in particular the location of the APS data bytes.

Figure 5 shows the APS channel format.

Figure 6 shows the field values for the APS channel.

Figure 7 shows a typical implementation of an OTN switching system.

Figure 8 shows the information flow of the APS channel data in a typical implementation of an OTN switch system.

Figure 9 shows a typical implementation of an APS data processing card.

Detailed Description of the Invention

Analogously to the seven-layer-model of network architecture developed by the International Organization for Standardization (ISO) the ITU recommendation G.709 defines several transport layers for the Optical Transport Networks. Figure 1 shows these layers and their arrangement.

The Optical Payload Unit (OPU) encapsulates the client signal and does any rate justification that is needed. Client signals may be e.g. signals of the Synchronous Optical Network (SONET), of the Synchronous Digital Hierarchy (SDH) or Constant Bit Rate signals like Time Division Multiplex (TDM) signals of the classical telephony multiplexing hierarchy, but also Ethernet Local

Area Network (LAN) signals. Also lower data rate OTN signals may be multiplexed into a higher data rate OTN signal. The OPU layer is analogous to the Path layer in SONET/SDH in that it is mapped at the source, demapped at the sink, but not modified by the network.

The Optical channel Data Unit (ODU) performs similar functions as the Line Overhead in SONET/SDH. It takes care about Automatic Protection Switching by alarms and maintenance messages as may be required within the network.

The Optical channel Transport Unit (OTU) contains the forward error correction (FEC) and the section monitoring ensuring the transport of the payload data between two nodes of an OTN.

Figure 2 lists the data rates, the payload data rates, the APS data rates and also the frame period for OTN hierarchy levels according to the ITU recommendation G.709; hierarchy levels defined for the transmission of Ethernet LAN signals are not considered here. The individual hierarchy levels are numbered consecutively, so that ODU types from ODU0 to ODU4 are defined. The listed data rates of the OTN hierarchy are defined in such a way that the OTN links are adapted to carry corresponding SONET/SDH data streams in an efficient and straightforward way. In addition lower data rate OTN signals may be multiplexed into a higher data rate OTN signal. So it is possible to multiplex e.g. up to sixteen ODU1's or four ODU2's into an ODU3, whereby the ODU1's and the ODU2's may be mixed.

Each OTN frame comprises 16320 bytes organized in four rows and 4080 columns (see Figure 3), whereby the frame

structure is the same for every OTN hierarchy level. The Optical Payload Unit comprises the OPU overhead (columns 15 and 16) and the OPU payload (columns 17 to 3824). The columns 1 to 14 comprise the frame alignment, the OTU overhead and the ODU overhead. The OTU forward error correction is implemented in columns 3825 to 4080.

Figure 4 shows in more detail the overhead area including the location of the APS data bytes. The APS data bytes are byte five to eight of row four and are part of the ODU overhead.

An APS channel is carried over the first three bytes of the APS/PCC field of the ODU overhead. The fourth byte of the APS/PCC field is reserved. The format of the four APS bytes within each frame is given in Figure 5.

The field values for the APS channels are defined in Figure 6. APS byte #1 reports configuration and maintenance states and transfers switching commands. Byte #2 indicates the signal that the near-end requests to be carried over the protection entity, typically either the Null Signal (0) or Extra Traffic (255). Byte #3 indicates the signal that is actually carried over the protection entity. For 1+1 protection, this should always indicate Normal traffic Signal 1, for 1:n protection, this will indicate what is actually transmitted to the protection entity: Either the Null Signal (0), Extra Traffic (255), or the number of a normal traffic signal. Byte #4 is reserved for future standardization.

Figure 7 shows a typical hardware implementation of the inventive APS data processing in an OTN switch system. At

the line interface APS data from the transmission link are received together with payload user data. The APS data are separated from the user data for further processing. Because of the big amount of APS data the classical solution to process maintenance data, in this case the APS data, by the local control processor of the line card may not be well suited here; the performance of a line card controller may not be enough for this task. Instead it may be more advantageous to centralize the APS data evaluation hardware, be it a pool of suited controllers or be it specialized hardware like field-programmable gate arrays (FPGAs) or application-specific integrated circuits (ASICs), on one or more cards. In this case there may be in every shelf point-to-point links carrying internal APS channels from the line cards to a shelf-central APS data processing card. Several APS data processing cards may be interconnected e.g. by a ring-like cross channel so that APS data may be exchanged between all line cards and all ports of the switch.

Figure 8 illustrates an information flow of APS channel data in a typical implementation of an OTN switch system. In a line card the data stream received over the I/O interface is split up. The payload user data are forwarded over the User Traffic unit, the APS data are separated and sorted according to ODUk classes. In this example every line card may be able to receive at maximum an ODU4 signal with a line rate of about 112 Gbit/sec. Since an ODU4 signal may transport up to 80 ODU0 signals or up to 40 ODU1 signals or up to ten ODU2 signals or up to two ODU3 signals, there may be up to 80 ODU0 APS channels or up to 40 ODU1 APS channels or up to ten ODU2 APS channels or up to two ODU3 APS channels or one ODU4 APS channel that the

switch system must be prepared to process. If this processing is performed by dedicated hardware, each hardware may be specialized to process an individual OTN hierarchy level; in this case it may be necessary to route the APS data streams of all OTN hierarchy levels in parallel to the APS data processing card. This leads to a very high amount of APS data: 80 x APS_{ODU0} + 40 x APS_{ODU1} + 10 x APS_{ODU2} + 2 x APS_{ODU3} + 1 x APS_{ODU4} = 80 x 0.325 Mbit/sec + 40 x 0.653 Mbit/sec + 10 x 2.62 Mbit/sec + 2 x 10.54 Mbit/sec + 1 x 27.40 Mbit/sec = 26.03 Mbit/sec + 26.14 Mbit/sec + 26.25 Mbit/sec + 21.09 Mbit/sec + 27.40 Mbit/sec = 126.90 Mbit/sec APS data has to be routed from one line card to the APS data processing card and has to be processed in the APS data processing card.

According to the invention the APS data rate between the line cards is reduced.

In order to reduce the amount of APS data itself some preprocessing on the line card is done, as shown in Figure 8: On the line card the APS data are extracted from the data stream received by the I/O interface and are split up into individual data streams per OTN hierarchy level "ODU1" to "ODU4" by the "Function processing" entity. These five data streams are transmitted to the "Reduce APS Protocol Data" entity, where the APS protocol data are reduced according to the invention. Sampling and reporting only one APS four-byte-data-set per one millisecond and per channel results in 4 bytes per 80 ODU0 channels + 40 ODU1 channels + 10 ODU2 channels + 2 ODU3 channels + 1 ODU4 channel per millisecond = 4 x 133 bytes per millisecond = 532 bytes/msec = 4.256 kbit/msec = 4.256 Mbit/sec. These e.g. 4.256 Mbit/sec data are then

transmitted to the allocated APS data processing card, where they are further processed. The APS data processing cards may also share information with each other and exchange it via a cross channel interconnecting them.

The grey shaded protocol fields in Figure 8 indicate a possible way and a possible format, by which the APS data may be routed between the individual APS data handling entities and units.

Figure 9 illustrates a typical hardware implementation of an APS data processing card in an OTN switch system. The APS data coming over the APS interface are extracted and are separated for the individual Optical channel Data Units. Then they are provided to the allocated protection group engine, which performs the final processing by evaluating the data, rating the quality of the link the APS data belongs to and deciding, if necessary, on protection switching or on other quality ensuring steps. Each protection group engine is designed to independently implement the ODUk Sub Network Connection compliant to the ITU-T standard G.808.1. There may be up to 64000 protection group engines per system OTN switch.

List of Abbreviations

APS	Automatic Protection Switching
ATM	Asynchronous Transfer Mode
DWDM	Dense Wavelength Division Multiplexing
FEC	Forward Error Correction
IP	Internet Protocol
ISO	International Organization for Standardization
ITU	International Telecommunication Union
LAN	Local Area Network
ODU	Optical channel Data Unit
OPU	Optical Payload Unit
OTN	Optical Transport Network
OTU	Optical channel Transport Unit
PCC	Protection Communication Channel
SDH	Synchronous Digital Hierarchy
SONET	Synchronous Optical Network
TDM	Time Division Multiplex

Claims

1. A method for processing Automatic Protection Switch protocol data in an Optical Transport Network switch system comprising reducing a data rate of raw Automatic Protection Switching protocol data prior to inserting them into a system internal data channel;

2. Method according to claim 1 whereby changes in the raw Automatic Protection Switching protocol data are identified and determined and whereby the data rate is reduced depending on the determination of the changes;

3. Method according to claim 2 whereby a change in the raw Automatic Protection Switching protocol data is taken as valid only if said changed data stay constant for a predefined time period;

4. Method according to claim 3 whereby the predefined time period is defined by a predetermined number of Optical channel Data Unit frames;

5. Method according to claim 2, 3 or 4 whereby a change in the raw Automatic Protection Switching protocol data is reported by means of a message inserted into the system internal data channel;

6. Method according to claim 1 whereby the raw Automatic Protection Switching protocol data are sampled and said data are reduced by taking in a predetermined period of time only one sample of said data;

7. Method according to claim 6 wherein only the reduced data is inserted into the system internal data channel;

8. Method according to claim 6 or 7 whereby the predetermined period of time is about 1 msec;

9. Network switch for processing Automatic Protection Switch protocol data in an Optical Transport Network switch system, adapted to perform the method according to claims 1 to 8;

10. Network switch according to claim 9 comprising a plurality of line cards, whereby at least a part of said line cards comprises modules which are connected to at least one ODU module on the line card and at least one APS Data Processing Card, for reducing the data rate of the raw Automatic Protection Switching protocol data, and further inserting said data into a system internal data channel;

11. Network switch according to Claim 10 further comprising at least one APS Data Processing Card, each said APS Data Processing Card further comprising at least one Protection Group Engine, said plurality of Protection Group Engines being combined to perform one or more of the steps of claims 1 to 8.

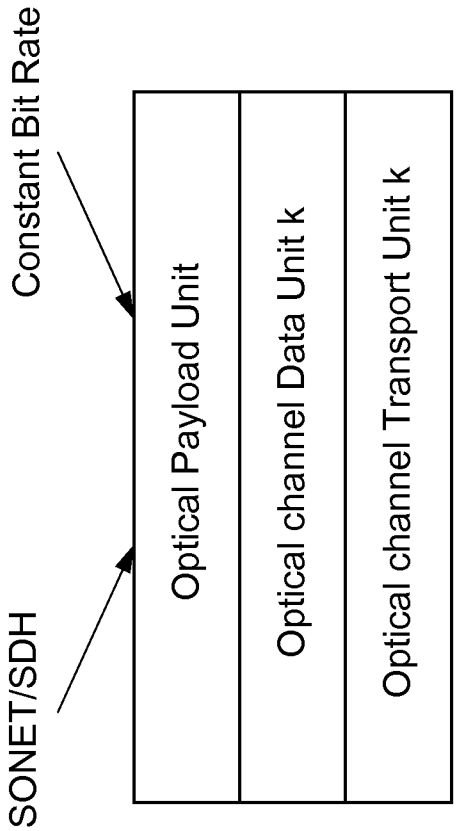

Fig. 1 OTN Hierarchy

ODU Type	Line Data Rate (Gbit/s)	Payload Data Rate (Gbit/s)	APS Data Rate (Mbit/s)	Frame Period (μ sec)
ODU0	1.33	1.24	0.325	98.35
ODU1	2.66	2.50	0.653	48.97
ODU2	10.70	10.04	2.62	12.19
ODU3	43.01	40.32	10.54	3.034
ODU4	112.28	104.79	27.40	1.167

Fig. 2 Data Rates of the OTN Hierarchy

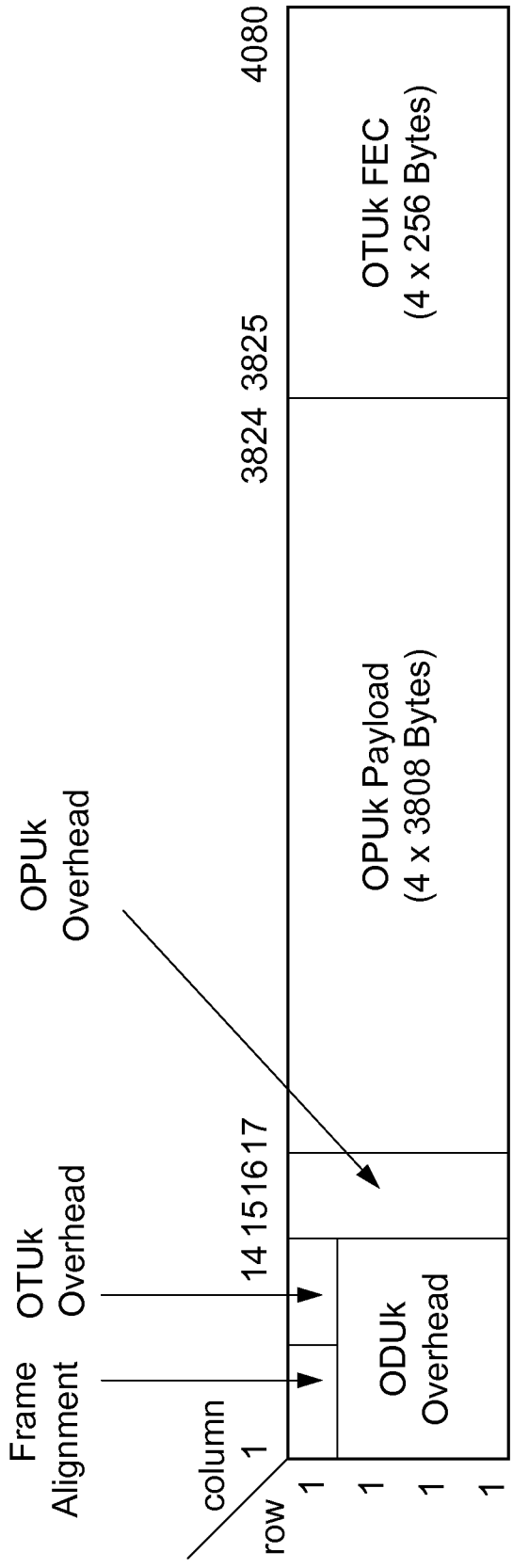

Fig. 3 OTUk Frame Structure

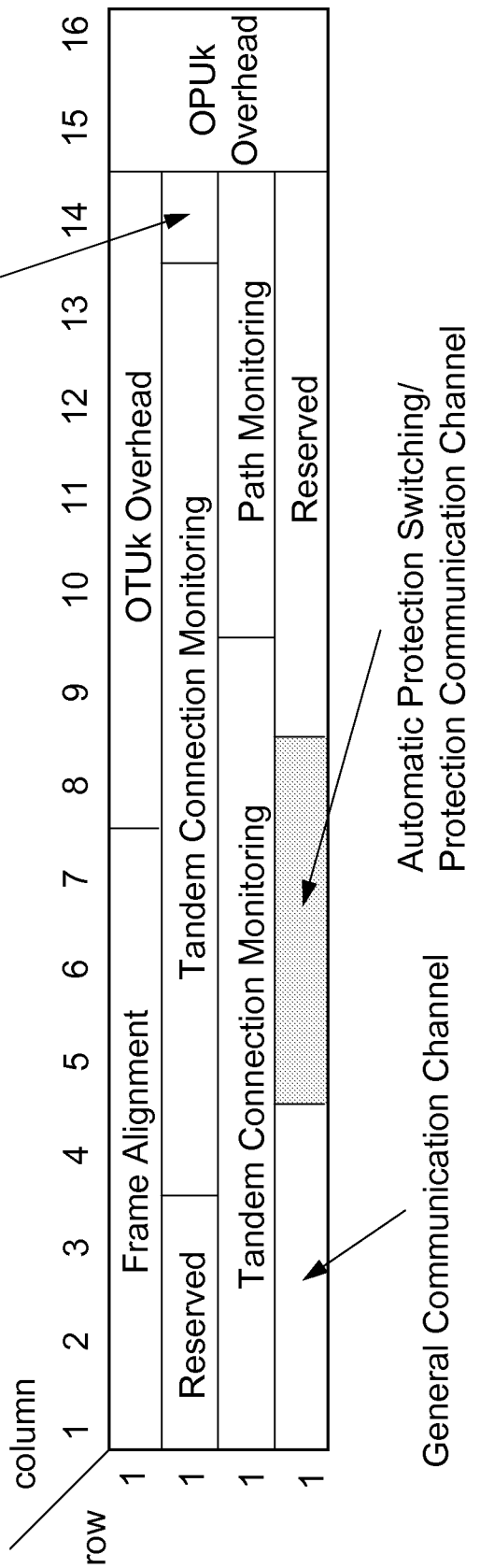

Fig. 4 ODUk Overhead

Byte #	1								2								3								4							
Bit #	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
	Request / State				Protection Type				Requested Signal								Bridged Signal								Reserved							
					A	B	D	R																								

Fig. 5 APS Channel Format

Field		Value	Description
Request/ State		1111	Lockout of Protection (LoP)
		1110	Forced switch (FS)
		1100	Signal fail (SF)
		1010	Signal degrade (SD)
		1000	Manual switch (MS)
		0110	Wait-to-restore (WTR)
		0100	Exercise (EXER)
		0010	Reverse request (RR)
		0001	Do not revert (DNR)
		0000	No request (NR)
		others	Reserved for future
Protec- tion Type	A	0	No APS channel
		1	APS channel
	B	0	1+1 (permanent bridge)
		1	1:n (no permanent bridge)
	D	0	Unidirectional switching
		1	Bidirectional switching
	R	0	Non-revertive operation
		1	Revertive operation
Requested Signal		0	Null signal
		1-254	Normal traffic Signal 1-254
		255	Extra traffic signal
Bridged Signal		0	Null signal
		1-254	Normal traffic Signal 1-254
		255	Extra traffic signal

Fig. 6 Field Values for the APS Channel

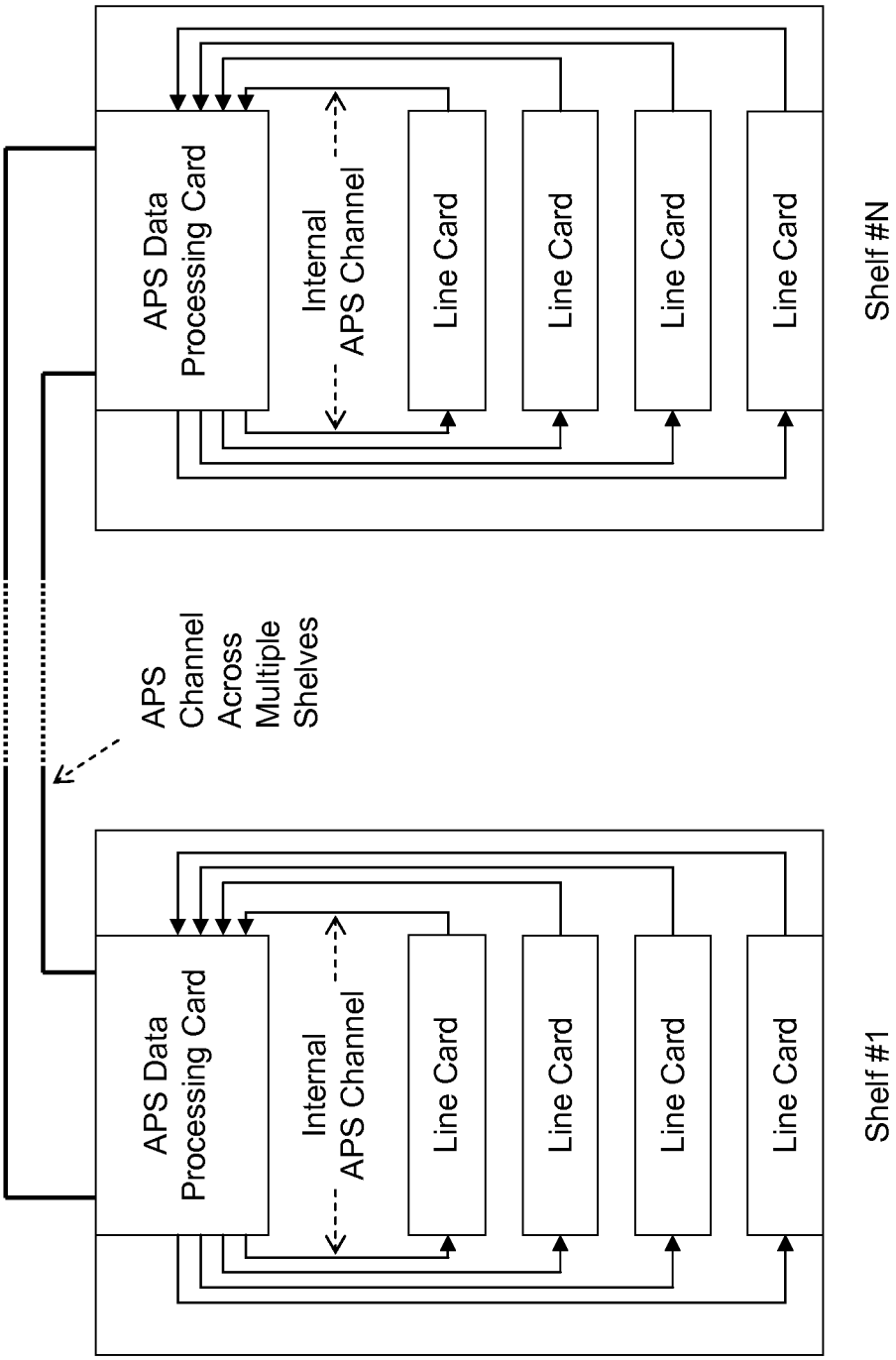

Fig. 7 APS Channel within an OTN Switch

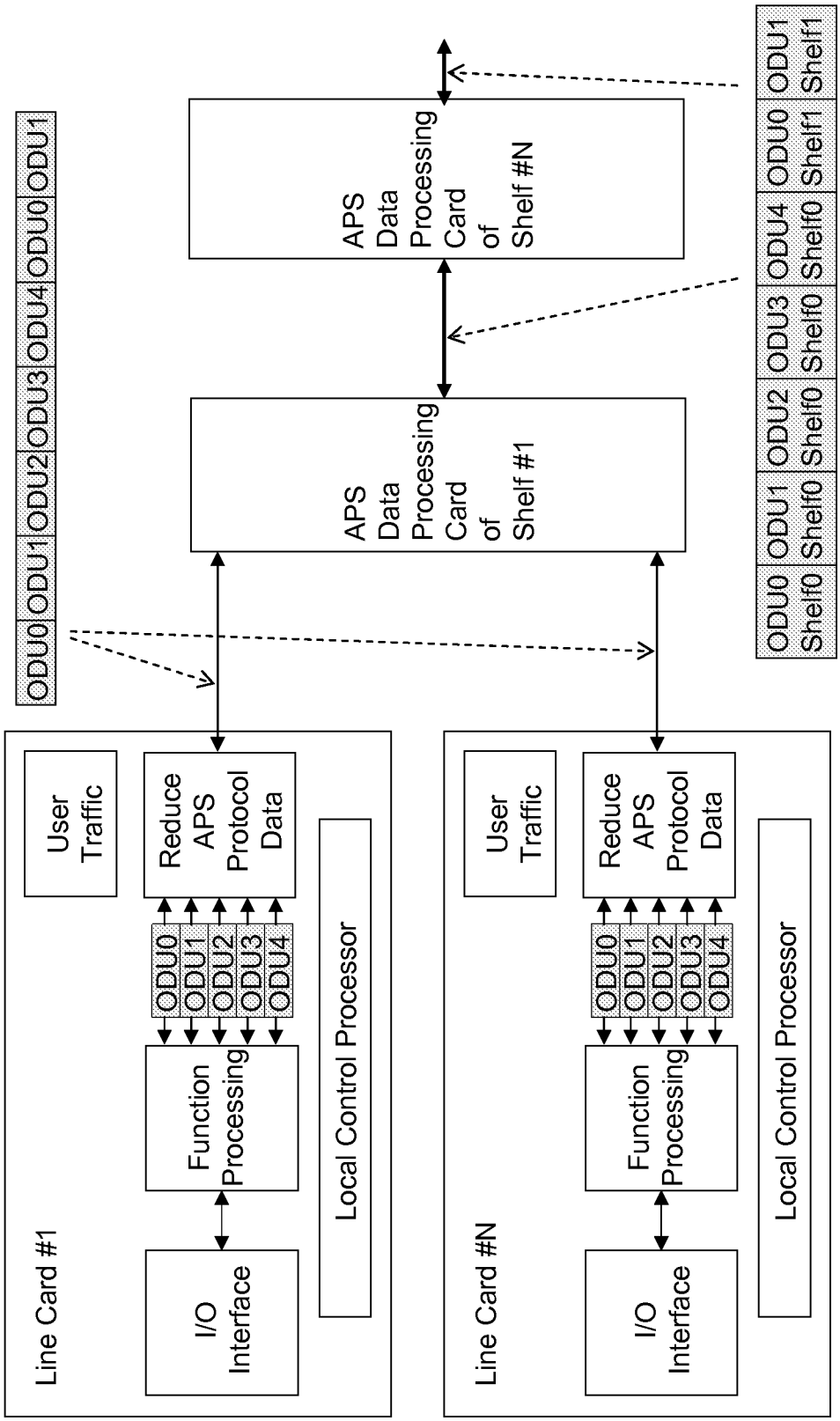

Fig. 8 APS Frame Structure in an OTN Switch

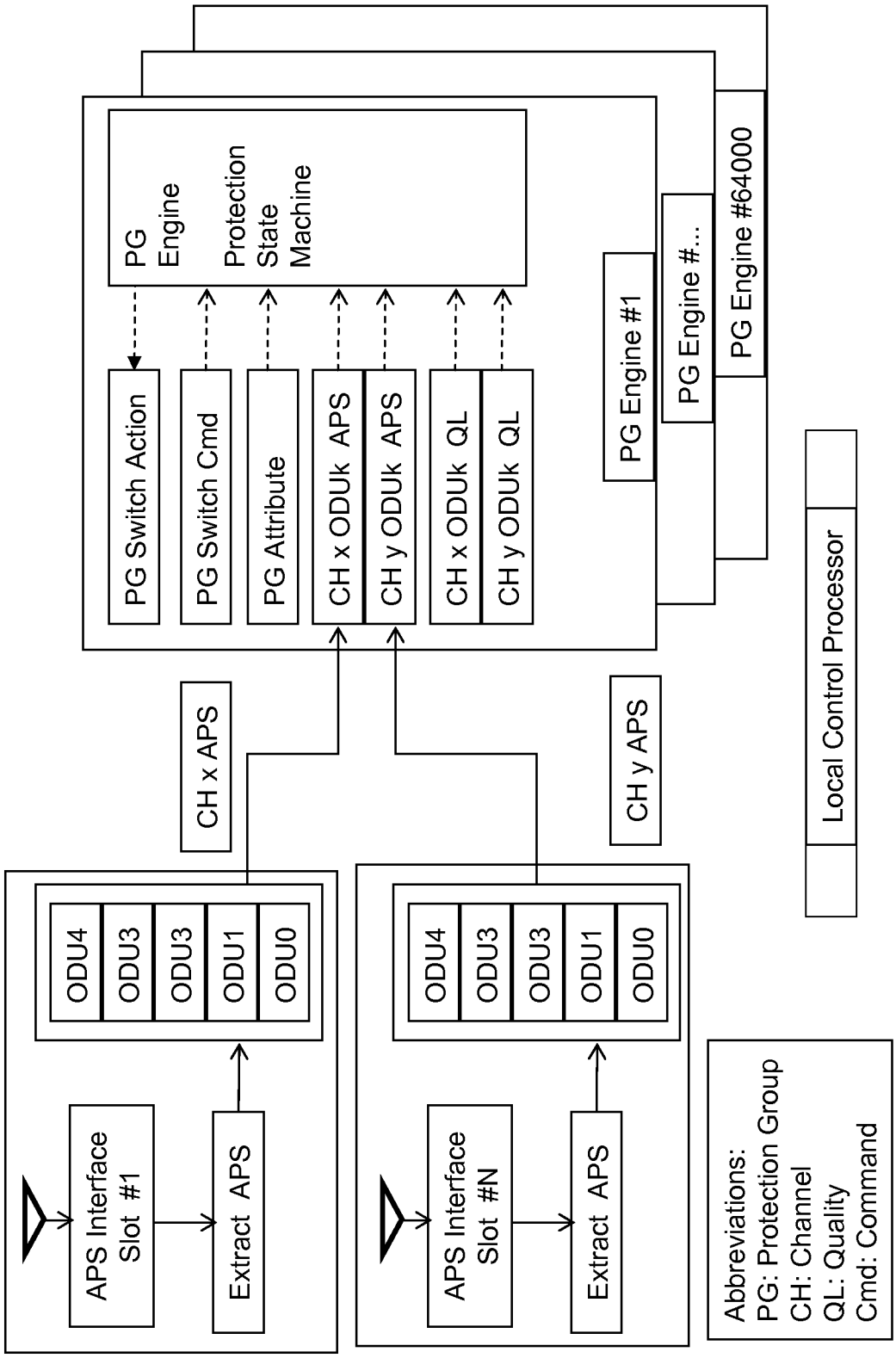

Fig. 9 APS Data Processing Card

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2012/079804

A. CLASSIFICATION OF SUBJECT MATTER

H04L 12/70 (2013.01) i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC: H04L; H04W; H04Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CNPAT,CNKI,WPI,EPODOC: raw, protocol, data, speed, rate, APS, automatic, protect+, switch+, reduc???, increas???, improv???, SDH, OTN, optical, transport, network, channel

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 2112791 A1 (TELLABS OY) 28 Oct. 2009 (28.10.2009) paragraph 0010 in the description	1-11
A	US 7602814 B2 (CIENA CORPORATION) 13 Oct.2009 (13.10.2009) the whole document	1-11

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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"&"document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
24 Apr. 2013 (24.04.2013)	**16 May 2013 (16.05.2013)**
Name and mailing address of the ISA/CN The State Intellectual Property Office, the P.R.China 6 Xitucheng Rd., Jimen Bridge, Haidian District, Beijing, China 100088 Facsimile No. 86-10-62019451	Authorized officer YANG,Kaipeng Telephone No. (86-10)62413341

Form PCT/ISA /210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2012/079804

Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
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