EUROPEAN PATENT SPECIFICATION

DYNAMIC AND INTELLIGENT BUFFER MANAGEMENT FOR SAN EXTENSION
DYNAMISCHE UND INTELLIGENTE PUFFERVERWALTUNG FÜR DIE SAN-ERWEITERUNG
GESTION DE TAMPONS DYNAMIQUE ET INTELLIGENTE POUR EXTENSION DE RESEAU SAN

Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HU IE IS IT LI LT LU LV MC NL PL PT RO SE SI SK TR

Priority: 14.01.2005 US 36596

Date of publication of application: 26.09.2007 Bulletin 2007/39

Proprietor: Cisco Technology, Inc.
San Jose, CA 95134-1706 (US)

Inventors:
• SUNDARAM, Ganesh
Rohnert Park, California 94928 (US)
• DIAB, John
Santa Rosa, California 95407 (US)
• AMIN, Hitesh
Petaluma, California 94954 (US)
• RYLE, Thomas, Eric
Raleigh, North Carolina 27617 (US)

Representative: Roberts, Gwilym Vaughan
Kilburn & Strode LLP
Lacon London
84 Theobalds Road
London WC1X 8NL (GB)

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The present invention relates generally to digital communication networks, and more specifically, to methods and systems for efficiently transporting Fibre Channel/FICON client data over a SONET/SDH network path.

SONET/SDH and optical fiber have emerged as significant technologies for building large scale, high speed, IP (Internet Protocol)-based networks. SONET, an acronym for Synchronous Optical Network, and SDH, an acronym for Synchronous Digital Hierarchy, are a set of related standards for synchronous data transmission over fiber optic networks. SONET/SDH is currently used in wide area networks (WAN) and metropolitan area networks (MAN). A SONET system consists of switches, multiplexers, and repeaters, all connected by fiber. The connection between a source and destination is called a path.

One network architecture for the network interconnection of computer devices is Fibre Channel, the core standard of which is described in ANSI (American National Standards Institute) X3.230-1994. Arising out of data storage requirements, Fibre Channel currently provides for bi-directional gigabits-per-second transport over Storage Area Networks (SANs) in Fibre Channel frames that consist of standardized sets of bits used to carry data over the network system. Fibre Channel links are limited to no more than 10 kilometers. Similar to Fibre Channel is FICON, a proprietary I/O channel which was developed by IBM for the data storage requirements for main frame computers.

New standards and protocols have emerged to combine the advantages of the SONET/SDH and Fibre Channel/FICON technologies. For example, it is sometimes desirable to link two SANs, which operate with Fibre Channel or FICON protocols, over a MAN (Metropolitan Area Network), or even a WAN (Wide Area Network), which typically operate under SONET or SDH standards. This extension of SANs from 100 kilometers to over several hundred, or even thousand, kilometers, is made by mapping Fibre Channel/FICON ports to a SONET/SDH path for transport across a SONET/SDH network. One way to perform this function is to encapsulate Fibre Channel/FICON client data frames into transparent Generic Framing Protocol (GFP-T) frames and then map the GFP-T frames into SONET/SDH frames for transport across the SONET/SDH network. In this manner two Fibre Channel/FICON ports can communicate with each other over a SONET/SDH network as though the intervening network links are part of a Fibre Channel/FICON network. The Fibre Channel/FICON ports remain "unaware" of the SONET/SDH transport path. For example, see U.S. Patent Application No. 10/390,813, entitled, "Method and System for Emulating a Fibre Channel Link Over a Sonet/SDH Path," filed March 18, 2003 and assigned to the present assignee.

For the effective movement of data across SAN networks, these network systems have two types of flow control: 1) end-to-end, and 2) buffer-to-buffer credit. In both types of flow control, two Fibre Channel/FICON ports report to each other how many frames is available at the reporting port’s buffer to receive Fibre Channel/FICON frames from the other port. In end-to-end flow control, the source and destination ports are the two ports and the ports signal each other the reception of a transmitted frame by an ACK Link Control frame. In buffer-to-buffer credit, the two ports on opposite sides of a link are the two ports and the ports communicate the reception of a transmitted frame with an R Rdy Primitive signal. But flow control remains within the SAN network and is based on counting Fibre Channel/FICON frames which can vary. Flow control may also be extended across SONET/SDH transport networks which connect frame-based protocol networks, such as Fibre Channel/FICON and gigabit Ethernet. See, for example, U.S. Patent Application No. 10/613,426, entitled, "Method and System For Efficient Flow Control For Client Data Frames Over GFP Across a SONET/SDH Transport Path," filed July 3, 2003 and assigned to the present assignee.

Nonetheless, for SAN extensions, i.e., interconnecting SANs by SONET/SDH transport networks, the SAN extension devices (the Fibre Channel/FICON ports communicating over a SONET/SDH network) usually provide a large amount of buffering in order to maintain a 100% throughput over very long distances. Because of the large number of buffers in the SAN extension devices, a great deal of latency can be created for the frames passing through the devices. It is possible that sometimes the latency introduced by extra buffering can be a significant portion of the total latency, even compared to the latency of the long distance communication.

US 2004/153566 discloses a method to dynamically allocate credits for a particular port to port link based on measured link distance during the initial interswitch link configuration process. US 2004/085902 discloses a method for extending the reach of a data communication channel using flow control interception devices. The method decreases the latency-induced reduction in the data throughput and permits data transmission at subrates through the data communication channel. The method includes transmitting a data frame from a sending device. The data frame is transmitted through the data communication channel if a flow control signal is not asserted. The data frame is buffered if the flow control signal is asserted. The buffered data frame is transmitted through the data communication channel in response to the flow control signal changing to an asserted state.

US 2005/002338 discloses a method and system for flow control of GFP-encapsulated client data frames over SONET/SDH transport networks. Transport interfaces, in the form of port cards, have FIFO buffers for receiving the GFP frames. In acknowledgment of the received frames, a transmitting transport interface receives an acknowledgement in form of a returned frame sequence.
number tag along with the available capacity in bytes of the buffer of the receiving transport interface. With a continuous update of buffer capacity and tracking the number of bytes in transit to the receiving transport interface, the transmitting transport interface maximizes the utilization of the channel through the SONET/SDH transport network, even with dropped frames or dropped acknowledgment tags. US 2003/074449 discloses a method of transporting a packet oriented client signal which uses a buffer-to-buffer flow control mechanism over a synchronous transmission network by assigning an arbitrary synchronous payload width may be significantly smaller than the full bandwidth of the client signal. Flow control over the synchronous network is provided by the buffer-to-buffer flow control mechanism of the client signal to automatically regulate network. Flow control over the synchronous network by assigning an arbitrary synchronous payload to automatically regulate flow control over the synchronous network. The present invention addresses this problem of inappropriate buffering with buffer management which is dynamic and intelligently selective for the particular SAN extension.

SUMMARY OF THE INVENTION

The present invention provides for a method of operating a transport interface for at least one local Fibre Channel/FICON port, the transport interface having buffers for Fibre Channel/FICON data encapsulated in GFP frames transported over a SONET/SDH network from a remote Fibre Channel/FICON port. The method has the steps of inserting a special latency instruction message into Fibre Channel/FICON data to be encapsulated in a GFP frame for transmission to the remote Fibre Channel/FICON port; sending the GFP frame over the SONET/SDH transport network to the remote Fibre Channel/FICON port; timing a return of the special latency number over the said SONET/SDH transport network; determining an appropriate amount of buffers in the transport interface for GFP frames from the remote Fibre Channel/FICON port from the timing step; and allocating the appropriate amount of buffers in the transport interface for GFP frames from the remote Fibre Channel/FICON port; whereby sufficient buffering is ensured in the transport interface to provide maximum throughput over the SONET/SDH network and any additional latency due to buffering in the transport interface is reduced.

Furthermore, the inserting, sending, timing, determining and allocating steps are repeated periodically so that the amount of allocated buffers is adjusted even if the latency of GFP frames transported over said SONET/SDH network between the local and remote Fibre Channel/FICON ports changes. A period of about 1 second is used for the described embodiment of the present invention. The special latency instruction message, which is inserted in a Client Payload Information field of the Payload Area of the GFP frame, includes a latency sequence number to identify one sequence of inserting, sending, timing, determining and allocating steps from another sequence of inserting, sending, timing, determining and allocating steps; a special character encoded in a 4-bit mapping of the 64B/65B control characters as Fh; and a command to a transport interface for the remote Fibre Channel/FICON port to resend said special latency instruction message back to the transport interface for the at least one local Fibre Channel/FICON port upon receiving the special latency instruction message.

In a network system for transporting GFP-encapsulated Fibre Channel/FICON data across a SONET/SDH transport network between first and second Fibre Channel/FICON ports, the first Fibre Channel/FICON port connected to the SONET/SDH transport network through a first transport interface and the second Fibre Channel/FICON port connected to the SONET/SDH transport network through a second transport interface, the present invention also provides for the first transport interface which has at least one integrated circuit adapted to insert a special latency instruction message into Fibre Channel/FICON data from the first Fibre Channel/FICON port and to encapsulate the Fibre Channel/FICON data in a GFP frame, to send the GFP frame over the SONET/SDH transport network to the second transport interface of the second Fibre Channel/FICON port, to time a return of the special latency instruction message over the SONET/SDH transport network, to determine an appropriate amount of buffers in the first transport interface from a time interval of the special latency instruction message to return, and to allocate the appropriate amount of buffers in the first transport interface for GFP frames from the second Fibre Channel/FICON port so that sufficient buffering is ensured in the first transport interface to provide maximum throughput over the SONET/SDH network and any additional latency due to buffering in the transport interface is reduced.

At least one integrated circuit is further adapted to insert the special latency instruction message, to encapsulate the Fibre Channel/FICON data in a GFP frame, to send the GFP frame, to time the return of the special latency instruction message, to determine the appropriate amount of buffers and to allocate the appropriate amount of buffers periodically so that the amount of allocated buffers is adjusted as the actual latency of GFP frames transported over the SONET/SDH network between the first and second Fibre Channel/FICON ports changes.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a diagram illustrating an exemplary network employing the present invention;

Fig. 2A is a flow chart of operations of a local transport interface, in the exemplary network of Fig. 1 in the transmission of a special latency instruction message to a remote transport interface, according to
DESCRIPTION OF SPECIFIC EMBODIMENTS

[0015] The following description is presented to enable one of ordinary skill in the art to make and use the invention. Descriptions of specific embodiments and applications are provided only as examples and various modifications will be readily apparent to those skilled in the art. The general principles described herein may be applied to other embodiments and applications without departing from the scope of the invention. Thus, the present invention is not to be limited to the embodiments shown, but is to be accorded the widest scope consistent with the principles and features described herein. For purpose of clarity, details relating to technical material that is known in the technical fields related to the invention have not been described in detail.

[0016] Fig. 1 illustrates an exemplary network of Fiber Channel/FICON ports are connected over a SONET/SDH transport network 10 in which an embodiment of the present invention can operate. In the present example, it is assumed that the ports operate under Fibre Channel or FICON protocols, though the ports may also operate under other frame-based protocols, such as gigabit Ethernet, in accordance with the present invention.

[0017] In the exemplary network Fibre Channel/FICON ports 16 and 18 are connected by Fibre Channel/FICON links 15 and 17 respectively to a multi-port Fibre Channel/FICON card 14. Likewise, a second Fibre Channel/FICON port card 24 is connected by Fibre Channel/FICON links 25 and 27 to Fibre Channel/FICON ports 26 and 28 respectively. The Fibre Channel/FICON ports 16, 18, 26 and 28 are associated with elements which are interconnected by Fibre Channel/FICON protocols in SANs. These elements include data storage elements, including disk drive arrays, RAID's, disk farms, or possibly Fibre Channel network elements, such as routers, switches, or other Fibre Channel network elements. In Fig. 1 each Fibre Channel/FICON port card 14 and 24 is connected to a pair of Fibre Channel/FICON ports for purposes of illustration, and more ports may be connected to each Fibre Channel/FICON port card.

[0018] The SONET/SDH network 10 provides a transport path to connect the Fibre Channel/FICON ports 16 and 18 with the Fibre Channel ports 26 and 28 so that Fibre Channel/FICON client data can be transferred between the ports 16, 18 and 26, 28. Optical transport platforms 12 and 22, such as ONS 15454 (available from Cisco Systems, Inc. of San Jose, California), provide the interface between the Fibre Channel/FICON and SONET/SDH networks. The Fibre Channel/FICON ports 16 and 18 are connected to the multi-port Fibre Channel/FICON card 14 which is adapted to fit into the optical transport platform 12; the Fibre Channel/FICON ports 26 and 28 are connected to the multi-port Fibre Channel/FICON card 24 which adapted to fit into the optical transport platform 22. Through the Fibre Channel/FICON port cards 14 and 24, which function as transport interfaces with the platforms 12 and 22 respectively, the Fibre Channel/FICON ports 16 and 18 are interconnected to the Fibre Channel/FICON ports 26 and 28 across the SONET/SDH network transport path. The result is that there are two virtual wires for the connection between a representative Fibre Channel/FICON port at one end of the SONET/SDH network 10, say, port 18, and a representative Fibre Channel port at the other end, say, port 28. As explained above, GFP-T, transparent Generic Framing Procedure, is conventionally used as the framing protocol for such a network to encapsulate the Fibre Channel/FICON payloads at one end of the SONET/SDH network 10 for transmission across the SONET/SDH network and to decapsulate the Fibre Channel/FICON data at the other end. By GFP-T protocol, the GFP-T frames have fixed lengths.

[0019] While the port cards 14 and 24 and their respective optical platforms 12 and 22 are the transport interfaces for the exemplary network of Fig. 1, the transport interfaces can be considered to be located in the port cards 14 and 24 for the described embodiment of the present invention. The cards 14 and 24 each have FIFO (First-In First-Out) buffers to hold the GFP frames received from the SONET/SDH transport network 10 before the encapsulated Fibre Channel/FICON frames of the described embodiment of the present invention, are stripped out of the GFP-encapsulation frames and passed on to their Fibre Channel port destinations.

[0020] The port cards 14 and 24, which extend the SANs so that they are interconnected, operate as intermediate transparent devices on a SAN network. Heretofore, such SAN extension devices typically have a configuration mechanism by which the user could select the number of FIFO buffers for the frames transported across the SONET/SDH network. The mechanism helps the user choose the number of buffers required for the SAN extension over a long distance and in order to maintain a 100% throughput over the long distances of SONET/SDH transport network 10, the mechanism typically
selects a large amount of buffering usually provided in the SAN extension devices. However, a large amount of latency is added for the frames passing through the devices, because of the large number of buffers in the SAN extension devices.

[0021] These configuration mechanisms may not be accurate nor appropriate for the particular SONET/SDH transport path. Also, changes can occur in a transport network, e.g., an increased path delay because of a SONET/SDH switchover, thus changing the buffering requirements for the SAN extension devices.

[0022] To address these problems, the present invention accurately determines the round trip delay (a measure of distance) from one SAN extension device across a SONET/SDH transport network to another SAN extension device and back. Once the latency is accurately determined, the number of buffers required in the first SAN extension device is calculated and programmed into the hardware of the device. Since the number of required buffers are configured for the current distance between the two SAN extension devices, any additional latency due to extra buffering is avoided. Only the required number of buffers on the SAN extension devices is allocated to reduce latency. For example, 1G (base clock rate of 1.0625 GHz for Fibre Channel/FICON data transfer) Fibre Channel/FICON client data sent over a 1200Km (one-way) transport path requires 600 (2Kbyte) buffers for a sustained 100% throughput. However, if the same 600 buffers are used for a 200Km circuit, the extra 500 buffers add an unwanted latency of about 5ms, thereby making the solution unsuitable for certain applications. Due to the inherent bursty nature of Fibre Channel/FICON traffic, the extra buffering can be filled with an additional 500 frames to add undesired latency. By limiting the number of buffers used, traffic is backpressured all the way to the Fibre Channel/FICON source and thereby reduces unwanted latency on all traffic.

[0023] It should be noted that although a 1G Fibre Channel/FICON client operation speed is mentioned above, the present invention works effectively with Fibre Channel/FICON clients operating at 2G (double base clock rate or 2.125 GHz) or any other Fibre Channel/FICON speed.

[0024] Also, with the present invention any SONET/SDH switchover or protection event which leads to a new SONET/SDH path and new distance is automatically detected and the amount of buffers is adjusted accordingly. The buffer adjustments are performed without any hits or errors to the SAN traffic.

[0025] In accordance with the present invention, a special latency instruction message with an incrementing latency sequence number is periodically inserted into the GFP Client Payload Information field of the GFP-T frames encapsulating the Fibre Channel/FICON payload frames that are to be transported across SONET/SDH transport path. The special latency instruction message with latency sequence number includes a special K character that is not used in the Fibre Channel/FICON protocol and is never forwarded to the Fibre Channel/FICON client. It is only used between the Fibre Channel/FICON-Over-SONET/SDH equipment, such as the transport interfaces, i.e., the port cards 14 and 24, with the interconnecting SONET/SDH transport network 10 in the Fig. 1 network, for example. Upon sending the Fibre Channel/FICON frames encapsulated in the GFP frame with the special latency number, the local transport interface, i.e., the GFP transmitter, starts a timer.

[0026] At the remote or receiving transport interface, i.e., the GFP receiver, immediately responds to the special latency number by sending it back to the GFP transmitter across the SONET/SDH transport network.

[0027] Upon receiving the special latency instruction message and latency sequence number, the local transport interface reads its timer and has an accurate determination of the latency in sending frames across the SONET/SDH network to and from the GFP receiver. From the latency determination, the number of buffers required in the local transport interface, the port card 14 in this embodiment, is calculated and programmed into the hardware of the device. The local transport interface monitors the latency in the SONET/SDH transport path to the remote transport interface continually by repeating the procedure described above periodically. In the described embodiment this period is 1 second.

[0028] Figs. 2A and 2B are flow charts which illustrate the steps of operation of an exemplary local transport interface, the port card 14 in this case, in transmitting and receiving encapsulating GFP frames to and from a remote transport interface, the port card 24, in accordance with the present invention. In this manner the local and remote transport interfaces effectively extend their respective SANs to each other’s SAN.

[0029] As shown in Fig. 2A, after the initialization of the local and remote transport interfaces and initial communication is established over the SONET/SDH transport path, as indicated by a dotted arrow, a Timer 1 in the port card 14 is started in step 30. After engaging in different operations not directly related to the present operations, the port card 14 reaches a decision step 31. Has the Timer 1 reached a value T1, in this example, one second? If not, other operations between steps 30 and 31 not directly related to the present invention are resumed. For example, the transfer of GFP superblock frames may be resumed. If so, on the other hand, then a special latency number is inserted into a special latency counter in the port card 14 and is never forwarded to the Fibre Channel/FICON client. It is only used between the Fibre Channel/FICON-Over-SONET/SDH equipment, such as the transport interfaces, i.e., the port cards 14 and 24, with the interconnecting SONET/SDH transport network 10 in the Fig. 1 network, for example. Upon sending the Fibre Channel/FICON frames encapsulated in the GFP frame with the special latency number, the local transport interface, i.e., the GFP transmitter, starts a timer.

[0030] As shown in Fig. 3A, at the remote or receiving transport interface, i.e., the GFP receiver, immediately responds to the special latency number by sending it back to the GFP transmitter across the SONET/SDH transport network.
Thus, across the SONET/SDH transport network 10, the special instruction message and latency sequence number is placed in the GFP Client Payload Information field 54, such as found in the exemplary GFP frame 50 with its component Core Header 51 and Payload Area 52. Within the Payload Area 52 is a Payload Header field 53 and the Client Payload Information field 54. Fig. 3B illustrates the 36-bit special latency instruction message and latency sequence number which is inserted into the 10B/8B client data stream from the Fibre Channel/FICON port 18 at the Fibre Channel/FICON port card 14. In accordance with GFP-T procedures (see clause 8 of the ITU-T Generic Framing Procedure standard G.7041/Y.1303, for example), the decoded 10B/8B client data is mapped into 65B/64B block code and then into 65B/64B superblocks for placement into a GFP Client Payload Information field. In the special latency instruction message, the 4-bit “8h” (8 in hexadecimal) defines the data[31:24] as a control word; the 8-bit “44h” within the control word is a special control character to the Fibre Channel/FICON receiving port card, the port card 24 in this example. The 20-bit incrementing latency sequence number identifies each latency determining operation. It should be noted that, as other Fibre Channel/FICON control characters, the special latency control character “44h” is encoded in a 4-bit mapping of 65B/64B control characters. The special latency control character is mapped as Fh (“111 1”), with the associated command in the following 4 bits to instruct the receiving port card to send back the special latency instruction message and back over the SONET/SDH transport network to the initial transmitter port card.

The embodiment of the present invention described above is best implemented in the port cards 14 and 24 in the exemplary network of Fig. 1. The operations described above require a timer and counter, besides logic. A hardware implementation in an ASIC (Application Specific Integrated Circuit) or an FPGA (Field Programmable Gate Array) is preferred for a high-speed implementation of the present invention for optimal transmission of the client data frames across the SONET/SDH transport network.

Where throughput is not necessarily paramount, the present invention might be implemented in firmware, such as the ROM (Read-Only Memory) of a microcontroller, or in software which offers certain advantages. For instance, the processor unit instructed by the software might also perform operations other than those described, or upgrades can be made easily in software. Fig. 4 shows a block diagram of a representative computer system 60 that may be used to execute the software of an embodiment of the invention. The computer system 60 includes memory 62 which can store and retrieve software programs incorporating computer code that implements aspects of the invention, data for use with the invention, and the like. Exemplary computer readable storage media include CD-ROM, floppy disk, tape, flash memory, semiconductor system memory, and hard drive. The computer system 60 further includes subsystems such as a central processor 61, fixed storage 64 (e.g., hard drive), removable storage 66 (e.g., CD-ROM drive), and one or more network interfaces 67, all connected by a system bus 68. Other computer systems suitable for use with the invention may include additional or fewer subsystems. For example, computer system 60 may include more than one processor 61 (i.e., a multiprocessor system) or a cache memory. The computer system 60 may also include a display, keyboard, and processor system) or a cache memory.
mouse (not shown) for use as a host. Therefore, while the description above provides a full and complete disclosure of the preferred embodiments of the present invention, various modifications, alternate constructions, and equivalents will be obvious to those with skill in the art. Thus, the scope of the present invention is limited solely by the metes and bounds of the appended claims.

Claims

1. A method of operating a transport interface for at least one local Fibre Channel/FICON port, said method comprising:

receiving at the transport interface Fibre Channel/FICON data from the at least one local Fibre Channel/FICON port;

inserting (32) a special latency instruction message into the Fibre Channel/FICON data comprising a control character field, a special control character field, and a latency sequence number, wherein said control character field indicates that said special control character field contains a special control character;

encapsulating said Fibre Channel/FICON data in a generic framing procedure, GFP, client data frame;

sending (34) said GFP client data frame over a SONET/SDH transport network to a remote Fibre Channel/FICON port;

starting (34) a timer concurrently with said sending of said GFP client data frame for timing a return of said special latency instruction message over said SONET/SDH transport network to produce a round trip time;

calculating (41) a number of buffers needed for receiving GFP client data frames from said remote Fibre Channel/FICON port in order to maximise throughput over said SONET/SDH network and reduce latency based on said round trip time; and

allocating (42) said number of buffers in said transport interface.

2. The method of claim 1, wherein said inserting comprises inserting said special latency instruction message into said Fibre Channel/FICON data periodically, and further comprising:

adjusting said number of buffers when a new round trip time differs from said round trip time; and

allocating said number of buffers in said transport interface based on said new round trip time.

3. The method of claim 2, wherein said inserting is repeated with a period of about 1 second.

4. The method of claim 1, wherein said special latency instruction message is inserted in a Client Payload Information field of a Payload Area of said GFP client data frame.

5. The method of claim 1, wherein said latency sequence number is incremented each time said special latency instruction message is inserted into said Fibre Channel/FICON data.

6. The method of claim 1, wherein said special latency instruction message further comprises a four bit special mapped control character, wherein said special control character is an eight bit control character that is mapped to said special mapped control character as a four bit 64B/65B control character.

7. The method of claim 1, wherein said special control character is configured to command a transport interface for said remote Fibre Channel/FICON port to resend said special latency instruction message back to said transport interface for said at least one local Fibre Channel/FICON port upon receiving said special latency instruction message.

8. The method of claim 1, wherein said special control character is a special K character not defined for Fibre Channel/FICON protocols.

9. An apparatus comprising:

a first transport interface (67) configured to receive Fibre Channel/FICON data across a SONET/SDH transport network from a local Fibre Channel/FICON port;

a second transport interface (67) configured to send and receive generic framing procedure, GFP, client data frames;

a processor (61) configured to:

receive Fibre Channel/FICON data from the local Fibre Channel/FICON port via the first transport interface;

insert a special latency instruction message into said Fibre Channel/FICON data comprising a control character field, a special control character field, and a latency sequence number, wherein said control character field indicates that said special control character field contains a special control character;

encapsulate said Fibre Channel/FICON data in a GFP client data frame;

send said GFP client data frame over said SONET/SDH transport network to a remote Fibre Channel/FICON port via said second transport interface;

start a timer concurrently with said sending.
of said GFP client data frame for timing a return of said special latency instruction message over said SONET/SDH transport network to produce a round trip time at said second interface; calculate a number of buffers needed at said second transport interface for receiving GFP client data frames from said remote Fibre Channel/FICON port in order to maximise throughput and reduce latency based on said round trip time; and allocate said number of buffers at said second transport interface.

10. The apparatus of claim 9, wherein said processor is configured to:

insert said special latency instruction message into said Fibre Channel/FICON data periodically;
adjust said number of buffers when a new round trip time differs from said round trip time; and allocate said number of buffers for said second transport interface based on said new round trip time.

11. The apparatus of claim 10, wherein said processor is configured to insert said special latency instruction message into said Fibre Channel/FICON data with a period of about 1 second.

12. The apparatus of claim 9, wherein said processor is configured to insert said special latency instruction message in a Client Payload Information field of a Payload Area of said GFP client data frame.

13. The apparatus of claim 10, wherein said processor is further configured to increment said latency sequence number each time said special latency instruction message is inserted into said Fibre Channel/FICON data.

14. The apparatus of claim 9, wherein said processor is further configured to map said special control character into a special mapped control character in said special latency instruction message, wherein said special control character is an eight bit control character that is mapped to said special mapped control character as a four bit 64B/65B control character.

15. The apparatus of claim 9, wherein said processor is further configured to insert said special control character that is configured to command said second transport interface for said remote Fibre Channel/FICON port to resend said special latency instruction message back to said second transport interface upon receiving said special latency instruction message.

16. The apparatus of claim 9, wherein said processor is configured to insert said special control character as a special K character not defined for Fibre Channel/FICON protocols.

17. A computer readable medium including executable instructions which, when executed on a processor, provide a method of operating a transport interface according to the method of any one of claims 1 to 8.

Patentansprüche

1. Verfahren zum Betreiben einer Transportschnittstelle für mindestens einen lokalen Fibre Channel/FICON-Anschluss, wobei das Verfahren Folgendes aufweist:

Empfangen von Fibre Channel/FICON-Daten an der Transportschnittstelle von dem mindestens einen lokalen Fibre Channel/FICON-Anschluss;
Einfügen (32) einer Befehlsnachricht für eine spezielle Latenzzeit in die Fibre Channel/FICON-Daten, die ein Steuerzeichenfeld, ein spezielles Steuerzeichenfeld und eine Sequenznummer der Latenzzeit aufweisen, wobei das Steuerzeichenfeld anzeigt, dass das spezielle Steuerzeichenfeld ein spezielles Steuerzeichen enthält;
Einkapseln der Fibre Channel/FICON-Daten in einem Generic Framing Procedure(GFP)-Client-Datenframe;
Senden (34) des GFP-Client-Datenframes über ein SONET-/SDH-Transportnetzwerk an einen entfernten Fibre Channel/FICON-Anschluss;
Starten (34) eines Timers gleichzeitig mit dem Senden des GFP-Client-Datenframes zur zeitlichen Steuerung einer Rückkehr der Befehlsnachricht für eine spezielle Latenzzeit über das SONET-/SDH-Transportnetzwerk, um eine Umlaufzeit zu erzeugen;
Berechnen (41) einer Anzahl von Puffern, die zum Empfangen von GFP-Client-Datenframes von dem entfernten Fibre Channel/FICON-Anschluss benötigt werden, um den Durchsatz über das SONET-/SDH-Netzwerk zu maximieren und die Latenzzeit, die auf der Umlaufzeit basiert, zu reduzieren; und
Zuweisen (42) der Anzahl von Puffern in der Transportschnittstelle.

2. Verfahren nach Anspruch 1, wobei das Einfügen das periodische Einfügen der Befehlsnachricht für eine spezielle Latenzzeit in die Fibre Channel/FICON-Daten aufweist, und ferner Folgendes aufweist:

Einstellen der Anzahl der Puffer, wenn sich eine
3. Verfahren nach Anspruch 2, wobei das Einfügen mit einem Zeitabstand von etwa 1 Sekunde wiederholt wird.

4. Verfahren nach Anspruch 1, wobei die Befehlsnachricht für eine spezielle Latenzzzeit in ein Client-Nutzlast-Informationsfeld eines Nutzlastbereichs des GFP-Client-Datenframes eingefügt wird.

5. Verfahren nach Anspruch 1, wobei die Sequenznummer der Latenzzzeit jedes Mal inkrementiert wird, wenn die Befehlsnachricht für eine spezielle Latenzzzeit in die Fibre Channel-/FICON-Daten eingefügt wird.

6. Verfahren nach Anspruch 1, wobei die Befehlsnachricht für eine spezielle Latenzzzeit ferner ein speziell zugeordnetes Steuerzeichen von vier Bit aufweist, wobei das spezielle Steuerzeichen ein Steuerzeichen von acht Bit ist, das dem speziellen Steuerzeichen als ein 64B/65B Steuerzeichen von vier Bit zugeordnet wird.

7. Verfahren nach Anspruch 1, wobei das spezielle Steuerzeichen konfiguriert ist, eine Transport Schnittstelle für den entfernten Fibre Channel-/FICON-Anschluss anzuweisen, die Befehlsnachricht für eine spezielle Latenzzzeit an die Transportschnittstelle für den mindestens einen lokal Fibre Channel-/FICON-Anschluss nach Empfangen der Befehlsnachricht für eine spezielle Latenzzzeit wieder zurückzusenden.

8. Verfahren nach Anspruch 1, wobei das spezielle Steuerzeichen ein spezielles K-Zeichen ist, das für Fibre Channel-/FICON-Protokolle nicht definiert ist.

9. Vorrichtung, welche Folgendes aufweist:

   eine erste Transportschnittstelle (67), die zum Empfangen von Fibre-Channel-/FICON-Daten über ein SONET-/SDH-Transportnetzwerk von einem lokalen Fibre Channel-/FICON-Anschluss konfiguriert ist;
   eine zweite Transportschnittstelle (67), die zum Senden und Empfangen von Generic Framing Procedure(GFP)-Client-Datenframes konfiguriert ist;
   einen Prozessor (61), der zu Folgendem konfiguriert ist:

   Empfangen von Fibre Channel-/FICON-Daten von dem lokalen Fibre Channel/FICON-Anschluss über die erste Transportschnittstelle;
   Einfügen einer Befehlsnachricht für eine spezielle Latenzzzeit in die Fibre Channel-/FICON-Daten, die ein Steuerzeichenfeld, ein spezielles Steuerzeichenfeld und eine Sequenznummer der Latenzzzeit aufweisen, wobei das Steuerzeichenfeld zeigt, dass das spezielle Steuerzeichenfeld ein spezielles Steuerzeichen enthält;
   Einkapseln der Fibre Channel-/FICON-Daten in einem GFP-Client-Datenframe; Senden des GFP-Client-Datenframes über das SONET-/SDH-Transportnetzwerk an einen entfernten Fibre Channel-/FICON-Anschluss über die zweite Transportschnittstelle;

   Starten eines Timers gleichzeitig mit dem Senden des GFP-Client-Datenframes zur zeitlichen Steuerung einer Rückkehr der Befehlsnachricht für eine spezielle Latenzzzeit über das SONET-/SDH-Transportnetzwerk, um eine Umlaufzeit an der zweiten Schnittstelle zu erzeugen;
   Berechnen einer Anzahl von Puffern, die an der zweiten Transportschnittstelle zum Empfangen von GFP-Client-Datenframes von dem entfernten Fibre Channel/FICON-Anschluss benötigt werden, um den Durchsatz zu maximieren und die Latenzzzeit, die auf der Umlaufzeit basiert, zu reduzieren; und
   Zuweisen der Anzahl von Puffern an der zweiten Transportschnittstelle.

10. Vorrichtung nach Anspruch 9, wobei der Prozessor ferner zu Folgendem konfiguriert ist:

   periodischem Einfügen der Befehlsnachricht für eine spezielle Latenzzzeit in die Fibre Channel-/FICON-Daten;
   Einstellen der Anzahl der Puffer, wenn sich eine neue Umlaufzeit von der Umlaufzeit unterscheidet; und
   Zuweisen der Anzahl von Puffern für die zweite Transportschnittstelle, die auf der neuen Umlaufzeit basiert.

11. Vorrichtung nach Anspruch 10, wobei der Prozessor zum Einfügen der Befehlsnachricht für eine spezielle Latenzzzeit in die Fibre Channel-/FICON-Daten mit einem Zeitabstand von etwa 1 Sekunde konfiguriert ist.

12. Vorrichtung nach Anspruch 9, wobei der Prozessor zum Einfügen der Befehlsnachricht für eine spezielle Latenzzzeit in die Fibre Channel-/FICON-Daten mit einem Zeitabstand von etwa 1 Sekunde konfiguriert ist.
Latenzzeit in ein Client-Nutzlast-Informationsfeld eines Nutzlastbereichs des GFP-Client-Datenframes konfiguriert ist.

13. Vorrichtung nach Anspruch 10, wobei der Prozessor ferner zum Inkrementieren der Sequenznummer der Latenzzeit jedes Mal, wenn die Befehlsnachricht für eine spezielle Latenzzeit in die Befehlsfluss-/FICON-Daten eingefügt wird, konfiguriert ist.

14. Vorrichtung nach Anspruch 9, wobei der Prozessor ferner zum Zuordnen des speziellen Steuerzeichens in ein speziell zugeordnetes Steuerzeichen in der Befehlsflussnachricht für eine spezielle Latenzzeit konfiguriert ist, wobei das spezielle Steuerzeichen ein Steuerzeichen von acht Bit ist, das dem speziell zugeordneten Steuerzeichen als ein 64B/65B Steuerzeichen von vier Bit zugeordnet wird.

15. Vorrichtung nach Anspruch 9, wobei der Prozessor ferner zum Einfügen des speziellen Steuerzeichens konfiguriert ist, das konfiguriert ist, die zweite Transportschnittstelle für den entfernten Fibre Channel-/FICON-Anschluss anzuweisen, die Befehlsnachricht für eine spezielle Latenzzeit an die zweite Transportschnittstelle nach Empfangen der Befehlsnachricht für eine spezielle Latenzzeit wieder zurückzusenden.


17. Computerlesbares Medium, welches ausführbare Anweisungen einschließt, die, wenn sie auf einem Prozessor ausgeführt werden, ein Verfahren zum Betreiben einer Transportschnittstelle gemäß dem Verfahren nach einem der Ansprüche 1 bis 8 bereitstellen.

**Revidierungen**

1. Procédé de fonctionnement d'une interface de transport pour au moins un port local de connexion Fibre Channel / FICON, ledit procédé comprenant de :

   recevoir, au niveau de l'interface de transport Fibre Channel / FICON, des données d'au moins un port local Fibre Channel / FICON ;

   insérer (32) un message d'instruction de latence spécial dans les données Fibre Channel / FICON comprenant un champ de caractères de contrôle, un champ de caractères de contrôle spéciaux et un numéro de séquence de latence, ledit champ de caractères de contrôle indiquant que ledit champ de caractères de contrôle spéciaux contient un caractère de contrôle spécial ;

   encapsuler lesdites données Fibre Channel / FICON dans une trame de données client de procédure générique de tramage GFP ;

   envoyer (34) ladite trame de données client GFP via un réseau de transport SONET/SDH à un port Fibre Channel / FICON distant ;

   démarrer (34) un chronomètre en même temps que ledit envoi de ladite trame de données client GFP pour chronométrer un retour dudit message d'instruction de latence spécial via ledit réseau de transport SONET/SDH pour produire un temps d'aller-retour ;

   calculer (41) un nombre de tampons nécessaires pour recevoir les trames de données client GFP dudit port Fibre Channel / FICON distant afin de maximiser le débit de données via ledit réseau de transport SONET/SDH et réduire la latence en fonction dudit temps d'aller-retour ; et

   assigner (42) ledit nombre de tampons dans ladite interface de transport.

2. Procédé selon la revendication 1, dans lequel ladite insertion comprend d'insérer périodiquement ledit message d'instruction de latence spécial dans lesdites données Fibre Channel / FICON, et comprenant en outre de :

   ajuster ledit nombre de tampons quand un nouveau temps d'aller-retour diffère dudit temps d'aller-retour ; et

   assigner ledit nombre de tampons dans ladite interface de transport en fonction dudit nouveau temps d'aller-retour.

3. Procédé selon la revendication 2, dans lequel ladite insertion est répétée avec une période d'environ 1 seconde.

4. Procédé selon la revendication 1, dans lequel ledit message d'instruction de latence spécial est inséré dans un champ d'information de charge utile de client de la zone charge utile de ladite trame de données client GFP.

5. Procédé selon la revendication 1, dans lequel ledit numéro de séquence de latence est incrémenté chaque fois que ledit message d'instruction de latence spécial est inséré dans lesdites données Fibre Channel / FICON.

6. Procédé selon la revendication 1, dans lequel ledit message d'instruction de latence spécial comprend un caractère de contrôle spécial mappé de quatre bits, ledit caractère de contrôle spécial étant un caractère de contrôle de huit bits mappé en ledit caractère de contrôle spécial sous forme d'un caractère de contrôle de quatre bits 64B/65B.
7. Procédé selon la revendication 1, dans lequel ledit caractère de contrôle spécial est conçu pour commander une interface de transport pour ledit port Fibre Channel / FICON distant afin de renvoyer ledit message d'instruction de latence spécial à ladite interface de transport pour ledit au moins un port local Fibre Channel / FICON à réception dudit message d'instruction de latence spécial.

8. Procédé selon la revendication 1, dans lequel ledit caractère de contrôle spécial est un caractère K spécial non défini pour des protocoles Fibre Channel / FICON.

9. Appareil comprenant :

   une première interface de transport (67) conçue pour recevoir des données Fibre Channel / FICON à travers un réseau de transport SONET/SDH depuis un port local Fibre Channel / FICON ;

   une deuxième interface de transport (67) conçu pour envoyer et recevoir des trames de données client de procédure générique de tramage GFP ;

   un processeur (61) conçu pour :

   - recevoir des données Fibre Channel / FICON du port local Fibre Channel / FICON via la première interface de transport ;
   - insérer un message d'instruction de latence spécial dans lesdites données Fibre Channel / FICON comprenant un champ de caractères de contrôle, un champ de caractères spéciaux et un numéro de séquence de latence, ledit champ de caractères de contrôle indiquant que ledit champ de caractères spéciaux contient un caractère de contrôle spécial ;
   - encapsuler lesdites données Fibre Channel / FICON dans une trame de données client de procédure générique de tramage GFP ;
   - envoyer (34) ladite trame de données client GFP via un réseau de transport SONET/SDH à un port Fibre Channel / FICON distant via ladite deuxième interface de transport ;
   - démarrer un chronomètre en même temps que ledit envoi de ladite trame de données client GFP pour chronométrer un retour dit message d'instruction de latence spécial via ledit réseau de transport SONET/SDH pour produire un temps d'aller-retour au niveau de ladite deuxième interface ;
   - calculer un nombre de tampons nécessaires au niveau de ladite deuxième interface de transport pour recevoir des trames de données client GFP dudit port Fibre Channel / FICON distant afin de maximiser le débit de données via ledit réseau de transport SONET/SDH et réduire la latence en fonction dudit temps d'aller-retour ;
   - assigner ledit nombre de tampons dans la deuxième interface de transport.

10. Appareil selon la revendication 9, dans lequel ledit processeur est conçu pour :

    - insérer périodiquement ledit message d'instruction de latence spécial dans lesdites données Fibre Channel / FICON ;
    - ajuster ledit nombre de tampons quand un nouveau temps d'aller-retour diffère dudit temps d'aller-retour ;
    - assigner ledit nombre de tampons dans ladite interface de transport en fonction dudit nouveau temps d'aller-retour.

11. Appareil selon la revendication 10, dans lequel ledit processeur est conçu pour insérer ledit message d'instruction de latence spécial dans un champ d'information de charge utile de client d'une zone charge utile de ladite trame de données client GFP.

12. Appareil selon la revendication 10, dans lequel ledit processeur est conçu en outre pour incrémenter ledit numéro de séquence de latence chaque fois que ledit message d'instruction de latence spécial est inséré dans lesdites données Fibre Channel / FICON.

13. Appareil selon la revendication 10, dans lequel ledit processeur est conçu en outre pour mapper ledit caractère de contrôle spécial en un caractère de contrôle spécial mappé dans ledit message d'instruction de latence spécial dans un champ de données client GFP.

14. Appareil selon la revendication 9, dans lequel ledit processeur est en outre conçu pour mapper ledit caractère de contrôle spécial en un caractère de contrôle spécial mappé dans ledit message d'instruction de latence spécial, ledit caractère de contrôle spécial étant un caractère de contrôle de huit bits mappé en ledit caractère de contrôle spécial sous forme d'un caractère de contrôle de quatre bits 64B/65B.

15. Appareil selon la revendication 9, dans lequel ledit processeur est en outre configuré pour insérer ledit caractère de contrôle spécial conçu pour commander ladite deuxième interface de transport pour ledit port Fibre Channel / FICON distant afin de renvoyer ledit message d'instruction de latence spécial à ladite deuxième interface de transport à réception dudit message d'instruction de latence spécial.

16. Appareil selon la revendication 9, dans lequel ledit processeur est configuré pour insérer ledit caractère de contrôle spécial comme un caractère K spécial
non défini pour des protocoles Fibre Channel / FI-

17. Support lisible par ordinateur contenant des instruc-
tions exécutables qui, quand elles sont exécutées
par un processeur, fournissent un procédé de fonc-
tionnement d’une interface de transport suivant le
procédé selon l’une quelconque des revendications
1 à 8.
30  Start Timer 1

31  Has T1 in Timer 1 been reached?

32  Yes

32  Insert special latency number into next GFP frame to be sent

33  Increment special latency number counter

34  Send GFP frame and start Timer 2

35  Reset Timer 1

Fig. 2A
Receive GFP frame from remote transport interface

Does received GFP frame have special latency number?

Yes

Determine latency from T2 of Timer 2

Determine appropriate number of buffers

Allocate number of buffers from determined latency

Reset Timer 2

No

Fig. 2B
FIG. 3B

FIG. 4
REFERENCES CITED IN THE DESCRIPTION

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