Network Working Group
Request for Comments: 1987
Category: Informational

P. Newman, Ipsilon
W. Edwards, Sprint
R. Hinden, Ipsilon
E. Hoffman, Ipsilon
F. Ching Liaw, Ipsilon
T. Lyon, Ipsilon
G. Minshall, Ipsilon

August 1996

# Ipsilon's General Switch Management Protocol Specification
# Version 1.1

## Status of this Memo



## Abstract

The General Switch Management Protocol (GSMP), is a general purpose protocol to control an ATM switch. GSMP allows a controller to establish and release connections across the switch; add and delete leaves on a point-to-multipoint connection; manage switch ports; request configuration information; and request statistics.

Table of Contents

## 1. Introduction

The General Switch Management Protocol (GSMP), is a general purpose protocol to control an ATM switch. GSMP allows a controller to establish and release connections across the switch; add and delete leaves on a point-to-multipoint connection; manage switch ports; request configuration information; and request statistics. It also allows the switch to inform the controller of asynchronous events such as a link going down. GSMP runs across an ATM link connecting the controller to the switch, on a control connection (virtual channel) established at initialization. The GSMP protocol is asymmetric, the controller being the master and the switch being the slave. Multiple switches may be controlled by a single controller using multiple instantiations of the protocol over separate control connections.

A switch is assumed to contain multiple "ports". Each port is a combination of one "input port" and one "output port". Some GSMP requests refer to the port as a whole whereas other requests are specific to the input port or the output port. ATM cells arrive at the switch from an external communication link on incoming virtual channels at an input port. ATM cells depart from the switch to an external communication link on outgoing virtual channels from an output port. Virtual channels on a port or link are referenced by their virtual path and virtual channel identifiers (VPI/VCI). A virtual channel connection across a switch is formed by connecting an incoming virtual channel to one or more outgoing virtual channels. Virtual channel connections are referenced by the input port on which they arrive and the virtual path and virtual channel identifiers (VPI/VCI) of their incoming virtual channel.

In general a virtual channel is established with a certain quality of service (QOS). Unfortunately this is an ill defined and changing concept as new ideas make their way into hardware. For this version of the GSMP protocol it is assumed that each virtual channel connection may be assigned a priority when it is established. It may be assumed that for virtual channel connections that share the same output port, an ATM cell on a connection with a higher priority is much more likely to exit the switch before an ATM cell on a connection with a lower priority if they are both in the switch at the same time. The number of priorities that each port of the switch supports may be obtained from the port configuration message.

Switch ports are described by a 32 bit port number. The switch assigns port numbers and it may typically choose to structure the 32 bits into sub-fields that have meaning to the physical structure of the switch (e.g. shelf, slot, port). In general, a port in the same physical location on the switch will always have the same port

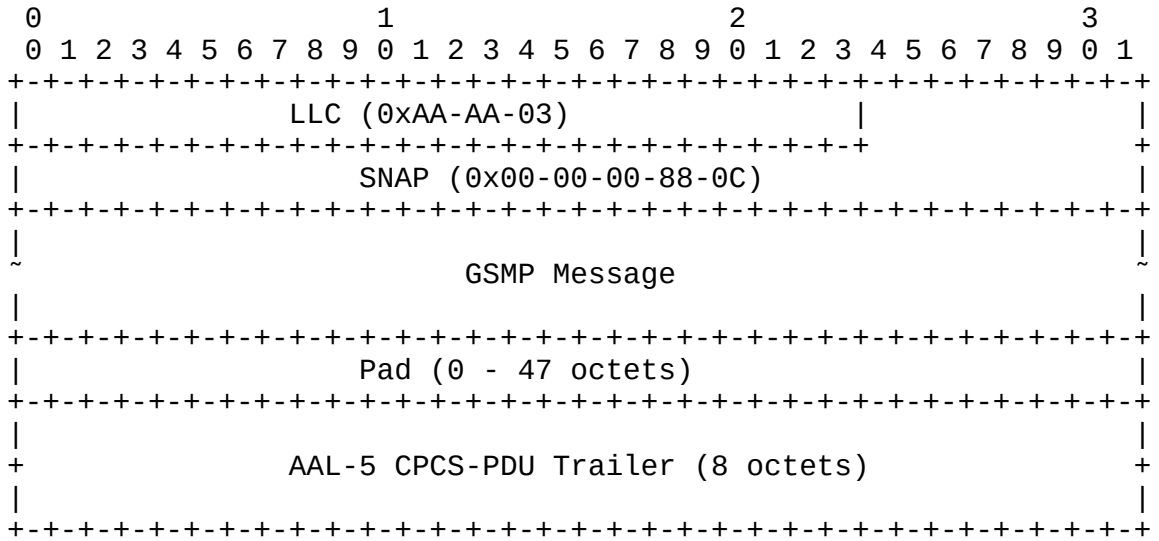
number, even across power cycles. The internal structure of the port number is opaque to the GSMP protocol. However, by looking up the product identity in a database, network management tools may discover the partitioning of the port number and the physical meaning of the sub-fields.

Each switch port also maintains a port session number assigned by the switch. A connection management message or a port management message with an incorrect port session number must be rejected. This allows the controller to detect a link failure and to keep state synchronized. The port session number of a port remains unchanged while the port is continuously in the available state and the link status is continuously up. When a port returns to the available state after it has been unavailable or in any of the loopback states, or when the line status returns to the up state after it has been down or in test, or after a power cycle, its port session number will have changed. Port session numbers should be assigned using some form of random number.

GSMP also contains an adjacency protocol. The adjacency protocol is used to synchronize state across the link, to discover the identity of the entity at the other end of a link, and to detect when it changes.

## 2. GSMP Packet Format

GSMP packets are variable length and are encapsulated directly in an AAL-5 CPCS-PDU [I.363] with an LLC/SNAP header as illustrated:



(The convention in the documentation of Internet Protocols [rfc1700] is to express numbers in decimal and to picture data in "big-endian" order. That is, fields are described left to right, with the most significant octet on the left and the least significant octet on the right. Whenever a diagram shows a group of octets, the order of transmission of those octets is the normal order in which they are read in English. Whenever an octet represents a numeric quantity the left most bit in the diagram is the high order or most significant bit. That is, the bit labeled 0 is the most significant bit. Similarly, whenever a multi-octet field represents a numeric quantity the left most bit of the whole field is the most significant bit. When a multi-octet quantity is transmitted, the most significant octet is transmitted first. This is the same coding convention as is used in the ATM layer [I.361] and AAL-5 [I.363].)

The LLC/SNAP header contains the octets: 0xAA 0xAA 0x03 0x00 0x00 0x00 0x88 0x0C.

The maximum transmission unit (MTU) of the GSMP message is 1500 octets.

The default virtual channel for LLC/SNAP encapsulated messages is:

VPI = 0
VCI = 15.

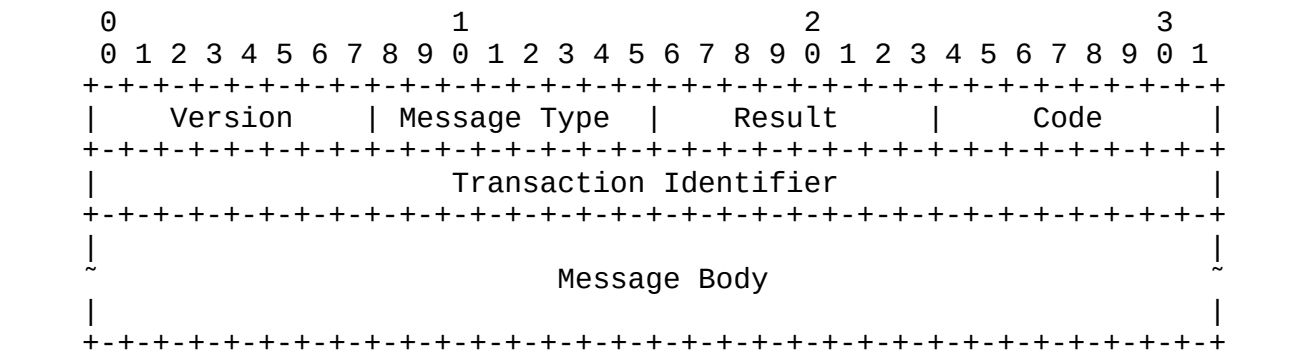
GSMP is a master-slave protocol. The controller issues request messages to the switch. Each request message indicates whether a response is required from the switch and contains a transaction identifier to enable the response to be associated with the request. The switch replies with a response message indicating either a successful result or a failure. There are four classes of GSMP request-response message: Connection Management, Port Management, Statistics, and Configuration. The switch may also generate asynchronous Event messages to inform the controller of asynchronous events. Event messages are not acknowledged by the controller. There is also an adjacency protocol message used to establish synchronization across the link and maintain a handshake.

For the request-response messages each message type has a format for the request message and a format for the success response. Unless otherwise specified a failure response message is identical to the request message that caused the failure, with the Code field indicating the nature of the failure. Event messages have only a single format defined as they are not acknowledged by the controller.

Except for the adjacency protocol message, no GSMP messages may be sent across the link until the adjacency protocol has achieved

synchronization, and all GSMP messages received on a link that does not currently have state synchronization must be discarded.

All GSMP messages, except the adjacency protocol message, have the following format:




Version
: The GSMP protocol version number, currently Version = 1. It should be set by the sender of the message to the GSMP protocol version that the sender is currently running.

Message Type
: The GSMP message type. GSMP messages fall into five classes: Connection Management, Port Management, Statistics, Configuration, and Events. Each class, except for port management, has a number of different message types. In addition, one Message Type is allocated to the adjacency protocol.

Result
: Field in a connection management request message or a port management request message, is used to indicate whether a response is required to the request message if the outcome is successful. A value of "NoSuccessAck" indicates that the request message does not expect a response if the outcome is successful, and a value of "AckAll" indicates that a response is expected if the outcome is successful. In both cases a failure response will be generated if the request fails. This facility reduces the traffic in the case where the controller is simply checking that the state in the switch is correct. For all other request messages a value of "NoSuccessAck" in the request message is ignored and the request message is handled as if the field were set to "AckAll". In a response message the result field can have two values: "Success" and "Failure".

The encoding of the result field is:

```
NoSuccessAck:  Result = 1
AckAll:        Result = 2
Success:       Result = 3
Failure:       Result = 4.
```

The Result field is not used in an adjacency protocol message and should be set to zero by the sender and ignored by the receiver.

Code

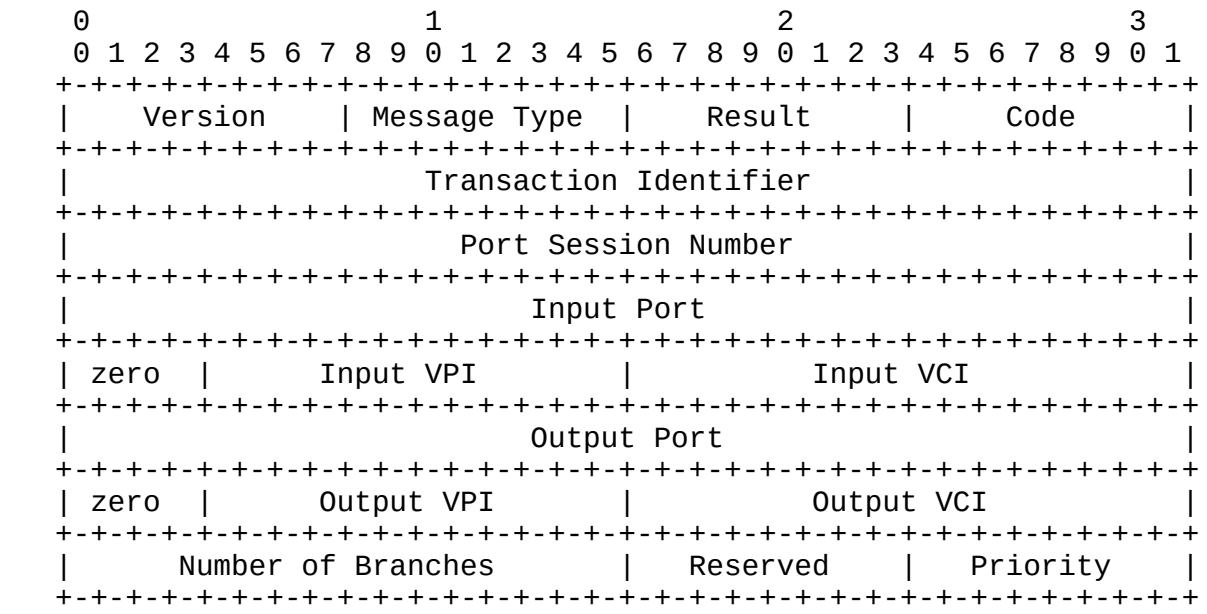
Field gives further information concerning the result in a response message. It is mostly used to pass an error code in a failure response but can also be used to give further information in a success response message or an event message. In a request message the code field is not used and is set to zero. In an adjacency protocol message the Code field is used to determine the function of the message.

Transaction Identifier

Used to associate a request message with its response message. For request messages the controller may select any transaction identifier. For response messages the transaction identifier is set to the value of the transaction identifier from the message to which it is a response. For event messages the transaction identifier should be set to zero. In the adjacency protocol the Transaction Identifier is not used. This field is not present in the adjacency protocol message.

## 3. Connection Management Messages

Connection management messages are used by the controller to establish, delete, modify and verify connections across the switch. The Add Branch, Delete Branch, Delete Tree, Verify Tree, and Delete All connection management messages have the following format for both request and response messages:




Port Session Number

Field gives the session number of the input port. Each switch port maintains a Port Session Number assigned by the switch. The port session number of a port remains unchanged while the port is continuously in the Available state and the link status is continuously Up. When a port returns to the Available state after it has been Unavailable or in any of the Loopback states, or when the line status returns to the Up state after it has been Down or in Test, or after a power cycle, a new Port Session Number must be generated. Port session numbers should be assigned using some form of random number. The switch must reject any connection management request message that has an invalid Port Session Number for the port specified in the Input Port field by returning a failure response message with the Code field indicating, "Invalid port session number." The current port session number may be obtained using a configuration message.

Input Port

Indicates a switch input port. Switch ports are referenced by a 32 bit value assigned by the switch.

Input VPI

Identifies an ATM virtual path arriving at the switch input port indicated by the Input Port field.

Input VCI
: Identifies an ATM virtual channel arriving on the virtual path indicated by the Input VPI field at the switch input port indicated by the Input Port field.

Output Port
: Indicates a switch output port. Switch ports are referenced by a 32 bit value assigned by the switch.

Output VPI
: Identifies an outgoing virtual path departing from the switch output port indicated in the Output Port field.

Output VCI
: Identifies an outgoing virtual channel departing on the virtual path indicated by the Output VPI field from the switch output port indicated in the Output Port field.

Number of Branches
: Gives the number of output branches on a virtual channel connection. (A unicast connection will have one branch, a multicast connection will have two or more branches.) This field is only used in the Verify Tree message. In all other connection management messages this field should be set to zero by the sender and ignored by the receiver.

Reserved
: This field is not used. It is set to zero by the sender and ignored by the receiver.

Priority
: Gives the priority of the connection. The highest priority is numbered zero and the lowest priority is numbered "Q-1" where "Q" is the number of priorities that the output port can support. The ability to offer different qualities of service to different connections based upon their priority is assumed to be a property of the output port of the switch. It is assumed that for virtual channel connections that share the same output port, an ATM cell on a connection with a higher priority is much more likely to exit the switch before an ATM cell on a connection with a lower priority if they are both in the switch at the same time. The number of priorities that each output port can support is given in the Port Configuration message. If a connection request is received with a value in the priority field that the switch cannot support, the switch will assign the closest priority that it is capable of supporting. This field is only used in the Add Branch and

Move Branch messages. In all other connection management messages this field should be set to zero by the sender and ignored by the receiver.

If the result field of the request message is "AckAll" the switch must reply to all connection management request messages with a success response message or a failure response message. If the result field of the request message is "NoSuccessAck" the switch must only reply in the case of a failure.

A success response message must not be sent until the operation has been successfully completed. For connection management messages the success response message is a copy of the request message returned with a Result field indicating success. The Code field is not used in a connection management success response message and should be set to zero. The failure response message is a copy of the request message returned with a Result field indicating failure. The Code field is used to pass the Failure Code in a connection management failure response message. If the switch issues a failure response the connection state within the switch must not be modified by the request message that resulted in the failure.

No distinction is made between unicast connections and multicast connections. The first Add Branch message for a particular Input Port, Input VPI, and Input VCI will establish a unicast connection. The second Add Branch message with the same Input Port, Input VPI, and Input VCI fields will convert the connection to a multicast connection with two branches. Subsequent Add Branch messages with the same Input Port, Input VPI, and Input VCI fields will add further branches to the multicast connection. Use of the Delete Branch message on a multicast connection with two branches will result in a unicast connection. Use of the Delete Branch message on a unicast connection will delete the unicast connection. There is no concept of a connection with zero output branches. All connections are unidirectional, one input virtual channel to one or more output virtual channels.

The connection management messages may be issued regardless of the Port Status of the switch port. Connections may be established or deleted when a switch port is in the Available, Unavailable, or any of the Loopback states. However, all connection state on an input port will be deleted when the port returns to the Available state from any other state, i.e. when a Port Management message is received for that port with the Function field indicating either Bring Up, or Reset Input Port.

### 3.1 Add Branch Message

The Add Branch message is a connection management message used to establish a virtual channel connection or to add an additional branch to an existing virtual channel connection. It may also be used to check the connection state stored in the switch. The connection is specified by the Input Port, Input VPI, and Input VCI fields. The output branch is specified by the Output Port, Output VPI, and Output VCI fields. The priority of the connection is specified by the Priority field. The Add Branch message is:

Message Type = 16

If the virtual channel connection specified by the Input Port, Input VPI, and Input VCI fields does not already exist, it must be established with the single output branch specified in the request message. The output branch should have the priority specified by the Priority field. If the Result field of the request message is "AckAll" a success response message must be sent upon successful establishment of the specified branch. The success response message must not be sent until the Add Branch operation has been completed.

If the virtual channel connection specified by the Input Port, Input VPI, and Input VCI fields already exists, but the specified output branch does not, the new output branch must be added. The new output branch should have the priority specified by the Priority field. If the Result field of the request message is "AckAll" a success response message must be sent upon successful establishment of the specified branch. The success response message must not be sent until the Add Branch operation has been completed.

If the virtual channel connection specified by the Input Port, Input VPI, and Input VCI fields already exists and the specified output branch also already exists, the priority of the connection, if different from the request message, should be changed to that in the request message. A success response message must be sent if the Result field of the request message is "AckAll". This allows the controller to periodically reassert the state of a connection or to change its priority. If the result field of the request message is "NoSuccessAck" a success response message should not be returned. This may be used to reduce the traffic on the control link for messages that are reasserting previously established state. For messages that are reasserting previously established state, the switch must always check that this state is correctly established in the switch hardware (i.e. the actual connection tables used to forward cells).

The behavior is undefined if the output virtual channel specified by the Output Port, Output VPI, and Output VCI fields is already in use by any connection other than that specified by the Input Port, Input VPI, and Input VCI fields.

A failure response must be returned if the switch is unable to establish the specified branch or if there is an error in any of the fields of the request message. If a failure message is returned the state of the switch must not have been modified by the request message.

It should be noted that different switches support multicast in different ways. There will be a limit to the total number of multicast connections any switch can support, and possibly a limit on the maximum number of branches that a multicast connection may specify. Some switches also impose a limit on the number of different VPI/VCI values that may be assigned to the output branches of a multicast connection. Many switches are incapable of supporting more than a single branch of any particular multicast connection on the same output port. Specific failure codes are defined for some of these conditions. If a switch sends a failure response to an Add Branch message it must choose the most specific failure code.

## 3.2 Delete Branch Message

The Delete Branch message is a connection management message used to delete a single branch of a virtual channel connection, or in the case of the last branch, to delete the connection. The virtual channel connection is specified by the Input Port, Input VPI, and Input VCI fields. The specific branch is indicated by the Output Port, Output VPI, and Output VCI fields. The Delete Branch message is:

Message Type = 17

If the Result field of the request message is "AckAll" a success response message must be sent upon successful deletion of the specified branch. The success response message must not be sent until the delete branch operation has been completed and if possible, not until all data on that branch, queued for transmission, has been transmitted. A failure message indicating, "The specified connection does not exist," must be sent if the connection specified by the Input Port, Input VPI, and Input VCI fields does not exist. A failure message indicating, "The specified branch does not exist," must be sent if the connection specified by the Input Port, Input VPI, and Input VCI fields exists but the branch specified by the Output Port, Output VPI, and Output VCI fields does not exist.

### 3.3 Delete Tree Message

The Delete Tree message is a connection management message used to delete an entire virtual channel connection. All remaining branches of the connection are deleted. The virtual channel connection is specified by the Input Port, Input VPI, and Input VCI fields. The Output Port, Output VPI, and Output VCI fields are not used in this message and their contents should be set to zero by the sender and ignored by the receiver. The Delete Tree message is:

Message Type = 18

If the Result field of the request message is "AckAll" a success response message must be sent upon successful deletion of the specified connection. The success message must not be sent until the delete operation has been completed and if possible, not until all data on the connection, queued for transmission, has been transmitted. A failure message indicating, "The specified connection does not exist," must be sent if the connection specified by the Input Port, Input VPI, and Input VCI fields does not exist.

### 3.4 Verify Tree Message

The Verify Tree message is a connection management message used to verify the number of branches on a virtual channel connection. The virtual channel connection is specified by the Input Port, Input VPI, and Input VCI fields. The Output Port, Output VPI, and Output VCI fields are not used in this message and their contents should be set to zero by the sender and ignored by the receiver. The number of branches that the sender believes that this virtual channel connection should contain is given by the Number of Branches field. The Verify Tree message is:

Message Type = 19

If the Result field of the request message is "AckAll" a success response message must be sent if the receiver agrees that the actual number of branches of the specified virtual channel connection matches the number contained in the Number of Branches field of the request message. The failure response message, with the code field set to "Failure specific to the particular message type," must be sent if the actual number of branches of the specified virtual channel connection does not match the number contained in the Number of Branches field of the request message. In this failure response message the Number of Branches field must be changed to contain the actual number of branches of the specified virtual channel connection. A failure response message with the code field set to a different value must be used to indicate some other failure such as,

"The specified connection does not exist." In this case the Number of Branches field will be the same as that of the request message.

The Verify Tree message can only be guaranteed to yield a correct response when there are no other connection request messages or their response messages pending for the specified connection. If this is not the case the result of the Verify Tree message is undefined.

### 3.5 Delete All Message

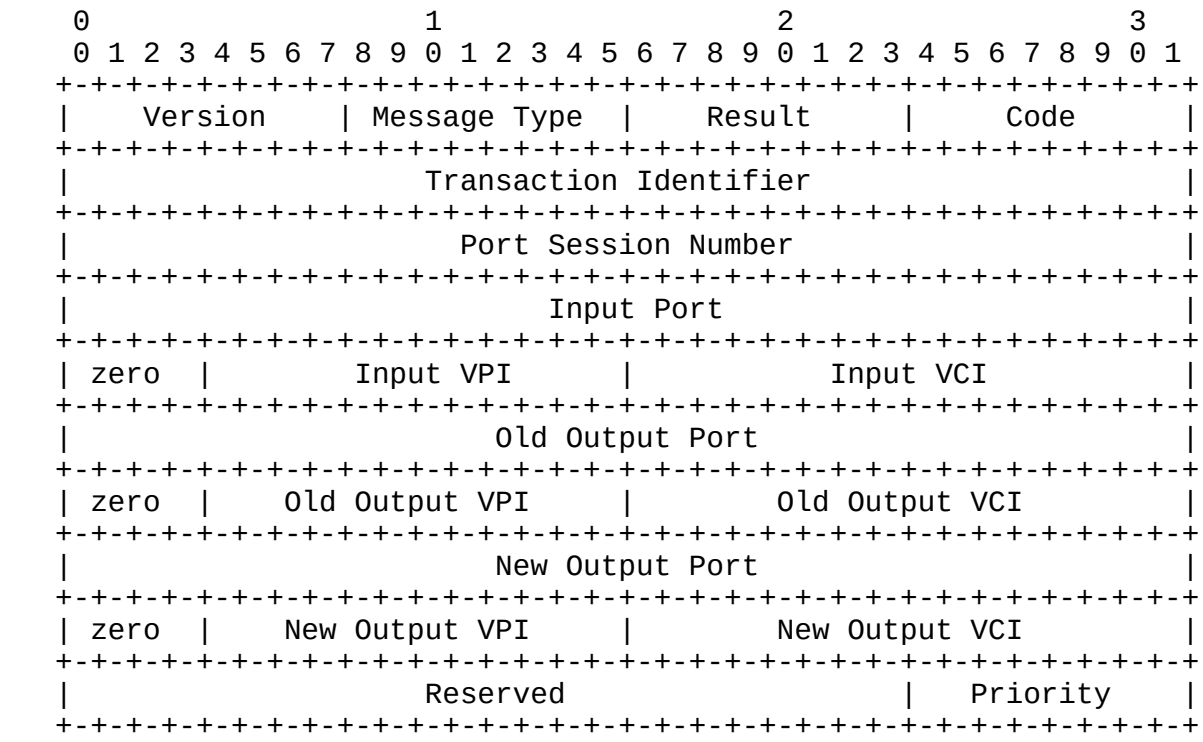
The Delete All message is a connection management message used to delete all connections on a switch input port. All connections that arrive at the specified input port must be deleted. On completion of the operation all dynamically assigned VPI/VCI values for the specified port must be unassigned, i.e. there must be no virtual connections established in the VPI/VCI space that GSMP controls on this port. The Input VPI, Input VCI, Output Port, Output VPI, and Output VCI fields are not used in this message and their contents are ignored and unspecified. The Delete All message is"

Message Type = 20

If the Result field of the request message is "AckAll" a success response message must be sent upon completion of the operation. The success response message must not be sent until the operation has been completed.

### 3.6 Move Branch Message

The Move Branch connection management message has the following format for both request and response messages:




The Move Branch message is a connection management message used to move a single output branch of a virtual channel connection from its current output port, output VPI, and output VCI, to a new output port, output VPI, and output VCI on the same virtual channel connection. None of the other output branches are modified. When the operation is complete the original output VPI/VCI on the original output port will be deleted from the connection. The Move Branch message is:

Message Type = 22

If the virtual channel connection specified by the Input Port, Input VPI, and Input VCI fields already exists, and the output branch specified by the Old Output Port, Old Output VPI, and Old Output VCI fields exists as a branch on that connection, the output branch specified by the New Output Port, New Output VPI, and New Output VCI fields is added to the connection and the branch specified by the Old Output Port, Old Output VPI, and Old Output VCI fields is deleted. If the Result field of the request message is "AckAll" a success response message must be sent upon successful completion of the operation. The success response message must not be sent until the Move Branch operation has been completed.

If the virtual channel connection specified by the Input Port, Input VPI, and Input VCI fields already exists, but the output branch specified by the Old Output Port, Old Output VPI, and Old Output VCI fields does not exist as a branch on that connection, a failure response must be returned with the Code field indicating, "The specified branch does not exist." The connection state of the switch must not be modified in this case.

If the virtual channel connection specified by the Input Port, Input VPI, and Input VCI fields does not exist, a failure response must be returned with the Code field indicating, "The specified connection does not exist." The connection state of the switch must not be modified in this case.

The behavior is undefined if the output virtual channel specified by the New Output Port, New Output VPI, and New Output VCI fields is already in use by any connection.

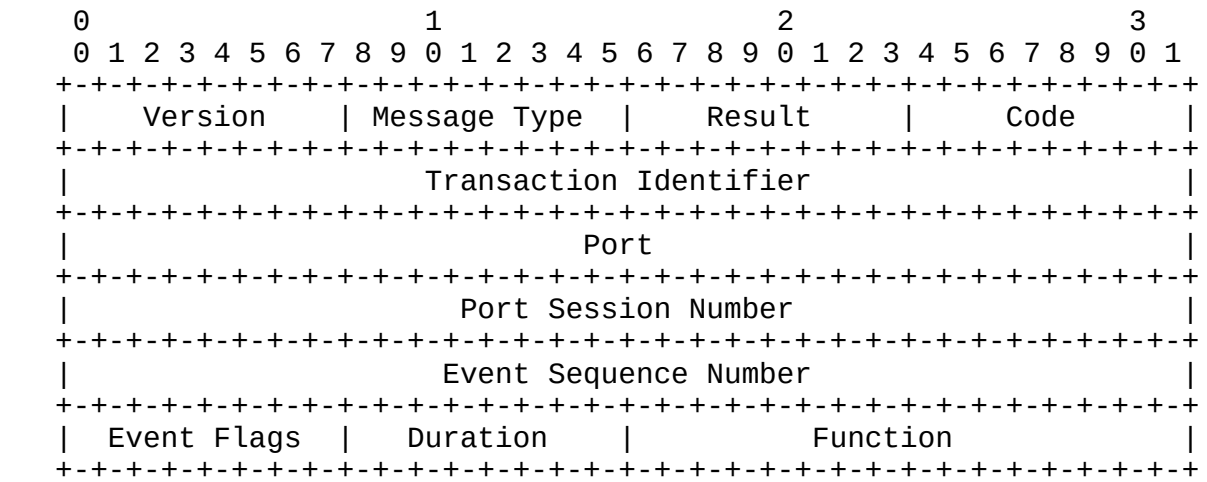
A failure response will be returned if the switch is unable to establish the specified branch or if there is an error in any of the fields of the request message. If a failure message is returned the state of the switch must not have been modified by the request message.

## 4. Port Management Message

The Port Management message allows a port to be brought into service, taken out of service, looped back, or reset. Only the Bring Up and the Reset Input Port functions change the connection state (established connections) on the input port. Only the Bring Up function changes the value of the Port Session Number. If the Result field of the request message is "AckAll" a success response message must be sent upon successful completion of the operation. The success response message must not be sent until the operation has been completed. The Port Management Message is:

Message Type = 32

The Port Management message has the following format for the request and success response messages:




Port

Gives the port number of the port to which the message applies.

Port Session Number

Gives the current port session number for the port. If the Port Session Number in the request message does not match the current port session number of the port indicated by the Port field of the request message, a failure response must be returned with, "Invalid port session number," indicated in the Code field. If the specified function requires a new Port Session Number to be generated the new Port Session Number must be given in the success response message. The Port Session Number must be generated using some form of random number.

Event Sequence Number

In the success response message gives the current value of the Event Sequence Number of the switch port indicated by the Port field. The Event Sequence Number is set to zero when the port is initialized and is incremented by one each time an asynchronous event is detected on that port that the switch would normally report via an Event message. If the Event Sequence Number in the success response differs from the Event Sequence Number of the most recent Event message received for that port, events have occurred that were not reported via an Event message. This is most likely to be due to the flow control that restricts the rate at which a switch can send Event messages for each port. In the request message this field is not used and should be set to zero by the sender and ignored by the receiver.

Event Flags

Field in the request message is used to reset the Event Flags in the switch port indicated by the Port field. Each Event Flag in a switch port corresponds to a type of Event message. When a switch port sends an Event message it sets the corresponding Event Flag on that port. The port is not permitted to send another Event message of the same type until the Event Flag has been reset. If the Function field in the request message is set to "Reset Event Flags," for each bit that is set in the Event Flags field, the corresponding Event Flag in the switch port is reset.

The Event Flags field is only used in a request message with the Function field set to "Reset Event Flags." For all other values of the Function field, the Event Flags field should be set to zero in the request message and must be ignored by the receiver. In the success response message the Event Flags field must be set to the current value of the Event Flags for the port, after the completion of the operation specified by the request message, for all values of the Function field. Setting the Event Flags field to all zeros in a "Reset Event Flags" request message allows the controller to obtain the current state of the Event Flags and the current Event Sequence Number of the port without changing the state of the Event Flags.

The correspondence between the types of Event message and the bits of the Event Flags field is as follows:

```
Port Up:          Bit 0, (most significant bit)
Port Down:        Bit 1,
Invalid VPI/VCI:  Bit 2,
New Port:         Bit 3,
Dead Port:        Bit 4.
```

Duration

Is the length of time, in seconds, that any of the loopback states remain in operation. When the duration has expired the port will automatically be returned to service. If another Port Management message is received for the same port before the duration has expired, the loopback will continue to remain in operation for the length of time specified by the Duration field in the new message. The Duration field is only used in request messages with the Function field set to Internal Loopback, External Loopback, or Bothway Loopback. In all other request messages it should be set to zero by the sender and ignored by the receiver.

Function

Specifies the action to be taken. The specified action will be taken regardless of the current status of the port (Available, Unavailable, or any Loopback state). The defined values of the Function field are:

Bring Up:
Function = 1. Bring the port into service. All connections that arrive at the specified input port must be deleted and a new Port Session Number must be selected using some form of random number. On completion of the operation all dynamically assigned VPI/VCI values for the specified input port must be unassigned, i.e. no virtual connections will be established in the VPI/VCI space that GSMP controls on this input port. The Port Status of the port afterwards will be Available.

Take Down:
Function = 2. Take the port out of service. Any cells received at this port will be discarded. No cells will be transmitted from this port. The Port Status of the port afterwards will be Unavailable. The behavior is undefined if the port over which the GSMP protocol is running is taken down.

Internal Loopback:
Function = 3. Cells arriving at the output port from the switch fabric are looped through to the input port to return to the switch fabric. All of the ATM functions of the input port above the PHY layer, e.g. header translation, are performed upon the looped back cells. The Port Status of the port afterwards will be Internal Loopback.

External Loopback:
Function = 4. Cells arriving at the input port from the external communications link are immediately looped back to the communications link at the physical layer without entering the input port. None of the ATM functions of the input port above the PHY layer are performed upon the looped back cells. The Port Status of the port afterwards will be External Loopback.

Bothway Loopback:
Function = 5. Both internal and external loopback are performed. The Port Status of the port afterwards will be Bothway Loopback.

Reset Input Port:
Function = 6. All connections that arrive at the specified input port must be deleted and the input and output port hardware re-initialized. On completion of the operation all dynamically assigned VPI/VCI values for the specified input port must be unassigned, i.e. no virtual connections will be established in the VPI/VCI space that GSMP controls on this input port. The Port Session Number is not changed by the Reset Input Port function. The Port Status of the port afterwards will be Unavailable.

Reset Event Flags:
Function = 7. For each bit that is set in the Event Flags field, the corresponding Event Flag in the switch port must be reset. The Port Status of the port is not changed by this function.

## 5. Statistics Messages

The statistics messages permit the controller to request the values of various hardware counters associated with the switch input and output ports, and virtual channels. Two classes of statistics message are defined: the VC Activity Message, and the Port and VC Statistics Messages. The VC Activity message is used to determine whether one or more specific VCs have recently been carrying traffic. The Port and VC Statistics message is used to query the various port and VC specific traffic and error counters.

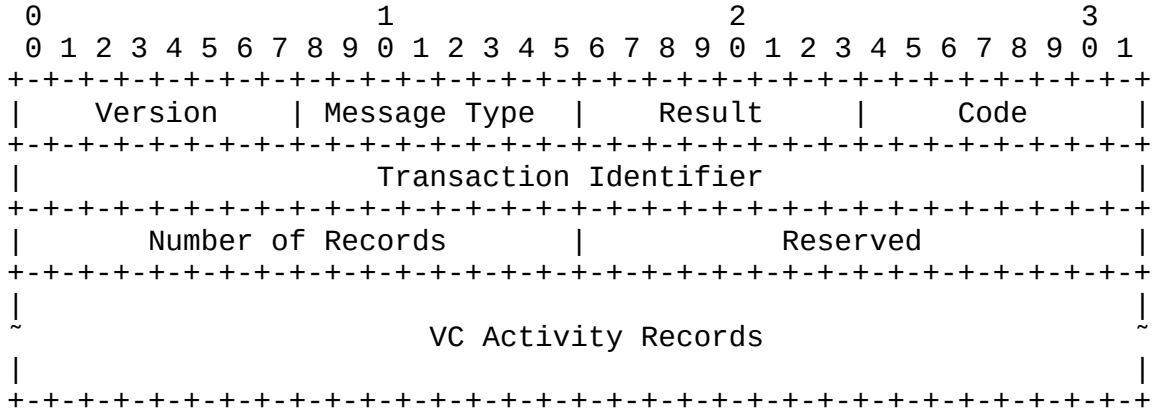
### 5.1 VC Activity Message

The VC Activity message is used to determine whether one or more specific VCs have recently been carrying traffic. The VC Activity message contains one or more VC Activity records. Each VC Activity record is used to request and return activity information concerning a single virtual connection. Each VC is specified by its input port, input VPI, and input VCI. These are specified in the Input Port, Input VPI, and Input VCI fields of each VC Activity record. Two forms of activity detection are supported. If the switch supports per VC traffic accounting the current value of the traffic counter for each specified VC must be returned. The units of traffic counted are not specified but will typically be either cells or frames. The controller must compare the traffic counts returned in the message with previous values for each of the specified VCs to determine whether each VC has been active in the intervening period. If the switch does not support per VC traffic accounting, but is capable of detecting per-VC activity by some other unspecified means, the result

may be indicated for each VC using the Flags field. The VC Activity message is:

Message Type = 48

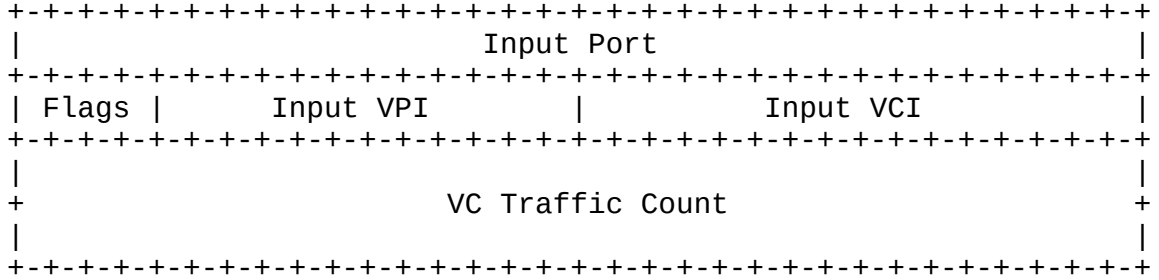
The VC Activity request and success response messages have the following format:




Number of Records
Field specifies the number of VC Activity records to follow. The maximum number of VC Activity records permitted in a single VC Activity message is 120.

Reserved
Field is not used. It is set to zero by the sender and ignored by the receiver.

Each VC Activity Record has the following format:




Input Port
Identifies the port number of the input port on which the VC of interest arrives in order to identify the VC (regardless of whether the traffic count for the VC is maintained on the input port or the output port).

Input VPI
Input VCI

Fields identify the specific virtual channel for which statistics are being requested.

Flags

In the request message this field is unused, it should be set to zero by the sender and ignored by the receiver. In the success response message bit 0 (msb) of the Flags field is used to indicate an invalid VC Activity record. This bit must be zero if any of the fields in this VC Activity record are invalid, if the input port specified by the Input Port field does not exist, or if the specified connection does not exist. If this bit is zero in a success response message bits 1 and 2 of the Flags field and the VC Traffic Count field are undefined. If bit 0 of the flags field is set, the VC Activity record is valid, and bits 1 and 2 of the Flags field in the VC Activity record are used as follows:

Bit 1 of the Flags field: if set, indicates that the value in bit 2 of the Flags field is valid; if zero, indicates that the value in the VC Traffic Count field is valid.

If bit 1 of the Flags field is set, bit 2 of the Flags field, if set, indicates that there has been some activity on this virtual channel since the last VC Activity message for this virtual channel.

If bit 1 of the Flags field is set, bit 2 of the Flags field, if zero, indicates that there has been no activity on this virtual channel since the last VC Activity message for this virtual channel.

Bit 3 of the Flags field is not used, it should be set to zero by the sender and ignored by the receiver.

VC Traffic Count

Field is unused in the request message, it should be set to zero by the sender and ignored by the receiver. In the success response message, if the switch supports per-VC traffic counting, the VC Traffic Count field must be set to the value of a free running, VC specific, 64 bit traffic counter counting traffic flowing across the specified virtual channel. The value of the traffic counter is not modified by reading it. If per-VC traffic counting is supported, the switch must report the VC Activity result

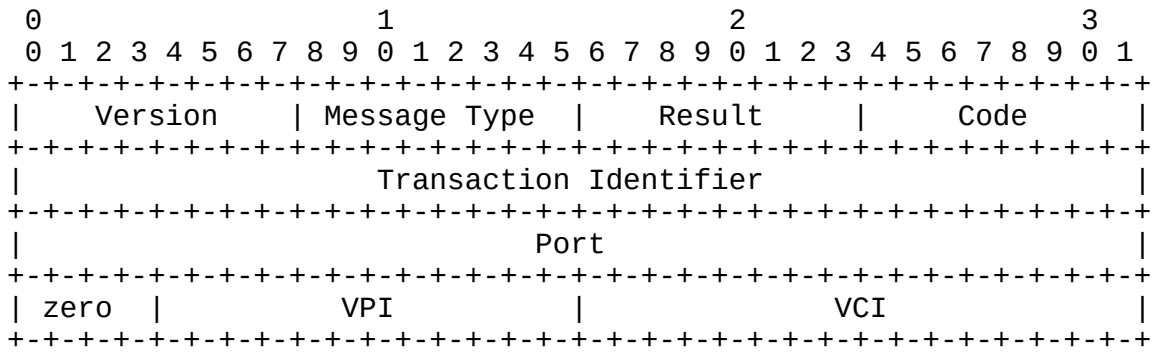
using the traffic count rather than using bit 2 of the Flags field.

The format of the failure response is the same as the request message with the Number of Records field set to zero and no VC Activity records returned in the message. If the switch is incapable of detecting per-VC activity, a failure response must be returned indicating, "The specified request is not implemented on this switch."

## 5.2 Port and VC Statistics Messages

The Port and VC Statistics messages are used to query the various port and VC specific traffic and error counters.

The Port and VC Statistics request messages have the following format:



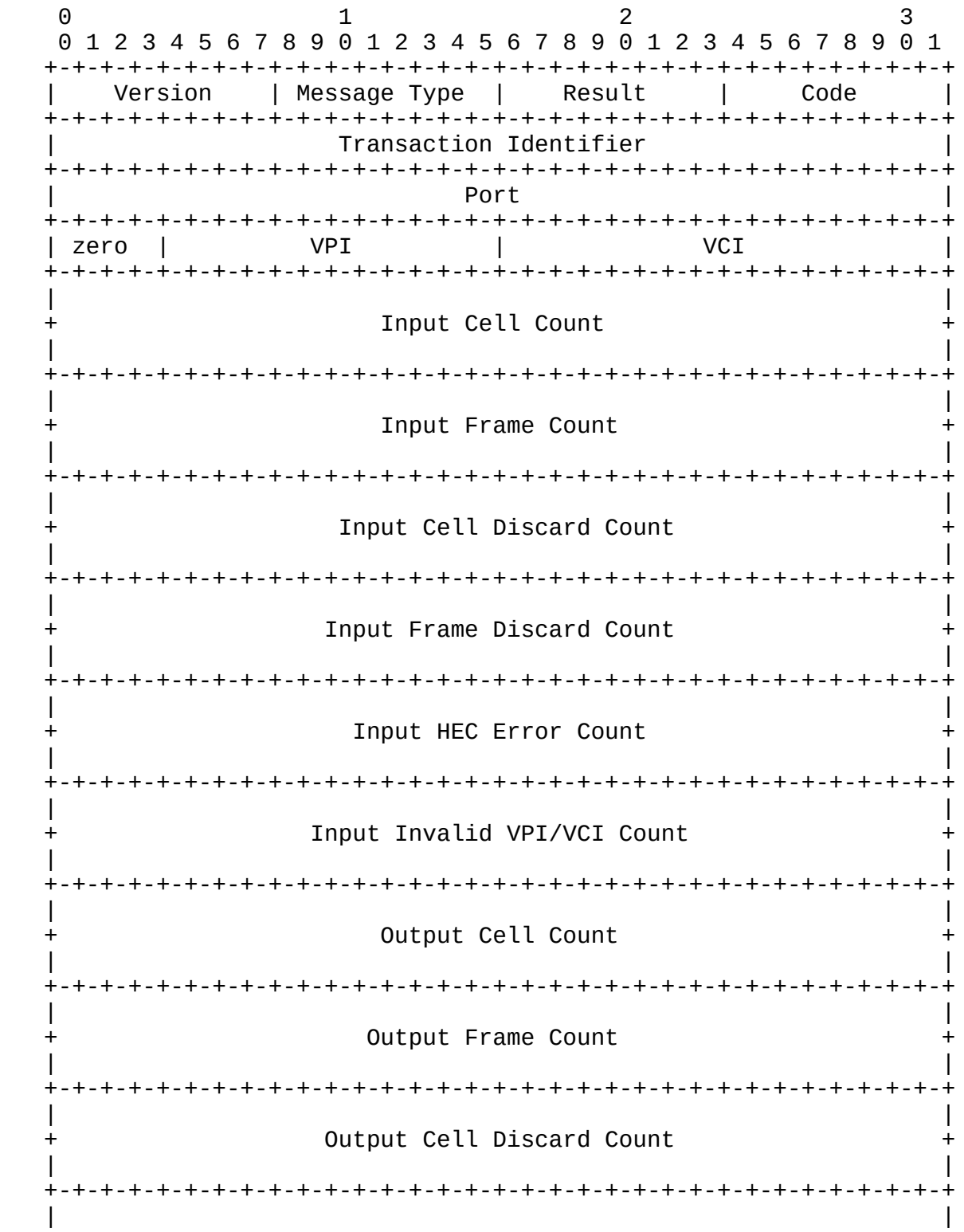

Port

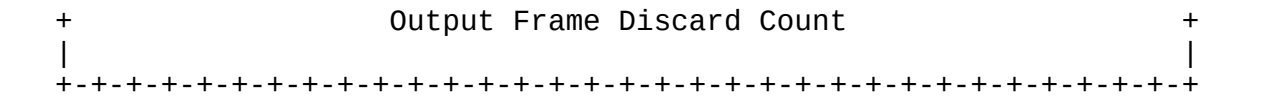
Identifies the port number of the port for which statistics are being requested.

VPI
VCI

Fields identify the specific virtual channel for which statistics are being requested. For requests that do not require a virtual channel to be specified these fields should be set to zero in the request and ignored by the receiver.

The success response messages for the port and VC statistics group have the following format:


0 1 2 3
0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
Version
Message Type
Result
Code
Transaction Identifier
Port
zero
VPI
VCI
Input Cell Count
Input Frame Count
Input Cell Discard Count
Input Frame Discard Count
Input HEC Error Count
Input Invalid VPI/VCI Count
Output Cell Count
Output Frame Count
Output Cell Discard Count




Port
VPI/VCI
: Fields are the same as those of the request message.

Input Cell Count
Output Cell Count
: Each gives the value of a free running 64 bit counter counting cells arriving at the input or departing from the output respectively. In response to a Port Statistics message the count will be on a per port basis and in response to a VC Statistics message the count will be on a per VC basis.

Input Frame Count
Output Frame Count
: Each gives the value of a free running 64 bit counter counting frames (packets) arriving at the input or departing from the output respectively. In response to a Port Statistics message the count will be on a per port basis and in response to a VC Statistics message the count will be on a per VC basis.

Input Cell Discard Count
Output Cell Discard Count
: Each gives the value of a free running 64 bit counter counting cells discarded due to queue overflow on an input port or on an output port respectively. In response to a Port Statistics message the count will be on a per port basis and in response to a VC Statistics message the count will be on a per VC basis.

Input Frame Discard Count
Output Frame Discard Count
: Each gives the value of a free running 64 bit counter counting frames discarded due to queue overflow on an input port or on an output port respectively. In response to a Port Statistics message the count will be on a per port basis and in response to a VC Statistics message the count will be on a per VC basis.

HEC Error Count
: Gives the value of a free running 64 bit counter counting cells discarded due to header checksum errors on arrival at an input port.

Invalid VPI/VCI Count
: Gives the value of a free running 64 bit counter counting cells discarded because their VPI/VCI is invalid on arrival at an input port. An incoming VPI/VCI is invalid if no connection is currently established having that value of VPI/VCI.

### 5.2.1 Port Statistics Message

The Port Statistics message requests the statistics for the switch port specified in the Port field. The contents of the VPI/VCI field in the Port Statistics request message are ignored. All of the count fields in the success response message refer to per-port counts regardless of the virtual channels to which the cells belong. Any of the count fields in the success response message not supported by the port will be set to zero. The Port Statistics message is:

Message Type = 49

### 5.2.2 VC Statistics Message

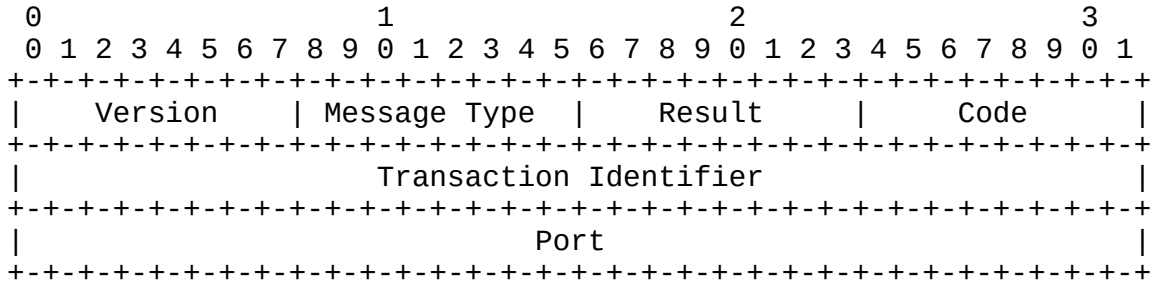
The VC Statistics message requests the statistics for the virtual channel specified in the VPI/VCI field that arrives on the switch input port specified in the Port field. All of the count fields in the success response message refer only to the specified virtual channel. The HEC Error Count and Invalid VPI/VCI Count fields are not VC specific and are set to zero. Any of the other count fields not supported on a per virtual channel basis will be set to zero in the success response message. The VC Statistics message is:

Message Type = 50

## 6. Configuration

The configuration messages permit the controller to discover the capabilities of the switch. Three configuration request messages have been defined: Switch, Port, and All Ports.

All configuration request messages have the following format:




Port
Identifies the port number for which configuration information is being requested. If the Port field is not required by the message it is set to zero by the sender and ignored by the receiver.

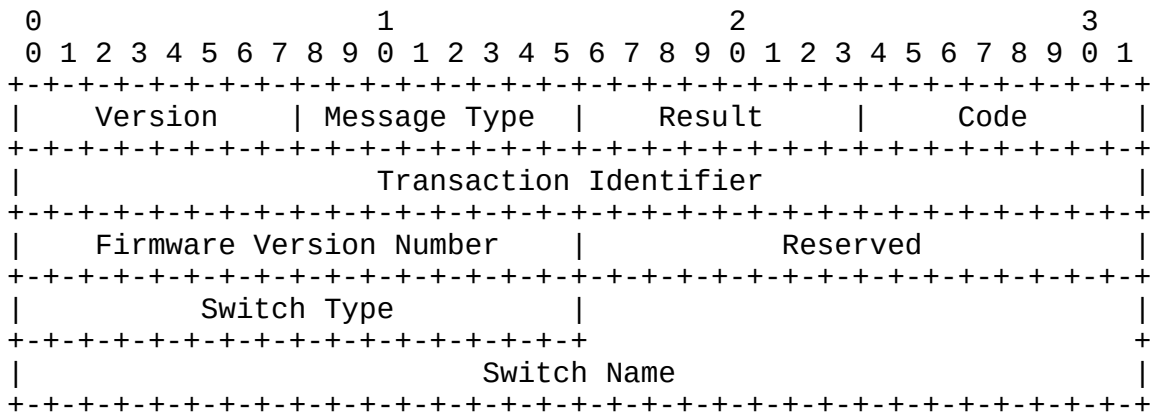
## 6.1 Switch Configuration Message

The Switch Configuration message requests the global (non port-specific) configuration for the switch. The Switch Configuration message is:

Message Type = 64

The Port field is not used in the request message and is set to zero.

The Switch Configuration success response message has the following format:




Firmware Version Number
The version number of the switch control firmware installed.

Reserved
: Field is not used. It is set to zero by the sender and ignored by the receiver.

Switch Type
: A 16 bit field allocated by the manufacturer of the switch. (For these purposes the manufacturer of the switch is assumed to be the organization identified by the OUI in the Switch Name field.) The Switch Type identifies the product. When the Switch Type is combined with the OUI from the Switch Name the product is uniquely identified. Network Management may use this identification to obtain product related information from a database.

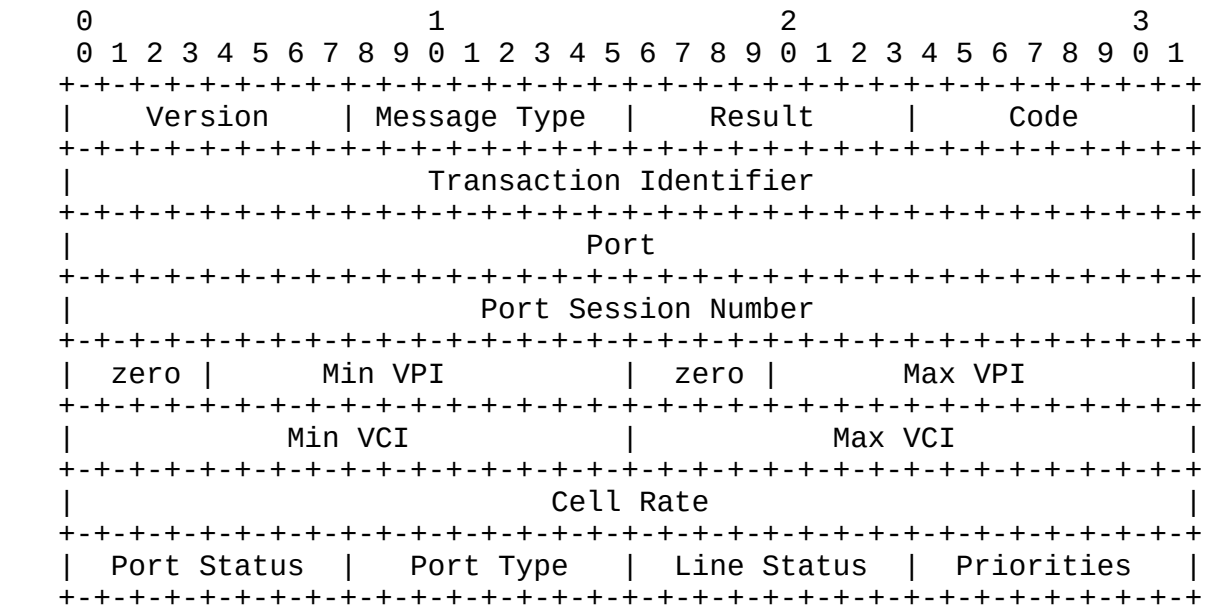
Switch Name
: A 48 bit quantity that is unique within the operational context of the device. A 48 bit IEEE 802 MAC address, if available, may be used as the Switch Name. The most significant 24 bits of the Switch Name must be an Organizationally Unique Identifier (OUI) that identifies the manufacturer of the switch.

## 6.2 Port Configuration Message

The Port Configuration message requests the switch for the configuration information of a single switch port. The Port field in the request message specifies the port for which the configuration is requested. The Port Configuration message is:

Message Type = 65.

The Port Configuration success response message has the following format:




Port

The switch port to which the configuration information refers. Configuration information relating to both the input and the output sides of the switch port is given. Port numbers are 32 bits wide and allocated by the switch. The switch may choose to structure the 32 bits into sub fields that have meaning to the physical structure of the switch hardware (e.g. shelf, slot, interface).

Port Session Number

The current Port Session Number for the specified port. Each switch port maintains a Port Session Number assigned by the switch. The Port Session Number of a port remains unchanged while the port is continuously in the Available state. When a port returns to the Available state after it has been Unavailable, or after a power cycle, its Port Session Number must be changed, preferably using some form of random number.

Min VPI

The minimum value of dynamically assigned incoming VPI that the connection table on the input port can support and may be controlled by GSMP.

Max VPI

The maximum value of dynamically assigned incoming VPI that the connection table on the input port can support and may be controlled by GSMP. It is assumed that the input port

can handle all values of VPI within the range Min VPI to Max VPI inclusive and that GSMP may control all values within this range. If the switch does not support virtual paths it is acceptable for both Min VPI and Max VPI to specify the same value, most likely zero.

Min VCI
: The minimum value of dynamically assigned incoming VCI that the connection table on the input port can support and may be controlled by GSMP.

Max VCI
: The maximum value of dynamically assigned incoming VCI that the connection table on the input port can support and may be controlled by GSMP. It is assumed that the input port can handle all values of VCI within the range Min VCI to Max VCI inclusive for each of the virtual paths in the range Min VPI to Max VPI inclusive and that GSMP may control all values within this range.

Cell Rate
: A measure of the bandwidth of the port. It is the rate of cells arriving at or departing from the port in cells/s. It is assumed that both input port and output port have the same cell rate.

Port Status
: Gives the administrative state of the port. The defined values of the Port Status field are:

  Available:
  : Port Status = 1. The port is available to both send and receive cells. When a port changes to the Available state from any other administrative state, all dynamically assigned virtual connections must be cleared and a new Port Session Number must be generated.

  Unavailable:
  : Port Status = 2. The port has intentionally been taken out of service. No cells will be transmitted from this port. No cells will be received by this port.

  Internal Loopback:
  : Port Status = 3. The port has intentionally been taken out of service and is in internal loopback: cells arriving at the output port from the switch fabric are looped through to the input port to return to the

switch fabric. All of the ATM functions of the input port above the PHY layer, e.g. header translation, are performed upon the looped back cells.

External Loopback:
Port Status = 4. The port has intentionally been taken out of service and is in external loopback: cells arriving at the input port from the external communications link are immediately looped back to the communications link at the physical layer without entering the input port. None of the ATM functions of the input port above the PHY layer are performed upon the looped back cells.

Bothway Loopback:
Port Status = 5. The port has intentionally been taken out of service and is in both internal and external loopback.

Port Type
The type of physical transmission interface for this port. The values for this field are given by the IANAifTYPE object from the MIB defined for the IANAifTYPE-MIB specified in RFC 1573 [rfc1573]. Example values are: SONET or SDH (39), DS-3 (30).

Line Status
The status of the physical transmission medium connected to the port. The defined values of the Line Status field are:

Up:
Line Status = 1. The line is able to both send and receive cells. When the Line Status changes to Up from either the Down or Test states, a new Port Session Number must be generated.

Down:
Line Status = 2. The line is unable either to send or receive cells or both.

Test:
Line Status = 3. The port or line is in a test mode, for example, power-on test.

Priorities
The number of different priorities that this output port can assign to virtual channel connections. Zero is invalid in this field. If an output port is able to support "Q"

priorities, the highest priority is numbered zero and the lowest priority is numbered "Q-1". The ability to offer different qualities of service to different connections based upon their priority is assumed to be a property of the output port of the switch. It may be assumed that for virtual channel connections that share the same output port, an ATM cell on a connection with a higher priority is much more likely to exit the switch before an ATM cell on a connection with a lower priority if they are both in the switch at the same time.

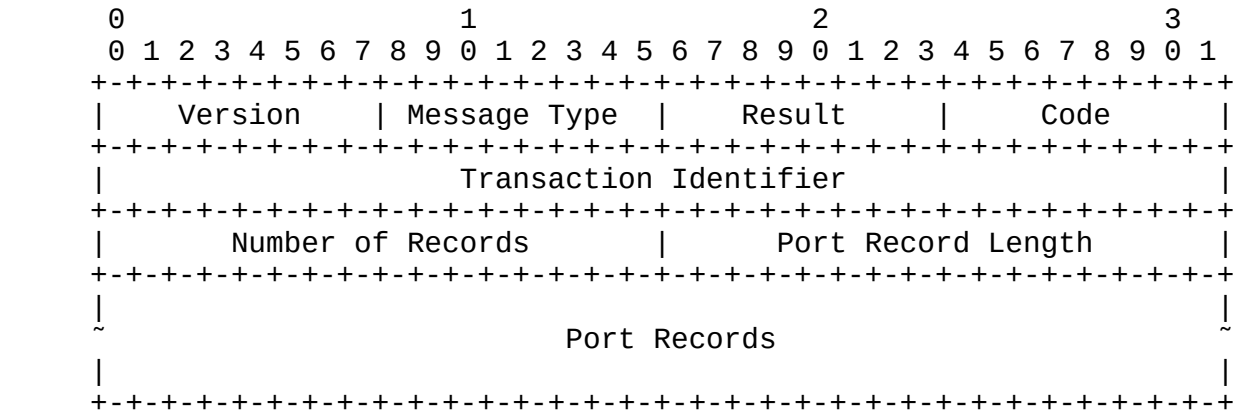
## 6.3 All Ports Configuration Message

The All Ports Configuration message requests the switch for the configuration information of all of its ports. The All Ports Configuration message is:

Message Type = 66

The Port field is not used in the request message and is set to zero.

The All Ports Configuration success response message has the following format:

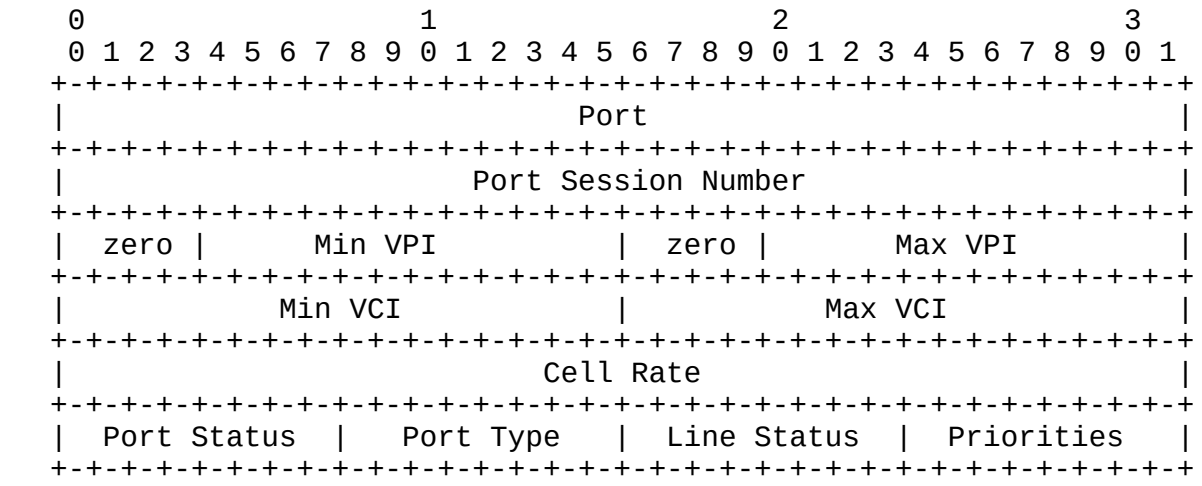



Number of Records
: Field gives the number of Port Records to follow in the message. The maximum number of port records allowed in a single All Ports Configuration success response is 64. If a switch has more than 64 ports it must send them in multiple success response messages.

Port Record Length
: Field gives the length of each port record in bytes. This is currently 24 but the Port Record Length field allows for

the future definition of further fields at the end of the port record while preserving compatibility with earlier versions of the protocol.

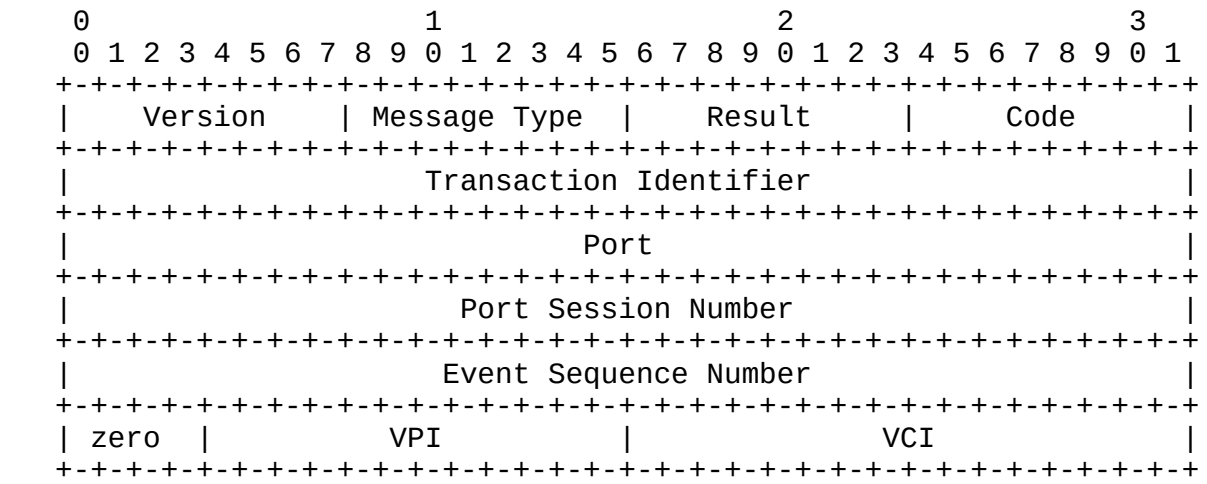
Port Records follow in the remainder of the message. Each port record has the following format:




The definition of the fields in the port record is exactly the same as that of the Port Configuration message.

## 7. Event Messages

Event messages allow the switch to inform the controller of certain asynchronous events. Event messages are not acknowledged. The Result field and the Code field in the message header are not used and should be set to zero. Event messages are not sent during initialization. Event messages have the following format:




Port
: Field gives the switch port to which the event message refers.

Port Session Number
: The current Port Session Number for the specified port.

Event Sequence Number
: The current value of the Event Sequence Number for the specified port. The Event Sequence Number is set to zero when the port is initialized and is incremented by one each time an asynchronous event is detected on that port that the switch would normally report via an Event message. The Event Sequence Number must be incremented each time an event occurs even if the switch is prevented from sending an Event message due to the action of the flow control.

VPI/VCI
: Field gives the VPI/VCI to which the event message refers. If this field is not required by the event message it is set to zero.

Each switch port must maintain an Event Sequence Number and a set of Event Flags, one Event Flag for each type of Event message. When a switch port sends an Event message it must set the Event Flag on that port corresponding to the type of the event. The port is not permitted to send another Event message of the same type until the Event Flag has been reset. Event Flags are reset by the "Reset Event Flags" function of the Port Management message. This is a simple flow control preventing the switch from flooding the controller with event messages. The Event Sequence Number of the port must be incremented every time an event is detected on that port even if the port is

prevented from reporting the event due to the action of the flow control. This allows the controller to detect that it has not been informed of some events that have occurred on the port due to the action of the flow control.

### 7.1 Port Up Message

The Port Up message informs the controller that the Line Status of a port has changed from either the Down or Test state to the Up state. When the Line Status of a switch port changes to the Up state from either the Down or Test state a new Port Session Number must be generated, preferably using some form of random number. The new Port Session Number is given in the Port Session Number field. The VPI/VCI field is not used and is set to zero. The Port Up message is:

Message Type = 80

### 7.2 Port Down Message

The Port Down message informs the controller that the Line Status of a port has changed from the Up state to the Down state. This message will be sent to report link failure if the switch is capable of detecting link failure. The port session number that was valid before the port went down is reported in the Port Session Number field. The VPI/VCI field is not used and is set to zero. The Port Down message is:

Message Type = 81

### 7.3 Invalid VPI/VCI Message

The Invalid VPI/VCI message is sent to inform the controller that one or more cells have arrived at an input port with a VPI/ VCI that is currently not allocated to an assigned connection. The input port is indicated in the Port field, and the VPI/VCI in the VPI/VCI field. The Invalid VPI/VCI message is:

Message Type = 82

### 7.4 New Port Message

The New Port message informs the controller that a new port has been added to the switch. The port number of the new port is given in the Port field. A new Port Session Number must be assigned, preferably using some form of random number. The new Port Session Number is given in the Port Session Number field. The state of the new port is undefined so the VPI/VCI field is not used and is set to zero. The New Port message is:

Message Type = 83

### 7.5 Dead Port Message

The Dead Port message informs the controller that a port has been removed from the switch. The port number of the port is given in the Port field. The Port Session Number that was valid before the port was removed is reported in the Port Session Number field. The VPI/VCI fields are not used and are set to zero. The Dead Port message is:

Message Type = 84

## 8. Adjacency Protocol

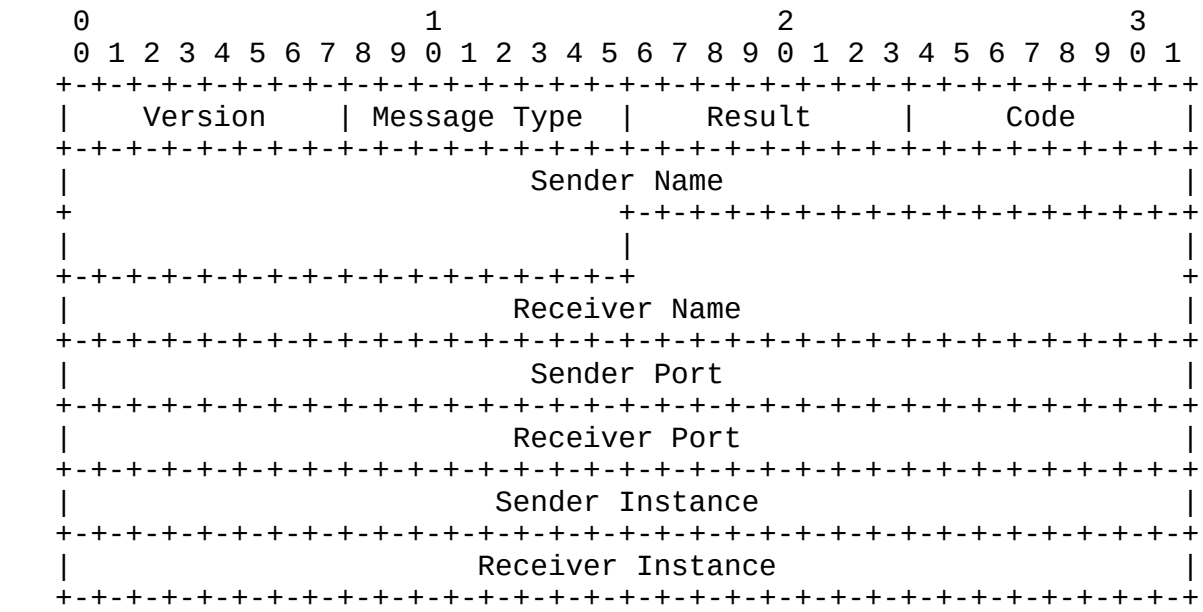
The adjacency protocol is used to synchronize state across the link, to discover the identity of the entity at the other end of a link, and to detect when it changes. No GSMP messages other than those of the adjacency protocol may be sent across the link until the adjacency protocol has achieved synchronization.

### 8.1 Packet Format

The adjacency protocol is:

Message Type = 10

All GSMP messages belonging to the adjacency protocol have the following structure:




Version

The GSMP protocol version number, currently Version = 1. It should be set by the sender of the message to the GSMP protocol version that the sender is currently running.

Result

Field is not used in the adjacency protocol. It should be set to zero by the sender and ignored by the receiver.

Code

Field specifies the function of the message. Four Codes are defined for the adjacency protocol:

```
SYN:     Code = 1
SYNACK:  Code = 2
ACK:     Code = 3
RSTACK:  Code = 4.
```

Sender Name

For the SYN, SYNACK, and ACK messages, is the name of the entity sending the message. The Sender Name is a 48 bit quantity that is unique within the operational context of the device. A 48 bit IEEE 802 MAC address, if available, may be used for the Sender Name. For the RSTACK message, the Sender Name field is set to the value of the Receiver Name field from the incoming message that caused the RSTACK message to be generated.

Receiver Name
: For the SYN, SYNACK, and ACK messages, is the name of the entity that the sender of the message believes is at the far end of the link. If the sender of the message does not know the name of the entity at the far end of the link, this field should be set to zero. For the RSTACK message, the Receiver Name field is set to the value of the Sender Name field from the incoming message that caused the RSTACK message to be generated.

Sender Port
: For the SYN, SYNACK, and ACK messages, is the local port number of the link across which the message is being sent. Port numbers are locally assigned 32 bit values. For the RSTACK message, the Sender Port field is set to the value of the Receiver Port field from the incoming message that caused the RSTACK message to be generated.

Receiver Port
: For the SYN, SYNACK, and ACK messages, is what the sender believes is the local port number for the link, allocated by the entity at the far end of the link. If the sender of the message does not know the port number at the far end of the link, this field should be set to zero. For the RSTACK message, the Receiver Port field is set to the value of the Sender Port field from the incoming message that caused the RSTACK message to be generated.

Sender Instance
: For the SYN, SYNACK, and ACK messages, is the sender’s instance number for the link. It is used to detect when the link comes back up after going down or when the identity of the entity at the other end of the link changes. The instance number is a 32 bit number that is guaranteed to be unique within the recent past and to change when the link or node comes back up after going down. Zero is not a valid instance number. For the RSTACK message, the Sender Instance field is set to the value of the Receiver Instance field from the incoming message that caused the RSTACK message to be generated.

Receiver Instance
: For the SYN, SYNACK, and ACK messages, is what the sender believes is the current instance number for the link, allocated by the entity at the far end of the link. If the sender of the message does not know the current instance number at the far end of the link, this field should be set to zero. For the RSTACK message, the Receiver Instance

field is set to the value of the Sender Instance field from the incoming message that caused the RSTACK message to be generated.

## 8.2 Procedure

The adjacency protocol is described by the rules and state tables given in this section.

The rules and state tables use the following operations:

- The "Update Peer Verifier" operation is defined as storing the values of the Sender Instance, Sender Port, and Sender Name fields from a SYN or SYNACK message received from the entity at the far end of the link.

- The procedure "Reset the link" is defined as:

    1. Generate a new instance number for the link
    2. Delete the peer verifier (set to zero the values of Sender Instance, Sender Port, and Sender Name previously stored by the Update Peer Verifier operation)
    3. Send a SYN message
    4. Enter the SYNSENT state

- The state tables use the following Boolean terms and operators:

    A The Sender Instance in the incoming message matches the value stored from a previous message by the "Update Peer Verifier" operation.

    B The Sender Instance, Sender Port, and Sender Name fields in the incoming message match the values stored from a previous message by the "Update Peer Verifier" operation.

    C The Receiver Instance, Receiver Port, and Receiver Name fields in the incoming message match the values of the Sender Instance, Sender Port, and Sender Name currently sent in outgoing SYN, SYNACK, and ACK messages.

    "&&" Represents the logical AND operation

    "||" Represents the logical OR operation

    "!" Represents the logical negation (NOT) operation.

- A timer is required for the periodic generation of SYN, SYNACK, and ACK messages. The period of the timer is unspecified but a value of one second is suggested.

  There are two independent events: the timer expires, and a packet arrives. The processing rules for these events are:

```
Timer Expires:   Reset Timer
                 If state = SYNSENT Send SYN
                 If state = SYNRCVD Send SYNACK
                 If state = ESTAB   Send ACK

Packet Arrives:  If incoming message is an RSTACK
                    If A && C && !SYNSENT
                       Reset the link
                    Else Discard the message
                 Else the following State Tables.
```

- State synchronization across a link is considered to be achieved when the protocol reaches the ESTAB state.

State Tables

State: SYNSENT

| Condition | Action | New State |
|---|---|---|
| SYNACK && C | Update Peer Verifier; Send ACK | ESTAB |
| SYNACK && !C | Send RSTACK | SYNSENT |
| SYN | Update Peer Verifier; Send SYNACK | SYNRCVD |
| ACK | Send RSTACK | SYNSENT |

State: SYNRCVD

| Condition | Action | New State |
|---|---|---|
| SYNACK && C | Update Peer Verifier; Send ACK | ESTAB |
| SYNACK && !C | Send RSTACK | SYNRCVD |
| SYN | Update Peer Verifier; Send SYNACK | SYNRCVD |
| ACK && B && C | Send ACK | ESTAB |
| ACK && !(B && C) | Send RSTACK | SYNRCVD |

State: ESTAB

| Condition | Action | New State |
|---|---|---|
| SYN \|\| SYNACK | Send ACK (note 1) | ESTAB |
| ACK && B && C | Send ACK (note 1) | ESTAB |
| ACK && !(B && C) | Send RSTACK | ESTAB |

Note 1: No more than one ACK should be sent within any time period of length defined by the timer.

## 9. Failure Response Messages

A failure response message is formed by returning the request message that caused the failure with the Result field in the header indicating failure (Result = 4) and the Code field giving the failure code. The failure code specifies the reason for the switch being unable to satisfy the request message. A failure code of 16 is used for a failure that is specific to the particular request message and its meaning is defined within the text describing that message. The following failure codes are defined:

1: Unspecified reason not covered by other failure codes.
2: Invalid request message.
3: The specified request is not implemented on this switch.
4: Invalid port session number.
5: One or more of the specified ports does not exist.

6: One or more of the specified ports is down.
7: One or more of the specified VPIs or VCIs is out of range on one or more of the requested ports.
8: The specified connection does not exist.
9: The specified branch does not exist.
10: A branch belonging to the specified multicast connection is already established on the specified output port and the switch cannot support more than a single branch of any multicast connection on the same output port.
11: The limit on the maximum number of multicast connections that the switch can support has been reached.
12: The limit on the maximum number of branches that the specified multicast connection can support has been reached.
13: Unable to assign the requested VPI/VCI value to the requested branch on the specified multicast connection.
14: General problem related to the manner in which multicast is supported by the switch.
15: Out of resources (e.g. memory exhausted, etc.).
16: Failure specific to the particular message type.

## REFERENCES

[I.361] "B-ISDN ATM Layer Specification," International Telecommunication Union, ITU-T Recommendation I.361, Mar. 1993.

[I.363] "B-ISDN ATM Adaptation Layer (AAL) Specification," International Telecommunication Union, ITU-T Recommendation I.363, Mar. 1993.

[rfc1700] "Assigned Numbers," STD 2, RFC 1700, October 1994.

[rfc1573] "Evolution of the Interfaces Group of MIB-II," RFC 1573, January 1994.

## SECURITY CONSIDERATIONS

Security issues are not discussed in this document.

## AUTHORS' ADDRESSES

Peter Newman
Ipsilon Networks, Inc.
Phone: +1 (415) 846-4603
Email: pn@ipsilon.com

W. L. Edwards, Chief Scientist
Sprint
Phone: +1 (913) 534 5334
Email: texas@sprintcorp.com

Robert M. Hinden
Ipsilon Networks, Inc.
Phone: +1 (415) 846-4604
Email: hinden@ipsilon.com

Eric Hoffman
Ipsilon Networks, Inc.
Phone: +1 (415) 846-4610
Email: hoffman@ipsilon.com

Fong Ching Liaw
Ipsilon Networks, Inc.
Phone: +1 (415) 846-4607
Email: fong@ipsilon.com

Tom Lyon
Ipsilon Networks, Inc.
Phone: +1 (415) 846-4601
Email: pugs@ipsilon.com

Greg Minshall
Ipsilon Networks, Inc.
Phone: +1 (415) 846-4605
Email: minshall@ipsilon.com

Ipsilon Networks, Inc. is located at:

2191 East Bayshore Road
Suite 100
Palo Alto, CA 94303
USA

Sprint is located at:

Sprint
Sprint Technology Services - Long Distance Division
9300 Metcalf Avenue
Mailstop KSOPKB0802
Overland Park, KS 66212-6333
USA