

```

/*
 * Protocol Header 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   |   Type   |   Message Length   |
 *      +-----+-----+-----+-----+-----+-----+-----+-----+
 *      |                                     Transaction ID                                     |
 *      +-----+-----+-----+-----+-----+-----+-----+-----+
 *
 * Version
 *     Indicates version of OpenFlow protocol.
 *
 * Type
 *     Indicates type of OpenFlow protocol message.
 *     0 Hello
 *     1 Error
 *     2 Echo Request
 *     3 Echo Reply
 *     4 Vendor
 *     5 Features Request
 *     6 Features Reply
 *     7 Get Config Request
 *     8 Get Config Reply
 *     9 Set Config
 *    10 Packet Input Notification
 *    11 Flow Removed Notification
 *    12 Port Status Notification
 *    13 Packet Output
 *    14 Flow Modification
 *    15 Port Modification
 *    16 Stats Request
 *    17 Stats Reply
 *    18 Barrier Request
 *    19 Barrier Reply
 *
 * Message Length
 *     Length of total message (header + payloads), in octets.
 *
 * Transaction ID
 *     Transaction ID used to control transaction of packets and matching
 *     of requests and responses. Transaction ID associated with this
packet.
 *     Reply messages use the same ID as was in the request to facilitate
 *     pairing.

```

```

*/

/*
* Protocol Payload Format - Hello
*
*      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
*      +-----+-----+-----+-----+-----+-----+-----+-----+
*      | <Arbitrary Data> ...
*      +-----+-----+-----+-----+
*
*      Arbitrary Data
*      TBD (but must be ignored by receiver)
*/

/*
* Protocol Payload Format - Error
*
*      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
*      +-----+-----+-----+-----+-----+-----+-----+-----+
*      |              Type              |              Code              |
*      +-----+-----+-----+-----+-----+-----+-----+-----+
*      | <Data> ...
*      +-----+-----+-----+-----+
*
*      Type
*      TBD
*      0 Hello protocol failed.
*      1 Request was not understood.
*      2 Error in action description.
*      3 Problem modifying flow entry.
*
*      Code
*      TBD
*      Type 0: 0 No compatible version.
*      Type 0: 1 Permissions error.
*      Type 1: 0 ofp_header.version not supported.
*      Type 1: 1 ofp_header.type not supported.
*      Type 1: 2 ofp_stats_request.type not supported.
*      Type 1: 3 Vendor not supported.
*      Type 1: 4 Vendor subtype not supported.
*      Type 1: 5 Permissions error.
*      Type 2: 0 Unknown action type.
*      Type 2: 1 Length problem in actions.
*      Type 2: 2 Unknown vendor id specified.

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*   Type 2: 3   Unknown action type for vendor ID.
*   Type 2: 4   Problem validating output action.
*   Type 2: 5   Bad action argument.
*   Type 2: 6   Permissions error.
*   Type 3: 0   Flow not added because of full tables.
*   Type 3: 1   Attempted to add overlapping flow with CHECK_OVERLAP flag
set.
*   Type 3: 2   Permissions error.
*   Type 3: 3   Flow not added because of non-zero idle/hard.
*
*   Data
*   Interpreted based on the type and code.
*/

```

```

/*
*   Protocol Payload Format - Echo Request
*                               Echo Reply
*
*       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
*   +-----+-----+-----+-----+-----+-----+-----+-----+
*   | <Arbitrary Data> ...
*   +-----+-----+-----+-----+-----+
*
*   Arbitrary Data
*   TBD (but must be replied to sender)
*/

```

```

/*
*   Protocol Payload Format - Vendor
*
*       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
*   +-----+-----+-----+-----+-----+-----+-----+-----+
*   |                               Vendor ID                               |
*   +-----+-----+-----+-----+-----+-----+-----+-----+
*   | <Vendor Defined Arbitrary Data> ...
*   +-----+-----+-----+-----+-----+-----+-----+-----+
*
*   Vendor ID
*   TBD
*
*   Vendor Defined Arbitrary Data
*   TBD
*/

```



```

* Switch Capability Flags
*   See Payload Element <Switch Capability Flags>
*

```

```

* Action Capability Flags
*   TBD
*   0x00000001  Output to switch port
*   0x00000002  Set 802.1Q VID
*   0x00000004  Set 802.1Q PCP
*   0x00000008  Strip 802.1Q tag
*   0x00000010  Set Ethernet source address
*   0x00000020  Set Ethernet destination address
*   0x00000040  Set IPv4 source address
*   0x00000080  Set IPv4 destination address
*   0x00000100  Set IPv4 DSCP
*   0x00000200  Set TCP/UDP source port
*   0x00000400  Set TCP/UDP destination port
*

```

```

* Port Descriptors
*   See Payload Element <Port Descriptor>
*/

```

```

/*
* Protocol Payload Format - Get Config Request
*
*   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
*   +-----+-----+-----+-----+-----+-----+-----+-----+
*   |
*   +---+
*
* There is no payload for Get Config Request
*/

```

```

/*
* Protocol Payload Format - Get Config Reply
*                               Set Config
*
*   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
*   +-----+-----+-----+-----+-----+-----+-----+-----+
*   | <Switch Configuration Flags> |           Miss Send Length           |
*   +-----+-----+-----+-----+-----+-----+-----+-----+
*
* Switch Configuration Flags
*   See Payload Element <Switch Configuration Flags>
*

```

```

* Miss Send Length
*   Indicates maximum octets of new flow should send to the controller.
*   Default value is 128.
*/

```

```

/*
* Protocol Payload Format - Packet Input Notification
*
*   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
*   +-----+-----+-----+-----+-----+-----+-----+-----+
*   |                                     Packet Buffer ID                                     |
*   +-----+-----+-----+-----+-----+-----+-----+-----+
*   |   Ethernet Frame Length   |   Ingresss <Port Number>   |
*   +-----+-----+-----+-----+-----+-----+-----+-----+
*   |   Reason   |   Reserved   |                               |
*   +-----+-----+-----+-----+-----+-----+-----+-----+
*   |                                     Ethenret Frame                                     +
*   |                                     |
*   ~                                     ~
*   |                                     |
*
* Packet Buffer ID
*   TBD
*
* Ethernet Frame Length
*   TBD
*
* Ingress Port Number
*   See Payload Element <Port Number>
*
* Reason
*   TBD
*   0 No matching flow.
*   1 Action explicitly output to controller.
*
* Reserved
*   Must be zero.
*
* Ethernet Frame
*   TBD
*/

```

```

/*
* Protocol Payload Format - Flow Removed Notification
*
*   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
*  +-----+
*  |
*  ~                               <Flow Match Descriptor>                               ~
*  |
*  +-----+
*  |          Priority          |          Reason          |          Reserved          |
*  +-----+
*  |          Lifetime Duration          |
*  +-----+
*  |          Soft Lifetime          |
*  +-----+
*  |                               Reserved                               +
*  |
*  +-----+
*  |
*  +          Number of Packets Transferred          |
*  |
*  +-----+
*  |
*  +          Number of Octets Transferred          |
*  |
*  +-----+

```

```

* Flow Match Descriptor
*   See Payload Element <Flow Match Descriptor>

```

```

* Priority
*   TBD
*   Default value is 32768.

```

```

* Reason
*   TBD
*   0 Flow idle time exceeded soft lifetime.
*   1 Time exceeded hard lifetime.
*   2 Evicted by a DELETE flow mod.

```

```

* Reserved
*   Must be zero.

```

```

* Lifetime Duration
*   TBD

```

```

* Soft Lifetime
*   TBD

```

```

* Reserved

```

```

*      Must be zero.
*
*      Number of Packets Transferred
*      TBD
*
*      Number of Octets Transferred
*      TBD
*/

```

```

/*
*      Protocol Payload Format - Port Status Notification
*
*      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
*      +-----+-----+-----+-----+-----+-----+-----+-----+
*      |          Reason          |                                     |
*      +-----+-----+-----+-----+-----+-----+-----+-----+
*      |                                     Reserved                                     |
*      +-----+-----+-----+-----+-----+-----+-----+-----+
*      |                                     <Port Descriptor>                                     |
*      ~                                     ~
*      +-----+-----+-----+-----+-----+-----+-----+-----+
*
*      Reason
*      TBD
*      0  Indicates the port was attached.
*      1  Indicates the port was detached.
*      2  Indicates the port configuration was modified.
*
*      Reserved
*      Must be zero.
*
*      Port Descriptor
*      See Payload Element <Port Descriptor>
*/

```

```

/*
*      Protocol Payload Format - Packet Output
*
*      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
*      +-----+-----+-----+-----+-----+-----+-----+-----+
*      |                                     Packet Buffer ID                                     |
*      +-----+-----+-----+-----+-----+-----+-----+-----+
*      |      Ingress <Port Number>      | Length of Action Descriptors |

```



```

* +-----+
* | <Action Descriptors> ...
* +-----+
* | <Packet Data> ...
* +-----+
*
* Packet Buffer ID
*   TBD
*
* Ingress Port Number
*   See Payload Element <Port Number>
*
* Length of Action Descriptors
*   TBD
*
* Action Descriptors
*   See Payload Element <Action Descriptor>
*
* Packet Data
*   TBD
*/

```

```
/*
```

```

* Protocol Payload Format - Flow Modification
*
*   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
* +-----+
* |                                           |
* ~                               <Flow Match Descriptor>                               ~
* |                                           |
* +-----+
* |           Command           |           Soft Lifetime           |
* +-----+
* |           Hard Lifetime      |           Priority                 |
* +-----+
* |           Packet Buffer ID   |
* +-----+
* |   Egress <Port Number>   |           CU           | IEIOIRI
* +-----+
* |           Reserved           |
* +-----+
* | <Action Descriptors> ...
* +-----+
*
* Flow Match Descriptor

```

```

*   See Payload Element <Flow Match Descriptor>
*
* Command
*   TBD
*   0 Add new flow.
*   1 Modify all matching flows.
*   2 Modify entry strictly matching wildcard flows.
*   3 Delete all matching flows.
*   4 Delete Strictly match wildcards and priority.
*
* Soft Lifetime
*   TBD
*
* Hard Lifetime
*   TBD
*
* Priority
*   TBD
*   Default value is 32768.
*
* Packet Buffer ID
*   TBD
*
* Egress Port Number
*   See Payload Element <Port Number>.
*
* CU (currently unused)
*   Must be zero.
*
* E
*   Remark this is for emergency.
*
* O
*   Check for overlapping entries first.
*
* R
*   Send flow removed message when flow expires or is deleted.
*
* Reserved
*   Must be zero.
*
* Action Descriptors
*   See Payload Element <Action Descriptor>
*/
/*

```

* Protocol Payload Format - Port Modification

*

```

*      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
*  +-+-+-+-+-+-+-+-+
*  |               <Port Number>               |
*  +-+-+-+-+-+-+-+-+ Ethernet Address +
*  |
*  +-+-+-+-+-+-+-+-+
*  |               <Port Configuration Flags>               |
*  +-+-+-+-+-+-+-+-+
*  |               <Port Configuration Flags> Mask           |
*  +-+-+-+-+-+-+-+-+
*  |               <Port Feature Flags>                       |
*  +-+-+-+-+-+-+-+-+
*  |               Reserved                                     |
*  +-+-+-+-+-+-+-+-+

```

* Port Number

* See Payload Element <Port Number>.

*

* Ethernet Address

* TBD

*

* Port Configuration Flags

* See Payload Element <Port Configuration Flags>.

*

- * Port Configuration Flags Mask

* See Payload Element <Port Configuration Flags>.

*

- * Port Feature Flags

* See Payload Element <Port Feature Flags>.

*

* Reserved

* Must be zero.

*** /**

/*

* Protocol Payload Format - Stats Request

*

```

*      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
*      +-+-+-+-+-+-+-+-+ +-+-+-+-+-+-+-+-+ +-+-+-+-+-+-+-+-+ +-+-+-+-+-+-+-+-+
*      |               Type               |               Flags               |
*      +-+-+-+-+-+-+-+-+ +-+-+-+-+-+-+-+-+ +-+-+-+-+-+-+-+-+ +-+-+-+-+-+-+-+-+
*      | <Stats Option> ...

```

```

* +---+---+---+---+---+---+
*
* Type
*   TBD
*   0 Description of this OpenFlow switch.
*   1 Individual flow statistical information.
*   2 Aggregate flow statistical information.
*   3 Flow table statistical information.
*   4 Port statistical information.
*   65535 Vendor extension.
*
* Flags
*   TBD
*   Must be zero.
*
* Option
*   TBD
*   See Payload <Stats Option>.
*
* Possible Option
*   <Flow Stats Request>
*   <Aggregate Flow Stats Request>
*/

/*
* Protocol Payload Format - Stats Reply
*
*   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
*   +---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
*   |                               |                               |                               |
*   |                               Type                               |                               Flags                               |
*   +---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
*   | <Stats Option> ...
*   +---+---+---+---+---+---+
*
* Type
*   TBD
*   0 Description of this OpenFlow switch.
*   1 Individual flow statistical information.
*   2 Aggregate flow statistical information.
*   3 Flow table statistical information.
*   4 Port statistical information.
*   65535 Vendor extension.
*
* Flags
*   TBD

```

* 0x0001 More replies to follow.

*

* Option

* TBD

* See Payload <Stats Option>.

*

* Possible Option

* <Description of Switch>

* <Individual Flow Stats>

* <Aggregate Flow Stats>

* <Table Stats>

* <Port Stats>

*/

/*

* Protocol Payload Format - Barrier Request

* Barrier Reply

*

* 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

* +-----+

* |

* +---+-

*

* There is no payload for Barrier Request and Barrier Reply

*/

/*

* Protocol Payload Element Format - Switch Configuration Flags

*

* 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

* +-----+

* | CU IRIDI

* +-----+

*

* CU (currently unused)

* Must be zero.

*

* R

* Reassemble IPv4 fragment packets only if OFPC_IP_REASM set.

*

* D

* Drop IPv4 fragemnt packets.

*/


```

* +                               Port Description                               +
* |                               |                               |
* +                               +                               +
* |                               |                               |
* +-----+
* |                               <Port Configuration Flags>                               |
* +-----+
* |                               <Port Status Flags>                               |
* +-----+
* |                               Current <Port Feature Flags>                               |
* +-----+
* |                               Advertising <Port Feature Flags>                               |
* +-----+
* |                               Supported <Port Feature Flags>                               |
* +-----+
* |                               Link Layer Neighbor Advertising <Port Feature Flags>                               |
* +-----+
*
* Port Number
*   See Payload Element <Port Number>.
*
* Ethernet Address
*   TBD
*
* Port Description
*   TBD
*
* Port Configuration Flags
*   See Payload Element <Port Configuration Flags>.
*
* Port Status Flags
*   See Payload Element <Port Status Flags>.
*
* Current Port Feature Flags
*   See Payload Element <Port Feature Flags>.
*
* Advertising Port Feature Flags
*   See Payload Element <Port Feature Flags>.
*
* Supported Port Feature Flags
*   See Payload Element <Port Feature Flags>.
*
* Link Layer Neighbor Advertising Port Feature Flags
*   See Payload Element <Port Feature Flags>.
*/

```

```

/*
 * Protocol Payload Element Format - Port Number
 *
 *      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
 *      +-----+-----+-----+-----+
 *      |           Port Number           |
 *      +-----+-----+-----+-----+
 *
 * Port Prefix  0x00 - 0xfe  Indicates switch ports
 *               0xff      Indicates output action ports
 *
 * Range          M/O  Description
 *
 *-----
 * 0x0000          M   Reserved
 * 0x0001 - 0xfeff  M   Switch ports
 * 0xff00          M   Reserved, Maximum number of switch ports
 * 0xff01 - 0xffff7 M   Reserved
 * 0xffff8         M   IN_PORT, Send the packet out the ingress port.
 * 0xffff9         M   TABLE, Perform actions in flow table, only for
 *                     PACKET_OUT message.
 * 0xffffa         O   NORMAL, Process the packet using the traditional
 *                     L2/L3 switching.
 * 0xffffb         O   FLOOD, Flood the packet except ingress port.
 * 0xffffc         M   ALL, Send the packet out all ports except ingress
 *                     and non-xSTP ports.
 * 0xffffd         M   CONTROLLER, Send the packet to the controller.
 * 0xffffe         M   LOCAL, Send the packet to switch local port such
 *                     as bridge/switch virtual interface.
 * 0xfffff         M   NONE, TBD
 */

```

```

/*
 * Protocol Payload Element Format - Port Configuration Flags
 *
 *      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
 *      +-----+-----+-----+-----+
 *      |                                           IPIFIFIDIDISIAI
 *      |                               CU           I I W I L I C I D I T I S I
 *      |                                           I N I D I P I P I T I
 *      +-----+-----+-----+-----+
 *
 * CU (currently unused)
 * Must be zero.

```



```

*
* PIN
*   TBD
*   Indicates please o not send packet-in msgs for port.
*
* FWD
*   TBD
*   Indicates forwarded packets to port will be dropped.
*
* FLD
*   TBD
*   Inidcates please do not include this port when flooding.
*
* DCP
*   TBD
*   Indicates received 802.1D STP packets (BPDU) will be dropped.
*
* DDP
*   TBD
*   Indicates all packets will be dropped except 802.1D spanning tree
*   packets.
*
* STP
*   TBD
*   Indicates IEEE 802.1D spanning tree status will be disabled.
*
* AST
*   TBD
*   Indicates port administratevely status.
*/

```

```
/*
```

```

* Protocol Payload Element Format - Port Status Flags
*

```

```

*      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
*  +---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
*  |                                         ISISISI                                         IOI
*  |                               CU          IBIFILI          CU          ISI
*  |                                         ILIWINI                                         ITI
*  +---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+

```

```

* CU (currently unseud)
*   Must be zero.
*

```

```

* SBL

```

```

*   TBD
*   Not part of spanning tree.
*
*   SFW
*   TBD
*   Learning and relaying frames.
*
*   SLN
*   TBD
*   Learning but not relaying frames.
*
*   CU (currently unseud)
*   Must be zero.
*
*   OST
*   Indicates operational status.
*/

```

```
/*
```

```

*   Protocol Payload Element Format - Port Feature Flags
*

```

```

*   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
*   +-----+-----+-----+-----+-----+-----+-----+-----+
*   |                                                     IPIPIAIFICITIGIGIFIFIEIEI
*   |                         CU                         IAIAINIBIPIGIEIEIEIEITITI
*   |                                                     ISIUIGIRIRIFIFIHIFIHIFIHI
*   +-----+-----+-----+-----+-----+-----+-----+-----+

```

```

*   CU (currently unusd)
*   Must be zero.
*

```

```

*   PAS
*   TBD
*   Asymmetric pause.
*

```

```

*   PAU
*   TBD
*   Pause.
*

```

```

*   ANG
*   TBD
*   Auto-negotiation.
*

```

```

*   FBR
*   TBD

```

```

*   Fiber medium.
*
*   CPR
*   TBD
*   Copper medium.
*
*   TGF
*   TBD
*   10Gbps full-duplex rate support.
*
*   GEF
*   TBD
*   1Gbps full-duplex rate support.
*
*   GEH
*   TBD
*   1Gbps half-duplex rate support.
*
*   FEF
*   TBD
*   100Mbps full-duplex rate support.
*
*   FEH
*   TBD
*   100Mbps half-duplex rate support.
*
*   ETF
*   TBD
*   10Mbps full-duplex rate support.
*
*   ETH
*   TBD
*   10Mbps half-duplex rate support.
*/

```

```
/*
```

```

*   Protocol Payload Element Format - Output Action Descriptor
*

```

```

*   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
*   +-----+-----+-----+-----+-----+-----+-----+-----+
*   |                                         |                                         |
*   |                                         Type                                         |
*   |                                         |                                         |
*   |                                         Length                                         |
*   +-----+-----+-----+-----+-----+-----+-----+-----+
*   |                                         |                                         |
*   |                                         Egress <Port Number>                                         |
*   |                                         |                                         |
*   |                                         Max Length                                         |
*   +-----+-----+-----+-----+-----+-----+-----+-----+
*

```

```

*   Type
*   0
*
*   Length
*   8
*
*   Egress Port Number
*   TBD
*   See Payload Element <Port Number>
*
*   Max Length
*   Indicates maximum octets of new flow should send to the controller.
*   Default value is 128.
*/

```

```

/*
*   Protocol Payload Element Format - VLAN VID Action Descriptor
*
*   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
*   +-----+-----+-----+-----+-----+-----+-----+-----+
*   |                                         |                                         |
*   |                                         Type                                         |
*   |                                         |                                         Length                                         |
*   +-----+-----+-----+-----+-----+-----+-----+-----+
*   | CU | 802.1Q VID |                                         Reserved                                         |
*   +-----+-----+-----+-----+-----+-----+-----+-----+
*
*   Type
*   1
*
*   Length
*   8
*
*   CU (currently unused)
*   Must be zero.
*
*   802.1Q VID
*   IEEE 802.1Q VLAN Identifier.
*
*   Reserved
*   Must be zero.
*/

```

```

/*
*   Protocol Payload Element Format - VLAN PCP Action Descriptor
*
*   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
* +-----+-----+-----+-----+-----+-----+-----+-----+
* |                                         |                                         |
* |                                         Type                                         |
* |                                         |                                         |
* |                                         Length                                        |
* |                                         |                                         |
* | CU | PCP |                                         Reserved                                         |
* +-----+-----+-----+-----+-----+-----+-----+-----+
*
* Type
* 2
*
* Length
* 8
*
* CU (currently unused)
* Must be zero.
*
* PCP
* IEEE 802.1Q PCP (Priority Code Point).
*
* Reserved
* Must be zero.
*/

```

```

/*
* Protocol Payload Element Format - Strip VLAN tag Action Descriptor
*

```

```

* 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
* +-----+-----+-----+-----+-----+-----+-----+-----+
* |                                         |                                         |
* |                                         Type                                         |
* |                                         |                                         |
* |                                         Length                                        |
* |                                         |                                         |
* |                                         Reserved                                         |
* +-----+-----+-----+-----+-----+-----+-----+-----+
*
* Type
* 3
*
* Length
* 8
*
* Reserved
* Must be zero.
*/

```

```

/*
* Protocol Payload Element Format - Ethernet Address Action Descriptor

```

```

*
*      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
*      +---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
*      |                                     |                                     |
*      +---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
*      |                                     |                                     |
*      +      Ethernet Address              +---+---+---+---+---+---+---+---+
*      |                                     |                                     |
*      +---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
*      |                                     |                                     |
*      +---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
*
*      Type
*      4 - 5
*      4  Set Ethernet source address.
*      5  Set Ethernet destination address.
*
*      Length
*      16
*
*      Ethernet Address
*      TBD
*
*      Reserved
*      Must be zero.
*/

```

```

/*
*      Protocol Payload Element - IPv4 Address Action Descriptor
*
*      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
*      +---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
*      |                                     |                                     |
*      +---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
*      |                                     |                                     |
*      +---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
*
*      Type
*      6 - 7
*      6  Set IPv4 source address.
*      7  Set IPv4 destination address.
*
*      Length
*      8

```

```

*
* IPv4 Address
*   TBD
*/

/*
* Protocol Payload Element - IPv4 DSCP Action Descriptor
*
*   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
*   +-----+-----+-----+-----+-----+-----+-----+-----+
*   |                                         |                                         |
*   |                                         Type                                         |
*   +-----+-----+-----+-----+-----+-----+-----+-----+
*   | IPv4 DSCP |CU |                                         Reserved                                         |
*   +-----+-----+-----+-----+-----+-----+-----+-----+
*
*   Type
*   8
*
*   Length
*   8
*
*   IPv4 DSCP (DiffServ Code Point)
*   TBD
*
*   CU (currently unused)
*   Must be zero.
*
*   <IPv4 ToS = IPv4 DSCP + CU>
*
*   Reserved
*   Must be zero.
*/

/*
* Protocol Payload Element - TCP/UDP Port Action Descriptor
*
*   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
*   +-----+-----+-----+-----+-----+-----+-----+-----+
*   |                                         |                                         |
*   |                                         Type                                         |
*   +-----+-----+-----+-----+-----+-----+-----+-----+
*   |                                         Port                                         |
*   +-----+-----+-----+-----+-----+-----+-----+-----+
*
*   Type

```

```

*      9 - 10
*      9  Set TCP/UDP source port.
*      10 Set TCP/UDP destination port.
*
* Length
*      8
*
* Port
*      TBD
*
* Reserved
*      Must be zero.
*/

```

```

/*
* Protocol Payload Element - Vendor Action Descriptor
*
*      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
*      +-----+-----+-----+-----+-----+-----+-----+-----+
*      |                                     |                                     |
*      |                                     Type                                     |
*      |                                     |                                     Length                                     |
*      +-----+-----+-----+-----+-----+-----+-----+-----+
*      |                                     Vendor ID                                     |
*      +-----+-----+-----+-----+-----+-----+-----+-----+
*
* Type
*      65535
*
* Length
*      8
*
* Vendor ID
*      TBD
*      Vendor ID, which takes the same form as in Vendor Message.
*/

```

```

/*
* Protocol Payload Element - Flow Match Descriptor
*
*      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
*      +-----+-----+-----+-----+-----+-----+-----+-----+
*      |                                     <Flow Wildcard>                                     |
*      +-----+-----+-----+-----+-----+-----+-----+-----+
*      |      Ingress <Port Number>      |                                     |
*      +-----+-----+-----+-----+-----+-----+ Ethernet Source Address |

```



```

* |
* +-----+
* |
* + Ethernet Destination Address +-----+
* |                               | VD | 802.1Q VID |
* +-----+
* | CU | PCP | Reserved | Ethernet Type/Length |
* +-----+
* | IPv4 Protocol | Reserved |
* +-----+
* | IPv4 Source Address |
* +-----+
* | IPv4 Destination Address |
* +-----+
* | Source Port | Destination Port |
* +-----+
*
* Flow Wildcard
*   See Protocol Payload Element <Flow Wildcard>
*
* Ingress Port Number
*   See Protocol Payload Element <Port Number>
*
* Ethernet Source Address
*   TBD
*
* Ethernet Destination Address
*   TBD
*
* VD (VLAN Designator)
*   0x0 (0000) Indicates IEEE 802.1Q tag exists.
*   0xf (1111) Indicates no IEEE 802.1Q tag exists.
*
* 802.1Q VID
*   IEEE 802.1Q VLAN Identifier.
*
* <VD + 802.1Q VID>
*   0x0000 - 0x0fff Indicates IEEE 802.1Q tag exists.
*   0xffff          Indicates no IEEE 802.1Q tag exists.
*
* CU (currently unused)
*   TBD
*
* 802.1Q PCP
*   IEEE 802.1Q PCP (Priority Code Point).
*

```

```

*   Reserved
*     Must be zero.
*
*   Ethernet Type/Length
*     TBD
*
*   IPv4 Protocol
*     TBD
*
*   Reserved
*     Must be zero.
*
*   IPv4 Source Address
*     TBD
*
*   IPv4 Destination Address
*     TBD
*
*   TCP/UDP Source Port
*     TBD
*
*   TCP/UDP Destination Port
*     TBD
*/

```

```
/*
```

```

*   Protocol Payload Element Format - Flow Wildcard
*
*       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
*   +---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
*   |                               IPI IPv4 Dst | IPv4 Src |LILILILILILIVII|
*   |               CU               |CI  Address |  Address |4|4|3|2|2|2|IINI|
*   |                               IPIWildcardMsk|WildcardMsk|DISIPIPIDISIDIPI|
*   +---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
*
*   CU (currently unused)
*     Must be zero.
*
*   PCP
*     TBD
*     IEEE 802.1Q PCP.
*
*   IPv4 Destination Address Wildcard Mask
*     TBD
*     IPv4 destination address wildcard bit count. 0 is exact match,

```

* 1 ignores the LSB of IPv4 address, 2 ignores the 2 least-significant
 * bits, ..., 32 and higher wildcard the entire field. This is the
 * *opposite* of the usual convention where e.g. /24 indicates that 8

bits

* (not 24 bits) are wildcarded.
 * e.g.,
 * Wildcard Mask Address/PfxLen
 * 0 255.255.255.255 a.b.c.d/32 (exact match)
 * 1 255.255.255.254 a.b.c.d/31
 * 2 255.255.255.252 a.b.c.d/30
 * 3 255.255.255.248 a.b.c.d/29
 * 4 255.255.255.240 a.b.c.d/28
 * :
 * 8 255.255.255.0 a.b.c.d/24
 * :
 * 28 240.0.0.0 a.b.c.d/4
 * 29 224.0.0.0 a.b.c.d/3
 * 30 192.0.0.0 a.b.c.d/2
 * 31 128.0.0.0 a.b.c.d/1
 * 32 - 63 0.0.0.0 a.b.c.d/0
 *

* IPv4 Source Address Wildcard Mask

* TBD

*

* L4D

* TBD

* TCP/UDP destination port.

*

* L4S

* TBD

* TCP/UDP source port.

*

* L3P

* TBD

* IPv4 protocol.

*

* L2P

* TBD

* Ethernet frame type.

*

* L2D

* TBD

* Ethernet destination address.

*

* L2S

* TBD


```

* | |
* ~ <Flow Match Descriptor> ~
* | |
* +-----+
* | Table ID | Reserved | Egress Port Number |
* +-----+
*
* Flow Match Descriptor
* See Payload Element <Flow Match Descriptor>
*
* Table ID
* TBD
* 0 - 253 Normal Flow Table
* 254 Emergency Flow Table
* 255 All Normal Flow Table
*
* Reserved
* Must be zero.
*
* Egress Port Number
* See Payload Element <Port Numver>
*/

```

```

/*
* Protocol Payload Stats Option Format - Description of Switch
*
* 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
* +-----+
* | |
* ~ Manufacturer Description ~
* | |
* +-----+
* | |
* ~ Hardware Description ~
* | |
* +-----+
* | |
* ~ Software Description ~
* | |
* +-----+
* | Serial Number Description |
* +-----+
*
* Manufacturer Description
* TBD

```

```

*   256 octets
*
*   Hardware Description
*   TBD
*   256 octets
*
*   Software Description
*   TBD
*   256 octets
*
*   Serial Number Description
*   TBD
*/

```

```

/*
*   Protocol Payload Stats Option Format - Individual Flow Stats
*
*   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
*   +-----+-----+-----+-----+-----+-----+-----+-----+
*   |                               Length                               | Table ID | Reserved |
*   +-----+-----+-----+-----+-----+-----+-----+-----+
*   |                               <Flow Match Descriptor>                               |
*   ~                               ~
*   |                               |
*   +-----+-----+-----+-----+-----+-----+-----+-----+
*   |                               Lifetime Duration                               |
*   +-----+-----+-----+-----+-----+-----+-----+-----+
*   |                               Priority                               | Soft Lifetime |
*   +-----+-----+-----+-----+-----+-----+-----+-----+
*   |                               Hard Lifetime                               | Reserved |
*   +-----+-----+-----+-----+-----+-----+-----+-----+
*   |                               |
*   +                               Number of Packets Transferred                               +
*   |                               |
*   +-----+-----+-----+-----+-----+-----+-----+-----+
*   |                               |
*   +                               Number of Octets Transferred                               +
*   |                               |
*   +-----+-----+-----+-----+-----+-----+-----+-----+
*   | <Action Descriptors> ...
*   +-----+-----+-----+-----+-----+-----+
*/

```

```

/*
*   Protocol Payload Stats Option Format - Aggregate Flow Stats

```

```

*
*      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
*      +-----+-----+-----+-----+-----+-----+-----+-----+
*      |
*      +              Number of Packets Transferred              +
*      |
*      +-----+-----+-----+-----+-----+-----+-----+-----+
*      |
*      +              Number of Octets Transferred              +
*      |
*      +-----+-----+-----+-----+-----+-----+-----+-----+
*      |              Number of Flows                            |
*      +-----+-----+-----+-----+-----+-----+-----+-----+
*      |              Reserved                                    |
*      +-----+-----+-----+-----+-----+-----+-----+-----+
*/

```

```

/*
* Protocol Payload Stats Option Format - Table Stats
*
*      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
*      +-----+-----+-----+-----+-----+-----+-----+-----+
*      |  Table ID  |              Reserved              |
*      +-----+-----+-----+-----+-----+-----+-----+-----+
*      |
*      +              +
*      |              |
*      +              Table Description String              +
*      |              |
*      +              +
*      |              |
*      +-----+-----+-----+-----+-----+-----+-----+-----+
*      |              <Flow Wildcard>                    |
*      +-----+-----+-----+-----+-----+-----+-----+-----+
*      |              Maximum Number of Flows Supported    |
*      +-----+-----+-----+-----+-----+-----+-----+-----+
*      |              Number of Flows Installed            |
*      +-----+-----+-----+-----+-----+-----+-----+-----+
*      |              Number of Packets Looked up          |
*      +-----+-----+-----+-----+-----+-----+-----+-----+
*      |              Number of Packets Matched            |
*      +-----+-----+-----+-----+-----+-----+-----+-----+
*/

```

```

/*
 * Protocol Payload Stats Option Format - Port Stats
 *
 *      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
 *      +-----+-----+-----+-----+-----+-----+-----+-----+
 *      |                                                                 |
 *      +               Number of Pakctes Received                     +
 *      |                                                                 |
 *      +-----+-----+-----+-----+-----+-----+-----+-----+
 *      |                                                                 |
 *      +               Number of Pakctes Transmitted                   +
 *      |                                                                 |
 *      +-----+-----+-----+-----+-----+-----+-----+-----+
 *      |                                                                 |
 *      +               Number of Octets Received                       +
 *      |                                                                 |
 *      +-----+-----+-----+-----+-----+-----+-----+-----+
 *      |                                                                 |
 *      +               Number of Octets Transmitted                    +
 *      |                                                                 |
 *      +-----+-----+-----+-----+-----+-----+-----+-----+
 *      |                                                                 |
 *      +               Number of Packets Dropped in Reception          +
 *      |                                                                 |
 *      +-----+-----+-----+-----+-----+-----+-----+-----+
 *      |                                                                 |
 *      +               Number of Packets Dropped in Transmission       +
 *      |                                                                 |
 *      +-----+-----+-----+-----+-----+-----+-----+-----+
 *      |                                                                 |
 *      +               Number of Errors in Reception                   +
 *      |                                                                 |
 *      +-----+-----+-----+-----+-----+-----+-----+-----+
 *      |                                                                 |
 *      +               Number of Errors in Transmission                +
 *      |                                                                 |
 *      +-----+-----+-----+-----+-----+-----+-----+-----+
 *      |                                                                 |
 *      +               Number of Alignment Errors                      +
 *      |                                                                 |
 *      +-----+-----+-----+-----+-----+-----+-----+-----+
 *      |                                                                 |
 *      +               Number of Overrun Errors                        +
 *      |                                                                 |
 *      +-----+-----+-----+-----+-----+-----+-----+-----+

```



```
* |
* +
* |
* +-----+
* |
* +
* |
* +-----+
*/
```

Number of CRC Errors

Number of Collision Errors