Network Working Group
Request for Comments: 1172

D. Perkins
CMU
R. Hobby
UC Davis

July 1990

The Point-to-Point Protocol (PPP) Initial Configuration Options

Status of this Memo

This RFC specifies an IAB standards track protocol for the Internet community.

Please refer to the current edition of the "IAB Official Protocol Standards" for the standardization state and status of this protocol.

This proposal is the product of the Point-to-Point Protocol Working Group of the Internet Engineering Task Force (IETF). Comments on this memo should be submitted to the IETF Point-to-Point Protocol Working Group chair.

Distribution of this memo is unlimited.

Abstract

The Point-to-Point Protocol (PPP) provides a method for transmitting datagrams over serial point-to-point links. PPP is composed of

1) a method for encapsulating datagrams over serial links,
2) an extensible Link Control Protocol (LCP), and
3) a family of Network Control Protocols (NCP) for establishing and configuring different network-layer protocols.

The PPP encapsulating scheme, the basic LCP, and an NCP for controlling and establishing the Internet Protocol (IP) (called the IP Control Protocol, IPCP) are defined in The Point-to-Point Protocol (PPP) [1].

This document defines the intial options used by the LCP and IPCP. It also defines a method of Link Quality Monitoring and a simple authentication scheme.

Table of Contents

1. Introduction

The Point-to-Point Protocol (PPP) [1] proposes a standard method of encapsulating IP datagrams, and other Network Layer protocol information, over point-to-point links. PPP also proposes an extensible Option Negotiation Protocol. [1] specifies only the protocol itself; the initial set of Configuration Options are described in this document. These Configuration Options allow MTUs to be changed, IP addresses to be dynamically assigned, header compression to be enabled, and much more.

This memo is divided into several sections. Section 2 describes Configuration Options for the Link Control Protocol. Section 3 specifies the use of the Link Quality Monitoring option. Section 4 defines a simple Password Authentication Protocol. Finally, Section 5 specifies Configuration Options for the IP Control Protocol.

2. Link Control Protocol (LCP) Configuration Options

As described in [1], LCP Configuration Options allow modifications to the standard characteristics of a point-to-point link to be negotiated. Negotiable modifications proposed in this document include such things as the maximum receive unit, async control character mapping, the link authentication method, etc.

The initial proposed values for the LCP Configuration Option Type field (see [1]) are assigned as follows:

1	Maximum-Receive-Unit
2	Async-Control-Character-Map
3	Authentication-Type
4	NOT ASSIGNED
5	Magic-Number
6	Link-Quality-Monitoring
7	Protocol-Field-Compression
8	Address-and-Control-Field-Compression

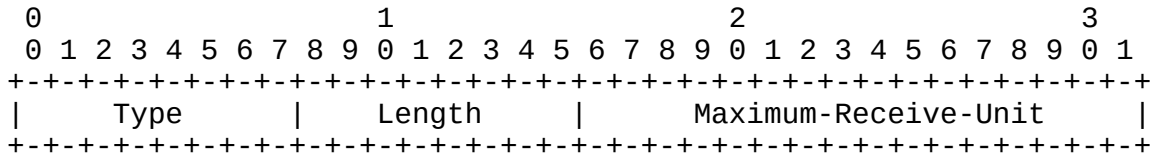
2.1. Maximum-Receive-Unit

Description

This Configuration Option provides a way to negotiate the maximum packet size used across one direction of a link. By default, all implementations must be able to receive frames with 1500 octets of Information.

This Configuration Option may be sent to inform the remote end that you can receive larger frames, or to request that the remote end send you smaller frames. If smaller frames are requested, an implementation MUST still be able to receive 1500 octet frames in case link synchronization is lost.

A summary of the Maximum-Receive-Unit Configuration Option format is shown below. The fields are transmitted from left to right.



Type

1

Length

4

Maximum-Receive-Unit

The Maximum-Receive-Unit field is two octets and indicates the new maximum receive unit. The Maximum-Receive-Unit covers only the Data Link Layer Information field but not the header, trailer or any transparency bits or bytes.

Default

1500

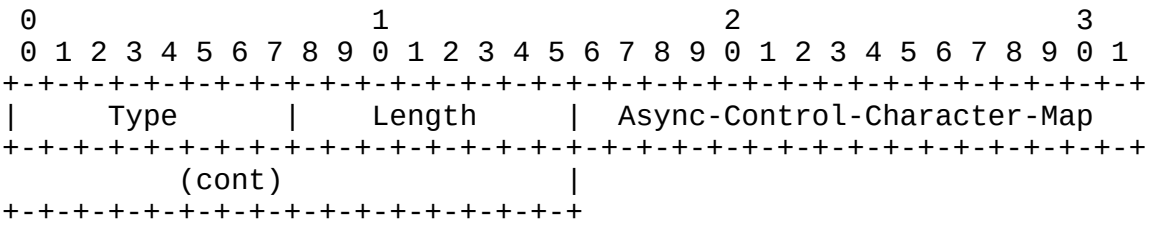
2.2. Async-Control-Character-Map

Description

This Configuration Option provides a way to negotiate the use of control character mapping on asynchronous links. By default, PPP maps all control characters into an appropriate two character sequence. However, it is rarely necessary to map all control characters and often times it is unnecessary to map any characters. A PPP implementation may use this Configuration Option to inform the remote end which control characters must remain mapped and which control characters need not remain mapped when the remote end sends them. The remote end may still send these control characters in mapped format if it is necessary because of constraints at its (the remote) end. This option does not solve problems for communications links that can send only 7-bit characters or that can not send all non-control characters.

There may be some use of synchronous-to-asynchronous converters (some built into modems) in Point-to-point links resulting in a synchronous PPP implementation on one end of a link and an asynchronous implemention on the other. It is the responsibility of the converter to do all mapping conversions during operation. To enable this functionality, synchronous PPP implementations MUST always accept a Async-Control-Character-Map Configuration Option (it MUST always respond to an LCP Configure-Request specifying this Configuration Option with an LCP Configure-Ack). However, acceptance of this Configuration Option does not imply that the synchronous implementation will do any character mapping, since synchronous PPP uses bit-stuffing rather than character-stuffing. Instead, all such character mapping will be performed by the asynchronous-to-synchronous converter.

A summary of the Async-Control-Character-Map Configuration Option format is shown below. The fields are transmitted from left to right.



Type

2

Length

6

Async-Control-Character-Map

The Async-Control-Character-Map field is four octets and indicates the new async control character map. The map is encoded in big-endian fashion where each numbered bit corresponds to the ASCII control character of the same value. If the bit is cleared to zero, then that ASCII control character need not be mapped. If the bit is set to one, then that ASCII control character must remain mapped. E.g., if bit 19 is set to zero, then the ASCII control character 19 (DC3, Control-S) may be sent in the clear.

Default

All ones (0xffffffff).

2.3. Authentication-Type

Description

On some links it may be desirable to require a peer to authenticate itself before allowing Network Layer protocol data to be exchanged. This Configuration Option provides a way to negotiate the use of a specific authentication protocol. By default, authentication is not necessary. If an implementation requires that the remote end authenticate with some specific authentication protocol, then it should negotiate the use of that authentication protocol with this Configuration Option.

Successful negotiation of the Authentication-Type option adds an additional Authentication phase to the Link Control Protocol. This phase is after the Link Quality Determination phase, and before the Network Layer Protocol Configuration Negotiation phase. Advancement from the Authentication phase to the Network Layer Protocol Configuration Negotiation phase may not occur until the peer is successfully authenticated using the negotiated authentication protocol.

An implementation may allow the remote end to pick from more than one authentication protocol. To achieve this, it may include multiple Authentication-Type Configuration Options in its Configure-Request packets. An implementation receiving a Configure-Request specifying multiple Authentication-Types may accept at most one of the negotiable authentication protocols and should send a Configure-Reject specifying all of the other specified authentication protocols.

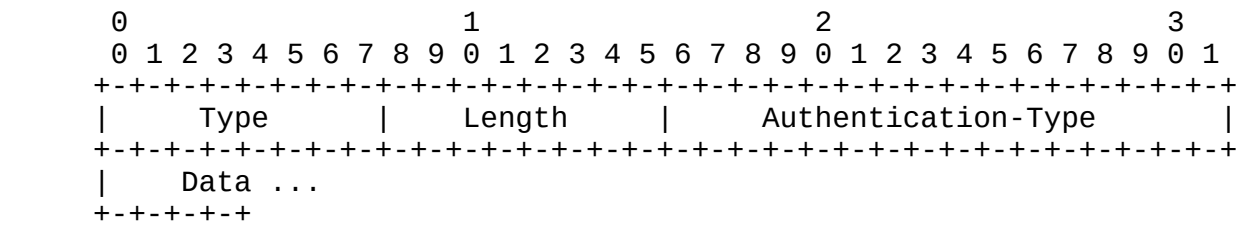
It is recommended that each PPP implementation support configuration of authentication parameters at least on a per-interface basis, if not a per peer entity basis. The parameters should specify which authetication techniques are minimally required as a prerequisite to establishment of a PPP connection, either for the specified interface or for the specified peer entity. Such configuration facilities are necessary to prevent an attacker from negotiating a reduced security authentication protocol, or no authentication at all, in an attempt to circumvent this authentication facility.

If an implementation sends a Configure-Ack with this Configuration Option, then it is agreeing to authenticate with the specified protocol. An implementation receiving a Configure-Ack with this Configuration Option should expect the remote end to authenticate with the acknowledged protocol.

There is no requirement that authentication be full duplex or that the same authentication protocol be used in both directions. It is perfectly acceptable for different authentication protocols to be used in each direction. This will, of course, depend on the specific authentication protocols negotiated.

This document defines a simple Password Authentication Protocol in Section 4. Development of other more secure protocols is encouraged.

A summary of the Authentication-Type Configuration Option format is shown below. The fields are transmitted from left to right.



Type

3

Length

>= 4

Authentication-Type

The Authentication-Type field is two octets and indicates the type of authentication protocol desired. Values for the Authentication-Type are always the same as the PPP Data Link Layer Protocol field values for that same authentication protocol. The most up-to-date values of the Authentication-Type field are specified in "Assigned Numbers" [2]. Initial values are assigned as follows:

Value (in hex)	Protocol
c023	Password Authentication Protocol

Data

The Data field is zero or more octets and contains additional data as determined by the particular authentication protocol.

Default

No authentication protocol necessary.

2.4. Magic-Number

Description

This Configuration Option provides a way to detect looped-back links and other Data Link Layer anomalies. This Configuration Option may be required by some other Configuration Options such as the Link-Quality-Monitoring Configuration Option.

Before this Configuration Option is requested, an implementation must choose its Magic-Number. It is recommended that the Magic-Number be chosen in the most random manner possible in order to guarantee with very high probability that an implementation will arrive at a unique number. A good way to choose a unique random number is to start with an unique seed. Suggested sources of uniqueness include machine serial numbers, other network hardware addresses, time-of-day clocks, etc. Particularly good random number seeds are precise measurements of the inter-arrival time of physical events such as packet reception on other connected networks, server response time, or the typing rate of a human user. It is also suggested that as many sources as possible be used simultaneously.

When a Configure-Request is received with a Magic-Number Configuration Option, the received Magic-Number should be compared with the Magic-Number of the last Configure-Request sent to the peer. If the two Magic-Numbers are different, then the link is not looped-back, and the Magic-Number should be acknowledged. If the two Magic-Numbers are equal, then it is possible, but not certain, that the link is looped-back and that this Configure-Request is actually the one last sent. To determine this, a Configure-Nak should be sent specifying a different Magic-Number value. A new Configure-Request should not be sent to the peer until normal processing would cause it to be sent (i.e., until a Configure-Nak is received or the Restart timer runs out).

Reception of a Configure-Nak with a Magic-Number different from that of the last Configure-Nak sent to the peer proves that a link is not looped-back, and indicates a unique Magic-Number. If the Magic-Number is equal to the one sent in the last Configure-Nak, the possibility of a loop-back is increased, and a new Magic-Number should be chosen. In either case, a new Configure-Request should be sent with the new Magic-Number.

If the link is indeed looped-back, this sequence (transmit Configure-Request, receive Configure-Request, transmit Configure-Nak, receive Configure-Nak) will repeat over and over again. If the link is not looped-back, this sequence may occur a few times, but it is extremely unlikely to occur repeatedly. More likely, the Magic-Numbers chosen at either end will quickly diverge, terminating the sequence. The following table shows the probability of collisions assuming that both ends of the link select Magic-Numbers with a perfectly uniform distribution:

Number of Collisions	Probability
1	1/2**32 = 2.3 E-10
2	1/2**32**2 = 5.4 E-20
3	1/2**32**3 = 1.3 E-29

Good sources of uniqueness or randomness are required for this divergence to occur. If a good source of uniqueness cannot be found, it is recommended that this Configuration Option not be enabled; Configure-Requests with the option should not be transmitted and any Magic-Number Configuration Options which the peer sends should be either acknowledged or rejected. In this case, loop-backs cannot be reliably detected by the implementation, although they may still be detectable by the peer.

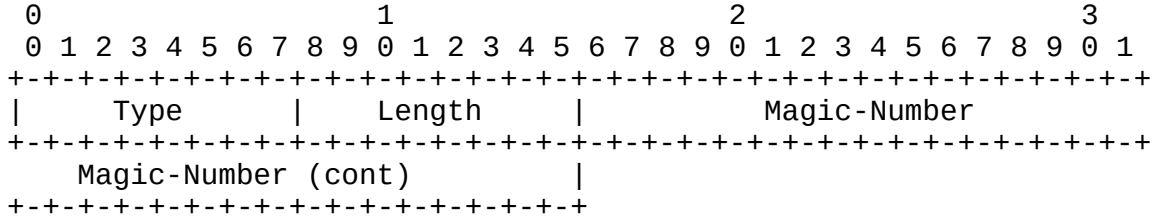
If an implementation does transmit a Configure-Request with a Magic-Number Configuration Option, then it MUST NOT respond with a Configure-Reject if its peer also transmits a Configure-Request with a Magic-Number Configuration Option. That is, if an implementation desires to use Magic Numbers, then it MUST also allow its peer to do so. If an implementation does receive a Configure-Reject in response to a Configure-Request, it can only mean that the link is not looped-back, and that its peer will not be using Magic-Numbers. In this case, an implementation may act as if the negotiation had been successful (as if it had instead received a Configure-Ack).

The Magic-Number also may be used to detect looped-back links during normal operation as well as during Configuration Option negotiation. All Echo-Request, Echo-Reply, Discard-Request, and Link-Quality-Report LCP packets have a Magic-Number field which MUST normally be transmitted as zero, and MUST normally be ignored on reception. However, once a Magic-Number has been successfully negotiated, an LCP implementation MUST begin transmitting these packets with the Magic-Number field set to its negotiated Magic-Number. Additionally, the Magic-Number field of these packets may be inspected on reception. All received Magic-Number fields should be equal to either zero or the peer’s unique Magic-Number,

depending on whether or not the peer negotiated one. Reception of a Magic-Number field equal to the negotiated local Magic-Number indicates a looped-back link. Reception of a Magic-Number other than the negotiated local Magic-Number or or the peer's negotiated Magic-Number, or zero if the peer didn't negotiate one, indicates a link which has been (mis)configured for communications with a different peer.

Procedures for recovery from either case are unspecified and may vary from implementation to implementation. A somewhat pessimistic procedure is to assume an LCP Physical-Layer-Down event and make an immediate transition to the Closed state. A further Active-Open event will begin the process of re-establishing the link, which can't complete until the loop-back condition is terminated and Magic-Numbers are successfully negotiated. A more optimistic procedure (in the case of a loop-back) is to begin transmitting LCP Echo-Request packets until an appropriate Echo-Reply is received, indicating a termination of the loop-back condition.

A summary of the Magic-Number Configuration Option format is shown below. The fields are transmitted from left to right.



Type

5

Length

6

Magic-Number

The Magic-Number field is four octets and indicates a number which is very likely to be unique to one end of the link. A Magic-Number of zero is illegal and must not be sent.

Default

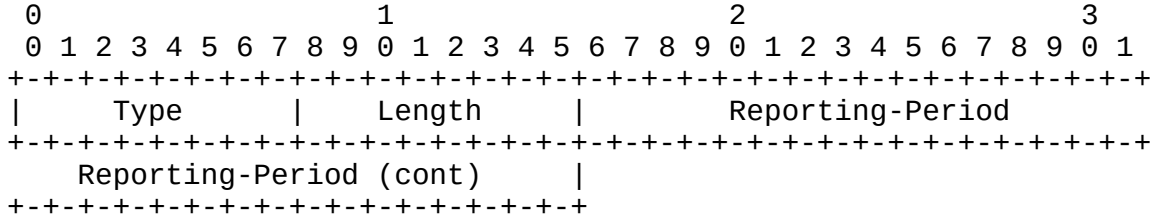
None.

2.5. Link-Quality-Monitoring

Description

On some links it may be desirable to determine when, and how often, the link is dropping data. This process is called Link Quality Monitoring and is implemented by periodically transmitting Link-Quality-Report packets as described in Section 3. The Link-Quality-Monitoring Configuration Option provides a way to enable the use of Link-Quality-Report packets, and also to negotiate the rate at which they are transmitted. By default, Link Quality Monitoring and the use of Link-Quality-Report packets is disabled.

A summary of the Link-Quality-Monitoring Configuration Option format is shown below. The fields are transmitted from left to right.



Type

6

Length

6

Reporting-Period

The Reporting-Period field is four octets and indicates the maximum time in micro-seconds that the remote end should wait between transmission of LCP Link-Quality-Report packets. A value of zero is illegal and should always be nak'd or rejected. An LCP implementation is always free to transmit LCP Link-Quality-Report packets at a faster rate than that which was requested by, and acknowledged to, the remote end.

Default

None

2.6. Protocol-Field-Compression

Description

This Configuration Option provides a way to negotiate the compression of the Data Link Layer Protocol field. By default, all implementations must transmit standard PPP frames with two octet Protocol fields. However, PPP Protocol field numbers are chosen such that some values may be compressed into a single octet form which is clearly distinguishable from the two octet form. This Configuration Option may be sent to inform the remote end that you can receive compressed single octet Protocol fields. Compressed Protocol fields may not be transmitted unless this Configuration Option has been received.

As previously mentioned, the Protocol field uses an extension mechanism consistent with the ISO 3309 extension mechanism for the Address field; the Least Significant Bit (LSB) of each octet is used to indicate extension of the Protocol field. A binary "0" as the LSB indicates that the Protocol field continues with the following octet. The presence of a binary "1" as the LSB marks the last octet of the Protocol field. Notice that any number of "0" octets may be prepended to the field, and will still indicate the same value (consider the two representations for 3, 00000011 and 00000000 00000011).

In the interest of simplicity, the standard PPP frame uses this fact and always sends Protocol fields with a two octet representation. Protocol field values less than 256 (decimal) are prepended with a single zero octet even though transmission of this, the zero and most significant octet, is unnecessary.

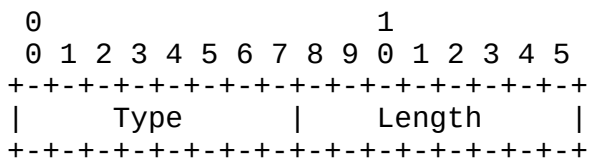
However, when using low speed links, it is desirable to conserve bandwidth by sending as little redundant data as possible. The Protocol Compression Configuration Option allows a trade-off between implementation simplicity and bandwidth efficiency. If successfully negotiated, the ISO 3309 extension mechanism may be used to compress the Protocol field to one octet instead of two. The large majority of frames are compressible since data protocols are typically assigned with Protocol field values less than 256.

To guarantee unambiguous recognition of LCP packets, the Protocol field must never be compressed when sending any LCP packet. In addition, PPP implementations must continue to be robust and MUST accept PPP frames with double-octet, as well as single-octet, Protocol fields, and MUST NOT distinguish between them.

When a Protocol field is compressed, the Data Link Layer FCS field

is calculated on the compressed frame, not the original uncompressed frame.

A summary of the Protocol-Field-Compression Configuration Option format is shown below. The fields are transmitted from left to right.



Type

7

Length

2

Default

Disabled.

2.7. Address-and-Control-Field-Compression

Description

This Configuration Option provides a way to negotiate the compression of the Data Link Layer Address and Control fields. By default all implementations must transmit frames with Address and Control fields and must use the hexadecimal values 0xff and 0x03 respectively. Since these fields have constant values, they are easily compressed. this Configuration Option may be used to inform the remote end that you can receive compressed Address and Control fields.

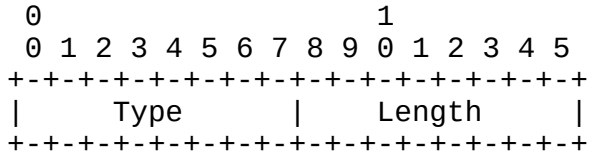
Compressed Address and Control fields are formed by simply omitting them in all non-ambiguous cases. Ambiguous frames may not be compressed. Ambiguous cases result when the two octets following the Address and Control fields have values that could be interpreted as valid Address and Control fields (i.e., 0xff, 0x03). This can happen when Protocol-Field-Compression is enabled and the Protocol field is compressed to one octet. If the Protocol value is 0xff, and the first octet of the Information field is 0x03, the result is ambiguous and the Address and Control fields must not be compressed on transmission.

On reception, the Address and Control fields are decompressed by examining the first two octets. If they contain the values 0xff and 0x03, they are assumed to be the Address and Control fields. If not, it is assumed that the fields were compressed and were not transmitted.

One additional case in which the Address and Control fields must never be compressed is when sending any LCP packet. This rule guarantees unambiguous recognition of LCP packets.

When the Address and Control fields are compressed, the Data Link Layer FCS field is calculated on the compressed frame, not the original uncompressed frame.

A summary of the Address-and-Control-Field-Compression configuration option format is shown below. The fields are transmitted from left to right.



Type

8

Length

2

Default

Not compressed.

3. Link Quality Monitoring

Data communications links are rarely perfect. Packets can be dropped or corrupted for various reasons (line noise, equipment failure, buffer overruns, etc.). Sometimes, it is desirable to determine when, and how often, the link is dropping data. Routers, for example, may want to temporarily allow another route to take precedence. An implementation may also have the option of disconnecting and switching to an alternate link. The process of determining data loss is called "Link Quality Monitoring".

3.1. Design Motivation

There are many different ways to measure link quality, and even more ways to react to it. Rather than specifying a single scheme, Link Quality Monitoring is divided into a "mechanism" and a "policy". PPP fully specifies the "mechanism" for Link Quality Monitoring by defining the LCP Link-Quality-Report (LQR) packet and specifying a procedure for its use. PPP does NOT specify a Link Quality Monitoring "policy" -- how to judge link quality or what to do when it is inadequate. That is left as an implementation decision, and can be different at each end of the link. Implementations are allowed, and even encouraged, to experiment with various link quality policies. The Link Quality Monitoring mechanism specification insures that two implementations with different policies may communicate and interoperate.

To allow flexible policies to be implemented, the PPP Link Quality Monitoring mechanism measures data loss in units of packets, octets, and Link-Quality-Reports. Each measurement is made separately for each half of the link, both inbound and outbound. All measurements are communicated to both ends of the link so that each end of the link can implement its own link quality policy for both its outbound and inbound links.

Finally, the Link Quality Monitoring protocol is designed to be implementable on many different kinds of systems. Although it may be common to implement PPP (and especially Link Quality Monitoring) as a single software process, multi-process implementations with hardware support are also envisioned. The PPP Link Quality Monitoring mechanism provides for this by careful definition of the Link-Quality-Report packet format, and by specifiying reference points for all data transmission and reception measurements.

3.2. Design Overview

Each Link Quality Monitoring implementation maintains counts of the number of packets and octets transmitted and successfully received,

and periodically transmits this information to its peer in a Link-Quality-Report packet. These packets contain three sections: a Header section, a Counters section, and a Measurements section.

The Header section of the packet consists of the normal LCP Link Maintenance packet header including Code, Identifier, Length and Magic-Number fields.

The Counters section of the packet consists of four counters, and provides the information necessary to measure the quality of the link. The LQR transmitter fills in two of these counters: Out-Tx-Packets-Ctr and Out-Tx-Octets-Ctr (described later). The LQR receiver fills in the two remaining counters: In-Rx-Packets-Ctr and In-Rx-Octets-Ctr (described later). These counters are similar to sequence numbers; they are constantly increasing to give a "relative" indication of the number of packets and octets communicated across the outbound link. By comparing the values in successive Link-Quality-Reports, an LQR receiver can compute the "absolute" number of packets and octets communicated across its inbound link. Comparing these absolute numbers then gives an indication of an inbound link's quality. Relative numbers, rather than absolute, are transmitted because they greatly simplify link synchronization; an implementation merely waits to receive two LQR packets.

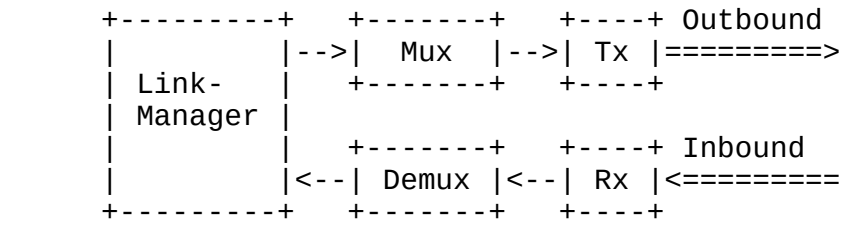
The Measurements section of the packet consists of six state variables: In-Tx-LQRs, Last-In-Id, In-Tx-Packets, In-Tx-Octets, In-Rx-Packets, and In-Rx-Octets (described later). This section allows an implementation to report inbound link quality measurements to its peer (for which the report will instead indicate outbound link quality) by transmitting the absolute, rather than relative, number of LQRs, packets, and octets communicated across the inbound link. These values are calculated by observing the Counters section of the Link-Quality-Report packets received on the inbound link. Absolute numbers may be used in this section without synchronization problems because it is necessary to receive only one LQR packet to have valid information.

Link Quality Monitoring is described in more detail in the following sections. First, a description of the processes comprising the Link Quality Monitoring mechanism is presented. This is followed by the packet and byte counters maintained; the measurements, calculations, and state variables used; the format of the Link-Quality-Report packet; some policy suggestions; and, finally, an example link quality calculation.

3.3. Processes

The PPP Link Quality Monitoring mechanism is described using a

"logical process" model. As shown below, there are five logical processes duplicated at each end of the duplex link.



Link-Manager

The Link-Manager process transmits and receives Link-Quality-Reports, and implements the desired link quality policy. LQR packets are transmitted at a constant rate, which is negotiated by the LCP Link-Quality-Monitoring Configuration Option. The Link-Manager process fills in only the Header and Measurements sections of the packet; the Counters section of the packet is filled in by the Tx and Rx processes.

Mux

The Mux process multiplexes packets from the various protocols (e.g., LCP, IP, XNS, etc.) into a single, sequential, and prioritized stream of packets. Link-Quality-Report packets MUST be given the highest possible priority to insure that link quality information is communicated in a timely manner.

Tx

The Tx process maintains the counters Out-Tx-Packets-Ctr and Out-Tx-Octets-Ctr which are used to measure the amount of data which is transmitted on the outbound link. When Tx processes a Link-Quality-Report packet, it inserts the values of these counters into the Counters section of the packet. Because these counters represent relative, rather than absolute, values, the question of when to update the counters, before or after they are inserted into a Link-Quality-Report packet, is left as an implementation decision. However, an implementation MUST make this decision the same way every time. The Tx process MUST follow the Mux process so that packets are counted in the order transmitted to the link.

Rx

The Rx process maintains the counters In-Rx-Packets-Ctr and In-Rx-Octets-Ctr which are used to measure the amount of data which is received by the inbound link. When Rx processes a Link-

Quality-Report packet, it inserts the values of these counters into the Counters section of the packet. Again, the question of when to update the counters, before or after they are inserted into a Link-Quality-Report packet, is left as an implementation decision which MUST be made consistently the same way.

Demux

The Demux process demultiplexes packets for the various protocols. The Demux process MUST follow the Rx process so that packets are counted in the order received from the link.

3.4. Counters

In order to fill in the Counters section of a Link-Quality-Report packet, Link Quality Monitoring requires the implementation of one 8-bit unsigned, and four 32-bit unsigned, monotonically increasing counters. These counters may be reset to any initial value before the first Link-Quality-Report is transmitted, but MUST NOT be reset again until LCP has left the Open state. Counters wrap to zero when their maximum value is reached (for 32 bit counters: 0xffffffff + 1 = 0).

Out-Identifier-Ctr

Out-Identifier-Ctr is an 8-bit counter maintained by the Link-Manager process which increases by one for each transmitted Link-Quality-Report packet.

Out-Tx-Packets-Ctr

Out-Tx-Packets-Ctr is a 32-bit counter maintained by the Tx process which increases by one for each transmitted Data Link Layer packet.

Out-Tx-Octets-Ctr

Out-Tx-Octets-Ctr is a 32-bit counter maintained by the Tx process which increases by one for each octet in a transmitted Data Link Layer packet. All octets which are included in the FCS calculation MUST be counted, as should the FCS octets themselves. All other octets MUST NOT be counted.

In-Rx-Packets-Ctr

In-Rx-Packets-Ctr is a 32-bit counter maintained by the Rx process which increases by one for each successfully received Data Link Layer packet. Packets with incorrect FCS fields or other problems

MUST not be counted.

In-Rx-Octets-Ctr

In-Rx-Octets-Ctr is a 32-bit counter maintained by the Rx process which increases by one for each octet in a successfully received Data Link Layer packet. All octets which are included in an FCS calculation MUST be counted, as should the FCS octets themselves. All other octets MUST NOT be counted.

3.5. Measurements, Calculations, State Variables

In order to fill in the Measurements section of a Link-Quality-Report packet, Link Quality Monitoring requires the Link-Manager process to make a number of calculations and keep a number of state variables. These calculations are made, and these state variables updated, each time a Link-Quality-Report packet is received from the inbound link.

In-Tx-LQRs

In-Tx-LQRs is an 8-bit state variable which indicates the number of Link-Quality-Report packets which the peer had to transmit in order for the local end to receive exactly one LQR. In-Tx-LQRs defines the length of the "period" over which In-Tx-Packets, In-Tx-Octets, In-Rx-Packets, and In-Rx-Octets were measured. In-Tx-LQRs is calculated by subtracting Last-In-Id from the received Identifier. If more than 255 LQRs in a row are lost, In-Tx-LQRs will be ambiguous since the Identifier field and all state variables based on it are only 8 bits. It is assumed that the Link Quality Monitoring policy will be robust enough to handle this case (it should probably close down the link long before this happens).

Last-In-Id

Last-In-Id is an 8-bit state variable which stores the value of the last received Identifier. Last-In-Id should be updated after In-Tx-LQRs has been calculated.

In-Tx-Packets

In-Tx-Packets is a 32-bit state variable which indicates the number of packets which were transmitted on the inbound link during the last period. In-Tx-Packets is calculated by subtracting Last-Out-Tx-Packets-Ctr from the received Out-Tx-Packets-Ctr.

Last-Out-Tx-Packets-Ctr

Last-Out-Tx-Packets-Ctr is a 32-bit state variable which stores the value of the last received Out-Tx-Packets-Ctr. Last-Out-Tx-Packets-Ctr should be updated after In-Tx-Packets has been calculated.

In-Tx-Octets

In-Tx-Octets is a 32-bit state variable which indicates the number of octets which were transmitted on the inbound link during the last period. In-Tx-Octets is calculated by subtracting Last-Out-Tx-Octets-Ctr from the received Out-Tx-Octets-Ctr.

Last-Out-Tx-Octets-Ctr

Last-Out-Tx-Octets-Ctr is a 32-bit state variable which stores the value of the last received Out-Tx-Octets-Ctr. Last-Out-Tx-Octets-Ctr should be updated after In-Tx-Octets has been calculated.

In-Rx-Packets

In-Rx-Packets is a 32-bit state variable which indicates the number of packets which were received on the inbound link during the last period. In-Rx-Packets is calculated by subtracting Last-In-Rx-Packets-Ctr from the received In-Rx-Packets-Ctr.

Last-In-Rx-Packets-Ctr

Last-In-Rx-Packets-Ctr is a 32-bit state variable which stores the value of the last received In-Rx-Packets-Ctr. Last-In-Rx-Packets-Ctr should be updated after In-Rx-Packets has been calculated.

In-Rx-Octets

In-Rx-Octets is a 32-bit state variable which indicates the number of octets which were received on the inbound link during the last period. In-Rx-Octets is calculated by subtracting Last-In-Rx-Octets-Ctr from the received In-Rx-Octets-Ctr.

Last-In-Rx-Octets-Ctr

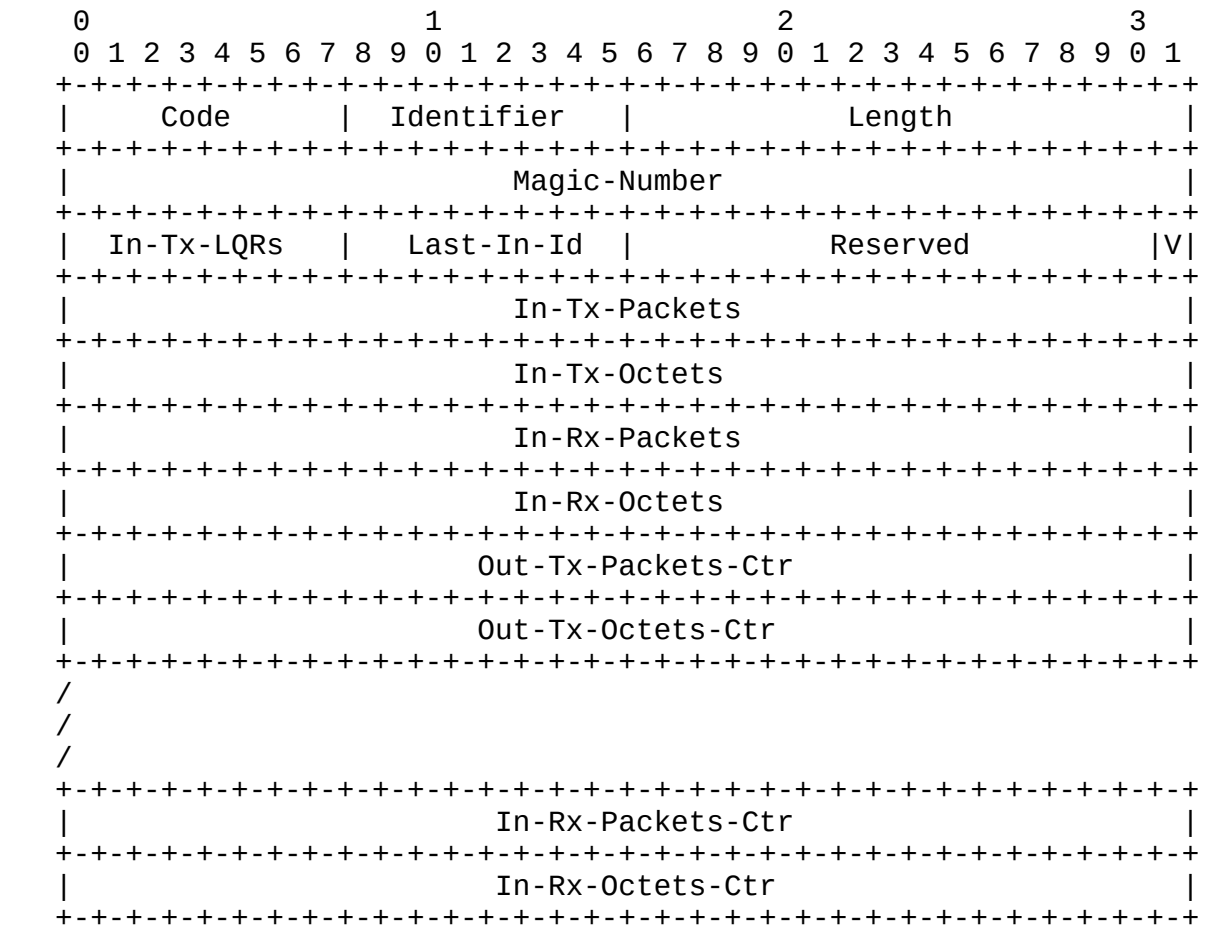
Last-In-Rx-Octets-Ctr is a 32-bit state variable which stores the value of the last received In-Rx-Octets-Ctr. Last-In-Rx-Octets-Ctr should be updated after In-Rx-Octets has been calculated.

Measurements-Valid

Measurements-Valid is a 1-bit boolean state variable which indicates whether or not the In-Tx-Packets, In-Tx-Octets, In-Rx-Packets, and In-Rx-Octets state variables contain valid measurements. These measurements cannot be considered valid until two or more Link-Quality-Report packets have been received on the inbound link. This bit should be reset when LCP reaches the Open state and should be set after the receipt of exactly two LQRs.

3.6. Link-Quality-Report Packet Format

A Summary of the Link-Quality-Report packet format is shown below. The fields are transmitted from left to right. The Code, Identifier, Length, and Magic-Number fields make up the normal LCP Link Maintenance packet header; the In-Tx-LQRS, Last-In-Id, V, In-Tx-Packets, In-Tx-Octets, In-Rx-Packets, In-Rx-Octets fields contain digested absolute measurements; and the Out-Tx-Packets-Ctr, Out-Tx-Octets-Ctr, In-Rx-Packets-Ctr, and In-Rx-Octets-Ctr fields contain raw relative counts. Note that as transmitted over the link, this packet format does not include the In-Rx-Packets-Ctr and In-Rx-Octets-Ctr fields which are logically appended to the packet by the Rx process after reception on the inbound link.



Code

12 for Link-Quality-Report.

Identifier

The Identifier field is one octet and indicates the sequence number for this Link-Quality-Report. The Identifier field is copied from the Out-Identifier-Ctr counter on transmission. On reception, the Identifier field is used to calculate In-Tx-LQRs and is then stored in Last-In-Id.

The Link-Quality-Report Identifier sequence number space MUST be separate from that of all other LCP packets; for example, transmission of an LCP Echo-Request must not cause the Out-Identifier-Ctr counter to be incremented.

Length

The Length field is two octets and indicates the length of the LQM packet including the Code, Identifier, Length and all defined fields. Octets outside the range of the length field should be treated as Data Link Layer padding and should be ignored on reception. In order for the correct In-Tx-Octets and In-Rx-Octets values to be calculated, Link-Quality-Reports MUST be consistently transmitted with the same amount of padding.

Magic-Number

The Magic-Number field is four octets and aids in detecting looped-back links. Unless modified by a Configuration Option, the Magic-Number MUST always be transmitted as zero and MUST always be ignored on reception. If Magic-Numbers have been negotiated, incoming LQM packets should be checked to make sure that the local end is not seeing its own Magic-Number and thus a looped-back link.

In-Tx-LQRs

The In-Tx-LQRs field is one octet and indicates the number of periods covered by the Measurements section of this Link-Quality-Report. The In-Tx-LQRs field is copied from the In-Tx-LQRs state variable on transmission.

Last-In-Id

The Prev-In-Id field is one octet and indicates the age of the Measurements section of this Link-Quality-Report. The Last-In-Id field is copied from the Last-In-Id field on transmission. On reception, the Last-In-Id field may be compared with the Out-Identifier-Ctr to determine how many, if any, outbound Link-Quality-Reports have been lost.

V

The V field is 1 bit and indicates whether or not the Measurements section of this Link-Quality-Report is valid. The V field is copied from the Measurements-Valid state variable on transmission. If the V field is not set to 1, then the In-Tx-LQRs, Last-In-Id, In-Tx-Packets, In-Tx-Octets, In-Rx-Packets and In-Rx-Octets fields should be ignored.

Reserved

The Reserved field is 15 bits and is intended to pad the remaining

packet fields to even four-octet boundaries for the convenience of hardware implementations. The Reserved field should always be transmitted as zero and ignored on reception.

In-Tx-Packets

The In-Tx-Packets field is four octets and indicates the number of packets transmitted on the inbound link of the Link-Quality-Report transmitter during the last measured period. The In-Tx-Packets field is copied from the In-Tx-Packets state variable on transmission.

In-Tx-Octets

The In-Tx-Octets field is four octets and indicates the number of octets transmitted on the inbound link of the Link-Quality-Report transmitter during the last measured period. The In-Tx-Octets field is copied from the In-Tx-Octets state variable on transmission.

In-Rx-Packets

The In-Rx-Packets field is four octets and indicates the number of packets received on the inbound link of the Link-Quality-Report transmitter during the last measured period. The In-Rx-Packets field is copied from the In-Rx-Packets state variable on transmission.

In-Rx-Octets

The In-Rx-Octets field is four octets and indicates the number of octets received on the inbound link of the Link-Quality-Report transmitter during the last measured period. The In-Rx-Octets field is copied from the In-Rx-Octets state variable on transmission.

Out-Tx-Packets

The Out-Tx-Packets field is four octets and is used to calculate the number of packets transmitted on the outbound link of the Link-Quality-Report transmitter during a period. The Out-Tx-Packets field is copied from the Out-Tx-Packets-Ctr counter on transmission.

Out-Tx-Octets

The Out-Tx-Octets field is four octets and is used to calculate the number of octets transmitted on the outbound link of the

Link-Quality-Report transmitter during a period. The Out-Tx-Octets field is copied from the Out-Tx-Octets-Ctr counter on transmission.

In-Rx-Packets

The In-Rx-Packets field is four octets and is used to calculate the number of packets received on the inbound link of the Link-Quality-Report receiver during a period. The In-Rx-Packets field is copied from the In-Rx-Packets-Ctr counter on reception. The In-Rx-Packets is not shown because it is not actually transmitted over the link. Rather, it is logically appended (in an implementation dependent manner) to the packet by the implementation's Rx process.

In-Rx-Octets

The In-Rx-Octets field is four octets and is used to calculate the number of octets received on the inbound link of the Link-Quality-Report receiver during a period. The In-Rx-Octets field is copied from the In-Rx-Octets-Ctr counter on reception. The In-Rx-Octets is not shown because it is not actually transmitted over the link. Rather, it is logically appended (in an implementation dependent manner) to the packet by the implementation's Rx process.

3.7. Policy Suggestions

Link-Quality-Report packets provide a mechanism to determine the link quality, but it is up to each implementation to decide when the link is usable. It is recommended that this policy implement some amount of hysteresis so that the link does not bounce up and down. A particularly good policy is to use a K out of N algorithm. In such an algorithm, there must be K successes out of the last N periods for the link to be considered of good quality.

Procedures for recovery from poor quality links are unspecified and may vary from implementation to implementation. A suggested approach is to immediately close all other Network-Layer protocols (i.e., cause IPCP to transmit a Terminate-Req), but to continue transmitting Link-Quality-Reports. Once the link quality again reaches an acceptable level, Network-Layer protocols can be reconfigured.

3.8. Example

An example may be helpful. Assume that Link-Manager implementation A transmits a Link-Quality-Report which is received by Link-Manager implementation B at time t0 with the following values:

```
Out-Tx-Packets    5
Out-Tx-Octets   100
In-Rx-Packets     3
In-Rx-Octets     70
```

Assume that A then transmits 20 IP packets with 200 octets, of which 15 packets and 150 octets are received by B. At time t1, A transmits another LQR which is received by B as follows:

```
Out-Tx-Packets   26 (5 old, plus 20 IP, plus 1 LQR)
Out-Tx-Octets   342 (42 for LQR)
In-Rx-Packets    19
In-Rx-Octets    262
```

Implementation B can now calculate the number of packets and octets transmitted, received and lost on its inbound link as follows:

```
In-Tx-Packets   =  26 -   5 =  21
In-Tx-Octets    = 342 - 100 = 242
In-Rx-Packets   =  10 -   3 =  16
In-Rx-Octets    = 262 -  70 = 192
In-Lost-Packets =  21 -  16 =   5
In-Lost-Octets  = 242 - 192 =  50
```

After doing these calculations, B evaluates the measurements in what ever way its implemented policy specifies. Also, the next time that B transmits an LQR to A, it will report these values in the Measurements section, thereby allowing A to evaluate these same measurements.

4. Password Authentication Protocol

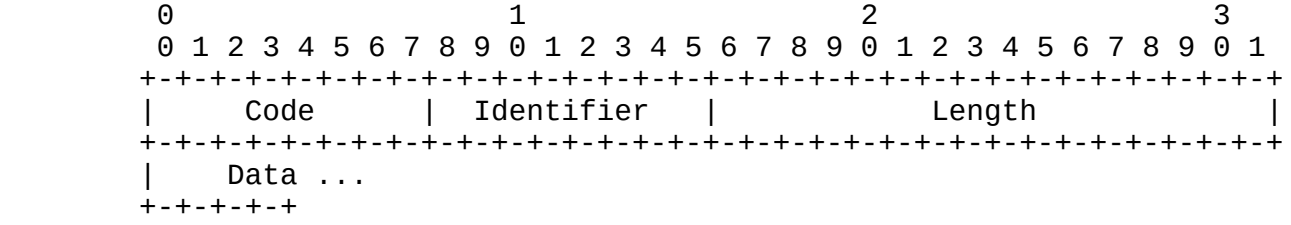
The Password Authentication Protocol (PAP) may be used to authenticate a peer by verifying the identity of the remote end of the link. Use of the PAP must first be negotiated using the LCP Authentication-Type Configuration Option. Successful negotiation adds an additional Authentication phase to the Link Control Protocol, after the Link Quality Determination phase, and before the Network Layer Protocol Configuration Negotiation phase. PAP packets received before the Authentication phase is reached should be silently discarded. The Authentication phase is exited once an Authenticate-Ack packet is sent or received.

PAP is intended for use primarily by hosts and routers that connect via switched circuits or dial-up lines to a PPP network server. The server can then use the identification of the connecting host or router in the selection of options for network layer negotiations or failing authentication, drop the connection.

Note that PAP is not a strong authentication method. Passwords are passed over the circuit in the clear and there is no protection from repeated trial and error attacks. Work is currently underway on more secure authentication methods for PPP and other protocols. It is strongly recommended to switch to these methods when they become available.

4.1. Packet Format

Exactly one Password Authentication Protocol packet is encapsulated in the Information field of PPP Data Link Layer frames where the protocol field indicates type hex c023 (Password Authentication Protocol). A summary of the Password Authentication Protocol packet format is shown below. The fields are transmitted from left to right.



Code

The Code field is one octet and identifies the type of PAP packet. PAP Codes are assigned as follows:

```
      1       Authenticate
      2       Authenticate-Ack
      3       Authenticate-Nak
```

Identifier

The Identifier field is one octet and aids in matching requests and replies.

Length

The Length field is two octets and indicates the length of the PAP packet including the Code, Identifier, Length and Data fields. Octets outside the range of the Length field should be treated as Data Link Layer padding and should be ignored on reception.

Data

The Data field is zero or more octets. The format of the Data field is determined by the Code field.

4.2. Authenticate

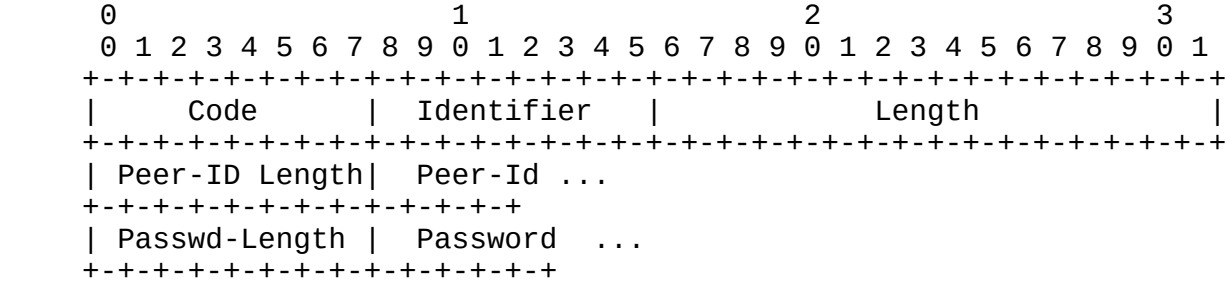
Description

The Authenticate packet is used to begin the Password Authentication Protocol. An implementation having sent a LCP Configure-Ack packet with an Authentication-Type Configuration Option further specifying the Password Authentication Protocol must send an Authenticate packet during the Authentication phase. An implementation receiving a Configure-Ack with said Configuration Option should expect the remote end to send an Authenticate packet during this phase.

An Authenticate packet is sent with the Code field set to 1 (Authenticate) and the Peer-ID and Password fields filled as desired.

Upon reception of an Authenticate, some type of Authenticate reply MUST be transmitted.

A summary of the Authenticate packet format is shown below. The fields are transmitted from left to right.



Code

1 for Authenticate.

Identifier

The Identifier field is one octet and aids in matching requests and replies. The Identifier field should be changed each time a Authenticate is transmitted which is different from the preceding request.

Peer-ID-Length

The Peer-ID-Length field is one octet and indicates the length of the Peer-ID field

Peer-ID

The Peer-ID field is zero or more octets and indicates the name of the peer to be authenticated.

Passwd-Length

The Passwd-Length field is one octet and indicates the length of the Password field

Password

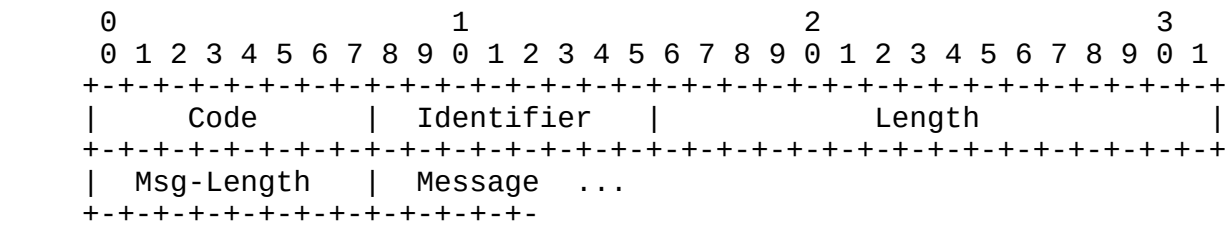
The Password field is zero or more octets and indicates the password to be used for authentication.

4.3. Authenticate-Ack

Description

If the Peer-ID/Password pair received in an Authenticate is both recognizable and acceptable, then a PAP implementation should transmit a PAP packet with the Code field set to 2 (Authenticate-Ack), the Identifier field copied from the received Authenticate, and the Message field optionally filled with an ASCII message.

A summary of the Authenticate-Ack packet format is shown below. The fields are transmitted from left to right.



Code

2 for Authenticate-Ack.

Identifier

The Identifier field is one octet and aids in matching requests and replies. The Identifier field MUST be copied from the Identifier field of the Authenticate which caused this Authenticate-Ack.

Msg-Length

The Msg-Length field is one octet and indicates the length of the Message field

Message

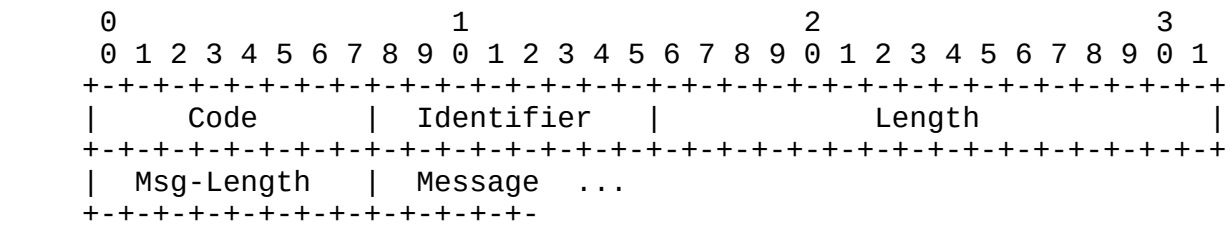
The Message field is zero or more octets and indicates an ASCII message.

4.4. Authenticate-Nak

Description

If the Peer-ID/Password pair received in a Authenticate is not recognizable or acceptable, then a PAP implementation should transmit a PAP packet with the Code field set to 3 (Authenticate-Nak), the Identifier field copied from the received Authenticate, and the Message field optionally filled with an ASCII message.

A summary of the Authenticate-Nak packet format is shown below. The fields are transmitted from left to right.



Code

3 for Authenticate-Nak.

Identifier

The Identifier field is one octet and aids in matching requests and replies. The Identifier field MUST be copied from the Identifier field of the Authenticate which caused this Authenticate-Nak.

Msg-Length

The Msg-Length field is one octet and indicates the length of the Message field

Message

The Message field is zero or more octets and indicates an ASCII message.

5. IP Control Protocol (IPCP) Configuration Options

IPCP Configuration Options allow negotiatiation of desirable Internet Protocol parameters. Negotiable modifications proposed in this document include IP addresses and compression protocols.

The initial proposed values for the IPCP Configuration Option Type field (see [1]) are assigned as follows:

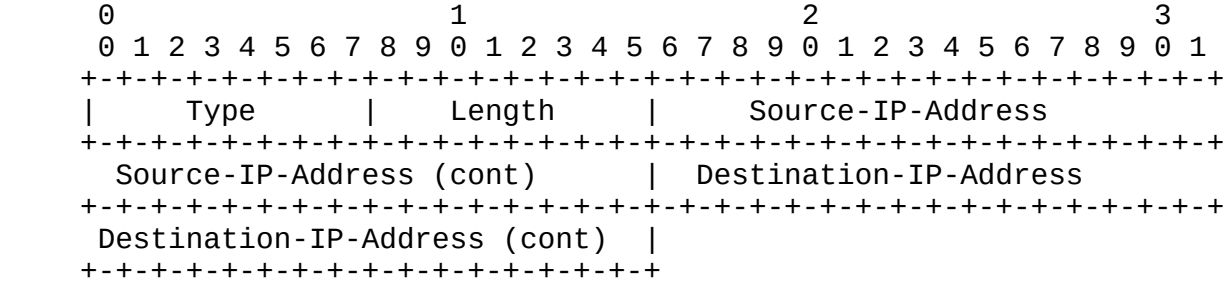
1	IP-Addresses
2	Compression-Type

5.1. IP-Addresses

Description

This Configuration Option provides a way to negotiate the IP addresses to be used on each end of the link. By default, no IP addresses are assigned to either end. An address specified as zero shall be interpreted as requesting the remote end to specify the address. If an implementation allows the assignment of multiple IP addresses, then it may include multiple IP Address Configuration Options in its Configure-Request packets. An implementation receiving a Configure-Request specifying multiple IP Address Configuration Options may send a Configure-Reject specifying one or more of the specified IP Addresses. An implementation which desires that no IP addresses be assigned (such as a "half-gateway") may reject all IP Address Configuration Options.

A summary of the IP-Addresses Configuration Option format is shown below. The fields are transmitted from left to right.



Type

1

Length

10

Source-IP-Address

The four octet Source-IP-Address is the desired local address of the sender of a Configure-Request. In a Configure-Ack, Configure-Nak or Configure-Reject, the Source-IP-Address is the remote address of the sender, and is thus a local address with respect to the Configuration Option receiver.

Destination-IP-Address

The four octet Destination-IP-Address is the remote address with respect to the sender of a Configure-Request. In a Configure-Ack, Configure-Nak or Configure-Reject, the Destination-IP-Address is the local address of the sender, and is thus a remote address with respect to the Configuration Option receiver.

Default

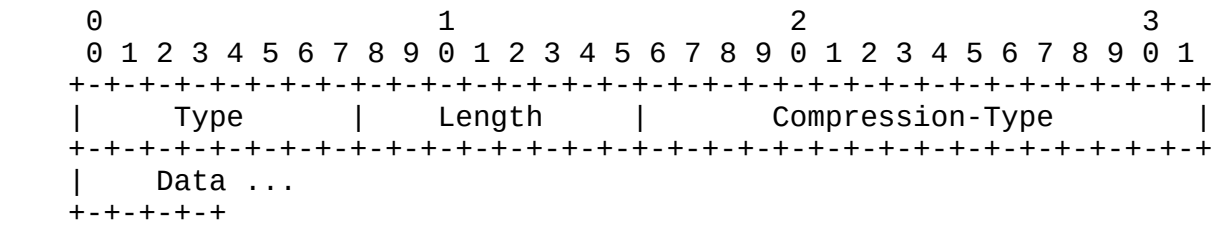
No IP addresses assigned.

5.2. Compression-Type

Description

This Configuration Option provides a way to negotiate the use of a specific compression protocol. By default, compression is not enabled.

A summary of the Compression-Type Configuration Option format is shown below. The fields are transmitted from left to right.



Type

2

Length

>= 4

Compression-Type

The Compression-Type field is two octets and indicates the type of compression protocol desired. Values for the Compression-Type are always the same as the PPP Data Link Layer Protocol field values for that same compression protocol. The most up-to-date values of the Compression-Type field are specified in "Assigned Numbers" [2]. Initial values are assigned as follows:

Value (in hex)	Protocol
0037	Van Jacobson Compressed TCP/IP

Data

The Data field is zero or more octets and contains additional data as determined by the compression protocol indicated in the Compression-Type field.

Default

No compression protocol enabled.

References

[1] Perkins, D., "The Point-to-Point Protocol for the Transmission of Multi-Protocol of Datagrams Over Point-to-Point Links", RFC 1171, July, 1990.

[2] Reynolds, J., and J. Postel, "Assigned Numbers", RFC 1060, USC/Information Sciences Institute, March 1990.

Security Considerations

Security issues are discussed in Section 2.3.

Author's Address

This proposal is the product of the Point-to-Point Protocol Working Group of the Internet Engineering Task Force (IETF). The working group can be contacted via the chair:

Russ Hobby
UC Davis
Computing Services
Davis, CA 95616

Phone: (916) 752-0236

EMail: rdhobby@ucdavis.edu

Questions about this memo can also be directed to:

Drew D. Perkins
Carnegie Mellon University
Networking and Communications
Pittsburgh, PA 15213

Phone: (412) 268-8576

EMail: ddp@andrew.cmu.edu

Acknowledgments

Many people spent significant time helping to develop the Point-to-Point Protocol. The complete list of people is too numerous to list, but the following people deserve special thanks: Ken Adelman (TGV), Craig Fox (NSC), Phill Gross (NRI), Russ Hobby (UC Davis), David Kaufman (Proteon), John LoVerso (Xylogics), Bill Melohn (Sun Microsystems), Mike Patton (MIT), Drew Perkins (CMU), Greg Satz (cisco systems) and Asher Waldfogel (Wellfleet).