University of Glasgow
School of Computing Science

Parsing Protocol Standards

draft-mcquistin-augmented-ascii-diagrams

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Virtual Formal Languages Side Meeting
15 May 2020

Improving protocol standards

- **Goal: shift towards a test-driven development style approach, where running a suite of validation and verification tools over a standards document becomes commonplace**
- Don’t want to replace the process, but to augment it

Describing protocol parsing

- First aim: build a tool that allows for a parser for the specified protocol to be generated automatically

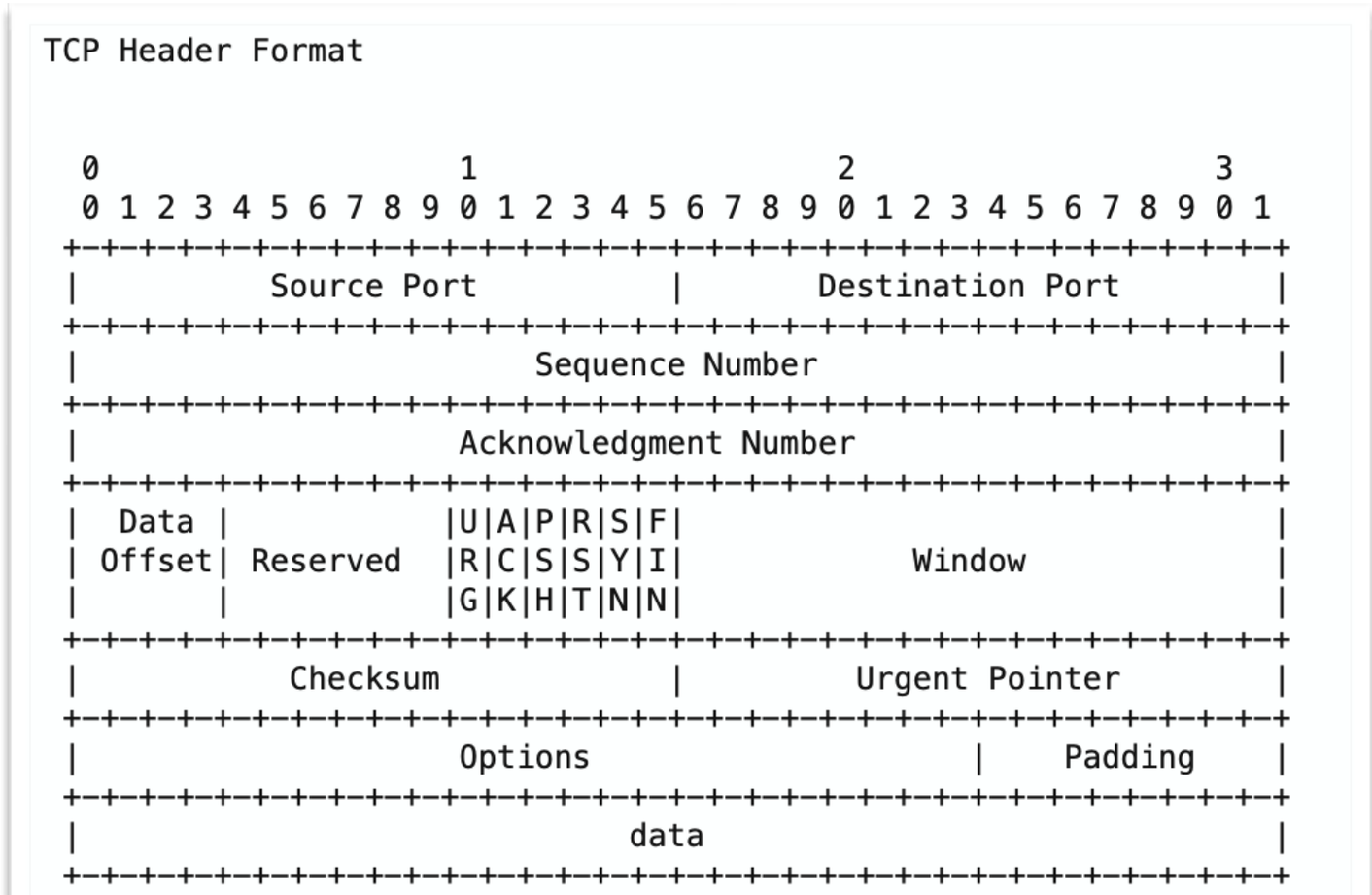
- Need a machine-readable description of the protocol's data units, and all the metadata needed to parse them

- Good place to start: knowing what the protocol looks like forms the basis of more complex tools

Design principles

- Most readers are human
- Authorship tools are diverse
- Canonical specifications
- Expressiveness
- Minimise required change

ASCII packet diagrams



TCP Header Format

Note that one tick mark represents one bit position.

Figure 3.

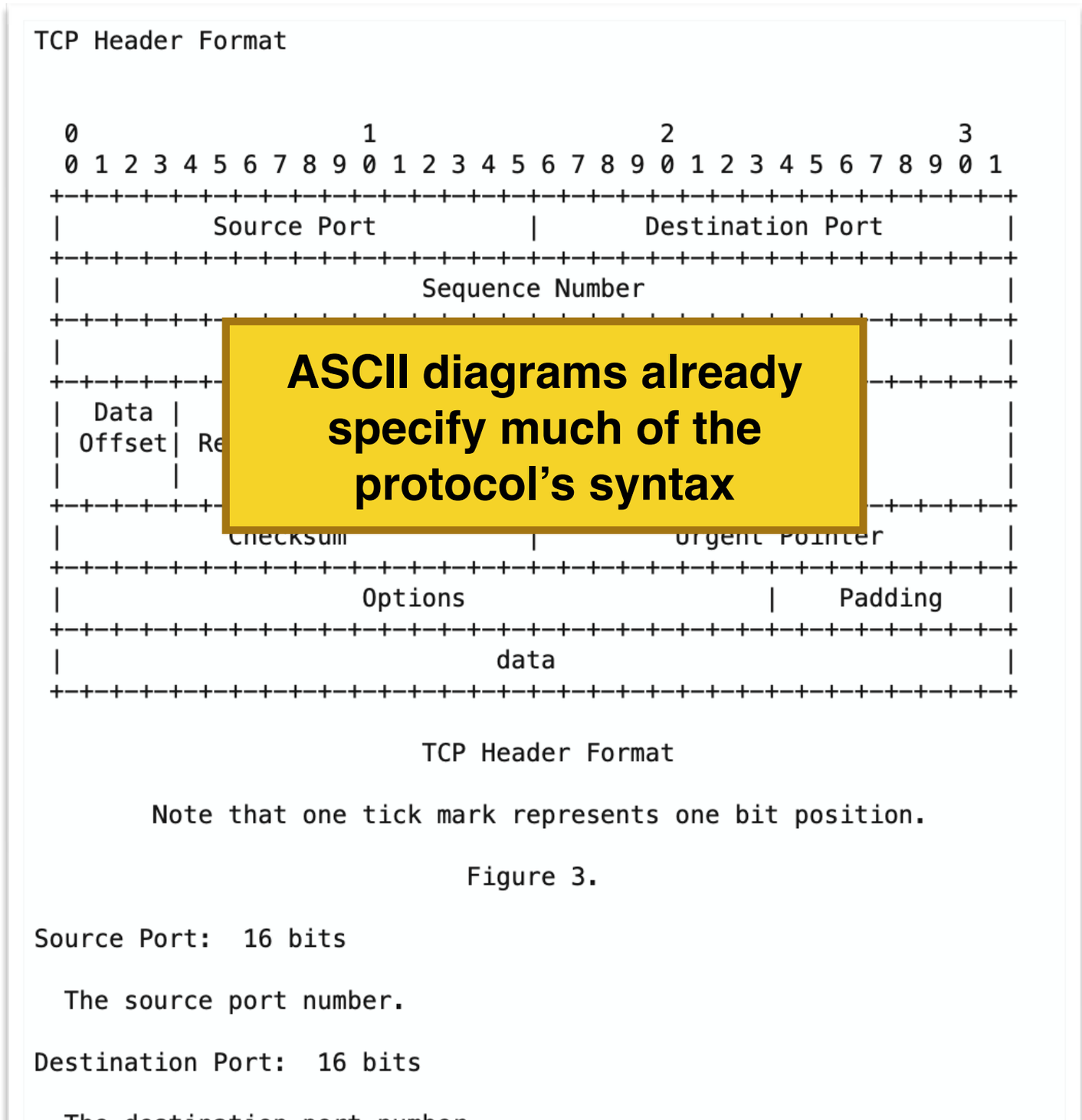
Source Port: 16 bits

  The source port number.

Destination Port: 16 bits

  The destination port number.

ASCII packet diagrams



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ASCII packet dia

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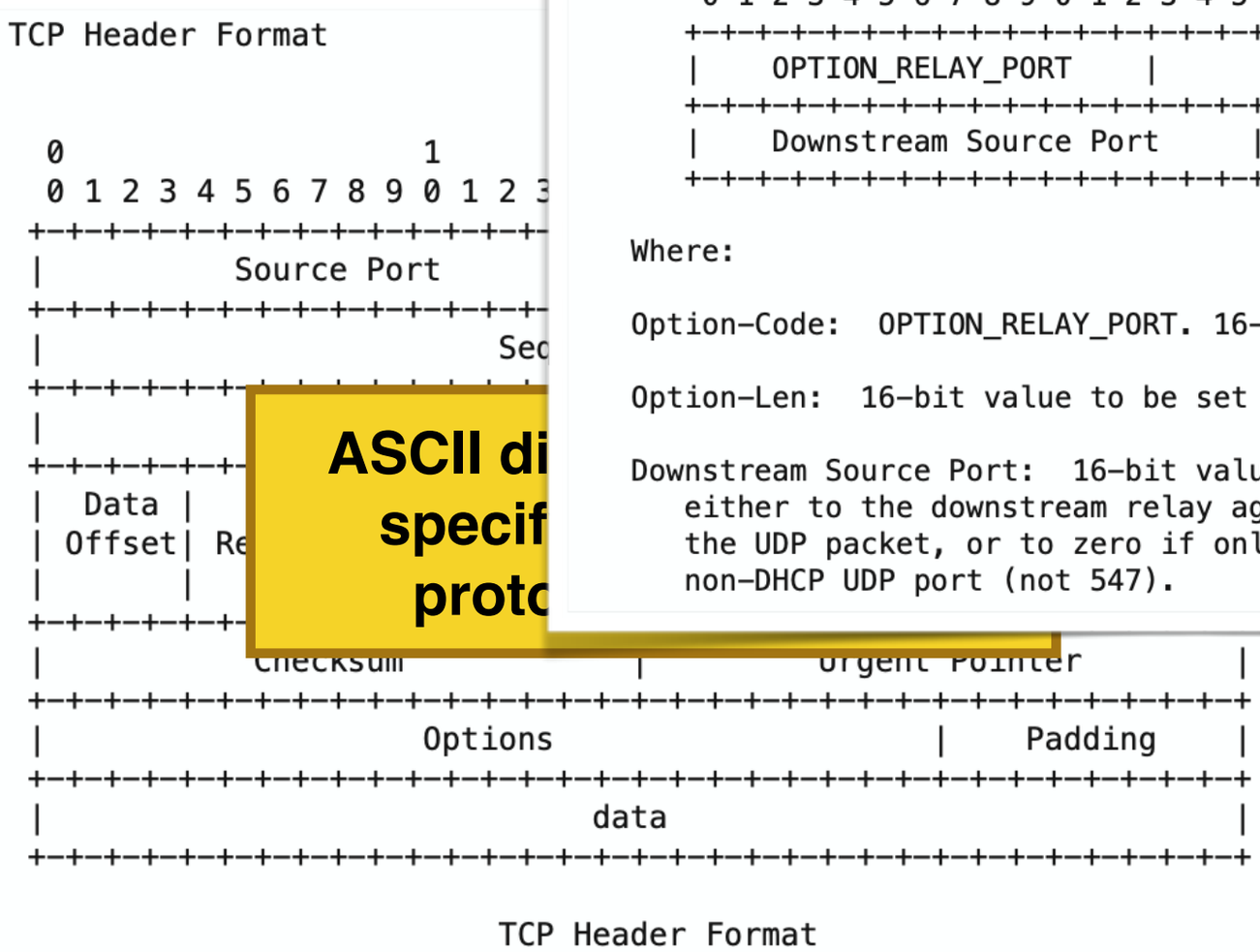

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ASCII di
specif
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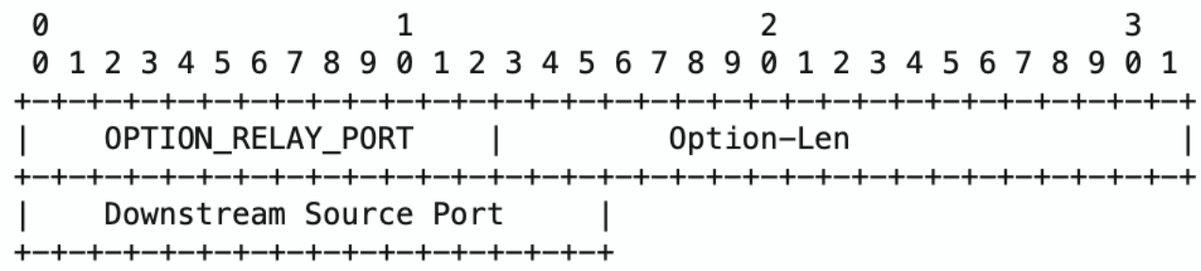
4.2. Relay Source Port Option for DHCPv6

The "Relay Source Port Option" is a new DHCPv6 option. It MUST be used by either 1) a DHCPv6 relay agent that uses a non-DHCP UDP port (not 547) communicating with the IPv6 server and the upstream relay agent or 2) an IPv6 relay agent that detects the use of a non-DHCP UDP port (not 547) by a downstream relay agent.

The format of the "Relay Source Port Option" is shown below:



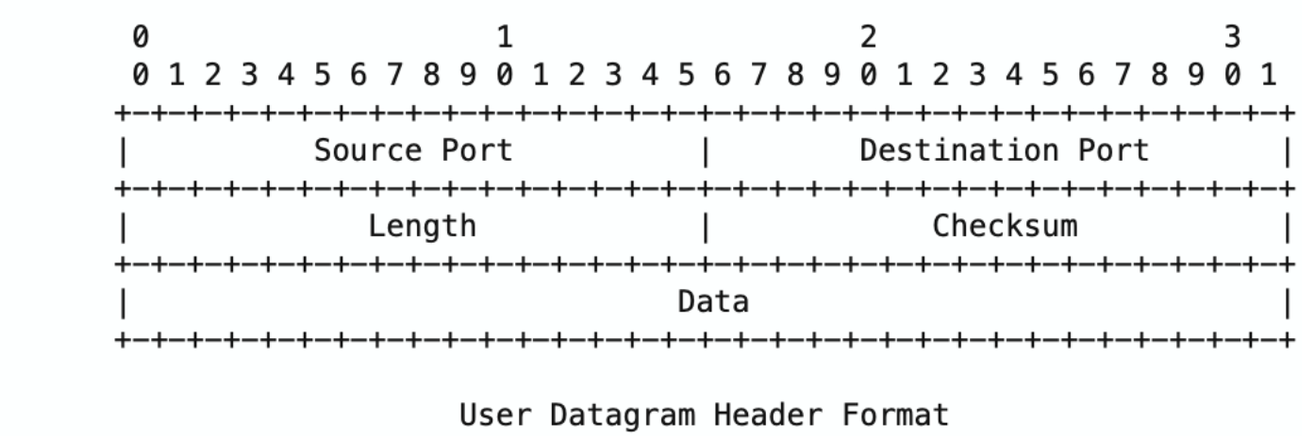
Where:

Option-Code: OPTION_RELAY_PORT. 16-bit value, 135.

Option-Len: 16-bit value to be set to 2.

Downstream Source Port: 16-bit value. To be set by the IPv6 relay either to the downstream relay agent's UDP source port used for the UDP packet, or to zero if only the local relay agent uses the non-DHCP UDP port (not 547).

Format



User Datagram Header Format

Fields

Source Port is an optional field, when meaningful, it indicates the port of the sending process, and may be assumed to be the port to which a reply should be addressed in the absence of any other information. If not used, a value of zero is inserted.

Destination Port has a meaning within the context of a particular internet destination address.

Length is the length in octets of this user datagram including this header and the data. (This means the minimum value of the length is eight.)

Checksum is the 16-bit one's complement of the one's complement sum of a pseudo header of information from the IP header, the UDP header, and the data, padded with zero octets at the end (if necessary) to make a multiple of two octets.

The pseudo header conceptually prefixed to the UDP header contains the source address, the destination address, the protocol, and the UDP length. This information gives protection against misrouted datagrams. This checksum procedure is the same as is used in TCP.

4.2. Relay Source Port Option for DHCPv6

ay Source Port Option" is a new DHCPv6 option. It MUST be either 1) a DHCPv6 relay agent that uses a non-DHCP UDP port) communicating with the IPv6 server and the upstream relay 2) an IPv6 relay agent that detects the use of a non-DHCP (not 547) by a downstream relay agent.

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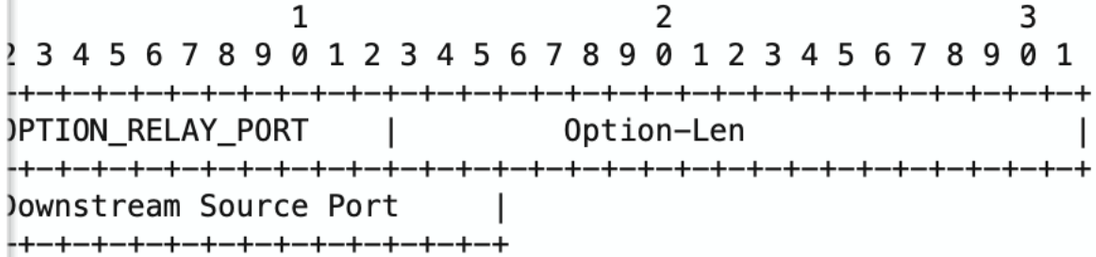

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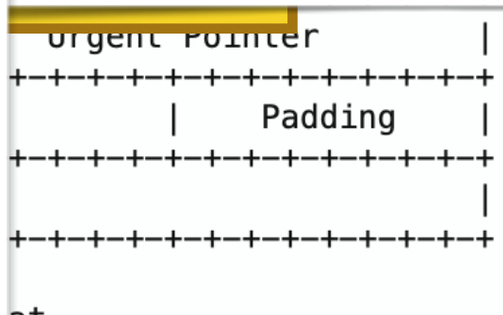

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```
                    1                   2                   3
8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|          Source Port          |       Destination Port        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|             Length            |            Checksum           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                               Data                            |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

User Datagram Header Format

Fields

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of the sending process, and may be assumed to be the port to which
reply should be addressed in the absence of any other information.
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This checksum procedure is the same as is used in TCP.

4.1. Availability SCSI-TLV

The Generalized SCSI is defined in [RFC8258]. This document d
a new type of Generalized SCSI-TLV called the Availability SCS
The Availability SCSI-TLV can be included one or more times.
the following format:

```
 0                   1                   2
 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|               Type            |             Length
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                   Availability level
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                   LSP Bandwidth at Availability level n
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Type: 0x000A, 16 bits

Length: 2 octets (16 bits)

Availability level: 32 bits

This field is a binary32-format floating-point number as
defined by [IEEE754-2008]. The bytes are transmitted in
network order; that is, the byte containing the sign bit
transmitted first. This field describes the decimal val
the availability guarantee of the Switching Capability i
Interface Switching Capability Descriptor object [RFC420
The value MUST be less than 1. The Availability level f
usually expressed as the value 0.99/0.999/0.9999/0.99999

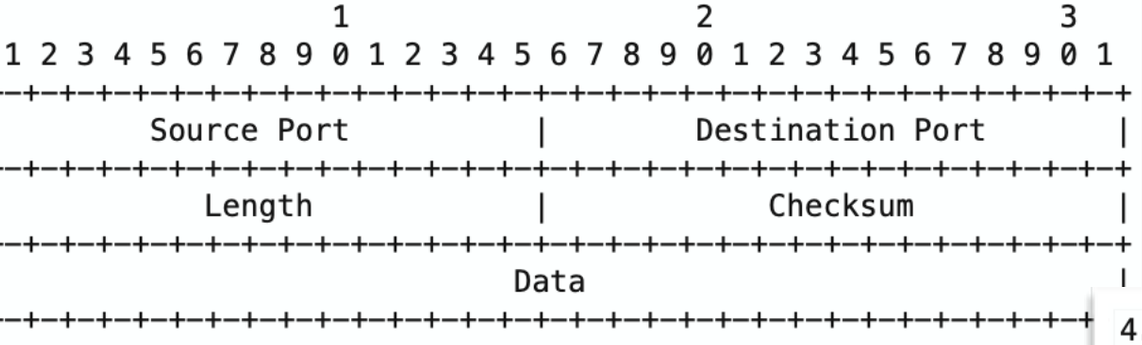
Source Port: 16 bits

The source port number.

Destination Port: 16 bits

The destination port number.

Format



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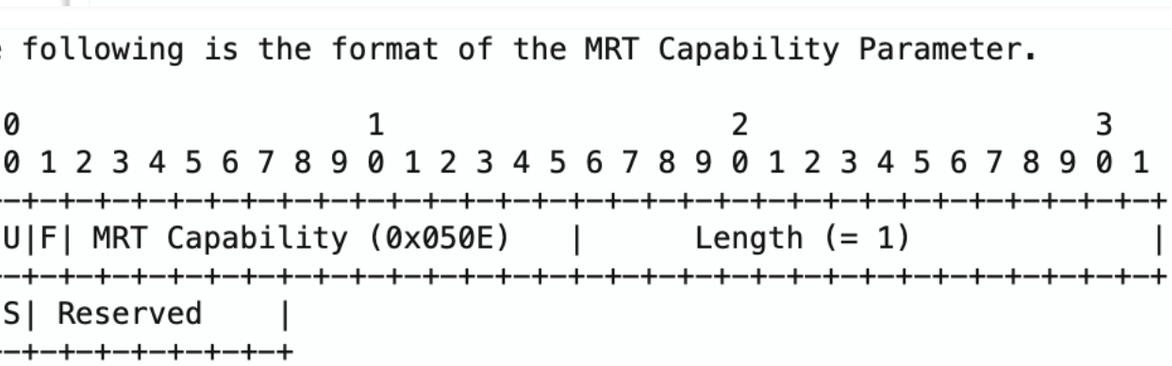
following is the format of the MRT Capability Parameter.



MRT Capability TLV Format

re:

it: The unknown TLV bit MUST be 1. A router that does not
recognize the MRT Capability TLV will silently ignore the TLV and
process the rest of the message as if the unknown TLV did not
exist.

it: The forward unknown TLV bit MUST be 0 as required by
Section 3 of [RFC5561].

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datagram

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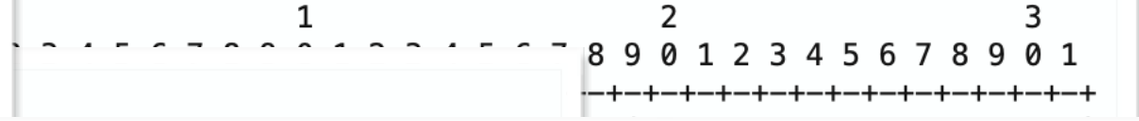

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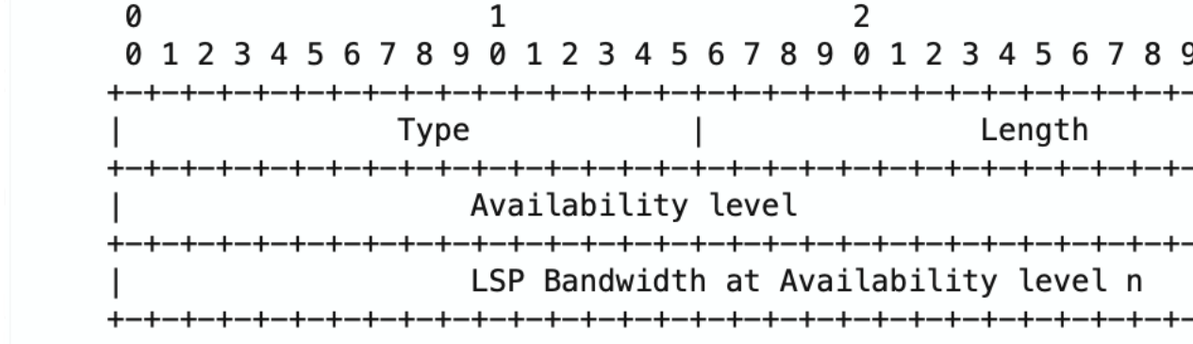

Type: 0x000A, 16 bits

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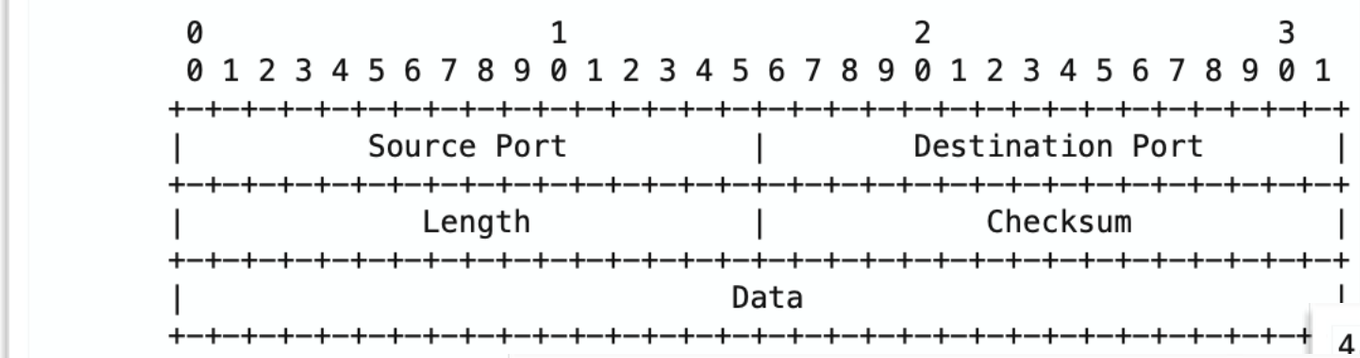

Fields

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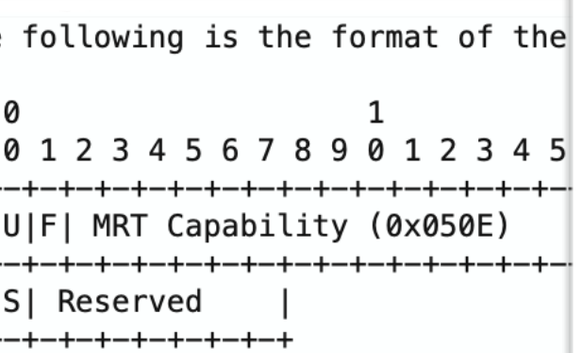

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2. ICMP Extended Echo Request

The ICMP Extended Echo Request message is defined for both ICMPv4 and ICMPv6. Like any ICMP message, the ICMP Extended Echo Request message is encapsulated in an IP header. The ICMPv4 version of the Extended Echo Request message is encapsulated in an IPv4 header, while the ICMPv6 version is encapsulated in an IPv6 header.

Figure 1 depicts the ICMP Extended Echo Request message.

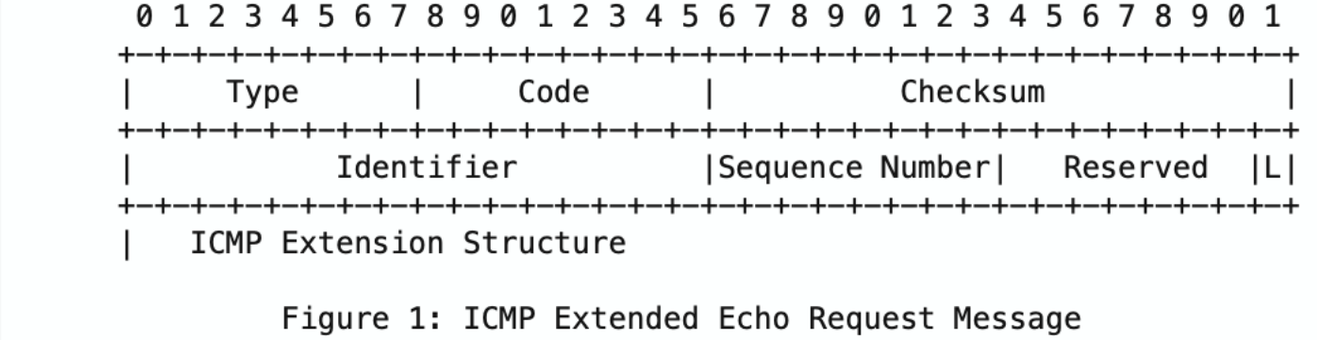

Figure 1: ICMP Extended Echo Request Message

IP Header fields:

- Source Address: The Source Address identifies the probing interface. It MUST be a valid IPv4 or IPv6 unicast address.

- Destination Address: The Destination Address identifies the proxy interface. It MUST be a unicast address.

ICMP fields:

- Type: Extended Echo Request. The value for ICMPv4 is 42. The value for ICMPv6 is 160.

- Code: MUST be set to 0 and MUST be ignored upon receipt.

The FEC type for the P2MP PW Upstream FEC Element is encoded as follows:

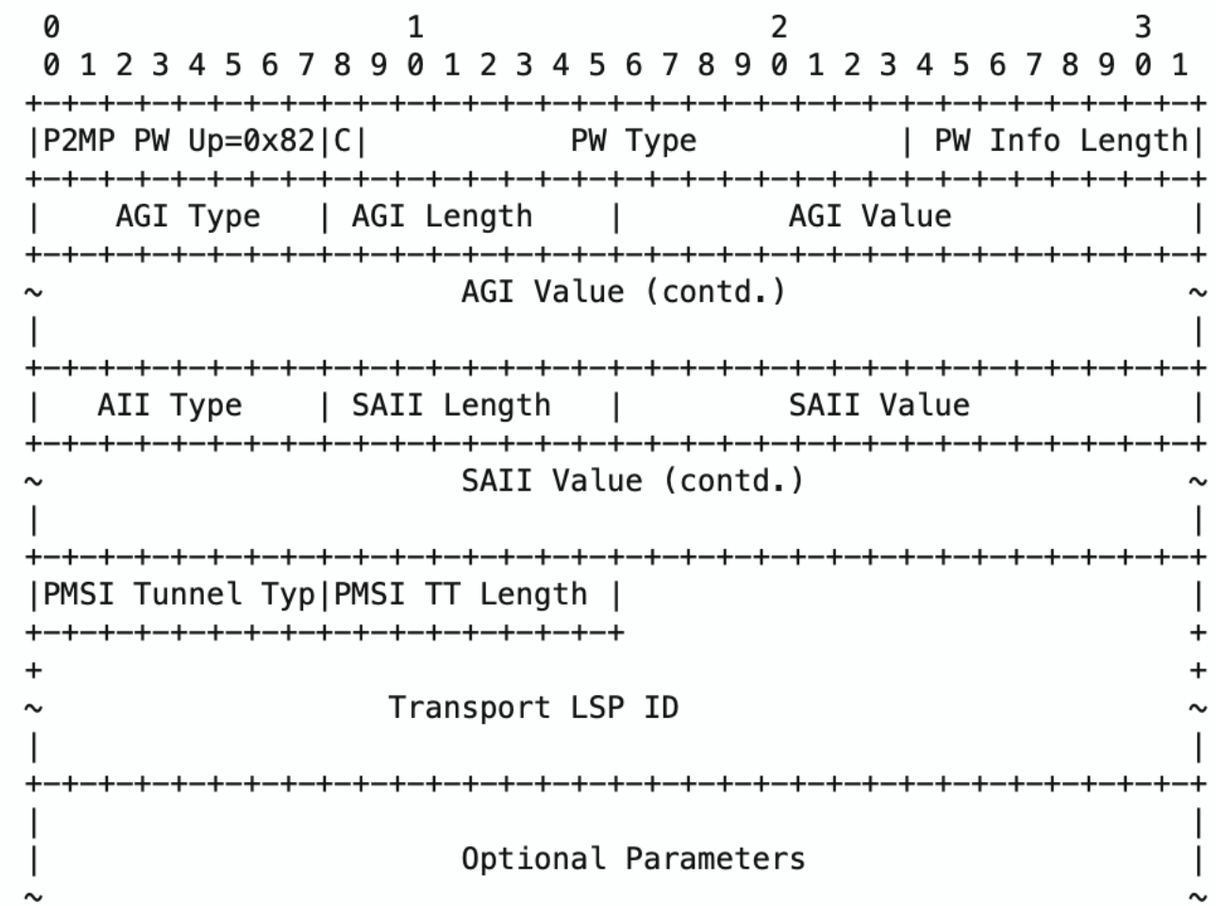

Figure 2: P2MP PW Upstream FEC Element

* P2MP PW Up:

  8-bit representation for the P2MP PW Upstream FEC type.

* C bit:

  A value of 1 or 0 indicating whether a control word is present or absent for the P2MP PW.

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lated in an IPv6 header.

Echo Request message.

Echo Request Message

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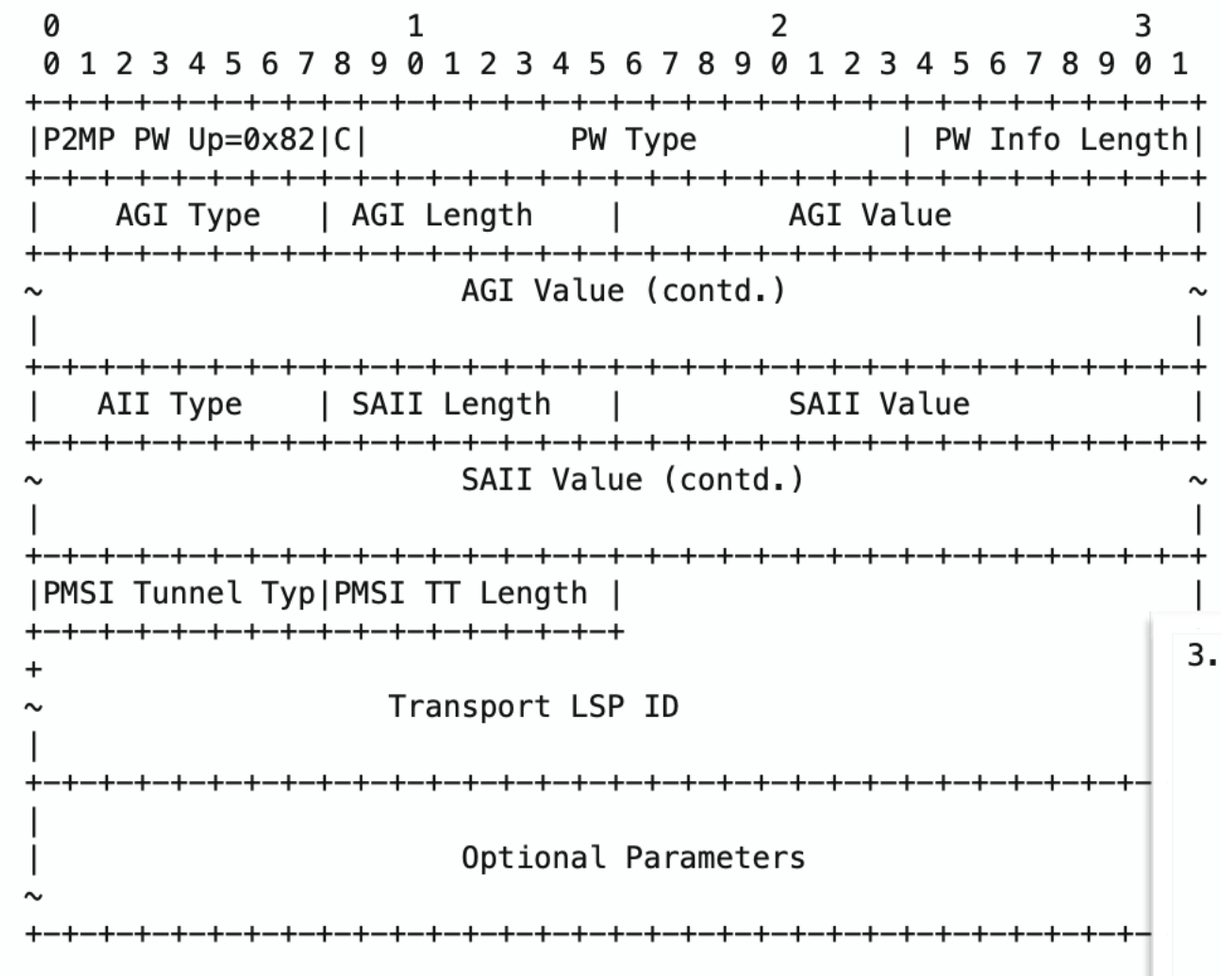

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3.2. Message Format

The CoAP message format defined in [RFC7252], as shown in Figure 3, relies on the datagram transport (UDP, or DTLS over UDP) for keeping the individual messages separate and for providing length information.

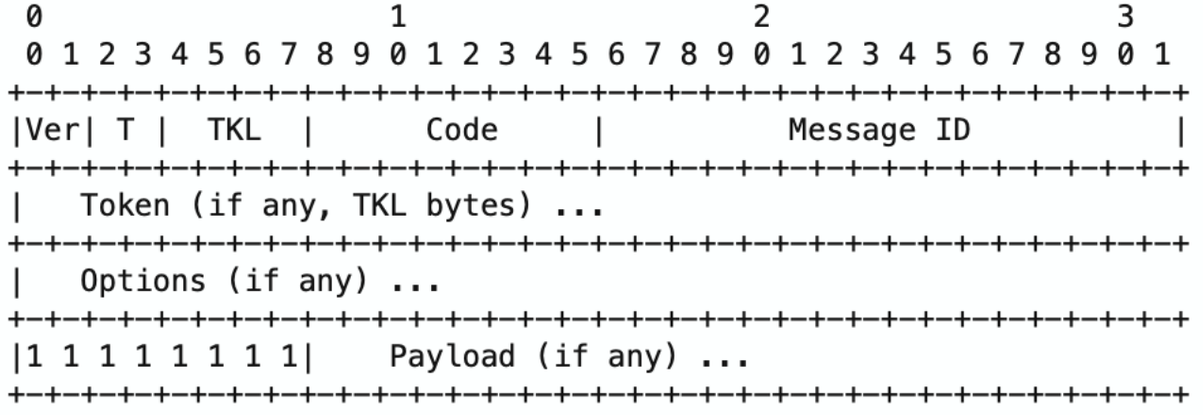

Figure 3: CoAP Message Format as Defined in RFC 7252

The message format for CoAP over TCP is very similar to the format specified for CoAP over UDP. The differences are as follows:

o Since the underlying TCP connection provides retransmissions and deduplication, there is no need for the reliability mechanisms provided by CoAP over UDP. The Type (T) and Message ID fields in the CoAP message header are elided.

o The Version (Vers) field is elided as well. In contrast to the message format of CoAP over UDP, the message format for CoAP over

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o Destination Address: The D
interface. It MUST be a u

ICMP fields:

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o Code: MUST be set to 0 and

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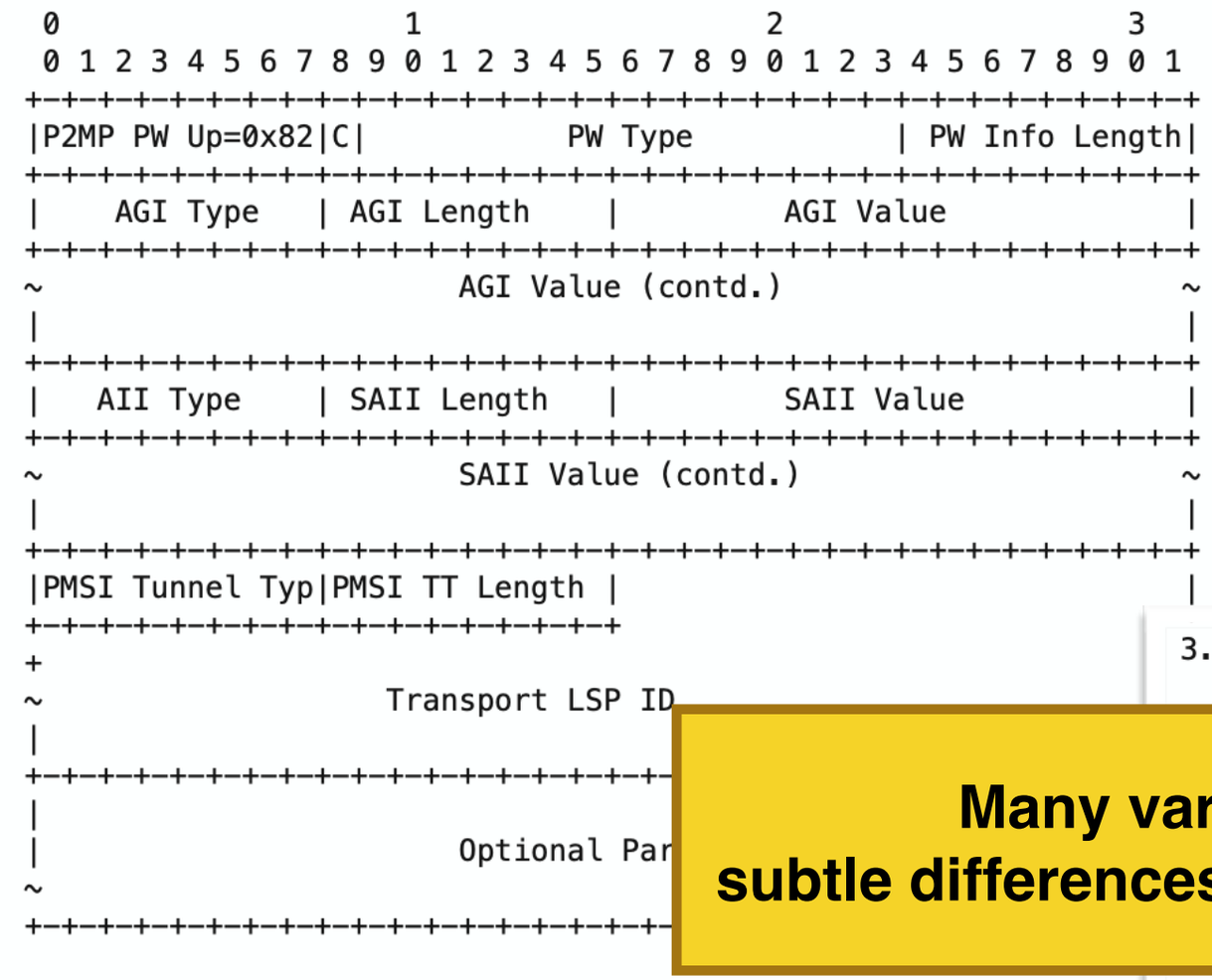

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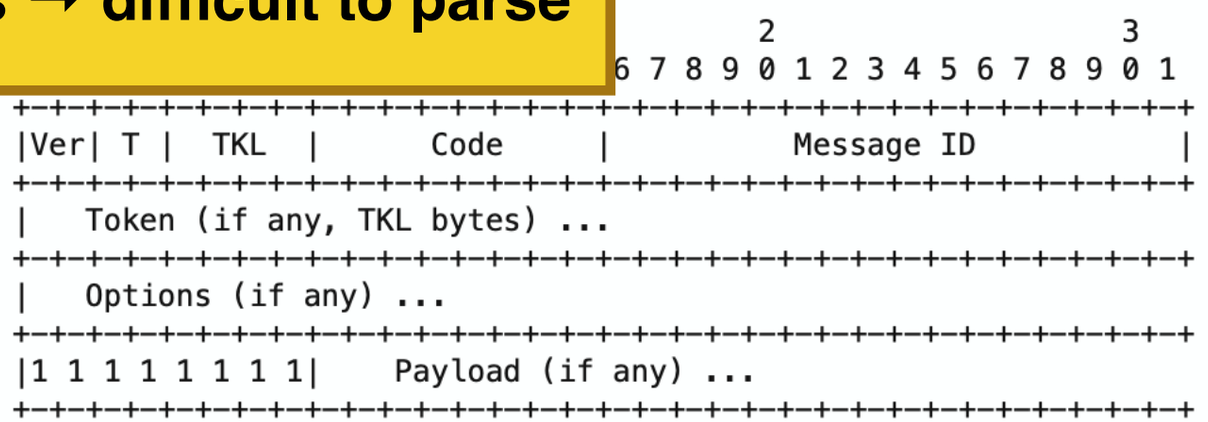

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value for ICMPv6 is 160.

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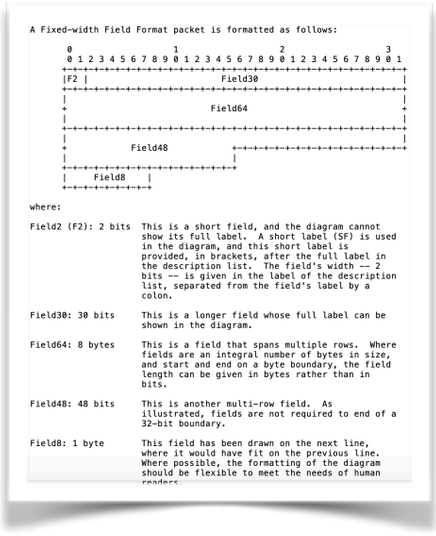
Many variations with subtle differences → difficult to parse

Augmented ASCII diagrams

- Much can be achieved just by being consistent
- Need other elements: constraints on field values, optional fields, links between PDUs, …
- Adheres to the design principles given earlier

Parsing protocol standards



A Fixed-width Field Format packet is formatted as follows:

```
      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
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
     |F2 |                     Field30                               |
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
     |                                                               |
     +                            Field64                            +
     |                                                               |
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
     |                                                               |
     +             Field48           +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
     |                               |
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
     |    Field8     |
     +-+-+-+-+-+-+-+-+
```

where:

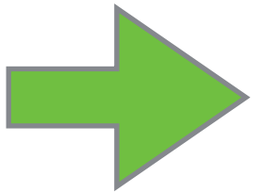
Field2 (F2): 2 bits — This is a short field, and the diagram cannot show its full label. A short label (SF) is used in the diagram, and this short label is provided, in brackets, after the full label in the description list. The field's width -- 2 bits -- is given in the label of the description list, separated from the field's label by a colon.

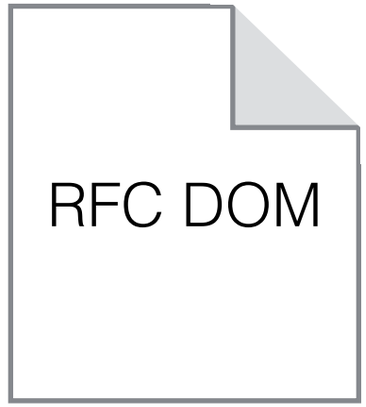
Field30: 30 bits — This is a longer field whose full label can be shown in the diagram.

Field64: 8 bytes — This is a field that spans multiple rows. Where fields are an integral number of bytes in size, and start and end on a byte boundary, the field length can be given in bytes rather than in bits.

Field48: 48 bits — This is another multi-row field. As illustrated, fields are not required to end of a 32-bit boundary.

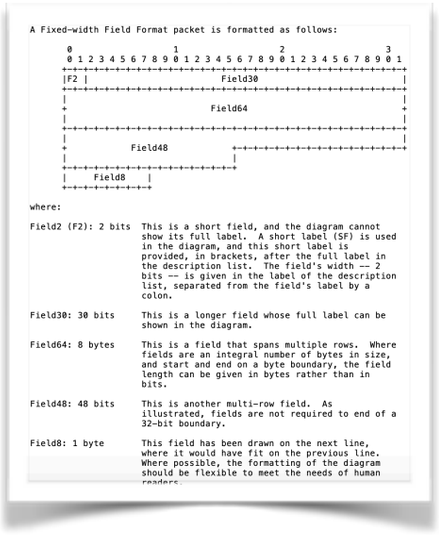
Field8: 1 byte — This field has been drawn on the next line, where it would have fit on the previous line. Where possible, the formatting of the diagram should be flexible to meet the needs of human readers.





- Parse input into an RFC document object model
- RFC DOM is already well specified
- Allows for different input formats

Parsing protocol standards



A Fixed-width Field Format packet is formatted as follows:

```
      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
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
     |F2 |                     Field30                               |
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
     |                                                               |
     +                          Field64                              +
     |                                                               |
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
     |                                                               |
     +            Field48            +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
     |                               |
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
     |    Field8     |
     +-+-+-+-+-+-+-+-+
```

where:

Field2 (F2): 2 bits	This is a short field, and the diagram cannot show its full label. A short label (SF) is used in the diagram, and this short label is provided, in brackets, after the full label in the description list. The field's width -- 2 bits -- is given in the label of the description list, separated from the field's label by a colon.
Field30: 30 bits	This is a longer field whose full label can be shown in the diagram.
Field64: 8 bytes	This is a field that spans multiple rows. Where fields are an integral number of bytes in size, and start and end on a byte boundary, the field length can be given in bytes rather than in bits.
Field48: 48 bits	This is another multi-row field. As illustrated, fields are not required to end of a 32-bit boundary.
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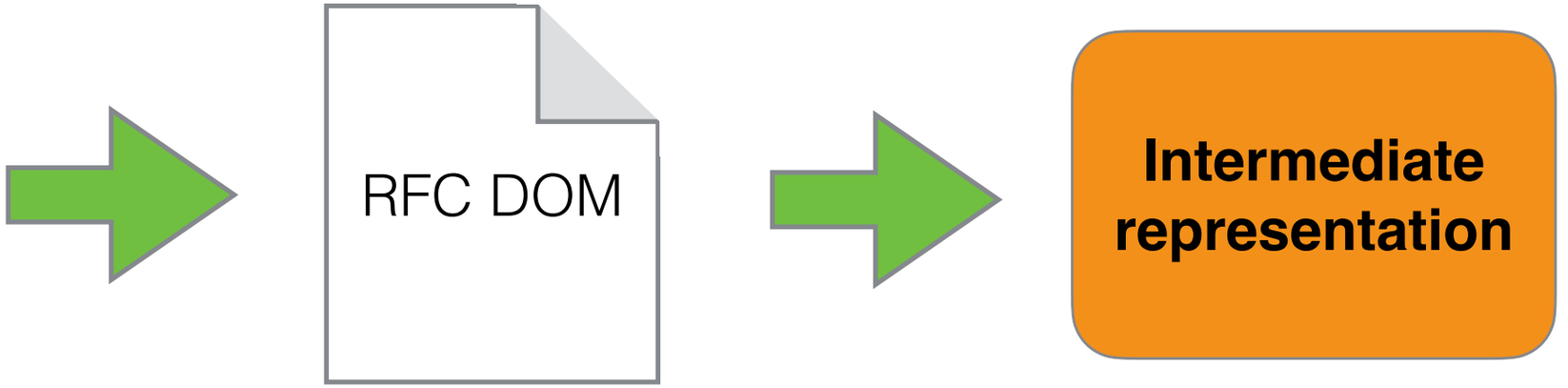
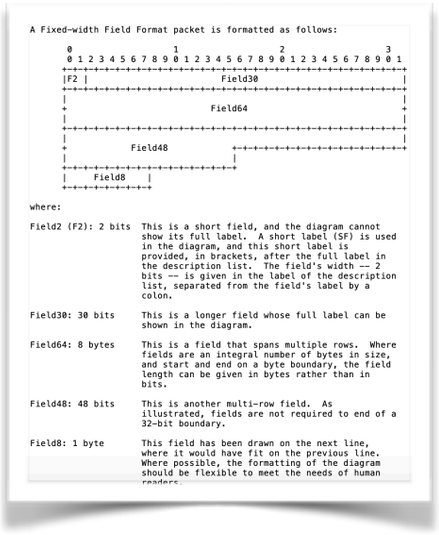


- Extract a protocol definition from the RFC DOM, and capture it in an intermediate representation
- Captures the syntax of the protocol and how to parse it
- Allows for different input languages, whose expressivity might vary

Parsing protocol standards



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     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
     |F2 |                     Field30                               |
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
     |                                                               |
     +                          Field64                              +
     |                                                               |
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
     |                                                               |
     +            Field48            +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
     |                               |
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
     |    Field8     |
     +-+-+-+-+-+-+-+-+
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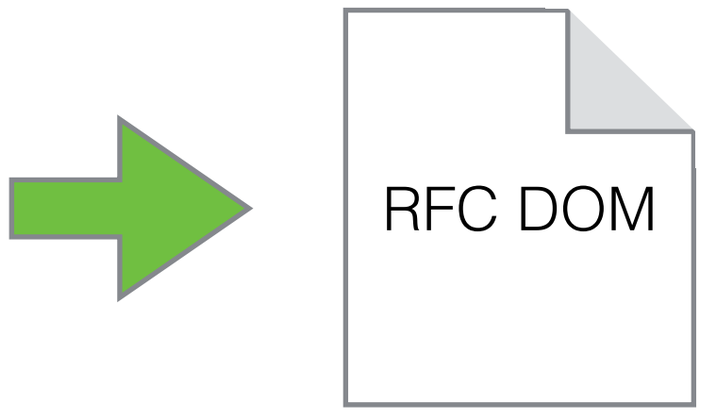
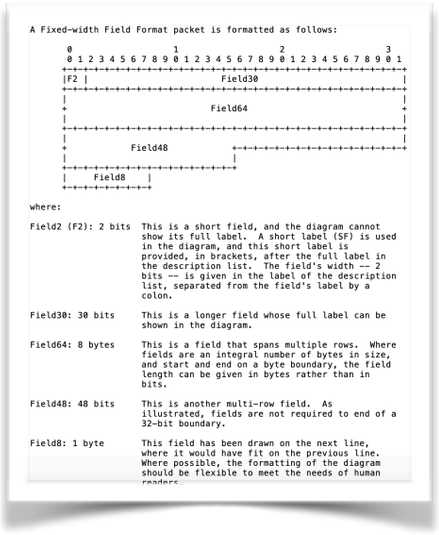


- Intermediate representation captures all of metadata required to parse the protocol
- The layout of each PDU
- Parsing context for out-of-band data
- Helper methods for encrypted fields

Parsing protocol standards



A Fixed-width Field Format packet is formatted as follows:

```
      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
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
     |F2 |                    Field30                                  |
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
     |                                                               |
     +                          Field64                              +
     |                                                               |
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
     |                                                               |
     +            Field48            +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
     |                               |
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
     |    Field8     |
     +-+-+-+-+-+-+-+-+
```

where:

Field2 (F2): 2 bits	This is a short field, and the diagram cannot show its full label. A short label (SF) is used in the diagram, and this short label is provided, in brackets, after the full label in the description list. The field's width -- 2 bits -- is given in the label of the description list, separated from the field's label by a colon.
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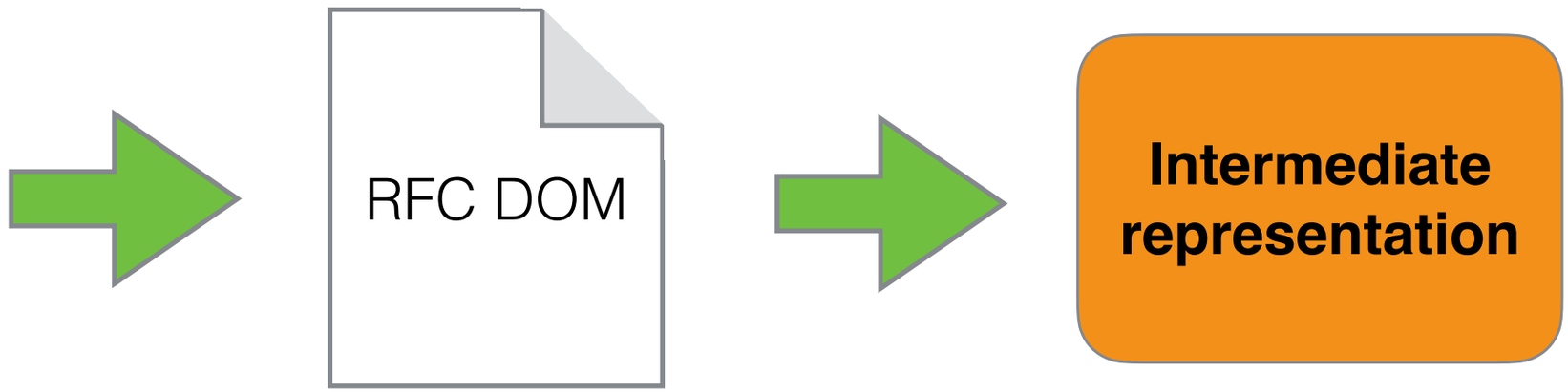
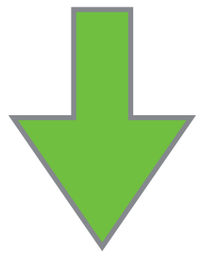


- Generate parser code from the intermediate representation
- Split means that a parser generator only needs to be written once per output language



Summary

- IETF standardisation process can create ambiguous standards: want to introduce tooling without harming the parts of the process that work well

- ASCII diagrams already capture much of a protocol's syntax

- Augmenting ASCII diagrams and using them consistently allows tooling to extract protocol syntax

- Capturing protocol parsing in a common intermediary format allows for flexibility

- Automated parser generation from the intermediary format enables test-driven development → better standards