CACE Technologies

Per-Packet Information Header Specification

Version 1.0.9

Revision History

Date	Version	Description	Author
04/16/2007	0.6	Updated 802.11 common and 802.11n header, split now into 802.11n basic/MAC and 802.11n extended/MAC+PHY	Gianluca Varenni
04/18/2007	0.7	Renamed from Airhead to PPI. Minor fixes and updates	Gerald Combs
05/09/2007	0.8	Fixed the invalid values for MCS, dBm values and RSSI.	Gianluca Varenni
05/18/2007	0.9	Added abbreviations and acronyms section. Added member element to the Channel-Flags element in both 802.11-Common and 802.11n MAC+PHY fields. General cleanup. Filled in purpose section to clarify PPI's intent.	Dustin Johnson
6/11/2007	0.95	Update the "Purpose" section. Explicitly refer to NTAR	Gerald Combs
6/12/2007	1.0	Bump to 1.0.	Gerald Combs
6/15/2007	1.0.1	Fix remaining "Airhead" references	Gerald Combs
9/24/2007	1.0.2	Update spectrum section, fix typos	Gerald Combs
4/24/2008	1.0.3	Add vendor id 30001 (Mohamed Thaga)	Gerald Combs
4/24/2008	1.0.4	Added the definition of the 802.3 Field and the Aggregation Field	Gianluca Varenni
5/19/2008	1.0.5	Defined the error bits for the 802.3 Field	Gianluca Varenni
8/29/2008	1.0.6	Fixed RSSIAntXExt descriptions	Dustin Johnson
09/11/2008	1.0.7	Clarified the packet header length	Gerald Combs
05/11/2009	1.0.9	Add vendor ID 30006 (Mike Kershaw)	Gianluca Varenni

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1. Introduction

When capturing live network data, it is often useful to collect out-of-band information and provide it along with in-band packet data. The traditional method of doing this is to prefix each PDU with a meta-information header (often called a pseudoheader). Current implementations include such information as 802.11 radio information, access server user IDs, and point-to-point link direction.

The Per-Packet Information (PPI) Header is a general and extensible meta-information header format originally developed to provide 802.11n radio information, but can handle other information as well.

1.1 Purpose

PPI is intended to supplement individual packets received from a hardware or software engine with interesting data in a light-weight fashion.

Often such data of interest pertains to the PHY layer, but this need not always be the case. Whatever the carried information may be, the intent is that the information contained is only added to data captured in real-time, not stored packets.

It is not intended to add arbitrary data to packets, such as annotations. That task is better suited to NTAR.

1.2 Scope

This document defines the general format of the PPI header, along with the formats of several fields. Performance and security are outside the scope of this document.

1.3 Definitions, Acronyms and Abbreviations

ASCII	American Standard Code for Information Interchange
A-MPDU	aggregate MAC protocol data unit
A-MSDU	aggregate MAC service data unit
CCK	complementary code keying
CRC	cyclic redundancy check
CR-LF	carriage return-line feed
DLT	data link type
EVM	error vector magnitude
FCS	frame check sequence
FHSS	frequency-hopping spread spectrum
GFSK	gaussian frequency shift key or keying
GID	group identifier
HT	high throughput
MAC	medium access control
MPDU	MAC protocol data unit
OFDM	orthogonal frequency division multiplexing
PHY	physical layer
PPI	per-packet information
RF	radio frequency

RSSI	receive signal strength indicator
RX	receive or receiver
SGI	short guard interval
TSF	timing synchronization function
TSFT	timing synchronization function timer
UID	unique identifier
UTF	Unicode transformation format

1.4 Notational Conventions

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in RFC 2119.

1.5 References

Radiotap manual page: http://netbsd.gw.com/cgi-bin/man-cgi?ieee80211_radiotap+9+NetBSD-current

NTAR documentation: http://www.winpcap.org/ntar/

RFC 2119: http://www.ietf.org/rfc/rfc2119.txt

1.6 Overview

Section 2 provides a description of the PPI header, along with an explanation of its necessity. Section 3 defines the structure of the header, complete with C and C++-compatible data structures. Section 4 defines each data type. Data structures are assumed to be packed.

2. Overall Description

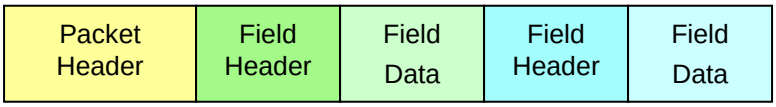
Existing header formats are typically made up of static data structures filled in by the capture mechanism and passed to user space. They suffer from the following problems:

- Limited scope. They are restricted to specific elements within a single domain.
- Rigidity. It is either impossible or very difficult to add new elements.
- Fixed DLTs. Each format only supports one encapsulated data link type.

PPI attempts to address each of these issues in a clean, consistent manner. Data elements are formatted as type-length-value (TLV) triplets, which allows for future expansion of the header while providing backward compatibility. Per-packet DLTs can be implemented by using an “empty” PPI header.

3. PPI Header Format

Each PPI packet header is made up of a packet header followed by zero or more fields. Each field is a type-length-value triplet.



PPI headers may contain only a packet header with no field header or field data elements. This removes any assumption or requirement that supplemental data exists for every packet captured. It also makes it possible to save packets with multiple data link types in a single capture file.

Multi-byte integers in the packet header and field headers MUST be stored as little-endian. The endian-ness of field data may be either big- or little-endian, and MUST be noted in the field description. The total length of the packet header plus all field headers and field data MUST be padded to a 32-bit boundary.

3.1 PPI Packet Header Structure

The PPI packet header provides a version, indicator flags, and the header length:

```
typedef struct ppi_packetheader {
    u_int8_t pph_version;     /* Version.  Currently 0 */
    u_int8_t pph_flags;       /* Flags.    */
    u_int16_t pph_len;        /* Length of entire message,
                               * including this header and TLV
                               * payload. */
    u_int32_t pph_dlt;        /* Data Link Type of the captured
                               * packet data. */
} ppi_packetheader_t;
```

3.1.1 pph_version

The version of the PPI header. MUST be set to zero (0).

3.1.2 pph_flags

An 8-bit mask that defines the behavior of the header. The following values are defined:

Bits (Bit 0 = LSB)	**Values**
0	Alignment. 32-bit aligned = 1, non-aligned = 0 Explained further in section 3.3
1-7	Reserved. MUST be 0.

3.1.3 pph_len

The length of the entire PPI header, including the packet header and fields. It MUST be between 8 and 65,532 inclusive.

3.1.4 pph_dlt

This MUST contain a valid data link type as defined in pcap-bpf.h from the libpcap distribution. If an official DLT registry is ever created by the libpcap development team, then it will supersede this list.

A capture facility can implement per-packet DLTs by setting pph_version to 0, pph_flags to 0, pph_len to 8, and pph_dlt to the DLT of the encapsulated packet.

3.2 PPI Field Structure

Each PPI field includes a type and length:

```
typedef struct ppi_fieldheader {
    u_int16_t pfh_type;       /* Type */
    u_int16_t pfh_datalen;    /* Length of data */
} ppi_fieldheader_t;
```

3.2.1 pfh_type

The type of data following the field header MUST be a valid type value as defined below:

Range	**Possible Values**
0-29,999	General-purpose field. Defined in section 4.
30,000-65,535	Vendor-specific fields. Defined in section 5.

If an unknown field value is encountered, it MUST be skipped according to the length rule in section 3.3. Implementations MAY mark it as “unknown” as appropriate.

3.2.2 pfh_datalen

The length of the data, in bytes, that follows MUST be between 0 and 65,520 inclusive. The end of the data MUST NOT exceed the total header length.

3.3 Field Processing

The first field header immediately follows the packet header (that is, if the packet header starts at byte 0, the first field header starts at byte 8). The starting point of each subsequent field header is defined by the "alignment" bit in pph_flags:

- If the "alignment" bit in pph_flags is set to 1 AND pfh_datalen in field *n* is not a multiple of 4, then field *n+1* will start at the next multiple of 4. For example, if pph_datalen in field 3 is 9, then the next three bytes MUST be considered padding, and field 4 will begin at byte 12.
- If the "alignment" bit in pph_flags is 0, then field *n+1* will start at the next byte offset following the data in field *n*.

The "alignment" bit in pph_flags also applies to field data. That is, if the "alignment" bit is set and the field type is 7 bytes long, then there will be one byte of padding between the field header and field data.

All padding bytes MUST be set to 0 in order to keep from exposing kernel memory to user space.

4. General-Purpose Field Types

The following general-purpose fields are currently defined. Further general-purpose fields will be defined in later revisions of this document. Vendor-specific fields may be defined externally.

Type	Length (Bytes)	Description
0-1		RESERVED
2	20	802.11-Common. Common (pre-n and .11n) radio information.
3	12	802.11n MAC Extensions. Extended (.11n) radio information.
4	48	802.11n MAC+PHY Extensions. Extended (.11n) radio information.
5	22-65,520	Spectrum-Map. Radio frequency spectrum information.
6	19-65,520	Process-Info. Process information, e.g. UID and GID
7	???	Capture-Info. Capture information, e.g. interface, drop counts, etc.
8	4	Aggregation Extension. Interface information for packets coming from aggregating interfaces.
9	8	802.3 Extension. Information regarding 802.3 (Ethernet) packets.
10 – 29,999	-	RESERVED

4.1 Field Descriptions

4.1.2 802.11-Common

Zero or one 802.11-Common fields may be present in a single header. All fields are little-endian.

The 802.11-Common field is loosely based on the existing Radiotap header format. It contains data common to both pre-n and 802.11n. Total length is 20 bytes.

Field Name	Semantics	Value Type	Length

TSF-Timer	7.3.1.10 and 11.1 of IEEE 802.11-1999 Invalid value = 0	Unsigned integer	8 bytes
Flags	Packet flags LSB = bit 0. Bits: Bit 0 = If set, FCS present Bit 1 = If set to 1, the TSF-timer is in ms, if set to 0 the TSF-timer is in us Bit 2 = If set, the FCS is not valid Bit 3 = If set, there was a PHY error receiving the packet. If this bit is set, Bit 2 is not relevant	Unsigned integer	2 bytes
Rate	Data rate in multiples of 500 Kbps Invalid value = 0x0000	Unsigned integer	2 bytes
Channel-Freq	Radiotap-formatted channel frequency, in MHz Invalid value = 0x0000	Unsigned integer	2 bytes
Channel-Flags	Radiotap-formatted channel flags: Bit 0-3 = Reserved Bit 4 = Turbo Bit 5 = Complementary Code Keying (CCK) Bit 6 = Orthogonal Frequency-Division Multiplexing (OFDM) Bit 7 = 2 GHz spectrum Bit 8 = 5 GHz spectrum Bit 9 = Only passive scan allowed Bit 10 = Dynamic CCK-OFDM Bit 11 = Gaussian Frequency Shift Keying (GFSK) (FHSS PHY) Bit 12-15 = Reserved	Unsigned integer	2 bytes
FHSS-Hopset	Radiotap-formatted Frequency-hopping spread spectrum (FHSS) hopset	Unsigned integer	1 byte
FHSS-Pattern	Radiotap-formatted Frequency-hopping spread spectrum (FHSS) pattern	Unsigned integer	1 byte
dBm-Antsignal	RF signal power at antenna Invalid value = -128	Signed integer	1 byte
dBm-Antnoise	RF noise at antenna Invalid value = -128	Signed integer	1 byte

Unlike Radiotap, these fields are packed without any padding or alignment.

4.1.3 802.11n MAC Extension (basic)

Zero or one 802.11-Common fields may be present in a single header. Correct parsing the 802.11n-MAC Extension field depends on values from the 802.11-Common field. If present, it MUST be immediately preceded by an 802.11-Common field. All 802.11n MAC Extension fields are little-endian.

The 802.11n MAC Extension field contains radio information specific to 802.11n. Total length is 27 bytes.

Field Name	Semantics	Value Type	Length
Flags	LSB = bit 0. Bits: Bit 0 = Greenfield Bit 1 = HT20 (0) or HT40 (1) indicator Bit 2 = RX short guard interval (SGI) Bit 3 = Duplicate RX Bit 4 = Aggregate Bit 5 = More aggregates Bit 6 = Aggregate delimiter CRC error after this frame	Unsigned integer	4 bytes
A-MPDU-ID	Unique A-MPDU ID used for A-MPDU reassembly	Unsigned integer	4 bytes
Num-Delimiters	Number of zero-length pad delimiters	Unsigned integer	1 byte
Reserved		Unsigned integer	3 bytes

If the aggregate flag (bit 4 of the Flags field) is set, then each MPDU in a particular A-MPDU MUST have the same A-MPDU-ID. The A-MPDU-ID SHOULD be randomly assigned in order to prevent improper reassembly if capture files are merged.

4.1.4 802.11n MAC+PHY Extension (Extended)

Zero or one 802.11-Common fields may be present in a single header. Correct parsing the 802.11n-MAC+PHY Extension field depends on values from the 802.11-Common field. If present, it MUST be immediately preceded by an 802.11-Common field. All 802.11n MAC+PHY Extension fields are little-endian.

The 802.11n MAC+PHY Extension field contains radio information specific to 802.11n. Total length is 48 bytes.

Field Name	Semantics	Value Type	Length
Flags	LSB = bit 0. Bits: Bit 0 = Greenfield Bit 1 = HT20 (0) or HT40 (1) indicator Bit 2 = RX guard interval Bit 3 = Duplicate RX Bit 4 = Aggregate Bit 5 = More aggregates Bit 6 = Aggregate delimiter CRC error after this frame	Unsigned integer	4 bytes
A-MPDU-ID	Unique A-MPDU ID used for A-MPDU reassembly	Unsigned integer	4 bytes
Num-Delimiters	Number of zero-length pad delimiters	Unsigned integer	1 byte
MCS	Modulation Coding Scheme	Unsigned integer	1 byte

	Invalid Value = 255		
Num-Streams	Number of spatial streams. 0 (zero) means that the information is not available	Unsigned integer	1 byte
RSSI-Combined	Combined Received Signal Strength Indication (RSSI) value from all the active antennas and channels. Invalid value = 255	Unsigned integer	1 byte
RSSIAnt0Ctl	Received Signal Strength Indication (RSSI) value for the antenna 0, control channel Invalid value = 255	Unsigned integer	1 byte
RSSIAnt1Ctl	Received Signal Strength Indication (RSSI) value for the antenna 1, control channel Invalid value = 255	Unsigned integer	1 byte
RSSIAnt2Ctl	Received Signal Strength Indication (RSSI) value for the antenna 2, control channel Invalid value = 255	Unsigned integer	1 byte
RSSIAnt3Ctl	Received Signal Strength Indication (RSSI) value for the antenna 3, control channel Invalid value = 255	Unsigned integer	1 byte
RSSIAnt0Ext	Received Signal Strength Indication (RSSI) value for the antenna 0, extension channel Invalid value = 255	Unsigned integer	1 byte
RSSIAnt1Ext	Received Signal Strength Indication (RSSI) value for the antenna 1, extension channel Invalid value = 255	Unsigned integer	1 byte
RSSIAnt2Ext	Received Signal Strength Indication (RSSI) value for the antenna 2, extension channel Invalid value = 255	Unsigned integer	1 byte
RSSIAnt3Ext	Received Signal Strength Indication (RSSI) value for the antenna 3, extension channel Invalid value = 255	Unsigned integer	1 byte
Extension Channel-Freq	Radiotap-formatted extension channel frequency, in Channel Frequency in MHz Invalid value = 0x0000. The frequency of the control channel is stored in the Channel-Freq field of the 802.11 Common header.	Unsigned integer	2 bytes
Extension Channel-Flags	Radiotap-formatted extension channel flags. The flags of the control channel are stored in the Channel-Flags field of the 802.11 Common header. Bit 0-3 = Reserved	Unsigned integer	2 bytes

	Bit 4 = Turbo Bit 5 = Complementary Code Keying (CCK) Bit 6 = Orthogonal Frequency-Division Multiplexing (OFDM) Bit 7 = 2 GHz spectrum Bit 8 = 5 GHz spectrum Bit 9 = Only passive scan allowed Bit 10 = Dynamic CCK-OFDM Bit 11 = Gaussian Frequency Shift Keying (GFSK) (FHSS PHY) Bit 12-15 = Reserved		
dBm-Ant0signal	RF signal power at antenna 0 Invalid value = -128	Signed integer	1 byte
dBm-Ant0noise	RF noise at antenna 0 Invalid value = -128	Signed integer	1 byte
dBm-Ant1signal	RF signal power at antenna 1 Invalid value = -128	Signed integer	1 byte
dBm-Ant1noise	RF noise at antenna 1 Invalid value = -128	Signed integer	1 byte
dBm-Ant2signal	RF signal power at antenna 2 Invalid value = -128	Signed integer	1 byte
dBm-Ant2noise	RF noise at antenna 2 Invalid value = -128	Signed integer	1 byte
dBm-Ant3signal	RF signal power at antenna 3 Invalid value = -128	Signed integer	1 byte
dBm-Ant3noise	RF noise at antenna 3 Invalid value = -128	Signed integer	1 byte
EVM0	Error vector magnitude for Chain 0 Invalid value = 0	Unsigned integer	4 bytes
EVM1	Error vector magnitude for Chain 1 Invalid value = 0	Unsigned integer	4 bytes
EVM2	Error vector magnitude for Chain 2 Invalid value = 0	Unsigned integer	4 bytes
EVM3	Error vector magnitude for Chain 3 Invalid value = 0	Unsigned integer	4 bytes

4.1.5 Spectrum-Map

Zero or more Spectrum-Map fields may be present in a single header. If more than one Spectrum-Map field is present, each field SHOULD contain unique frequency values. All fields are little-endian.

The Spectrum-Map field is intended to be compatible with the sweep records returned by the Wi-Spy spectrum analyzer.

Field Name	Semantics	Value Type	Length
Start-kHz	Starting frequency in kHz	Unsigned integer	4 bytes
Res-Hz	Resolution of each sample in Hz	Unsigned integer	4 bytes
Amp-Offset-mdBm	Amplitude offset in 0.001 dBm, stored as an unsigned value. The application is expected to multiply this value by -1, stored unsigned to prevent endian conversion issues.	Unsigned integer	4 bytes
Amp-Res-mdBm	Amplitude Resolution in .001 dBm.	Unsigned integer	4 bytes
RSSI-Max	Maximum raw RSSI value reported by the device.	Unsigned integer	2 bytes
Num-Samples	Number of samples	Unsigned integer	2 bytes
Sample-Data	Array of unsigned bytes. Length is Num-Samples.	Unsigned integer	variable

This information should be suitable for generating histograms. RSSI values can be converted to dB utilizing the following formula (including the conversion of Amp-Offset-mdBm to a negative value):

```
dBm = (RSSI * (Amp_Res_mdBm / 1000)) + (Amp_Offset_mdBm / 1000 * -1)
```

4.1.6 Process-Info

Zero or one Process-Info fields may be present in a single header. All fields are little-endian.

Field Name	Semantics	Value Type	Length
Process-ID	Process ID	Unsigned integer	4 bytes
Thread-ID	Thread ID	Unsigned integer	4 bytes
Process-Path-Len	Length of the process name	Unsigned integer	1 byte
Process-Path	Path and filename of the process	UTF-8 string	variable
User-ID	User ID	Unsigned integer	4 bytes
User-Name-Len	Length of user name	Unsigned integer	1 byte
User-Name	User name	UTF-8 string	variable
Group-ID	Primary group ID	Unsigned integer	4 bytes
Group-Name-Len	Length of primary group name	Unsigned integer	1 byte
Group-Name	Primary group name	UTF-8 string	variable

4.1.7 Capture-Info

To be defined.

4.1.8 *Aggregation Extension*

Zero or one Aggregation Extensions may be present in a single header. All Aggregation Extension fields are little-endian.

The Aggregation Extension contains the zero-based physical interface Id the packet was captured from when using an aggregating source (i.e. a source of packets delivering packets captured from multiple interfaces). Total length is 4 bytes.

Field Name	Semantics	Value Type	Length
InterfaceId	Zero-based index of the physical interface the packet was captured from	Unsigned integer	4 bytes

4.1.9 *802.3 Extension*

Zero or one 802.3 Extensions fields may be present in a single header. All 802.3 Extension fields are little-endian.

The 802.3 Extension contains information specific to 802.3 packets, like the presence of the Frame Check Sequence at the end of the packet, and the errors that were detected when the packet was captured. Total length is 8 bytes.

Field Name	Semantics	Value Type	Length
Flags	LSB = bit 0. Bits: Bit 0 = FCS (4 bytes) is present at the end of the packet.	Unsigned integer	4 bytes
Errors	LSB = bit 0. Bits: Bit 0 = The frame has an invalid Frame Check Sequence (FCS) Bit 1 = The frame has a sequence error. A valid delimiter sequence consists of Idle→start-of-frame(SOF) →data, →pad(optional) →end-of-frame(EOF) →fill(optional) →idle Bit 2 = The frame has a symbol error. Bit 3 = The frame has a data error.	Unsigned integer	4 bytes

5. Vendor-Specific Field Types

Type values 30,000 to 65,535 are reserved for vendor-specific applications. Vendor numbers are assigned by the WinPcap development team, and assignment may be handed over to a formal standards body in the future. To request a vendor number, send and mail to winpcap-users@winpcap.org.

A vendor-specific type MUST NOT be used without first obtaining an assignment from the WinPcap development team. The intent behind such a large space for vendor-specific types is to allow easy and unadulterated registration, thus maintaining some sanity in version tracking and parsing.

Type	Length	Description
30,000	-	Intel Corporation
30,001	-	Mohamed Thaga <thagha@yahoo.com>
30,002	-	GPS tagging <johnycsh@gmail.com>

30,003 – 30,005	-	Private < johnycsh@gmail.com>
30,006	-	Private <dragorn@kismetwireless.net>
30,007 – 59,917	-	Unassigned.
51,918	-	Reserved for CACE. (51918_{10} = $CACE_{16}$)
51,919 – 65,535	-	Unassigned.