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Internet Printing Protocol/1.0: Protocol Specification
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Status of this Memo

Abstract

This document is one of a set of documents, which together describe all aspects of a new Internet Printing Protocol (IPP). IPP is an application level protocol that can be used for distributed printing using Internet tools and technology. The protocol is heavily influenced by the printing model introduced in the Document Printing Application (ISO/IEC 10175 DPA) standard. Although DPA specifies both end user and administrative features, IPP version 1.0 is focused only on end user functionality.

The full set of IPP documents includes:

- Internet Printing Protocol: Requirements
- Internet Printing Protocol/1.0: Model and Semantics
- Internet Printing Protocol/1.0: Security
- Internet Printing Protocol/1.0: Protocol Specification
- Internet Printing Protocol/1.0: Directory Schema

The requirements document takes a broad look at distributed printing functionality, and it enumerates real-life scenarios that help to clarify the features that need to be included in a printing protocol for the Internet. It identifies requirements for three types of users: end users, operators, and administrators. The requirements document calls out a subset of end user requirements that MUST be satisfied in the first version of IPP. Operator and administrator requirements are out of scope for v1.0. The model and semantics document describes a simplified model with abstract objects, their attributes, and their operations. The model introduces a Printer object and a Job object. The Job object supports multiple documents per job. The security document covers potential threats and proposed counters to those threats. The protocol specification is formal document which incorporates the ideas in all the other documents into a concrete mapping using clearly defined data representations and transport protocol mappings that real implementers can use to develop interoperable client and server side components. Finally, the directory schema document shows a generic schema for directory service entries that represent instances of IPP Printers.

This document is the "Internet Printing Protocol/1.0: Protocol Specification" document.

Table of Contents

1. Introduction

This document contains the rules for encoding IPP operations and describes two layers: the transport layer and the operation layer.

The transport layer consists of an HTTP/1.1 request or response. RFC 2068 describes HTTP/1.1. This document specifies the HTTP headers that an IPP implementation supports.

The operation layer consists of a message body in an HTTP request or response. The document "Internet Printing Protocol/1.0: Model and Semantics" defines the semantics of such a message body and the supported values. This document specifies the encoding of an IPP operation.

2. Conformance Terminology

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 [25].

3. Encoding of the Operation Layer

The operation layer SHALL contain a single operation request or operation response.

The encoding is defined using both a diagram and Augmented Backus-Naur Form (ABNF), as specified by draft-ietf-drums-abnf-02.txt [29]

All binary integers in this encoding SHALL be transmitted in big-endian format (also known as “network order” and “most significant byte first”)

3.1 Syntax of Encoding

The syntax for the operation layer is:

```
ipp-message = ipp-request / ipp-response
ipp-request = version operation parameters %xFF %xFF [ data ]
ipp-response = version status parameters %xFF %xFF [ data ]
version = major-version minor-version
major-version = SIGNED-BYTE  ; initially %d1
minor-version = SIGNED-BYTE  ; initially %d0
operation = SIGNED-SHORT  ; mapping from model defined below
status = SIGNED-SHORT     ; mapping from model defined below
parameters = parameter-group *(%xFF %xFE parameter-group)
parameter-group = *parameter
parameter = single-parameter *(more-values)
single-parameter = name-length name value-length value
more-values = zero-name-length value-length value
name-length = SIGNED-SHORT    ; number of octets of ‘name’
name = LALPHA *( LALPHA / DIGIT / “-” / “_” )
value-length = SIGNED-SHORT  ; number of octets of ‘value’
value = OCTET-STRING
zero-name-length = %x00 %x00
data = OCTET-STRING
```

```
SIGNED-BYTE = %x0..%xFF
SIGNED-SHORT = %x0..%xFF %x0..%xFF
DIGIT = "0".."9"
LALPHA = "a".."z"
BYTE = %x0..%xFF
OCTET-STRING = *BYTE
```

NOTE: there are 3 additional fields that are positioned, from a decoding view, in the same position as the 'name-length' field. These fields are defined in the syntax above, and they have the following 3 special values:

- 0 (0x0000): denotes an additional value of a parameter. When a parameter has more than one value, the parameter-name for all but the first value is empty and has a length of zero.
- -1 (0xFFFF): denotes the end of the parameters. The 'data' starts in the next byte. The 2 bytes of -1 are present even when there is no data.
- -2 (0xFFFE): denotes the end of a parameter group. The next parameter-group starts in the next byte. This special value exists only when an operation contains 2 or more parameter groups. A parameter group is defined in greater detail in section 3.7 "Mapping of Attribute and Parameter Names".

3.2 Diagram of Encoding

The following is a diagram of the encoding of a request operation.

Note: there are be 1 or more parameter groups and data may be omitted.

```
-----------------------------------------------
|    major version       |    minor version   |    2 bytes
-----------------------------------------------
|                  operation                  |    2 bytes
-----------------------------------------------
|               parameter-group               |    k bytes
-----------------------------------------------------------
|                   0xFFFE                    |    2 bytes |
-----------------------------------------------            |
|                     …                       |    m bytes |
-----------------------------------------------            |
|               parameter-group               |    n bytes |- optional
-----------------------------------------------            |
|                   0xFFFE                    |    2 bytes |
-----------------------------------------------            |
|               parameter-group               |    p bytes |
-----------------------------------------------------------
|                   0xFFFF                    |    2 bytes
-----------------------------------------------
|                    data                     |    q bytes - optional
-----------------------------------------------
```

The following is a diagram of the parameter-group which is 0 or more parameters

```
-----------------------------------------------
|                  parameter                  |    r bytes
-----------------------------------------------
|                     …                       |    s bytes
-----------------------------------------------
|                  parameter                  |    t bytes
-----------------------------------------------
```

The following is a diagram of a parameter. The optional fields are present only when a parameter has more than one value.

```
 -----------------------------------------------
 |              length-of-name                 |    2 bytes
 -----------------------------------------------
 |              parameter-name                 |    u bytes
 -----------------------------------------------
 |              length-of-value                |    2 bytes
 -----------------------------------------------
 |              parameter-value                |    v bytes
 ---------------------------------------------------------------
 |                  0x0000                     |    2 bytes |
 -----------------------------------------------            |
 |              length-of-value                |    2 bytes |
 -----------------------------------------------            |
 |              parameter-value                |    w bytes |- optional
 -----------------------------------------------            |
 |                    …                        |    x bytes |
 -----------------------------------------------            |
 |                  0x0000                     |    2 bytes |
 -----------------------------------------------            |
 |              length-of-value                |    2 bytes |
 -----------------------------------------------            |
 |              parameter-value                |    y bytes |
 ---------------------------------------------------------------
```

The encoding of a response operation is identical to the encoding of a request operation except that the ‘status’ field replaces the ‘operation’ field.

3.3 Version

The version SHALL consist of a major and minor version, each of which SHALL be represented by a one byte signed integer. The protocol described in this document SHALL have a major version of 1 (0x01) and a minor version of 0 (0x00).

3.4 Mapping of Operations

The following SHALL be the mapping of operations names to integer values which are encoded as two byte binary signed integers. The operations are defined in the document "Internet Printing Protocol/1.0: Model and Semantics".

Operation	**Integer Encoding (in decimal)**
Get-Operations	0
Print-Job	1
Print-URI	2
Validate-Job	3
Create-Job	4
Send-Document	5
Send-URI	6
Cancel-Job	7
Get-Attributes	8
Get-Jobs	9

3.5 Mapping of Status

The following SHALL be the mapping of status names to integer values which are encoded as two byte binary signed integers. The status names are defined in the document "Internet Printing Protocol/1.0: Model and Semantics".

If an IPP status is returned, then the HTTP status MUST be 200 (OK). With any other HTTP status value, the HTTP response SHALL NOT contain an IPP message-body, and thus no IPP status is returned.

Note: the integer encodings below were chosen to be similar to corresponding status values in HTTP. But the status returned at the HTTP level will always be different except in the case where ‘OK’ is returned at both levels, 200 (OK) in HTTP and 0 (successful-OK) in IPP.

Status Name	Integer Encoding (in decimal)
successful-OK	0
client-error-bad-request	400
client-error-unauthorized	401
client-error-payment-required	402
client-error-forbidden	403
client-error-not-found	404
client-error-method-not-allowed	405
client-error-timeout	408
client-error-gone	410
client-error-request-entity-too-large	413
client-error-request-URI-too-long	414
client-error-unsupported-document-format	415
client-error-attribute-not-supported	416
server-error-internal-server-error	500
server-error-operation-not-implemented	501
server-error-service-unavailable	503
server-error-timeout	504
server-error-version-not-supported	505
server-error-printer-error	506
server-error-temporary-error	507

3.6 Lengths of Parameter Names

Each parameter name SHALL be preceded by a two byte binary signed integer in big endian order which SHALL specify the number of octets in the name which follows this length, exclusive of the two bytes specifying the length.

3.7 Mapping of Attribute and Parameter Names

Attribute names and parameter names are ASCII text strings whose values SHALL be the text names defined in the document "Internet Printing Protocol/1.0: Model and Semantics".

The document "Internet Printing Protocol/1.0: Model and Semantics" defines the parameters for each operation. Some of these parameters SHALL receive special handling in the protocol, as described below.

The parameter named “status” for each response SHALL become the “status” field in the operation layer. A response may optionally include the parameter “reason-phase” to specify human readable text associated with the status. If this parameter is in the response, it SHALL be the first one.

The parameter named “document-content”, which is defined for some requests, SHALL become the “data” in the operation layer.

Requests and responses contain a mixture of parameters and attributes. All parameters SHALL be in the first parameter-group. Attributes shall be in the second parameter-group. If an operation returns attributes from more than one object (e.g. Get-Jobs), the attributes from each object shall be in a separate parameter-group.

3.8 Lengths of Parameter Values

Each parameter value SHALL be preceded by a two byte binary signed integer in big endian order which SHALL specify the number of octets in the value which follows this length, exclusive of the two bytes specifying the length.

3.9 Mapping of Attribute and Parameter Values

The following SHALL be the mapping of attribute and parameter values to their IPP encoding. The syntax types are defined in the document "Internet Printing Protocol/1.0: Model and Semantics".

Syntax of Attribute Value	**Encoding**
text	an octet string where each character is encoded in UTF-8. The first character in the octet string is the encoding of the first character in the text value
name	same as text
fileName	same as text
keyword	same as text. Allowed text values are defined in the document "Internet Printing Protocol/1.0: Model and Semantics".
uri	same as text
uriScheme	same as text
locale	same as text
boolean	one binary octet where 0x00 is ‘false’ and 0x01 is ‘true’
integer	number of octets is a power of 2 (i.e. 1, 2 or 4). These octets represent a signed binary integer in big endian order (MSB first).
enum	same as integer. Allowed integer values are defined in the document "Internet Printing Protocol/1.0: Model and Semantics".
dateTime	same as text. Syntax of data and time is defined by ISO 8601 ISSUE: should ISO 8601 be called out in the model document?
seconds	same as integer
milliseconds	same as integer
1setOf X	encoding according to the rules for a parameter with more than more value. Each value X is encoded according to the rules for encoding its type.
rangeOf X	same 1setOf X where the number of values is 2.

There is sometimes a need for a parameter to have some special ‘out-of-band’ values. Such value are represented by empty values with special negative lengths as specified by the table below.

Special Value	**Value of Value-length**
default	-1
unsupported	-2

3.10 Encoding of Data

No encoding SHALL be applied to the data. It is included within the operation as is.

NOTE: HTTP, however, allows an encoding to be applied to the entire message-body.

4. Encoding of Transport Layer

HTTP/1.1 shall be the transport layer for this protocol.

The operation layer has been designed with the assumption that the transport layer contains the following information:

- the URI of the target job or printer operation
- the total length of the data in the operation layer, either as a single length or as a sequence of chunks each with a length.

Each HTTP operation shall use the POST method where the URI the object target of the operation, and where the “Content-Type” of the message-body in each request and response shall be “application/ipp”. The message-body shall contain the operation layer and shall have the syntax described in section 2 “Conformance Terminology

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 [25].

Encoding of the Operation Layer”.

ISSUE: Should the URI of the operation be in the operation layer? Should the URI in the POST be a server/printer always with the target object as a parameter within the message-body?

In the following sections, there are a tables of all HTTP headers which describe their use in an IPP client or server. The following is an explanation of each column in these tables.

- the “header” column contains the name of a header
- the “request/client” column indicates whether a client sends the header. The values in each cell are described below:
- the “request/server” column indicates whether a server supports the header when received. The values in each cell are described below.
- the “response/server” column indicates whether a server sends the header. The values in each cell are described below:
- the “response /client” column indicates whether a client supports the header when received. The values in each cell are described below.
- the “values and conditions” column specifies the allowed header values and the conditions for the header to be present in a request/response.

The table for “request headers” does not have columns for responses, and the table for “response headers” does not have columns for requests.

The following is an explanation of the values in the “request client” and “response server” columns.

- man: (mandatory) the client or server MUST send the header,
- c-man: (conditionally mandatory) the client or server MUST send the header when the condition described in the “values and conditions” column is met,
- opt: (optional) the client or server MAY send the header
- not: (not needed) the client or server NEED NOT send the header. It is not relevant to an IPP implementation.

The following is an explanation of the values in the “response client” and “request server” columns.

- man: (mandatory) the client or server MUST support the header,
- opt: (optional) the client or server MAY support the header
- not: (not needed) the client or server NEED NOT support the header. It is not relevant to an IPP implementation.

4.1 General Headers

The following is a table for the general headers.

ISSUE: an HTTP expert should review these tables for accuracy.

General-Header	**Request**		**Response**		**Values and Conditions**
	Client	**Server**	**Server**	**Client**	
Cache-Control	man	not	man	not	“no-cache” only
Connection	c-man	man	c-man	man	“close” only. Header must be present only for last request/response before the connection is closed.
Date	opt	opt	man	opt	per RFC 1123
Pragma`	man	not	man	not	“no-cache” only
Transfer-Encoding	c-man	man	c-man	man	“chunked” only . Header must be present if Content-Length is absent.
Upgrade	not	not	not	not	
Via	not	not	not	not	

4.2 Request Headers

The following is a table for the request headers.

Request-Header	**Client**	**Server**	**Request Values and Conditions**
Accept	opt	man	“application/ipp” only. This value is the default if the client omits it
Accept-Charset	opt	man	per IANA Character Set registry. ISSUE: is this useful for IPP?
Accept-Encoding	opt	man	empty and per RFC 2068 and IANA registry for content-codings
Accept-Language	opt	man	see RFC 1766
Authorization	c-man	man	per RFC 2068. A client sends this header when it receives a 401 “Unauthorized” response and no “Proxy-Authenticate” header.
From	not	not	per RFC 2068. Because RFC recommends sending this header only with the user’s approval, it is not very useful
Host	man	man	per RFC 2068
If-Match	not	not	
If-Modified-Since	not	not	
If-None-Match	not	not	
If-Range	not	not	
If-Unmodified-Since	not	not	
Max-Forwards	not	not	
Proxy-Authorization	c-man	not	per RFC 2068. A client must send this header when it receives a 401 “Unauthorized” response and a “Proxy-Authenticate” header.
Range	not	not	
Referer	not	not	
User-Agent	not	not	

4.3 Response Headers

The following is a table for the request headers.

Response-Header	Server	Client	Response Values and Conditions
Accept-Ranges	not	not	
Age	not	not	
Location	c-man	opt	per RFC 2068. When URI needs redirection.
Proxy-Authenticate	not	man	per RFC 2068
Public	opt	opt	per RFC 2068
Retry-After	opt	opt	per RFC 2068
Server	not	not	
Vary	not	not	
Warning	opt	opt	per RFC 2068
WWW-Authenticate	c-man	man	per RFC 2068. When a server needs to authenticate a client.

4.4 Entity Headers

The following is a table for the request headers.

Entity-Header	Request		Response		Values and Conditions
	Client	Server	Server	Client	
Allow	not	not	not	not	
Content-Base	not	not	not	not	
Content-Encoding	opt	man	man	man	per RFC 2068 and IANA registry for content codings.
Content-Language	opt	man	man	man	see RFC 1766.
Content-Length	c-man	man	c-man	man	the length of the message-body per RFC 2068. Header must be present if Transfer-Encoding is absent..
Content-Location	not	not	not	not	
Content-MD5	opt	opt	opt	opt	per RFC 2068
Content-Range	not	not	not	not	
Content-Type	man	man	man	man	“application/ipp” only
ETag	not	not	not	not	
Expires	not	not	not	not	
Last-Modified	not	not	not	not	

5. Security Considerations

When utilizing HTTP 1.1 as a transport for IPP, all of the security considerations specified in RFC 2068 apply. In addition, the IPP adds some additional application-specific security considerations, including denial-of-service attacks, mutual authentication, and privacy. The IPP Model document addresses IPP-specific security considerations, while RFC 2068 addresses HTTP-related security considerations.

ISSUE: the security subgroup is free to add whatever is necessary to fill out the "security considerations" section of this document. However, the IPP model document should include the bulk of security discussions that are IPP-specific.

6. Appendix A: Requirements with Transports other than HTTP/1.1

Some transports, such as raw TCP/IP, don't have a way to specify length or carry along parameters supported by a transport layer, such as HTTP/1.1. An example of such a parameter is the Content-Encoding for an operation. Another example is the target URI.

This section specifies the modifications to the operation-layer encoding for transports, such as raw TCP/IP. The following changes would have to made. All of these changes are upward compatible with the encoding defined in section 3 "Encoding of the Operation Layer".

6.1 Additional Parameter-group for HTTP header information

First there is an additional parameter-group which SHALL appear as the first parameter-group and which SHALL contain the target URI along with relevant HTTP header information, including those shown below. This parameter-group SHALL be preceded by a name-length of -4 (0xFFFC) which functions like the other negative lengths defined in section 3 "Encoding of the Operation Layer". This special number specifies that the first parameter group contains header type information, and distinguishes it from the protocol which have these parameters outside of the operation layer.

The following table shows the mapping of HTTP headers to parameters in the operation layer.

HTTP header or other concept	**IPP parameter name**	**Syntax Type of Parameter**
URI	target-URI	uri
Connection	Close-Connection	Boolean
Accept-Charset	Accept-Charset	keyword
Accept-Encoding	Accept-Encoding	keyword
Accept-Language	Accept-Language	keyword
Content-Encoding	Content-Encoding	keyword
Content-Language	Content-Language	keyword
charset parameter	Content-Charset	keyword
miscellaneous security	if needed at this level	

The first parameter in the header parameter-group for a request SHALL be the attribute "target-URI" which is the target object of the operation.

ISSUE: should the reason-phrase be in the initial parameter group instead of the second one for responses?

6.2 Chunking of Data

Second the "parameters" and "data" of the operation layer are separated by -3 (0xFFFD) instead of -1 (0xFFFF) to denote that the following data is chunked. A chunk of length 0 denotes the end of the data. The syntax for the chunked data is:

```
chunked-data = *data-chunk %x00 %x00
data-chunk = data-segment-length data-segment
data-segment-length = SIGNED-SHORT   ; number of octets of the data in binary
data-segment = OCTET-STRING
```

A data-segment contains fragments of the data. When all the data-segments are concatenated together, they form the complete data.

6.3 Revised Syntax for the Operation Layer

The following is the revised syntax for the operation layer.

```
ipp-message = ipp-request / ipp-response
ipp-request = version operation parameters data
ipp-response = version status parameters %xFF %xFF [ data ]
version = major-version minor-version
major-version = SIGNED-BYTE  ; initially %d1
minor-version = SIGNED-BYTE  ; initially %d0
operation = SIGNED-SHORT  ; mapping from model defined below
status = SIGNED-SHORT     ; mapping from model defined below
parameters = (headers / parameter-group ) *(%xFF %xFE parameter-group)
headers = %xFF %xFC parameter-group
parameter-group = *parameter
parameter = single-parameter *(more-values)
single-parameter = name-length name value-length value
more-values = zero-name-length value-length value
name-length = SIGNED-SHORT    ; number of octets of 'name'
name = LALPHA *( LALPHA / DIGIT / "-" / "_" )
value-length = SIGNED-SHORT  ; number of octets of 'value'
value = OCTET-STRING
zero-name-length = %x00 %x00
data = (%xFF %xFF [ full-data ] ) / ( %xFF %xFD chunked-data )
full-data = OCTET-STRING
chunked-data = *data-chunk %x00 %x00
data-chunk = data-segment-length data-segment
data-segment-length = SIGNED-SHORT   ; number of octets of the data in binary
data-segment = OCTET-STRING

SIGNED-BYTE = %x0..%xFF
SIGNED-SHORT = %x0..%xFF %x0..%xFF
DIGIT = "0".."9"
LALPHA = "a".."z"
BYTE = %x0..%xFF
OCTET-STRING = *BYTE
```

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NOTE: if I missed someone, please let me know.