INTERNET-DRAFT
<draft-ietf-ipp-protocol-v11-05.txt>

Robert Herriot (editor)
Xerox Corporation
Sylvan Butler
Hewlett-Packard
Paul Moore
Peerless Systems Networking
Randy Turner
2wire.com
John Wenn
Xerox Corporation
March 1, 2000

Internet Printing Protocol/1.1: Encoding and Transport

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 technologies. This document defines the rules for encoding IPP operations and IPP attributes into a new Internet mime media type called "application/ipp". This document also defines the rules for transporting over HTTP a message body whose Content-Type is "application/ipp". This document defines a new scheme named 'ipp' for identifying IPP printers and jobs.

The full set of IPP documents includes:

Design Goals for an Internet Printing Protocol [RFC2567]
Rationale for the Structure and Model and Protocol for the Internet Printing Protocol [RFC2568]
Internet Printing Protocol/1.1: Model and Semantics [ipp-mod]
Internet Printing Protocol/1.1: Encoding and Transport (this document)
Internet Printing Protocol/1.1: Implementer's Guide [ipp-iig]
Mapping between LPD and IPP Protocols [RFC2569]

The document, "Design Goals for an Internet Printing Protocol", 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. It calls out a subset of end user requirements that are satisfied in IPP/1.1. A few OPTIONAL operator operations have been added to IPP/1.1.

The document, "Rationale for the Structure and Model and Protocol for the Internet Printing Protocol", describes IPP from a high level view, defines a roadmap for the various documents that form the suite of IPP specification documents, and gives background and rationale for the IETF working group's major decisions.

The document, "Internet Printing Protocol/1.1: Model and Semantics", describes a simplified model with abstract objects, their attributes, and their operations that are independent of encoding and transport. It introduces a Printer and a Job object. The Job object optionally supports multiple documents per Job. It also addresses security, internationalization, and directory issues.

The document "Internet Printing Protocol/1.1: Implementer's Guide", gives advice to implementers of IPP clients and IPP objects.

The document "Mapping between LPD and IPP Protocols" gives some advice to implementers of gateways between IPP and LPD (Line Printer Daemon) implementations.

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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 2616 [RFC2616] 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/1.1: Model and Semantics" [ipp-mod] defines the semantics of such a message body and the supported values. This document specifies the encoding of an IPP operation. The aforementioned document [ipp-mod] is henceforth referred to as the "IPP model document"

2. Conformance Terminology

The key words "MUST", "MUST NOT", "REQUIRED", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in RFC 2119 [RFC2119].

3. Encoding of the Operation Layer

The operation layer MUST contain a single operation request or operation response. Each request or response consists of a sequence of values and attribute groups. Attribute groups consist of a sequence of attributes each of which is a name and value. Names and values are ultimately sequences of octets

The encoding consists of octets as the most primitive type. There are several types built from octets, but three important types are integers, character strings and octet strings, on which most other data types are built. Every character string in this encoding MUST be a sequence of characters where the characters are associated with some charset and some natural language. A character string MUST be in "reading order" with the first character in the value (according to reading order) being the first character in the encoding. A character string whose associated charset is US-ASCII whose associated natural language is US English is henceforth called a US-ASCII-STRING. A character string whose associated charset and natural language are specified in a request or response as described in the model document is henceforth called a LOCALIZED-STRING. An octet string MUST be in "IPP model document order" with the first octet in the value (according to the IPP model document order) being the first octet in the encoding Every integer in this encoding MUST be encoded as a signed integer using two's-complement binary encoding with big-endian format (also known as "network order" and "most significant byte first"). The number of octets for an integer MUST be 1, 2 or 4, depending on usage in the protocol. Such one-octet integers, henceforth called SIGNED-BYTE, are used for the version-number and tag fields. Such two-byte integers, henceforth called SIGNED-SHORT are used for the operation-id, status-code and length fields. Four byte integers, henceforth called SIGNED-INTEGER, are used for values fields and the sequence number.

The following two sections present the operation layer in two ways

- informally through pictures and description
- formally through Augmented Backus-Naur Form (ABNF), as specified by RFC 2234 [RFC2234]

3.1 Picture of the Encoding

The encoding for an operation request or response consists of:

```
-----------------------------------------------
|                  version-number             |   2 bytes  - required
-----------------------------------------------
|               operation-id (request)        |
|                      or                     |   2 bytes  - required
|               status-code (response)        |
-----------------------------------------------
|                   request-id                |   4 bytes  - required
-----------------------------------------------------------
|               xxx-attributes-tag            |   1 byte  |
-----------------------------------------------           |-0 or more
|             xxx-attribute-sequence          |   n bytes |
-----------------------------------------------------------
|              end-of-attributes-tag          |   1 byte   - required
-----------------------------------------------
|                     data                    |   q bytes  - optional
-----------------------------------------------
```

The xxx-attributes-tag and xxx-attribute-sequence represents four different values of "xxx", namely, operation, job, printer and unsupported. The xxx-attributes-tag and an xxx-attribute-sequence represent attribute groups in the model document. The xxx-attributes-tag identifies the attribute group and the xxx-attribute-sequence contains the attributes.

The expected sequence of xxx-attributes-tag and xxx-attribute-sequence is specified in the IPP model document for each operation request and operation response.

A request or response SHOULD contain each xxx-attributes-tag defined for that request or response even if there are no attributes except for the unsupported-attributes-tag which SHOULD be present only if the unsupported-attribute-sequence is non-empty. A receiver of a request MUST be able to process as equivalent empty attribute groups:

a) an xxx-attributes-tag with an empty xxx-attribute-sequence,

b) an expected but missing xxx-attributes-tag.

The data is omitted from some operations, but the end-of-attributes-tag is present even when the data is omitted. Note, the xxx-attributes-tags and end-of-attributes-tag are called 'delimiter-tags'. Note: the xxx-attribute-sequence, shown above may consist of 0 bytes, according to the rule below.

An xxx-attributes-sequence consists of zero or more compound-attributes.

```
-----------------------------------------------
|             compound-attribute              |   s bytes - 0 or more
-----------------------------------------------
```

A compound-attribute consists of an attribute with a single value followed by zero or more additional values.

Note: a 'compound-attribute' represents a single attribute in the model document. The 'additional value' syntax is for attributes with 2 or more values.

Each attribute consists of:

```
   -----------------------------------------------
   |                   value-tag                 |   1 byte
   -----------------------------------------------
   |               name-length  (value is u)     |   2 bytes
   -----------------------------------------------
   |                     name                    |   u bytes
   -----------------------------------------------
   |              value-length  (value is v)     |   2 bytes
   -----------------------------------------------
   |                     value                   |   v bytes
   -----------------------------------------------
```

An additional value consists of:

```
   -----------------------------------------------------------
   |                   value-tag                 |   1 byte  |
   -----------------------------------------------           |
   |            name-length  (value is 0x0000)   |   2 bytes |
   -----------------------------------------------           |-0 or more
   |              value-length (value is w)      |   2 bytes |
   -----------------------------------------------           |
   |                     value                   |   w bytes |
   -----------------------------------------------------------
```

Note: an additional value is like an attribute whose name-length is 0.

From the standpoint of a parsing loop, the encoding consists of:

```
   -----------------------------------------------
   |                  version-number             |   2 bytes  - required
   -----------------------------------------------
   |               operation-id (request)        |
   |                     or                      |   2 bytes  - required
   |               status-code (response)        |
   -----------------------------------------------
   |                   request-id                |   4 bytes  - required
   -----------------------------------------------------------
   |        tag (delimiter-tag or value-tag)     |   1 byte  |
   -----------------------------------------------           |-0 or more
   |           empty or rest of attribute        |   x bytes |
   -----------------------------------------------------------
   |              end-of-attributes-tag          |   2 bytes  - required
   -----------------------------------------------
   |                     data                    |   y bytes  - optional
   -----------------------------------------------
```

The value of the tag determines whether the bytes following the tag are:

- attributes
- data
- the remainder of a single attribute where the tag specifies the type of the value.

3.2 Syntax of Encoding

The syntax below is ABNF [RFC2234] except 'strings of literals' MUST be case sensitive. For example 'a' means lower case 'a' and not upper case 'A'. In addition, SIGNED-BYTE and SIGNED-SHORT fields are represented as '%x' values which show their range of values.

```
ipp-message = ipp-request / ipp-response
ipp-request = version-number operation-id request-id
        *(xxx-attributes-tag  xxx-attribute-sequence) end-of-attributes-tag data
ipp-response = version-number status-code request-id
        *(xxx-attributes-tag xxx-attribute-sequence)  end-of-attributes-tag  data
xxx-attribute-sequence = *compound-attribute

xxx-attributes-tag = operation-attributes-tag / job-attributes-tag /
     printer-attributes-tag / unsupported-attributes-tag

version-number = major-version-number minor-version-number
major-version-number = SIGNED-BYTE  ; initially %d1
minor-version-number = SIGNED-BYTE  ; initially %d0

operation-id = SIGNED-SHORT    ; mapping from model defined below
status-code = SIGNED-SHORT  ; mapping from model defined below
request-id = SIGNED-INTEGER ; whose value is > 0

compound-attribute = attribute *additional-values

attribute = value-tag name-length name value-length value
additional-values = value-tag 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

data = OCTET-STRING

zero-name-length = %x00.00                    ; name-length of 0
operation-attributes-tag =  %x01              ; tag of 1
job-attributes-tag          =  %x02           ; tag of 2
printer-attributes-tag =  %x04                ; tag of 4
unsupported- attributes-tag =  %x05    ; tag of 5
end-of-attributes-tag = %x03                  ; tag of 3
value-tag = %x10-FF

SIGNED-BYTE = BYTE
SIGNED-SHORT = 2BYTE
SIGNED-INTEGER = 4BYTE
DIGIT = %x30-39    ;  "0" to "9"
LALPHA = %x61-7A   ;  "a" to "z"
BYTE = %x00-FF
OCTET-STRING = *BYTE
```

The syntax allows an xxx-attributes-tag to be present when the xxx-attribute-sequence that follows is empty. The syntax is defined this way to allow for the response of Get-Jobs where no attributes are returned for some job-objects. Although it is

RECOMMENDED that the sender not send an xxx-attributes-tag if there are no attributes (except in the Get-Jobs response just mentioned), the receiver MUST be able to decode such syntax.

3.3 Version-number

The version-number MUST consist of a major and minor version-number, each of which MUST be represented by a SIGNED-BYTE. The protocol described in this document MUST have a major version-number of 1 (0x01) and a minor version-number of 1 (0x01). The ABNF for these two bytes MUST be %x01.01.

3.4 Operation-id

Operation-ids are defined as enums in the model document. An operation-ids enum value MUST be encoded as a SIGNED-SHORT.

3.5 Status-code

Status-codes are defined as enums in the model document. A status-code enum value MUST be encoded as a SIGNED-SHORT.

The status-code is an operation attribute in the model document. In the protocol, the status-code is in a special position, outside of the operation attributes.

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

3.6 Request-id

The request-id allows a client to match a response with a request. This mechanism is unnecessary in HTTP, but may be useful when application/ipp entity bodies are used in another context.

The request-id in a response MUST be the value of the request-id received in the corresponding request. A client can set the request-id in each request to a unique value or a constant value, such as 1, depending on what the client does with the request-id returned in the response. The value of the request-id MUST be greater than zero.

3.7 Tags

There are two kinds of tags:

- delimiter tags: delimit major sections of the protocol, namely attributes and data
- value tags: specify the type of each attribute value

3.7.1 Delimiter Tags

The following table specifies the values for the delimiter tags:

Tag Value (Hex)	Delimiter
0x00	reserved for definition in a future IETF standards track document
0x01	operation-attributes-tag
0x02	job-attributes-tag
0x03	end-of-attributes-tag
0x04	printer-attributes-tag
0x05	unsupported-attributes-tag
0x06-0x0e	reserved for future delimiters in IETF standards track documents
0x0F	reserved for future chunking-end-of-attributes-tag for definition in a future IETF standards track document

When an xxx-attributes-tag occurs in the protocol, it MUST mean that zero or more following attributes up to the next delimiter tag are attributes belonging to group xxx as defined in the model document, where xxx is operation, job, printer, unsupported.

Doing substitution for xxx in the above paragraph, this means the following. When an operation-attributes-tag occurs in the protocol, it MUST mean that the zero or more following attributes up to the next delimiter tag are operation attributes as defined in the model document. When an job-attributes-tag occurs in the protocol, it MUST mean that the zero or more following attributes up to the next delimiter tag are job attributes or job template attributes as defined in the model document. When a printer-attributes-tag occurs in the protocol, it MUST mean that the zero or more following attributes up to the next delimiter tag are printer attributes as defined in the model document. When an unsupported-attributes-tag occurs in the protocol, it MUST mean that the zero or more following attributes up to the next delimiter tag are unsupported attributes as defined in the model document.

The operation-attributes-tag and end-of-attributes-tag MUST each occur exactly once in an operation. The operation-attributes-tag MUST be the first tag delimiter, and the end-of-attributes-tag MUST be the last tag delimiter. If the operation has a document-content group, the document data in that group MUST follow the end-of-attributes-tag.

Each of the other three xxx-attributes-tags defined above is OPTIONAL in an operation and each MUST occur at most once in an operation, except for job-attributes-tag in a Get-Jobs response which may occur zero or more times.

The order and presence of delimiter tags for each operation request and each operation response MUST be that defined in the model document. For further details, see section 3.9 "(Attribute) Name" and 13 "Appendix A: Protocol Examples".

A Printer MUST treat the reserved delimiter tags differently from reserved value tags so that the Printer knows that there is an entire attribute group that it doesn't understand as opposed to a single value that it doesn't understand.

3.7.2 Value Tags

The remaining tables show values for the value-tag, which is the first octet of an attribute. The value-tag specifies the type of the value of the attribute. The following table specifies the "out-of-band" values for the value-tag.

Tag Value (Hex)	Meaning
0x10	unsupported
0x11	reserved for 'default' for definition in a future IETF standards track document
0x12	unknown
0x13	no-value
0x14-0x1F	reserved for "out-of-band" values in future IETF standards track documents.

The "unsupported" value MUST be used in the attribute-sequence of an error response for those attributes which the printer does not support. The "default" value is reserved for future use of setting value back to their default value. The "unknown" value is used for the value of a supported attribute when its value is temporarily unknown. The "no-value" value is used for a supported attribute to which no value has been assigned, e.g. "job-k-octets-supported" has no value if an implementation supports this attribute, but an administrator has not configured the printer to have a limit.

The following table specifies the integer values for the value-tag:

Tag Value (Hex)	**Meaning**
0x20	reserved for definition in a future IETF standards track document
0x21	integer
0x22	boolean
0x23	enum
0x24-0x2F	reserved for integer types for definition in future IETF standards track documents

NOTE: 0x20 is reserved for "generic integer" if it should ever be needed.

The following table specifies the octetString values for the value-tag:

Tag Value (Hex)	**Meaning**
0x30	octetString with an unspecified format
0x31	dateTime
0x32	resolution
0x33	rangeOfInteger
0x34	reserved for definition in a future IETF standards track document
0x35	textWithLanguage
0x36	nameWithLanguage
0x37-0x3F	reserved for octetString type definitions in future IETF standards track documents

The following table specifies the character-string values for the value-tag:

Tag Value (Hex)	**Meaning**
0x40	reserved for definition in a future IETF standards track document
0x41	textWithoutLanguage
0x42	nameWithoutLanguage
0x43	reserved for definition in a future IETF standards track document
0x44	keyword
0x45	uri
0x46	uriScheme
0x47	charset
0x48	naturalLanguage
0x49	mimeMediaType
0x4A-0x5F	reserved for character string type definitions in future IETF standards track documents

NOTE: 0x40 is reserved for "generic character-string" if it should ever be needed.

NOTE: an attribute value always has a type, which is explicitly specified by its tag; one such tag value is "nameWithoutLanguage". An attribute's name has an implicit type, which is keyword.

The values 0x60-0xFF are reserved for future type definations in IETF standards track documents.

The tag 0x7F is reserved for extending types beyond the 255 values available with a single byte. A tag value of 0x7F MUST signify that the first 4 bytes of the value field are interpreted as the tag value. Note, this future extension doesn't affect parsers that are unaware of this special tag. The tag is like any other unknown tag, and the value length specifies the length of a value which contains a value that the parser treats atomically. Values from 0x00 to 0x37777777 are reserved for definition in future IETF standard track documents. The values 0x40000000 to0x7FFFFFFF are reserved for vendor extensions.

3.8 Name-Length

The name-length field MUST consist of a SIGNED-SHORT. This field MUST specify the number of octets in the name field which follows the name-length field, excluding the two bytes of the name-length field.

If a name-length field has a value of zero, the following name field MUST be empty, and the following value MUST be treated as an additional value for the preceding attribute. Within an attribute-sequence, if two or more attributes have the same name, the attribute-sequence is mal-formed (see [ipp-mod] section 3.1.3). The zero-length name is the only mechanism for multi-valued attributes.

3.9 (Attribute) Name

Some operation elements are called parameters in the model document [ipp-mod]. They MUST be encoded in a special position and they MUST NOT appear as operation attributes. These parameters are:

- "version-number": The parameter named "version-number" in the IPP model document MUST become the "version-number" field in the operation layer request or response.

- "operation-id": The parameter named "operation-id" in the IPP model document MUST become the "operation-id" field in the operation layer request.

- "status-code": The parameter named "status-code" in the IPP model document MUST become the "status-code" field in the operation layer response.

- "request-id": The parameter named "request-id" in the IPP model document MUST become the "request-id" field in the operation layer request or response.

All Printer and Job objects are identified by a Uniform Resource Identifier (URI) [RFC2396] so that they can be persistently and unambiguously referenced. The notion of a URI is a useful concept, however, until the notion of URI is more stable (i.e., defined more completely and deployed more widely), it is expected that the URIs used for IPP objects will actually be URLs [RFC1738] [RFC1808]. Since every URL is a specialized form of a URI, even though the more generic term URI is used throughout the rest of this document, its usage is intended to cover the more specific notion of URL as well.

Some operation elements are encoded twice, once as the request-URI on the HTTP Request-Line and a second time as a REQUIRED operation attribute in the application/ipp entity. These attributes are the target URI for the operation and are called printer-uri and job-uri. Note: The target URI is included twice in an operation referencing the same IPP object, but the two URIs NEED NOT be literally identical. One can be a relative URI and the other can be an absolute URI. HTTP/1.1 allows clients to generate and send a relative URI rather than an absolute URI. A relative URI identifies a resource with the scope of the HTTP server, but does not include scheme, host or port. The following statements characterize how URLs should be used in the mapping of IPP onto HTTP/1.1:

1. Although potentially redundant, a client MUST supply the target of the operation both as an operation attribute and as a URI at the HTTP layer. The rationale for this decision is to maintain a consistent set of rules for mapping application/ipp to possibly many communication layers, even where URLs are not used as the addressing mechanism in the transport layer.

2. Even though these two URLs might not be literally identical (one being relative and the other being absolute), they MUST both reference the same IPP object.
3. The URI in the HTTP layer is either relative or absolute and is used by the HTTP server to route the HTTP request to the correct resource relative to that HTTP server. The HTTP server need not be aware of the URI within the operation request.
4. Once the HTTP server resource begins to process the HTTP request, it might get the reference to the appropriate IPP Printer object from either the HTTP URI (using to the context of the HTTP server for relative URLs) or from the URI within the operation request; the choice is up to the implementation.
5. HTTP URIs can be relative or absolute, but the target URI in the operation MUST be an absolute URI.

The model document arranges the remaining attributes into groups for each operation request and response. Each such group MUST be represented in the protocol by an xxx-attribute-sequence preceded by the appropriate xxx-attributes-tag (See the table below and section 13 "Appendix A: Protocol Examples"). In addition, the order of these xxx-attributes-tags and xxx-attribute-sequences in the protocol MUST be the same as in the model document, but the order of attributes within each xxx-attribute-sequence MUST be unspecified. The table below maps the model document group name to xxx-attributes-sequence:

Model Document Group	***xxx*-attributes-sequence**
Operation Attributes	operations-attributes-sequence
Job Template Attributes	job-attributes-sequence
Job Object Attributes	job-attributes-sequence
Unsupported Attributes	unsupported- attributes-sequence
Requested Attributes (Get-Job-Attributes)	job-attributes-sequence
Requested Attributes (Get-Printer-Attributes)	printer-attributes-sequence
Document Content	in a special position as described above

If an operation contains attributes from more than one job object (e.g. Get-Jobs response), the attributes from each job object MUST be in a separate job-attribute-sequence, such that the attributes from the ith job object are in the ith job-attribute-sequence. See Section 13 "Appendix A: Protocol Examples" for table showing the application of the rules above.

3.10 Value Length

Each attribute value MUST be preceded by a SIGNED-SHORT, which MUST specify the number of octets in the value which follows this length, exclusive of the two bytes specifying the length.

For any of the types represented by binary signed integers, the sender MUST encode the value in exactly four octets.

For any of the types represented by character-strings, the sender MUST encode the value with all the characters of the string and without any padding characters.

If a value-tag contains an "out-of-band" value defined in this document, such as "unsupported", the value-length MUST be 0 and the value empty; the value has no meaning when the value-tag has one of these "out-of-band" values. However, the definitions of additional "out-of-band" values in future documents are able to explicitly use the value field and have a value-length that is non-zero, if there is a need for additional information to be associated with the out-of-band value. Unless the definition of an "out-of-band" value explicitly allows for a value, the value-length MUST be 0 and the value empty.

3.11 (Attribute) Value

The syntax types and most of the details of the representation of attribute values are defined in the IPP model document. The table below augments the information in the model document, and defines the syntax types from the model document in terms of the 5 basic types defined in section 3 "Encoding of the Operation Layer". The 5 types are US-ASCII-STRING, LOCALIZED-STRING, SIGNED-INTEGER, SIGNED-SHORT, SIGNED-BYTE, and OCTET-STRING.

Syntax of Attribute Value	**Encoding**
textWithoutLanguage, nameWithoutLanguage	LOCALIZED-STRING.
textWithLanguage	OCTET_STRING consisting of 4 fields: a. a SIGNED-SHORT which is the number of octets in the following field b a value of type natural-language, c. a SIGNED-SHORT which is the number of octets in the following field, d. a value of type textWithoutLanguage. The length of a textWithLanguage value MUST be 4 + the value of field a + the value of field c.
nameWithLanguage	OCTET_STRING consisting of 4 fields: a. a SIGNED-SHORT which is the number of octets in the following field b. a value of type natural-language, c. a SIGNED-SHORT which is the number of octets in the following field d. a value of type nameWithoutLanguage. The length of a nameWithLanguage value MUST be 4 + the value of field a + the value of field c.
charset, naturalLanguage, mimeMediaType, keyword, uri, and uriScheme	US-ASCII-STRING.
boolean	SIGNED-BYTE where 0x00 is 'false' and 0x01 is 'true'.
integer and enum	a SIGNED-INTEGER.
dateTime	OCTET-STRING consisting of eleven octets whose contents are defined by "DateAndTime" in RFC 1903 [RFC1903].
resolution	OCTET_STRING consisting of nine octets of 2 SIGNED-INTEGERs followed by a SIGNED-BYTE. The first SIGNED-INTEGER contains the value of cross feed direction resolution. The second SIGNED-INTEGER contains the value of feed direction resolution. The SIGNED-BYTE contains the units value.
rangeOfInteger	Eight octets consisting of 2 SIGNED-INTEGERs. The first SIGNED-INTEGER contains the lower bound and the second SIGNED-INTEGER contains the upper bound.
1setOf X	Encoding according to the rules for an attribute with more than 1 value. Each value X is encoded according to the rules for encoding its type.
octetString	OCTET-STRING

The type of the value in the model document determines the encoding in the value and the value of the value-tag.

3.12 Data

The data part MUST include any data required by the operation

4. Encoding of Transport Layer

HTTP/1.1 [RFC2616] is 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.

It is REQUIRED that a printer implementation support HTTP over the IANA assigned Well Known Port 631 (the IPP default port), though a printer implementation may support HTTP over some other port as well.

Each HTTP operation MUST use the POST method where the request-URI is the object target of the operation, and where the "Content-Type" of the message-body in each request and response MUST be "application/ipp". The message-body MUST contain the operation layer and MUST have the syntax described in section 3.2 "Syntax of Encoding". A client implementation MUST adhere to the rules for a client described for HTTP1.1 [RFC2616] . A printer (server) implementation MUST adhere the rules for an origin server described for HTTP1.1 [RFC2616].

An IPP server sends a response for each request that it receives. If an IPP server detects an error, it MAY send a response before it has read the entire request. If the HTTP layer of the IPP server completes processing the HTTP headers successfully, it MAY send an intermediate response, such as "100 Continue", with no IPP data before sending the IPP response. A client MUST expect such a variety of responses from an IPP server. For further information on HTTP/1.1, consult the HTTP documents [RFC2616].

An HTTP server MUST support chunking for IPP requests, and an IPP client MUST support chunking for IPP responses according to HTTP/1.1[RFC2616]. Note: this rule causes a conflict with non-compliant implementations of HTTP/1.1 that don't support chunking for POST methods, and this rule may cause a conflict with non-compliant implementations of HTTP/1.1 that don't support chunking for CGI scripts

5. IPP URL Scheme

The IPP/1.1 document defines a new scheme 'ipp' as the value of a URL that identifies either an IPP printer object or an IPP job object. The IPP attributes using the 'ipp' scheme are specified below. Because the HTTP layer does not support the 'ipp' scheme, a client MUST map 'ipp' URLs to 'http' URLs, and then follows the HTTP [RFC2616][RFC2617] rules for constructing a Request-Line and HTTP headers. The mapping is simple because the 'ipp' scheme implies all of the same protocol semantics as that of the 'http' scheme [RFC2616], except that it represents a print service and the implicit (default) port number that clients use to connect to a server is port 631.

In the remainder of this section the term 'ipp-URL' means a URL whose scheme is 'ipp' and whose implicit (default) port is 631. The term 'http-URL' means a URL whose scheme is 'http', and the term 'https-URL' means a URL whose scheme is 'https',

A client and an IPP object (i.e. the server) MUST support the ipp-URL value in the following IPP attributes.

job attributes:
job-uri
job-printer-uri
printer attributes:
printer-uri-supported

```
   operation attributes:
               job-uri
               printer-uri
```

Each of the above attributes identifies a printer or job object. The ipp-URL is intended as the value of the attributes in this list, and for no other attributes. All of these attributes have a syntax type of 'uri', but there are attributes with a syntax type of 'uri' that do not use the 'ipp' scheme, e.g. 'job-more-info'.

If a printer registers its URL with a directory service, the printer MUST register an ipp-URL.

User interfaces are beyond the scope of this document. But if software exposes the ipp-URL values of any of the above five attributes to a human user, it is REQUIRED that the human see the ipp-URL as is.

When a client sends a request, it MUST convert a target ipp-URL to a target http-URL for the HTTP layer according to the following rules:

1. change the 'ipp' scheme to 'http'
2. add an explicit port 631 if the URL does not contain an explicit port. Note: port 631 is the IANA assigned Well Known Port for the 'ipp' scheme.

The client MUST use the target http-URL in both the HTTP Request-Line and HTTP headers, as specified by HTTP[RFC2616][RFC2617] . However, the client MUST use the target ipp-URL for the value of the "printer-uri" or "job-uri" operation attribute within the application/ipp body of the request. The server MUST use the ipp-URL for the value of the "printer-uri", "job-uri" or "printer-uri-supported" attributes within the application/ipp body of the response.

For example, when an IPP client sends a request directly (i.e. no proxy) to an ipp-URL "ipp://myhost.com/myprinter/myqueue", it opens a TCP connection to port 631 (the ipp implicit port) on the host "myhost.com" and sends the following data:

```
POST /myprinter/myqueue HTTP/1.1
Host: myhost.com:631
Content-type: application/ipp
Transfer-Encoding: chunked
...
"printer-uri" "ipp://myhost.com/myprinter/myqueue"
                    (encoded in application/ipp message body)
...
```

As another example, when an IPP client sends the same request as above via a proxy "myproxy.com", it opens a TCP connection to the proxy port 8080 on the proxy host "myproxy.com" and sends the following data:

```
POST http://myhost.com:631/myprinter/myqueue   HTTP/1.1
Host: myhost.com:631
Content-type: application/ipp
Transfer-Encoding: chunked
...
"printer-uri" "ipp://myhost.com/myprinter/myqueue"
                    (encoded in application/ipp message body)
...
```

The proxy then connects to the IPP origin server with headers that are the same as the "no-proxy" example above.

6. IANA Considerations

This section describes the procedures for allocating encoding for the following IETF standards track extensions and vendor extensions to the IPP/1.1 Encoding and Transport document:

1. attribute syntaxes - see [ipp-mod] section 6.3
2. attribute groups - see [ipp-mod] section 6.5
3. out-of-band attribute values - see [ipp-mod] section 6.7

These extensions follow the "type2" registration procedures defined in [ipp-mod] section 6. Extensions registered for use with IPP/1.1 are OPTIONAL for client and IPP object conformance to the IPP/1.1 Encoding and Transport document.

These extension procedures are aligned with the guidelines as set forth by the IESG [IANA-CON]. The [ipp-mod] Section 11 describes how to propose new registrations for consideration. IANA will reject registration proposals that leave out required information or do not follow the appropriate format described in [ipp-mod] Section 11. The IPP/1.1 Encoding and Transport document may also be extended by an appropriate RFC that specifies any of the above extensions.

7. Internationalization Considerations

See the section on "Internationalization Considerations" in the document "Internet Printing Protocol/1.1: Model and Semantics" [ipp-mod] for information on internationalization. This document adds no additional issues.

8. Security Considerations

The IPP Model and Semantics document [ipp-mod] discusses high level security requirements (Client Authentication, Server Authentication and Operation Privacy). Client Authentication is the mechanism by which the client proves its identity to the server in a secure manner. Server Authentication is the mechanism by which the server proves its identity to the client in a secure manner. Operation Privacy is defined as a mechanism for protecting operations from eavesdropping.

8.1 Security Conformance Requirements

This section defines the security requirements for IPP clients and IPP objects.

8.1.1 Digest Authentication

IPP clients MUST support:

Digest Authentication [RFC2617].

MD5 and MD5-sess MUST be implemented and supported.

The Message Integrity feature NEED NOT be used.

IPP Printers SHOULD support:

Digest Authentication [RFC2617].

MD5 and MD5-sess MUST be implemented and supported.

The Message Integrity feature NEED NOT be used.

The reasons that IPP Printers SHOULD (rather than MUST) support Digest Authentication are:

1. While Client Authentication is important, there is a certain class of printer devices where it does not make sense. Specifically, a low-end device with limited ROM space and low paper throughput may not need Client Authentication. This class of device typically requires firmware designers to make trade-offs between protocols and functionality to arrive at the lowest-cost solution possible. Factored into the designer's decisions is not just the size of the code, but also the testing, maintenance, usefulness, and time-to-market impact for each feature delivered to the customer. Forcing such low-end devices to provide security in order to claim IPP/1.1 conformance would not make business sense and could potentially stall the adoption of the standard.

2. Print devices that have high-volume throughput and have available ROM space have a compelling argument to provide support for Client Authentication that safeguards the device from unauthorized access. These devices are prone to a high loss of consumables and paper if unauthorized access should occur.

8.1.2 Transport Layer Security (TLS)

IPP Printers SHOULD support Transport Layer Security (TLS) [RFC2246] for Server Authentication and Operation Privacy. IPP Printers MAY also support TLS for Client Authentication. If an IPP Printer supports TLS, it MUST support the TLS_DHE_DSS_WITH_3DES_EDE_CBC_SHA cipher suite as mandated by RFC 2246 [RFC2246]. All other cipher suites are OPTIONAL. An IPP Printer MAY support Basic Authentication (described in HTTP/1.1 [RFC2617]) for Client Authentication if the channel is secure. TLS with the above mandated cipher suite can provide such a secure channel.

If a IPP client supports TLS, it MUST support the TLS_DHE_DSS_WITH_3DES_EDE_CBC_SHA cipher suite as mandated by RFC 2246 [RFC2246]. All other cipher suites are OPTIONAL.

The IPP Model and Semantics document defines two printer attributes ("uri-authentication-supported" and "uri-security-supported") that the client can use to discover the security policy of a printer. That document also outlines IPP-specific security considerations and should be the primary reference for security implications with regard to the IPP protocol itself. For backward compatibility with IPP version 1.0, IPP clients and printers may also support SSL3 [ssl]. This is in addition to the security required in this document.

8.2 Using IPP with TLS

IPP/1.1 uses the "Upgrading to TLS Within HTTP/1.1" mechanism [http-tls]. An initial IPP request never uses TLS. The client requests a secure TLS connection by using the HTTP "Upgrade" header, while the server agrees in the HTTP response. The switch to TLS occurs either because the server grants the client's request to upgrade to TLS, or a server asks to switch to TLS in its response. Secure communication begins with a server's response to switch to TLS.

9. Interoperability with IPP/1.0 Implementations

It is beyond the scope of this specification to mandate conformance with previous versions. IPP/1.1 was deliberately designed, however, to make supporting previous versions easy. It is worth noting that, at the time of composing this specification (1999), we would expect IPP/1.1 Printer implementations to:

understand any valid request in the format of IPP/1.0, or 1.1;

respond appropriately with a response containing the same "version-number" parameter value used by the client in the request.

And we would expect IPP/1.1 clients to:

understand any valid response in the format of IPP/1.0, or 1.1.

9.1 The "version-number" Parameter

The following are rules regarding the "version-number" parameter (see section 3.3):

1. Clients MUST send requests containing a "version-number" parameter with a '1.1' value and SHOULD try supplying alternate version numbers if they receive a 'server-error-version-not-supported' error return in a response.

2. IPP objects MUST accept requests containing a "version-number" parameter with a '1.1' value (or reject the request for reasons other than 'server-error-version-not-supported').

3. It is recommended that IPP objects accept any request with the major version '1' (or reject the request for reasons other than 'server-error-version-not-supported'). See [ipp-mod] "versions" sub-section.

4. In any case, security MUST NOT be compromised when a client supplies a lower "version-number" parameter in a request. For example, if an IPP/1.1 conforming Printer object accepts version '1.0' requests and is configured to enforce Digest Authentication, it MUST do the same for a version '1.0' request.

9.2 Security and URL Schemes

The following are rules regarding security, the "version-number" parameter, and the URL scheme supplied in target attributes and responses:

1. When a client supplies a request, the "printer-uri" or "job-uri" target operation attribute MUST have the same scheme as that indicated in one of the values of the "printer-uri-supported" Printer attribute.

2. When the server returns the "job-printer-uri" or "job-uri" Job Description attributes, it SHOULD return the same scheme ('ipp', 'https', 'http', etc.) that the client supplied in the "printer-uri" or "job-uri" target operation attributes in the Get-Job-Attributes or Get-Jobs request, rather than the scheme used when the job was created. However, when a client requests job attributes using the Get-Job-Attributes or Get-Jobs operations, the jobs and job attributes that the server returns depends on: (1) the security in effect when the job was created, (2) the security in effect in the query request, and (3) the security policy in force.

3. It is recommended that if a server registers a non-secure ipp-URL with a directory service (see [IPP-MOD] "Generic Directory Schema" Appendix), then it also register an http-URL for interoperability with IPP/1.0 clients (see section 9).

4. In any case, security MUST NOT be compromised when a client supplies an 'http' or other non-secure URL scheme in the target "printer-uri" and "job-uri" operation attributes in a request.

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11. Author's Address

Robert Herriot (editor)
Xerox Corporation
3400 Hillview Ave., Bldg #1
Palo Alto, CA 94304

Phone: 650-813-7696
Fax: 650-813-6860
Email: robert.herriot@pahv.xerox.com

Sylvan Butler
Hewlett-Packard
11311 Chinden Blvd.
Boise, ID 83714

Phone: 208-396-6000
Fax: 208-396-3457
Email: sbutler@boi.hp.com

IPP Mailing List: ipp@pwg.org
IPP Mailing List Subscription: ipp-request@pwg.org
IPP Web Page: http://www.pwg.org/ipp/

Paul Moore
Peerless Systems Networking
10900 NE 8th St #900
Bellevue, WA 98004

Phone: 425-462-5852

Email: pmoore@peerless.com

Randy Turner
2Wire, Inc.
694 Tasman Dr.
Milpitas, CA 95035

Phone: 408-546-1273

John Wenn
Xerox Corporation
737 Hawaii St
El Segundo, CA 90245

Phone: 310-333-5764
Fax: 310-333-5514
Email: jwenn@cp10.es.xerox.com

12. Other Participants:

Chuck Adams - Tektronix
Shivaun Albright - HP
Stefan Andersson - Axis
Jeff Barnett - IBM
Ron Bergman - Hitachi Koki Imaging Systems
Dennis Carney - IBM
Keith Carter - IBM
Angelo Caruso - Xerox
Rajesh Chawla - TR Computing Solutions
Nancy Chen - Okidata
Josh Cohen - Microsoft
Jeff Copeland - QMS
Andy Davidson - Tektronix
Roger deBry - IBM
Maulik Desai - Auco
Mabry Dozier - QMS
Lee Farrell - Canon Information Systems
Satoshi Fujitami - Ricoh
Steve Gebert - IBM
Sue Gleeson - Digital
Charles Gordon - Osicom
Brian Grimshaw - Apple
Jerry Hadsell - IBM
Richard Hart - Digital
Tom Hastings - Xerox
Henrik Holst - I-data
Stephen Holmstead
Zhi-Hong Huang - Zenographics
Scott Isaacson - Novell
Babek Jahromi - Microsoft
Swen Johnson - Xerox
David Kellerman - Northlake Software
Robert Kline - TrueSpectra
Charles Kong - Panasonic
Carl Kugler - IBM
Dave Kuntz - Hewlett-Packard
Takami Kurono - Brother
Rick Landau - Digital
Scott Lawrence - Agranot Systems
Greg LeClair - Epson
Dwight Lewis - Lexmark
Harry Lewis - IBM
Tony Liao - Vivid Image
Roy Lomicka - Digital
Pete Loya - HP
Ray Lutz - Cognisys
Mike MacKay - Novell, Inc.
David Manchala - Xerox
Carl-Uno Manros - Xerox
Jay Martin - Underscore
Stan McConnell - Xerox
Larry Masinter - Xerox
Sandra Matts - Hewlett Packard
Peter Michalek - Shinesoft
Ira McDonald - High North Inc.
Mike Moldovan - G3 Nova
Tetsuya Morita - Ricoh
Yuichi Niwa - Ricoh
Pat Nogay - IBM
Ron Norton - Printronics
Hugo Parra, Novell
Bob Pentecost - Hewlett-Packard
Patrick Powell - Astart Technologies
Jeff Rackowitz - Intermec
Eric Random - Peerless
Rob Rhoads - Intel
Xavier Riley - Xerox
Gary Roberts - Ricoh
David Roach - Unisys
Stuart Rowley - Kyocera
Yuji Sasaki - Japan Computer Industry
Richard Schneider - Epson
Kris Schoff - HP
Katsuaki Sekiguchi - Canon Information Systems
Bob Setterbo - Adobe
Gail Songer - Peerless
Hideki Tanaka - Cannon Information Systems
Devon Taylor - Novell, Inc.
Mike Timperman - Lexmark
Atsushi Uchino - Epson
Shigeru Ueda - Canon
Bob Von Andel - Allegro Software
William Wagner - NetSilicon/DPI
Jim Walker - DAZEL
Chris Wellens - Interworking Labs
Trevor Wells - Hewlett Packard
Craig Whittle - Sharp Labs
Rob Whittle - Novell, Inc.
Jasper Wong - Xionics
Don Wright - Lexmark
Michael Wu - Heidelberg Digital
Rick Yardumian - Xerox
Michael Yeung - Canon Information Systems
Lloyd Young - Lexmark
Atsushi Yuki - Kyocera
Peter Zehler - Xerox
William Zhang- Canon Information Systems
Frank Zhao - Panasonic
Steve Zilles - Adobe
Rob Zirnstein - Canon Information Systems

13. Appendix A: Protocol Examples

13.1 Print-Job Request

The following is an example of a Print-Job request with job-name, copies, and sides specified. The "ipp-attribute-fidelity" attribute is set to 'true' so that the print request will fail if the "copies" or the "sides" attribute are not supported or their values are not supported.

Octets	**Symbolic Value**	**Protocol field**
0x0101	1.1	version-number
0x0002	Print-Job	operation-id
0x00000001	1	request-id
0x01	start operation-attributes	operation-attributes-tag
0x47	charset type	value-tag
0x0012		name-length
attributes-charset	attributes-charset	name
0x0008		value-length
us-ascii	US-ASCII	value
0x48	natural-language type	value-tag
0x001B		name-length
attributes-natural-language	attributes-natural-language	name
0x0005		value-length
en-us	en-US	value
0x45	uri type	value-tag
0x000B		name-length
printer-uri	printer-uri	name
0x0015		value-length
ipp://forest/pinetree	printer pinetree	value
0x42	nameWithoutLanguage type	value-tag
0x0008		name-length
job-name	job-name	name
0x0006		value-length
foobar	foobar	value
0x22	boolean type	value-tag
0x0016		name-length
ipp-attribute-fidelity	ipp-attribute-fidelity	name
0x0001		value-length
0x01	true	value
0x02	start job-attributes	job-attributes-tag
0x21	integer type	value-tag
0x0006		name-length
copies	copies	name
0x0004		value-length
0x00000014	20	value
0x44	keyword type	value-tag
0x0005		name-length
sides	sides	name
0x0013		value-length
two-sided-long-edge	two-sided-long-edge	value
0x03	end-of-attributes	end-of-attributes-tag
%!PS...	<PostScript>	data

13.2 Print-Job Response (successful)

Here is an example of a successful Print-Job response to the previous Print-Job request. The printer supported the "copies" and "sides" attributes and their supplied values. The status code returned is 'successful-ok'.

Octets	Symbolic Value	Protocol field
0x0101	1.1	version-number
0x0000	successful-ok	status-code
0x00000001	1	request-id
0x01	start operation-attributes	operation-attributes-tag
0x47	charset type	value-tag
0x0012		name-length
attributes-charset	attributes-charset	name
0x0008		value-length
us-ascii	US-ASCII	value
0x48	natural-language type	value-tag
0x001B		name-length
attributes-natural-language	attributes-natural-language	name
0x0005		value-length
en-us	en-US	value
0x41	textWithoutLanguage type	value-tag
0x000E		name-length
status-message	status-message	name
0x000D		value-length
successful-ok	successful-ok	value
0x02	start job-attributes	job-attributes-tag
0x21	integer	value-tag
0x0006		name-length
job-id	job-id	name
0x0004		value-length
147	147	value
0x45	uri type	value-tag
0x0007		name-length
job-uri	job-uri	name
0x0019		value-length
ipp://forest/pinetree/123	job 123 on pinetree	value
0x23	enum type	value-tag
0x0009		name-length
job-state	job-state	name
0x0004		value-length
0x0003	pending	value
0x03	end-of-attributes	end-of-attributes-tag

13.3 Print-Job Response (failure)

Here is an example of an unsuccessful Print-Job response to the previous Print-Job request. It fails because, in this case, the printer does not support the "sides" attribute and because the value '20' for the "copies" attribute is not supported. Therefore, no job is created, and neither a "job-id" nor a "job-uri" operation attribute is returned. The error code returned is 'client-error-attributes-or-values-not-supported' (0x040B).

Octets	**Symbolic Value**	**Protocol field**
0x0101	1.1	version-number
0x040B	client-error-attributes-or-values-not-supported	status-code
0x00000001	1	request-id
0x01	start operation-attributes	operation-attribute tag
0x47	charset type	value-tag
0x0012		name-length
attributes-charset	attributes-charset	name
0x0008		value-length
us-ascii	US-ASCII	value
0x48	natural-language type	value-tag
0x001B		name-length
attributes-natural-language	attributes-natural-language	name
0x0005		value-length
en-us	en-US	value
0x41	textWithoutLanguage type	value-tag
0x000E		name-length
status-message	status-message	name
0x002F		value-length
client-error-attributes-or-values-not-supported	client-error-attributes-or-values-not-supported	value
0x05	start unsupported-attributes	unsupported-attributes tag
0x21	integer type	value-tag
0x0006		name-length
copies	copies	name
0x0004		value-length
0x00000014	20	value
0x10	unsupported (type)	value-tag
0x0005		name-length
sides	sides	name
0x0000		value-length
0x03	end-of-attributes	end-of-attributes-tag

13.4 Print-Job Response (success with attributes ignored)

Here is an example of a successful Print-Job response to a Print-Job request like the previous Print-Job request, except that the value of 'ipp-attribute-fidelity' is false. The print request succeeds, even though, in this case, the printer supports neither the "sides" attribute nor the value '20' for the "copies" attribute. Therefore, a job is created, and both a "job-id" and a "job-uri" operation attribute are returned. The unsupported attributes are also returned in an Unsupported Attributes Group. The error code returned is 'successful-ok-ignored-or-substituted-attributes' (0x0001).

Octets	Symbolic Value	Protocol field
0x0101	1.1	version-number
0x0001	successful-ok-ignored-or-substituted-attributes	status-code
0x00000001	1	request-id
0x01	start operation-attributes	operation-attributes-tag
0x47	charset type	value-tag
0x0012		name-length
attributes-charset	attributes-charset	name
0x0008		value-length
us-ascii	US-ASCII	value
0x48	natural-language type	value-tag
0x001B		name-length
attributes-natural-language	attributes-natural-language	name
0x0005		value-length
en-us	en-US	value
0x41	textWithoutLanguage type	value-tag
0x000E		name-length
status-message	status-message	name
0x002F		value-length
successful-ok-ignored-or-substituted-attributes	successful-ok-ignored-or-substituted-attributes	value
0x05	start unsupported-attributes	unsupported-attributes tag
0x21	integer type	value-tag
0x0006		name-length
copies	copies	name
0x0004		value-length
0x00000014	20	value
0x10	unsupported (type)	value-tag
0x0005		name-length
sides	sides	name
0x0000		value-length
0x02	start job-attributes	job-attributes-tag
0x21	integer	value-tag
0x0006		name-length
job-id	job-id	name
0x0004		value-length
147	147	value
0x45	uri type	value-tag
0x0007		name-length
job-uri	job-uri	name
0x0019		value-length
ipp://forest/pinetree/123	job 123 on pinetree	value
0x23	enum type	value-tag
0x0009		name-length
job-state	job-state	name
0x0004		value-length
0x0003	pending	value
0x03	end-of-attributes	end-of-attributes-tag

13.5 Print-URI Request

The following is an example of Print-URI request with copies and job-name parameters:

Octets	Symbolic Value	Protocol field
0x0101	1.1	version-number
0x0003	Print-URI	operation-id
0x00000001	1	request-id
0x01	start operation-attributes	operation-attributes-tag
0x47	charset type	value-tag
0x0012		name-length
attributes-charset	attributes-charset	name
0x0008		value-length
us-ascii	US-ASCII	value
0x48	natural-language type	value-tag
0x001B		name-length
attributes-natural-language	attributes-natural-language	name
0x0005		value-length
en-us	en-US	value
0x45	uri type	value-tag
0x000B		name-length
printer-uri	printer-uri	name
0x0015		value-length
ipp://forest/pinetree	printer pinetree	value
0x45	uri type	value-tag
0x000C		name-length
document-uri	document-uri	name
0x0011		value-length
ftp://foo.com/foo	ftp://foo.com/foo	value
0x42	nameWithoutLanguage type	value-tag
0x0008		name-length
job-name	job-name	name
0x0006		value-length
foobar	foobar	value
0x02	start job-attributes	job-attributes-tag
0x21	integer type	value-tag
0x0006		name-length
copies	copies	name
0x0004		value-length
0x00000001	1	value
0x03	end-of-attributes	end-of-attributes-tag

13.6 Create-Job Request

The following is an example of Create-Job request with no parameters and no attributes:

Octets	Symbolic Value	Protocol field
0x0101	1.1	version-number
0x0005	Create-Job	operation-id
0x00000001	1	request-id
0x01	start operation-attributes	operation-attributes-tag
0x47	charset type	value-tag
0x0012		name-length
attributes-charset	attributes-charset	name
0x0008		value-length
us-ascii	US-ASCII	value
0x48	natural-language type	value-tag
0x001B		name-length
attributes-natural-language	attributes-natural-language	name
0x0005		value-length
en-us	en-US	value
0x45	uri type	value-tag
0x000B		name-length
printer-uri	printer-uri	name
0x0015		value-length
ipp://forest/pinetree	printer pinetree	value
0x03	end-of-attributes	end-of-attributes-tag

13.7 Get-Jobs Request

The following is an example of Get-Jobs request with parameters but no attributes:

Octets	Symbolic Value	Protocol field
0x0101	1.1	version-number
0x000A	Get-Jobs	operation-id
0x00000123	0x123	request-id
0x01	start operation-attributes	operation-attributes-tag
0x47	charset type	value-tag
0x0012		name-length
attributes-charset	attributes-charset	name
0x0008		value-length
us-ascii	US-ASCII	value
0x48	natural-language type	value-tag
0x001B		name-length
attributes-natural-language	attributes-natural-language	name
0x0005		value-length
en-us	en-US	value
0x45	uri type	value-tag
0x000B		name-length
printer-uri	printer-uri	name
0x0015		value-length
ipp://forest/pinetree	printer pinetree	value
0x21	integer type	value-tag
0x0005		name-length
limit	limit	name
0x0004		value-length
0x00000032	50	value
0x44	keyword type	value-tag
0x0014		name-length
requested-attributes	requested-attributes	name
0x0006		value-length
job-id	job-id	value
0x44	keyword type	value-tag
0x0000	additional value	name-length
0x0008		value-length
job-name	job-name	value
0x44	keyword type	value-tag
0x0000	additional value	name-length
0x000F		value-length
document-format	document-format	value
0x03	end-of-attributes	end-of-attributes-tag

13.8 Get-Jobs Response

The following is an of Get-Jobs response from previous request with 3 jobs. The Printer returns no information about the second job (because of security reasons):

Octets	Symbolic Value	Protocol field
0x0101	1.1	version-number
0x0000	successful-ok	status-code
0x00000123	0x123	request-id (echoed back)
0x01	start operation-attributes	operation-attribute-tag
0x47	charset type	value-tag
0x0012		name-length
attributes-charset	attributes-charset	name
0x000A		value-length
ISO-8859-1	ISO-8859-1	value
0x48	natural-language type	value-tag
0x001B		name-length
attributes-natural-language	attributes-natural-language	name
0x0005		value-length
en-us	en-US	value
0x41	textWithoutLanguage type	value-tag
0x000E		name-length
status-message	status-message	name
0x000D		value-length
successful-ok	successful-ok	value
0x02	start job-attributes (1st object)	job-attributes-tag
0x21	integer type	value-tag
0x0006		name-length
job-id	job-id	name
0x0004		value-length
147	147	value
0x36	nameWithLanguage	value-tag
0x0008		name-length
job-name	job-name	name
0x000C		value-length
0x0005		sub-value-length
fr-ca	fr-CA	value
0x0003		sub-value-length
fou	fou	name
0x02	start job-attributes (2nd object)	job-attributes-tag
0x02	start job-attributes (3rd object)	job-attributes-tag
0x21	integer type	value-tag
0x0006		name-length
job-id	job-id	name
0x0004		value-length
148	149	value
0x36	nameWithLanguage	value-tag
0x0008		name-length
job-name	job-name	name
0x0012		value-length
0x0005		sub-value-length
de-CH	de-CH	value
0x0009		sub-value-length
isch guet	isch guet	name
0x03	end-of-attributes	end-of-attributes-tag

14. Appendix B: Registration of MIME Media Type Information for "application/ipp"

This appendix contains the information that IANA requires for registering a MIME media type. The information following this paragraph will be forwarded to IANA to register application/ipp whose contents are defined in Section 3 "Encoding of the Operation Layer" in this document:

MIME type name: application

MIME subtype name: ipp

A Content-Type of "application/ipp" indicates an Internet Printing Protocol message body (request or response). Currently there is one version: IPP/1.1, whose syntax is described in Section 3 "Encoding of the Operation Layer" of [ipp-pro], and whose semantics are described in [ipp-mod].

Required parameters: none

Optional parameters: none

Encoding considerations:

IPP/1.1 protocol requests/responses MAY contain long lines and ALWAYS contain binary data (for example attribute value lengths).

Security considerations:

IPP/1.1 protocol requests/responses do not introduce any security risks not already inherent in the underlying transport protocols. Protocol mixed-version interworking rules in [ipp-mod] as well as protocol encoding rules in [ipp-pro] are complete and unambiguous.

Interoperability considerations:

IPP/1.1 requests (generated by clients) and responses (generated by servers) MUST comply with all conformance requirements imposed by the normative specifications [ipp-mod] and [ipp-pro]. Protocol encoding rules specified in [ipp-pro] are comprehensive, so that interoperability between conforming implementations is guaranteed (although support for specific optional features is not ensured). Both the "charset" and "natural-language" of all IPP/1.1 attribute values which are a LOCALIZED-STRING are explicit within IPP protocol requests/responses (without recourse to any external information in HTTP, SMTP, or other message transport headers).

Published specifications:

[ipp-mod] Isaacson, S., deBry, R., Hastings, T., Herriot, R., Powell, P., "Internet Printing Protocol/1.1: Model and Semantics" draft-ietf-ipp-model-v11-06.txt, March 1, 2000.

[ipp-pro] Herriot, R., Butler, S., Moore, P., Turner, R., "Internet Printing Protocol/1.1: Encoding and Transport", draft-ietf-ipp-protocol-v11-05.txt, March 1, 2000.

Applications which use this media type:

Internet Printing Protocol (IPP) print clients and print servers, communicating using HTTP/1.1 (see [IPP-PRO]), SMTP/ESMTP, FTP, or other transport protocol. Messages of type "application/ipp" are self-contained and transport-independent, including "charset" and "natural-language" context for any LOCALIZED-STRING value.

Person & email address to contact for further information:

Tom Hastings
Xerox Corporation
 737 Hawaii St. ESAE-231
El Segundo, CA

Phone: 310-333-6413
Fax: 310-333-5514
Email: hastings@cp10.es.xerox.com

or

Robert Herriot
Xerox Corporation
3400 Hillview Ave., Bldg #1
Palo Alto, CA 94304

Phone: 650-813-7696
Fax: 650-813-6860
Email: robert.herriot@pahv.xerox.com

Intended usage:

COMMON

15. Appendix C: Changes from IPP/1.0

IPP/1.1 is identical to IPP/1.0 [RFC2565] with the follow changes:

1. Attributes values that identify a printer or job object use a new 'ipp' scheme. The 'http' and 'https' schemes are supported only for backward compatibility. See section 5.

2. Clients MUST support of Digest Authentication, IPP Printers SHOULD support Digest Authentication. See Section 8.1.1

3. TLS is recommended for channel security. In addition, SSL3 may be supported for backward compatibility. See Section 8.1.2

4. It is recommended that IPP/1.1 objects accept any request with major version number '1'. See section 9.1.

5. IPP objects SHOULD return the URL scheme requested for "job-printer-uri" and "job-uri" Job Attributes, rather than the URL scheme used to create the job. See section 9.2.

6. The IANA and Internationalization sections have been added. The terms "private use" and "experimental" have been changed to "vendor extension". The reserved allocations for attribute group tags, attribute syntax tags, and out-of-band attribute values have been clarified as to which are reserved to future IETF standards track documents and which are reserved to vendor extension. Both kinds of extensions use the type2 registration procedures as defined in [ipp-mod].

7. Clarified that future "out-of-band" value definitions may use the value field if additional information is needed.

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