The Printer Working Group

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**Working Draft**

# IPP Encrypted Jobs and Documents v1.0 (TRUSTNOONE)

Status: Prototype

Abstract: This specification defines new encrypted IPP message formats and operations that provide IPP with end-to-end encryption of IPP Job attributes, Document attributes, and Document data.

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https://ftp.pwg.org/pub/pwg/general/pwg-process30.pdf

This document is available electronically at:

https://ftp.pwg.org/pub/pwg/ipp/wd/wd-ipptrustnoone10-20210519.docx
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To meet this objective, the PWG documents the results of their work as open standards that define print related protocols, interfaces, procedures, and conventions. A PWG standard is a stable, well understood, and technically competent specification that is widely used with multiple independent and interoperable implementations. Printer manufacturers and vendors of printer related software benefit from the interoperability provided by voluntary conformance to these standards.

For additional information regarding the Printer Working Group visit:

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# 1. Introduction

This specification defines new encrypted IPP message formats that provide IPP with end-to-end encryption of IPP Job attributes, Document attributes, and Document data. The encrypted formats use public key cryptography with an optional password to effectively protect the IPP message/Document data payload from intermediaries and when the data is at rest in the destination Output Device.

The new message format reuses the existing S/MIME 4.0 [RFC8551] message format to protect the combination of IPP message and Document data normally sent in the clear as part of a Job Creation Request.

# 2. Terminology

## 2.1 Conformance Terminology

Capitalized terms, such as MUST, MUST NOT, RECOMMENDED, REQUIRED, SHOULD, SHOULD NOT, MAY, and OPTIONAL, have special meaning relating to conformance as defined in Key words for use in RFCs to Indicate Requirement Levels [BCP14]. The term CONDITIONALLY REQUIRED is additionally defined for a conformance requirement that applies to a particular capability or feature.

## 2.2 Protocol Role Terminology

This document also defines the following protocol roles in order to specify unambiguous conformance requirements:

*Client*: Initiator of outgoing connections and sender of outgoing operation requests (Hypertext Transfer Protocol -- HTTP/1.1 [RFC7230] User Agent).

*Printer*: Listener for incoming connections and receiver of incoming operation requests (Hypertext Transfer Protocol -- HTTP/1.1 [RFC7230] Server) that represents one or more Physical Devices or a Logical Device.

## 2.3 Printing Terminology

Normative definitions and semantics of printing terms are imported from IETF Printer MIB v2 [RFC3805], IETF Finisher MIB [RFC3806], and IETF Internet Printing Protocol/1.1 [STD92].

*Certificate*: A type that binds an entity's name to a Public Key with a Digital Signature [RFC5751].

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Digital Signature: A cryptographic hash of data (a Certificate, a Document, a message, etc.) that has been associated with an entity that can be verified mathematically, for example by using Public-Key Encryption.

*Document*: An object created and managed by a Printer that contains the description, processing, and status information. A Document object may have attached data and is bound to a single Job.

*Encrypted Job*: A Job whose Document data, Job Receipt, and Job Ticket are encrypted so that only the recipient of the information can access it.

*End User*: A person or automata using a Client to communicate with a Printer.

*Job*: An object created and managed by a Printer that contains description, processing, and status information. The Job also contains zero or more Document objects.

*Job Creation Request*: Any operation that causes the creation of a Job object, e.g., the Create-Job, Print-Job, and Print-URI operations [STD92].

*Job Receipt*: The Job Status attributes that provide a summary of the work performed by the Printer such as the owner, state, dates and times, actual values used for Job Template attributes, and work counters.

*Job Ticket*: The operation and Job Template attributes supplied in a Job Creation request that provide the End User's intent for Job and Document processing as well as descriptive information about the Job and its Document(s).

*Logical Device*: a print server, software service, or gateway that processes jobs and either forwards or stores the processed job or uses one or more Physical Devices to render output.

*One-Time Pad*: A symmetric encryption key that is randomly generated and is used to encrypt or decrypt a single message.

*Output Device*: a single Logical or Physical Device

*Physical Device*: a hardware implementation of a endpoint device, e.g., a marking engine, a fax modem, etc.

*Private Key*: The recipient's key value in Public-Key Encryption.

*Public Key*: The sender's key value in Public-Key Encryption.

*Public-Key Encryption*: An encryption technique that uses a paired (asymmetric) key algorithm for secure data communication. Messages are encrypted with one key value and decrypted using the other key value, so the security of the technique depends on verifying that the first key originated from the intended recipient. This is typically done by comparing a cryptographic hash (Digital Signature) of the recipient's Certificate against a hash that was encrypted using the second key.

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227 *Symmetric-Key Encryption*: An encryption technique that uses a single (symmetric) key
228 algorithm for secure data communication. Messages are encrypted and decrypted with the
229 same secret key value, so the security of the technique depends on the confidentiality of the
230 key. This is typically done by using One-Time Pads.

## 231 2.4 Acronyms and Organizations

232 *IANA*: Internet Assigned Numbers Authority, https://www.iana.org/

233 *IETF*: Internet Engineering Task Force, https://www.ietf.org/

234 *ISO*: International Organization for Standardization, https://www.iso.org/

235 *NFC*: Near Field Communications, https://www.nfc-forum.org/

236 *PIN*: Personal Identification Number

237 *PWG*: Printer Working Group, https://www.pwg.org/
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# 3. Requirements

## 3.1 Rationale

Existing specifications define the following:

1. The Internet Printing Protocol/1.1[STD92] defines the "document-format" attribute.
2. "Internet Printing Protocol (IPP) over HTTPS Transport Binding and the 'ipps' URI Scheme" **Error! Reference source not found.** defines the IPP over HTTPS transport binding which provides session transport encryption.

This specification defines a new IPP convention for encrypting Jobs and Documents by:

1. Defining a standard encrypted IPP message format that securely convey Job and Document information;
2. Defining new IPP Printer Description attributes that convey information about the encryption capabilities of the Printer;
3. Defining amended IPP Job and Document operation semantics for encrypted IPP messages; and
4. Defining new operations for transferring Encrypted Job Receipts.

## 3.2 Use Cases

### 3.2.1 Printing Encrypted Document Locally on Printer

Garrett is visiting a client and needs to print a sensitive document but wants to be sure that a print job with the document is not readable if it is recovered from the printer or print server, and that he can detect whether it has been changed.

Garrett chooses a printer supporting end-to-end encryption, makes his job choices, enters a passcode for the print job, and taps "Print" to submit his choices. The client software validates the public key of the receiving printer, encrypts the print job request using the public key and passcode, and sends it to the printer. Garrett then goes to the printer and enters his passcode, allowing the printer to decrypt the print job using his passcode and the corresponding private key.

### 3.2.2 Pull Print Encrypted Document from Print Service to Local Printer

Helen is on the train, viewing a document on her tablet and wants to print a copy when she gets to work. Helen taps the control to print the document, and a print dialog UI is presented on the tablet's screen. Her tablet is configured with a printer that is a personal account on a cloud print service. She selects that to be the target printer, chooses “Encrypt Job” in the printing options presented, and specifies a credential to be used for encryption. She then taps “Print”, and the document is encrypted and sent to her cloud print service account.

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Later, when Helen arrives at the office, she goes to a printer that she identifies as one that can pull jobs from her cloud print service. Helen chooses the document or the job containing the document and taps “Print”. The printer asks for the credential to decrypt the document and Helen provides that to the printer. The printer decrypts and prints the document, and Helen collects it from the output bin.

### 3.2.3 Query Job Receipt After Printing

Jane wishes to query the job receipts of a printer in order to do accounting of encrypted print jobs for the day. She uses her client software to send a query for the job receipt of each encrypted job, providing her public key and authentication credentials to the printer. The printer then validates her credentials and returns an encrypted job receipt using her public key. Her client software then decrypts the job receipt using her private key and retrieves the needed accounting information from the decrypted receipt.

## 3.3 Exceptions

### 3.3.1 Unauthorized Access to Document Data

Herbert is a disenchanted IT administrator who wishes to examine everyone's print jobs and sends each print job's document content to a repository for later examination. Herbert is unable to read the encrypted documents because he does not have the private key or passcode associated with the print job.

### 3.3.2 Signed Document Modified

Garrett prints another document and the document is changed by some entity at some stage in the print system between the client and the printer. The printer notifies Garrett that the document has been changed. Garrett chooses to abandon the output since it can no longer be trusted.

## 3.4 Out of Scope

The following are considered out of scope for this document:

1. Authentication infrastructure that may be used by the Printer, such as LDAP or RADIUS, and
2. Definition of the method for loading public and private keys on a Printer.

## 3.5 Design Requirements

The design requirements for this specification are:

1. Define IPP attributes and values to describe the supported encryption methods and public keys,
2. Define amended semantics for all affected IPP operations,

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3. Register all new IPP attributes, attribute keywords, attribute enum values, operations, and other IPP specific values in the IANA IPP registry,
4. Define security requirements necessary to support encrypted Jobs and Documents,
5. Define a MIME media type for providing encrypted IPP Job Template and Document Template attributes along with Document data, and
6. Register the new MIME media type in the IANA MIME Media Type registry.

The design recommendations for this specification are:

1. Define best practices for user experience.

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# 4. IPP Model

This document defines a new encrypted printing model where the Printer provides attributes to the Client containing a Certificate to use for encryption of messages from the Client to the Printer. Clients then use the Printer Certificate (and optionally a User-supplied Certificate and/or passphrase) to produce an encrypted IPP message containing the operation, Job Template, and/or Document Template attributes along with the associated Document data. The encrypted message is sent in a Print-Job or Send-Document request as the request's Document data. The use of Public-Key Encryption ensures that the encrypted messages can only be decrypted by the entity that possesses the Private Key corresponding to the Printer's Certificate and (if used) the User passphrase. In the same way that TLS [RFC8446] provides protection of IPP messages and data in transit between the Client and Printer, the model defined in this document provides protection of IPP messages and data at rest.

Figure 1 shows how an encrypted Print Job is submitted from a Client to a Printer. Because this model encapsulates the encrypted data as a Document, it does not offer support for encrypted Print Jobs that use the Print-URI or Send-URI operations. However, such Jobs can still use traditional access control mechanisms (authentication, passwords, etc.) to protect access to sensitive Document data.

Clients can request an Encrypted Job Receipt using a supplied User Certificate, subject to the Printer's access control policies. The contents of the Encrypted Job Receipt are only guaranteed to be stable once the Job reaches a terminating state, just as for regular Job Receipts. Figure 2 shows how a Client requests an encrypted Job Receipt.

Note: The encrypted printing model defined by this document applies equally to the original (2D) print service defined in the Internet Printing Protocol/1.1 [STD92] and the 3D print service defined in the IPP 3D Printing Extensions v1.1 [PWG5100.21].

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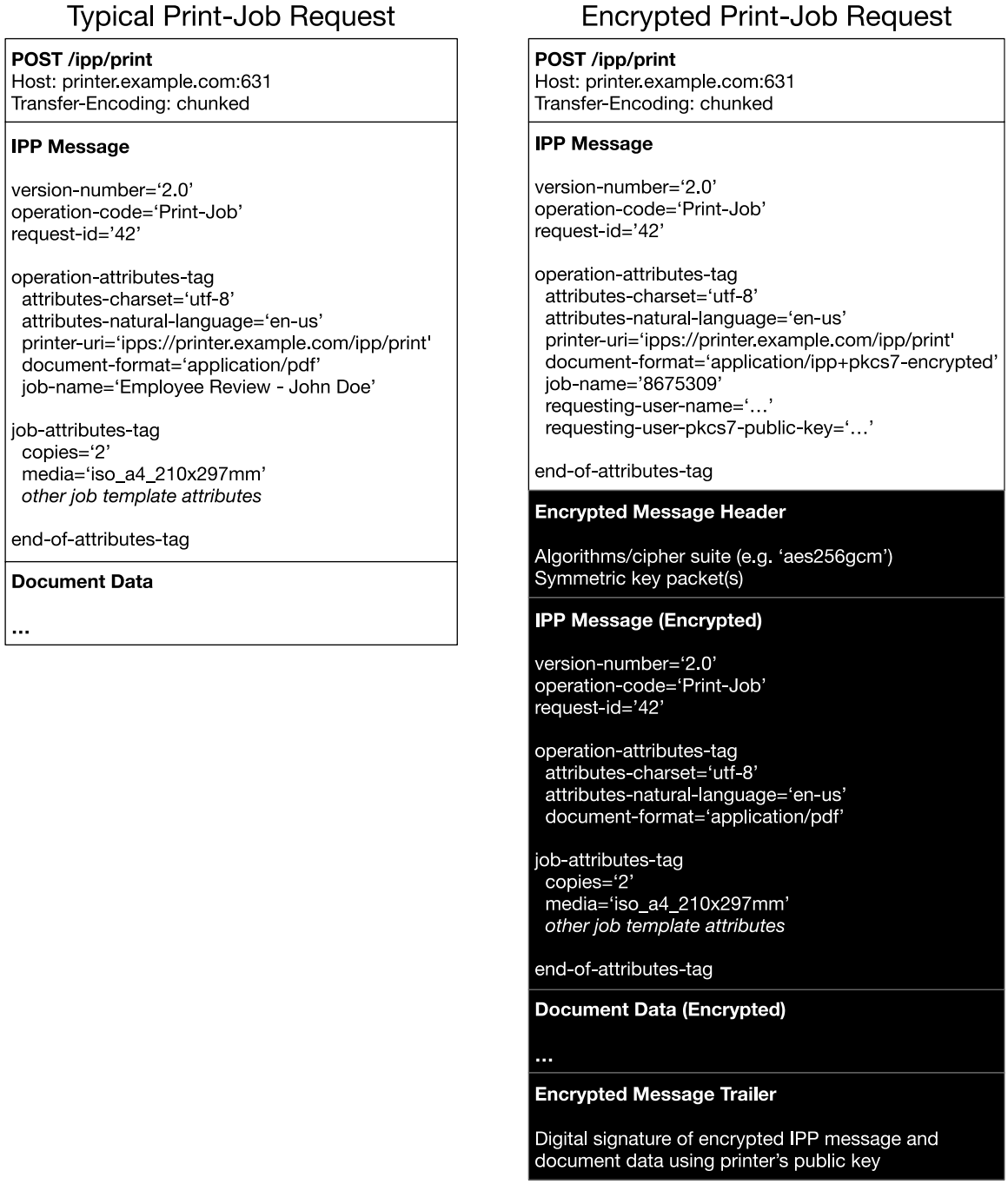


**Figure 1 - Encrypted Print-Job Request**

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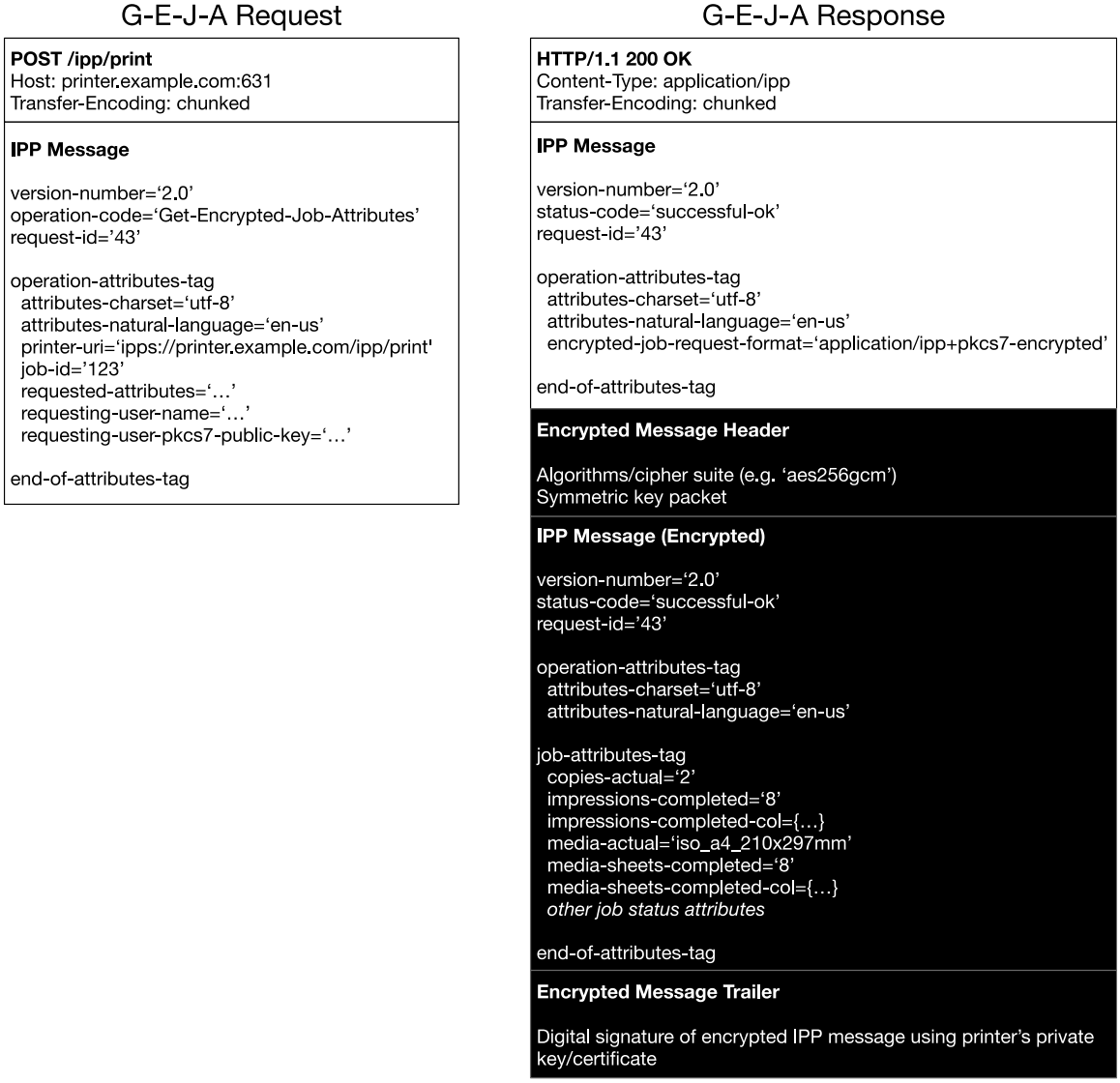


**Figure 2 - Encrypted Get-Job-Attributes Request**

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## 4.1 Overview of Secure/Multipurpose Internet Mail Extensions (S/MIME)

S/MIME is an encryption standard defined in the Secure/Multipurpose Internet Mail Extensions (S/MIME) Version 4.0 Message Specification [RFC8551] which uses a combination of Public Key Encryption and Symmetric Key Encryption to protect and authenticate a message, in this case an IPP message combined with any Document data.

Symmetric Key Encryption is generally fast but uses the same key (sequence of bits) to encrypt and decrypt the message. Public Key Encryption is much slower and uses a pair of keys commonly known as the public (shared with others) and private (not shared with others) key - messages are encrypted using one key and decrypted using the other key.

S/MIME uses Public Key Encryption to protect (encrypt) a symmetric encryption key (called the session key) and a cryptographic hash of the message being encrypted using the public key. The session key is generated by the sender and is only used once. Symmetric Key Encryption is then used to encrypt the message quickly. The receiver of the encrypted message then decrypts the session key and message hash using its private key, decrypts the message, and verifies that the hash of the decrypted message matches the hash that was sent in the encrypted message.

S/MIME can additionally use a password or passcode to further protect the message.

## 4.2 Using S/MIME with IPP

Clients use the Printer's public key to encrypt an IPP message and any Document data. The Printer then decrypts and validates these IPP messages and Document data using its private key, which only the Printer has access to. When the Client uses an additional password or passcode, the Printer will hold the Job until the End User can enter it at the Printer's console.

When sending a receipt for the Encrypted Job, Printers will encrypt the response using the Client's (or End User's) public key so that only that Client is able to decrypt the Printer's response.

Encrypted IPP messages add an additional layer of protection (beyond TLS) in transit as well as protection of the data at rest. Figure 3 shows the Encrypted IPP architecture for a typical Cloud printing configuration. While a malicious actor could eavesdrop on the normal unencrypted attributes and document data, the same actor cannot easily do the same for encrypted attributes and document data.

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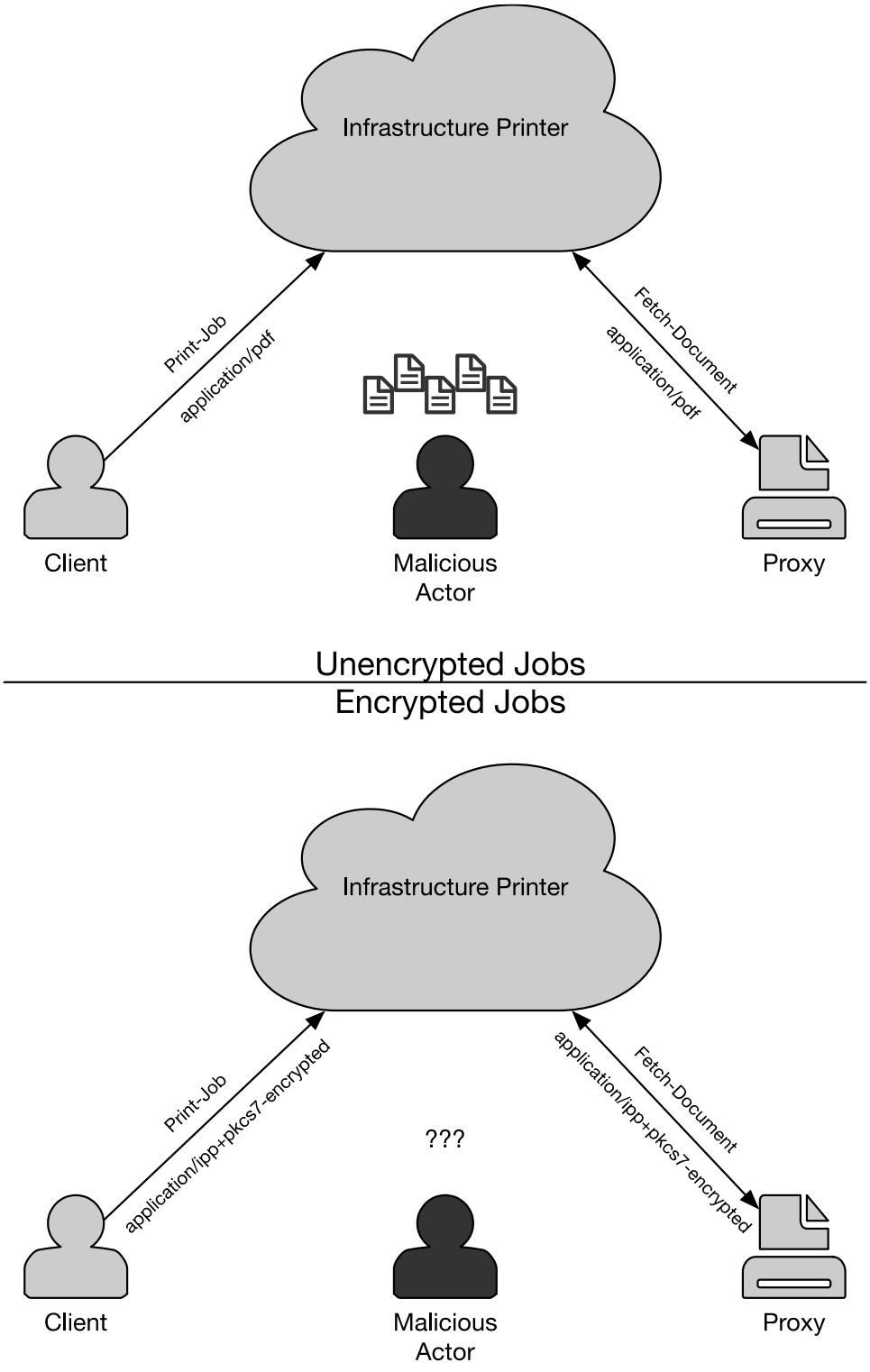


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376 **Figure 3 - Encrypted IPP Architecture**

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## 4.3 IPP Printer Behavior

When enabled, the Printer MUST provide a Public Key along with the supported and configured End User password repertoire in the Printer Description attributes defined in section 7.2. If decryption and processing is performed by the Printer, it MUST also provide a list of document formats that are supported inside encrypted IPP messages.

When a Print-Job or Send-Document request is received, the Printer validates any attributes that are provided in the unencrypted portion of the IPP message and defers additional validation and processing until the Job moves to the 'processing' state and the Document data can be decrypted. Document data MUST remain encrypted when the Job is not in the 'processing' or 'processing-stopped' states.

As part of the Print-Job and Send-Document request, Clients include the End User's Public Key in the encrypted portion of the request. Printers use this Public Key to authenticate the Client in subsequent Get-Encrypted-Job-Attributes requests.

When the Printer is acting as an Infrastructure Printer [PWG5100.18] and the Public Key and repertoire information is supplied by the IPP Proxy, the Printer does no additional validation or processing of the Document data and MUST pass the Document data to the IPP Proxy without decryption or alteration.

Printers can require encrypted Print Jobs by listing only the encrypted IPP message format in the "document-format-supported" Printer Description attribute.

## 4.4 IPP Proxy Behavior

An IPP Proxy [PWG5100.18] for a Printer that conforms to this specification provides the Infrastructure Printer with the Certificates, repertoire, and document format values using the Update-Output-Device-Attributes operation. If the IPP Proxy has access to the corresponding Private Keys, it MUST NOT provide them to the Infrastructure Printer.

Proxies can require encrypted Print Jobs by reporting only the encrypted IPP message format in the "document-format-supported" Printer Description attribute supplied in the Update-Output-Device-Attributes request.

If supported by the Infrastructure Printer, Proxies receive notifications when a Client has requested an Encrypted Job Receipt. When such an event occurs, the IPP Proxy fetches the Encrypted Job request, generates the Encrypted Job Receipt, and acknowledges the request with the attached Encrypted Job Receipt.

## 4.5 IPP Client Behavior

When an End User initiates a print action, the Client software will query the Printer's capabilities and status using the Get-Printer-Attributes request. If the response contains the

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attributes listed in section 7.2, the Client software can either automatically encrypt the Job Creation Request or offer the End User the option to do so.

When encrypting the request message, the Client generates a single session key which is encrypted only using the Printer's Public Key. The End User's Public Key is provided as an operation attribute in the encrypted request message, allowing the Printer to authenticate the Client in a subsequent Get-Encrypted-Job-Attributes request.

As part of the encryption process, Clients SHOULD allow End Users to provide a passphrase conforming to the Printer's configured password repertoire.

When sending the "job-name" [STD92] Job Template attribute, the Client SHOULD provide a unique identifying string such as a PIN instead of sending the usual source name, End User name, title, or other value(s) that can uniquely identify the source of the Job.

### 4.6 Job Tickets

Job Tickets consist of operation and Job Template attributes submitted as part of a Job Creation Request. For Encrypted Jobs, all Job Ticket attributes are included in the encrypted portion of the Print-Job request.

### 4.7 Job Receipts

Job Receipts consist of Job Description and Job Status attributes generated by the Printer during Job processing, including the "-actuals" attributes corresponding to Job Template attributes. For Encrypted Jobs, all Job Receipt attributes are retrieved using the Get-Encrypted-Job-Attributes (section 6.3) operation.

## 5. Document Format

### 5.1 application/ipp+pkcs7-encrypted

This REQUIRED MIME media type consists of an IPP message ("application/ipp") followed by Document data that is stored inside an S/MIME message [RFC8551]. The symmetric key for the message is encrypted using the Public Key from the "printer-pkcs7-public-key (1setOf text(MAX))" Printer Description attribute (section 1.1.1) and any passphrase supplied by the End User as described in section 3.2 of [RFC8551].

## 6. IPP Operations

### 6.1 Acknowledge-Encrypted-Job-Attributes

This CONDITIONALLY REQURIED operation is sent by an IPP Proxy to acknowledge the receipt of an Encrypted Job attributes request from a Client that was retrieved using a Fetch-

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Encrypted-Job-Attributes request. IPP Proxies and Infrastructure Printers that support Encrypted Jobs MUST support this operation.

### 6.1.1 Acknowledge-Encrypted-Job-Attributes Request

The following groups of attributes are part of an Acknowledge-Encrypted-Job-Attributes request:

Group 1: Operation Attributes

"attributes-charset" (charset) and
"attributes-natural-language" (naturalLanguage):

The Client MUST supply and the Printer MUST support both of these attributes.

Target:

The "printer-uri" (uri) operation attribute which is the target Printer for the operation.

"output-device-uuid" (uri):

The IPP Proxy MUST supply and the Infrastructure Printer MUST support this attribute which provides the identity of the Output Device for the request.

"encrypted-job-request-id" (integer(1:MAX)):

The IPP Proxy MUST supply and the Infrastructure Printer MUST support this attribute that specifies which Encrypted Job request is being acknowledged.

"encrypted-job-request-format" (mimeMediaType):

The IPP Proxy MUST supply and the Infrastructure Printer MUST support this attribute that specifies the Encrypted Job Receipt format.

Group 2: Encrypted Job Receipt Message

The Encrypted Job Receipt message.

### 6.1.2 Acknowledge-Encrypted-Job-Attributes Response

The following groups of attributes are part of an Acknowledge-Encrypted-Job-Attributes response:

Group 1: Operation Attributes

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"attributes-charset" (charset) and
"attributes-natural-language" (naturalLanguage):

The Printer MUST return both of these attributes.

"status-message" (text(255)) and/or
"detailed-status-message" (text(MAX)):

The Printer MAY return one or both of these attributes.

Group 2: Unsupported Attributes

See [STD92] for details on returning Unsupported Attributes.

Group 3: Printer Attributes

"printer-state-reasons" (1setOf type2 keyword):

The state of the Infrastructure Printer after processing the request. Clients can look for the presence of the 'encrypted-job-request' keyword to know whether to send another Fetch-Encrypted-Job-Attributes request.

## 6.2 Fetch-Encrypted-Job-Attributes

This CONDITIONALLY REQUIRED operation allows an IPP Proxy to fetch a request for Encrypted Job attributes from the Client. IPP Proxies and Infrastructure Printers that support Encrypted Jobs MUST support this operation.

### 6.2.1 Fetch-Encrypted-Job-Attributes Request

The following groups of attributes are part of a Fetch-Encrypted-Job-Attributes request:

Group 1: Operation Attributes

"attributes-charset" (charset) and
"attributes-natural-language" (naturalLanguage):

The Client MUST supply and the Printer MUST support both of these attributes.

Target:

The "printer-uri" (uri) operation attribute which is the target Printer for the operation.

"output-device-uuid" (uri):

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The IPP Proxy MUST supply and the Infrastructure Printer MUST support this attribute which provides the identity of the Output Device for the request.

### 6.2.2 Fetch-Encrypted-Job-Attributes Response

The following groups of attributes are part of a Fetch-Encrypted-Job-Attributes response:

Group 1: Operation Attributes

"attributes-charset" (charset) and
"attributes-natural-language" (naturalLanguage):

The Printer MUST return both of these attributes.

"status-message" (text(255)) and/or
"detailed-status-message" (text(MAX)):

The Printer MAY return one or both of these attributes.

"job-id" (integer(1:MAX)):

The Job identifier for the Printer.

"encrypted-job-request-id" (integer(1:MAX)):

A unique identifier for the Encrypted Job request is being fetched.

"requested-attributes" (1setOf keyword):

The requested attributes sent by the Client to the Infrastructure Printer that specify which attributes the Client would like returned.

"requesting-user-name" (name(MAX)) and "requesting-user-uri" (uri):

The name and URI of the User requesting the attributes.

"requesting-user-pkcs7-public-key" (1setOf text(MAX)):

The X.509 certificate and public key supplied by the Client to be used for encrypting the Job attributes.

Group 2: Unsupported Attributes

See [STD92] for details on returning Unsupported Attributes.

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## 6.3 Get-Encrypted-Job-Attributes

This REQUIRED operation allows a Client to query Encrypted Job attributes from a Printer. Once authorized, the attributes are encrypted using the Public Key supplied by the Client and returned as data following the IPP response.

If the supplied Public Key does not match the one supplied in the corresponding Print-Job or Send-Document request (section 8.1) or a Public Key that has been registered with the Printer through some means outside of IPP (e.g., for Administrators or Operators), the Printer MUST reject the request with the 'client-error-forbidden' status code.

### 6.3.1 Get-Encrypted-Job-Attributes Request

The following groups of attributes are part of a Get-Encrypted-Job-Attributes request:

Group 1: Operation Attributes

"attributes-charset" (charset) and
"attributes-natural-language" (naturalLanguage):

The Client MUST supply and the Printer MUST support both of these attributes.

Target:

The "printer-uri" (uri) and "job-id" (integer(1:MAX)) operation attributes which are the target Job for the operation.

"requested-attributes" (1setOf keyword):

The Client MAY supply and the Printer MUST support this attribute which specifies the attributes the Client would like returned.

"requesting-user-name" (name(MAX)) and "requesting-user-uri" (uri):

The name and URI of the User requesting the attributes.

"requesting-user-pkcs7-public-key" (1setOf text(MAX)):

The X.509 certificate and public key supplied by the Client to be used for encrypting the Job attributes.

### 6.3.2 Get-Encrypted-Job-Attributes Response

The following groups of attributes are part of an Get-Encrypted-Job-Attributes response:

Group 1: Operation Attributes

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"attributes-charset" (charset) and
"attributes-natural-language" (naturalLanguage):

The Printer MUST return both of these attributes.

"status-message" (text(255)) and/or
"detailed-status-message" (text(MAX)):

The Printer MAY return one or both of these attributes.

"encrypted-job-request-format" (mimeMediaType):

The Printer MUST return this attribute that specifies the Encrypted Job Receipt format.

Group 2: Unsupported Attributes

See [STD92] for details on returning Unsupported Attributes.

Group 3: Encrypted Job Receipt Message

The Encrypted Job Receipt message.

# 7. IPP Attributes

## 7.1 Operation Attributes

### 7.1.1 encrypted-job-request-format (mimeMediaType)

This CONDITIONALLY REQUIRED attribute specifies the MIME media type for the Encrypted Job attributes message. IPP Proxies and Infrastructure Printers that support Encrypted Jobs MUST support this attribute.

### 7.1.2 encrypted-job-request-id (integer(1:MAX))

This CONDITIONALLY REQUIRED attribute specifies a unique request identifier for the Acknowledge-Encrypted-Job-Attributes (section 6.1) and Fetch-Encrypted-Job-Attributes (section 6.2) operations. IPP Proxies and Infrastructure Printers that support Encrypted Jobs MUST support this attribute.

### 7.1.3 requesting-user-pkcs7-public-key (1setOf text(MAX))

This REQUIRED attribute specifies the X.509 certificate and public key to use when encrypting the IPP Job Receipt using S/MIME. The values are concatenated to form the Base64-encoded X.509 certificate and public key.

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## 7.2 Printer Description Attributes

### 7.2.1 pkcs7-document-format-supported (1setOf mimeMediaType)

This REQUIRED attribute lists the Document formats that can be embedded in Document data of type "application/ipp-pkcs7-encrypted".

### 7.2.2 printer-pkcs7-public-key (1setOf text(MAX))

This REQUIRED attribute contains the currently configured X.509 certificate and public key to use when encrypting IPP requests using S/MIME.

### 7.2.3 printer-pkcs7-repertoire-configured (type2 keyword)

This REQUIRED attribute specifies the password repertoire currently configured in the Printer. The value of this attribute MUST be one of the set of values specified by the Printer's "printer-pkcs7-repertoire-supported" attribute. A supporting Client can use this attribute's value to limit End User input when encrypting the symmetric key for S/MIME.

### 7.2.4 printer-pkcs7-repertoire-supported (1setOf type2 keyword)

This REQUIRED attribute lists the repertoires the Printer can be configured to use if the Printer supports an additional passphrase at the Printer console. Any keyword registered for use with "job-password-repertoire-supported" can be listed.

# 8. Additional Semantics for Existing Operations

## 8.1 Print-Job and Send-Document: Encrypted IPP Message Data

This specification adds additional semantics when a Client submits Document data in the format 'application/ipp+pkcs7-encrypted'. When supplied, the Printer that decrypts the data for processing MUST:

1. Merge any attributes in the encrypted message with the attributes provided in the unencrypted portion of the original request,
2. Validate the combined request attributes as required for a standard request, and
3. Abort or continue processing the Job using the merged attributes.

When merging attributes, the values of encrypted attributes take precedence over unencrypted attributes.

When using S/MIME encryption, Clients MUST include the "requesting-user-pkcs7-public-key" (section 7.1.3) operation attribute in the encrypted Document data.

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# 9. Additional Values for Existing Attributes

## 9.1 printer-state-reasons (1setOf type2 keyword)

This specification adds the 'encrypted-job-attributes-requested' keyword, which is present when one or more Get-Encrypted-Job-Attributes requests are pending on an Infrastructure Printer.

# 10. Conformance Requirements

## 10.1 Printer Conformance Requirements

In order for a Printer to claim conformance to this document, a Printer MUST support:

1. The 'application/ipp+pkcs7-encrypted' MIME media type defined in section 5;
2. The Get-Encrypted-Job-Attributes operation as defined in section 6;
3. The REQUIRED attributes and values defined in section 7.2;
4. The additional semantics defined in section 8;
5. The internationalization considerations defined in section 11; and
6. The security considerations defined in section 0.

## 10.2 Infrastructure Printer Conformance Requirements

In order for an Infrastructure Printer to claim conformance to this document, an Infrastructure Printer MUST support:

1. The restrictions on processing of encrypted data as defined in section 4.3;
2. The 'application/ipp+pkcs7-encrypted' MIME media type defined in section 5;
3. The Acknowledge-Encrypted-Job-Attributes, Fetch-Encrypted-Job-Attributes, and Get-Encrypted-Job-Attributes operations as defined in section 6;
4. The REQUIRED attributes and values defined in section 7.2;
5. The additional semantics defined in section 8;
6. The additional values defined in section 9;
7. The internationalization considerations defined in section 11; and
8. The security considerations defined in section 0.

## 10.3 Client Conformance Requirements

In order for a Client to claim conformance to this document, a Client MUST support:

1. The 'application/ipp+pkcs7-encrypted' MIME media type defined in section 5;
2. The Get-Encrypted-Job-Attributes operation as defined in section 6;
3. The REQUIRED attributes and values defined in section 7.2;
4. The internationalization considerations defined in section 11; and

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5. The security considerations defined in section 0.

## 10.4 IPP Proxy Conformance Requirements

In order for an IPP Proxy to claim conformance to this document, an IPP Proxy MUST support:

1. The 'application/ipp+pkcs7-encrypted' MIME media type defined in section 5;
2. The Acknowledge-Encrypted-Job-Attributes and Fetch-Encrypted-Job-Attributes operations as defined in section 6;
3. The REQUIRED attributes and values defined in section 7.2;
4. The additional semantics defined in section 8;
5. The additional values defined in section 9;
6. The internationalization considerations defined in section 11; and
7. The security considerations defined in section 0.

# 11. Internationalization Considerations

For interoperability and basic support for multiple languages, conforming implementations MUST support:

- The Universal Character Set (UCS) Transformation Format -- 8 bit (UTF-8) [STD63] encoding of Unicode [UNICODE] [ISO10646]; and

- The Unicode Format for Network Interchange [RFC5198] which requires transmission of well-formed UTF-8 strings and recommends transmission of normalized UTF-8 strings in Normalization Form C (NFC) [UAX15].

Unicode NFC is defined as the result of performing Canonical Decomposition (into base characters and combining marks) followed by Canonical Composition (into canonical composed characters wherever Unicode has assigned them).

WARNING – Performing normalization on UTF-8 strings received from Clients and subsequently storing the results (e.g., in Job objects) could cause false negatives in Client searches and failed access (e.g., to Printers with percent-encoded UTF-8 URIs now 'hidden').

Implementations of this specification SHOULD conform to the following standards on processing of human-readable Unicode text strings, see:

- Unicode Bidirectional Algorithm [UAX9] – left-to-right, right-to-left, and vertical

- Unicode Line Breaking Algorithm [UAX14] – character classes and wrapping

- Unicode Normalization Forms [UAX15] – especially NFC for [RFC5198]

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- Unicode Text Segmentation [UAX29] – grapheme clusters, words, sentences
- Unicode Identifier and Pattern Syntax [UAX31] – identifier use and normalization
- Unicode Collation Algorithm [UTS10] – sorting
- Unicode Locale Data Markup Language [UTS35] – locale databases

Implementations of this specification are advised to also review the following informational documents on processing of human-readable Unicode text strings:

- Unicode Character Encoding Model [UTR17] – multi-layer character model
- Unicode Character Property Model [UTR23] – character properties
- Unicode Conformance Model [UTR33] – Unicode conformance basis

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# 12. Security Considerations

The following sub-sections define security considerations in addition to those defined in the Internet Printing Protocol/1.1 [STD92].

## 12.1 job-name (name(MAX))

Because the "job-name" value is not part of the Encrypted Job Ticket, Clients SHOULD supply a One-Time Pad such as a PIN instead of the usual value based on the source name, user name, title, or other value(s) that can uniquely identify the source of the Job.

## 12.2 TLS Support

Clients and Printers MUST support TLS [RFC8446] version 1.2 or later. Clients MUST validate the Printer's X.509 certificate and use TLS for Encrypted Jobs in order to protect the encrypted IPP message data from replay attacks.

## 12.3 S/MIME Considerations

Clients and Printers MUST NOT use the AES-128 CBC cipher suite that is required by S/MIME 4.0 [RFC8551].

Clients MUST validate the Public Key reported by the Printer, by employing a local Trust On First Use (TOFU) [RFC7435] policy and/or by validating the issuing Certificate Authority (CA). Printers SHOULD support validation of Public Keys supplied by Clients.

Clients SHOULD use an additional passphrase in order to protect against replay attacks.

## 12.4 End User Authentication at Output Device

Printers SHOULD support additional methods of authenticating End Users at the Output Device such as NFC and/or biometrics.

## 12.5 Unicode Considerations

Implementations of this specification SHOULD conform to the following standard on processing of human-readable Unicode text strings:

- Unicode Security Mechanisms [UTS39] – detecting and avoiding security attacks

Implementations of this specification are advised to also review the following informational document on processing of human-readable Unicode text strings:

- Unicode Security FAQ [UNISECFAQ] – common Unicode security issues

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## 12.6 Job Ticket and Job Receipt Privacy

Printers MUST protect all encrypted Job Ticket and Job Receipt data and MUST NOT return encrypted attributes in the response to Get-Jobs or Get-Job-Attributes requests.

Attributes submitted outside the encrypted IPP message MUST be returned in the response to Get-Jobs or Get-Job-Attributes requests.

# 13. IANA Considerations

## 13.1 Attribute Registrations

The attributes defined in this document will be published by IANA according to the procedures in the Internet Printing Protocol/1.1 [STD92] in the following location:

https://www.iana.org/assignments/ipp-registrations

The registry entries will contain the following information:

| Operation attributes: | Reference |
|---|---|
| encrypted-job-request-format (mimeMediaType) | [TRUSTNOONE] |
| encrypted-job-request-id (integer(1:MAX)) | [TRUSTNOONE] |
| requesting-user-pkcs7-public-key (1setOf text(MAX)) | [TRUSTNOONE] |
| | |
| **Printer Description attributes:** | **Reference** |
| pkcs7-document-format-supported (1setOf mimeMediaType) | [TRUSTNOONE] |
| printer-pkcs7-public-key (1setOf text(MAX)) | [TRUSTNOONE] |
| printer-pkcs7-repertoire-configured (type2 keyword) | [TRUSTNOONE] |
| printer-pkcs7-repertoire-supported (1setOf type2 keyword) | [TRUSTNOONE] |

## 13.2 Type2 keyword Registrations

The attributes defined in this document will be published by IANA according to the procedures in the Internet Printing Protocol/1.1 [STD92] in the following location:

https://www.iana.org/assignments/ipp-registrations

The registry entries will contain the following information:

| Attributes (attribute syntax) Keyword Attribute Value | Reference |
|---|---|
| printer-pkcs7-repertoire-configured (type2 keyword) | [TRUSTNOONE] |
| < all printer-pkcs7-repertoire-supported values > | [TRUSTNOONE] |
| printer-pkcs7-repertoire-supported (1setOf type2 keyword) | [TRUSTNOONE] |
| < all job-password-repertoire-supported values > | [TRUSTNOONE] |
| printer-state-reasons (1setOf type2 keyword) | [RFC8011] |

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```
encrypted-job-attributes-requested                          [TRUSTNOONE]
```

## 13.3 Type2 enum Registrations

The enum values defined in this specification will be published by IANA according to the procedures in the Internet Printing Protocol/1.1 [STD92] in the following location:

https://www.iana.org/assignments/ipp-registrations

The registry entries will contain the following information:

```
Attributes (attribute syntax)
  Enum Value      Enum Symbolic Name                    Reference
  ----------      ------------------                    ---------
operations-supported (1setOf type2 enum)                [RFC8011]
  0x0068          Acknowledge-Encrypted-Job-Attributes   [TRUSTNOONE]
  0x0069          Fetch-Encrypted-Job-Attributes         [TRUSTNOONE]
  0x006A          Get-Encrypted-Job-Attributes           [TRUSTNOONE]
```

## 13.4 Operation Registrations

The operations defined in this specification will be published by IANA according to the procedures in the Internet Printing Protocol/1.1 [STD92] in the following location:

https://www.iana.org/assignments/ipp-registrations

The registry entries will contain the following information:

```
Operation Name                                          Reference
--------------                                          ---------
Acknowledge-Encrypted-Job-Attributes                    [TRUSTNOONE]
Fetch-Encrypted-Job-Attributes                          [TRUSTNOONE]
Get-Encrypted-Job-Attributes                            [TRUSTNOONE]
Print-Job(extension)                                    [TRUSTNOONE]
Send-Document(extension)                                [TRUSTNOONE]
```

## 13.5 MIME Media Type Registration

The MIME media type defined in this white paper will be published by IANA according to the procedures in the Media Type Specifications and Registration Procedures [BCP13] in the following location:

https://www.iana.org/assignments/media-types

The registry will contain the following information for the "application/ipp+pkcs7-encrypted" MIME media type:

```
Type name: application
```

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```
Subtype name: ipp+pkcs7-encrypted

Required parameters: N/A

Optional parameters: N/A

Encoding considerations: Binary

Security considerations: Same as application/pkcs7-mime

Interoperability considerations: Same as for application/pkcs7-mime and
application/ipp

Published specification: [this specification]

Applications that use this media type: IPP

Fragment identifier considerations: N/A

Additional information:

  Deprecated alias names for this type: N/A
  Magic number(s): N/A
  File extension(s): N/A
  Macintosh file type code(s): N/A

Person & email address to contact for further information: IPP workgroup,
ipp@pwg.org

Intended usage: COMMON

Restrictions on usage: N/A

Author/Change controller: The Printer Working Group, c/o The IEEE Industry
Standards and Technology Organization, 445 Hoes Lane, Piscataway, NJ
08854, USA

Provisional registration? (standards tree only): No
```

# 14. References

## 14.1 Normative References


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[PWG5100.12] M. Sweet, I. McDonald, "IPP Version 2.0, 2.1, and 2.2", PWG 5100.12-2015, October 2015, https://ftp.pwg.org/pub/pwg/standards/std-ipp20-20151030-5100.12.pdf

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[STD92] M. Sweet, I. McDonald, "Internet Printing Protocol/1.1", STD 92, January 2017, https://tools.ietf.org/html/std92

[UAX9] Unicode Consortium, “Unicode Bidirectional Algorithm”, UAX#9, https://www.unicode.org/reports/tr9

[UAX14] Unicode Consortium, “Unicode Line Breaking Algorithm”, UAX#14, https://www.unicode.org/reports/tr14

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[UAX15] Unicode Consortium, “Normalization Forms”, UAX#15, https://www.unicode.org/reports/tr15

[UAX29] Unicode Consortium, “Unicode Text Segmentation”, UAX#29, https://www.unicode.org/reports/tr29

[UAX31] Unicode Consortium, “Unicode Identifier and Pattern Syntax”, UAX#31, https://www.unicode.org/reports/tr31

[UNICODE] Unicode Consortium, "Unicode Standard", Version 13.0.0, March 2020, https://www.unicode.org/versions/Unicode13.0.0/

[UTS10] Unicode Consortium, “Unicode Collation Algorithm”, UTS#10, https://www.unicode.org/reports/tr10

[UTS35] Unicode Consortium, “Unicode Locale Data Markup Language”, UTS#35, https://www.unicode.org/reports/tr35

[UTS39] Unicode Consortium, “Unicode Security Mechanisms”, UTS#39, https://www.unicode.org/reports/tr39

## 14.2 Informative References

[EFAIL] D. Poddebniak, C. Dresen, J. Müller, F. Ising, S. Schinzel, S. Friedberger, J. Somorovsky, J. Schwenk, "Efail: Breaking S/MIME and OpenPGP Email Encryption using Exfiltration Channels", August 2018, https://www.usenix.org/conference/usenixsecurity18/presentation/poddebniak

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# 15. Authors' Addresses

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# 16. Appendix A: File Formats Considered

The following file formats were considered in the development of this specification.

## 16.1 S/MIME

The S/MIME file format, defined in [RFC8551], is primarily used for signing and encrypting email message body content. Its cryptography is based on existing public key infrastructure (PKI) and depends on certificates issued by known certificate authorities (CAs) for establishing trust.

Older S/MIME cipher suites are vulnerable to several known CBC attacks [EFAIL]. This specification requires the use of non-CBC cipher suites such as AES-256 GCM and ChaCha20-Poly1305.

## 16.2 OpenPGP

The OpenPGP file format, defined in , has been used for signing and encrypting email message bodies as well as arbitrary file content. OpenPGP depends on a "web of trust" trust model to establish trust but may also derive trust from more centralized trust models.

Certain older cipher suites utilizing the CFB mode of operation are vulnerable to attack [EFAIL]. Therefore, modern cipher suites using Authenticated Encryption with Associated Data (AEAD) are necessary for IPP with OpenPGP.

After considerable discussion, the IPP workgroup decided not to pursue standardization of IPP with OpenPGP. The following subsections provide the proposed OpenPGP content modeled on IPP with S/MIME as defined in this specification.

### 16.2.1 Proposed Document Format: application/ipp+pgp-encrypted

This proposed MIME media type consists of an IPP message ("application/ipp") followed by Document data that is stored inside an OpenPGP message [RFC4880]. In requests, the symmetric key for the message is encrypted using the Public Key from the "printer-pgp-public-key (1setOf text(MAX))" Printer Description attribute (section 1.1.1) and any passphrase supplied by the End User as described in section 3.7.2.2 of [RFC4880]. In responses, the symmetric key for the message is encrypted using the Public Key from the "requesting-user-pgp-public-key (1setOf text(MAX))" operation attribute (section 1.1.1).

Request messages can also be signed using the End User's Private Key in order to authenticate the request source. Similarly, response messages can be signed using the Printer's Private Key in order to authenticate the response source.

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### 16.2.2 Proposed Attributes

#### 16.2.2.1 pgp-document-format-supported (1setOf mimeMediaType)

This Printer Description attribute lists the Document formats that can be embedded in Document data of type "application/ipp+pgp-encrypted".

#### 16.2.2.2 printer-pgp-public-key (1setOf text(MAX))

This Printer Description attribute contains the currently configured OpenPGP public key to use when encrypting IPP requests using OpenPGP. The values are concatenated to form the Base64-encoded OpenPGP public key block.

#### 16.2.2.3 printer-pgp-repertoire-configured (type2 keyword)

This Printer Description attribute contains the currently configured password repertoire for the Printer. The value of this attribute is one of the set of values specified by the Printer's "printer-pgp-repertoire-supported" (section 1.1.1) Printer Description attribute. A supporting Client can use this attribute's value to limit End User input when encrypting the symmetric key for OpenPGP.

#### 16.2.2.4 printer-pgp-repertoire-supported (1setOf type2 keyword)

This Printer Description attribute lists the repertoires the Printer can be configured to use if the Printer supports an additional passphrase at the Printer console. Any keyword registered for use with "job-password-repertoire-supported" can be listed.

#### 16.2.2.5 requesting-user-pgp-public-key (1setOf text(MAX))

This operation attribute specifies the OpenPGP public key to use when encrypting the IPP Job Receipt using OpenPGP. The values are concatenated to form the Base64-encoded OpenPGP public key block.

### 16.2.3 Proposed Security Considerations

Clients and Printers will use modern cipher suites with Authenticated Encryption with Associated Data (AEAD) [RFC5116].

Clients validate the Public Key reported by the Printer, by employing a local Trust On First Use (TOFU) [RFC7435] policy and/or by looking up the Public Key in a public key store. Printers typically also validate Public Keys supplied by Clients.

Clients typically use an additional passphrase in order to protect against replay attacks.

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## 16.3 ZIP Archive

The ZIP archive file format has encryption features, but the password-based encryption is weak, and implementations that support public key cryptography suffer from interoperability problems.

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# 17. Change History

## 17.1 May 19, 2021

- Moved PGP content to section 16/appendix A
- Moved PGP reference (RFC4880) to informative references
- Updated figures and text to only show S/MIME

## 17.2 April 28, 2021

- Bring back S/MIME thanks to the IETF publishing S/MIME v4.0
- Added reference to RFC8551 (S/MIME 4.0)
- OpenPGP is now RECOMMENDED, S/MIME is now REQUIRED

## 17.3 February 18, 2020

- Status: Prototype
- Updated conformance language throughout so that operations and attributes are correctly annotated.
- Section 2: Consolidated Printing and Other terminology, added NFC acronym
- Section 4: Expanded discussion of PGP and IPP using PGP, added figure showing architecture, added note about job-name values
- Section 12: Added job-name, PGP, and End User authentication considerations.

## 17.4 January 28, 2020

- Changed to working draft for a PWG specification.
- Section 2.4: Updated definitions of Encrypted Job and Job Ticket
- Section 4: Fixed typographical errors and did some rewording, added TLS reference
- Added figures to section 4 showing the sequences for Print-Job and Get-Encrypted-Job-Attributes
- Added TLS and Job Ticket/Receipt privacy subsections to section 12

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- Section 14.1: Added RFC 5116 (AEAD) and RFC 8446 (TLS 1.3) references.
- Global: Use IPP Proxy throughout when referring to proxies

## 17.5 April 18, 2019

- Updated to use specification template (now standards-track).
- Changed Registration to Specification throughout
- Changed encrypted Job to Encrypted Job throughout
- Section 2.4: Added Encrypted Job, Job Receipt, and Job Ticket terms.
- Section 6.3: Only the originator and admins/operators can access the encrypted job attributes
- Section 7.1.3: Base64 key block, application/ipp+pgp-encrypted mime type
- Section 7.2.2: Base64 key block
- Section 8.1: Added the requesting-user-pgp-public-key operation attribute to the attributes that are included in the encrypted IPP message passed in Print-Job and Send-Document requests.
- Section 11, 14.2: Drop XML Unicode TR
- Section 12: Added considerations for the PGP cipher suite used (AEAD)
- Section 13: Updated IANA stuff
- Section 14: Updated references

## 17.6 January 31, 2019

- Dropped S/MIME due to EFAIL vulnerabilities
- Added reference to EFAIL presentation and paper
- Added use case for retrieving an encrypted job receipt
- Added Acknowledge-Encrypted-Job-Attributes, Fetch-Encrypted-Job-Attributes, and Get-Encrypted-Job-Attributes operations
- Added 'encrypted-job-attributes-requested' printer state reason keyword.

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- Updated all references as needed.

## 17.7 March 28, 2018

- Updated to current IPP Registration template.
- Abstract: Simplified
- Section 1: Rewrote
- Section 2: Added/updated terminology
- Section 3: Updated use cases, exceptions, out-of-scope, and requirements
- Section 4: Model, talk about how it all works together
- Section 5: Rewrite as application/ipp+pgp-encrypted and application/ipp+pkcs7-encrypted
- Section 6: Added S/MIME attributes, normalized to current template style
- Section 7: Added amended semantics for Print-Job and Send-Document
- Section 8: Expanded to spell out separate requirements for Printers, Infrastructure Printers, Clients, and Proxies
- Section 9: Added security considerations.
- Section 10: Updated with all of the current attributes and amended
- Updated all references.

## 17.8 February 19, 2018

Moved back to using Microsoft Word format. Incorporates product of feedback from February 2018 PWG virtual F2F meeting and content from a slide set presented at that meeting by Mike Sweet (https://ftp.pwg.org/pub/pwg/ipp/slides/ipp-document-encryption-february-18.pdf).

## 17.9 February 5, 2018

Resurrected and updated with more current scheme, where the encryption attributes are now conveyed using new IPP attributes rather than embedded within the document format itself. Also rewrote the use cases and requirements to rekindle discussion about scope and possible solutions.

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## 17.10 February 4, 2015

Initial revision, presented at PWG February 2015 F2F.

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