TCG Trusted Network Communications

SWID Message and Attributes for IF-M

Specification Version 1.0
Revision 29
3 August 2015
Published

Contact:
admin@trustedcomputinggroup.org

TCG

TCG PUBLISHED

Disclaimer

Acknowledgements

The TCG wishes to thank all those who contributed to this specification. This document builds on considerable work done in the various working groups in the TCG.

Adrien Raffin	**AMOSSYS**
Nancy Cam-Winget	**Cisco Systems**
Scott Pope	**Cisco Systems**
Allan Thompson	**Cisco Systems**
Henk Birkholz	**Fraunhofer SIT**
Nicolai Kuntze	**Fraunhofer SIT**
Gerald Maunier	**Germalto**
Ira McDonald	**High North**
Josef von Helden	**Hochschule Hannover**
Andreas Steffen	**HSR**
Yi Zhang	**Huawei**
Steve Hanna (TNC Co-Chair)	**Infineon Technologies**
Lisa Lorenzin	**Pulse Secure**
Cliff Kahn	**Pulse Secure**
Atul Shah (TNC Co-Chair)	**Microsoft**
Jon Baker	**MITRE**
Charles Schmidt	**MITRE**
Rainer Enders	**NCP Engineering**
David Waltermire	**NIST**
Steve Klos	**TagVault.org**
Mike Boyle	**US Department of Defense**
Emily Doll	**US Department of Defense**
Jessica Fitzgerald-McKay	**US Department of Defense**
Jonathan Hersack	**US Department of Defense**
Mary Lessels	**US Department of Defense**
Chris Salter	**US Department of Defense**
Andrew Cathrow	**Verisign**

Table of Contents

1 Introduction

1.1 Scope and Audience

The Trusted Network Communications (TNC) Work Group defines an open solution architecture that enables network operators to collect and utilize information about endpoint configuration and state. This information can be used to enforce policies, monitor endpoint health, and for many other activities. Information about the software present on an endpoint is an important consideration for such activities. Software Identification tags (SWID tags) [3] are formatted records (usually XML documents) that identify a specific software product. In this case, a "software product" can be a distinct release of some piece of software, such as an operating system, web browser, etc.; a patch or plug-in for such an application; or a suite of such applications. The SWID specification describes the format of these documents as well as rules governing their use on computer systems. In particular, software that supports SWID tags is expected to deposit an identifying tag on the endpoint when the software is installed, modify or replace the tag as the software is updated, and delete the tag when the software is uninstalled. SWID tags can also be created and managed by third-party tools or by local enterprises, allowing for tags to indicate the presence of software even when that software's manufacturer has not included SWID support. As such, by collecting a list of tags on an endpoint, one receives evidence as to the software present on that endpoint. The attributes defined in this document are used to communicate software inventory evidence, in the form of SWID tags, between IMVs and IMCs using the IF-M interface, as shown in Figure 1 below.

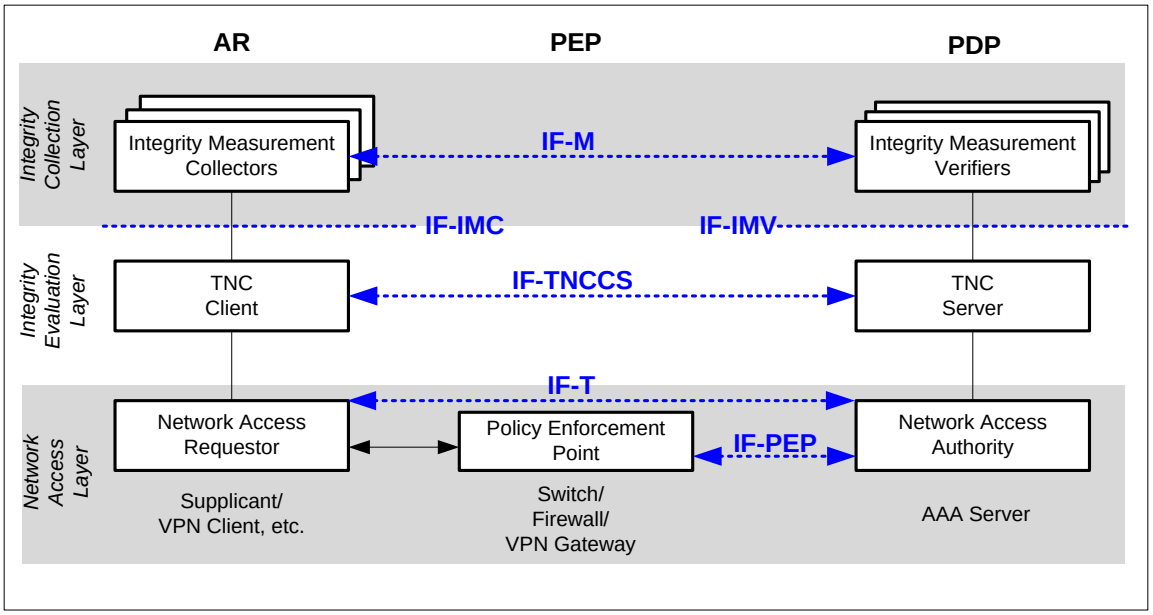


Figure 1 - TNC Architecture

The use of standard protocols and formats for conveying evidence about endpoint state (in this case, endpoint inventory information) has a number of benefits. The use of standard protocols and formats facilitates interoperability between products developed by different vendors. This allows consumers to select the product that has features that best fit with the needs of their environment, with the expectation that it will be able to interoperate with other parts of their infrastructure (at least with regard to the aforementioned protocols and formats). In addition, because a standard is expected to be implemented by multiple independent parties, this means that the standard protocols and formats receive more review than might be expected in a proprietary solution. When the standard is managed by a group that is responsive to feedback from such implementers, as is the case with the TNC Work Group, this can lead to improvements in efficiency and security of those protocols and formats. For these reasons, a standard means of conveying endpoint inventory

information such as the one described in this document provides significant value to users. Vendors benefit from utilizing SWIDs to serve as evidence of software inventory because it reduces their need to develop remote software inventory tools for the increasing variety of endpoint platforms. If those endpoints support SWID Message and Attributes for IF-M, vendors can use these protocols to gather software inventory information remotely.

This specification defines a new set of IF-M attributes, carried over IF-M messages, which are used to communicate requests for SWID tags and events surrounding those tags, and for conveying that information back to a Policy Decision Point (PDP).

Possession of a list of an endpoint's SWID tags is very useful in understanding and maintaining the security state of an enterprise. For example, if an enterprise policy requires the presence of certain pieces of software and/or prohibits the presence of other software, SWID tags can be used to indicate compliance or non-compliance with these requirements. SWID tags indicating software presence and the patch level of that software can be compared to vulnerability or threat alerts to determine an endpoint's exposure to attack. SWID tags provide a great deal of information about unfamiliar software products, including the software author and potentially including where the software is installed on the endpoint and what files on the endpoint are associated with this installed software. All of these uses make an understanding of an endpoint's SWID tag collection highly useful to PDPs and other enterprise security applications.

Before reading this specification any further, the reader should review and understand the TNC architecture as described in TNC Architecture for Interoperability [1]. The reader should also understand the capabilities and requirements common to IF-M interfaces as defined in the TNC IF-M TLV Binding specification [4]. If the reader is building an IMC that supports IF-IMC, the reader is encouraged to read the TNC IF-IMC Specification [8] prior to reading this specification. If the reader is building an IMV that supports IF-IMV, the reader is encouraged to read the TNC IF-IMV Specification [9] prior to reading this specification.

1.2 Keywords

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this specification are to be interpreted as described in RFC 2119 [2]. This specification does not distinguish blocks of informative comments and normative requirements. Therefore, for the sake of clarity, note that lower case instances of must, should, etc. do not indicate normative requirements.

1.3 Definitions

This section defines terms with special meaning within this document.

SWID-IMC - An Integrity Measurement Collector (IMC) that conforms to this specification. Note that such an IMC might also support other IF-M exchanges beyond SWID Message and Attributes for IF-M.

SWID-IMV - An Integrity Measurement Verifier (IMV) that conforms to this specification. Note that such an IMV might also support other IF-M exchanges beyond SWID Message and Attributes for IF-M.

Endpoint's SWID Tag Collection The set of SWID tags installed and managed on an endpoint for software installed on that endpoint. An endpoint’s SWID tag collection might include SWID tags from multiple sources, including but not limited to SWID tag files deposited on the file system during software installation, SWID tags generated to report output from software discovery tools, and SWID tags dynamically generated by a software or package management system on an endpoint.

2 Background

2.1 Role of SWID Message and Attributes for IF-M

Understanding the software inventory of an endpoint is a critical aspect of assessing and securing that endpoint. Patch management, vulnerability scanning, license compliance, and policy conformance all have central dependencies upon understanding what software is installed on a given endpoint. Today, inventory scans are performed by a range of software discovery processes including specialized software tools designed to discover software, operating system capabilities for software inventory, or general scanning tools provided with software signature checks. These different processes have their own strengths and limitations and might express their findings using disparate proprietary formats. For these reasons, policy decisions that incorporate software inventory information from such discovery processes need to be individually tailored to the individual discovery process(es) that provides this information, making these policies harder to craft and less portable.

The International Organization for Standardization and the International Electrotechnical Commission (ISO/IEC) published the specification governing SWID tag construction and use in 2009.[1] [3] Since that time, a growing number of vendors have integrated SWID tags into their software products. Doing so significantly simplifies the task of identifying these pieces of software: instead of relying on discovery processes that look for clues as to software presence, such as the presence of particular files or registry keys, a readily available list of SWID tags provides simple and immediate evidence as to the presence of the given piece of software.

SWID tags can also be useful even when a piece of software does not supply the tags itself. Discovery processes are permitted to express their findings using SWID tags, place these in the endpoint's SWID tag collection, and maintain them like vendor-created SWID tags. This means that an endpoint's SWID tag collection is not necessarily limited to containing SWID tags for software whose authors have taken the time to integrate SWID maintenance into their installation and update processes. Similarly, software and package managers on an endpoint (such as RPM and YUM) keep records of installed software, and these records can be exported as a series of SWID tags, allowing these managers to expose their information about software inventories in a standards-based manner. Finally, for organizations that centrally manage the distribution of software, in-house-developed SWID tags can be added to any software product that does not natively support SWID tags allowing the organization to accurately identify any software it has distributed.

The PDP needs access to this inventory evidence if it is to use this information for policy decisions. The SWID Message and Attributes for IF-M specification has been created for this purpose. Specifically, the attributes defined in this specification allow an IMV to request evidence of an endpoint's inventory in the form of SWID tags and allow the IMC to respond with the appropriate information.

It is not necessary to understand the details of SWID tag construction and maintenance to understand the behaviors described in the SWID Message and Attributes for IF-M specification, and it is beyond the scope of this specification to discuss the details of the SWID standard. Implementers, however, will likely need to be familiar with the SWID tag format and how to locate tags on an endpoint. The SWID specification is available from ISO/IEC at http://www.iso.org/iso/catalogue_detail.htm?csnumber=53670. The XML schema for a SWID tag file is available from ISO: http://standards.iso.org/iso/19770/-2/2009/schema.xsd. The most current working and production versions of the XML schema for SWID tags can be found in the directory listing at http://standards.iso.org/iso/19770/-2/. The US National Institute of Standards and Technology (NIST) also has published guidelines for SWID tag creation, which provide further guidance for those interested in the use and best practices surrounding SWID tags. [14]

[1] In 2015, at the time of this specification's publication, ISO/IEC is developing a revised draft of the SWID tag specification. The SWID Message and Attributes for IF-M is intended to be compatible with both the 2009 and imminent revision of the ISO/IEC SWID specification.

2.2 Supported Use Cases

This section describes the SWID Message and Attributes for IF-M use cases supported by this specification. The primary use of exchanging SWID tag information over the IF-M interface is to enable a challenger (e.g. PDP) to obtain inventory evidence about some system in a way that conforms to TNC procedures while taking advantage of the simplicity and precision of SWID tags. Collected SWID tags can support a range of security activities including determining whether an endpoint is permitted to connect to the enterprise, determining which endpoints contain software that requires patching, and similar activities.

2.2.1 Use Software Inventory as a Factor in Determining Endpoint Access

Some enterprises might define security policies that require connected endpoints to have certain pieces of security software installed. By contrast, some security policies might prevent access by endpoints that have certain prohibited pieces of software installed, such as applications that pose known security risks. To support such policies, the PDP needs to collect evidence indicating the software inventory of an endpoint that is seeking to initiate or continue connectivity to the enterprise.

SWID Message and Attributes for IF-M facilitates policy decisions that consider an endpoint's software inventory by providing the PDP with a list of the SWID tags in the endpoint's SWID tag collection. The tags in this collection serve as evidence as to the endpoint's installed software. The SWID-IMC can provide a complete or partial list of tags to the SWID-IMV as required to determine policy compliance. The SWID-IMV can then use this as evidence of compliance or non-compliance with enterprise policy.

2.2.2 Maintain a Central Repository Reflecting an Endpoint's Software Inventory

Many tools can use information about an endpoint's software inventory to monitor and enforce the security of an enterprise. For example, a software patching service can use an endpoint's software inventory to determine whether certain endpoints have software that requires patching. A vulnerability management tool might identify endpoints with known vulnerabilities (patched or otherwise) and use this to gauge enterprise exposure to attack. A license management tool might verify that all copies of a particular piece of software are accounted for within the enterprise. The presence of a central repository representing a real-time understanding of each endpoint's software inventory facilitates all such activities. Using a central repository that can ensure the freshness of its collected information is generally more efficient than having each tool collect the same inventory information from each endpoint individually and leads to a more consistent understanding of enterprise state.

SWID Message and Attributes for IF-M supports this activity through a number of mechanisms. As noted above, it allows a SWID-IMC to provide a complete list of the tags present in an endpoint's SWID tag collection to the SWID-IMV, which can then pass this information on to a central repository such as a Configuration Management Database (CMDB) or similar application. In addition, SWID-IMCs are required to be able to monitor for changes to an endpoint's SWID tag collection in near real-time and push reports of changes to the SWID-IMV as soon as those changes are detected. Thus any central repository fed by a SWID-IMV receiving such information can be updated soon after the change occurs. Keeping such a central repository synchronized with the state of each endpoint's SWID tag collection allows tools that use this information for their own security activities to make decisions in a consistent, efficient manner.

2.2.3 IF-M Use Cases

SWID Message and Attributes for IF-M are intended to operate over the IF-M interface and, as such, are intended to meet the use cases set out in the IF-M TLV Binding specification.

2.3 Non-supported Use Cases

Some use cases not covered by this version of SWID Message and Attributes for IF-M include:

- This specification does not address how the endpoint's SWID tag collection is populated. In particular, TNC components are not expected to perform software discovery activities beyond compiling the tags in an endpoint's SWID tag collection. This collection might potentially come from multiple sources on the endpoint (e.g., SWID tags generated dynamically by package management tools or discovery tools, as well as SWID tag files discovered on the file system). While an enterprise might make use of software discovery procedures to identify installed software, especially software that does not install or manage its own SWID tag, such procedures are outside the scope of this specification.
- This specification does not address converting inventory information expressed in a proprietary format into the SWID tag format or converting a SWID tag into a proprietary format. Instead, it focuses exclusively on defining interfaces for the transportation of SWID tags in the expectation that this is the format around which reporting tools will converge.
- This specification provides no mechanisms for an IMV to request a specific list of tags based on arbitrary tag properties from the endpoint. For example, requesting only tags representing software from a particular vendor is not supported. After the endpoint's SWID tag collection has been copied to some central location, such as the CMDB, processes there can perform queries based on any criteria present in the collected SWID tags, but this specification does not address using such queries to constrain the initial collection of this information from the endpoint.
- This specification does not address utilization of certain SWID tag fields designed to facilitate local tests (i.e., on the endpoint) of endpoint state. For example, the optional `package_footprint` field of a SWID tag can contain a list of files and hash values associated with the software indicated by the tag. Tools on the endpoint can use the values in this field to test for the presence of the indicated files. Successful evaluation of such tests leads to greater assurance that the indicated software is present on the endpoint. Currently, most SWID tag creators do not provide values for tag fields that support local testing. For this reason, the added complexity of supporting endpoint testing using these fields is out of scope for this specification. Future versions of this specification might add support for such testing.

2.4 Specification Requirements

Below are the requirements that the SWID Message and Attributes for IF-M specification is required to meet in order to successfully play its role in the TNC architecture.

- Efficient

  The TNC architecture enables delay of network access until the endpoint is determined not to pose a security threat to the network based on its asserted integrity information. To minimize user frustration, the SWID Message and Attributes for IF-M ought to minimize overhead delays and make IF-M communications as rapid and efficient as possible.

  Efficiency is also important when one considers that some network endpoints are small and low powered, some networks are low bandwidth and/or high latency, and some IF-T protocols (such as IF-T for Tunneled EAP Methods [11]) or their underlying carrier protocol might allow only one packet in flight at a time or only one roundtrip. However, when the underlying IF-T protocol imposes fewer constraints on communications, this protocol ought to be capable of taking advantage of more robust communication channels (e.g. using larger messages or multiple roundtrips).

- Loosely Coupled to the SWID Specification

  Because the SWID specification is managed by ISO/IEC, the TCG has no direct influence over this specification or any revisions made to it. For this reason, the SWID Message and Attributes for IF-M specification ought to minimize its requirements and assumptions with regard to the structure and content of the SWID tags. While some level of visibility into tag

contents is required for certain features of this specification, minimization of such dependencies is necessary to improve compatibility with future revisions of the SWID specification.

- Scalable

  SWID Message and Attributes for IF-M needs to be usable in enterprises that contain tens of thousands of endpoints or more. As such, it needs to allow a PDP to make decisions based on up-to-date information about an endpoint's software inventory without creating an excessive burden on the enterprise's network.

- Interoperable

  This specification defines the protocol for how IMCs and IMVs can exchange and use SWID tags to provide a PDP with information about an endpoint's software inventory. Therefore a key goal for this specification is ensuring that all SWID IMCs and IMVs, regardless of the vendor who created them, are able to interoperate in their performance of these duties.

- Support precise and complete historical reporting

  This specification is expected to outline capabilities that support the use of Trusted Network Communications as outlined in the Trusted Computing Group's Endpoint Compliance Profile. One of the requirements for this Profile is that a Configuration Management Database (CMDB) be able to contain information about all endpoints connected to the enterprise for all points in time between the endpoint's first connection and the present. As such, it is required that any IMC supporting this specification be able to report any changes to its SWID tag collection in near real-time while connected and, upon reconnection to the enterprise, be able to update the PDP (and through it the CMDB) with regard to the state of its SWID tag collection throughout the entire interval when it was not connected.

2.5 Non-Requirements

There are certain requirements that the SWID Message and Attributes for IF-M specification explicitly is not required to meet. This list is not exhaustive.

- End to End Confidentiality

  SWID tags have no inherent mechanism for confidentiality, nor is this property automatically provided by IF-M interface use. Confidentiality is generally provided by the underlying transport protocols, such as the IF-T Binding to TLS [10] or IF-T for Tunneled EAP Methods [11] - see Section 7 for more information on related standards. Should users wish confidentiality protection of assessment instructions or results, this needs to be provided by parts of the TNC architecture other than this specification.

2.6 Assumptions

Here are the assumptions that SWID Message and Attributes for IF-M makes about other components in the TNC architecture.

- Reliable Message Delivery

  The TNC Client and TNC Server are assumed to provide reliable delivery for IF-M messages and therefore the SWID Attributes sent between the SWID IMCs and the IMVs. In the event that reliable delivery cannot be provided, the TNC Client or TNC Server is expected to terminate the connection.

2.7 Non-Assumptions

The SWID Message and Attributes for IF-M specification explicitly does not assume:

- Authenticity and Accuracy of SWID tags with Regard to Endpoint Inventory

  This specification makes no assumption as to whether the SWID tags that it reports are authentic tags (rather than maliciously generated) or that these tags correctly reflect software state on the endpoint. This specification does not attempt to detect when the endpoint is providing false information, either through malice or error, but instead focuses on correctly and reliably providing the existing SWID tags to the PDP. Similarly, this specification makes no assumption with regard to the completeness of the SWID tag collection's coverage of the total set of software installed on the endpoint. It is possible, and even likely, that some installed software is not represented by a tag in an endpoints SWID tag collection. See Section 5.1 for more on this security consideration.

2.8 Caveat Regarding Persistent Connections

One of the features defined in this specification describes the ability for SWID-IMCs to monitor the state of their endpoint's SWID tag collection and, when changes are detected, to push updates to the SWID-IMV without the SWID-IMV sending a request. (This feature is described in more detail in section 3.8.) This capability is tied to the SWID-IMC's ability to initiate an Integrity Check Handshake (as described in section 2.10.1 of the IF-IMC 1.3 specification [8]), which in turn is only possible if there is an active connection with a valid connection ID (as described in section 2.10.2 of the IF-IMC 1.3 specification).

The other specifications of the TNC architecture do not require endpoints (in particular, the TNCC) to maintain active connections outside of an Integrity Check Handshake. While TNCC implementers are allowed to maintain connections outside of an Integrity Check Handshake (and there are advantages to doing so), maintaining open connections also consumes resources on both the endpoint and the PDP, so some implementers may choose to close connections as soon as a handshake completes. Moreover, for devices with intermittent connectivity (such as mobile phones), maintaining an active, ongoing connection may be impractical.

This specification requires that all SWID-IMCs and SWID-IMVs support subscriptions. However, for the reasons noted above, subscriptions may not be practical in all environments where SWID-IMCs and SWID-IMVs are deployed. Parties deploying SWID-IMCs and SWID-IMVs as part of their enterprise protection strategy are encouraged to understand the limits of specific devices and their TNC architecture as a whole. In some cases, while other features of the SWID Message and Attributes for IF-M specification may be employed, the use of subscriptions may be limited or impractical without additional infrastructure changes.

2.9 SWID Message and Attributes for IF-M Diagram Conventions

This specification defines the syntax of the SWID Message and Attributes for IF-M using diagrams. Each diagram depicts the format and size of each field in bits. Implementations MUST send the bits in each diagram as they are shown from left to right for each 32-bit quantity traversing the diagram from top to bottom. Multi-octet fields representing numeric values MUST be sent in network (big endian) byte order.

Descriptions of bit fields (e.g. flags) values refer to the position of the bit within the field. These bit positions are numbered from the most significant bit through the least significant bit. As such, an octet with only bit 0 set would have a value of 0x80 (1000 0000), an octet with only bit 1 set would have a value of 0x40 (0100 0000), and an octet with only bit 7 set would have a value of 0x01 (0000 0001).

3 SWID Message and Attributes for IF-M System Requirements

The SWID Message and Attributes for IF-M specification facilitates the exchange of SWID tag inventories and event information. Specifically, each application supporting SWID Message and Attributes for IF-M includes a component known as the SWID-IMC that receives messages sent with the SWID Attributes component type. The SWID-IMC is also responsible for sending appropriate SWID Attributes back to the SWID-IMV in response. Similarly, the SWID-IMV exists on a PDP or similar server and is responsible for interpreting responses, forwarding information to a CMDB if desired, and making policy decisions based upon the received information. This section outlines what a SWID tag inventory is, important features of tags used by this specification, and the requirements on SWID-IMCs and SWID-IMVs in order to support the stated use cases of this specification.

3.1 SWID Tags as Inventory Evidence

As noted in Section 2.1, SWID tags are intended to be open, easily accessible evidence indicating the presence of a particular piece of software on an endpoint. A SWID tag contains multiple fields intended to uniquely identify a single software product. Ideally, a SWID tag is managed by the software that installs, modifies, replaces, amends (e.g. patches, updates), and/or uninstalls the product. Discovery processes, software package managers, and other tools can also create and manage tags as a way to represent software that they discover or manage on the endpoint.

It is important to note that, even in the ideal cases where a product manages its own SWID tag, a tag is inherently distinct from the product that it identifies. For this reason, a SWID tag needs to be treated as evidence of software presence, but cannot be treated as proof of software presence. That noted, a standardized representation of evidence indicative of an endpoint's software inventory is a powerful tool in managing software within an enterprise.

3.2 Basic SWID Tag Inventory Exchange

In the most basic exchange supported by this specification, a SWID-IMV sends a request to the SWID-IMC requesting a copy of all the SWID tags in the endpoint's SWID tag collection. This simple exchange is shown in Figure 2.

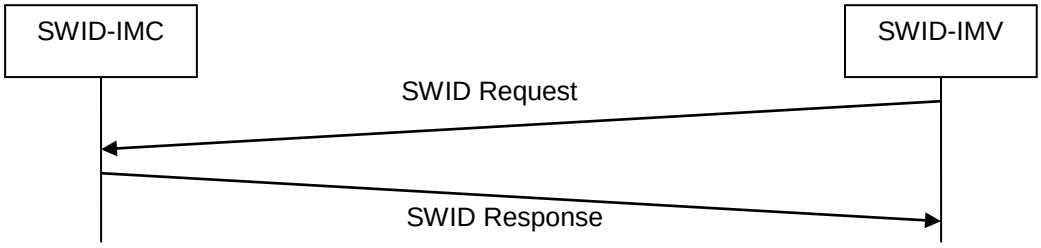


Figure 2 - Basic SWID Message Exchange

Upon receiving such a SWID Request from the SWID-IMV, the SWID-IMC is expected to locate the endpoint's SWID tags and then create copies of all identified SWID tags and place them within its response attribute.

SWID-IMVs MUST discard without error any SWID Response attributes that they receive for which they do not know the SWID Request parameters that led to this SWID Response. This is due to the fact that the SWID Request includes parameters that control the nature of the response (as will be described in the following sections) and without knowing those parameters the SWID Response cannot be reliably interpreted. Most often receiving an unsolicited SWID Response attribute happens when a PDP has multiple SWID-IMVs; one SWID-IMV sends a SWID Request but, unless exclusive delivery is used by the SWID-IMC in sending the response, both SWID-IMVs receive copies of the resulting SWID Response. In this case, the SWID-IMV that didn't send the SWID Request would lack

the context necessary to correctly interpret the SWID Response it received and would simply discard it. Note, however, that proprietary measures might allow a SWID-IMV to discover the SWID Request parameters for a SWID Response even if that SWID-IMV did not send the given SWID Request. As such, there is no blanket requirement for a SWID-IMV to discard all SWID Responses to SWID Request the SWID-IMV did not generate itself, only that SWID-IMVs are required to discard SWID Responses for which they cannot get the necessary context to interpret.

In the case that it is possible to do so, the SWID-IMC MAY send its SWID Response attribute to the SWID-IMV that requested it using exclusive delivery as described in section 3.3.2.2 of the IF-IMV r1.4 specification. Exclusive delivery ensures that only the sender of the SWID Request receives the resulting SWID Response. However, exclusive delivery is not always possible (it requires the use of IF-IMC 1.3 or later and IF-IMV 1.3 or later, and not all products currently do this) or necessarily desirable in all cases. As such, SWID Message and Attributes for IF-M does not require support for exclusive delivery of attributes.

3.3 SWID Tag Identifiers

SWID tags can contain a great deal of information about a software product. In addition to identifying name, manufacturer, and version of a software product, SWID tags might contain references to related products, associated files and libraries, dependencies on other software, and many other details. Moreover, SWID tags might be customized on the endpoint to indicate when the SWID tag was last checked for accuracy relative to the endpoint's installed software and other information about how the software was received. (This document refers to this customized information as "installation-specific" tag information.) For this reason, actual possession of a SWID tag can be useful for reasoning about details of an endpoint's software inventory. However, a SWID tag file that contains all optional fields might be tens of KB in size. This means that an endpoint's full SWID inventory, encompassing hundreds of applications, can be quite large.

If bandwidth is a concern within an enterprise, there is a way to identify a SWID tag without needing the complete tag. All tags contain specific fields that can be used to distinguish a tag for a particular piece of software from tags for different pieces of software. The Tag Creator RegID is a string that uniquely identifies the creator of this SWID tag (who might or might not be the same as the entity who created the described software) while the Unique ID is a string that uniquely identifies the described piece of software according to that tag creator. These two pieces of information together create a "tag identifier".

3.3.1 Tag Identifier Data

Some attributes defined in this specification contain fields to hold tag identifiers rather than whole tags. When populating these fields, both the Tag Creator RegID and the Unique ID values MUST be copies of the values of fields within the SWID tag that is being identified. The specific fields of a SWID tag that correspond to the Tag Creator RegID and Unique ID values vary between the different releases of the ISO SWID tag specification. It is important to note that, in all other parts of this specification, the terms Tag Creator RegID and Unique ID refer to the general field values defined above rather to any term used in any specific release of the ISO SWID tag specification.

To identify the SWID tag field corresponding to the Tag Creator RegID, identify the field containing the regid value of the entity that created the given SWID tag. Note that this might not be the same entity that created the software. The Tag Creator RegID MUST be the regid, rather than any prose name that might be associated with the tag creator. The specific structure of a regid is defined in the ISO/IEC SWID specification.

To identify the SWID tag field corresponding to the Unique ID, find the field that contains a string that uniquely identifies a specific product, version, edition, revision, etc. of a piece of software. Note that this is a single field within the SWID tag, rather than a concatenation of multiple fields. In particular, SWID tags often contain designated fields for just the product name, product version, product edition, etc., but these fields are not used to populate the Unique ID. Instead, look for a single field that is designed to uniquely identify a specific software product, version, etc. (and thus uniquely identifies a specific tag, at least according to the tag's creator).

Consult the ISO/IEC specification for the specific fields that correspond to the requirements of the Tag Creator RegID and Unique ID, as defined above. For example, in the 2009 version of the ISO/IEC SWID specification [3], the Tag Creator RegID corresponds to the value of the `software_identification_tag/software_id/tag_creator_regid` field in a SWID tag. The Unique ID corresponds to the value of the `software_identification_tag/software_id/unique_id` field in a SWID tag. In subsequent releases of the ISO/IEC SWID specification, different fields might be used to convey the same information.

3.3.2 Tag Identifier Instances

A tag identifier (i.e., the combination of the Tag Creator RegID and the Unique ID fields) uniquely identifies a particular SWID tag, which corresponds to a single software product. Assuming that this product manages its own SWID tag (i.e., creates the tag on installation and deletes the tag when the product is uninstalled) then every system with an instance of this software product installed would also have a copy of this same SWID tag file with the same tag identifier field values. (Presence of SWID tags managed by other tools, such as discovery tools, would also depend on the presence of those tools on the device.) In fact, if multiple instances of the same software product are installed on a single device (i.e., it has been installed twice in different locations) that device would have two instances of the same SWID tag, one for each installation. Both instances of the SWID tag would have the same tag identifier field values. This is true even though the tags themselves might differ with regard to their installation-specific tag fields. In many cases it is important to distinguish between instances of a particular tag on a particular endpoint. For example, if one is alerted to the deletion of a particular SWID tag and there are multiple instances of that SWID tag on the endpoint, one will likely wish to know which instance was deleted.

Individual instances of SWID tags are distinguished by providing an "Instance ID" value along with the tag identifier. An Instance ID is a string that is uniquely associated with a particular instance of a SWID tag on a particular endpoint. The exact nature of the Instance ID depends on the source of the SWID tag. If the SWID tag is represented as a file on disk, the Instance ID might be the full path of the SWID tag file, including the name of the SWID tag file itself. (Note that the SWID tag filename MUST be included in the tag file path because it is possible for two SWID tags, each for different instances of the same software product, to co-exist in the same directory under different file names.) In the case that the SWID tag is dynamically generated upon request by some source, such as an RPM or YUM package manager, the generation process MUST create an Instance ID to distinguish instances of a particular tag. Inclusion of this Instance ID ensures each tag is uniquely identified on a given endpoint.

To the extent that it is possible, the generation of Instance IDs SHOULD be repeatable for a single installation of a single SWID tag. In the case where a product is installed once, and then SWID tags are generated upon request, each time the SWID tag is generated the tag identifier instance SHOULD all have the same Instance ID value. For example, if a package manager generates a SWID tag in response to a request based on some record it possesses, and then later generates the SWID tag again based on the same record of package installation, then the same Instance ID value SHOULD be created both times. This is necessary to allow remote parties to understand whether a reported SWID tag instance is for the same product installation they saw reported earlier or if it represents a new installation of the same product. Note, however, that some exceptional situations might result in the changing of a product's Instance ID. For example, it is not explicitly prohibited by the SWID specification for tags to move after installation, and thus have their tag file path change. If the file path was used as the tag's Instance ID, subsequent tag identifier instances for that same product might appear to be different. Implementers and users need to be aware of this possibility.

The combination of a tag identifier with an Instance ID is referred to as a "tag identifier instance". A tag identifier instance uniquely identifies a particular instance of a particular tag on a given endpoint. Note that two endpoints might produce identical tag identifier instances, but these do not mean that the tag files on the two endpoints are identical - the tags in question indicate the same software product on both endpoints (since the respective tag identifiers are identical), but the tags might still differ in their installation-specific fields. Therefore, it is important to remember that tag identifier

instances are only comparable in the scope of a single endpoint; when comparing across different endpoints, only the tag identifier fields (Tag Create RegID and Unique ID) can be meaningfully compared - any Instance ID value will need to be excluded from comparison.

3.3.3 Comparing Tag Identifiers and Tag Identifier Instances

Comparison of tag identifiers can be used to determine whether a particular SWID tag is present in an endpoint's SWID tag collection. A pair of SWID tag identifiers is said to "match" if their Tag Creator RegID and Unique ID fields are identical. Similarly, a pair of tag identifier instances is said to match if their Tag Creator RegID, Unique ID, and Instance ID fields are identical. Fields in SWID Message and Attributes for IF-M attributes that contain tag identifiers or tag identifier instances MUST always be normalized to Network Unicode, so comparison between values transported in attributes can be a simple string comparison. When comparing tag identifiers and tag identifier instances from attributes with the corresponding values from other sources (such as when comparing them to a full SWID tag file or similar record), the relevant fields from the latter need to undergo normalization prior to comparison. See Section 4.7 for more on normalization of the encoding for these fields. Comparisons are case-sensitive.

Matching tag identifiers and tag identifier instances indicate very specific things about the respective tags. The following sections describe what one can and cannot deduce based on matching tag identifiers.

3.3.3.1 Matching Tag Identifiers Indicate the Same Software Product

The Unique ID value of a tag identifier represents a value that the given tag creator will only use to indicate a particular software product (e.g., a particular release of a particular application). The ISO SWID specification prohibits the tag creator from associating a Unique ID value with multiple, different software products. At the same time, the Tag Creator RegID element value uniquely identifies a given tag creator. As such, even if two different tag creators were to assign the same Unique ID value to two different software products, the Tag Creator RegID values will be different, and therefore the tag identifiers will be different. For these reasons, the expectation is that if one sees two tags with the same tag identifiers, these tags are both associated with the same software product (assuming the tag's fields are correctly populated).

3.3.3.2 Matching Tag Identifiers DO NOT Necessarily Indicate Identical Tag Files

Some optional fields in SWID tags can reflect installation-specific information. As such, the SWID tags for a piece of software residing on two different endpoints (or installed twice on a single endpoint) will have the same tag identifier value (same tag creator with the same Unique ID for the same software product) but might contain different information in their installation-specific fields. For this reason, one cannot assume that just because two endpoints provide the same tag identifier value for their software inventories, that the tags on those endpoints are identical in all their fields (although one can deduce that the same software product was present on both endpoints).

Informative note: Initial drafts of the revised ISO SWID specification indicate that modification of SWID tags might no longer be permitted by parties other than the original tag creator (usually the vendor of the software identified by the tag). If this becomes part of the revised SWID specification, then for SWID tags that conform to this revised specification, this will mean that matching tag identifiers do imply identical tag files.

3.3.3.3 Matching Tag Identifier Instances MIGHT Indicate Identical Tag Files

For a single endpoint, matching tag identifier instance values might indicate identical tag files, at least within a narrow time window. Tag identifier instance values are unique to a specific SWID tag record on that particular endpoint at a particular point in time. The Instance ID in the tag identifier instance information ought to be unique relative to any other instances of the same SWID tag currently also on that endpoint. However, tag identifier instances are still not guaranteed to be unique to a single SWID tag file over a long period of time. Consider a piece of software that is installed (adding a SWID tag), uninstalled (removing the SWID tag), and then reinstalled (adding that SWID tag back but with a different installation-specific field values). It is possible that the two SWID tag files, present at

different points in time, might have identical tag identifier instance values even though the tag files themselves were different.

As noted above, SWID tag identifier instances are only comparable within the context of a single endpoint. When SWID tag identifier instances are collected from multiple endpoints and then compared, the Instance ID MUST be ignored in any comparison of tag identifiers from different endpoints.

3.3.3.4 Differing Tag Identifiers DO NOT Necessarily Indicate Different Software Products

While a tag identifier uniquely identifies a software product (i.e., that tag identifier cannot be associated with a different software product), a single product might have more than one tag identifier. This is because it is possible for more than one tag creator to create a SWID tag for the same software product. Multiple tags for the same software product but created by different tag creators will have different Tag Creator RegID values and will also likely differ in their Unique ID value. Thus, these two tags will have different tag identifiers even though they were associated with the same software product. In fact, in some circumstances, two parties might create two different SWID tag records for a single instance of the same software product. For example, when a product is installed, it creates a SWID tag file on the file system, and a software discovery tool also notes the installation of the product and generates its own SWID tag record for the same installation. In this case, that single installation is associated with two SWID tags with different SWID tag identifiers. In short, identical tag identifiers always indicate the same software product, but different tag identifiers do not necessarily indicate different software products.

3.3.4 Using Tag Identifiers in SWID Attributes

A SWID attribute reporting an endpoint's SWID tag collection can contain SWID tag identifier instances instead of copies of SWID tag files. The message exchange is identical to the diagram shown in Figure 2, but the contents of the SWID Response are SWID tag identifier instances instead of tags. The SWID Request attribute indicates whether the response is required to use full tags or tag identifier instances. Using tag identifier instances can reduce the attribute size of the response by multiple orders of magnitude when compared to sending the same inventory using full tags. A SWID-IMC responds to a SWID Request attribute requesting SWID tag identifier instances the same way it responds to a request for full SWID tags, except that instead of copying each SWID tag entirely into the attribute body of the response, it provides the specific values that comprise a SWID tag identifier instance for each tag.

3.4 Targeted Requests

Sometimes a SWID-IMV does not require information about every tag on an endpoint but only needs to know about certain tags. For example, an endpoint might be required to have a particular patch installed. In determining compliance with this policy, the SWID-IMV is only interested in the specific SWID tag associated with this patch. Instead of requesting a complete inventory just to see if the patch's SWID tag is present, the SWID-IMV can make a "targeted request" for the tag in question.

Targeted requests follow the same message exchange described in Figure 2. The SWID-IMV targets its request by providing one or more SWID tag identifiers in its SWID Request attribute. The SWID-IMC MUST then limit its response to contain only tags that match the indicated tag identifier(s). This allows the network exchange to exclude information that is not relevant to a given policy question, thus reducing unnecessary bandwidth consumption. The SWID-IMC's response might consist of full tags or of tag identifier instances, depending on the parameters of the SWID Request.

Targeted requests cannot target specific SWID tag instances; the SWID Request does not include fields for Instance IDs. As a result, when responding to a targeted request, a SWID-IMC MUST return applicable results for every instance of the identified tags.

Note that targeted requests identify the SWID tags relevant to the request only through SWID tag identifiers for those tags. This specification does not support arbitrary, parameterized querying of tags. For example, one cannot request all tags from a certain software publisher, or all tags created by a particular tag creator. Targeted requests only allow a requestor to request specific tags (as

identified by their tag identifiers) and receive a response that is limited to the named tags. There is also no assumption that a SWID-IMC will recognize "synonymous tags" - that is, tags by different tag creators for the same software product. The SWID-IMC returns only tags that match the tag identifiers in the SWID Request, even if there might be other SWID tags in the endpoint's SWID tag collection for the same software product.

SWID-IMCs MUST accept targeted requests and process them correctly as described above. SWID-IMVs MUST be capable of making targeted requests and processing the responses thereto.

3.5 Monitoring Changes in an Endpoint's SWID Tag Collection

The SWID collection on an endpoint is not static. As software is installed, uninstalled, patched, or updated, the SWID tag collection is expected to change to reflect the new software state on the endpoint. For tags managed by an application's installer, tag changes usually occur at the time of installation or update. For tags added by discovery tools, software and package managers, and other sources, changes to the endpoint's SWID tag collection occur when some process discovers the new or altered software product, which typically lags behind the actual installation or update time.

All SWID-IMCs MUST be able to be able to detect changes to the SWID tag repositories on their endpoint. Specifically, SWID-IMCs MUST be able to detect:

- The creation of tags
- The deletion of tags
- The alteration of tags

An "alteration" is anything that modifies the contents of a SWID tag file (or would modify it, if the tag file is dynamically generated on demand) in any way, regardless of whether the change is functionally meaningful. Changes MUST be monitored for all utilized sources of SWID tags. This includes, but is not limited to, monitoring sources that dynamically generate SWID tags.

SWID-IMCs MUST detect such changes to the endpoint's SWID tag collection in close to real-time (i.e., within seconds) when the IMC is operating. In addition, in the case where there is a period during which the SWID-IMC is not operating, the SWID-IMC MUST be able to determine the *net* change to the endpoint's SWID tag collection over the period it was not operational. Specifically, the "net change" represents the difference between the state of the endpoint's SWID tag collection when the SWID-IMC was last operational and monitoring its state, and the state of the endpoint's SWID tag collection when the SWID-IMC resumed operation. Note that a net change might not reflect the total number of change events over this interval. For example, if a SWID tag file was altered three times during a period when the SWID-IMC was unable to monitor for changes, the net change of this interval might only note that there was an alteration to the file, but not how many individual alteration events occurred. It is sufficient for a SWID-IMC's determination of a net change to note that there was a difference between the earlier and current state rather than enumerating all the individual events that allowed the current state to be reached.

The SWID-IMC MUST assign a time to each detected change in the endpoint's SWID tag collection. These timestamps correspond to the SWID-IMC’s best understanding as to when the detected change occurred. These timestamps MUST be as accurate as possible. For changes to the endpoint's SWID tag collection that occur while the SWID-IMC is operating, the SWID-IMC ought to be able to assign a time to the event that is accurate to within a few seconds. For changes to the endpoint's SWID tag collection that occur while the SWID-IMC is not operational, upon becoming operational the SWID-IMC needs to make a best guess as to the time of the relevant events (possibly by looking at timestamps on the files), but these values might be off. In the case of dynamically generated SWID tags, the time of change is the time at which the data from which the SWID tags are generate changes, not the time at which a changed SWID tag is generated. For example, if SWID tags are dynamically generated based on data in an RPM database, the time of change would be when the RPM record was changed.

With regard to deletions of SWID tags, the SWID-IMC needs to detect the deletion and MUST retain a copy of the full deleted tag so that the tag itself can be provided to the SWID-IMV upon request. This copy of the SWID tag MUST be retained for a reasonable amount of time. Vendors and administrators determine what "reasonable" means, but a copy of the tag SHOULD be retained for as long as the event recording the deletion of the tag remains in the SWID-IMC's records. This is recommended because, as long as the event is in the SWID-IMC's records, the SWID-IMC might send an event attribute (described in section 3.6) that references this tag, and a copy of the tag is needed if the SWID-IMV wanted a full copy of the relevant tags.

With regard to alterations to a SWID tag file, SWID-IMCs MUST detect any alterations to the contents of a tag file. Alterations need to be detected even if they have no functional impact on the tag file. For example, the addition of whitespace between XML attributes does not have any impact on the meaning of the SWID tag file, but still needs to be detected as a tag file alteration by a SWID-IMC. A good guideline is that any alteration to a file that might change the value of a hash taken on the file's contents needs to be detected by the SWID-IMC. A SWID-IMC might be unable to distinguish modifications to the content of a tag file from modifications to the metadata the file system associates with the tag file. For example, a SWID-IMC might use the "last modification" timestamp as an indication of alteration to a given tag file, but a file's last modification time can change for reasons other than modifications to the file contents. A SWID-IMC is still considered compliant with this specification if it also reports metadata change events that do not change the SWID tag file itself as alterations to the SWID tag file. In other words, while SWID-IMC authors are encouraged to exclude modifications that do not affect the bytes within the tag file when detecting alterations to a SWID tag record, discriminating between modifications to file contents and changes to file metadata can be difficult and time consuming on some systems. As such, as long as the alterations detected by a SWID-IMC always cover all modifications to the contents of tag files, the SWID-IMC is considered compliant even if it also registers alterations that do not modify the contents of a tag file as well. When recording an alteration to a tag file, the SWID-IMC is only required to note that an alteration occurred. The SWID-IMC is not required to note or record how the tag file altered, nor is it possible to include such details in SWID Attributes reporting the change to a SWID-IMV.

3.6 Reporting Change Events

As noted in the preceding section, SWID-IMCs MUST be able to detect changes to the SWID tag repositories (tag creation, tag removal, and tag alteration) in near real-time while the SWID-IMC is operational, and MUST be able to account for any net change to the endpoint's SWID tag collection that occurs when the SWID-IMC is not operational. However, to be of use to the enterprise, the PDP needs to be able to receive these events and be able to understand how new changes relate to earlier changes. In SWID Message and Attributes for IF-M, this is facilitated by reporting change events. All SWID-IMCs MUST be capable of receiving requests for change events and sending change event attributes. All SWID-IMVs MUST be capable of requesting and receiving change event attributes.

3.6.1 Change Event Records

A change event record consists of either a complete SWID tag or SWID tag identifier instance along with the following pieces of information:

- The nature of the change (i.e., tag creation, tag deletion, or tag alteration)
- An Event Identifier (EID) value
- An EID Epoch value

An EID is a 4-byte unsigned integer that the SWID-IMC assigns sequentially to each observed event (whether detected in real-time or deduced by looking for net changes over a period of SWID-IMC inactivity). All EIDs exist within the context of some "EID Epoch", which is also represented as a 4-byte unsigned integer. EID Epochs are used to ensure synchronization between the SWID-IMC and any SWID-IMVs with which it communicates. EID Epoch values SHOULD be generated randomly and in such a way that it is unlikely that the same EID Epoch is generated twice, even if the SWID-IMC reverted to an earlier state (e.g., resetting it to factory defaults). In the case where a SWID-IMC

needs to reset its EID counter, either because it has exhausted all available EID values or because the SWID-IMC's event log becomes corrupted, then a new EID Epoch MUST be selected.

Within an Epoch, EIDs MUST be assigned sequentially, so that if a particular event is assigned an EID of N, the next observed event is given an EID of N+1. In some cases, events might occur simultaneously, or the SWID-IMC might not otherwise be able to determine an ordering for events. In these cases, the SWID-IMC creates an arbitrary ordering of the events and assigns EIDs according to this ordering. Two change events MUST NOT ever be assigned the same EID within the same EID Epoch. No meaningful comparison can be made between EID values of different Epochs.

The EID value of 0 is reserved and MUST NOT be associated with any event. Specifically, an EID of 0 in a SWID Request attribute indicates that a SWID-IMV wants an inventory response rather than an event response, while an EID of 0 in a SWID Response is used to indicate the initial state of the endpoint's SWID tag collection prior to the observation of any events. Thus the very first recorded event in a SWID-IMC's records within an EID Epoch MUST be assigned a value of 1 or greater.

Note that EID and EID Epoch values are assigned by the SWID-IMC without regard to whether events are being reported to one or more SWID-IMVs. The SWID-IMC records events and assigns EIDs during its operation. Any and all SWID-IMVs that request event information from the SWID-IMC will have those requests served from the same records and thus will see the same EIDs and EID Epochs for the same events.

The SWID-IMC MUST ensure there is no coverage gap (i.e., change events that are not recorded in the SWID-IMC's records) in its records of change events. This is necessary because a coverage gap might give a SWID-IMV a false impression of the endpoint's state. For example, if a SWID-IMV saw an event indicating that a particular SWID tag had been installed, and saw no subsequent events indicating that tag had been deleted, it might reasonably assume that this tag was still installed (assuming the Epoch has not changed). If there is a coverage gap in the SWID-IMC's records, however, this assumption is false. For this reason, the SWID-IMC's event records MUST NOT contain gaps. In the case where there are periods where it is possible that changes occurred without the SWID-IMC detecting or recording them, the SWID-IMC MUST either compute a net change and update its records appropriately, or pick a new EID Epoch to indicate a discontinuity with previous event records.

Within a given Epoch, once a particular event has been assigned an EID, this association MUST NOT be changed. That is, within an Epoch, once an EID is assigned to an event, that EID cannot be reassigned to a different event, and the event cannot be assigned a different EID. When the SWID-IMC's Epoch changes, all of these associations between EIDs and events are cancelled, and EID values once again become free for assignment.

3.6.2 Updating Inventory Knowledge Based on Events

Modern endpoints can have hundreds of software products installed, most of which are unlikely to change from one day to the next. As such, instead of exchanging a complete list of an endpoint's inventory on a regular basis, one might wish to only identify changes since some earlier known state of this inventory. This is readily facilitated by the use of EIDs to place change events in a context relative to earlier state.

Every inventory sent by a SWID-IMC to a SWID-IMV (as described in Sections 3.2 through 3.4) includes the EID Epoch and EID of the last event recorded prior to that inventory being compiled. This allows the SWID-IMV to place all subsequently received event records in context relative to this inventory (since the EIDs represent a total ordering of all changes to the endpoint's SWID tag collection). Specifically, a SWID-IMV (or, more likely, a database that collects and records its findings) can record an endpoint's full inventory and also the EID and Epoch of the most recent event reflected in that state. From that point on, if change events are observed, the attribute describing these events indicates the nature of the change, the affected SWID tags, and the order in which these events occurred (as indicated by the sequential EIDs). Using this information, any remote record of the endpoint's SWID tag collection can be updated appropriately.

3.6.3 Using Event Records in SWID Attributes

A SWID-IMV MUST be able to request a list of event records instead of an inventory. The message flow in such an exchange looks the same as the basic flow shown in Figure 2. The only difference is that, in the SWID Request attribute, the SWID-IMV provides an EID other than 0. (A value of 0 in these fields represents a request for an inventory.) When the SWID-IMC receives such a request, instead of identifying SWID tags in the endpoint's SWID tag collection, it consults its record of detected changes. The SWID-IMC MUST add an event record to the SWID Response attribute for each recorded change event with an EID greater than or equal to the EID in the SWID Request attribute (although targeting of requests, as described in the next paragraph, may limit this list). A list of event records MUST only contain events with EIDs that all come from the current Epoch.

SWID-IMVs can target requests for event records by including one or more tag identifiers, as described in Section 3.4, in the SWID Request that requests an event record list. A targeted request for event records is used to indicate that only events affecting SWID tags that match the provided SWID tag identifiers are to be returned. Specifically, in response to a targeted request for event records, the SWID-IMC MUST exclude any event records that are less than the indicated EID (within the current EID Epoch) and exclude any event records where the affected SWID tag does not match one of the provided SWID tag identifiers. This might mean that the resulting list of event records sent in the response attribute does not provide a continuous sequence of EIDs. Both SWID-IMCs and SWIC-IMVs MUST support targeted request for event records.

3.6.4 Partial and Complete Lists of Event Records in SWID Attributes

Over time, a SWID-IMC might record a large number of change events. If a SWID-IMV requests all change events covering a large period of time, the resulting SWID Response attribute might be extremely large, especially if the SWID-IMV is requesting the use of full SWID tags instead of the use of SWID Identifier instances (as described in Section 3.3.4). In the case that the resulting attribute is too large to send (either because it exceeds the 4GB attribute size limit imposed by the IF-M TLV Binding specification, or because it exceeds some smaller size limit imposed on the SWID-IMC) the SWID-IMC MAY send a partial list of events back to the SWID-IMV.

Generation of a partial list of events in a SWID Response attribute requires the SWID-IMC to identify a "consulted range" of EIDs. A consulted range is the set of event records that are examined for inclusion in the SWID Response attribute and that are included in that attribute if applicable. Recall that, if a SWID Request is targeted, only event records that involve the indicated SWID tags would be applicable. (See Section 3.4 for more on Targeted Request.) If a request is not targeted, all event records in the considered range are applicable and included in the SWID Response attribute.

The lower bound of the consulted range MUST be the EID provided in the SWID Request. (Recall that a SWID Request indicates a request for event records by providing a non-0 EID value in the SWID Request. See Section 3.6.3.) The upper bound of the consulted range is the EID of the latest event record (as ordered by EID values) that is included in the SWID Response attribute if it is applicable to the request. The EID of this last event record is called the "Last Consulted EID". The SWID-IMC chooses this Last Consulted EID based on the size of the event record list it is willing to provide to the SWID-IMV.

A partial result list MUST include all applicable event records within the consulted range. This means that for any *applicable* event record whose EID is greater than or equal to the EID provided in the SWID Request and whose EID is less than or equal to the Last Consulted EID, that event record MUST be included in the SWID Response conveying this partial list of event records. This ensures that every partial list of event records is always complete within its indicated range.

All SWID Response attributes that convey event records (either using full SWID tags or using SWID tag identifier instances) include an Epoch, Last EID, and Last Consulted EID field. The Last EID contains the EID of the last event record known to the SWID-IMC at the time that the SWID Response attribute was generated. The Last EID might or might not be part of the consulted range. As noted above, the Last Consulted EID field contains the EID of the last event record in the consulted range. The Epoch field contains the EID Epoch associated with the Last EID and Last Consulted EID fields as well as all the EIDs in event records contained within the SWID Response attribute. Note that, if

responding to a targeted SWID Request, the SWID Response attribute might not contain the event record whose EID matches the Last Consulted EID value. For example, the last consulted EID record might have been deemed inapplicable because it did not match the specified list of SWID tag identifiers in the SWID Request.

If a SWID-IMV receives a SWID Response attribute where the Last EID and Last Consulted EID fields are identical, the SWID-IMV knows that it has received a result list that is complete, given the parameters of the request, up to the present time. On the other hand, if the Last EID and Last Consulted EID values differ, the SWID-IMV has received a partial result list. In the latter case, if the SWID-IMV wishes to try to collect the rest of the partially delivered result list it then sends a new SWID Request whose EID is one greater than the Last Consulted EID in the preceding response. Doing this causes the SWID-IMC to generate another SWID Response attribute containing event records where the earliest reported event record is the one immediately after the event record with the Last Consulted EID (since EIDs are assigned sequentially). By repeating this process until it receives a SWID Response where the Last EID and Last Consulted EID are equal, the SWID-IMV is able to collect all event records over a given range, even if the complete set of event records would be too large to deliver via a single attribute.

Implementers need to be aware that a SWID Request might specify an EID that is greater than the EID of the last event recorded by a SWID-IMC. In accordance with the behaviors described in Section 3.6.3, a SWID-IMC MUST respond to such a request with a SWID Response attribute of the appropriate type (using SWID tags or SWID tag identifier instances as specified in the SWID Request) that contains zero event records. This is because the SWID-IMC has recorded no event records with EIDs greater than or equal to the EID in the SWID Request. In such a case, the Last Consulted EID field MUST be set to the same value as the Last EID field in this SWID response attribute. This case is called out because consulted range on a SWID-IMC in such a situation is a negative range, where the "first" EID in the range (provided in the SWID Request) is greater than the "last" EID in the range (this being the EID of the last recorded event on the SWID-IMC). Implementers need to ensure that SWID-IMCs do not experience problems in such a circumstance.

Note that this specification only supports the returning of partial results when returning event records. There is no way to return a partial inventory list under this specification.

3.6.5 Synchronizing Event Identifiers and Epochs

Since EIDs are sequential within an Epoch, if a SWID-IMV's list of event records contains gaps in the EID values within a single Epoch, the SWID-IMV knows that there are events that have not been accounted for. The SWID-IMV can either request a new event list to collect the missing events or request a full inventory to re-sync its understanding of the state of the SWID tags on the endpoint. In either case, after the SWID-IMV's record of the endpoint's SWID tag collection has been updated, the SWID-IMV records the new latest EID value and tracks events normally from that point on.

If the SWID-IMV receives any attribute from a SWID-IMC where the EID Epoch differs from the EID Epoch that was used previously, then SWID-IMV or any entity using this information to track the endpoint's SWID tag collection knows that there is a discontinuity in their understanding of the endpoint's state. To move past this discontinuity and reestablish a current understanding of the state of the endpoint's SWID tag collection, the SWID-IMV needs to receive a full inventory from the endpoint. This is because it is not possible to account for all events on the SWID-IMC over the interval since the previous Epoch was used, because there is no way to query for EIDs from a previous Epoch. Once the SWID-IMV has received a full inventory for the new Epoch, the SWID-IMV records the latest EID reported in this new Epoch and can track further events normally.

A SWID-IMC MUST NOT report events with EIDs from any Epoch other than the current EID Epoch. The SWID-IMC MAY choose to purge all event records from a previous Epoch from memory after an Epoch change. Alternately, the SWID-IMC MAY choose to retain some event records from a previous EID Epoch and assign them new EIDs in the current Epoch. However, in the case where a SWID-IMC chooses the latter option it MUST ensure that the order of events according to their EIDs is unchanged and that there is no coverage gap between the first retained event recorded during the previous Epoch (now reassigned with an EID in the current Epoch) and the first event recorded during

the current Epoch. In particular, the SWID-IMC MUST ensure that all change events that occurred after the last recorded event from the previous Epoch are known and recorded. (This might not be possible if the Epoch change is due to state corruption on the SWID-IMC.) A SWID-IMC might choose to reassign EIDs to records from a preceding Epoch to create a "sliding window" of events, where each Epoch change represents a shift in the window of available events.

In the case where a SWID-IMC suffers a crash and loses track of its current EID Epoch or current EID, then it MUST generate a new EID Epoch value and begin assigning EIDs within that Epoch. In this case, the SWID-IMC MUST purge all event records from before the crash as it cannot ensure that there is not a gap between the last of those records and the next detected event. The process for generating a new EID Epoch MUST minimize the possibility that the newly generated EID Epoch is the same as a previously used EID Epoch.

The SWID-IMV will normally never receive an attribute indicating that the latest EID is less than the latest EID reported in a previous attribute within the same EID Epoch. If this occurs, the SWID-IMC has suffered an error of some kind, possibly indicative of at least partial corruption of its event log. In this case, the SWID-IMV SHOULD treat the situation as if there was a change in Epoch and treat any local copy of the endpoint's SWID tag collection as out-of-sync until a full inventory can be reported by the SWID-IMC. In this case, the SWID-IMV SHOULD flag the event so it can be examined to ensure it is now operating properly.

3.7 Supporting Multiple Instances of a Single Tag

One important consideration is that it is possible for multiple instances of a SWID tag to be present on an endpoint. (I.e., multiple SWID tag files whose tag identifiers are the same.) This can happen if there are multiple instances of the indicated software product installed on the endpoint. In order to account for the possibility, all SWID-IMCs MUST follow specific rules, outlined below.

3.7.1 Inventory Reporting in the Presence of Multiply-Instantiated Tags

When sending an inventory, either full or based on a targeted request, the SWID-IMC MUST include one entry for each instance of a relevant tag. (All tags are relevant in a full inventory. In a targeted request for an inventory, only tags that match the tag identifiers provided by the SWID-IMV are considered relevant.) For example, if a particular piece of software is installed twice on an endpoint, and thus there are two instances of its SWID tag present in the endpoint's SWID tag collection, an inventory for which this tag is relevant will contain at least two records for this piece of software, one for each tag instance. (It might contain more if multiple tag creators each created tags for the same piece of installed software.) In the case where the SWID-IMC's response is expressed using full tags, the response MUST contain one copy of each instance of the given tag. In other words, the SWID-IMC MUST send one copy of each tag instance, rather than send multiple copies of one tag instance. In the case where the SWID-IMC's response is expressed using tag identifiers, the response MUST include the tag identifier instance for each instance of the given tag.

3.7.2 Event Reporting in the Presence of Multiply Instantiated Tags

When reporting events, the specific tags that were added, deleted, or changed MUST be indicated. For example, in the case where tags A and B are two instances of the same SWID tag, each for separate installations of the same software product, and tag A changes in the endpoint's SWID tag collection, the SWID-IMC MUST report the event using tag A (rather than reporting it using B). This means that the report MUST contain the tag file or the tag identifier instance for the affected tag.

3.8 Subscriptions

Thus far, all message exchanges discussed assume that a SWID-IMV sent an SWID Request attribute and the SWID-IMC is providing a direct response to that request. The SWID Message and Attributes for IF-M specification also supports the ability for a SWID-IMC to send a message with a SWID Attribute to the SWID-IMV in response to observed changes in the endpoint's SWID tag collection, instead of in direct response to a SWID Request. An agreement by a SWID-IMC to send content when certain changes are detected to the endpoint's SWID tag collection is referred to in this

specification as a "subscription", and the SWID-IMV that receives this content is said to be "subscribed to" the given SWID-IMC. All SWID-IMCs and SWID-IMVs MUST support the use of subscriptions.

3.8.1 Establishing Subscriptions

A SWID-IMV establishes a subscription on a particular SWID-IMC by sending a SWID Request attribute with the Subscription flag set. The SWID Request attribute is otherwise identical to the SWID Requests discussed in previous sections. Specifically, such a SWID Request might request full tags or tag identifier instances, might be targeted, and might request change event records or endpoint inventory. Assuming no error is encountered, a SWID-IMC MUST send a SWID Response attribute in direct response to this SWID Request attribute, just as if the Subscription flag was not set. As such, the message exchange that establishes a new subscription in a SWID-IMC has the same flow seen in the previous message exchanges, as depicted in Figure 2. If the SWID-IMV does not receive an IF-M Error attribute (as described in Sections 3.10 and 4.14) in response to their subscription request, the subscription has been successfully established on the SWID-IMC. The SWID Request attribute that establishes a new subscription is referred to as the "establishing request" for that subscription.

When a subscription is established it is assigned a Subscription ID value. The Subscription ID is equal to the value of the Request ID of the establishing request. (For more about Request IDs, see Section 4.8.)

A SWID-IMC MUST have the ability to record and support multiple simultaneous subscriptions from a single party and subscriptions from multiple parties. A SWID-IMV MUST have the ability to record and support multiple simultaneous subscriptions to a single party and subscriptions to multiple parties.

3.8.2 Managing Subscriptions

The SWID-IMC MUST record each accepted subscription along with the identity of the party to whom attributes are to be pushed in compliance with the subscription. If the attribute is received by the SWID-IMC using the TNC_IMC_ReceiveMessage (section 3.8.4 of IF-IMC 1.3 [8]) or TNC_IMC_ReceiveMessageSOH (section 3.8.5 of IF-IMC 1.3) functions, then only the connection ID of the SWID-IMV's PDP is available to the SWID-IMC. If the attribute is received by the SWID-IMC using the TNC_IMC_ReceiveMessageLong function (section 3.8.6 of IF-IMC) then the SWID-IMC has both the PDP's connection ID and the IMV ID of the sending SWID-IMV. SWID-IMCs SHOULD support TNC_IMC_ReceiveMessageLong function calls. SWID-IMCs MUST record the connection ID of the SWID-IMV's PDP for each accepted subscription. SWID-IMCs SHOULD record the SWID-IMV's IMV ID for each accepted subscription if this information is available.

Likewise, SWID-IMVs MUST record each accepted subscription for which they are the subscribing party along with its Subscription ID and the identity of the SWID-IMC that will be fulfilling the subscription. The SWID-IMV needs to retain this information in order to correctly interpret pushed SWID Response attributes sent in fulfillment of the subscription. As with the SWID-IMC, the SWID-IMV might only have access to the connection ID of the SWID-IMC's endpoint, or might have both this connection ID and the SWID-IMC's IMC ID depending on the supported IF-IMV functions [9]. SWID-IMVs SHOULD support TNC_IMV_ReceiveMessageLong function calls so as to be capable of receiving the SWID-IMC's IMC ID. SWID-IMVs MUST record the connection ID of the SWID-IMC's endpoint for each accepted subscription. The SWID-IMV SHOULD record the SWID-IMC's IMC ID for each accepted subscription if this information is available.

3.8.3 Terminating Subscriptions

Subscriptions MAY be terminated at any time by the subscribing SWID-IMV by setting the Clear Subscriptions flag in a SWID Request. (See Section 4.9 for more on using this flag.) In the case that the SWID-IMC receives both the connection ID and the IMV ID of the SWID-IMV requesting that subscriptions be cleared (i.e., the clear subscription request is received via a TNC_IMC_ReceiveMessageLong function) and the SWID-IMC has been recording IMV IDs associated with subscriptions when available, the SWID-IMC MUST only clear subscriptions that match both the connection ID and the IMV ID, and MUST clear all such subscriptions. In the case

that the SWID-IMC only has the connection ID of the party requesting that subscriptions be cleared or the SWID-IMC has not been recording IMV IDs associated with subscriptions even when available, it MUST only clear subscriptions that match the connection ID and that have no associated IMV ID, and MUST clear all such subscriptions.

This specification does not give the SWID-IMV the ability to terminate subscriptions individually - all subscriptions to the SWID-IMV are cleared when the Clear Subscriptions flag is set.

This specification does not give the SWID-IMC the ability to unilaterally terminate a subscription. However, if the SWID-IMC experiences a fatal error fulfilling a subscription, resulting in sending an IF-M Error attribute of type TNC_IFM_SWID_SUBSCRIPTION_FULFILLMENT_ERROR, then the subscription whose fulfillment led to the error MUST be treated as terminated by both the SWID-IMC and the SWID-IMV. Only the subscription experiencing the error is cancelled and other subscriptions are unaffected. See Section 3.10 for more on this error condition.

Finally, a subscription is terminated if the connection between the SWID-IMC and SWID-IMV is deleted, as indicated by the connection state changing to DELETE. (Described in section 3.5.2.2 of IF-IMC [8] and section 3.5.2.2 of IF-IMV [9].) Doing this renders the SWID-IMC incapable of pushing additional SWID Response attributes to the subscribing party. Both the SWID-IMC and SWID-IMV MUST delete all subscriptions for which the connection has been deleted. SWID-IMCs MUST support the TNC_IMC_NotifyConnectionChange function, as defined in IF-IMC 1.3 section 3.8.2, so that the SWID-IMC can be informed when a connection's state changes to DELETE. Likewise, a SWID-IMV MUST support the TNC_IMV_NotifyConnectionChange function, as defined in IF-IMV 1.4 section 3.8.2, for the same reason.

3.8.4 Subscription Status

A SWID-IMV can request that a SWID-IMC report the list of active subscriptions where the SWID-IMV is the subscriber. A SWID-IMV can use this to recover lost information about active subscriptions. A SWID-IMV can also use this capability to verify that a SWID-IMC has not forgotten any of its subscriptions. The latter is especially useful where a SWID-IMC does not send any attributes in fulfillment of a given subscription for a long period of time. The SWID-IMV can check the list of active subscriptions on the SWID-IMC and verify whether the inactivity is due to a lack of reportable events, or due to the SWID-IMC forgetting its obligations to fulfill a given subscription.

A SWID-IMV requests a list of its subscriptions on a given SWID-IMC by sending that SWID-IMC a Subscription Status Request. The SWID-IMC MUST then respond with a Subscription Status Response (or an IF-M Error if an error condition is experienced). The Subscription Status Response contains one subscription record for each of the active subscriptions for which the SWID-IMV is the subscribing party. Specifically, in the case that the Subscription Status Request arrives with both a connection ID and an IMV ID and the SWID-IMC has been recording IMV IDs associated with subscriptions when available, the SWID-IMC MUST include only subscription records associated with both the given connection ID and IMV ID, and MUST include all such records. In the case that the Subscription Status Request arrives with only a connection ID or the SWID-IMC has not been recording IMV IDs associated with subscriptions even when available, the SWID-IMC MUST include only subscription records associated with the given connection ID and that have no associated IMV ID, and MUST include all such records.

3.8.5 Fulfilling Subscriptions

As noted in Section 3.5 SWID-IMCs MUST have the ability to automatically detect changes to an endpoint's SWID tag collection in near real-time. For every active subscription, the SWID-IMC MUST send an attribute to the subscribed SWID-IMV whenever a change is detected to relevant tags within the endpoint's SWID tag collection. The SWID-IMC MAY choose to exclusively deliver this attribute in the case that the SWID-IMV's IMV ID is known. (See section 3.3.2.2 of IF-IMC 1.3 [8] or section 3.3.2.2 of IF-IMV 1.4 [9] for more on exclusive delivery.) Such an attribute is said to be sent "in fulfillment of" the given subscription and any such attribute include that subscription's Subscription ID. If the establishing request for that subscription was a targeted request, then only tags that match the SWID tag identifiers provided in that establishing request are considered relevant. Otherwise,

(i.e., for non-targeted requests) any tag is considered relevant for this purpose. Figure 3 shows a sample message exchange where a subscription is established and then later messages are sent from the SWID-IMC in fulfillment of the established subscription.

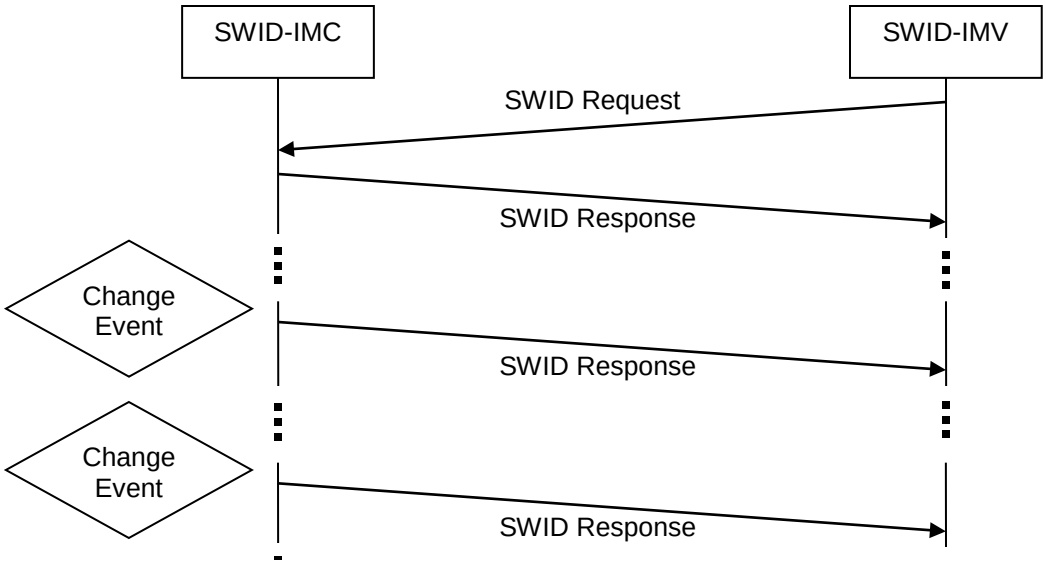


Figure 3 - Subscription Establishment and Fulfillment

The contents of an attribute sent in fulfillment of a subscription depend on the parameters provided in the establishing request for that subscription. Specifically, the contents of an attribute sent in fulfillment of a subscription have the same format as would a direct response to the establishing request. For example, if the establishing request stipulated a response that contained an event record list wherein affected SWID tags were indicated using SWID tag identifier instances, all attributes sent in fulfillment of this subscription will also consist of event record lists expressed using SWID tag identifier instances. As such, all SWID Responses displayed in the exchange depicted in Figure 3 have the same format. A SWID Response generated in fulfillment of an active subscription MUST be a valid SWID Response attribute according to all the rules outlined in the preceding sections. In other words, an attribute constructed in fulfillment of a subscription will look the same as an attribute sent in direct response to an explicit request from a SWID-IMV that had the same request parameters and which arrived immediately after the given change event. There are a few special rules that expand on this guideline:

3.8.5.1 Subscriptions Reporting Inventories

In the case that a SWID-IMV subscribes to a SWID-IMC requesting an inventory attribute whenever changes are detected (i.e. the EID in the establishing request is 0), then the SWID-IMC MUST send the requested inventory whenever a relevant change is detected. (A "relevant change" is any change for untargeted requests, or a change to an indicated SWID tag in a targeted request.) Upon detection of a relevant change for an active subscription, the SWID-IMC sends the appropriate inventory information as if it had just received the establishing request. Attributes sent in fulfillment of this subscription will probably have a large amount of redundancy, as the same tags are likely to be present in each of these SWID Attributes. The role of an inventory subscription is not to report tags just for the items that changed - that is the role of a subscription that reports events (see section 3.8.5.2). A SWID-IMC MUST NOT exclude a tag from an attribute sent in fulfillment of an inventory subscription simply because that tag was not involved in the triggering event (although the tag might be excluded for other reasons, such as if the subscription is targeted - see Section 3.8.5.3).

3.8.5.2 Subscriptions Reporting Events

The way in which a SWID-IMV indicates it wishes to establish a subscription requesting event records is by providing a non-zero EID in the SWID Request establishing the subscription (see Section 3.6.1). However, when the SWID-IMC constructs an attribute in fulfillment of the subscription (other than the direct response to the establishing request), it MUST only include event records for the detected change(s) that precipitated this response attribute. In other words, it MUST NOT send a complete list of all changes starting with the indicated EID, up through the latest change, every time a new event is detected. In effect, the EID in the establishing request is treated as being updated every time an attribute is sent in fulfillment of this subscription, such that a single event is not reported twice in fulfillment of a single subscription. As such, every SWID-IMC MUST track the EID of the last event that triggered an attribute for the given subscription. When the next event (or set of events) is detected, the SWID-IMC MUST only report events with later EIDs. In the case that the EID Epoch of the SWID-IMC changes, the SWID-IMC MUST treat EID values in the new Epoch as being after all EIDs assigned in the previous Epoch regardless of the relative numeric values of these EIDs.

Note that while a subscription is active, the subscribing SWID-IMV MAY make other requests for event records that overlap with events that are reported due to a subscription. Such requests are unaffected by the presence of the subscription, nor is the subscription affected by such requests. In other words, a given request will get the same results back whether or not there was a subscription. Likewise, an attribute sent in fulfillment of a subscription will contain the same information whether or not other requests had been received from the SWID-IMV.

A SWID-IMV needs to pay attention to the EID Epoch in these messages, as changes in the Epoch might create discontinuities in the SWID-IMV's understanding of the endpoint's SWID tag collection state, as discussed in Section 0. In particular, once the EID Epoch changes, a SWID-IMV is unable have confidence that it has a correct understanding of the state of an endpoint’s SWID tag collection until after the SWID-IMV collects a complete inventory.

SWID-IMCs MAY send partial lists of event records in fulfillment of a subscription. (See Section 3.6.4 for more on partial list of event records.) In the case that a SWID-IMC sends a partial list of event records, it MUST immediately send the next consecutive partial list, and continue doing so until it has sent the equivalent of the complete list of event records. In other words, if the SWID-IMC sends a partial list it does not wait for another change event to send another SWID Response, but continues sending SWID Responses until it has sent all event records that would have been included in a complete fulfillment of the subscription.

3.8.5.3 Targeted Subscriptions

Subscriptions MAY be targeted to only apply to tags that match a given set of tag identifiers. In the case where changes are detected that affect multiple tags, some matching the establishing request's tag identifiers and some not, the attribute sent in fulfillment of the subscription MUST only include inventory or events (as appropriate) for tags that match the establishing request's tag identifiers. The SWID-IMC MUST NOT include non-matching tags in the attribute, even if those non-matching tags experienced change events that were co-temporal with change events on the matching tags.

In addition, a SWID-IMC MUST send an attribute in fulfillment of a targeted subscription only when changes to the endpoint's SWID tag collection impact one or more tags matching the subscription's establishing request's tag identifiers. A SWID-IMC MUST NOT send any attribute in fulfillment of a targeted subscription based on detected change to the endpoint's SWID tag collection that did not involve any of the tags targeted by that subscription.

3.8.5.4 No Subscription Consolidation

A SWID-IMV MAY establish multiple subscriptions to a given SWID-IMC. If this is the case, it is possible that a single change event on the endpoint might require fulfillment by multiple subscriptions, and that the information included in attributes that fulfill each of these subscriptions might overlap. The SWID-IMC MUST send separate attributes for each established subscription that requires a response due to the given event. Each of these attributes MUST contain all information required to fulfill that individual subscription, even if that information is also sent in other attributes sent in fulfillment of other subscriptions at the same time. In other words, SWID-IMCs MUST NOT attempt

to combine information when fulfilling multiple subscriptions simultaneously, even if this results in some redundancy in the attributes sent to the SWID-IMV.

3.8.5.5 Delayed Subscription Fulfillment

A SWID-IMC MAY delay the fulfillment of a subscription following a change event in the interest of waiting to see if additional change events are forthcoming and, if so, conveying the relevant records back to the SWID-IMV in a single SWID Response attribute. This can help reduce network bandwidth consumption between the SWID-IMC and the SWID-IMV. For example, consider a situation where 10 changes occur a tenth of a second apart. If the SWID-IMC does not delay in assembling and sending SWID Response attributes, the SWID-IMV will received 10 separate SWID Response attributes over a period of 1 second. However, if the SWID-IMC waits half a second after the initial event before assembling a SWID Response, the SWID-IMV only receives two SWID Response attributes over the same period of time.

Note that the ability to consolidate events for a single subscription over a given period of time does not contradict the rules in Section 3.8.5.4 prohibiting consolidation across multiple subscriptions. When delaying fulfillment of subscriptions, SWID-IMCs are still required to fulfill each individual subscription separately. Moreover, in the case that change events within the delay window cancel each other out (e.g., a SWID tag is deleted and then re-added), the SWID-IMC MUST still report each change event rather than just reporting the net effect of changes over the delay period. In other words, delayed fulfillment can decrease the number of attributes send by the SWID-IMC, but it does not reduce the total number of change events reported.

SWID-IMCs are not required to support delayed fulfillment of subscriptions. However, in the case that the SWID-IMC does support delayed subscription fulfillment, it MUST be possible to configure the SWID-IMC to disable delayed fulfillment. In other words, parties deploying SWID-IMCs need to be allowed to disable delayed subscription fulfillment in their SWID-IMCs. The manner in which such configuration occurs is left to the discretion of implementers, although implementers MUST protect the configuration procedure from unauthorized tampering. In other words, there needs to be some assurance that unauthorized individuals are not able to introduce long delays in subscription fulfillment.

3.9 Multiple Sources of SWID Tags

As noted in section 2.1, the SWID tags in an endpoint's SWID tag collection might potentially come from multiple sources. For example, SWID tags might be deposited on the file system and collected therefrom. SWID tags might also be dynamically generated by tools such as software and package managers (e.g., RPM or YUM) or might be dynamically translated from software discovery reports expressed in some non-SWID format.

A SWID-IMC is not required to identify every possible source of SWID tags on its endpoint. Some SWID-IMCs might be explicitly tied only to one or a handful of SWID tag sources. SWID-IMCs are not required to be aware of SWID tags that come from sources other than those that they specifically support. In particular, if an endpoint has 3 sources of SWID tags, and a SWID-IMC supports collecting SWID tags from two of those sources, not only is that SWID-IMC only responsible for reporting tags that come from its two supported sources, but it is also only responsible for monitoring for change events from those two sources. This noted, for all of the SWID tag sources that a particular SWID-IMC supports, it MUST completely support all requirements of this specification with regard to its supported sources. In other words, for supported sources, the SWID-IMC is required to be capable of providing complete inventories of SWID tags; monitoring for changes in the SWID collections reported by those sources, correctly providing responses for both full and targeted requests, and providing either complete SWID tag files or SWID identifier instances as appropriate. The SWID-IMC MUST NOT provide any inventory or event information from SWID tag sources for which it cannot provide this full support.

The SWID Response attributes provide no way of distinguishing as to which SWID tags, identifier instances, or event records are associated with specific sources. The SWID-IMC MUST include the

complete set of relevant data from all supported sources of SWID tags in every SWID Response. In other words, a full inventory is required to contain all the SWID tags from all supported sources, a targeted inventory is required to contain all relevant tags from all sources, and event tracking is required to cover all events from both sources. With regard to events, a SWID-IMC's assignment of EIDs MUST reflect the presence and order of all events on the endpoint (at least for supported sources) regardless of the source. This means that if source A experiences an event, and then source B experiences two events, and then source A experiences another two events, the SWID-IMC is required to capture five events with consecutive EID values reflecting the order in which the events occur.

Note that, if a SWID-IMC collects data from multiple sources, it is possible that some software products might be "double counted". This can happen if both sources of SWID tags provide a SWID tag for a single instance of a software product. Moreover, each of these provided tags will probably have different SWID tag identifier instances, since Instance IDs are managed by the process that extracts the SWID tags from the individual sources, and such processes are under no obligation to coordinate with each other as to the Instance ID value. When a SWID-IMC reports information or records events from multiple SWID tag sources, it MUST use the information those sources provide, rather than attempting to perform some form of reduction. In other words, if multiple sources report a particular SWID tag corresponding to a single installation of a software product, all such tags from each source are required to be part of the SWID-IMC's processing even if this might lead to multiple reporting, and the SWID-IMC is not to ignore some tags to avoid such multiple reporting. Similarly, in the case that multiple sources report an event, the SWID-IMC MUST create separate event records with separate EIDs for each of these, even if there is the chance that they represent the two sources reporting the same action on the endpoint. Entities tracking SWID tags collected via SWID-IMCs and SWID-IMVs need to be aware that such double-reporting might occur. How (or if) such occurrences are detected and resolved is up to the implementers of those entities.

3.10 Error Handling

In the case where the SWID-IMC detects an error in a SWID Request attribute that it receives it MUST respond with an IF-M Error attribute with an error code appropriate to the nature of the error. (See Section 5.2.13 of the TNC IF-IM TLV Binding [4] for more details about IF-M Error attributes and error codes as well as Section 4.14 in this specification for error codes specific to SWID attributes.) In the cast that an error is detected in a SWID Request the SWID-IMC MUST NOT take any action requested by this SWID Request, even if some requested action can be completed successfully despite the error in the attribute. In other words, a SWID Request that contains an error is ignored by the SWID-IMC beyond sending an IF-M Error attribute, and possibly logging the error locally.

In the case where the SWID-IMC receives a valid SWID Request attribute but experiences an error during the process of responding to that attribute’s instructions where that error prevents the SWID-IMC from properly or completely fulfilling that request, the SWID-IMC MUST send an IF-M Error attribute with an error code appropriate to the nature of the error. In the case where an IF-M Error attribute is sent, the SWID-IMC MUST NOT take any of the actions requested by the SWID Request attribute which led to the detected error. This is the case even if some actions can be completed successfully, and might even require the SWID-IMC to reverse some successful actions already taken before the error condition was detected. In other words, either all aspects of a SWID Request complete fully and successfully (in which case the SWID-IMC sends a SWID Response attribute), or no aspects of the SWID Request occur (in which case the SWID-IMC sends an IF-M Error attribute). In the case that a SWID-IMC sends an IF-M Error attribute in response to a SWID Request then the SWID-IMC MUST NOT also send any SWID Response attribute in response to the same SWID Request. For this reason, the sending of a SWID Response attribute MUST be the last action taken by a SWID-IMC in response to a SWID Request to avoid the possibility of a processing error occurring after that SWID Response attribute is sent.

In the case that the SWID-IMC detects an error that prevents it from properly or completely fulfilling its obligations under an active subscription, the SWID-IMC MUST send an IF-M Error attribute of type TNC_IFM_SWID_SUBSCRIPTION_FULFILLMENT_ERROR to the SWID-IMV that established this

subscription. This type of IF-M Error attribute identifies the specific subscription that cannot be adequately honored due to the error condition as well as an error "sub-type". The error sub-type is used to indicate the type of error condition the SWID-IMC experienced that prevented it from honoring the given subscription. In the case that the error condition cannot be identified or does not align with any of the defined error codes, the TNC_IFM_SWID_ERROR error code SHOULD be used in the sub-type. In the case that a TNC_IFM_SWID_SUBSCRIPTION_FULFILLMENT_ERROR is sent, the associated subscription MUST be treated as cancelled by both the SWID-IMC and SWID-IMV.

The SWID-IMV MUST NOT send any IF-M Error attributes to SWID-IMCs. In the case that a SWID-IMV detects an error condition, it SHOULD log this error but does not inform any SWID-IMC's of this event. Errors might include, but are not limited to, detection of malformed SWID Response attributes sent from a given SWID-IMC, as well as detection of error conditions when the SWID-IMV processes SWID Responses.

Both SWID-IMCs and SWID-IMVs SHOULD log errors so that administrators can trace the causes of errors. Log messages SHOULD include the type of the error, the time it was detected, and additional descriptive information to aid in understanding the nature and cause of the error.

4 SWID Message and Attributes for IF-M Protocol

This section describes the format and semantics of the SWID Message and Attributes for IF-M protocol leveraging the existing SWID tag format. SWID Message and Attributes for IF-M uses the standard IF-M message header format. See the IF-M TLV Binding specification [4] for information on this header format.

4.1 IF-M Subtype (AKA IF-M Component Type)

The TNC IF-TNCCS interface provides a general message-batching protocol capable of carrying one or more IF-M messages between the TNC Client and TNC Server. When IF-TNCCS is carrying an IF-M message, the IF-TNCCS message headers contain a 32 bit identifier called the IF-M Subtype. The IF-M Subtype field indicates the type of component associated with all of the IF-M attributes carried by the IF-TNCCS message. The core set of IF-M Subtypes is defined in the IF-M TLV Binding specification. In order for the TNC protocols to carry SWID tags, this specification adds the following enumeration element to the table in section 4.4 of the IF-M TLV Binding specification [4] using the TCG Standard name space (SMI Private Enterprise Number 0x005597):

IF-M Subtype Component Type Name	TNC Standard Component Definition	Description
SWID Attributes	0x00000003	Attributes supporting the SWID Attribute binding to IF-M.

Table 1 - IF-M Subtype

Each IF-M attribute described in this specification is intended to be sent between the SWID-IMC and SWID-IMV, so will be carried in an IF-TNCCS message indicating an IF-M Subtype of SWID Attributes. Note that although the IF-M Error attribute is defined in the IF-M TLV Binding specification, when it is used in a SWID Attribute exchange, it uses the SWID Attributes Component Definition Value within the TCG Standard name space, as described in Section 5.2.13 of the IF-M TLV Binding specification [4]. IF-TNCCS messages MUST always include the SWID Attributes Subtype defined in this section when carrying SWID Attributes over IF-M.

4.2 IF-TNCCS and IF-M Messages

An IF-M message is wrapped within an IF-TNCCS message. Figure 4 shows the relationship between IF-M and IF-TNCCS messages. A single IF-M message might contain one or more IF-M attributes. All of these attributes within a single IF-M message use the same IF-M Subtype value. As such, SWID Attributes are never sent with attributes defined in other IF-M binding specifications in a single IF-M message. Note, however, that a single IF-TNCCS batch might contain multiple IF-TNCCS and IF-M messages, and each of those messages might use different IF-M Subtypes.

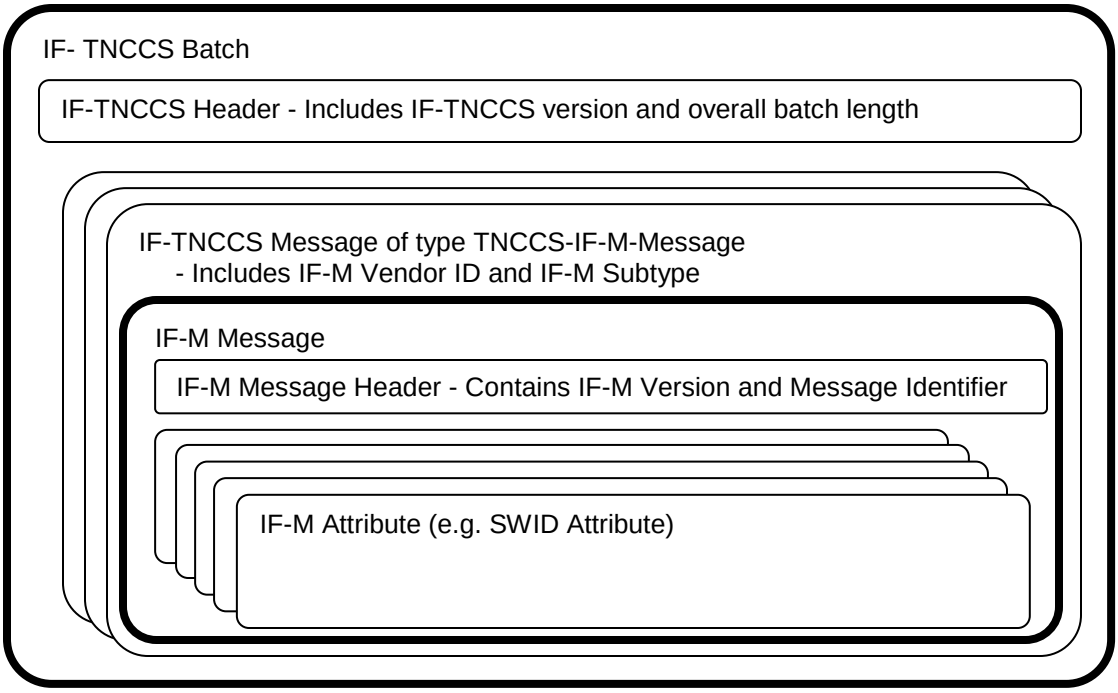


Figure 4 - Parts of an IF-TNCCS Batch

For more information on IF-TNCCS and IF-M messages and message headers, see the TNC IF-TNCCS TLV Binding [12] and TNC IF-M TLV Binding [4] specifications, respectively.

4.3 IF-M Attribute Header

The SWID Message and Attributes for IF-M protocol described in this specification is an extension of the IF-M TLV Binding protocol described in the TNC Architecture. IF-M was designed to be very flexible in order to carry many types of IF-M attributes that pertain to an enumerated set of component types (e.g. Table 1). IF-M attributes might be carried from IMC to IMV or vice versa and might carry information about endpoint state or other information to be sent between an IMC and an IMV. Therefore the SWID Message and Attributes for IF-M specification defines a collection of IF-M attributes relevant to the collection and transmission of SWID tag inventories.

Figure 5, reproduced from the IF-M TLV Binding specification, shows the format of an IF-M attribute. Multiple IF-M attributes can be sent in a single IF-TNCCS message, each housed within an attribute structure as described below.

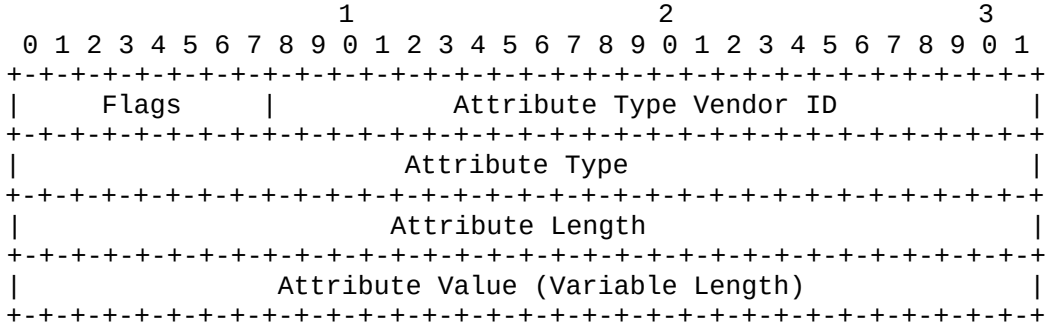


Figure 5 - IF-M Header and Attribute Format

TLV Field	Description
Flags	This field defines flags affecting the processing of the SWID Message and Attributes for IF-M. Permissible flags are given in the IF-M TLV Binding specification. [4]
Attribute Type Vendor ID	This field indicates the owner of the name space associated with the Attribute Type. Attributes defined in the SWID Message and Attributes for IF-M specification have a value corresponding to the TCG SMI Private Enterprise Number value (0x005597). The IF-M Error attribute is defined in the IF-M TLV Binding specification and the corresponding RFC 5792 [6] and thus uses the IETF SMI Private Enterprise Number Value (0x000000). See Table 3 for more information.
Attribute Type	This field defines the type of the Attribute. The values corresponding to SWID Attributes are given in Table 3.
Attribute Length	This field contains the length in octets of the entire Attribute, including the Attribute's header.
Attribute Value	This field contains the SWID Attribute.

Table 2 - Fields of the IF-M Attribute Format

4.4 SWID Attribute Overview

The attributes defined in this specification appear below with a short summary of their purposes. Each attribute is described in greater detail in subsequent sections.

- **SWID Request** - This attribute is used to request a SWID tag inventory or SWID event list from an endpoint. This attribute might also establish a subscription on the recipient SWID-IMC. A SWID-IMC MUST NOT send this attribute.
- **SWID Tag Identifier Inventory** - This attribute is used to convey an inventory expressed using SWID tag identifier instances (instead of full tags). When a SWID-IMC receives a SWID Request attribute requesting an inventory using SWID tag identifier instances, the SWID-IMC MUST send a SWID Tag Identifier Inventory attribute (or an IF-M Error) in response. This attribute also MAY be sent by the SWID-IMC in fulfillment of an active subscription. A SWID-IMV MUST NOT send this attribute.
- **SWID Tag Identifier Events** - This attribute is used to convey a list of events concerning changes to an endpoint's collection of SWID tags. Affected SWID tags are indicated using SWID tag identifier instances (instead of full tags). When a SWID-IMC receives a SWID Request attribute requesting an event collection using with SWID tag identifier instances, the SWID-IMC MUST send a SWID Tag Identifier Events attribute (or an IF-M Error) in response. This attribute also MAY be sent by the SWID-IMC in fulfillment of an active subscription. A SWID-IMV MUST NOT send this attribute.
- **SWID Tag Inventory** - This attribute is used to convey an inventory expressed using full SWID tags (instead of SWID tag identifier instances). When a SWID-IMC receives a SWID Request attribute requesting an inventory using full SWID tags, the SWID-IMC MUST send a SWID Tag Inventory attribute (or an IF-M Error) in response. This attribute also MAY be sent by the SWID-IMC in fulfillment of an active subscription. A SWID-IMV MUST NOT send this attribute.
- **SWID Tag Events** - This attribute is used to convey a list of events concerning changes to an endpoint's collection of SWID tags. Affected SWID tags are indicated using full SWID tags (instead of SWID tag identifier instances). When a SWID-IMC receives a SWID Request attribute requesting an event collection using full SWID tags, the SWID-IMC MUST send a SWID Tag Events attribute (or an IF-M Error) in response. This attribute also MAY be sent by the SWID-IMC in fulfillment of an active subscription. A SWID-IMV MUST NOT send this attribute.

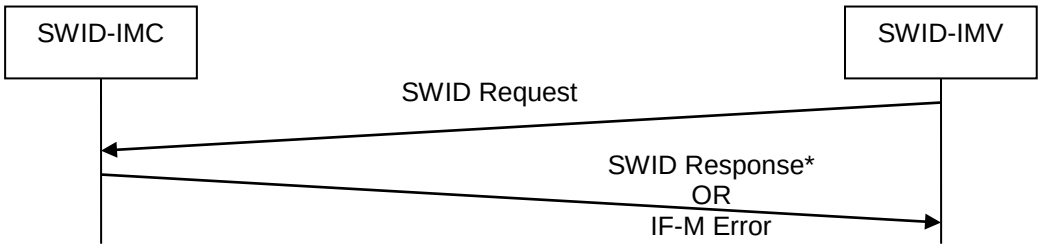
- **Subscription Status Request** - This attribute is used to request a SWID-IMC send a summary of all the active subscriptions it has where the requesting party is the subscriber. The SWID-IMC MUST respond with a Subscription Status Response (or an IF-M Error). A SWID-IMC MUST NOT send this attribute.
- **Subscription Status Response** - This attribute is used to convey information about the active subscriptions that a SWID-IMC has for a given subscriber. A SWID-IMV MUST NOT send this attribute.
- **IF-M Error** - This is the standard IF-M Error attribute as defined in the IF-M TLV Binding [4] and is used to indicate that an error was encountered during a SWID Attribute exchange. It MUST be sent by a SWID-IMC in response to a SWID Request in the case where the SWID-IMC encounters a fatal error (i.e., an error that prevents further processing of an exchange) relating to the attribute exchange. A SWID-IMV MUST NOT send this attribute. The SWID-IMC MUST then ignore the erroneous attribute after an IF-M Error attribute is sent (i.e., do not attempt to act on an attribute that generated an IF-M Error beyond sending the IF-M Error). In the case where the SWID-IMV experiences a fatal error, it MUST ignore the erroneous attribute without sending an IF-M Error attribute. It MAY take other actions in response to the error, such as logging the cause of the error, or even taking actions to isolate the endpoint.

Because one of the SWID Tag Identifier Inventory, SWID Tag Identifier Events, SWID Tag Inventory, or SWID Tag Events attributes is expected to be sent to a SWID-IMV in direct response to a SWID Request attribute or in fulfillment of an active subscription, those four attribute types are frequently referred to collectively in this document as "SWID Response" attributes.

All SWID-IMVs MUST be capable of sending SWID Requests and be capable of receiving and processing all SWID Response attributes as well as IF-M Error attributes. All SWID-IMCs MUST be capable of receiving and processing SWID Requests and be capable of sending all types of SWID Response attributes as well as IF-M Error attributes. In other words, both SWID-IMVs and SWID-IMCs are required to support their role in exchanges using any of the attribute types defined in this section. SWID-IMVs MUST ignore any SWID Request attributes that they receive. SWID-IMCs MUST ignore any SWID Response attributes or IF-M Error attributes that they receive.

4.5 SWID Attribute Exchanges

A SWID Attribute Exchange is used to provide the SWID-IMV with a SWID tag inventory or event collection from the queried endpoint.



*A SWID Response will be one of the following, as dictated by the parameters of the SWID Request attribute: SWID Tag Identifier Inventory, SWID Tag Identifier Events, SWID Tag Inventory, or SWID Tag Events.

Figure 6 - SWID Attribute Exchange (Direct Response to SWID Request)

In this exchange, the SWID-IMV indicates to the SWID-IMC, via a SWID Request, the nature of the information it wishes to receive (inventory vs. events, full or targeted) and how it wishes the returned inventory to be expressed (full tags or tag identifier instances). The SWID-IMC responds with the

requested information using the appropriate attribute type. A single SWID Request MUST only lead to a single SWID Response or IF-M Error that is in direct response to that request.

In addition, if there is an active subscription on the endpoint, the SWID-IMC sends a SWID Response to the SWID-IMV following a change event on the endpoint in fulfillment of that subscription. Such an exchange is shown in Figure 7.

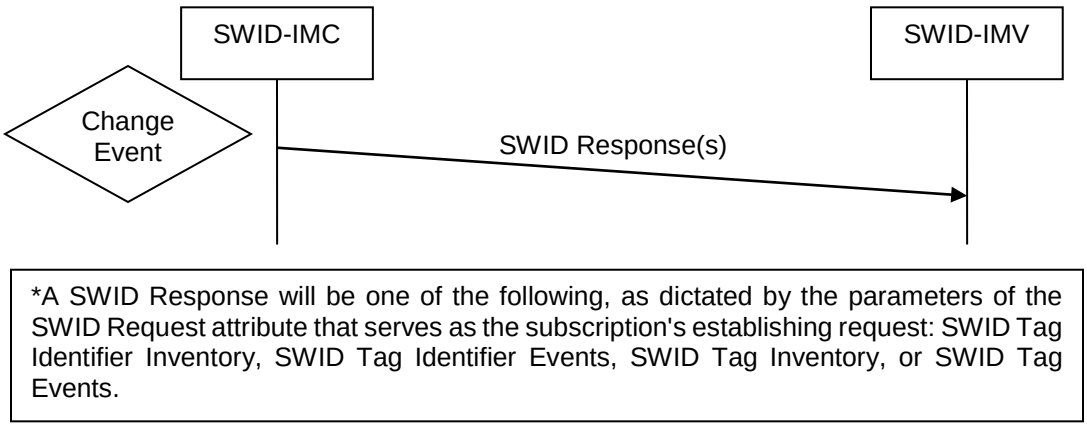


Figure 7 - SWID Attribute Exchange (In Fulfillment of an Active Subscription)

Note that, unlike direct responses to a SWID Request, a single change event can precipitate multiple SWID Responses, but only if all but the last of those SWID Responses convey partial lists of event records, and the last of those SWID Responses conveys a complete list of event records. (That is, the initial responses are partial lists and the last response is the remainder of the relevant event records, completing the delivery of all relevant events at the time of the change event.) A single Change Event MUST NOT be followed by multiple SWID Response or IF-M Error attributes in any combination except as noted earlier in this paragraph.

All SWID-IMVs and SWID-IMCs MUST support both exchanges. In particular, SWID-IMCs MUST be capable of pushing a SWID Response to a SWID-IMV immediately upon detection of a change to the endpoint's SWID tag collection in fulfillment of established SWID-IMV subscriptions, as described in Section 3.8.

4.6 SWID Message and Attributes for IF-M Attribute Enumeration

IF-M attribute types are identified in the IF-M Attribute Header (see Section 4.2) via the Attribute Type Vendor ID and Attribute Type fields. Table 3 identifies the appropriate values for these fields for each attribute type used within the SWID Message and Attributes for IF-M protocol.

Attribute Name	Attribute Type Vendor ID	Attribute Type	Description
SWID Request	0x005597	0x00000011	Request from a SWID-IMV to a SWID-IMC for the SWID-IMC to provide a SWID tag inventory or event list
SWID Tag Identifier Inventory	0x005597	0x00000012	A collection of SWID tag identifier instances sent from a SWID-IMC.
SWID Tag Identifier Events	0x005597	0x00000013	A collection of events impacting the endpoint's SWID tag collection, where impacted SWID tags are indicated using SWID tag identifier instances.
SWID Tag Inventory	0x005597	0x00000014	A collection of SWID tags sent from a SWID-IMC.

SWID Tag Events	0x005597	0x00000015	A collection of events impacting the endpoint's SWID tag collection, where impacted SWID tags are indicated using full SWID tags.
Subscription Status Request	0x005597	0x00000016	A request for a list of a SWID-IMV's active subscription.
Subscription Status Response	0x005597	0x00000017	A list of a SWID-IMV's active subscriptions.
Reserved	0x005597	0x00000018 - 0x0000001F	These attribute types are reserved for future use in revisions to SWID Message and Attributes for IF-M.
IF-M Error	0x000000	0x00000008	An error attribute as defined in the IF-M TLV Binding and corresponding RFC 5792.

Table 3 - SWID Attribute Enumeration

4.7 Normalization of Text Encoding

SWID tags do not have a required encoding format. The 2009 ISO SWID specification states that "For encoding purposes, the use of utf-8 is the suggested methodology for software identification tags...", but leaves implementers free to use different encodings if this makes sense in their local environment. As such, implementers of the SWID Message and Attributes for IF-M specification cannot assume any specific encoding of SWID tag fields (although, in most current examples of SWID tags, SWID tag creators have followed the suggestion of using UTF-8 encodings). Similarly, sometimes the SWID Message and Attributes for IF-M specification requires the use of data taken from other sources, such a path from the endpoint's file system, and different platforms might use different encodings for this information. In order to ensure the ability to consistently and reliably compare information sent using the SWID Message and Attributes for IF-M exchange, certain field values (identified explicitly in the attribute definitions in the following sections) are required to undergo normalization prior to their inclusion in an attribute.

In order to ensure consistency of transmitted attributes, a field requiring normalization, as indicated in its description, and only such fields MUST be normalized to Network Unicode format as defined in RFC 5198 [7]. Network Unicode format defines a refinement of UTF-8 that ensures a normalized expression of characters. SWID-IMCs and SWID-IMVs MUST NOT perform conversion and normalization on any field values except those specifically identified in the following sections.

4.8 Request IDs

All SWID Request attributes MUST include a Request ID value. The Request ID field provides a value that identifies a given request relative to other requests between a SWID-IMV and the receiving SWID-IMC. Specifically, the SWID-IMV assigns each SWID Request attribute a Request ID value that is intended to be unique within the lifetime of a given network connection ID as assigned by the SWID-IMV's TNCS (as described in section 3.5.2.2 of the IF-IMV specification [9]). In the case where all possible Request ID values have been exhausted within the lifetime of a single network connection ID, the sender MAY reuse previously used Request IDs within the same network connection that are not being used as Subscription IDs. (See below in this section for an explanation of Subscription ID assignment.) In this case of Request ID reuse, Request IDs SHOULD be reused in the order of their original use. For example, if a Request ID of X was the first Request ID used within a particular network connection and if the Request IDs are exhausted, X will be the first reused Request ID. In other words, a SWID-IMC SHOULD NOT use a given Request ID value more than once within a persistent connection between a given TNCC-TNCS pair, but, in the case where reuse is necessary due to exhaustion of possible ID values, the SWID-IMC SHOULD structure the reuse to maximize the time between original and subsequent use. The Request ID value is included in a response

attribute directly responding to this SWID Request to indicate which SWID Request was received and caused the response. Request IDs can be randomly generated or sequential, as long as values are not repeated per the rules in this paragraph. SWID-IMCs are not required to check for duplicate Request IDs.

In the case that a SWID Request requests the establishment of a subscription and the receiving SWID-IMC agrees to that subscription, the Request ID of that SWID Request (i.e., the establishing request of the subscription) becomes that subscription's Subscription ID. All attributes sent in fulfillment of this subscription include a flag indicating that the attribute fulfills a subscription and the subscription's Subscription ID. A SWID-IMV MUST NOT reuse a Request ID value in communicating to a given SWID-IMC while that Request ID is also serving as a Subscription ID for an active subscription with that SWID-IMC. In the case where a SWID-IMC receives a SWID Request from a given SWID-IMV where that Request ID is also the Subscription ID of an active subscription with that SWID-IMV, the SWID-IMC MUST respond with an IF-M Error attribute with an error code of TNC_IFM_SWID_SUBSCRIPTION_ID_REUSE_ERROR. Note that this error does not cancel the indicated subscription.

Subscription Status Requests and Subscription Status Responses do not include Request IDs.

4.9 SWID Request

A SWID-IMV sends this attribute to a SWID-IMC to request that the SWID-IMC send SWID tag-based information to the SWID-IMV. A SWID-IMC MUST NOT send this attribute.

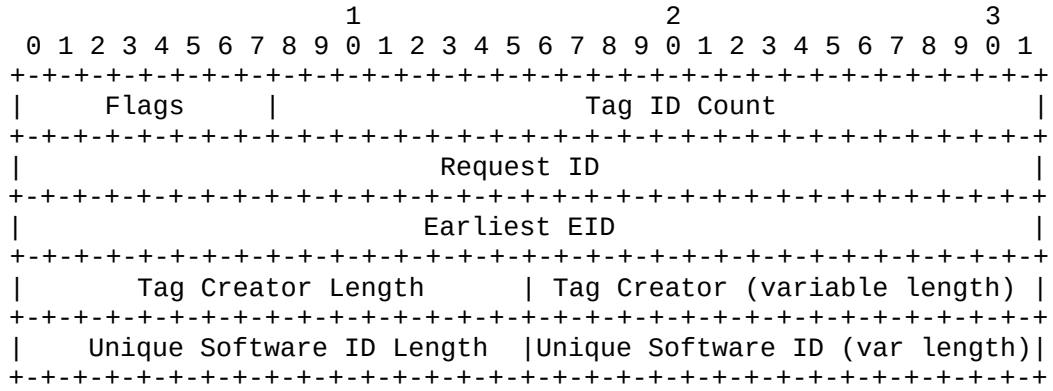


Figure 8 - SWID Request Attribute

<table>
<tr><th>Field</th><th>Description</th></tr>
<tr><td>Flags</td><td>
<table>
<tr><th>Bit Encoding</th><th>Description</th></tr>
<tr><td>Bit 0 - Clear Subscriptions</td><td>If set (1), the SWID-IMC MUST delete all subscriptions established by the requesting SWID-IMV (barring any errors).</td></tr>
<tr><td>Bit 1 - Subscribe</td><td>If set (1), in addition to responding to the request as described, the SWID-IMC MUST establish a subscription with parameters matching those in the request attribute (barring any errors).</td></tr>
<tr><td>Bit 2 - Result Type</td><td>If unset (0), the SWID-IMC's response MUST consist of complete SWID tags and thus the response MUST be a SWID Tag Inventory, a SWID Tag Events, or an IF-M Error attribute. If set (1), the response MUST consist of SWID tag identifier instances and thus the response MUST be a SWID Tag Identifier Inventory, a SWID Tag Identifier Events, or an IF-M Error attribute.</td></tr>
<tr><td>Bit 3-7 - Reserved</td><td>Reserved for future use. This field MUST be set to zero on transmission and ignored upon reception.</td></tr>
</table>
</td></tr>
<tr><td>Tag ID Count</td><td>A 3-byte unsigned integer indicating the number of tag identifiers that follow. If this value is non-zero, this is a targeted request, as described in Section 3.4. This field is a 3-byte unsigned integer. The Tag Creator Length, Tag Creator, Unique Software ID Length, and Unique Software ID fields are repeated, in order, the number of times indicated in this field. In the case where tag identifiers are present, the SWID-IMC MUST only respond with SWID tags or tag identifier instances that correspond to the identifiers the SWID-IMV provided in this attribute (or with an IF-M Error attribute).

This field value MAY be 0, in which case there are no instances of the Tag Creator Length, Tag Creator, Unique Software ID Length, and Unique Software ID fields. In this case, the SWID-IMV is indicating an interest in all SWID tags on the endpoint (i.e., this is not a targeted request).</td></tr>
<tr><td>Request ID</td><td>A value that uniquely identifies this SWID Request from a particular SWID-IMV.</td></tr>
<tr><td>Earliest EID</td><td>In the case where the SWID-IMV is requesting SWID events, this field contains the EID value of the earliest event the SWID-IMV wishes to have reported. (Note - the report will be inclusive of the event with this EID value.) In the case where the SWID-IMV is requesting an inventory, then this field MUST be 0. (0x00000000) In the case where this field is non-zero, the SWID-IMV is requesting events and the SWID-IMC MUST respond using a SWID Tag Events, SWID Tag Identifier Events, or an IF-M Error attribute. In the case where this field is zero, the SWID-IMV is requesting an inventory and the SWID-IMC MUST respond using a SWID Tag Inventory, a SWID Tag Identifier Inventory, or an IF-M Error attribute.</td></tr>
<tr><td>Tag Creator Length</td><td>A 2-byte unsigned integer indicating the length in bytes of the Tag Creator field.</td></tr>
<tr><td>Tag Creator</td><td>A string containing the Tag Creator RegID value from within a SWID tag. This field value MUST be normalized to Network Unicode format, as described in Section 4.7. This string MUST NOT be NULL terminated.</td></tr>
</table>

Unique Software ID Length	A 2-byte unsigned integer indicating the length in bytes of the Unique Software ID field.
Unique Software ID	A string containing the Unique ID value from within a SWID tag. This field value MUST be normalized to Network Unicode format, as described in Section 4.7. This string MUST NOT be NULL terminated.

Table 4 - SWID Request Attribute Fields

The SWID-IMV sends the SWID Request attribute to a SWID-IMC to request the indicated information. Note that between the Result Type flag and the Earliest EID field, the SWID-IMC is constrained to a single possible SWID Response attribute type (or an IF-M Error attribute) in its response to the request.

The Subscribe and Clear Subscription flags are used to manage subscriptions for the requesting SWID-IMV on the receiving SWID-IMC. Specifically, an attribute with the Subscribe flag set seeks to establish a new subscription by the requesting SWID-IMV to the given SWID-IMC, while an attribute with the Clear Subscription flag seeks to delete all existing subscriptions by the requesting SWID-IMV on the given SWID-IMC. Note that, in the latter case, only the subscriptions associated with the Connection ID and, if available, the IMV ID of the requester are deleted as described in section 3.8.3. A newly established subscription has the parameters outlined in the Request attribute. Specifically, the Result Type flag indicates the type of result to send in fulfillment of the subscription, the value of the Earliest EID field indicates whether the fulfillment attributes list inventories or events, and the fields describing tag identifiers (if present) indicate if and how a subscription is targeted. In the case that the SWID-IMC is unable or unwilling to comply with the SWID-IMV's request to establish or clear subscriptions, the SWID-IMC MUST respond with an IF-M Error attribute with the TNC_IFM_SWID_SUBSCRIPTION_DENIED_ERROR error code. (Note that if the SWID-IMV requests that subscriptions be cleared but has no existing subscriptions, this is not an error.)

An attribute requesting the establishment of a subscription is effectively doing double-duty, as it is a request for an immediate response from the SWID-IMC in addition to setting up the subscription. A SWID-IMC MUST send an appropriate response attribute to a request with the Subscribe flag set containing all requested information. The same is true of the Clear Subscription flag - the SWID-IMC MUST generate a response attribute without regard to the presence of this flag in addition to clearing its subscription list.

Both the Subscribe and Clear Subscription flags MAY be set in a single SWID Request attribute. In the case where this request is successful, the end result MUST be equivalent to the SWID-IMC clearing its subscription list for the given SWID-IMV first and then creating a new subscription in accordance with the request parameters. (In other words, do not first create the new subscription and then clear all the subscriptions including the one that was just created.) In the case that the requested actions are successfully completed, the SWID-IMC MUST respond with a SWID Response attribute. (The specific type of SWID Response attribute depends on the Result Type and Earliest EID fields, as described above.) In the case where there is a failure that prevents some part this request from completing, the SWID-IMC MUST NOT add a new subscription, MUST NOT clear the old subscriptions, and the SWID-IMC MUST respond with an IF-M Error attribute. In other words, the SWID-IMC MUST NOT partially succeed at implementing such a request; either both actions succeed, or neither succeed.

The Earliest EID field is used to indicate whether the SWID-IMV is requesting an inventory or event list from the SWID-IMC. A value of 0 (0x00000000) represents a request for inventory information. Otherwise, the SWID-IMV is requesting event information. For Earliest EID values other than 0, the SWID-IMC's response MUST respond with event records, as described in section 3.6. Note that the request does not identify a particular EID Epoch, since responses can only include events in the SWID-IMC's current EID Epoch.

The Tag ID Count indicates the number of tag identifiers in the attribute. This number might be any value between 0 and 16,777,216, inclusive. A single tag identifier is represented by four fields: Tag Creator Length, Tag Creator, Unique Software ID Length, and Unique Software ID. The two length

fields are used to indicate the number of bytes allocated to their corresponding string field. The two string fields, Tag Creator and Unique Software ID, contain copies of the SWID tag's Tag Creator RegID and Unique ID values, respectively, converted and normalized to Network Unicode format, as described in Section 4.7. Note that there is no field to indicate a particular Instance ID. Thus, targeted requests request all instances of the indicated SWID tags. The presence of one or more tag identifiers is used by the SWID-IMV to indicate a targeted request, which seeks only inventories of or events affecting SWID tags corresponding to the given identifiers. The SWID-IMC MUST only respond with tags that match the tag identifier structures provided in the SWID-IMVs SWID Request attribute (as described in Section 3.3.3) and MUST include all instances of matching tags in its response.

4.10 SWID Tag Identifier Inventory

A SWID-IMC sends this attribute to a SWID-IMV to convey a list of the endpoint's SWID tags expressed using SWID tag identifier instances. This list might represent a complete inventory or a targeted list of tags, depending on the parameters in the SWID-IMV's request. A SWID-IMV MUST NOT send this attribute. The SWID-IMC either sends this attribute in fulfillment of an existing subscription where the establishing request has a Result Type of 1 and the Earliest EID is zero, or in direct response to a SWID Request attribute where the Result Type is 1 and the Earliest EID is zero.

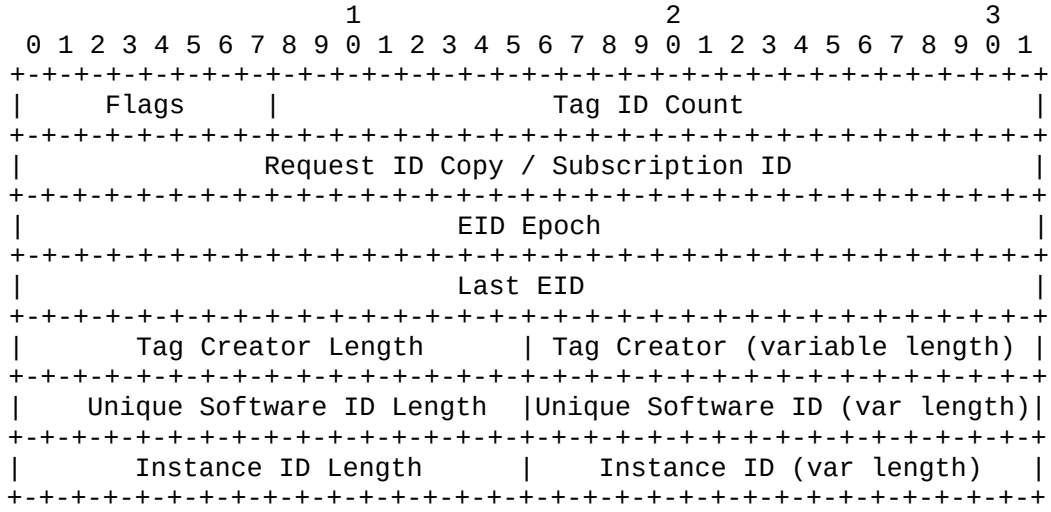


Figure 9 - SWID Tag Identifier Inventory Attribute

Field	Description
Flags	**Bit Encoding** / **Description** Bit 0 - Subscription Fulfillment: In this case that this attribute is sent in fulfillment of a subscription this bit MUST be set (1). In the case that this attribute is a direct response to a SWID Request, this bit MUST be unset (0). Bit 1-7 - Reserved: Reserved for future use. This field MUST be set to zero on transmission and ignored upon reception.
Tag ID Count	The number of tag identifier instances that follow. This field is an unsigned integer. The Tag Creator Length, Tag Creator, Unique Software ID Length, Unique Software ID, Instance ID Length, and Instance ID fields are repeated, in order, the number of times indicated in this field. This field value MAY be 0, in which case there are no instances of these fields.

Request ID Copy / Subscription ID	In the case where this attribute is in direct response to a SWID Request attribute from a SWID-IMV, this field MUST contain an exact copy of the Request ID field from that SWID Request. In the case where this attribute is sent in fulfillment of an active subscription, this field MUST contain the Subscription ID of the subscription being fulfilled by this attribute.
EID Epoch	The EID Epoch of the Last EID value. This field is an unsigned 4-byte integer.
Last EID	The EID of the last event recorded by the SWID-IMC, or 0 if the SWID-IMC has no recorded events. This field is an unsigned 4-byte integer.
Tag Creator Length	A 2-byte unsigned integer indicating the length in bytes of the Tag Creator field.
Tag Creator	A string containing the Tag Creator RegID value from within a SWID tag. This field value MUST be normalized to Network Unicode format, as described in Section 4.7.This string MUST NOT be NULL terminated.
Unique Software ID Length	A 2-byte unsigned integer indicating the length in bytes of the Unique Software ID field.
Unique Software ID	A string containing the Unique ID value from within a SWID tag. This field value MUST be normalized to Network Unicode format, as described in Section 4.7. This string MUST NOT be NULL terminated.
Instance ID Length	A 2-byte unsigned integer indicating the length in bytes of the Instance ID field.
Instance ID	A string containing the Instance ID of a given tag instance. The exact value of this field depends on the party that provides this SWID tag. This field value MUST be normalized to Network Unicode format, as described in Section 4.7. This string MUST NOT be NULL terminated.

Table 5 - SWID Tag Identifier Inventory Attribute Fields

In the case that this attribute is sent in fulfillment of a subscription, the Subscription Fulfillment bit MUST be set (1). In the case that this attribute is sent in direct response to a SWID Request, the Subscription Fulfillment bit MUST be unset (0). Note that the SWID response attribute sent in direct response to a SWID Request that establishes a subscription (i.e., a subscription's establishing request) MUST be treated as a direct response to that SWID Request (and thus the Subscription Fulfillment bit is unset). SWID Response attributes are only treated as being in fulfillment of a subscription (i.e., Subscription Fulfillment bit set) if they are sent following a change event, as shown in Figure 3.

The Tag ID Count field indicates the number of tag identifier instances present in this inventory. Each tag identifier instance is represented by a set of six fields: Tag Creator Length, Tag Creator, Unique Software ID Length, Unique Software ID, Instance ID Length, and Instance ID. These six fields, collectively referred to as the "Tag ID Fields", will appear once for each reported tag instance. Note that an endpoint's SWID tag collection might contain multiple instances of a single tag (i.e., multiple tag files with the same tag identifier value). When this occurs, in the case where that tag is reported, then the response MUST contain a set of Tag ID Fields for each instance of that tag. (The tag might not be reported if the SWID-IMV made a targeted request that does not match that tag's tag identifier.) For example, if an endpoint has three copies of tag X, and the SWID-IMV requests a full inventory, then the response is required to include three sets of Tag ID Fields corresponding to the three instances of that tag. Only the Instance ID fields are different between these three instances.

When responding directly to a SWID Request attribute, the Request ID Copy / Subscription ID field MUST contain an exact copy of the Request ID field from that SWID Request. When this attribute is

sent in fulfillment of an existing subscription on this IMC, then this field MUST contain the Subscription ID of the fulfilled subscription.

The EID Epoch field indicates the EID Epoch of the Last EID value. The Last EID field MUST contain the EID of the last recorded change event (see section 3.6 for more about EIDs and recorded events) at the time this inventory was collected. In the case where there are no recorded change events at the time that this inventory was collected, this field MUST contain 0. These fields can be interpreted to indicate that the provided inventory (be it full or targeted) reflects the record of events on the endpoint after all changes up to and including this last event have been accounted for.

4.11 SWID Tag Identifier Events

A SWID-IMC sends this attribute to a SWID-IMV to convey events where the affected SWID tags are expressed using SWID tag identifier instances. A SWID-IMV MUST NOT send this attribute. The SWID-IMC either sends this attribute in fulfillment of an existing subscription where the establishing request has a Result Type is 1 and the Earliest EID is non-zero, or in direct response to a SWID Request attribute where the Result Type is 1 and the Earliest EID is non-zero.

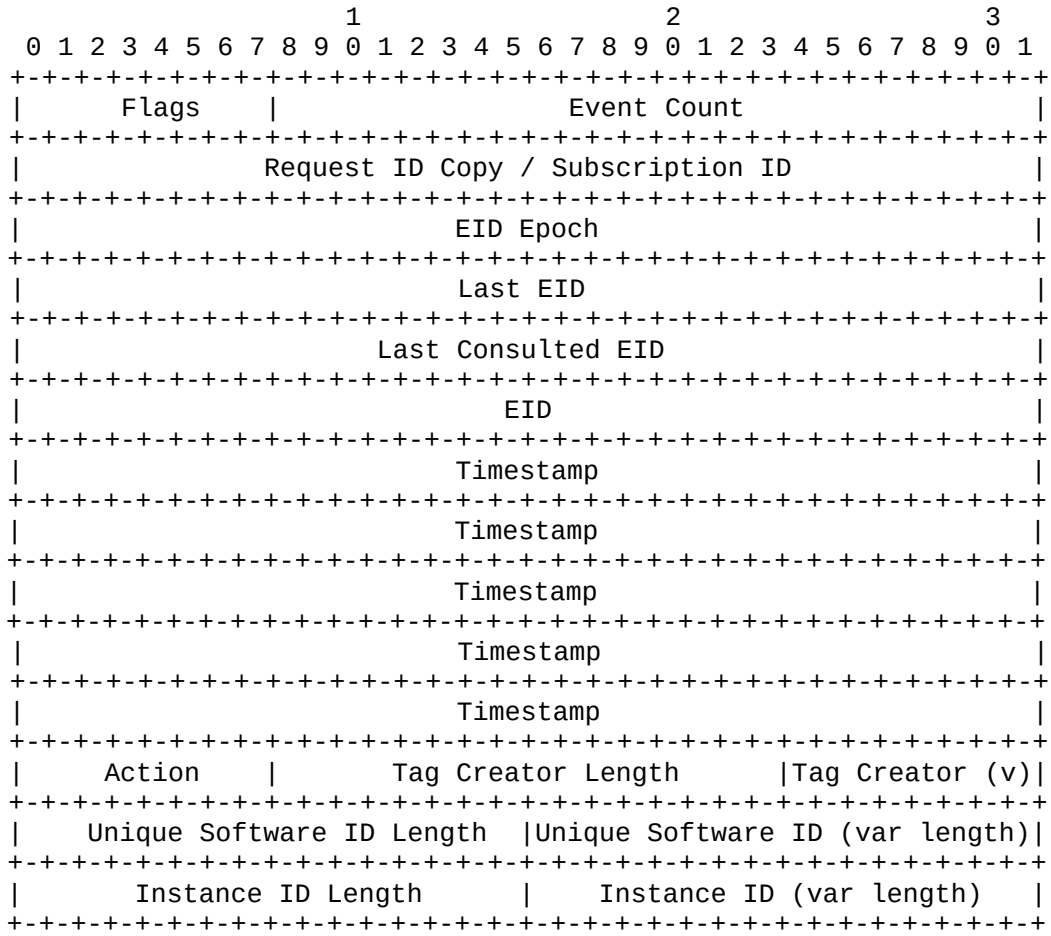


Figure 10 - SWID Tag Identifier Events Attribute

<table>
<tr><th>Field</th><th>Description</th></tr>
<tr><td>Flags</td><td>
<table>
<tr><th>Bit Encoding</th><th>Description</th></tr>
<tr><td>Bit 0 - Subscription Fulfillment</td><td>In this case that this attribute is sent in fulfillment of a subscription this bit MUST be set (1). In the case that this attribute is a direct response to a SWID Request, this bit MUST be unset (0).</td></tr>
<tr><td>Bit 1-7 - Reserved</td><td>Reserved for future use. This field MUST be set to zero on transmission and ignored upon reception.</td></tr>
</table>
</td></tr>
<tr><td>Event Count</td><td>The number of events that are reported in this attribute. This field is a 3-byte unsigned integer. The EID, Timestamp, Action, Tag Creator Length, Tag Creator, Unique Software ID Length, Unique Software ID, Instance ID Length, and Instance ID fields are repeated, in order, the number of times indicated in this field. (An instance of these nine fields is referred to as an "event record" in this attribute. Thus the Event Count field indicates the number of event records.) This field value MAY be 0, in which case there are no instances of these fields.</td></tr>
<tr><td>Request ID Copy / Subscription ID</td><td>In the case where this attribute is in direct response to a SWID Request attribute from a SWID-IMV, this field MUST contain an exact copy of the Request ID field from that SWID Request.

In the case where this attribute is sent in fulfillment of an active subscription, this field MUST contain the Subscription ID of the subscription being fulfilled by this attribute.</td></tr>
<tr><td>EID Epoch</td><td>The EID Epoch of the Last EID value and the EIDs of all reported event records. This field is an unsigned 4-byte integer.</td></tr>
<tr><td>Last EID</td><td>The EID of the last event recorded by the SWID-IMC, or 0 in the case where the SWID-IMC has no recorded events. This field contains the EID of the SWID-IMC's last recorded change event (which might or might not be included as an event record in this attribute).</td></tr>
<tr><td>Last Consulted EID</td><td>The EID of the last event record that was consulted when generating the event record list included in this attribute. This is different from the Last EID field value if and only if this attribute is conveying a partial list of event records. See Section 3.6.4 for more on partial list of event records.</td></tr>
<tr><td>EID</td><td>The EID of the event in this event record.</td></tr>
<tr><td>Timestamp</td><td>The timestamp associated with the event in this event record. This timestamps is the SWID-IMC’s best understanding of when the given event occurred. Note that this timestamp might be an estimate.

The Timestamp date and time MUST be represented as an RFC 3339 [5] compliant ASCII string in Coordinated Universal Time (UTC) time with the additional restrictions that the ‘T’ delimiter and the ‘Z’ suffix MUST be capitalized and fractional seconds (time-secfrac) MUST NOT be included. This field conforms to the date-time ABNF production from section 5.6 of RFC 3339 with the above restrictions. Leap seconds are permitted and SWID-IMVs MUST support them.

The Timestamp string MUST NOT be NULL terminated or padded in any way. The length of this field is always 20 octets.</td></tr>
</table>

<table>
<tr><td>Action</td><td>The type of event that is recorded in this event record. Possible values are:
<table><tr><th>Value</th><th>Meaning</th></tr><tr><td>1</td><td>CREATION - The addition of a tag to the endpoint's SWID tag collection</td></tr><tr><td>2</td><td>DELETION - The removal of a tag from the endpoint's SWID tag collection</td></tr><tr><td>3</td><td>ALTERATION - There was an alteration to a tag file within the endpoint's SWID tag collection.</td></tr></table>
All other values are reserved for future use and MUST NOT be used when sending attributes. In the case where a SWID-IMV receives an event record that uses an action value other than the ones defined here, it MUST ignore that event record but SHOULD process other event records in this attribute as normal.</td></tr>
<tr><td>Tag Creator Length</td><td>A 2-byte unsigned integer indicating the length in bytes of the Tag Creator field of the tag affected by the described event.</td></tr>
<tr><td>Tag Creator</td><td>A string containing the Tag Creator RegID value from within the SWID tag affected by the described event. This field value MUST be normalized to Network Unicode format, as described in Section 4.7. This string MUST NOT be NULL terminated.</td></tr>
<tr><td>Unique Software ID Length</td><td>A 2-byte unsigned integer indicating the length in bytes of the Unique Software ID field of the tag affected by the described event.</td></tr>
<tr><td>Unique Software ID</td><td>A string containing the Unique ID value from within the SWID tag affected by the described event. This field value MUST be normalized to Network Unicode format, as described in Section 4.7. This string MUST NOT be NULL terminated.</td></tr>
<tr><td>Instance ID Length</td><td>A 2-byte unsigned integer indicating the length in bytes of the Instance ID field.</td></tr>
<tr><td>Instance ID</td><td>A string containing the Instance ID of a given tag instance. The exact value of this field depends on the party that provides this SWID tag. This field value MUST be normalized to Network Unicode format, as described in Section 4.7. This string MUST NOT be NULL terminated.</td></tr>
</table>

Table 6 - SWID Tag Identifier Events Attribute Fields

The first few fields in the SWID Tag Identifier Events attribute mirror those in the SWID Tag Identifier Inventory attribute. The primary difference is that, instead of conveying an inventory using tag identifier instances, the attribute conveys zero or more event records, including the EID, timestamp, action type, and tag identifier instance of the affected tag.

With regard to the Timestamp field, it is important to note that clock skew between the SWID-IMC and SWID-IMV as well as between different SWID-IMCs within an enterprise might make correlation of timestamp values difficult. This specification does not attempt to resolve clock skew issues, although other mechanisms outside of this specification do exist to reduce the impact of clock skew and make the timestamp more useful for such correlation. Instead, SWID Message and Attributes for IF-M uses Timestamp value primarily as a means to indicate the amount of time between two events on a single endpoint. For example, by taking the difference of the times for when a SWID tag was removed and then subsequently re-added, one can get an indication as to how long the system was without the given tag (and, thus without the associated software). Since this will involve comparison of timestamp values all originating on the same system, clock skew between the SWID-IMC and

SWID-IMV is not an issue. However, if the SWID-IMC's clock was adjusted between two recorded events, it is possible for such a calculation to lead to incorrect understandings of the temporal distance between events. Users of this field need to be aware of the possibility for such occurrences. In the case where the Timestamp values of two events appear to contradict the EID ordering of those events (i.e., the later EID has an earlier timestamp) the recipient MUST treat the EID ordering as correct.

All event records in a Tag Identifier Events Attribute are required to be part of the same EID Epoch. Specifically, all reported events MUST have an EID from the same EID Epoch as each other, and which is the same as the EID Epoch of the Last EID and Last Consulted EID values. The SWID-IMC MUST NOT report events with EIDs from different EID Epochs.

The Last Consulted EID field contains the EID of the last event record considered for inclusion in this attribute. If this attribute contains a partial event set (as described in Section 3.6.4) this field value will differ from that of the Last EID field; if this attribute contains a complete event set, the Last EID and Last Consulted EID values are identical.

If multiple events are sent in a SWID Tag Identifier Events attribute, the order in which they appear within the attribute is not significant. The EIDs associated with them are used for ordering the indicated events appropriately. Also note that a single tag identifier instance might appear multiple times in an attribute, such as if multiple events involving the associated tag were being reported.

4.12 SWID Tag Inventory

A SWID-IMC sends this attribute to a SWID-IMV to convey a list of SWID tags. A SWID-IMV MUST NOT send this attribute. The SWID-IMC either sends this attribute in fulfillment of an existing subscription where the establishing request had a Result Type of 0 and the Earliest EID is zero, or in direct response to a SWID Request attribute where the Result Type is 0 and the Earliest EID is zero.

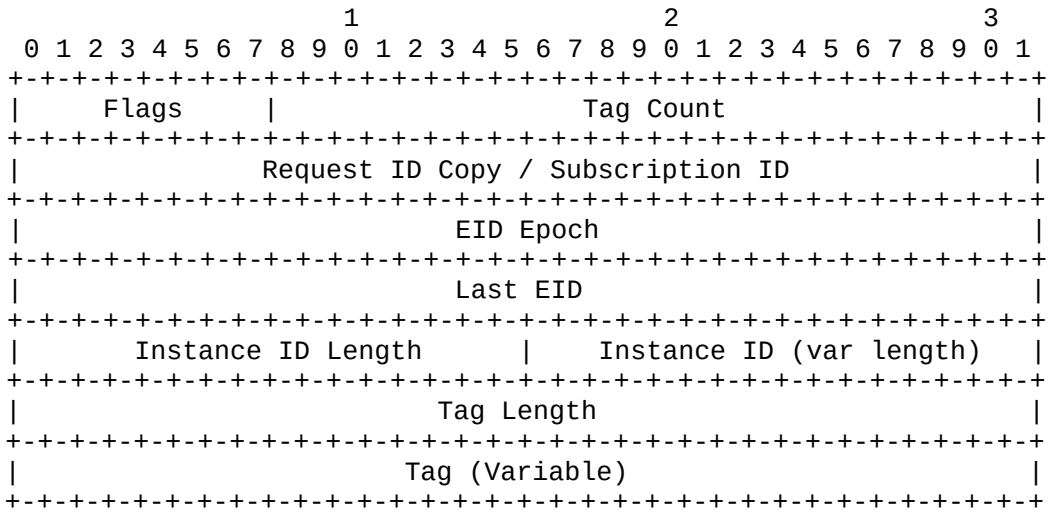


Figure 11 - SWID Tag Inventory Attribute

Field	Description	
Flags	**Bit Encoding**	**Description**
	Bit 0 - Subscription Fulfillment	In this case that this attribute is sent in fulfillment of a subscription this bit MUST be set (1). In the case that this attribute is a direct response to a SWID Request, this bit MUST be unset (0).
	Bit 1-7 - Reserved	Reserved for future use. This field MUST be set to zero on transmission and ignored upon reception.

Tag Count	The number of tags that follow. This field is a 3-byte unsigned integer. The Instance ID Length, Instance ID, Tag Length, and Tag fields are repeated, in order, the number of times indicated in this field. This field value MAY be 0 in which case there are no instances of these fields.
Request ID Copy / Subscription ID	In the case where this attribute is in direct response to a SWID Request attribute from a SWID-IMV, this field MUST contain an exact copy of the Request ID field from that SWID Request. In the case where this attribute is sent in fulfillment of an active subscription, this field MUST contain the Subscription ID of the subscription being fulfilled by this attribute.
EID Epoch	The EID Epoch of the Last EID value. This field is an unsigned 4-byte integer.
Last EID	The EID of the last event recorded by the SWID-IMC, or 0 in the case where the SWID-IMC has no recorded events. This field is an unsigned 4-byte integer.
Instance ID Length	A 2-byte unsigned integer indicating the length in bytes of the Instance ID field.
Instance ID	A string containing the Instance ID of a given tag instance. The exact value of this field depends on the party that provides this SWID tag. This field value MUST be normalized to Network Unicode format, as described in Section 4.7. This string MUST NOT be NULL terminated.
Tag Len	This is a 4-byte unsigned integer indicating the length of the following SWID tag in bytes.
Tag	A SWID tag as a string. In the case where the original SWID tag is not expressed using UTF-8 encoding, it MUST be converted and normalized to Network Unicode format, as described in Section 4.7. However, in the case where the original SWID tag is expressed using UTF-8 encoding, the SWID tag MUST be copied to this field without modification, even if the original SWID tag does not conform fully to Network Unicode format. This string MUST NOT be NULL terminated.

Table 7 - SWID Tag Inventory Attribute Fields

The SWID Tag Inventory attribute contains some number of SWID tags. Given that the size of tags can vary considerably, the length of this attribute is highly variable and, if transmitting a complete inventory, can be extremely large. Enterprises might wish to constrain the use of SWID Tag Inventory attributes to targeted requests to avoid over-burdening the network unnecessarily.

Note that the Instance ID is included in this attribute along with the tag. This is because, unlike the Tag Creator RegID and Unique ID fields that make up the tag identifier, the Instance ID cannot always be extracted from fields within a SWID tag. As such, in order to be able to associate a tag file with a given tag identifier instance, it is necessary to include the Instance ID value in the attribute.

When copying a SWID tag into the Tag field, conversion and normalization of the character encoding happens if and only if the source SWID tag does not use UTF-8 encoding. In the case where the source SWID tag is expressed using an encoding other than UTF-8, then that tag MUST be converted and normalized to use Network Unicode format prior to its inclusion in the tag field. However, in the case where the source SWID tag is expressed in UTF-8, the source tag MUST be copied to the Tag field without conversion or normalization. This is true even if the source SWID tag uses UTF-8 but is not fully conformant with Network Unicode format. This is done because any conversion or normalization of a full SWID tag is likely to break any cryptographic signatures included in the SWID tag. As such, conversion only happens to ensure a SWID tag is readable for the recipient (by ensuring it always uses UTF-8), but is otherwise avoided if possible. Recipients of this attribute can always be

assured that the Tag field uses UTF-8 format, but cannot depend on full Network Unicode format compliance.

4.13 SWID Tag Events

A SWID-IMC sends this attribute to a SWID-IMV to convey a list of events where the affected SWID tags are expressed using full tags. A SWID-IMV MUST NOT send this attribute. The SWID-IMC either sends this attribute in fulfillment of an existing subscription where the establishing request has a Result Type of 0 and the Earliest EID is non-zero, or in direct response to a SWID Request attribute where the Result Type is 0 and the Earliest EID is non-zero.

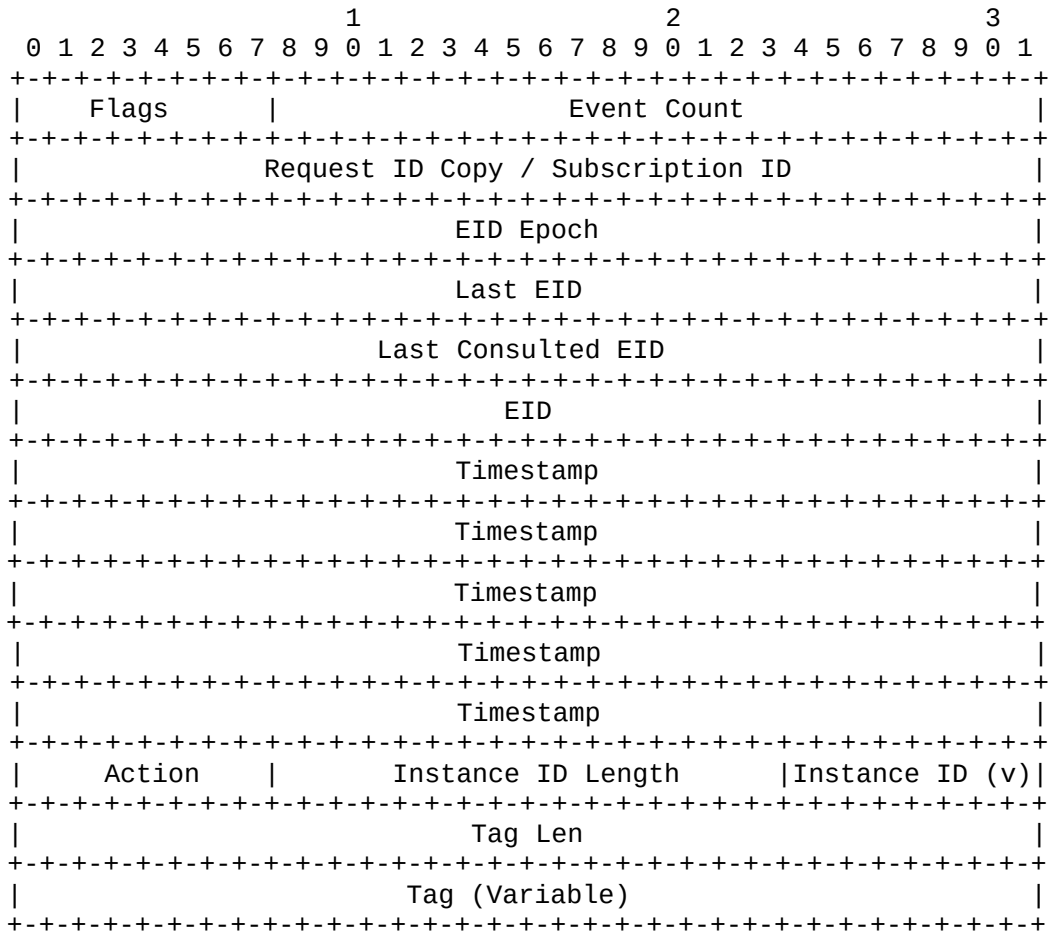


Figure 12 - SWID Tag Events Attribute

Field	Description	
Flags	**Bit Encoding**	**Description**
	Bit 0 - Subscription Fulfillment	In this case that this attribute is sent in fulfillment of a subscription this bit MUST be set (1). In the case that this attribute is a direct response to a SWID Request, this bit MUST be unset (0).
	Bit 1-7 - Reserved	Reserved for future use. This field MUST be set to zero on transmission and ignored upon reception.

Event Count	The number of events being reported in this attribute. This field is a 3-byte unsigned integer. The EID, Timestamp, Action, Instance ID Length, Instance ID, Tag Length, and Tag fields are repeated, in order, the number of times indicated in this field. (An instance of these five fields is referred to as an "event record" in this attribute. Thus the Event Count field indicates the number of event records.) This field value MAY be 0, in which case there are no instances of these fields.
Request ID Copy / Subscription ID	In the case where this attribute is in direct response to a SWID Request attribute from a SWID-IMV, this field MUST contain an exact copy of the Request ID field from that SWID Request. In the case where this attribute is sent in fulfillment of an active subscription, this field MUST contain the Subscription ID of the subscription being fulfilled by this attribute.
EID Epoch	The EID Epoch of the Last EID value. This field is an unsigned 4-byte integer.
Last EID	The EID of the last event recorded by the SWID-IMC, or 0 in the case where the SWID-IMC has no recorded events. This field contains the EID of the SWID-IMC's last recorded change event (which might or might not be included as an event record in this attribute).
Last Consulted EID	The EID of the last event record that was consulted when generating the event record list included in this attribute. This is different from the Last EID field value if and only if this attribute is conveying a partial list of event records. See Section 3.6.4 for more on partial list of event records.
EID	The EID of the event in this event record.
Timestamp	The timestamp associated with this event record. This timestamps is the SWID-IMC's best understanding of when the given event occurred. Note that this timestamp might be an estimate. The Timestamp date and time MUST be represented as an RFC 3339 [5] compliant ASCII string in Coordinated Universal Time (UTC) time with the additional restrictions that the 'T' delimiter and the 'Z' suffix MUST be capitalized and fractional seconds (time-secfrac) MUST NOT be included. This field conforms to the date-time ABNF production from section 5.6 of RFC 3339 with the above restrictions. Leap seconds are permitted and SWID-IMVs MUST support them. The Timestamp string MUST NOT be NULL terminated or padded in any way. The length of this field is always 20 octets.

<table>
<tr><td>Action</td><td>The type of event that is recorded in this event record. Possible values are:
<table><tr><th>Value</th><th>Meaning</th></tr><tr><td>1</td><td>CREATION - The addition of a tag to the endpoint's SWID tag collection</td></tr><tr><td>2</td><td>DELETION - The removal of a tag from the endpoint's SWID tag collection</td></tr><tr><td>3</td><td>ALTERATION - There was an alteration to a tag file within the endpoint's SWID tag collection.</td></tr></table>
All other values are reserved for future use and MUST NOT be used when sending attributes. In the case where a SWID-IMV receives an event record that uses an action value other than the ones defined here, it MUST ignore that event record but SHOULD process other event records in this attribute as normal.</td></tr>
<tr><td>Instance ID Length</td><td>A 2-byte unsigned integer indicating the length in bytes of the Instance ID field.</td></tr>
<tr><td>Instance ID</td><td>A string containing the Instance ID of a given tag instance. The exact value of this field depends on the party that provides this SWID tag. This field value MUST be normalized to Network Unicode format, as described in Section 4.7. This string MUST NOT be NULL terminated.</td></tr>
<tr><td>Tag Len</td><td>This is a 4-byte unsigned integer indicating the length of the following SWID tag in bytes.</td></tr>
<tr><td>Tag</td><td>A SWID tag as a string. In the case where the original SWID tag is not expressed using UTF-8 encoding, it MUST be converted and normalized to Network Unicode format, as described in Section 4.7. However, in the case where the original SWID tag is expressed using UTF-8 encoding, the SWID tag MUST be copied to this field without modification, even if the original SWID tag does not conform fully to Network Unicode format. This string MUST NOT be NULL terminated.</td></tr>
</table>

Table 8 - SWID Tag Events Attribute Fields

The fields of this attribute are used in the same way as the corresponding fields of the previous attributes. As with the SWID Tag Inventory attribute, a SWID Tag Events attribute can be quite large if many events have occurred following the event indicated by a request's Earliest EID. As such, it is recommended that the SWID Request attributes only request full tags be sent (Result Type set to 0) in a targeted request, thus constraining the response just to tags that match a given set of tag identifiers.

As with the SWID Tag Identifier Events Attribute, this attribute MUST only contain event records with EIDs coming from the current EID Epoch of the SWID-IMC.

As with the SWID Tag Inventory Attribute, the SWID-IMC MUST perform conversion and normalization of the SWID tag itself in the case where the source SWID tag is expressed using an encoding other than UTF-8, and MUST NOT perform conversion or normalization of the SWID tag itself in the case where the source SWID tag is expressed using UTF-8.

4.14 Subscription Status Request

A SWID-IMV sends this attribute to a SWID-IMC to request a list of active subscriptions for which the requesting SWID-IMV is the subscriber. A SWID-IMC MUST NOT send this attribute.

This attribute has no fields.

A SWID-IMC MUST respond to this attribute by sending a Subscription Status Response attribute (or an IF-M Error attribute if it is unable to correctly provide a response).

4.15 Subscription Status Response

A SWID-IMC sends this attribute to a SWID-IMV to report the list of active subscriptions for which the receiving SWID-IMV is the subscriber. A SWID-IMV MUST NOT send this attribute.

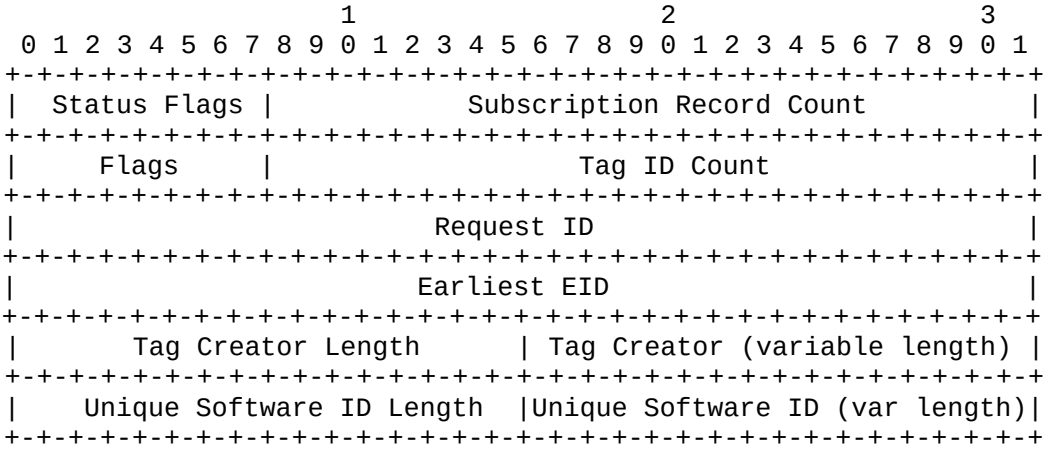


Figure 13 - Subscription Status Response Attribute

Field	Description	
Status Flags	**Bit Encoding**	**Description**
	Bit 0-7 - Reserved	Reserved for future use. This field MUST be set to zero on transmission and ignored upon reception.
Subscription Record Count	The number of subscription records that follow. This field is a 3-byte unsigned integer. The Flags, Tag ID Count, Request ID, Earliest EID, Tag Creator Length, Tag Creator, Unique Software ID Length, and Unique Software ID fields are repeated, in order, the number of times indicated in this field. This field value MAY be 0 in which case there are no instances of these fields.	
Flags, Tag ID Count, Request ID, Earliest EID, Tag Creator Length, Tag Creator, Unique Software ID Length, and Unique Software ID	For each active subscription, these fields contain an exact copy of the fields with the same name as provided in the subscription's establishing request.	

Table 9 - Subscription Status Response Fields

A Subscription Status Response contains zero or more subscription records. Specifically, it MUST contain one subscription record for each active subscription associated with the party that sent the Subscription Status Request to which this attribute is a response. As described in section 3.8.2, the SWID-IMC MUST use the requester's Connection ID and, if available, its IMV ID to determine which subscriptions are associated with the requester.

A SWID-IMC MUST send a Subscription Status Response attribute in response to a Subscription Status Request attribute. The only exception to this is if the SWID-IMC experiences an error condition

that prevents it from correctly populating the Subscription Status Response attribute, in which case it MUST respond with an IF-M Error attribute appropriate to the type of error experienced. If there are no active subscriptions associated with the requesting party, the Subscription Status Response attribute will consist of its Status Flags field, a Subscription Record Count field with a value of 0, and no additional fields.

Each subscription record included in a Subscription Status Response attribute duplicates the fields of a SWID Request attribute that was the establishing request of a subscription. Note that the Request ID field in the record captures the Subscription ID associated with the given subscription record (since the Subscription ID is the same as the Request ID of the establishing request). Note also that if the establishing request is targeted, then its Tag ID Count field will be non-zero and, within that subscription record, the Tag Creator Length, Tag Creator, Unique Software ID Length, and Unique Software ID fields are repeated, in order, the number of times indicated in the Tag ID Count field. As such, each subscription record can be different sizes. Likewise, if the establishing request is not targeted (Tag ID Count field is 0), the subscription record has no Tag Creator Length, Tag Creator, Unique Software ID Length, or Unique Software ID fields.

When a SWID-IMV compares the information received in a Subscription Status Response to its own records of active subscriptions it should be aware that the SWID-IMC might be unable to distinguish this SWID-IMV from other SWID-IMVs on the same PDP. As a result, it is possible that the SWID-IMC will report more subscription records than the SWID-IMV recognizes. For this reason, SWID-IMVs SHOULD NOT automatically assume that extra subscriptions reported in a Subscription Status Response indicate a problem.

4.16 IF-M Error as Used by SWID Message and Attributes for IF-M

The IF-M Error attribute is defined in the IF-M TLV Binding specification [4], and its use here conforms to that specification. An IF-M Error can be sent due to any error in the IF-M exchange, as noted in the TLV Binding, and might also be sent in response to error conditions specific to the SWID Message and Attributes for IF-M exchange. The latter case utilizes error codes defined below.

An IF-M Error attribute is sent instead of a SWID Response attribute due to factors that prevent the reliable creation of a SWID Response. As such, a SWID-IMC MUST NOT send both an IF-M Error attribute and a SWID Response attribute in response to a single SWID Request attribute.

Table 10 lists the Error Code values for the IF-M Error attribute specific to the SWID Message and Attributes for IF-M exchange. In all of these cases, the Error Code Vendor ID field MUST be set to 0x005597, corresponding to the TCG SMI Private Enterprise Number. The Error Information structures for each error type are described in the following subsections.

Note that a message with a SWID Message and Attributes for IF-M attribute might also result in an error condition covered by the Standard IF-M Error Codes defined in the TNC IF-M TLV Binding. For example, the SWID Attribute might have an invalid parameter, leading to an error code of "Invalid Parameter". In this case, the SWID-IMC MUST use the appropriate IF-M Error Code value as defined in Section 5.2.13 of the IF-M TLV Binding specification.

Error Code Value	Description
0x00000020	TNC_IFM_SWID_ERROR. This indicates a fatal error (i.e., an error that precludes the creation of a suitable response attribute) other than the errors described below but still specific to the processing of SWID Attributes. The Description field SHOULD contain additional diagnostic information.
0x00000021	TNC_IFM_SWID_SUBSCRIPTION_DENIED_ERROR. This indicates that the SWID-IMC denied the SWID-IMV's request to establish a subscription. The Description field SHOULD contain additional diagnostic information.

0x00000022	TNC_IFM_SWID_RESPONSE_TOO_LARGE_ERROR. This indicates that the SWID-IMC's response to the SWID-IMV's request was too large to be serviced. The error information structure indicates the largest possible size of a response supported by the SWID-IMC (see section 4.16.2). The Description field SHOULD contain additional diagnostic information.
0x00000023	TNC_IFM_SWID_SUBSCRIPTION_FULFILLMENT_ERROR. This indicates that the SWID-IMC experienced an error fulfilling a given subscription. The error information includes the Subscription ID of the relevant subscription, as well as a sub-error that describes the nature of the error the SWID-IMC experienced. The SWID-IMC and SWID-IMV MUST treat the identified subscription as cancelled.
0x00000024	TNC_IFM_SWID_SUBSCRIPTION_ID_REUSE_ERROR. This indicates that the SWID-IMC received a SWID Request from a given SWID-IMV where the Request ID of that SWID Request is currently used as the Subscription ID of an active subscription with that SWID-IMV. This error does not cancel the identified subscription.
0x00000025 - 0x0000002F	RESERVED. These Error Codes are reserved for use by future revisions of the SWID Message and Attributes for IF-M specification. Any IF-M Error attribute using one of these Error Codes MUST be treated as indicating a fatal error on the sender without further interpretation.

Table 10 - IF-M Error Codes for SWID Message and Attributes for IF-M

The following subsections describe the structures present in the Error Information fields.

4.16.1 TNC_IFM_SWID_ERROR, TNC_IFM_SWID_SUBSCRIPTION_DENIED_ERROR and TNC_IFM_SWID_SUBSCRIPTION_ID_REUSE_ERROR Information

The TNC_IFM_SWID_ERROR error code indicates that the sender (the SWID-IMC) has encountered an error related to the processing of a SWID Request attribute but which is not covered by more specific SWID error codes. The TNC_IFM_SWID_SUBSCRIPTION_DENIED_ERROR is used when the SWID-IMV requests to establish a subscription or clear all subscriptions from the given SWID-IMV, but the SWID-IMC is unable or unwilling to comply with this request. The TNC_IFM_SWID_SUBSCRIPTION_ID_REUSE_ERROR is used when the SWID-IMC receives a SWID Request whose Request ID duplicates a Subscription ID of an active subscription with the request's sender. All of these error codes use the following error information structure.

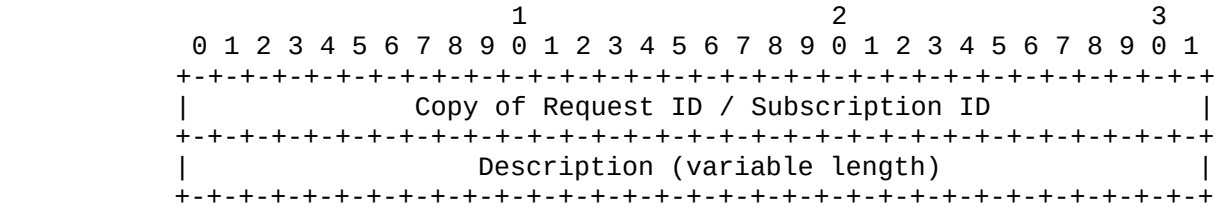


Figure 14 - SWID Error, Subscription Error, and Subscription ID Reuse Information

Field	Description
Copy of Request ID / Subscription ID	In the case that this error condition is generated in direct response to a SWID Request attribute, this field MUST contain an exact copy of the Request ID field in the SWID Request attribute that caused this error. In the case that the attribute in question is generated in fulfillment of an active subscription, this field MUST contain the Subscription ID of the subscription for which the attribute was generated. (This is only possible if the error code is TNC_IFM_SWID_ERROR as the other errors are not generated by subscription fulfillment.) Note that, in this case, the indicated error appears as a sub-error for a TNC_IFM_SWID_SUBSCRIPTION_FULFILLMENT_ERROR, as described in Section 4.16.3.
Description	A UTF-8 string describing the condition that caused this error. This field MAY be 0-length. However, senders SHOULD include some description in all IF-M Error attributes of these types. This field MUST NOT be NULL terminated.

Table 11 - SWID Error, Subscription Error, and Subscription ID Reuse Information Fields

This error information structure is used with TNC_IFM_SWID_ERROR, TNC_IFM_SWID_SUBSCRIPTION_DENIED_ERROR, and TNC_IFM_SWID_SUBSCRIPTION_ID_REUSE_ERROR status codes to identify the SWID Request attribute that precipitated the error condition and to describe the error. The Description field contains text describing the error. The SWID-IMC MAY encode machine-interpretable information in this field, but SHOULD also include a human-readable description of the error, since the receiving SWID-IMV might not recognize the SWID-IMC's encoded information.

4.16.2 TNC_IFM_SWID_RESPONSE_TOO_LARGE_ERROR Information

The TNC_IFM_SWID_RESPONSE_TOO_LARGE_ERROR error code indicates that a response generated by a SWID-IMC in response to a SWID-IMV's SWID Request attribute was too large to send.

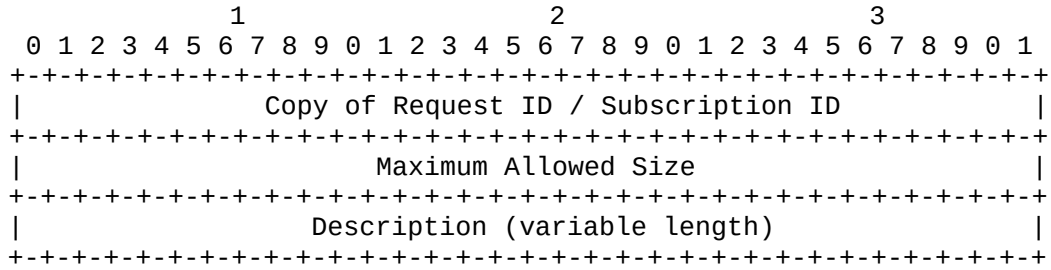


Figure 15 - SWID Response Too Large Error Information

Field	Description
Copy of Request ID / Subscription ID	In the case that the attribute in question is generated in direct response to a SWID Request, this field MUST contain an exact copy of the Request ID field in the SWID Request attribute that caused this error. In the case that the attribute in question is generated in fulfillment of an active subscription, this field MUST contain the Subscription ID of the subscription for which the attribute was generated. Note that, in this case, the TNC_IFM_SWID_RESPONSE_TOO_LARGE_ERROR appears as a sub-error for a

	TNC_IFM_SWID_SUBSCRIPTION_FULFILLMENT_ERROR, as described in Section 4.16.3.
Maximum Allowed Size	This field MUST contain an unsigned integer indicating the largest permissible size, in bytes, of SWID Attribute that the SWID-IMC is currently willing to send in response to a SWID Request attribute.
Description	A UTF-8 string describing the condition that caused this error. This field MAY be 0-length. However, senders SHOULD include some description in all IF-M Error attributes of these types. This field MUST NOT be NULL terminated.

Table 12 - SWID Response Too Large Error Information Fields

This error structure is used with the TNC_IFM_SWID_RESPONSE_TOO_LARGE_ERROR status code to identify the SWID Request attribute that precipitated the error condition and to describe the error. The Maximum Allowed Size field indicates the largest attribute the SWID-IMC is willing to send in response to a SWID Request under the current circumstances. Note that under other circumstances, the SWID-IMC might be willing to return larger responses than indicated (such as if the endpoint connects to the PDP using a different network protocol). The other fields in this error information structure have the same meanings as corresponding fields in the TNC_IFM_SWID_ERROR and TNC_IFM_SWID_SUBSCRIPTION_DENIED_ERROR information structure.

4.16.3 TNC_IFM_SWID_SUBSCRIPTION_FULFILLMENT_ERROR Information

The TNC_IFM_SWID_SUBSCRIPTION_FULFILLMENT_ERROR error code indicates that the SWID-IMC encountered an error while fulfilling a subscription. The bytes after the first 4 octets duplicate an IF-M Error attribute (as described in Section 5.2.13 of the TNC IF-M TLV Binding) that is used to identify the nature of the encountered error.

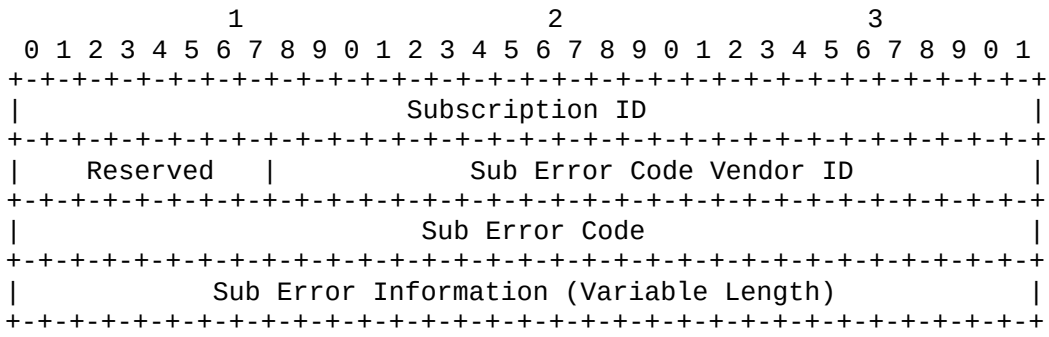


Figure 16 - SWID Subscription Fulfillment Error Information

Field	Description
Subscription ID	This field MUST contain the Subscription ID of the subscription whose fulfillment caused this error.
Reserved	This field MUST contain the value of the Reserved field of an IF-M Error attribute that describes the error condition encountered during subscription processing.
Sub Error Code Vendor ID	This field MUST contain the value of the Error Code Vendor ID field of an IF-M Error attribute that describes the error condition encountered during subscription processing.

Sub Error Code	This field MUST contain the value of the Error Code field of an IF-M Error attribute that describes the error condition encountered during subscription processing.
Sub Error Information	This field MUST contain the value of the Error Information field of an IF-M Error attribute that describes the error condition encountered during subscription processing.

Table 13 - SWID Subscription Fulfillment Error Information Fields

This error structure is used with the TNC_IFM_SWID_SUBSCRIPTION_FULFILLMENT_ERROR status code. The first 4 octets of this error structure contain the Subscription ID of the subscription that was being fulfilled when the error occurred. The remaining fields of this error structure duplicate the fields of an IF-M Error attribute, referred to as the "sub-error". The error code of the sub-error corresponds to the type of error that the SWID-IMC encountered while fulfilling the given subscription. The sub-error MUST NOT have an error code of TNC_IFM_SWID_SUBSCRIPTION_FULFILLMENT_ERROR.

The SWID-IMC sending an IF-M Error attribute with this error code, and the SWID-IMV receiving it, MUST treat the subscription identified by the Subscription ID field as cancelled. All other subscriptions are unaffected.

5 Security Considerations

This section discusses some of the security threats facing IMCs and IMVs that implement the SWID Message and Attributes for IF-M protocol. This section primarily notes potential issues for implementers to consider, although it does contain a handful of normative requirements to address certain security issues. Implementers need to make the final decision as to how their implementations address the given issues. The issues identified below focus on capabilities specific to this document. Implementers are advised to consult other relevant TNC specifications, such as the TNC IF-IMC and TNC IF-IMV specifications, for security issues that are applicable to such components in general.

Reading the Security Considerations section of any well-written specification can be discouraging, as a long list of possible threats is catalogued. Keep in mind that no security measure is absolute, but each one can be beneficial. By understanding the weaknesses of each security measure, we can put in place countermeasures to protect against exploitation of these weaknesses.

5.1 Evidentiary Value of SWID Tags

A SWID tag is only indirect evidence as to the installation of a piece of software on an endpoint. While the ideal is for the presence of a tag to correspond to the presence of the corresponding software, such a correlation hinges on software that accurately manages individual tags as software is added and removed. Utilization of the tests included in a tag's `package_footprint` and/or `validation` elements can provide more direct evidence of software presence, but this information might not be present in many tags and, because of its limited support, this version of the SWID Message and Attributes for IF-M specification does not support use of these flags. Tags can include cryptographic signatures of some or all of their fields, which can enable detection of field modification. This is extremely useful in ensuring that sensitive fields are not modified maliciously. However, the use of cryptographic signatures is not required in SWID tags, and even when utilized, not all fields will necessarily be protected by signatures. For these reasons, it is important to treat SWID tags as evidence rather than proof of software presence.

5.2 Integrity of the SWID Tag Collection

On a related note, while some systems might protect SWID tags against modification, on others there might be very few restrictions on who can add or delete tags on an endpoint. This can mean that a malicious party has relatively free rein to add and remove tags with the goal of obscuring the actual software inventory of the endpoint. As noted above, signatures on tag files can keep tag modification from going undetected, but an attacker can simply delete the signed tag and replace it with a modified tag that lacks the associated signature. In fact, even a signed tag can be added by an adversary and go undetected if the tag does not include fields to verify software presence, such as the `package_footprint` or `validation` element

There is little a SWID-IMC can do to prevent unauthorized modifications of the endpoint's SWID tag from occurring if the local system does not provide protections for tags. Instead, the SWID-IMV and PDP need to operate with an awareness that this type of modification can occur. The use of mechanisms to corroborate software inventories can help detect malicious modification of an endpoint's SWID tag collection. Likewise, the SWID-IMV can look for odd behavior such as the deletion and rapid re-installation of a particular tag, especially the replacement of a signed tag with an unsigned one. Parties that use SWID tags as evidence of compliance with security policies need to be aware of the possible risks of corruption of an endpoint’s SWID tag collection.

5.3 Sensitivity of Collected Tags

Tags on an endpoint are generally not considered to be sensitive, although there can be exceptions to this generalization as noted in the section on Privacy Considerations. In general, an endpoint's SWID tag collection can be browsed and individual tags read by any party with access to the endpoint. This is generally not considered to be problematic, as those with access to the endpoint can usually learn of everything disclosed by that endpoint's tags simply by inspecting other parts of the endpoint.

The situation changes when an endpoint's SWID tags are collected and stored off of the endpoint itself, such as on a PDP or CMDB. Tags represent a wealth of information about the endpoint in question and, for an adversary who does not already have access to the endpoint, a collection of the endpoint's tags might provide many details that are useful for mounting an attack. A list of the tags associated with an endpoint reveals a list of software installed on the endpoint. This list is very detailed, generally noting specific versions and even patch levels, which an adversary can use to identify vulnerable software and design efficacious attacks.

In addition, other information might also be gleaned from a collection of SWID tags:

- A SWID tag might include information about where the product was installed on a given endpoint. This can reveal details about the file organization of that endpoint that an attacker can utilize.
- A SWID tag might include information about how the software was provided to the endpoint, who in an organization signs off on the package release, and who packaged the product for installation. This information might be used as a starting point for the development of supply chain attacks.
- Events affecting SWID tags are reported with timestamps indicating when each given event occurred. This can give the attacker an indication of how quickly an organization distributes patches and updates, helping the attacker determine how long an attack window might remain open.

Any consolidated software inventory is a potential risk, because such an inventory can provide an adversary an insight into the enterprise's configuration and management process. It is recommended that a centralized tag collection be protected against unauthorized access. Mechanisms to accomplish this can include encrypting the data at rest, ensuring that access to the data is limited only to necessary individuals and processes, and other basic security precautions.

5.4 Integrity of Endpoint Records

SWID-IMCs maintain records of detected changes to the endpoint's SWID tag collection. These records are used to respond to a SWID-IMV's request for change events. The SWID-IMV might use a list of reported events to update its understanding of the endpoint's SWID tag collection without needing to receive a full inventory report from the SWID-IMC. For this reason, preserving the integrity of the SWID-IMC's record of events is extremely important. If an attacker modifies the SWID-IMC's record of changes to the endpoint's SWID tag collection, this might cause the SWID-IMV's understanding of the endpoint's SWID tag collection to differ from its actual state. Results might include leading the SWID-IMV to believe that absent software was present, that present software was absent, that patches have been installed even if this is not the case, or to be unaware of other changes to SWID tags. As such, the SWID-IMC MUST take steps to protect the integrity of its event record.

In addition, sometimes a SWID-IMC captures metadata about existing tags or even creates copies of whole tags. Metadata might include hash values of tag files or records of the last time a particular tag file was modified, while whole tags might be preserved to record tags that were deleted from the endpoint's SWID tag collection. If an attacker is able to corrupt or modify this information, they might cause a SWID-IMC to fail to detect certain change events, incorrectly report information, or otherwise fail to correctly fulfill SWID-IMV requests. As such, this additional information about SWID tags, if collected, MUST be integrity protected.

Finally, records of established SWID-IMV subscriptions also require protection against manipulation or corruption. If an attacker is able to modify or delete records of an established subscription by a SWID-IMV, the SWID-IMC might fail to correctly fulfill this subscription. The SWID-IMV would not be aware that its subscription was not being correctly fulfilled unless it received additional information that indicated a discrepancy. For example, the SWID-IMV might collect a full inventory and realize from this that certain events had not been correctly reported in accordance with an established subscription. For this reason, the SWID-IMC MUST protect the integrity of subscription records.

5.5 SWID-IMC Access Permissions

A SWID-IMC requires sufficient permissions to locate and read SWID tags on the endpoint that constitute the endpoint's SWID tag collection, and sufficient permissions to interact with the endpoint's TNCC. With regard to the former, this might require permissions to read the contents of directories throughout the file system. Depending on the operating environment and other activities undertaken by a SWID-IMC (or software that incorporates a SWID-IMC as one of its capabilities) additional permissions might be required by the SWID-IMC software. The SWID-IMC SHOULD NOT be granted permissions beyond what it needs in order to fulfill its duties.

5.6 Sanitization of Tag Fields

In most cases there is no constraint on an endpoint as to who can add tags. This open model allows applications that run in user space to register tags as easily as more privileged applications. However, this also means that any tool reading an endpoint's tags needs to treat these tags as un-vetted input and employ appropriate safeguards. In particular, tools that read SWID tags, including SWID-IMCs, need to be careful to sanitize input to prevent buffer overflow attacks, encoding attacks, and other weaknesses that might be exploited by an adversary who can control the contents of a tag.

Fields of a SWID tag that change the SWID-IMC's behavior, alter system state, or execute code need to be handled with special care. In particular, the `validation` element, which provides a command line that can nominally be executed to validate the tag's correctness, can be utilized by an attacker to point to a malicious executable. To defend against this, SWID-IMCs MUST NOT execute an application indicated by a `validation` element unless the element is signed and the SWID-IMC has determined that the signature is intact and trusted.

5.7 Tag Library Poisoning

It can be useful for a SWID-IMV to have access to a library of tags. If the SWID-IMV receives a list of tag identifier instances, it can consult this library and collect full tags corresponding to those identifiers. Assuming it does not need access to installation-specific information, it can perform calculations on these full tags as if it had received them from a SWID-IMC. For example, it can use this library to derive software names, publishers, and version by finding the tag that corresponds to the given tag identifier value.

If the SWID-IMV keeps a collection of full SWID tags for matching against tag identifiers, there might be a temptation to add any previously unknown tags that a SWID-IMC might report to this library automatically. In fact, this behavior can pose a security risk. If the endpoint has been compromised and the tag manipulated on that endpoint, the tag that it provides to the SWID-IMV might be misleading with regard to the software associated with this tag. If the SWID-IMV automatically adds this corrupted tag to its library, not only will the computations with the compromised endpoint be affected, but computations with other endpoints that provide tag identifier instances that map to the corrupted tag will also be affected. Instead, if the SWID-IMV does make use of a tag library, it is recommended to only populate that library with tags retrieved from a trusted source, or at least to segregate collections of reported tags by endpoint, so corrupted tags on one endpoint will not affect tag computations involving other endpoints. In general, tags retrieved from a trusted source and signed by a trusted authority are likely be safe for inclusion in a tag library.

5.8 IF-M Security Threats

In addition to the aforementioned considerations the SWID Message and Attributes for IF-M protocol is subject to the same security threats as other IF-M transactions, as noted in Section 6.2 of the IF-M TLV Binding specification [4]. These include, but are not limited to, attribute theft, message fabrication, attribute modification, attribute replay, attribute insertion, and denial of service. Implementers are advised to consult the IF-M TLV Binding specification to better understand these security issues.

6 Privacy Considerations

As noted in Section 5.3, if an adversary can gain an understanding of the software installed on an endpoint, they can utilize this to launch attacks and maintain footholds on this endpoint. For this reason, the PDP needs to ensure adequate safeguards are in place to prevent exposure of collected tags. For similar reasons, it is advisable that an endpoint only send tags to a PDP that is authorized to receive this information and that can be trusted to safeguard this information after collection.

7 Relationship to Other Specifications

This specification makes frequent reference to and use of other specifications. This section describes these relationships.

This specification is expected to participate in a standard TNC architecture. As such, it is expected to be used in conjunction with the other protocols used in a TNC exchange. In particular, the SWID-IMC communicates with the endpoint's TNC Client using IF-IMC [8], while the SWID-IMV communicates with the PDP's TNC Server using IF-IMV [9].

In addition, SWID Attributes are conveyed over IF-TNCCS [12] (a.k.a. PB-TNC using IETF terminology [13]), which is in turn conveyed over some variant of IF-T. These protocols have an especially important role, as they are responsible for ensuring that attributes defined under this specification are delivered reliably, securely, and to the appropriate party.

It is important to note that the Product Information, Numeric Version, and String Version attributes defined in the TNC IF-M TLV Binding specification [4] are also meant to convey information about installed applications and the versions thereof. As such, there is some conceptual overlap between those attributes and the intent of this specification. However, the TLV binding was designed to respond to very specific queries about specific classes of products, while the SWID Message and Attributes for IF-M specification is able to convey a broader query, resulting in a more comprehensive set of evidence regarding an endpoint's installed software. Moreover, because this specification makes use of the well-defined structures in SWID tags, it is able to convey information that is more concise (by making use of specific identifier fields instead of sending the whole SWID tag) and/or more comprehensive (as the SWID structures contain many more fields than expressible in the TLV binding). As such, this specification provides important capabilities not present in the IF-M TLV Binding specification.

8 References

8.1 Normative References

[1] Trusted Computing Group, *TNC Architecture for Interoperability*, Specification Version 1.5, Revision 3, May 2012.

[2] Bradner, S., "RFC 2119: Key words for use in RFCs to Indicate Requirement Levels", Internet Engineering Task Force, March 1997.

[3] The International Organization for Standardization/International Electrotechnical Commission (ISO/IEC), *Information Technology - Software Asset Management - Part 2: Software Identification Tag*, ISO/IEC 19770-2, November 2009

[4] Trusted Computing Group, *TNC IF-M: TLV Binding*, Specification Version 1.0, March 2010.

[5] Klyne, G., Newman, C., "RFC 3339: Date and Time on the Internet: Timestamps", Internet Engineering Task Force, July 2002

[6] Sangster, P., Narayan, K., "RFC 5792: PA-TNC A Posture Attribute (PA) Protocol Compatible with Trusted Network Connect (TNC)", The Internet Engineering Task Force, March 2010.

[7] Klensin, J., Padlipsky, M., "RFC 5197: Unicode Format for Network Exchange", The Internet Engineering Task Force, June 2008

8.2 Informative References

[8] Trusted Computing Group, *TNC IF-IMC*, Specification Version 1.3, February 2013.

[9] Trusted Computing Group, *TNC IF-IMV*, Specification Version 1.4, August 2013.

[10] Trusted Computing Group, *TNC IF-T: Binding to TLS*, Specification Version 2.0, February 2013

[11] Trusted Computing Group, *TNC IF-T: Protocol Bindings for Tunneled EAP Methods*, Specification Version 1.1, May 2007

[12] Trusted Computing Group, *TNC IF-TNCCS: TLV Binding*, Specification Version 2.0, January 2010

[13] Sahita, R., Hanna, S., Hurst, R., Narayan, K., " RFC 5793: PB-TNC: A Posture Broker (PB) Protocol Compatible with Trusted Network Connect (TNC)", Internet Engineering Task Force, March 2010

[14] Waltermire, D., Cheikes, B., “Guidelines for the Creation of Interoperable Software Identification (SWID) Tags”, The National Institute of Standards and Technology, May 2015

9 Appendix - Examples

This appendix includes examples of a SWID tag file and SWID attributes. All examples represent fictional content. Examples are provided using the 2009 release of the ISO/IEC SWID specification.

9.1 A Simple SWID Tag

Figure 17 shows an example SWID tag for a fictional software product called SomeApp created by Vendor Inc. This example includes only the required SWID tag fields. This tag is for version 2.3, build 12 of the product.

```
[1]    <?xml version="1.0" encoding="UTF-8"?>
[2]    <swid:software_identification_tag
[3]        xmlns:swid="http://standards.iso.org/iso/19770/-2/2009/schema.xsd"
[4]        xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">
[5]        <swid:entitlement_required_indicator>
[6]            true
[7]        </swid:entitlement_required_indicator>
[8]        <swid:product_title>SomeApp</swid:product_title>
[9]        <swid:product_version>
[10]           <swid:name>2.3 r12</swid:name>
[11]           <swid:numeric>
[12]               <swid:major>2</swid:major>
[13]               <swid:minor>3</swid:minor>
[14]               <swid:build>12</swid:build>
[15]               <swid:review>0</swid:review>
[16]           </swid:numeric>
[17]       </swid:product_version>
[18]       <swid:software_creator>
[19]           <swid:name>Vendor Inc.</swid:name>
[20]           <swid:regid>regid.2013-06.com.vendor</swid:regid>
[21]       </swid:software_creator>
[22]       <swid:software_licensor>
[23]           <swid:name>Vendor Inc.</swid:name>
[24]           <swid:regid>regid.2013-06.com.vendor</swid:regid>
[25]       </swid:software_licensor>
[26]       <swid:software_id>
[27]           <swid:unique_id>
[28]               someapp-21ec2020-3aea-1069-a2dd-08002b30309d
[29]           </swid:unique_id>
[30]           <swid:tag_creator_regid>
[31]               regid.2013-06.com.vendor
[32]           </swid:tag_creator_regid>
[33]       </swid:software_id>
[34]       <swid:tag_creator>
[35]           <swid:name>Vendor Inc.</swid:name>
[36]           <swid:regid>regid.2013-06.com.vendor</swid:regid>
[37]       </swid:tag_creator>
[38]   </swid:software_identification_tag>
```

Figure 17 - A Simple SWID Tag

The SWID tag described in Figure 17 is limited to only the information required by the SWID specification [3]. This information includes the following:

- Lines 5-7: Entitlement requirement indicator. This indicates whether some sort of entitlement (e.g., a license) is required in order to install and/or use the software.
- Line 8: Prose name of the product

- Lines 9-17: Product version. This includes both a prose expression of the full product version and the version information broken down into distinct fields.
- Lines 18-21: Software creator identification. This identifies the party that created the software. This includes both a prose name of the software creator and their "regid" value.
- Lines 22-25: Software licensor identification. This identifies the party that holds the rights to license others to use the software.
- Lines 26-33: Software unique identifier. This structure contains the regid for the party that created this tag and a value that party uses to uniquely identify the named software product. The SWID Message and Attributes for IF-M specification uses the values of these fields when constructing a SWID tag identifier, as described in Section 3.3.
- Lines 34-37: Tag creator identification. This identifies the party that created the tag.

Assume the SWID tag file is installed on the file system in the following location:

```
C:\ProgramData\Vendor\regid.2013-06.com.vendor_someapp-21ec2020-3aea-1069.swidtag
```

9.2 SWID Request Attributes

Below are hexadecimal dumps of example SWID Request attributes. SWID Request attributes are described in more detail in Section 4.7.

9.2.1 Simple Request

This is a basic SWID request for inventory information - the request is not targeted nor does the request establish a subscription on the endpoint. The SWID Request dictates that the response be expressed using SWID tag identifier instances.

`20 00 00 00`	Clear Subscriptions = 0 (don't clear subscriptions), Subscribe = 0 (don't establish a new subscription), Result Type = 1 (respond using SWID tag identifier instances), Tag ID Count = 0 (non-targeted request)
`00 00 3a 76`	Request ID = 14966
`00 00 00 00`	Earliest EID = 0 (respond with inventory rather than event records)

Note that this attribute does not contain any Tag Creator Length, Tag Creator, Unique Software ID Length, or Unique Software ID fields because the Tag ID Count field is 0.

9.2.2 Subscription Request for Events

This attribute establishes a request for a new subscription that will report new SWID change events as they occur.

`60 00 00 00`	Clear Subscriptions = 0 (don't clear subscriptions), Subscribe = 1 (establish a new subscription), Result Type = 1 (respond using SWID tag identifier instances), Tag ID Count = 0 (non-targeted request)
`00 00 3a 76`	Request ID = 14967
`00 02 cc 3a`	Earliest EID = 183354

As before, this attribute does not contain any Tag Creator Length, Tag Creator, Unique Software ID Length, or Unique Software ID fields because the Tag ID Count field is 0. The immediate response to this message (assuming no errors are encountered) will be a list of events with EIDs that are greater than or equal to 183354. Thereafter, if any new events are recorded, those events (and only those events) will be sent back to the SWID-IMV in fulfillment of this subscription. (See Section 3.8.2 for more on subscription fulfillment.)

9.2.3 Targeted Request

This example shows a targeted request. Specifically, the request includes two SWID tag identifiers. The two boxes with thicker outlines denote each of these SWID tag identifiers in the message. The attribute requests that the corresponding full SWID tags be returned.

00 00 00 02	Clear Subscriptions = 0 (don't clear subscriptions), Subscribe = 0 (don't establish a new subscription), Result Type = 0 (respond using full SWID tags), Tag ID Count = 2 (targeted request identifying two SWID tags)
00 00 3a 76	Request ID = 14968
00 00 00 00	Earliest EID = 0 (respond with inventory rather than event records)
00 18	Tag Creator Length = 24
72 65 67 69 64 2e 32 30 31 33 2d 30 36 2e 63 6f 6d 2e 76 65 6e 64 6f 72	Tag Creator = regid.2013-06.com.vendor
00 2c	Unique Software ID Length = 44
73 6f 6d 65 61 70 70 2d 32 31 65 63 32 30 32 30 2d 33 61 65 61 2d 31 30 36 39 2d 61 32 64 64 2d 30 38 30 30 32 62 33 30 33 30 39 64	Unique Software ID = someapp-21ec2020-3aea-1069-a2dd-08002b30309d
00 18	Tag Creator Length = 24
72 65 67 69 64 2e 32 30 31 33 2d 30 36 2e 63 6f 6d 2e 76 65 6e 64 6f 72	Tag Creator = regid.2013-06.com.vendor
00 2f	Unique Software ID Length = 47

61 6e 6f 74 68 65 72 61 70 70 2d 32 33 61 35 32 30 32 30 2d 33 61 65 61 2d 31 30 36 39 2d 61 32 64 64 2d 30 38 30 30 38 38 34 64 34 65 32 31	Unique Software ID = anotherapp-23a52020-3aea-1069-a2dd-0800884d4e21

This message contains SWID tag identifiers for two SWID tags. The first of these tags is the example SWID tag described in Section 9.1. The second tag is created by the same tag creator, but indicates a different software product.

9.3 SWID Response Attributes

This section contains examples of SWID response attributes.

9.3.1 SWID Tag Identifier Events Attribute

This shows an example of a SWID Tag Identifier Events attribute. In this case, this attribute is sent in fulfillment of an established subscription rather than in direct response to a SWID Request attribute. (This is indicated by setting the Subscription Fulfillment flag.) The SWID Request attribute shown in Section 9.2.2 established this subscription (as indicated by the Subscription ID field).

This response contains two event records. The boxes with heavy outlines denote each of these event records.

80 00 00 02	Subscription Fulfillment = 1, Event Count = 2
00 00 3a 76	Subscription ID = 14968
7e 82 1c aa	EID Epoch = 2122456234
00 02 cc 84	Last EID = 183428
00 02 cc 84	Last Consulted EID = 183428 (Same as Last EID so this is a complete result)
00 02 cc 83	EID = 183427
32 30 31 33 2d 30 37 2d 32 31 54 30 34 3a 33 32 3a 31 36 5a	Timestamp = 2013-07-21T04:32:16Z
01	Action = 1 (CREATION)
00 18	Tag Creator Length = 24
72 65 67 69 64 2e 32 30 31 33 2d 30 36 2e 63 6f 6d 2e 76 65 6e 64 6f 72	Tag Creator = regid.2013-06.com.vendor

00 2c	Unique Software ID Length = 44
73 6f 6d 65 61 70 70 2d 32 31 65 63 32 30 32 30 2d 33 61 65 61 2d 31 30 36 39 2d 61 32 64 64 2d 30 38 30 30 32 62 33 30 33 30 39 64	Unique Software ID = someapp-21ec2020-3aea-1069-a2dd-08002b30309d
00 51	Instance ID Length = 81
43 3a 5c 50 72 6f 67 72 61 6d 44 61 74 61 5c 56 65 6e 64 6f 72 5c 72 65 67 69 64 2e 32 30 31 33 2d 30 36 2e 63 6f 6d 2e 76 65 6e 64 6f 72 5f 73 6f 6d 65 61 70 70 2d 32 31 65 63 32 30 32 30 2d 33 61 65 61 2d 31 30 36 39 2e 73 77 69 64 74 61 67	Instance ID = C:\ProgramData\Vendor\regid.2013-06.com.vendor_someapp-21ec2020-3aea-1069.swidtag
00 02 cc 84	EID = 183428
32 30 31 33 2d 30 37 2d 32 31 54 30 34 3a 33 32 3a 32 32 5a	Timestamp = 2013-07-21T04:32:22Z
02	Action = 2 (DELETED)
00 18	Tag Creator Length = 24

72 65 67 69 64 2e 32 30 30 39 2d 30 38 2e 63 6f 6d 2e 63 6f 6d 70 61 6e 79	Tag Creator = regid.2009-08.com.company
00 24	Unique Software ID Length = 36
32 34 38 35 34 39 37 35 2d 31 32 35 65 2d 65 65 33 65 2d 39 38 61 63 2d 34 35 36 38 34 32 34 38 65 65 66 61	Unique Software ID = 24854975-125e-ee3e-98ac-45684248eefa
00 47	Instance ID Length = 71
43 3a 5c 50 72 6f 67 72 61 6d 20 46 69 6c 65 73 5c 43 6f 6d 70 61 6e 79 5c 4f 75 72 50 72 6f 64 75 63 74 5c 4f 75 72 50 72 6f 64 75 63 74 5f 38 37 34 39 2d 38 34 37 38 39 32 30 30 2d 30 32 2e 73 77 69 64 74 61 67	Instance ID = C:\Program Files\Company\OurProduct\OurProduct_8749-84789200-02.swidtag

This response contains two event records. Note that their timestamps indicate that they occurred a few seconds apart - some SWID-IMCs might choose to wait a brief time before sending messages in fulfillment of subscriptions so as to send multiple event records in a single attribute. The first event record indicates the creation of the SWID tag shown in Section 9.1. The second event record indicates the deletion of a different SWID tag. Finally, note that since the Last EID field is equal to the EID of one of the reported event records, this indicates that the SWID-IMC has no later recorded events.

9.3.2 SWID Tag Inventory Attribute

This shows an example of a SWID Tag Inventory attribute. In this case, this attribute is being sent in direct response to a SWID Request attribute, as indicated by the Subscription Fulfillment flag being unset. (Specifically, it is being sent in response to the SWID Request shown in Section 9.2.3, as can

be shown by comparing the Request ID and Request ID Copy fields.) The box with the heavy outline indicates the information specifically associated with the returned tag.

00 00 00 01	Subscription Fulfillment = 0, Tag Count = 1
00 00 3a 76	Request ID Copy = 14968
7e 82 1c aa	EID Epoch = 2122456234
00 02 cc 84	Last EID = 183428
00 51	Instance ID Length = 81
43 3a 5c 50 72 6f 67 72 61 6d 44 61 74 61 5c 56 65 6e 64 6f 72 5c 72 65 67 69 64 2e 32 30 31 33 2d 30 36 2e 63 6f 6d 2e 76 65 6e 64 6f 72 5f 73 6f 6d 65 61 70 70 2d 32 31 65 63 32 30 32 30 2d 33 61 65 61 2d 31 30 36 39 2e 73 77 69 64 74 61 67	Instance ID = C:\ProgramData\Vendor\regid.2013-06.com.vendor_someapp-21ec2020-3aea-1069.swidtag
05 ac	Tag Length = 1452
3c 3f 78 6d 6c 20 76 ... 69 6f 6e 5f 74 61 67 3e	The Tag field is equal to the SWID tag shown in Figure 17. Note that since the original tag used UTF-8 encoding, the tag is copied without undergoing any conversion or normalization.

This attribute contains a single SWID tag. As a response to the targeted SWID Request in Section 9.2.3, this indicates a single instance of the first requested SWID tag and no instances of the second requested tag were present in the endpoint's SWID tag collection. Moreover, if the same party receives both this attribute and the attribute in Section 9.3.1, one can tell that there have been no change events recorded since the preceding message, because the EID Epoch and Last EID values are unchanged.