Service Function Chaining
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P. Quinn, Ed.
Cisco Systems, Inc.
U. Elzur, Ed.
Intel

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Network Service Header
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Abstract

This document describes a Network Service Header (NSH) inserted onto packets or frames to realize service function paths. NSH also provides a mechanism for metadata exchange along the instantiated service path. NSH is the SFC encapsulation required to support the Service Function Chaining (SFC) Architecture (defined in RFC7665).

1. Requirements Language

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

Status of this Memo

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2. Introduction

Service functions are widely deployed and essential in many networks. These service functions provide a range of features such as security, WAN acceleration, and server load balancing. Service functions may be instantiated at different points in the network infrastructure such as the wide area network, data center, campus, and so forth.

Prior to development of the SFC architecture [RFC7665] and the protocol specified in this document, current service function deployment models have been relatively static, and bound to topology for insertion and policy selection. Furthermore, they do not adapt well to elastic service environments enabled by virtualization.

New data center network and cloud architectures require more flexible service function deployment models. Additionally, the transition to virtual platforms requires an agile service insertion model that supports dynamic and elastic service delivery; the movement of service functions and application workloads in the network and the ability to easily bind service policy to granular information such as per-subscriber state and steer traffic to the requisite service function(s) are necessary.

NSH defines a new service plane protocol specifically for the creation of dynamic service chains and is composed of the following elements:

1. Service Function Path identification

2. Transport independent service function chain

3. Per-packet network and service metadata or optional variable type-length-value (TLV) metadata.

NSH is designed to be easy to implement across a range of devices, both physical and virtual, including hardware platforms.

An NSH-aware control plane is outside the scope of this document.

[RFC7665] provides an overview of a service chaining architecture that clearly defines the roles of the various elements and the scope of a service function chaining encapsulation. NSH is the SFC encapsulation referenced in RFC7665.

2.1. Definition of Terms

Classification: Defined in [RFC7665].

Classifier: Defined in [RFC7665].

Metadata: Defined in [RFC7665].

Network Locator: dataplane address, typically IPv4 or IPv6, used to send and receive network traffic.

Network Node/Element: Device that forwards packets or frames based on outer header (i.e. transport) information.

Network Overlay: Logical network built on top of existing network (the underlay). Packets are encapsulated or tunneled to create the overlay network topology.

Service Classifier: Logical entity providing classification function. Since they are logical, classifiers may be co-resident with SFC elements such as SFs or SFFs. Service classifiers perform classification and impose NSH. The initial classifier imposes the initial NSH and sends the NSH packet to the first SFF in the path. Non-initial (i.e. subsequent) classification can occur as needed and can alter, or create a new service path.

Service Function (SF): Defined in [RFC7665].

Service Function Chain (SFC): Defined in [RFC7665].

Service Function Forwarder (SFF): Defined in [RFC7665].

Service Function Path (SFP): Defined in [RFC7665].

SFC Proxy: Defined in [RFC7665].

2.2. Problem Space

Network Service Header (NSH) addresses several limitations associated with service function deployments. [RFC7498] provides a comprehensive review of those issues.

2.3. NSH-based Service Chaining

The NSH creates a dedicated service plane, more specifically, NSH enables:

1. Topological Independence: Service forwarding occurs within the service plane, the underlying network topology does not require modification. NSH provides an identifier used to select the

network overlay for network forwarding.

2. Service Chaining: NSH enables service chaining per [RFC7665]. NSH contains path identification information needed to realize a service path. Furthermore, NSH provides the ability to monitor and troubleshoot a service chain, end-to-end via service-specific OAM messages. The NSH fields can be used by administrators (via, for example a traffic analyser) to verify (account, ensure correct chaining, provide reports, etc.) the path specifics of packets being forwarded along a service path.

3. NSH provides a mechanism to carry shared metadata between participating entities and service functions. The semantics of the shared metadata is communicated via a control plane, which is outside the scope of this document, to participating nodes. [SFC-CP] provides an example of such in section 3.3. Examples of metadata include classification information used for policy enforcement and network context for forwarding post service delivery.

4. Classification and re-classification: sharing the metadata allows service functions to share initial and intermediate classification results with downstream service functions saving re-classification, where enough information was enclosed.

5. NSH offers a common and standards-based header for service chaining to all network and service nodes.

6. Transport Agnostic: NSH is transport independent. An appropriate (for a given deployment) network transport protocol can be used to transport NSH-encapsulated traffic. This transport may form an overlay network and if an existing overlay topology provides the required service path connectivity, that existing overlay may be used.

3. Network Service Header

A Network Service Header (NSH) contains service path information and optionally metadata that are added to a packet or frame and used to create a service plane. An outer transport header is imposed, on NSH and the original packet/frame, for network forwarding.

A Service Classifier adds the NSH. The NSH is removed by the last SFF in the service chain or by a SF that consumes the packet.

3.1. Network Service Header Format

An NSH is composed of a 4-byte (all references to bytes in this draft refer to 8-bit bytes, or octets) Base Header, a 4-byte Service Path Header and Context Headers, as shown in Figure 1 below.

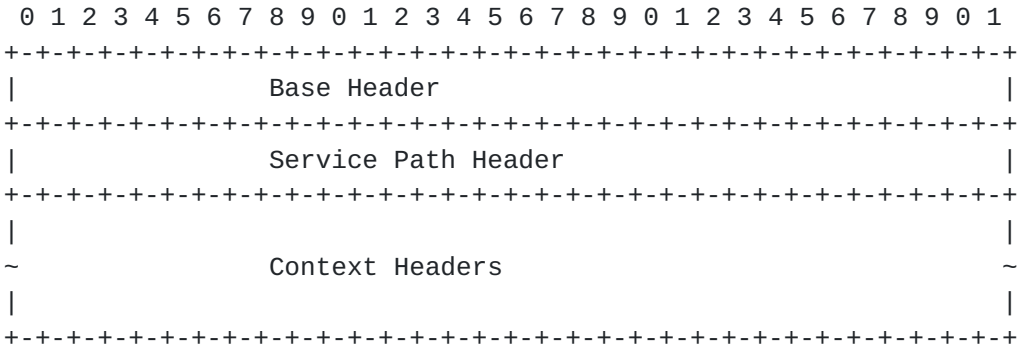


Figure 1: Network Service Header

Base header: provides information about the service header and the payload protocol.

Service Path Header: provide path identification and location within a service path.

Context headers: carry metadata (i.e. context data) along a service path.

3.2. NSH Base Header

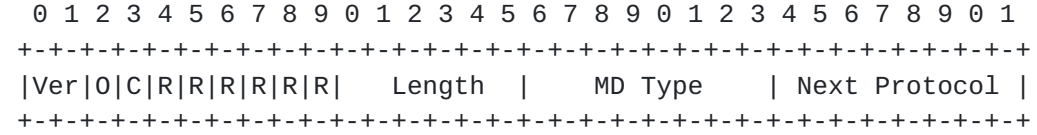


Figure 2: NSH Base Header

Base Header Field Descriptions:

Version: The version field is used to ensure backward compatibility going forward with future NSH updates. It MUST be set to 0x0 by the sender, in this first revision of NSH. Given the widespread implementation of existing hardware that uses the first nibble after an MPLS label stack for ECMP decision processing, this document reserves version 01 and this value MUST NOT be used in future versions of the protocol. Please see [RFC7325] for further discussion of MPLS-related forwarding requirements.

O bit: Setting this bit indicates an Operations, Administration, and Maintenance (OAM) packet. The actual packet format and processing of SFC OAM messages is outside the scope of this specification (see [I-D.ietf-sfc-oam-framework]).

SF/SFF/SFC Proxy/Classifer implementations, which do not support SFC OAM procedures, SHALL discard packets with O-bit set.

SF/SFF/SFC Proxy/Classifer implementations MAY support a configurable parameter to enable forwarding received SFC OAM packets unmodified to the next element in the chain. Such behavior may be acceptable for a subset of OAM functions, but can result in unexpected outcomes for others, thus it is recommended to analyze the impact of forwarding an OAM packet for all OAM functions prior to enabling this behavior. The configurable parameter MUST be disabled by default.

For non OAM packets, the O-bit MUST be cleared and MUST NOT be modified along the SFP.

C bit: Indicates that a critical metadata TLV is present. This bit acts as an indication for hardware implementers to decide how to handle the presence of a critical TLV without necessarily needing to parse all TLVs present. For an MD Type of 0x1 (i.e. no variable length metadata is present), the C bit MUST be set to 0x0.

All other flag fields are reserved for future use. Reserved bits MUST be set to zero when sent and MUST be ignored upon receipt.

Length: total length, in 4-byte words, of NSH including the Base Header, the Service Path Header and the context headers or optional variable length metadata. The Length MUST be of value 0x6 for MD Type equal to 0x1 and MUST be of value 0x2 or greater for MD Type equal to 0x2. The NSH header length MUST be an integer number of 4 bytes. The length field indicates the "end" of NSH and where the

original packet/frame begins.

MD Type: indicates the format of NSH beyond the mandatory Base Header and the Service Path Header. MD Type defines the format of the metadata being carried. Please see IANA Considerations section below.

NSH defines two MD types:

0x1 - which indicates that the format of the header includes fixed length context headers (see Figure 4 below).

0x2 - which does not mandate any headers beyond the Base Header and Service Path Header, but may contain optional variable length context information.

The format of the base header and the service path header is invariant, and not affected by MD Type.

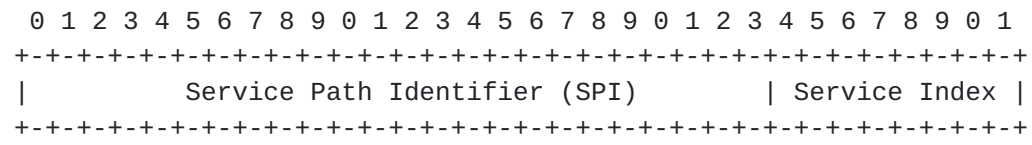
NSH implementations MUST support MD Type = 0x1, and SHOULD support MD Type = 0x2. There exists, however, a middle ground, wherein a device will support MD Type 0x1 (as per the MUST) metadata, yet be deployed in a network with MD Type 0x2 metadata packets. In that case, the MD Type 0x1 node, MUST utilize the base header length field to determine the original payload offset if it requires access to the original packet/frame.

Next Protocol: indicates the protocol type of the encapsulated data. NSH does not alter the inner payload, and the semantics on the inner protocol remain unchanged due to NSH service function chaining. Please see IANA Considerations section below.

This draft defines the following Next Protocol values:

0x1 : IPv4
0x2 : IPv6
0x3 : Ethernet
0x4: NSH
0x5: MPLS
0x6-0xFD: Unassigned
0xFE-0xFF: Experimental

3.3. Service Path Header



Service Path Identifier (SPI): 24 bits
Service Index (SI): 8 bits

Figure 3: NSH Service Path Header

Service Path Identifier (SPI): identifies a service path. Participating nodes MUST use this identifier for Service Function Path selection. The initial classifier MUST set the appropriate SPI for a given classification result.

Service Index (SI): provides location within the SFP. The initial classifier MUST set the appropriate SI value for a given classification result. The initial SI value SHOULD default to 255. However, the classifier MUST allow configuration of other SI values.

Service Index MUST be decremented by Service Functions or by SFC Proxy nodes after performing required services and the new decremented SI value MUST be used in the egress NSH packet. The initial Classifier MUST send the packet to the first SFF in the identified SFP for forwarding along an SFP. If re-classification occurs, and that re-classification results in a new SPI, the (re)classifier is, in effect, the initial classifier for the resultant SPI.

SI SHOULD be used in conjunction with SPI for SFP selection and, consequently, determining the next SFF/SF in the path. Service Index (SI) is also valuable when troubleshooting/ reporting service paths. When an SPI and SI do not correspond to a valid next hop in a SFP, it is an error and the SFF SHOULD generate an error/log message. The value zero for SI is not valid and indicates a broken SFC or malfunctioning SF. In addition to indicating the location within a Service Function Path, SI can be used for service plane loop detection.

3.4. NSH MD Type 1

When the Base Header specifies MD Type = 0x1, four Context Headers, 4-byte each, MUST be added immediately following the Service Path

Header, as per Figure 4. Context Headers that carry no metadata MUST be set to zero.

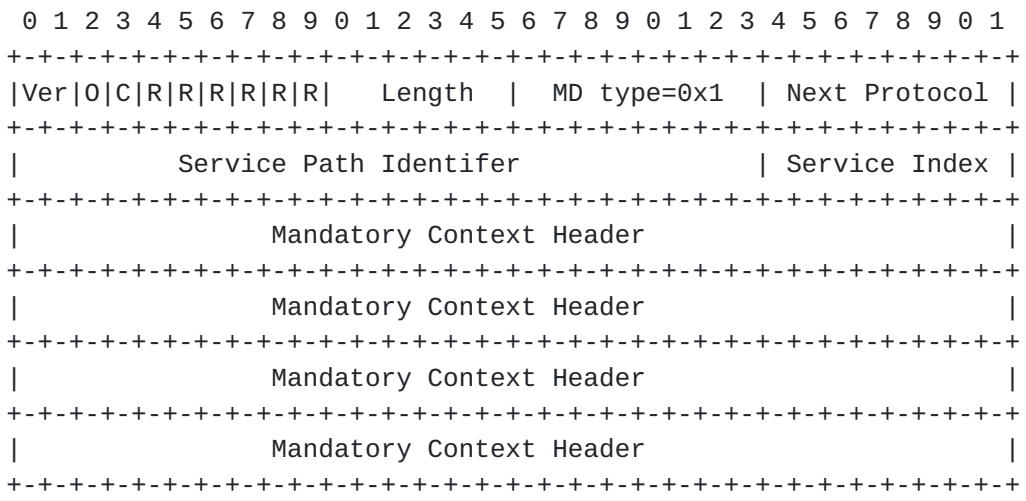


Figure 4: NSH MD Type=0x1

[dcalloc] and [broadalloc] provide specific examples of how metadata can be allocated.

3.5. NSH MD Type 2

When the base header specifies MD Type= 0x2, zero or more Variable Length Context Headers MAY be added, immediately following the Service Path Header. Therefore, Length = 0x2, indicates that only the Base Header followed by the Service Path Header are present. The optional Variable Length Context Headers MUST be of an integer number of 4-bytes. The base header length field MUST be used to determine the offset to locate the original packet or frame for SFC nodes that require access to that information.

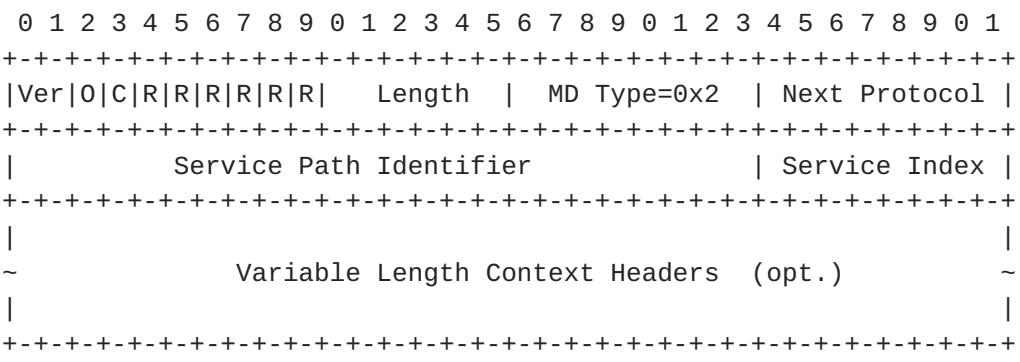


Figure 5: NSH MD Type=0x2

3.5.1. Optional Variable Length Metadata

The format of the optional variable length context headers, is as described below.

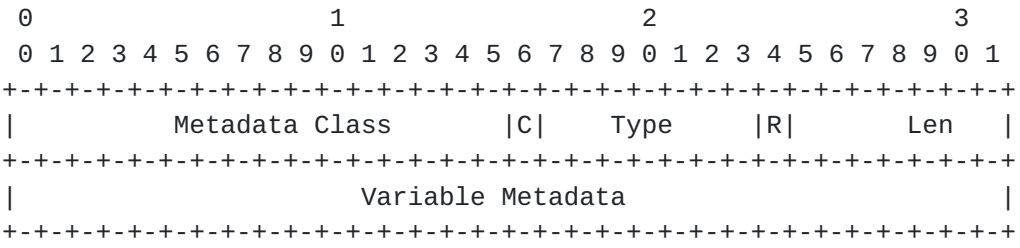


Figure 6: Variable Context Headers

Metadata Class (MD Class): The MD Class defines the scope of the 'Type' field to provide a hierarchical namespace. The IANA Considerations section defines how the MD Class values can be allocated to standards bodies, vendors, and others.

Type: the Type field is split into two ranges - 0 to 127 for non-critical options and 128-255 for critical options. While the value allocation is the responsibility of the MD Class owner, critical options MUST NOT be allocated from the 0 to 127 range and non-critical options MUST NOT be allocated from the 128-255 range.

Figure 7 below illustrates the placement of the Critical bit within the Type field.

Figure 7: Critical Bit Placement Within the TLV Type Field

If an NSH-aware node receives an encapsulated packet containing a TLV with the Critical bit set to 0x1 in the Type field and it does not understand how to process the Type, it MUST drop the packet. Transit devices (i.e. network nodes that do not participate in the service plane) MUST NOT drop packets based on the setting of this bit.

Reserved bit: one reserved bit is present for future use. The reserved bits MUST be set to 0x0.

Length: Length of the variable metadata, in single byte words. In case the metadata length is not an integer number of 4-byte words, the sender MUST add pad bytes immediately following the last metadata byte to extend the metadata to an integer number of 4-byte words. The receiver MUST round up the length field to the nearest 4-byte word boundary, to locate and process the next field in the packet. The receiver MUST access only those bytes in the metadata indicated by the length field (i.e. actual number of single byte words) and MUST ignore the remaining bytes up to the nearest 4-byte word boundary. A value of 0x0 or higher can be used.

A value of 0x0 denotes a TLV header without a Variable Metadata field.

4. NSH Actions

NSH-aware nodes are the only nodes that MAY alter the content of the NSH headers. NSH-aware nodes include: service classifiers, SFF, SF and SFC proxies. These nodes have several possible header related actions:

1. Insert or remove NSH: These actions can occur at the start and end respectively of a service path. Packets are classified, and if determined to require servicing, NSH will be imposed. A service classifier MUST insert NSH at the start of an SFP. An imposed NSH MUST contain valid Base Header and Service Path Header. At the end of a service function path, a SFF, MUST be the last node operating on the service header and MUST remove it.

   Multiple logical classifiers may exist within a given service path. Non-initial classifiers may re-classify data and that re-classification MAY result in a new Service Function Path. When the logical classifier performs re-classification that results in a change of service path, it MUST remove the existing NSH and MUST impose a new NSH with the Base Header and Service Path Header reflecting the new service path information and set the initial SI. Metadata MAY be preserved in the new NSH.

2. Select service path: The Service Path Header provides service chain information and is used by SFFs to determine correct service path selection. SFFs MUST use the Service Path Header for selecting the next SF or SFF in the service path.

3. Update NSH: NSH-aware service functions (SF) MUST decrement the service index. If an SFF receives a packet with an SPI and SI that do not correspond to a valid next hop in a valid Service Function Path, that packet MUST be dropped by the SFF.

   Classifier(s) MAY update Context Headers if new/updated context is available.

   If an SFC proxy is in use (acting on behalf of a non-NSH-aware service function for NSH actions), then the proxy MUST update Service Index and MAY update contexts. When an SFC proxy receives an NSH-encapsulated packet, it MUST remove the NSH headers before forwarding it to an NSH unaware SF. When the SFC Proxy receives a packet back from an NSH unaware SF, it MUST re-encapsulates it with the correct NSH, and MUST decrement the Service Index.

4. Service policy selection: Service Function instances derive policy (i.e. service actions such as permit or deny) selection and enforcement from the service header. Metadata shared in the service header can provide a range of service-relevant information such as traffic classification. Service functions SHOULD use NSH to select local service policy.

Figure 8 maps each of the four actions above to the components in the SFC architecture that can perform it.

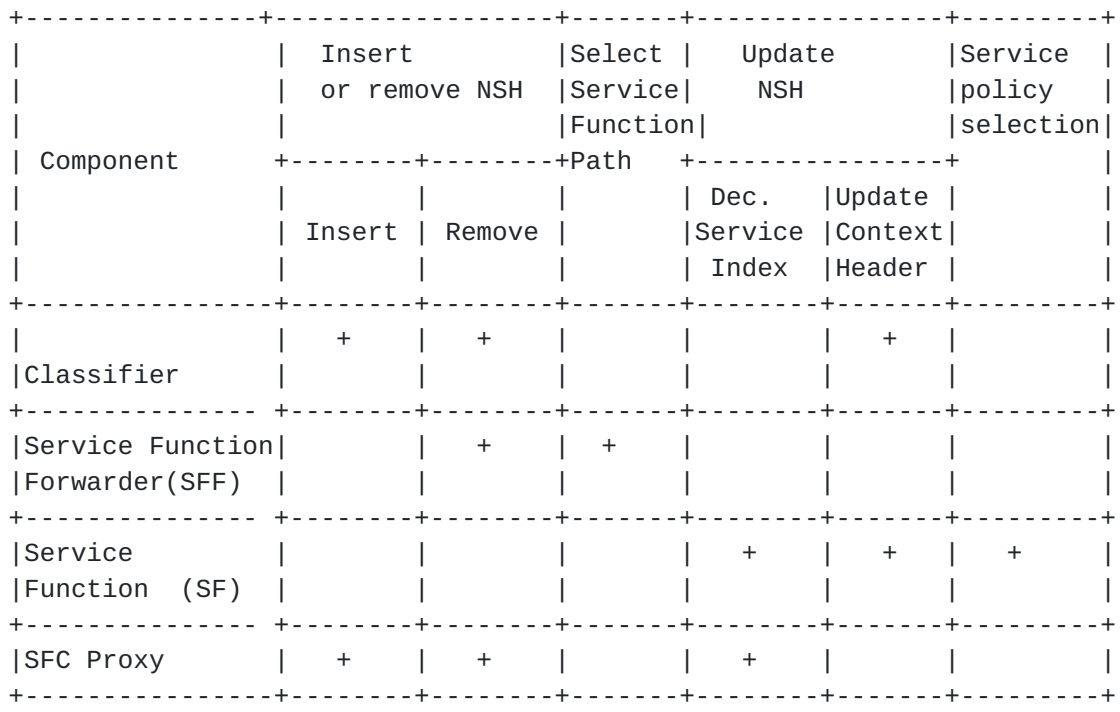


Figure 8: NSH Action and Role Mapping

5. NSH Encapsulation

Once NSH is added to a packet, an outer encapsulation is used to forward the original packet and the associated metadata to the start of a service chain. The encapsulation serves two purposes:

1. Creates a topologically independent services plane. Packets are forwarded to the required services without changing the underlying network topology

2. Transit network nodes simply forward the encapsulated packets as is.

The service header is independent of the encapsulation used and is encapsulated in existing transports. The presence of NSH is indicated via protocol type or other indicator in the outer encapsulation.

6. Fragmentation Considerations

NSH and the associated transport header are "added" to the encapsulated packet/frame. This additional information increases the size of the packet. In order to ensure proper forwarding of NSH packets, several options for handling fragmentation and re-assembly exist:

As discussed in [encap-considerations], within an administrative domain, an operator can ensure that the underlay MTU is sufficient to carry SFC traffic without requiring fragmentation.

However, there will be cases where the underlay MTU is not large enough to carry the NSH traffic. Since NSH does not provide fragmentation support at the service plane, the transport/overlay layer MUST provide the requisite fragmentation handling. Section 9 of [encap-considerations] provides guidance for those scenarios.

7. Service Path Forwarding with NSH

7.1. SFFs and Overlay Selection

As described above, NSH contains a Service Path Identifier (SPI) and a Service Index (SI). The SPI is, as per its name, an identifier. The SPI alone cannot be used to forward packets along a service path. Rather the SPI provide a level of indirection between the service path/topology and the network transport. Furthermore, there is no requirement, or expectation of an SPI being bound to a pre-determined or static network path.

The Service Index provides an indication of location within a service path. The combination of SPI and SI provides the identification of a logical SF and its order within the service plane, and is used to select the appropriate network locator(s) for overlay forwarding. The logical SF may be a single SF, or a set of eligible SFs that are equivalent. In the latter case, the SFF provides load distribution amongst the collection of SFs as needed.

SI can also serve as a mechanism for loop detection within a service path since each SF in the path decrements the index; an Service Index of 0 indicates that a loop occurred and the packet must be discarded.

This indirection -- path ID to overlay -- creates a true service plane. That is the SFF/SF topology is constructed without impacting the network topology but more importantly service plane only participants (i.e. most SFs) need not be part of the network overlay topology and its associated infrastructure (e.g. control plane, routing tables, etc.). As mentioned above, an existing overlay topology may be used provided it offers the requisite connectivity.

The mapping of SPI to transport occurs on an SFF (as discussed above, the first SFF in the path gets a NSH encapsulated packet from the Classifier). The SFF consults the SPI/ID values to determine the appropriate overlay transport protocol (several may be used within a given network) and next hop for the requisite SF. Figure 9 below depicts an example of a single next-hop SPI/SI to network overlay network locator mapping.

SPI	SI	Next hop(s)	Transport
10	255	192.0.2.1	VXLAN-gpe
10	254	198.51.100.10	GRE
10	251	198.51.100.15	GRE
40	251	198.51.100.15	GRE
50	200	01:23:45:67:89:ab	Ethernet
15	212	Null (end of path)	None

Figure 9: SFF NSH Mapping Example

Additionally, further indirection is possible: the resolution of the required SF network locator may be a localized resolution on an SFF, rather than a service function chain control plane responsibility, as per figures 10 and 11 below.

Please note: VXLAN-gpe and GRE in the above table refer to [VXLAN-gpe] and [RFC2784], respectively.

SPI	SI	Next hop(s)
10	3	SF2
245	12	SF34
40	9	SF9

Figure 10: NSH to SF Mapping Example

SF	Next hop(s)	Transport
SF2	192.0.2.2	VXLAN-gpe
SF34	198.51.100.34	UDP
SF9	2001:db8::1	GRE

=

Figure 11: SF Locator Mapping Example

Since the SPI is a representation of the service path, the lookup may return more than one possible next-hop within a service path for a given SF, essentially a series of weighted (equally or otherwise) paths to be used (for load distribution, redundancy or policy), see Figure 12. The metric depicted in Figure 12 is an example to help illustrated weighing SFs. In a real network, the metric will range from a simple preference (similar to routing next- hop), to a true dynamic composite metric based on some service function-centric state (including load, sessions state, capacity, etc.)

```
 +---------------------------------+
 | SPI | SI |   NH         |  Metric |
 +---------------------------------+
 | 10  |  3 | 203.0.113.1 |  1      |
 |     |    | 203.0.113.2 |  1      |
 |     |    |             |         |
 | 20  | 12 | 192.0.2.1   |  1      |
 |     |    | 203.0.113.4 |  1      |
 |     |    |             |         |
 | 30  |  7 | 192.0.2.10  |  10     |
 |     |    | 198.51.100.1|  5      |
 +---------------------------------+
  (encapsulation type omitted for formatting)
```

Figure 12: NSH Weighted Service Path

7.2. Mapping NSH to Network Transport

As described above, the mapping of SPI to network topology may result in a single path, or it might result in a more complex topology. Furthermore, the SPI to overlay mapping occurs at each SFF independently. Any combination of topology selection is possible. Please note, there is no requirement to create a new overlay topology if a suitable one already existing. NSH packets can use any (new or existing) overlay provided the requisite connectivity requirements are satisfied.

Examples of mapping for a topology:

1. Next SF is located at SFFb with locator 2001:db8::1
   SFFa mapping: SPI=10 --> VXLAN-gpe, dst-ip: 2001:db8::1

2. Next SF is located at SFFc with multiple network locators for load distribution purposes:
   SFFb mapping: SPI=10 --> VXLAN-gpe, dst_ip:203.0.113.1, 203.0.113.2, 203.0.113.3, equal cost

3. Next SF is located at SFFd with two paths from SFFc, one for redundancy:
   SFFc mapping: SPI=10 --> VXLAN-gpe, dst_ip:192.0.2.10 cost=10, 203.0.113.10, cost=20

In the above example, each SFF makes an independent decision about the network overlay path and policy for that path. In other words, there is no a priori mandate about how to forward packets in the network (only the order of services that must be traversed).

The network operator retains the ability to engineer the network paths as required. For example, the overlay path between SFFs may utilize traffic engineering, QoS marking, or ECMP, without requiring complex configuration and network protocol support to be extended to the service path explicitly. In other words, the network operates as expected, and evolves as required, as does the service plane.

7.3. Service Plane Visibility

The SPI and SI serve an important function for visibility into the service topology. An operator can determine what service path a packet is "on", and its location within that path simply by viewing the NSH information (packet capture, IPFIX, etc.). The information can be used for service scheduling and placement decisions, troubleshooting and compliance verification.

7.4. Service Graphs

While a given realized service function path is a specific sequence of service functions, the service as seen by a user can actually be a collection of service function paths, with the interconnection provided by classifiers (in-service path, non-initial re-classification). These internal re-classifiers examine the packet at relevant points in the network, and, if needed, SPI and SI are updated (whether this update is a re-write, or the imposition of a new NSH with new values is implementation specific) to reflect the "result" of the classification. These classifiers may also of course modify the metadata associated with the packet.
RFC7665, section 2.1 describes Service Graphs in detail.

8. Policy Enforcement with NSH

8.1. NSH Metadata and Policy Enforcement

As described in Section 3, NSH provides the ability to carry metadata along a service path. This metadata may be derived from several sources, common examples include:

Network nodes/devices: Information provided by network nodes can indicate network-centric information (such as VRF or tenant) that may be used by service functions, or conveyed to another network node post service path egress.

External (to the network) systems: External systems, such as orchestration systems, often contain information that is valuable for service function policy decisions. In most cases, this information cannot be deduced by network nodes. For example, a cloud orchestration platform placing workloads "knows" what application is being instantiated and can communicate this information to all NSH nodes via metadata carried in the context header(s).

Service Functions: A classifier co-resident with Service Functions often perform very detailed and valuable classification. In some cases they may terminate, and be able to inspect encrypted traffic.

Regardless of the source, metadata reflects the "result" of classification. The granularity of classification may vary. For example, a network switch, acting as a classifier, might only be able to classify based on a 5-tuple, whereas, a service function may be able to inspect application information. Regardless of granularity, the classification information can be represented in NSH.

Once the data is added to NSH, it is carried along the service path, NSH-aware SFs receive the metadata, and can use that metadata for local decisions and policy enforcement. The following two examples highlight the relationship between metadata and policy:

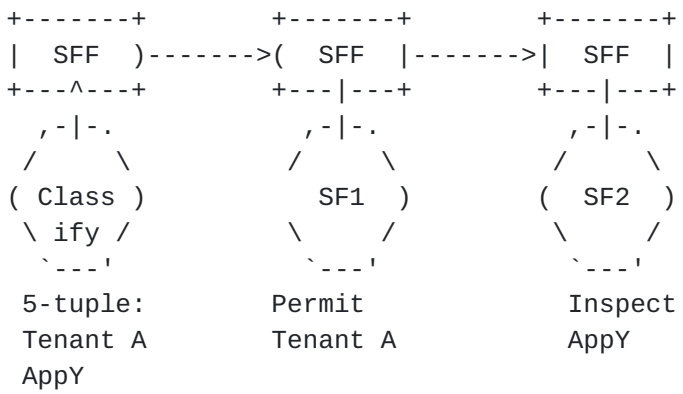


Figure 13: Metadata and Policy

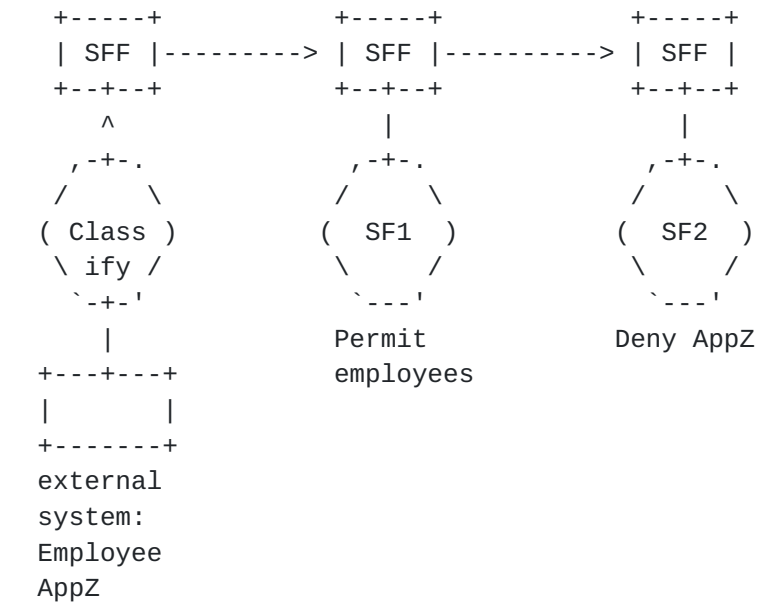


Figure 14: External Metadata and Policy

In both of the examples above, the service functions perform policy decisions based on the result of the initial classification: the SFs did not need to perform re-classification, rather they rely on a antecedent classification for local policy enforcement.

Depending on the information carried in the metadata, data privacy considerations may need to be considered. For example, if the metadata conveys tenant information, that information may need to be authenticated and/or encrypted between the originator and the intended recipients (which may include intended SFs only) . NSH

itself does not provide privacy functions, rather it relies on the transport/overlay layer. An operator can select the appropriate transport to ensure the confidentiality (and other security) considerations are met.

8.2. Updating/Augmenting Metadata

Post-initial metadata imposition (typically performed during initial service path determination), metadata may be augmented or updated:

1. Metadata Augmentation: Information may be added to NSH's existing metadata, as depicted in Figure 15. For example, if the initial classification returns the tenant information, a secondary classification (perhaps co-resident with DPI or SLB) may augment the tenant classification with application information, and impose that new information in the NSH metadata. The tenant classification is still valid and present, but additional information has been added to it.

2. Metadata Update: Subsequent classifiers may update the initial classification if it is determined to be incorrect or not descriptive enough. For example, the initial classifier adds metadata that describes the traffic as "internet" but a security service function determines that the traffic is really "attack". Figure 16 illustrates an example of updating metadata.

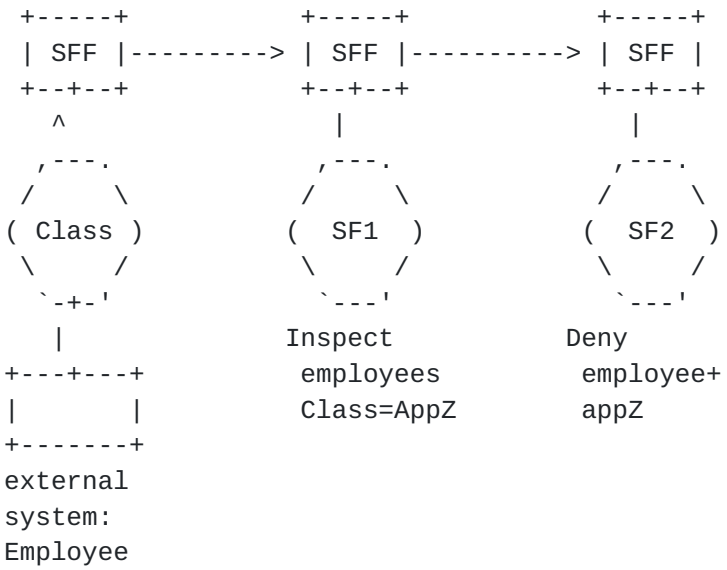


Figure 15: Metadata Augmentation

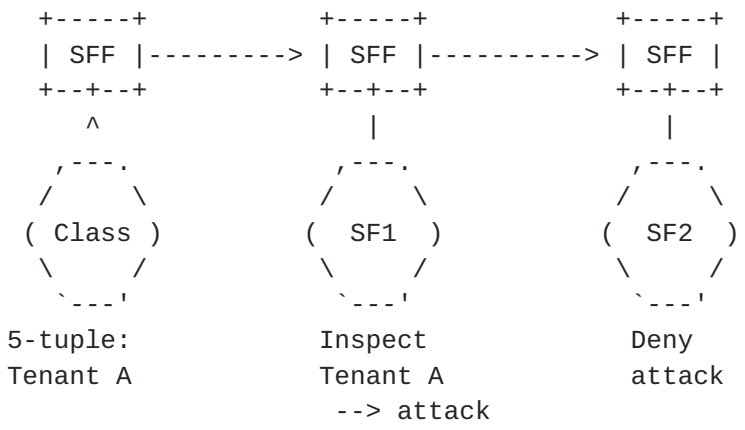


Figure 16: Metadata Update

8.3. Service Path Identifier and Metadata

Metadata information may influence the service path selection since the Service Path Identifier and Service Index values can represent the result of classification. A given SPI and SI can be defined based on classification results (including metadata classification). The imposition of the SPI/SI (new or an change of existing) reflect, as previously described, the new SFP.

This relationship provides the ability to create a dynamic service plane based on complex classification without requiring each node to be capable of such classification, or requiring a coupling to the network topology. This yields service graph functionality as described in Section 7.4. Figure 17 illustrates an example of this behavior.

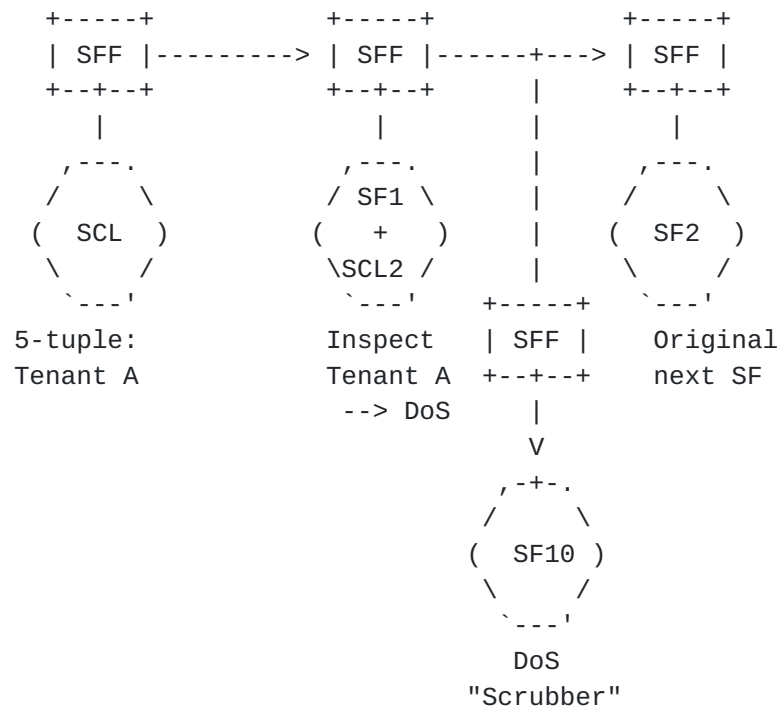


Figure 17: Path ID and Metadata

Specific algorithms for mapping metadata to an SPI are outside the scope of this document.

9. Security Considerations

As with many other protocols, NSH data can be spoofed or otherwise modified. As noted in the descriptive text in [sfc-security-requirements], in many deployments, NSH will be used in a controlled environment, with trusted devices (e.g. a data center) thus mitigating the risk of unauthorized header manipulation. As noted there, far fewer protection mechanisms are needed in these environments, which are the primary design target of NSH.

NSH is always encapsulated in a transport protocol and therefore, when required, existing security protocols that provide authenticity (e.g. [[RFC6071]) can be used between SFF or even to SF. Similarly if confidentiality is required, existing encryption protocols can be used in conjunction with encapsulated NSH.

Further, existing best practices, such as [RFC2827] should be deployed at the network layer to ensure that traffic entering the service path is indeed "valid". [encap-considerations] provides additional transport encapsulation considerations.

NSH metadata authenticity and confidentiality must be considered as well. In order to protect the metadata, an operator can leverage the aforementioned mechanisms provided the transport layer, authenticity and/or confidentiality. An operator MUST carefully select the transport/underlay services to ensure end to end security services, when those are sought after. For example, if RFC6071 is used, the operator MUST ensure it can be supported by the transport/underlay of all relevant network segments as well as SFF and SFs. Further, as described in [section 8.1], operators can and should use indirect identification for personally identifying information, thus significantly mitigating the risk of privacy violation.

Further, the extensibility of MD Type 2 to add information to packets, and where needed to mark that data as critical, allows for attaching signatures or even encryption keying information to the NSH header in the future. Based on the learnings from the work on [nsh-sec], it appears likely that this can provide any needed NSH-specific security mechanisms in the future.

Lastly, SF security, although out of scope of this document, should be considered, particularly if an SF needs to access, authenticate or update NSH metadata.

Further security considerations are discussed in [nsh-sec].

10. Contributors

This WG document originated as draft-quinn-sfc-nsh and had the following co-authors and contributors. The editors of this document would like to thank and recognize them and their contributions. These co-authors and contributors provided invaluable concepts and content for this document's creation.

Surendra Kumar
Cisco Systems
smkumar@cisco.com

Michael Smith
Cisco Systems
michsmit@cisco.com

Jim Guichard
Cisco Systems
jguichar@cisco.com

Rex Fernando
Cisco Systems
Email: rex@cisco.com

Navindra Yadav
Cisco Systems
Email: nyadav@cisco.com

Wim Henderickx
Alcatel-Lucent
wim.henderickx@alcatel-lucent.com

Andrew Dolganow
Alcaltel-Lucent
Email: andrew.dolganow@alcatel-lucent.com

Praveen Muley
Alcaltel-Lucent
Email: praveen.muley@alcatel-lucent.com

Tom Nadeau
Brocade
tnadeau@lucidvision.com

Puneet Agarwal
puneet@acm.org

Rajeev Manur

Broadcom
rmanur@broadcom.com

Abhishek Chauhan
Citrix
Abhishek.Chauhan@citrix.com

Joel Halpern
Ericsson
joel.halpern@ericsson.com

Sumandra Majee
F5
S.Majee@f5.com

David Melman
Marvell
davidme@marvell.com

Pankaj Garg
Microsoft
pankajg@microsoft.com

Brad McConnell
Rackspace
bmcconne@rackspace.com

Chris Wright
Red Hat Inc.
chrisw@redhat.com

Kevin Glavin
Riverbed
kevin.glavin@riverbed.com

Hong (Cathy) Zhang
Huawei US R&D
cathy.h.zhang@huawei.com

Louis Fourie
Huawei US R&D
louis.fourie@huawei.com

Ron Parker
Affirmed Networks
ron_parker@affirmednetworks.com

Myo Zarny

Goldman Sachs
myo.zarny@gs.com

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12. IANA Considerations

12.1. NSH EtherType

An IEEE EtherType, 0x894F, has been allocated for NSH.

12.2. Network Service Header (NSH) Parameters

IANA is requested to create a new "Network Service Header (NSH) Parameters" registry. The following sub-sections request new registries within the "Network Service Header (NSH) Parameters " registry.

12.2.1. NSH Base Header Reserved Bits

There are ten bits at the beginning of the NSH Base Header. New bits are assigned via Standards Action [RFC5226].

Bits 0-1 - Version
Bit 2 - OAM (O bit)
Bit 3 - Critical TLV (C bit)
Bits 4-9 - Reserved

12.2.2. NSH Version

IANA is requested to setup a registry of "NSH Version". New values are assigned via Standards Action [RFC5226].

Version 00: This protocol version. This document.
Version 01: Reserved. This document.
Version 10: Unassigned.
Version 11: Unassigned.

12.2.3. MD Type Registry

IANA is requested to set up a registry of "MD Types". These are 8-bit values. MD Type values 0, 1, 2, 254, and 255 are specified in this document. Registry entries are assigned by using the "IETF Review" policy defined in RFC 5226 [RFC5226].

MD Type	Description	Reference
0	Reserved	This document
1	NSH	This document
2	NSH	This document
3..253	Unassigned	
254	Experiment 1	This document
255	Experiment 2	This document

Table 1

12.2.4. MD Class Registry

IANA is requested to set up a registry of "MD Class". These are 16-bit values. MD Classes defined by this document are assigned as follows:

0x0000 to 0x01ff: IETF Review
0x0200 to 0xfff5: Expert Review
0xfff6 to 0xfffe: Experimental
0xffff: Reserved

12.2.5. NSH Base Header Next Protocol

IANA is requested to set up a registry of "Next Protocol". These are 8-bit values. Next Protocol values 0, 1, 2, 3, 4 and 5 are defined in this draft. New values are assigned via Standards Action [RFC5226].

Next Protocol	Description	Reference
0	Reserved	This document
1	IPv4	This document
2	IPv6	This document
3	Ethernet	This document
4	NSH	This document
5	MPLS	This document
6..253	Unassigned	
254	Experiment 1	This document
255	Experiment 2	This document

Table 2

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Authors' Addresses

Paul Quinn (editor)
Cisco Systems, Inc.

Email: paulq@cisco.com

Uri Elzur (editor)
Intel

Email: uri.elzur@intel.com