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Non-IP Networking (NIN); Signalling messages and protocols

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Foreword

This Group Specification (GS) has been produced by ETSI Industry Specification Group (ISG) Non-IP Networking (NIN).

Modal verbs terminology

In the present document "**shall**", "**shall not**", "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the ETSI Drafting Rules (Verbal forms for the expression of provisions).

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1 Scope

The present document specifies procedures and packet formats for network processes including: setting packet flows up, modifying and re-routing them and clearing them down; exchanging information on timing and synchronization and conveying user messages that are not part of a flow.

2 References

2.1 Normative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

Referenced documents which are not found to be publicly available in the expected location might be found at https://docbox.etsi.org/Reference/.

NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long term validity.

The following referenced documents are necessary for the application of the present document.

[1] ETSI GS NGP 013: "Next Generation Protocols (NGP); Flexilink: efficient deterministic packet forwarding in user plane for NGP; Packet formats and forwarding mechanisms".

[2] IEEE™: "Guidelines for Use of Extended Unique Identifier (EUI), Organizationally Unique Identifier (OUI), and Company ID (CID)".

NOTE: Available from https://standards.ieee.org/wp-content/uploads/import/documents/tutorials/eui.pdf.

[3] IANA: "SMI Private Codes".

NOTE: Available from https://www.iana.org/assignments/smi-numbers/smi-numbers.xhtml#smi-numbers-25.

[4] Recommendation ITU-T E.164: "The international public telecommunication numbering plan".

NOTE: Available from https://www.itu.int/itu-t/recommendations/rec.aspx?rec=10688.

[5] IETF RFC 791: "Internet Protocol".

[6] IETF RFC 8200: "Internet Protocol, Version 6 (IPv6) Specification".

[7] IETF RFC 1213: "Management Information Base for Network Management of TCP/IP-based internets: MIB-II".

[8] IEEE 802™-2014: "IEEE Standard for Local and Metropolitan Area Networks: Overview and Architecture".

NOTE: Available from https://ieeexplore.ieee.org/browse/standards/get-program/page/series?id=68.

[9] IETF RFC 3986: "Uniform Resource Identifier (URI): Generic Syntax".

[10] IETF RFC 4122: "A Universally Unique IDentifier (UUID) URN Namespace".

[11] SMPTE ST 330: "Unique Material Identifier (UMID)".

[12] IETF RFC 2579: "Textual Conventions for SMIv2".

[13] IETF RFC 1700: "Assigned Numbers".

[14] The Unicode Consortium: "The Unicode® Standard - Core Specification".

NOTE: Version 15.0 is available from https://www.unicode.org/versions/Unicode15.0.0/UnicodeStandard-15.0.pdf.

[15] Recommendation ITU-T X.690: "Information technology - ASN.1 encoding rules: Specification of Basic Encoding Rules (BER), Canonical Encoding Rules (CER) and Distinguished Encoding Rules (DER)".

NOTE: Available from https://www.itu.int/itu-t/recommendations/rec.aspx?rec=14472.

[16] AES67: "AES standard for audio applications of networks - High-performance streaming audio-over-IP interoperability".

[17] IEEE 802.3™: "IEEE Standard for Ethernet".

NOTE: Available from https://ieeexplore.ieee.org/browse/standards/get-program/page/series?id=68.

2.2 Informative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long term validity.

The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

[i.1] Recommendation ITU-T Q.850: "Usage of cause and location in the Digital Subscriber Signalling System No. 1 and the Signalling System No. 7 ISDN user part".

NOTE: Available from https://www.itu.int/itu-t/recommendations/rec.aspx?rec=13695.

[i.2] IETF RFC 1034: "Domain Concepts and Facilities".

[i.3] IETF RFC 3261: "SIP: Session Initiation Protocol".

[i.4] IETF RFC 4271: "A Border Gateway Protocol 4".

[i.5] ATM Forum af-pnni-0055.002: "Private Network-Network Interface Specification Version 1.1".

NOTE: Available from https://www.broadband-forum.org/technical/download/af-pnni-0055.002.pdf.

[i.6] AES5: "AES recommended practice for professional digital audio - Preferred sampling frequencies for applications employing pulse-code modulation".

[i.7] AES51: "AES standard for digital audio - Digital input-output interfacing - Transmission of ATM cells over Ethernet physical layer".

[i.8] ETSI TS 136 413: "LTE; Evolved Universal Terrestrial Radio Access Network (E-UTRAN); S1 Application Protocol (S1AP) (3GPP TS 36.413)".

[i.9] IEEE 802.1D™: "IEEE Standard for Local and metropolitan area networks: Media Access Control (MAC) Bridges".

3 Definition of terms, symbols and abbreviations

3.1 Terms

For the purposes of the present document, the terms given in ETSI GS NGP 013 [1] and the following apply:

cloud: set of islands connected together by loosely synchronized links

island: set of units connected together by tightly synchronized links

loosely synchronized link: See clause 7.1.1.

management information base: collection of objects, each of which is identified by an object identifier and has a value that can be expressed in ASN.1

network port: connector that is part of a unit and can terminate a point-to-point link that carries Flexilink packets

object identifier: globally unique value, in the form of a sequence of integers, associated with an object to unambiguously identify it

tightly synchronized link: See clause 7.1.1.

transaction: exchange of a set of messages between control plane entities that results in a change in the state of the system

unit: physical piece of equipment, such as a network switch or interface, or a virtual object with a similar role

3.2 Symbols

Void.

3.3 Abbreviations

For the purposes of the present document, the following abbreviations apply:

AES	Audio Engineering Society
ASN.1	Abstract Syntax Notation 1
BER	Basic Encoding Rules
CRC	Cyclic Redundancy Check
DARS	Digital Audio Reference Signal
DHCP	Dynamic Host Configuation Protocol
EUI	Extended Unique Identifier
IANA	Internet Assigned Numbers Authority
IE	Information Element
IEEE	Institute of Electrical and Electronics Engineers
IETF	Internet Engineering TaskForce
IP	Internet Protocol
ISP	Internet Service Provider
ITU-T	International Telecommunication Union - Telecommunication standardization sector
MAC	Media Access Control
MIB	Management Information Base
NGP	Next Generation Protocols
NUL	Null (Unicode code point zero)
OID	Object IDentifier
OUI	Organizationally Unique Identifier
PHY	PHYsical layer
PTP	Precision Time Protocol
SDN	Software Defined Networking
SFP	Small Form Pluggable
SMPTE	Society of Motion Picture and Television Engineers

TAI	International Atomic Time
TCP	Transmission Control Protocol
UDP	User Datagram Protocol
UMID	Unique Material IDentifier
URI	Uniform Resource Identifier
UTF-8	Unicode Transformation Format - 8 bit
UUID	Universally Unique IDentifier

4 Identifiers

4.1 Bit and byte order

All multiple-octet quantities shall be coded with the most significant octet first.

Bits within any value shall be numbered from left to right, with bit 0 being the most significant bit.

NOTE: It follows that if the octets of a multiple-octet value are numbered from the left with the most significant octet being octet 0, bit *n* of octet *m* will be bit 8*m*+*n* of the value.

4.2 Unit identifiers

A "unit" is typically a piece of physical equipment such as a network switch, a computer, or an IoT device, but may also be a virtual object with a similar role.

Each unit that is part of a Flexilink network shall have a globally-unique 64-bit identifier constructed as follows.

If bits 6 and 7 are 00, it shall be an EUI-64 identifier as specified in [2].

If the first octet contains the binary value 00000001, the next few octets shall be a Private Enterprise Number [3] coded as in an arc of an ASN.1 OID according to BER, and the remainder shall be assigned by the owner of the Private Enterprise Number.

NOTE 1: This provides blocks of globally-unique values that do not require an OUI to be purchased. Private Enterprise Numbers are allocated sequentially, and as of 15th October 2021 the largest was 58 012. Numbers up to two million can be coded in 3 octets, so the owner has a block of four billion identifiers that can be used.

All other code points with 0 in bit 6 are reserved.

Any identifier with 0 in bit 6 shall be assigned permanently to the unit.

An identifier with 1 in bit 6 shall have the same structure as the equivalent identifier with 0 in bit 6, but shall be assigned transiently by an adjacent unit. The assignment only lasts for as long as its link to the unit that assigned the identifier is up.

NOTE 2: This is intended for assigning identifiers to devices with "simple" interfaces and to processes running in equipment that is not Flexilink-aware.

Equipment connected via other technologies (e.g. RS232 or UDP/IP) may have its own identifier, or may be identified indirectly via its point of attachment (see address type 9 in Table 4.4.1).

Each interface that is capable of supporting standards in the IEEE 802 [8] family shall also have a 48-bit MAC address. A MAC address is not required for an interface that only supports Flexilink frames.

NOTE 3: A MAC address identifies an interface, not a piece of equipment. There is no relationship between the various MAC addresses and the identifier as far as the protocols are concerned, though in practice they can all be related to the unit's serial number.

A unit may also have other addresses such as an E.164 address [4], an IPv4 address [5] and/or an IPv6 address [6], and other forms of identification such as the MIB object `sysName` [7].

4.3 Call, route and flow identifiers

4.3.1 Calls

Flows that have the same endpoints may be bundled together to form a "call".

EXAMPLE 1: A call between a studio and an outside broadcast unit can be composed of flows which carry, respectively: programme audio; programme video; talkback; and automation data.

There shall be two kinds of call, unicast and multicast.

A unicast call conveys data between two units. It is created by one of the units originating a FindRoute transaction, and flows and routes can be added by AddFlow transactions or removed by Terminate transactions, see Table 5.4.1.

A multicast call conveys data between a "source" unit and one or more "destination" units. It is created by a destination unit originating a FindRoute transaction, and further destination units can request to be added to the call by originating FindRoute transactions. A destination can leave the call by originating a Terminate transaction.

NOTE 1: Multicast calls are intended for guaranteed service flows in the direction from source to destination. To carry basic service flows in the same direction switches would need to support copying of basic service packets, and a switch that did not have that capability would not be able to carry the flow. Similarly, the way in which guaranteed service flows are routed restricts any flow towards the source to come from a single destination. A basic service flow can be carried from multiple destinations to the source, provided the packet payloads include an identification of the sender.

NOTE 2: Connection to a multicast is controlled by the destination; this is similar to the way point-to-point audio and video are switched, where destinations "take" from a source. It is different from multicast calls in ATM, where destinations were added or removed by the source, and avoids the requirement for an "endpoint identifier" which in ATM was 15 bits and thus limited the number of destinations to 32 767.

EXAMPLE 2: Remote performance can be set up using a single call with each performer being a destination and the mixing desk being the source, and a separate guaranteed service flow from each performer to the desk. The mix is then carried by a single flow to all the performers. Listeners can join the same call by simply not requesting the flow towards the desk.

4.3.2 Routes

A "route" is the set of links over which a call is carried.

Copies of a flow may be transmitted over different routes to add resilience.

Different routes may carry different sets of flows, for instance a backup route may be set up to carry only the most important flows, or different kinds of flow may have different backup routes, or a backup route may be established without connecting any flows over it.

4.3.3 Identifiers

Each flow shall be identified in the control plane by a 128-bit value formatted as shown in Figure 4.3.1.

```
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                                                               |
+                            owner                              +
|                                                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                         call reference                        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|  route ref  |D|               flow reference                  |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 4.3.1: Structure of a flow identifier

The first 64 bits shall contain the identifier of the unit which created the flow identifier. This unit is referred to in the present document as the "owner" of the call, and of the flow identifier.

In the case of a unicast call, the owner shall be the unit that originated the FindRoute transaction. In the case of a multicast, the owner shall be the source or a unit associated with the source.

NOTE 1: "A unit associated with the source" can be another unit that, for resilience, is transmitting the same content over a different route. It can also be a control entity that manages media sources.

NOTE 2: If multicast flows were not owned by the source, in the case where A asks to consume content hosted by B and then C asks for it also and then A disconnects, there would be a call between B and C that is owned by A, and A would not in general be able to know when the call reference can be re-used.

The next 32 bits shall contain a non-zero reference number, chosen by the owner, such that the first 96 bits are a globally unique "call identifier" for the call of which the flow is a part. Call references should be chosen in a way that maximizes the time from when a call ceases to exist until its identifier is re-used for a new call.

The next 7 bits shall contain a non-zero reference number, chosen by the owner and unique within the call, selecting the route followed by the flow. The call identifier and the route reference together form a "route identifier".

The next bit shall contain a "direction" indicator which shall be 0 for a flow in the direction away from the owner and 1 for a flow in the direction towards the owner.

NOTE 3: A route can carry flows in both directions. When connecting to a server, the client asks for an uplink flow and a downlink flow. The client is the owner of the call, and specifies the two flows it needs. The routing table entries for a flow are set up as the FindRoute messages are passed through the network.

The remaining 24 bits shall contain a non-zero reference number, chosen by the owner, identifying the flow uniquely within the call. Where a pair of flows in opposite directions carries a two-way protocol such as TCP, the same flow reference value shall be used for each of them.

NOTE 4: If a call is connected over several different routes (for instance, to give resilience in the event of failure) the route reference distinguishes between them. The flow reference distinguishes between different flows within a call.

NOTE 5: The flow reference is orthogonal to the route reference, so flows carrying the same content over different routes have the same flow reference, and flows carrying different content have different flow references even if they do not follow the same route.

NOTE 6: Most calls will only have a very small number of flows, but the flow reference field is able to support a large number for applications such as that in example 2 to clause 4.3.1.

Zero in the route reference field shall indicate all routes for the call. Except where specified otherwise, zero in both the "direction" bit and the flow reference field shall indicate all flows that are included in the call, and zero in the flow reference with 1 in the "direction" bit is reserved.

A caller wishing to join a multicast shall use a temporary call identifier (which it owns) until the source's identifier for the multicast has been discovered.

NOTE 7: An existing multicast will already have an identifier (and if the "openness" value specified in clause 5.7.16 is 00 or 01 the caller can join it without the FindRoute propagating all the way to the source); otherwise the source creates it when it sends the response message.

NOTE 8: Flow identifiers are globally significant and globally unique, so can be used in control plane messages to unambiguously identify a call, route, or flow at any point in the system. They are not intended to be used in packet headers, where a locally significant identification (label or slot allocation) is both more economical and more secure.

4.4 Addresses

An address may serve to identify the endpoint to which a call is to be connected, such as a particular service, interface, unit, or piece of content; or to locate it within the topology of the network; or both.

NOTE 1: Addresses are not restricted to a single addressing scheme, and can include a number of different forms of identification, including but not limited to: conventional interface addresses such as IPv4 [5], IPv6 [6], and IEEE 802 [8] MAC (see IEEE 802 [8], clause 8); the unit identifiers specified in clause 4.2 of the present document; MIB objects such as `sysName [7]`; and identification of a service or piece of content (e.g. URI [9], UUID [10] or UMID [11]).

An address is represented as an octet string, and is thus a valid `TAddress` value as specified in IETF RFC 2579 [12], unless it is more than 255 octets long. The corresponding `TDomain` value is for further study.

The interpretation of an address depends on the "type" in its first octet, and anything that does not recognize the value in that octet will not be able to interpret the address or route calls to it. Values for the "type" are listed in Table 4.4.1.

Table 4.4.1: Address encoding

Type	Remainder of octet string
0	second octet contains *n*, next *n* octets are an address (which shall not be of type 0) which acts as the locator, remainder is another address (the "local" address, which may be of type 0) which is to be interpreted at the specified location
1	second octet contains *n*, next *n* octets are an AbsoluteOid, remainder is the object's value (see notes 1, 3 and 4)
2	second octet contains *n*, next *n* octets are an AbsoluteOid, remainder is the object's value (see notes 2, 3 and 4)
3	second octet contains *n*, next *n* octets are a TDomain value (coded as an AbsoluteOid), remainder is a TAddress value appropriate to that domain (see IETF RFC 2579 [12]) and notes 3 and 4)
4	either 4 octets containing an IPv4 address [5] or 8 octets consisting of 4 octets containing an IPv4 subnet address followed by 4 octets containing a subnet mask
5	unit identifier (see clause 4.2)
6	IPv6 address [6]
7	URI [9]
8	second octet contains a protocol number (as in IP headers [5] and [13], e.g. 6 for TCP and 17 for UDP); remainder contains a port number for the indicated protocol
9	identifier for a point of attachment to a piece of equipment (physical or virtual; local to the equipment)
10	service name coded as a UTF-8 string as specified in The Unicode® Standard [14], clause 2.5
11	E.164 address [4]
12	IEEE 802 MAC address (see IEEE 802 [8], clause 8)
13	UUID [10]
14	UMID [11]
15 to 255	reserved

NOTE 1: Type 1 shall identify a unit by searching for one in whose MIB the object identified by the OID (such as sysName or sysLocation [7]) has the specified value. In the case of scalar objects, the OID may omit the final zero arc. Units are not required to support all (or, indeed, any) objects in their MIBs that could be used in this context.

NOTE 2: Type 2 shall identify a network port, media port or other resource within a unit, by searching the unit's MIB, usually for a columnar object such as a table of the names assigned to physical media ports. The OID omits the index arcs. As with type 1, units are not required to support all objects in their MIBs.

NOTE 3: See clause 5.6.4 for the coding of an AbsoluteOid. The value which follows the AbsoluteOid in types 1 and 2 shall be coded using ASN.1 Basic Encoding Rules (see Recommendation ITU-T X.690 [15], clause 8), including the tag and length.

NOTE 4: Types 1, 2 and 3 should only be used for address formats that cannot be supported by any of the other types. An IPv4 address, for instance, should use type 4 although it can also be expressed as a type 3 address or, if the target unit's MIB includes its IP address, as a type 1. An IPv4 address together with a port number should be type 0, with a type 4 locator and a type 8 local address. For specifying an audio interface on a piece of equipment, type 9 should be used in preference to type 2.

NOTE 2: An address can be "source routed", i.e. consist of a series of addresses such that the call is routed to the first address, then from there to the next, etc, using type 0, with each address being interpreted in the context of the equipment, location or subnetwork specified by the previous address.

EXAMPLE 1: The address for an audio call can consist of the address of a piece of audio equipment followed by an identification of a particular audio port on that equipment.

EXAMPLE 2: The address of a gateway (or even of a specific network port on a gateway or switch) can be used as the locator for equipment accessed through that gateway.