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Next Generation Protocols (NGP); Flexilink: efficient deterministic packet forwarding in user plane for NGP; Packet formats and forwarding mechanisms

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Foreword

This Group Specification (GS) has been produced by ETSI Industry Specification Group (ISG) Next Generation Protocols (NGP).

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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Introduction

ISG NGP is tasked with finding a system of packet routing that does not suffer from the problems operators have experienced with LTE and also optimizes the performance, efficiency, and scalability of new services proposed for 5G.

Internet Protocol (IP) is not fully able to meet these requirements for a number of reasons which have been widely documented. Many of the constraints that applied when IP was developed, around 1980, (such as memory size) are no longer an issue, while other considerations that are important now (such as mobility and latency) were not an issue then. Furthermore, back then all processing had to be done by code running on a CPU, whereas now many tasks can be done more efficiently by dedicated logic in a System-on-a-Chip (SoC).

Most packets are part of a "flow" such as a TCP session or a video stream. Increasingly, there is a separation between the processes of deciding the route packets will follow and of forwarding the packets, for example in Software Defined Networking (SDN) and Control and User Plane Separation (CUPS). This is taken to its logical conclusion by specifying a system in which routing decisions are taken per-flow by control plane code, and per-packet processing is made simple enough that it can be implemented entirely in logic.

The system provides two separate services, a "basic" service suitable for traditional statistically multiplexed packet data, and a "guaranteed" service providing the lowest possible latency for continuous media, not only audio and video but also signals used in industrial automation and newer services proposed for 5G such as tactile feedback. Implementing these two services and multiplexing them together on communication links is less complex than attempting to serve both kinds of traffic with a single service.

The control plane procedures for managing flows are not specified in the present document. The system has been prototyped using the signalling messages specified in ISO/IEC 62379-5-2 [i.1]; messages containing similar information in other formats can also be used.

1 Scope

The present document specifies user plane packet formats and routing mechanisms for 5G core and access networks, based on the requirements documented in ETSI GS NGP 012 [i.3] and taking technologies from ETSI GR NGP 003 [i.2] as appropriate.

It does not specify the control plane procedures for managing routes.

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 document is necessary for the application of the present document.

[1] IEEE 802.3™-2008: "Local and metropolitan area networks - Specific requirements - Part 3: Carrier sense multiple access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications".

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] ISO/IEC 62379-5-2:2014: "Common control interface for networked digital audio and video products - Transmission over networks - Signalling".

[i.2] ETSI GR NGP 003: "NGP Next Generation Protocol; Packet Routing Technologies".

[i.3] ETSI GS NGP 012: "KPIs for Next Generation Protocols Basis for measuring benefits of NGP".

3 Definitions and abbreviations

3.1 Definitions

For the purposes of the present document, the following terms and definitions apply:

basic flow: flow with no guarantees as to latency or whether packets will be dropped

basic service: packet transmission service carrying basic flows

flow: specification for how packets are forwarded from source to destination(s), and interpreted at the destination

guaranteed flow: flow offering a specified latency and specified probability of packet loss for packets which are transmitted at a specified rate

guaranteed service: packet transmission service carrying guaranteed flows

3.2 Abbreviations

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

API	Application Program Interface
ATM	Asynchronous Transfer Mode
CPU	Central Processing Unit
CRC	Cyclic Redundancy Check
CUPS	Control and User Plane Separation
FCS	Frame Check Sequence
FF	FlipFlop
IP	Internet Protocol
ls	least significant
MAC	Media Access Control
MPLS	Multi-Protocol Label Switching
ms	most significant
MTU	Maximum Transmission Unit
PHY	PHYsical layer, or hardware that implements an interface to it
PTP	Precision Time Protocol
RAM	Random Access Memory
SDN	Software Defined Network
SFD	Start-of-Frame Delimiter
TC CYBER	Cybersecurity Technical Committee (ETSI)
TCP	Transmission Control Protocol
UDP	User Datagram Protocol
XOR	eXclusive OR

4 Packets and flows

A packet shall consist of a payload and encapsulation. The payload shall be an octet string which is conveyed unaltered (apart from the effect of transmission errors and equipment faults) from source to destination. The encapsulation shall depend on the medium over which the packet is conveyed.

NOTE 1: Thus in many cases the encapsulation will change as the packet progresses through the system.

Each packet shall be associated with a flow.

NOTE 2: Management of flows is handled by the control plane, and is thus out of scope for the present document.

The action to be taken when a packet is received at a network element shall be defined by the flow with which it is associated; it shall not (except at a destination of the flow and as provided in clause 5.3.2.3) depend on the content of the payload.

NOTE 3: The route taken by packets associated with the flow is established, and any required resources reserved, before the first packet is sent. This allows security checks to be made before any data is transmitted.

5 Basic service

5.1 Service characteristics

The service specified in clause 5 is intended for the kind of communication between software processes that commonly occurs in computer systems. Transmission will typically be intermittent, so that reservation of capacity would be inappropriate and thus latency is undefined and packet loss due to queue overflow can occur.

Each flow shall have exactly one destination. It may have more than one source.

NOTE 1: A flow with more than one source would be similar to an MPLS Forwarding Equivalence Class.

NOTE 2: Multicasting not supported by basic flows, to simplify implementation of the forwarding process. Typically, basic flows will be used in pairs, one in each direction, so that messages can be acknowledged and dropped packets repeated. Multicasting is supported by the guaranteed service (see clause 6).

Switches may support facilities similar to those specified for IP networks to prioritize particular classes of traffic. Such facilities would be invoked by control plane messages (with the traffic class being a property of the flow and not signalled in packet headers) and are thus out of scope for the present document. Consideration should be given to whether they are necessary, or whether all traffic for which they might be useful can use the guaranteed service.

NOTE 3: These facilities would add complexity, but could be useful for sharing out capacity in the context of network slicing, and possibly also for compatibility with legacy systems.

5.2 Encapsulation

The details of packet formats, including the encapsulation, shall be defined separately for each type of link (see clause 8).

The payload should be preceded by a label which serves as an identification of the flow which is local to the link.

The encapsulation shall indicate the number of payload octets, either directly or by marking the start and end of the packet or of the payload.

5.3 Payload

5.3.1 Size

The payload of a packet transmitted by an end system shall be any number of octets in the range 1 to 2 000 inclusive.

NOTE 1: The lower limit is much less than for Ethernet. Zero-length payloads are not supported because support for them has been found to increase complexity in the forwarding logic.

NOTE 2: The upper limit supports tunnelling of maximum-size Ethernet envelope frames; per-packet overheads are minimal, so there is no incentive to support larger packets. A fixed upper limit eliminates the need for path MTU discovery.

Switching equipment shall support payload sizes up to 2 016 octets.

NOTE 3: That allows for up to 16 octets of inner labels.

5.3.2 Format

5.3.2.1 General

The payload of a basic service packet shall consist of a user message and an integrity check.

The form taken by the integrity check shall be signalled in the control plane messages that set the flow up. The user message shall consist of all payload octets that are not part of the integrity check.

5.3.2.2 User message

The syntax and semantics of the user message shall be negotiated by the source and destination entities as part of the process of setting the flow up.

The network shall treat the user message as an unstructured octet string, and shall not take any action that is based on the value of any octet in the string.

5.3.2.3 Integrity check

Integrity check formats supported by the control plane messages shall include:

- No integrity check; all payload octets are part of the user message.
- Last two payload octets are coded with a nonzero value such that the sum of the set of 16-bit numbers derived as follows is a multiple of 65535. If the payload is an odd number of octets, a zero octet is inserted before the penultimate octet (i.e. at the end of the user message). Then, the payload is divided into pairs of octets, each holding a 16-bit number, with the more significant half of each number being in the first octet of the pair.
- Last four payload octets hold a CRC calculated as specified in clause 3.2.9 of IEEE 802.3-2008 [1].
- Last four payload octets hold longitudinal parity, calculated as specified in clause 8.2.2.

NOTE 1: The integrity check covers the user message but not the header, which has its own integrity check, and is changed at each switching point.

The integrity shall be checked by the destination entity. It may be checked at other points in the network, and the packet discarded if the check fails.

NOTE 2: In many cases corruption of a packet will be sufficiently unlikely that checking the integrity at intermediate nodes is not worth the effort.

5.3.2.4 Aggregated flows

A flow may be created that gathers together a bundle of other flows, by prepending a label that identifies the flow within the bundle (the "inner" label") to the payload of each packet.

NOTE 1: This is similar to an MPLS "push" operation, but unlike with MPLS the existence of the inner label is a property of the outer (aggregated) flow and not indicated in the packet format; the format of the inner label only needs to be understood by the network elements at the ends of the aggregated flow, not by any intermediate switches through which it passes.

Integrity check fields within the payload should not be adjusted to include the inner label. The format of the inner label shall include its own integrity check.

NOTE 2: It will usually be appropriate for an aggregated flow to be signalled as "no integrity check", so that switches through which it passes do not perform any checks on the payloads.

6 Guaranteed service

6.1 Service characteristics

The service specified in clause 6 is intended for continuous media such as digital audio and video, tactile feedback, and position of vehicles and industrial robots. However, it can also be used for other traffic.

NOTE 1: If the guaranteed service is used for file transfers, the data rate can be negotiated via control plane messages and packets will not be dropped due to buffer overflow, so the transport protocol can be greatly simplified.

Each flow shall have exactly one source. It may have more than one destination.