

Trademarks and Disclaimers

IEEE believes the information in this publication is accurate as of its publication date; such information is subject to change without notice. IEEE is not responsible for any inadvertent errors.

Copyright © 2020 IEEE. All rights reserved.

IEEE owns the copyright to this Work in all forms of media. Copyright in the content retrieved, displayed or output from this Work is owned by IEEE and is protected by the copyright laws of the United States and by international treaties. IEEE reserves all rights not expressly granted.

IEEE is providing the Work to you at no charge. However, the Work is not to be considered within the “Public Domain,” as IEEE is, and at all times shall remain the sole copyright holder in the Work.

Except as allowed by the copyright laws of the United States of America or applicable international treaties, you may not further copy, prepare, and/or distribute copies of the Work, nor significant portions of the Work, in any form, without prior written permission from IEEE.

Requests for permission to reprint the Work, in whole or in part, or requests for a license to reproduce and/or distribute the Work, in any form, must be submitted via email to stds-ipr@ieee.org, or in writing to:

IEEE SA Licensing and Contracts
445 Hoes Lane
Piscataway, NJ 08854

Comments on this report are welcomed by Nendica: the IEEE 802 “Network Enhancements for the Next Decade” Industry Connections Activity: <<https://1.ieee802.org/802-nendica>>
Comment submission instructions are available at: <<https://1.ieee802.org/802-nendica/nendica-sfi>>
Comments will be considered for a future revision of this document and may stimulate the development of a new revision.

*The Institute of Electrical and Electronics Engineers, Inc.
3 Park Avenue, New York, NY 10016-5997, USA*

*Copyright © 2020 by The Institute of Electrical and Electronics Engineers, Inc.
All rights reserved. Published [Month Year]. Printed in the United States of America.*

IEEE and 802 are registered trademarks in the U.S. Patent & Trademark Office, owned by The Institute of Electrical and Electronics Engineers, Incorporated.

PDF: ISBN [tbd]

IEEE prohibits discrimination, harassment, and bullying. For more information, visit <http://www.ieee.org/web/aboutus/whatis/policies/p9-26.html>.

No part of this publication may be reproduced in any form, in an electronic retrieval system, or otherwise, without the prior written permission of the publisher.

*To order IEEE Press Publications, call 1-800-678-IEEE.
Find IEEE standards and standards-related product listings at: <http://standards.ieee.org>*

NOTICE AND DISCLAIMER OF LIABILITY CONCERNING THE USE OF IEEE SA INDUSTRY CONNECTIONS DOCUMENTS

This IEEE Standards Association (“IEEE SA”) Industry Connections publication (“Work”) is not a consensus standard document. Specifically, this document is NOT AN IEEE STANDARD. Information contained in this Work has been created by, or obtained from, sources believed to be reliable, and reviewed by members of the IEEE SA Industry Connections activity that produced this Work. IEEE and the IEEE SA Industry Connections activity members expressly disclaim all warranties (express, implied, and statutory) related to this Work, including, but not limited to, the warranties of: merchantability; fitness for a particular purpose; non-infringement; quality, accuracy, effectiveness, currency, or completeness of the Work or content within the Work. In addition, IEEE and the IEEE SA Industry Connections activity members disclaim any and all conditions relating to: results; and workmanlike effort. This IEEE SA Industry Connections document is supplied “AS IS” and “WITH ALL FAULTS.”

Although the IEEE SA Industry Connections activity members who have created this Work believe that the information and guidance given in this Work serve as an enhancement to users, all persons must rely upon their own skill and judgment when making use of it. IN NO EVENT SHALL IEEE OR IEEE SA INDUSTRY CONNECTIONS ACTIVITY MEMBERS BE LIABLE FOR ANY ERRORS OR OMISSIONS OR DIRECT, INDIRECT, INCIDENTAL, SPECIAL, EXEMPLARY, OR CONSEQUENTIAL DAMAGES (INCLUDING, BUT NOT LIMITED TO: PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES; LOSS OF USE, DATA, OR PROFITS; OR BUSINESS INTERRUPTION) HOWEVER CAUSED AND ON ANY THEORY OF LIABILITY, WHETHER IN CONTRACT, STRICT LIABILITY, OR TORT (INCLUDING NEGLIGENCE OR OTHERWISE) ARISING IN ANY WAY OUT OF THE USE OF THIS WORK, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGE AND REGARDLESS OF WHETHER SUCH DAMAGE WAS FORESEEABLE.

Further, information contained in this Work may be protected by intellectual property rights held by third parties or organizations, and the use of this information may require the user to negotiate with any such rights holders in order to legally acquire the rights to do so, and such rights holders may refuse to grant such rights. Attention is also called to the possibility that implementation of any or all of this Work may require use of subject matter covered by patent rights. By publication of this Work, no position is taken by the IEEE with respect to the existence or validity of any patent rights in connection therewith. The IEEE is not responsible for identifying patent rights for which a license may be required, or for conducting inquiries into the legal validity or scope of patents claims. Users are expressly advised that determination of the validity of any patent rights, and the risk of infringement of such rights, is entirely their own responsibility. No commitment to grant licenses under patent rights on a reasonable or non-discriminatory basis has been sought or received from any rights holder. The policies and procedures under which this document was created can be viewed at <http://standards.ieee.org/about/sasb/iccom/>.

This Work is published with the understanding that IEEE and the IEEE SA Industry Connections activity members are supplying information through this Work, not attempting to render engineering or other professional services. If such services are required, the assistance of an appropriate professional should be sought. IEEE is not responsible for the statements and opinions advanced in this Work.

Table of Contents

SCOPE	5
PURPOSE	5
INTRODUCTION	6
STREAM AND FLOW CHARACTERIZATION	7
USES FOR STREAM AND FLOW IDENTIFICATION	7
INTERWORKING OF STREAMS AND FLOWS	11
STANDARDIZATION IMPLICATIONS	11
CONCLUSION	11
CITATIONS	12

Scope

The scope of this report is the characterization, from a unified perspective, of network streams and flows in IEEE 802 networks, and in some networks that are typically connected to IEEE 802 networks, including an assessment of the process of interworking flows and streams across network boundaries and the feasibility and value of such interworking in achieving end-to-end flow management and QoS. Standardization implications are identified.

Purpose

By taking a unified perspective toward the assessment of network streams and flows, this document is intended to encourage a common understanding of concepts that are largely considered from a unique perspective in each network technology. That unified perspective is intended to motivate efforts to consider procedures to interwork streams and flows across network boundaries, so that QoS characteristics that are managed within a single network by stream and flow control can be joined across network boundaries, allowing a level of end-to-end QoS control. The intention is not to specify interworking protocols but ideally to identify particular network pairs that can benefit from stream and flow interworking, assess the feasibility of such interworking in those cases, identify gaps preventing interworking, and identify standardization activities that would promote successful interworking.

Introduction

This document has been developed within the IEEE 802 IEEE 802 “Network Enhancements for the Next Decade” Industry Connections Activity (Nendica) in accordance with the Nendica Work Item on “Network Stream and Flow Interworking” **Error! Reference source not found.**¹).

Network Streams and Flows

Network traffic is increasingly managed as a set of streams or flows rather than series of frames or packets. IEEE 802 networks have developed and utilized flow concepts; e.g.:

- IEEE 802.11 Parameterized Traffic Streams (TSs)
- IEEE 802.1 TSN Streams for time-sensitive networking (various standards)
- IEEE Std 1722 Audio/Video Transport Protocol (AVTP) streams
- IEEE 802.1Qcz Congestion isolation
- IEEE 802.16 Service Flows for all traffic
- IEEE 802.15.4 use of Guaranteed Time Slots

Non-802 networks have developed and utilized flow concepts:

- MEF Carrier Ethernet Virtual Connections
- IETF DetNet
- IETF RAW
- Software-Defined Networking, including OpenFlow
- DOCSIS Service Flows
- 3GPP Bearers
- IP flows (DSCP; IPV6 flow identifier)
- other

While these network streams and flows can be characterized by various parameters and are qualitatively different concepts in different networks, some characteristics are common. Here we attempt to generalize the concept of a stream or flow into a definition suitable for use in this report...

¹Information on references can be found at the end of the document in the Citations section.

Uses for Stream and Flow identification

Stream and flows can be used for:

Stream and Flow Characterization

Stream and flows can be characterized by parameters including:

- Specification document
- Network architecture
- Conditions
- Addressing
- End station
- Control
- Flow-sensitive elements
- Flow name
- Flow identification
- Flow quantity
- Flow descriptor
- Flow addition process
- Flow deletion process
- Flow change process
- Flow QoS properties
- Frame classification
- Request/grant system and polling services
- Admission control
- Interworking

Characteristics of Stream and Flow Concepts in Specific Networks

IEEE 802.11 Traffic Streams

Characteristic	IEEE 802.11 Traffic Streams	notes
Specification document	IEEE Std 802.11	
Sub-specification	HCCA	
Network architecture	Shared medium Point-to-Multipoint	HCCA is centralized
Conditions	Operates under CSMA/CA	Scheduling is by an AP within its BSS; not guaranteed in the presence of non-HCCA devices, or another HCCA BSS
Addressing	802 unicast	
End station	Non-AP STA	
Control	Access point (AP) scheduler	
Flow-sensitive elements	AP	
Flow name	parameterized traffic stream (TS)	
Flow identification	traffic stream identifier (TSID)	
Flow quantity	8 (3 bits)	per connection (AP+STA), per direction
Flow descriptor	traffic specification (TSPEC)	
Flow addition process	add traffic stream (ADDTS)	
Flow deletion process	delete traffic stream (DELTS)	
Flow change process	[none]	
Flow QoS properties	Nominal MSDU Size, Maximum MSDU Size, Minimum Service Interval, Maximum Service Interval, Inactivity Interval, Suspension Interval, Service Start Time, Minimum Data Rate, Mean Data Rate, Peak Data Rate, Burst Size, Delay Bound, Minimum PHY Rate, Surplus Bandwidth Allowance, Medium Time	9.4.2.29
Frame classification	stream classification service (SCS)?	11.26
Request/grant system and polling services	Polled TXOP Buffer status report (BSR) [P802.11ax]	10.23.3.3
Admission control	yes	
Interworking	R.3 QoS mapping guidelines for interworking with external networks	

MEF Carrier Ethernet – Ethernet Virtual Connections

Characteristic	MEF Carrier Ethernet	notes
Specification document	MEF 6.3	and other MEF specs
Sub-specification	EVC: Ethernet Virtual Private Line (EVPL) Ethernet Virtual Private LAN (EVP-LAN) Ethernet Virtual Private Tree (EVP-Tree)	port-based services are not included here
Network architecture	Shared medium EVC Type: Point-to-Point, Multipoint-to-Multipoint, or Rooted-Multipoint	
Conditions		
Addressing	IEEE 802 48-bit address	
End station	Ethernet connected at port (UNI)	
Control		
Flow-sensitive elements	bridges or other operator elements	
Flow name	service	
Flow identification	Customer-Edge VLAN ID	
Flow quantity	4094 (12 bits)	
Flow descriptor	Service attributes	
Flow addition process	manual (historically)	may be automated per MEF Lifecycle Service Orchestration (LSO)
Flow deletion process	manual (historically)	may be automated per MEF Lifecycle Service Orchestration (LSO)
Flow change process	manual (historically)	may be automated per MEF Lifecycle Service Orchestration (LSO)
Flow QoS properties	many	
Frame classification	unspecified	
Request/grant system and polling services	None; full-duplex system, reservation-based	
Admission control	Yes	
Interworking	unspecified	

DOCSIS Service Flows

Characteristic	DOCSIS	notes
Specification document	DOCSIS 4.0 MAC and Upper Layer Protocols Interface Specification	key features date to DOCSIS 1.1
Sub-specification		
Network architecture	point-to-multipoint	
Conditions		
Addressing	IEEE 802 48-bit address	
End station	cable modem (CM)	
Control	cable modem termination system (CMTS)	
Flow-sensitive elements	CMTS and CM	
Flow name	service flow	unidirectional
Flow identification	service identifier (SID)	Service flows are identified by SFID and described by QoS parameters. Active service flows are assigned an SID.
Flow quantity	SID 14 bits	SFID is 32 bits
Flow descriptor	QoS Parameter Set	
Flow addition process	Dynamic Service Addition	
Flow deletion process	Dynamic Service Deletion	
Flow change process	Dynamic Service Change	
Flow QoS properties	Traffic Priority, Maximum Sustained Traffic Rate, Maximum Traffic Burst, Minimum Reserved Traffic Rate, etc.	
Frame classification	Upstream and Downstream Classifiers; Payload Header Suppression Rules;	
Request/grant system and polling services	Upstream Service Flow Scheduling Services, including Unsolicited Grant Service (UGS), Real-Time Polling Service (rtPS), Unsolicited Grant Service with Activity Detection (UGS-AD), Non-Real-Time Polling Service (nrtPS) and Best Effort (BE) service	
Admission control	yes	
Interworking		

Interworking of Streams and Flows

1. Value of interworking
2. Feasibility of interworking
3. Network combinations of practical interest

Standardization Implications

Suggestions for standardization

Conclusion

Conclusions regarding network stream and flow interworking

Citations

- [1] "IEEE 802 Nendica Work Item Proposal: Network Stream and Flow Interworking," 2020-02-20
<https://mentor.ieee.org/802.1/dcn/1-20-0004-04-ICne.pdf>
- [2] Marks, Roger; de la Oliva, Antonio; and Wuesteney, Lukas, "Deterministic WLAN: A problem of scheduling and identifiers" 2019-11-11
<https://mentor.ieee.org/802.1/dcn/1Parta>
- [3] Marks, Roger, "Examples of Stream and Flow Characterization" 2020-04-23
<https://mentor.ieee.org/802.1/dcn/1-20-0028-01-ICne.docx>
- [4] IEEE 802.1 Time-Sensitive Networking (TSN) Task Group webpage,
<https://1.ieee802.org/tsn/>
- [5] P802.11ax ("Enhancements for High Efficiency WLAN", draft)
https://standards.ieee.org/project/802_11ax.html
- [6] P802.11be ("Enhancements for Extremely High Throughput", pre-draft)
https://standards.ieee.org/project/802_11be.html
- [7] IEEE Std 802.1Q-2018 (Revision of IEEE Std 802.1Q-2011), IEEE Standard for Local and metropolitan area networks—Bridges and Bridged Networks, July 2019,
<https://ieeexplore.ieee.org/document/8686439/>
- [8] IEEE Std 802.1CF-2019, IEEE Recommended Practice for Network Reference Model and Functional Description of IEEE 802® Access Network, May 2019,
[https://ieeexplore.ieee.org/document/8726453.](https://ieeexplore.ieee.org/document/8726453)