International Telecommunication Union

ITU-T

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

G.8264/Y.1364

Amendment 1
(03/2018)

SERIES G: TRANSMISSION SYSTEMS AND MEDIA, DIGITAL SYSTEMS AND NETWORKS

Packet over Transport aspects – Synchronization, quality and availability targets

SERIES Y: GLOBAL INFORMATION INFRASTRUCTURE, INTERNET PROTOCOL ASPECTS, NEXT-GENERATION NETWORKS, INTERNET OF THINGS AND SMART CITIES

Internet protocol aspects – Transport

Distribution of timing information through packet networks

Amendment 1

Recommendation ITU-T G.8264/Y.1364 (2017) – Amendment 1

Documents
Document Sharing Hub

Copyright International Telecommunication Union/ITU Telcommunication Sector
Provided by IHS Markit under license with ITU-T
No reproduction or networking permitted without license from IHS
Licensee=/, User=,
Not for Resale,
Full document details: ITU-T Y.1364 AMD 1 2018

ITU-T G-SERIES RECOMMENDATIONS

TRANSMISSION SYSTEMS AND MEDIA, DIGITAL SYSTEMS AND NETWORKS

INTERNATIONAL TELEPHONE CONNECTIONS AND CIRCUITS	G.100–G.199
GENERAL CHARACTERISTICS COMMON TO ALL ANALOGUE CARRIER-TRANSMISSION SYSTEMS	G.200–G.299
INDIVIDUAL CHARACTERISTICS OF INTERNATIONAL CARRIER TELEPHONE SYSTEMS ON METALLIC LINES	G.300–G.399
GENERAL CHARACTERISTICS OF INTERNATIONAL CARRIER TELEPHONE SYSTEMS ON RADIO-RELAY OR SATELLITE LINKS AND INTERCONNECTION WITH METALLIC LINES	G.400–G.449
COORDINATION OF RADIOTELEPHONY AND LINE TELEPHONY	G.450–G.499
TRANSMISSION MEDIA AND OPTICAL SYSTEMS CHARACTERISTICS	G.600–G.699
DIGITAL TERMINAL EQUIPMENTS	G.700–G.799
DIGITAL NETWORKS	G.800–G.899
DIGITAL SECTIONS AND DIGITAL LINE SYSTEM	G.900–G.999
MULTIMEDIA QUALITY OF SERVICE AND PERFORMANCE – GENERIC AND USER-RELATED ASPECTS	G.1000–G.1999
TRANSMISSION MEDIA CHARACTERISTICS	G.6000–G.6999
DATA OVER TRANSPORT – GENERIC ASPECTS	G.7000–G.7999
PACKET OVER TRANSPORT ASPECTS	G.8000–G.8999
Ethernet over Transport aspects	G.8000–G.8099
MPLS over Transport aspects	G.8100–G.8199
Synchronization, quality and availability targets	**G.8200–G.8299**
Service Management	G.8600–G.8699
ACCESS NETWORKS	G.9000–G.9999

For further details, please refer to the list of ITU-T Recommendations.

Documents
Document Sharing Hub

Copyright International Telecommunication Union/ITU Telcommunication Sector
Provided by IHS Markit under license with ITU-T
No reproduction or networking permitted without license from IHS
Licensee=/, User=,
Not for Resale,
Full document details: ITU-T Y.1364 AMD 1 2018

Recommendation ITU-T G.8264/Y.1364

Distribution of timing information through packet networks

Amendment 1

Summary

Recommendation ITU-T G.8264/Y.1364 outlines aspects of distribution of timing information through packet networks and initially focuses on Ethernet networks. A number of methods may be used to transfer frequency which may be physical-layer based or protocol-layer based. This Recommendation provides information on architectural aspects of timing flows in Ethernet networks which will form the basis for future work related to time and phase transfer.

This Recommendation specifies the synchronization status message (SSM) protocol and formats for use with synchronous Ethernet. Adherence to the SSM formats specified in this Recommendation is required in order to ensure interoperability between synchronous Ethernet equipment involved in frequency transfer.

Amendment 1 makes changes to incorporate the enhanced primary reference clock (ePRC) into the tables of SSM codes for synchronous Ethernet.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T G.8264/Y.1364	2008-10-29	15	11.1002/1000/9420
1.1	ITU-T G.8264/Y.1364 (2008) Cor. 1	2009-11-13	15	11.1002/1000/10433
1.2	ITU-T G.8264/Y.1364 (2008) Amd. 1	2010-09-22	15	11.1002/1000/10927
1.3	ITU-T G.8264/Y.1364 (2008) Cor. 2	2012-02-13	15	11.1002/1000/11526
1.4	ITU-T G.8264/Y.1364 (2008) Amd. 2	2012-02-13	15	11.1002/1000/11525
2.0	ITU-T G.8264/Y.1364	2014-05-14	15	11.1002/1000/12192
2.1	ITU-T G.8264/Y.1364 (2014) Amd. 1	2015-01-13	15	11.1002/1000/12390
2.2	ITU-T G.8264/Y.1364 (2014) Amd. 2	2016-04-13	15	11.1002/1000/12810
3.0	ITU-T G.8264/Y.1364	2017-08-29	15	11.1002/1000/13321
3.1	ITU-T G.8264/Y.1364 (2017) Amd. 1	2018-03-16	15	11.1002/1000/13547

Keywords

ESMC, packet timing, physical timing, synchronization, synchronous Ethernet.

* To access the Recommendation, type the URL http://handle.itu.int/ in the address field of your web browser, followed by the Recommendation's unique ID. For example, http://handle.itu.int/11.1002/1000/11830-en.

Documents
Document Sharing Hub

Copyright International Telecommunication Union/ITU Telcommunication Sector
Provided by IHS Markit under license with ITU-T
No reproduction or networking permitted without license from IHS
Licensee=/, User=,
Not for Resale,
Full document details: ITU-T Y.1364 AMD 1 2018

FOREWORD

The International Telecommunication Union (ITU) is the United Nations specialized agency in the field of telecommunications, information and communication technologies (ICTs). The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of ITU. ITU-T is responsible for studying technical, operating and tariff questions and issuing Recommendations on them with a view to standardizing telecommunications on a worldwide basis.

The World Telecommunication Standardization Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

The approval of ITU-T Recommendations is covered by the procedure laid down in WTSA Resolution 1.

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

NOTE

In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

Compliance with this Recommendation is voluntary. However, the Recommendation may contain certain mandatory provisions (to ensure, e.g., interoperability or applicability) and compliance with the Recommendation is achieved when all of these mandatory provisions are met. The words "shall" or some other obligatory language such as "must" and the negative equivalents are used to express requirements. The use of such words does not suggest that compliance with the Recommendation is required of any party.

INTELLECTUAL PROPERTY RIGHTS

ITU draws attention to the possibility that the practice or implementation of this Recommendation may involve the use of a claimed Intellectual Property Right. ITU takes no position concerning the evidence, validity or applicability of claimed Intellectual Property Rights, whether asserted by ITU members or others outside of the Recommendation development process.

As of the date of approval of this Recommendation, ITU had not received notice of intellectual property, protected by patents, which may be required to implement this Recommendation. However, implementers are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database at http://www.itu.int/ITU-T/ipr/.

© ITU 2018

All rights reserved. No part of this publication may be reproduced, by any means whatsoever, without the prior written permission of ITU.

Documents
Document Sharing Hub
Copyright International Telecommunication Union/ITU Telcommunication Sector
Provided by IHS Markit under license with ITU-T
No reproduction or networking permitted without license from IHS
Licensee=/, User=,
Not for Resale,
Full document details: ITU-T Y.1364 AMD 1 2018

Table of Contents

		Page
1	Scope	1
2	References	1
3	Definitions	2
	3.1 Terms defined elsewhere	2
	3.2 Terms defined in this Recommendation	3
4	Abbreviations and acronyms	3
5	Conventions	5
6	Packet network architectures	5
	6.1 Network layers and synchronization	6
	6.2 Layer network performance impacts on synchronization	6
7	Timing flows	6
8	Functional blocks	8
9	Next generation timing architectures	9
	9.1 Current synchronization based on SDH	9
	9.2 Synchronization performance	9
	9.3 Network evolution	9
	9.4 Next generation synchronization networks	9
10	Frequency transfer using synchronous Ethernet	10
	10.1 Synchronous Ethernet: General	10
	10.2 Operation modes	11
11	SSM for synchronous Ethernet	12
	11.1 Packet-level SSM	12
	11.2 Sync selection based on SSM	13
	11.3 SSM for synchronous Ethernet: Format and protocol	13
	11.4 ESMC PDU extensions	20
	11.5 Interworking with existing synchronization networks	20
	11.6 SSM for clocks with enhanced holdover	20
12	Use of synchronous Ethernet in a multi-operator context	21
	12.1 Timing transparent transport of synchronous Ethernet client signals	21
	12.2 Synchronization service provided by the carrier operator based on an interface providing a physical timing reference (generation of synchronous Ethernet interface)	22
13	Synchronization management aspects	23
Annex A – Reference source selection mechanism		24
	A.1 Requirements	24
	A.2 Inputs	24

Documents
Document Sharing Hub
Copyright International Telecommunication Union/ITU Telcommunication Sector
Provided by IHS Markit under license with ITU-T
No reproduction or networking permitted without license from IHS
Licensee=/, User=,
Not for Resale,
Full document details: ITU-T Y.1364 AMD 1 2018

Page

A.3 Internal oscillator 24
A.4 Internal physical timing flows – Frequency ETY 24
A.5 Selection mechanism 24
A.6 Synchronization status message selection 25
A.7 Hybrid equipment selection function 25
Appendix I – Examples of timing flows 27
Appendix II – Functional models based on ITU-T G.805 and ITU-T G.809 29
II.1 Background 29
II.2 Application of ITU-T G.805 to the IWF 29
II.3 Timing information transported over layer networks 30
II.4 Functional model of Ethernet physical layer timing 31
II.5 Functional model for differential and adaptive methods 31
Bibliography 34

Copyright International Telecommunication Union/ITU Telcommunication Sector
Provided by IHS Markit under license with ITU-T
No reproduction or networking permitted without license from IHS
Licensee=/, User=,
Not for Resale,
Full document details: ITU-T Y.1364 AMD 1 2018
Documents
Document Sharing Hub

Recommendation ITU-T G.8264/Y.1364

Distribution of timing information through packet networks

Amendment 1

Editorial note: This is a complete-text publication. Modifications introduced by this amendment are shown in revision marks relative to Recommendation ITU-T G.8264/Y.1364 (2017).

1 Scope

This Recommendation outlines the requirements on Ethernet networks with respect to frequency transfer. It specifies the synchronization status message (SSM) transport channel namely the Ethernet synchronization messaging channel (ESMC), protocol behaviour and message format.

A number of methods may be used to transfer frequency which may be physical-layer based or protocol-layer based. The method used will be dependent on the actual architecture and what may be supported. This Recommendation focuses on physical layer synchronization. The physical layer that is relevant to this Recommendation is the Ethernet media types defined in [IEEE 802.3]. Other physical layers may also be relevant and may be addressed, along with other packet technologies, in future versions of this Recommendation.

This Recommendation also details the required architecture in formal modelling language. Timing flows are used to describe where and how time and timing will flow through the architecture. Such flows describe what is functionally allowed as an acceptable timing source. Such a source may only be available for use within the equipment or may be available outside as a client service.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

[ITU-T G.709] Recommendation ITU-T G.709/Y.1331 (2016), *Interfaces for the optical transport network*.
<http://www.itu.int/rec/T-REC-G.709/>

[ITU-T G.781] Recommendation ITU-T G.781 (2017), *Synchronization layer functions*.
<http://www.itu.int/rec/T-REC-G.781>

[ITU-T G.803] Recommendation ITU-T G.803 (2000), *Architecture of transport networks based on the synchronous digital hierarchy (SDH)*.
<http://www.itu.int/rec/T-REC-G.803>

[ITU-T G.805] Recommendation ITU-T G.805 (2000), *Generic functional architecture of transport networks*.
<http://www.itu.int/rec/T-REC-G.805>

[ITU-T G.809] Recommendation ITU-T G.809 (2003), *Functional architecture of connectionless layer networks*.
<http://www.itu.int/rec/T-REC-G.809>

Documents
Document Sharing Hub
Copyright International Telecommunication Union/ITU Telcommunication Sector
Provided by IHS Markit under license with ITU-T
No reproduction or networking permitted without license from IHS
Licensee=/, User=,
Not for Resale,
Full document details: ITU-T Y.1364 AMD 1 2018

[ITU-T G.811] Recommendation ITU-T G.811 (1997), *Timing characteristics of primary reference clocks*.
<http://www.itu.int/rec/T-REC-G.811>

[ITU-T G.812] Recommendation ITU-T G.812 (2004), *Timing requirements of slave clocks suitable for use as node clocks in synchronization networks*.
<http://www.itu.int/rec/T-REC-G.812>

[ITU-T G.813] Recommendation ITU-T G.813 (2003), *Timing characteristics of SDH equipment slave clocks (SEC)*.
<http://www.itu.int/rec/T-REC-G.813>

[ITU-T G.822] Recommendation ITU-T G.822 (1988), *Controlled slip rate objectives on an international digital connection*.
<http://www.itu.int/rec/T-REC-G.822>

[ITU-T G.823] Recommendation ITU-T G.823 (2000), *The control of jitter and wander within digital networks which are based on the 2048 kbit/s hierarchy*.
<http://www.itu.int/rec/T-REC-G.823>

[ITU-T G.824] Recommendation ITU-T G.824 (2000), *The control of jitter and wander within digital networks which are based on the 1544 kbit/s hierarchy*.
<http://www.itu.int/rec/T-REC-G.824>

[ITU-T G.825] Recommendation ITU-T G.825 (2000), *The control of jitter and wander within digital networks which are based on the synchronous digital hierarchy (SDH)*.
<http://www.itu.int/rec/T-REC-G.825>

[ITU-T G.8010] Recommendation ITU-T G.8010/Y.1306 (2004), *Architecture of Ethernet layer networks*.
<http://www.itu.int/rec/T-REC-G.8010>

[ITU-T G.8261] Recommendation ITU-T G.8261/Y.1361 (2013), *Timing and synchronization aspects in packet networks*.
<http://www.itu.int/rec/T-REC-G.8261>

[ITU-T G.8262] Recommendation ITU-T G.8262/Y.1362 (2015), *Timing characteristics of a synchronous Ethernet equipment slave clock*.
<http://www.itu.int/rec/T-REC-G.8262>

[IEEE 802] IEEE 802-2014, *IEEE Standard for Local and Metropolitan Area Networks: Overview and Architecture*.
<http://ieeexplore.ieee.org/document/6847097/>

[IEEE 802.1AX] IEEE 802.1AX-2014, *IEEE Standard for Local and Metropolitan Area Networks – Link Aggregation*.
<http://ieeexplore.ieee.org/document/7055197/>

[IEEE 802.3] IEEE 802.3 (2015), *IEEE Standard for Ethernet*
<http://ieeexplore.ieee.org/xpl/articleDetails.jsp?arnumber=8042052>

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 network clock [ITU-T G.8261]: The clock generating the network clock signal.

3.1.2 service clock [ITU-T G.8261]: The clock generating the service clock signal.

Documents
Document Sharing Hub
Copyright International Telecommunication Union/ITU Telcommunication Sector
Provided by IHS Markit under license with ITU-T
No reproduction or networking permitted without license from IHS
Licensee=/, User=,
Not for Resale,
Full document details: ITU-T Y.1364 AMD 1 2018

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.2.1 Ethernet synchronization message channel: The logical channel carrying the synchronization status message (SSM) code representing the quality level of the synchronous Ethernet equipment clock (EEC), which is bonded to the physical layer. The structure of the channel is provided by an organizational specific slow protocol (OSSP).

3.2.2 non-sync operation mode: A synchronous Ethernet interface configured in non-synchronous mode is an interface that, for the receive side, does not pass the recovered clock to the system clock and is therefore not a candidate reference to the synchronization selection process. It does not process the Ethernet synchronization messaging channel (ESMC) that may be present and therefore cannot extract the quality level (QL) value.

On the transmit side, its output frequency might be synchronized to the synchronous Ethernet equipment clock (EEC), but this remains unknown to the receive interface at the other termination of the link. Indeed, an interface in non-synchronous mode operation does not generate an ESMC and therefore does not transmit a QL.

Such an interface does not participate to the synchronization network and is functionally identical to an asynchronous interface, as defined in [IEEE 802.3].

3.2.3 synchronous operation mode: A synchronous Ethernet interface can be configured in synchronous operation mode.

Its receive side is able to extract the frequency of its input signal and pass it to a system clock (a synchronous Ethernet equipment clock (EEC)) or a better quality clock. It processes the Ethernet synchronization messaging channel (ESMC) and extracts the quality level (QL). This signal can now be used as a candidate frequency reference.

The transmit part of the interface is locked to the output timing of the system clock and generates the ESMC to transport a QL.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

AAL1	Asynchronous transfer mode Adaptation Layer 1
AI	Adapted Information
ATM	Asynchronous Transfer Mode
BITS	Building Integrated Timing Supply
BS	Base Station
CES	Circuit Emulation Services
CI	Characteristic Information
DNU	Do Not Use
DUS	Do not Use for Synchronization
EEC	synchronous Ethernet Equipment Clock
eEEC	Enhanced Ethernet Equipment Clock
EPL	Ethernet Private Line
ePRC	~~E~~enhanced Primary Reference Clock
ePRTC	~~E~~enhanced Primary Reference Time Clock

Documents
Document Sharing Hub
Copyright International Telecommunication Union/ITU Telcommunication Sector
Provided by IHS Markit under license with ITU-T
No reproduction or networking permitted without license from IHS
Licensee=/, User=,
Not for Resale,
Full document details: ITU-T Y.1364 AMD 1 2018

ESMC	Ethernet Synchronization Messaging Channel
ETH	Ethernet MAC layer network
ETY	Ethernet PHY layer network
EVPL	Ethernet Virtual Private Line
GPS	Global Positioning System
HOP	High Order Path
IWF	Interworking Function
LAG	Link Aggregation
LOP	Low Order Path
LSB	Least Significant Bit
MAC	Media Access Control
MA-M	MAC Address – Medium
MA-S	MAC Address – Small
MPLS	Multiprotocol Label Switching
MTIE	Maximum Time Interval Error
MS	Multiplex Section
NC	Network Controller
NE	Network Element
NTP	Network Time Protocol
OAM	Operation, Administration and Maintenance
OSI	Open Systems Interconnection
OSSP	Organizational Specific Slow Protocol
OTN	Optical Transport Network
OUI	Organizationally Unique Identifier
PDH	Plesiochronous Digital Hierarchy
PDU	Protocol Data Unit
PRC	Primary Reference Clock
PRTC	Primary Reference Time Clock
PTP	Precision Time Protocol
QL	Quality Level
QL TLV	Quality Level Type Length Value
RAN	Radio Access Network
RS	Regenerator Section
SASE	Stand Alone Synchronization Equipment
SDH	Synchronous Digital Hierarchy
SETG	Synchronous Equipment Timing Generator
SETS	Synchronous Equipment Timing Source

Documents
Document Sharing Hub
Copyright International Telecommunication Union/ITU Telcommunication Sector
Provided by IHS Markit under license with ITU-T
No reproduction or networking permitted without license from IHS
Licensee=/, User=,
Not for Resale,
Full document details: ITU-T Y.1364 AMD 1 2018

SRTS	Synchronous Residual Time Stamp
SSM	Synchronization Status Message
SSU	Synchronization Supply Unit
SyncE	Synchronous Ethernet
TDEV	Time Deviation
TDM	Time Division Multiplexing
TLV	Type Length Value
UTC	Coordinated Universal Time
VC	Virtual Container
WAN	Wide Area Network
WDM	Wave Division Multiplexing

5 Conventions

Within this Recommendation, the term "Ethernet" refers to an interface as defined in [IEEE 802.3] and that does not comply with the additional timing requirements of synchronous Ethernet as specified in [ITU-T G.8261], [ITU-T G.8262] and this Recommendation.

This Recommendation defines certain bit sequences that form part of an Ethernet frame. The following conventions are used when specific values are defined.

Binary strings are represented by pairs of hexadecimal characters (octets) each separated by the dash character. This convention is consistent with the representation of hexadecimal strings of data in [IEEE 802.3]. For example, the three-byte ITU-T subtype assigned by the IEEE is represented as 00-19-A7.

In cases where no more than two octets are to be specified, the use of the prefix 0x indicates that the characters are hexadecimal. For example, 0x12 represents the binary bit sequence 00010010.

The term enhanced Ethernet equipment clock (eEEC) refers to a synchronous Ethernet equipment clock (EEC) function as defined in [ITU-T G.8262], but with enhanced performance. The performance of this clock is for further study.

6 Packet network architectures

The architectural modelling principles in [ITU-T G.805] and [ITU-T G.809] are well known and have been employed in the development of transport network equipment and networks, and recently in the specification of packet networks. Formal high-level architectural description is necessary to define the underlying details of equipment that are contained in other Recommendations.

[ITU-T G.805] defines properties of architectural components (atomic functions) that allow generic specification of network architectures. These are used, for example, to define trails (i.e., what can be monitored) and sub-network connections (i.e., what can be switched or networked). [ITU-T G.805] was developed to describe traditional (i.e., layer 1) transport networks, and has been recently extended, through [ITU-T G.809], to cover packet networks.

Key points of the architecture include the concept of a layer network, of characteristic information (CI) and of recursion. CI is a signal of a specific format that is transferred over a network connection [ITU-T G.805] or a flow [ITU-T G.809]. A layer network consists of the access points associated with a specific type of CI. Recursion within the layer model allows definitions of underlying layers without restriction. Examples of layer networks below the Ethernet MAC layer (ETH) and Ethernet PHY layer (ETY) could be, for example, that of wave division multiplexing (WDM) or even a duct.

Documents
Document Sharing Hub
Copyright International Telecommunication Union/ITU Telcommunication Sector
Provided by IHS Markit under license with ITU-T
No reproduction or networking permitted without license from IHS
Licensee=/, User=,
Not for Resale,
Full document details: ITU-T Y.1364 AMD 1 2018

Descriptions have been developed for layer networks related to synchronous digital hierarchy (SDH), asynchronous transfer mode (ATM), Ethernet and multiprotocol label switching (MPLS). It is important to note that the technologies noted above may contain multiple layers. For example, Ethernet contains the ETY and ETH layers, while SDH contains the regenerator section (RS), multiplex section (MS), high order path (HOP) and low order path (LOP) layers. Due to the recursive nature of the architecture, the same set of interconnection rules apply to any layer network.

For Ethernet, two layer networks are defined: the ETH and ETY. The CI of the ETH layer is the media access control (MAC) frames. The ETY layer is the physical layer that supports the ETH layer (e.g., 10BaseT, 100BaseT). The simplified network model for Ethernet is shown in Figure 4 of [ITU-T G.8010].

6.1 Network layers and synchronization

The layer networks that define a network technology carry information across a network. Carrying this information may result in the information passing over multiple network layers. Crossing a layer is done via an adaptation function from an upper client layer to a lower server layer. The data of the upper client layer, the CI, is adapted by the adaptation function to be the adapted information (AI) and is carried over the server layer. For certain technologies, notably time division multiplexing (TDM) and WDM, timing information is part of the CI that is carried across the network. For example, plesiochronous digital hierarchy (PDH) timing must be carried across the network. SDH adapts the timing information and carries the adapted payload with timing (in the form of stuff control bits) to allow both timing and data to exit the network.

For packet networks, not all layers will include timing information as part of the CI. Timing information is only present at the physical layer. For example, timing information is part of the synchronous ETY layer. Timing information is not part of the CI of the packet layers; therefore, timing is not carried inherently by the packet network. This has implications for certain timing-related services, such as circuit emulation, where client timing needs to be carried across a network. In these cases, for example circuit emulation, alternative methods for carrying timing information are required. The interworking functions (IWFs) described in [ITU-T G.8261] are examples of alternative methods.

6.2 Layer network performance impacts on synchronization

A layer network adapts CI from one layer to become AI of a lower layer (due to the recursive properties of layer networks, this AI is now part of the CI of the lower layer). From the perspective of timing, the adaptation process is not noise free. For example, adapting a PDH client into an SDH virtual container (VC) causes jitter due to the stuff bit mechanism (the control bits are AI), adapting the MS adds jitter and wander due to pointers. For packet networks, the switching function relies on buffering packets, resulting in packet delay variation. For time-sensitive applications, packet delay variation needs to be considered.

7 Timing flows

Timing flows represent timing information that may be carried across a layer network. This timing information may be required to support the needs of a service or those of the network, or be part of the CI of that service. For example, a TDM service must have a clock associated with it and is thus part of the CI that defines the service (e.g., E1 service which meets [ITU-T G.823]).

In existing synchronization networks, the timing information that is carried across the network is often referred to as a timing trail (see [ITU-T G.781]). This follows from the definition of "trail" in [ITU-T G.805]. In the case of packet networks, the concept of a "trail" was extended and called a "flow", first in [ITU-T G.809], to describe the possibly non-continuous nature of traffic and the case where multiple packet streams are carried over a single lower layer network connection. The concept

Documents
Document Sharing Hub
Copyright International Telecommunication Union/ITU Telcommunication Sector
Provided by IHS Markit under license with ITU-T
No reproduction or networking permitted without license from IHS
Licensee=/, User=,
Not for Resale,
Full document details: ITU-T Y.1364 AMD 1 2018

of a timing flow can be considered synonymous with that of a timing trail; however, the use of a timing flow will enable timing to cover both the packet and TDM environments.

For the purposes of physical layer frequency transfer, a timing flow is equivalent to a timing trail.

A layer network may carry multiple timing flows. For example, the SDH network may contain a number of PDH signals mapped into a single synchronous transport module level-N (STM-N) signal. At the PDH layer, each PDH signal has a timing flow associated with it. For a specific service, however, only one timing flow is generally associated with a service. In the case of packet networks, the packet layer may not contain any timing flows (e.g., timing that is part of the CI and thus needs to be carried end-to-end), but the physical layer will always contain a timing flow.

When a service of the network is defined to contain timing as part of its CI, a timing flow through the network must exist (for example, an E1 through SDH provides the timing flow across the SDH/WDM network) and appropriate mechanisms must exist if multiple layer networks are to be traversed (e.g., stuff bits representing the frequency offset are carried across the network).

For the purposes of network synchronization, three categories of timing flow are considered: physical, service and message.

Physical timing flows represent the timing flow associated with the lowest layer network that can be used for synchronization (e.g., synchronous Ethernet, SDH). The physical flows are represented by the bit transitions in a digital network.

Service timing flows represent the timing that is associated with a specific timing-sensitive service (e.g., PDH service timing). Timing flows for these services may be carried over one or more server networks. The functions defined for a layer network specify how the client signals are adapted and carried over a server network. In general, when a client signal has timing information required by the service (e.g., an E1 service), the lower layers are specified to carry this information in some fashion (e.g., the E1 carried over SDH has its timing information encoded in the stuff bytes of the VC12).

In cases where the server layer network does not carry timing intrinsically, specific mechanisms need to be defined to allow client timing to be carried within the server layer network. Doing so allows the timing information of the client to traverse the network. An example of this is TDM circuit emulation over a packet network. A packet network cannot inherently transfer the frequency information of its client, so the timing associated with the PDH client must be contained within the payload of the packet network itself. The carriage of a TDM service over a packet network is often called a *layer violation* since the lower layers cannot encapsulate all of the CI associated with a client network.

A service timing flow may not be associated with an end-user service, but would be associated with the network only. For example, timing distribution over SDH lines is not associated with any end-user service.

Message timing flows represent the third type of flow. These pertain to messages, carried over a layer network, that contain some timing-related information that will be used by an upper layer (e.g., higher than the current layer network) to derive network or service timing. Examples of message flows are network time protocol (NTP) and precision time protocol (PTP).

Message timing flows may be restricted to timing between adaptation points of a network layer only (e.g., in the case of circuit emulation) or may be carried across a layer network. In the case of carriage across a layer network, message flows are typically protocols that operate at layer 2 or layer 3.

Examples of timing flows are shown in Appendix I.

The details of combining time and frequency are for further study.

--`,,```,,,,`````-`-`,,`,,`,`,,`---

Documents
Document Sharing Hub
Copyright International Telecommunication Union/ITU Telcommunication Sector
Provided by IHS Markit under license with ITU-T
No reproduction or networking permitted without license from IHS
Licensee=/, User=,
Not for Resale,
Full document details: ITU-T Y.1364 AMD 1 2018