**IN THE UNITED STATES DISTRICT COURT
FOR THE WESTERN DISTRICT OF TEXAS
WACO DIVISION**

FAR NORTH PATENTS, LLC, Plaintiff, v. ADVA OPTICAL NETWORKING SE, Defendant.	CIVIL ACTION NO. 6:20-CV-218 ORIGINAL COMPLAINT FOR PATENT INFRINGEMENT **JURY TRIAL DEMANDED**

ORIGINAL COMPLAINT FOR PATENT INFRINGEMENT

Plaintiff Far North Patents, LLC ("Far North Patents" or "Plaintiff") files this original complaint against Defendant ADVA Optical Networking SE ("ADVA" or "Defendant"), alleging, based on its own knowledge as to itself and its own actions and based on information and belief as to all other matters, as follows:

PARTIES

1. Far North Patents is a limited liability company formed under the laws of the State of Texas, with its principal place of business at 18383 Preston Rd Suite 250, Dallas, Texas, 75252.

2. Defendant ADVA Optical Networking SE is a European company. ADVA Optical Networking SE has an office at Fraunhoferstraße 9a, 82152 Martinsried, Germany.

3. ADVA Optical Networking SE and its foreign and United States subsidiaries, affiliates, and related companies ("ADVA and its affiliates") comprise one of the world's largest manufacturers of communications equipment.

4. ADVA and its affiliates are part of the same corporate structure and distribution chain for the making, importing, offering to sell, selling, and/or using of the accused devices in the United States, including in the State of Texas generally and this judicial district in particular.

5. ADVA and its affiliates share the same management, common ownership, advertising platforms, facilities, distribution chains and platforms, and accused product lines and products involving related technologies.

6. Thus, ADVA and its affiliates operate as a unitary business venture and are jointly and severally liable for the acts of patent infringement alleged herein.

JURISDICTION AND VENUE

7. This is an action for infringement of United States patents arising under 35 U.S.C. §§ 271, 281, and 284–85, among others. This Court has subject matter jurisdiction of the action under 28 U.S.C. § 1331 and § 1338(a).

8. This Court has personal jurisdiction over ADVA pursuant to due process and/or the Texas Long Arm Statute because, *inter alia*, (i) ADVA has done and continues to do business in Texas; and (ii) ADVA has committed and continues to commit acts of patent infringement in the State of Texas, including making, using, offering to sell, and/or selling accused products in Texas, and/or importing accused products into Texas, including by Internet sales and sales via retail and wholesale stores, inducing others to commit acts of patent infringement in Texas, and/or committing a least a portion of any other infringements alleged herein. In the alternative, ADVA is subject to this Court's specific personal jurisdiction consistent with the principles of due process and the Federal Long-Arm Statute of Fed. R. Civ. P. 4(k)(2) because: (1) it has substantial contacts with the United States and committed and/or induced acts of patent

infringement in the United States; and (2) it is not subject to jurisdiction in any state's courts of general jurisdiction.

9. Venue is proper as to ADVA, which is organized under the laws of Europe. 28 U.S.C. § 1391(c)(3) provides that "a defendant not resident in the United States may be sued in any judicial district, and the joinder of such a defendant shall be disregarded in determining where the action may be brought with respect to other defendants."

BACKGROUND

10. The patents-in-suit generally pertain to communications networks and other technology used in the provision of wireless services, Voice over Internet Protocol ("VoIP") phone systems, high speed networking, and other advanced communication services. The technology disclosed by the patents was developed by personnel at Path1 Network Technologies Inc. ("Path1 Network Technologies").

11. Path1 Network Technologies is a provider of video over IP services and solutions. The patents developed at Path1 Network Technologies ("the Fellman patents") relate to providing service guarantees for time sensitive signals in computer networks. The inventors of these patents include Dr. Ronald D. Fellman and Dr. Rene L. Cruz. Drs. Fellman and Cruz, both former professors of electrical and computer engineering at the University of California at San Diego, were pioneers in network technology. Dr. Fellman was an IEEE Senior Member, and his work was published in several IEEE Transactions journals, including IEEE Transactions on Networking, IEEE Transactions on Parallel and Distributed Systems, IEEE Transactions on Systems, Man, and Cybernetics, IEEE Transactions on Signal Processing, IEEE Transactions on Very Large Scale Integration (VLSI) Systems, IEEE Transactions on Acoustics, Speech and Signal Processing. He was also a co-founder of Path1 Network Technologies and of Qvidium

Technologies. Dr. Cruz, a distinguished scholar in the field of communication networks, was said to have established the field of Network Calculus. In Dr. Cruz's election to be a Fellow of the IEEE in 2003, he was "cited for his expertise in the area of Quality-of-Service guarantees in packet-switched networks." http://jacobsschool.ucsd.edu/news/news_releases/release.sfe?id=1385.

12. The Fellman patents (or the applications leading to them) have been cited during patent prosecution hundreds of times, by numerous leading companies in the computer networking and telecommunications industries, including ABB Research, Alcatel, AMD, Amazon, AT&T, Atheros Communications, Avaya, Bose, Broadcom, Canon, Centurylink, Chi Mei Optoelectronics, Ciena, Cox Communications, Dell, Ericsson, F5 Networks, Fujitsu, General Electric, Hitachi, Honeywell, Intel, IBM, Lucent, Lutron, Microsoft, National Instruments, National Semiconductor, NEC, Nortel Networks, Oceaneering, Path1, Phillips, Qualcomm, Robert Bosch, Rockwell Automation, Samsung, Siemens, Sonos, Sony, Symantec, Texas Instruments, Toshiba, Ubiquiti Networks, Verizon, and Viasat.

COUNT I

DIRECT INFRINGEMENT OF U.S. PATENT NO. 8,306,053

13. On November 6, 2012, United States Patent No. 8,306,053 ("the '053 Patent") was duly and legally issued by the United States Patent and Trademark Office for an invention entitled "Methods and Apparatus for Providing Quality-of-Service Guarantees in Computer Networks."

14. Far North Patents is the owner of the '053 Patent, with all substantive rights in and to that patent, including the sole and exclusive right to prosecute this action and enforce the '053 Patent against infringers, and to collect damages for all relevant times.

15. ADVA made, had made, used, imported, provided, supplied, distributed, sold, and/or offered for sale products and/or systems including, for example, its ADVA FSP 150-GO102Pro and ADVA FSP 150-GE102Pro families of products that include advanced quality of service capabilities (collectively, "accused products").

(Source : Screenshot of PDF downloaded from https://www.adva.com/-/media/adva-main-site/resources/data-sheets/pdfs/fsp-150-go-102-pro-series.ashx?la=de-de&hash=5122080C1CCB4C881E30D8D62F0DF92DF16C098B)

VLAN support

- 4096 VLANs (IEEE 802.1Q customer-tagged) and stacked VLANs (Q-in-Q service provider tagged)
- 2-tag management (push/pop/swap) for c-tag and s-tag
- IEEE 802.1ad provider bridging (c-tag, s-tag)
- Ethertype translation
- Eight Ethernet virtual circuits (EVC)
- 9612 byte-per-frame MTU transparency

Layer 2 traffic management

- Acceptable client frame policy: tagged or untagged
- Service classification based on IEEE 802.1p, 802.1Q and IP-TOS/DSCP
- VLAN tag priority mapping (IEEE 802.1ad PCP encoding)
- MEF-compliant policing (CIR/CBS/EIR/EBS) with three-color marking and eight classes of service
- Port shaping on transmit for both client and network ports
- MEF 10.3 hierarchical policing with token-share envelopes
- DiffServ supporting WFQ/SP mix

(Source : Screenshot of PDF downloaded from https://www.adva.com/-/media/adva-main-site/resources/data-sheets/pdfs/fsp-150-go-102-pro-series.ashx?la=de-de&hash=5122080C1CCB4C881E30D8D62F0DF92DF16C098B)

ADVA today answered the urgent need for small cell backhaul with the launch of the world's smallest cell site gateway device. The ADVA FSP 150-GO102Pro Series has been specifically engineered to be installed in the most challenging locations, enabling the easy deployment of small cells at street level. With its uniquely compact and ruggedized design, it provides multi-layer service demarcation in a wide range of outdoor locations, from walls to poles to lampposts. The ADVA FSP 150-GO102Pro Series also delivers highly precise time and frequency synchronization and features automated testing and in-service monitoring. With the ADVA FSP 150-GO102Pro Series, service providers can easily and cost-effectively introduce next-generation mobile connectivity services for the IoT and 5G era. The new solution is already in customer trials and is generally available from today.

"Our FSP 150-GO102Pro Series is the ultimate outdoor demarcation technology. It ensures the highest quality of service even in the harshest conditions. This phenomenally versatile device empowers operators to deliver reliable, programmable mobile backhaul connectivity without investing in expensive cabinets or power-hungry air conditioning systems," said Stephan Rettenberger, SVP, marketing and investor relations, ADVA. "We worked closely with major wholesale service providers to develop our FSP 150-GO102Pro Series. The solution is specifically engineered to meet their exacting requirements and facilitate their 5G ambitions. It offers full Layer 2 and 3 service demarcation with a complete set of Carrier Ethernet and routing features. The FSP 150-GO102Pro Series even provides highly automated zero touch provisioning for effortless installation and activation."

(Source : https://www.newswiretoday.com/news/168708/)

ADVA™

FSP 150-GE100Pro Series

Programmable Carrier Ethernet and IP demarcation

As complexity increases, network demarcation devices need to continuously extend their capabilities. Communication service provider need one product family for Ethernet and IP, indoor or outdoor, sophisticated security and highly precise synchronization.

Change is the norm. Today, your business customer wants Ethernet connectivity. Tomorrow, it's IP services. Frequency synchronization is no longer sufficient for your mobile network as time synchronization is mandatory for 4G. Meanwhile, your customers decide that they won't accept unencrypted transmission. The one constant is that requirements keep changing – and at an unprecedented pace. Our FSP 150-GE100Pro series belongs to the successful FSP 150 ProNID family. It enables network operators to offer true multi-service access by combining the demarcation of Carrier Ethernet 2.0 and IP services with a rich set of features in a single device. What's more, there's a range of designs from ultra-compact to rack-mountable devices, all aligned with distinct customer demand. The comprehensive FSP 150-GE100Pro series provides the perfect answer to any demarcation requirement.

(Source : Screenshot of PDF downloaded from https://www.adva.com/-/media/adva-main-site/resources/data-sheets/pdfs/fsp-150-ge-100-pro-series.ashx?la=de-DE&hash=46C2728AB543DEB24ECC9B31953C3463C4325AB5)

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- Ethertype translation
- $8^{1-2}/32^{3-5}/64^{6-10}$ Ethernet virtual circuits (EVC)
- 9612 Byte per frame MTU transparency
- EoMPLS encapsulation

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16. By doing so, ADVA has directly infringed (literally and/or under the doctrine of equivalents) at least Claims 1 and 14 of the '053 Patent. ADVA's infringement in this regard is ongoing.

17. ADVA has infringed the '053 Patent by making, having made, using, importing, providing, supplying, distributing, selling or offering for sale products including a device adapter comprising a transmission unit configured to transmit data from a real time device via a network according to a time frame, wherein the time frame is substantially synchronized in the device adapter and at least one other device adapter, the time frame repeating periodically and including a plurality of assigned time phases and a free access phase. For example, the accused products are configured to be used to implement the IEEE 802.1Q standard. IEEE standard 802.1Q implements a method in which a time aware bridged LAN transmits data from one end point i.e., Precision Time Protocol ("PTP") instance to another. The endpoints transmit data that is a mix

of time-critical traffic and other traffic, (i.e., real time data and non-real time data) via PTP instances such as bridges (device adapters). The end point can be either a real time device or a non-real time device. The bridged network uses 802.1AS base time to synchronize all the clocks of ports associated with bridges (device adapters). Using the Best Master Clock Algorithm, the synchronization time signal is transmitted from a grandmaster to other ports. IEEE Std. 802.1AS™-2011 is normative and essential to implement an IEEE Std. 802.1Q Compliant System. IEEE Std. 802.1Q-2018 defines parameters, such as AdminBaseTime and OpenBaseTime, which are used to synchronize the clocks across the network. The bridges containing ports schedule the transmission of traffic based on the synchronized time. Each port associated with a specific set of transmission queues includes a plurality of transmission gates. A transmission gate can be in a closed state or open state. The functionality of assigned time phases is achieved using open gates transmitting data packets during transmission time. The functionality of a free access phase is achieved when the gates are opened for transmission during any time. IEEE Std. 802.1Q-2018 supports cyclic queuing and forwarding structures to create synchronized frames and gates which repeat periodically (Annex T).

1.1 Project Number: P802.1Qbv
1.2 Type of Document: Standard
1.3 Life Cycle: Full Use

2.1 Title: Standard for Local and metropolitan area networks--Media Access Control (MAC) Bridges and Virtual Bridged Local Area Networks Amendment: Enhancements for Scheduled Traffic

5.2.b. Scope of the project: This amendment specifies time-aware queue-draining procedures, managed objects and extensions to existing protocols that enable bridges and end stations to schedule the transmission of frames based on a synchronized time. Virtual Local Area Network (VLAN) tag encoded priority values are allocated allowing simultaneous support of scheduled traffic, credit-based shaper traffic and other bridged traffic over Local Area Networks (LANs).

(Source: http://www.ieee802.org/1/files/public/docs2014/bv-p802-1Qbv-par-modification-1114.pdf)

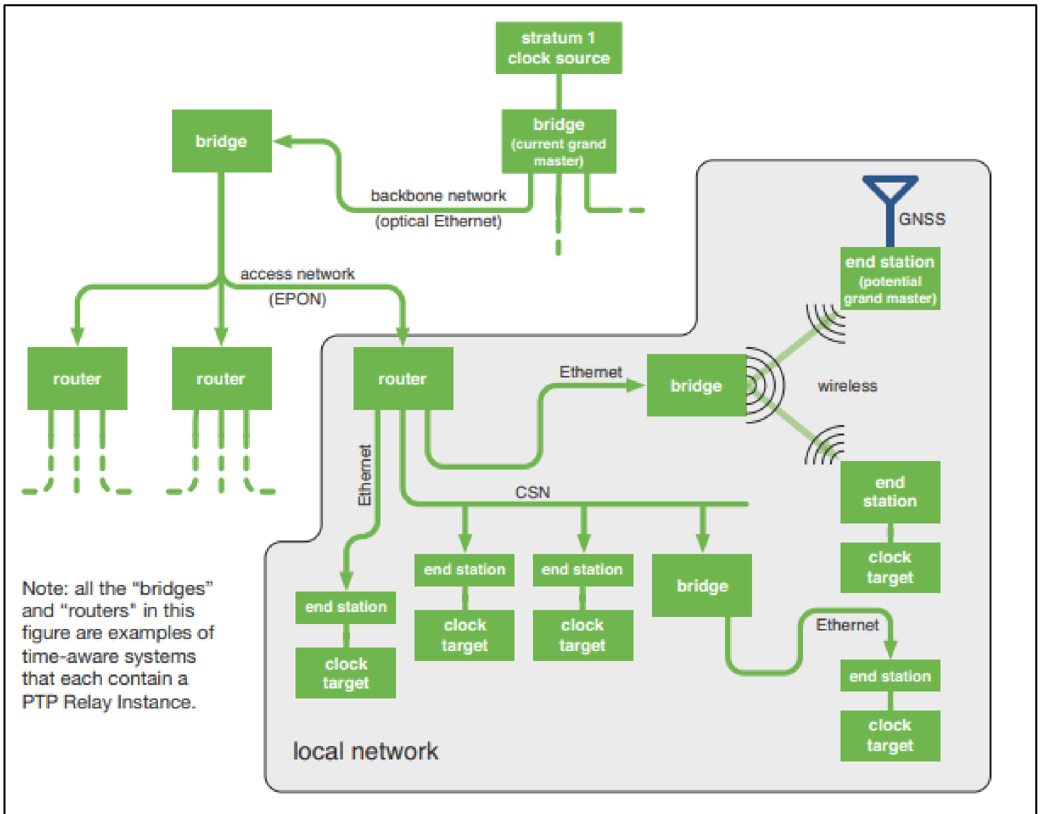

Figure 7-1—Time-aware network example

(Source: https://1.ieee802.org/wp-content/uploads/2019/03/802-1AS-rev-d8-0.pdf)

7.2 Architecture of a time-aware network

7.2.1 General

A time-aware network consists of a number of interconnected time-aware systems that support the gPTP defined within this standard. These time-aware systems can be any networking device, including, for example, bridges, routers, and end stations. A set of time-aware systems that are interconnected by gPTP-capable network elements is called a *gPTP network*. Each instance of gPTP that the time-aware systems support is in one *gPTP domain*, and the instances of gPTP are said to be part of that gPTP domain. A time-aware system can support, and therefore be part of, more than one gPTP domain. The entity of a single time-aware system that executes gPTP in one gPTP domain is called a PTP Instance. A time-aware system can contain multiple PTP Instances, which are each associated with a different gPTP domain. There are two

(Source: https://1.ieee802.org/wp-content/uploads/2019/03/802-1AS-rev-d8-0.pdf)

3.16 PTP End Instance: A PTP Instance that is capable of acting as the source of synchronized time on the network, or destination of synchronized time using the IEEE 802.1AS protocol, or both.

3.17 PTP Instance: A PTP Relay Instance or a PTP End Instance. A PTP Instance implements those portions of this standard indicated as applicable to a PTP Relay Instance or a PTP End Instance. Each PTP Instance operates in exactly one domain.

3.18 PTP Link: Within a domain, a network segment between two PTP Ports using the peer-to-peer delay mechanism of this standard. The peer-to-peer delay mechanism is designed to measure the propagation time over such a link.

NOTE—A PTP Link between PTP Ports of PTP Instances is also a gPTP Communication Path (see 3.9).

3.19 PTP Relay Instance: A PTP Instance that is capable of communicating synchronized time received on one port to other ports, using the IEEE 802.1AS protocol.

NOTE—A PTP Relay Instance could, for example, be contained in a bridge, a router, or a multi-port end station.

(Source: https://1.ieee802.org/wp-content/uploads/2019/03/802-1AS-rev-d8-0.pdf)

Traffic scheduling

This annex provides some background to the mechanisms provided in this standard for traffic scheduling, with the intent of providing some insight into the motivation for the provision of mechanisms for traffic scheduling and some of the ways that the mechanisms might be used.

Q.1 Motivation

Some applications have a need for frame delivery that is highly predictable in terms of the time at which frame transmission will occur, and the overall latency and jitter that will be experienced as the frame is propagated to its destination. Examples include industrial and automotive control applications, where data transmitted over the network is used to feed the parameters of control loops that are critical to the operation of the plant or machinery involved, and where frames carrying control data are transmitted on a repeating time schedule; late delivery of such frames can result in instability, inaccuracy, or failure of the operation of the control loops concerned. In some implementations, this need has been met by the provision of dedicated, highly engineered networks that are used solely for the transmission of time-critical control traffic; however, as the bandwidth occupied by such traffic is often low, and the cost of providing a dedicated control network can be high, it can be desirable to mix time-critical traffic with other classes of traffic in the same network, as long as such mixing can be achieved while still meeting the timing requirements of the time-critical traffic.

(Source: IEEE Standard for Local and metropolitan area networks— Bridges and Bridged Networks Amendment 25: Enhancements for Scheduled Traffic (IEEE 802.1Qbv-2015))

b) gPTP specifies a media-independent sublayer that simplifies the integration within a single timing domain of multiple different networking technologies with radically different media access protocols. gPTP specifies a media-dependent sublayer for each medium. The information exchanged between PTP Instances has been generalized to support different packet formats and management schemes appropriate to the particular networking technology. IEEE Std 1588-2019, on the other

(Source: https://1.ieee802.org/wp-content/uploads/2019/03/802-1AS-rev-d8-0.pdf)

7.2.2 Time-aware network consisting of a single gPTP domain

Figure 7-1 illustrates an example time-aware network consisting of a single gPTP domain, using all theabove network technologies (i.e., (c) - (f) of 7.2.1), where end stations on several local networks are connected to a grandmaster on a backbone network via an EPON access network.

Any PTP Instance with clock sourcing capabilities can be a potential grandmaster, so there is a selection method (the *best master clock algorithm*, or BMCA) that ensures that all of the PTP Instances in a gPTP domain use the same grandmaster.[12] The BMCA is largely identical to that used in IEEE Std 1588-2019,

(Source: https://1.ieee802.org/wp-content/uploads/2019/03/802-1AS-rev-d8-0.pdf)

10.3.1.1 Best master clock algorithm overview

In the BMCA (i.e., method (a) of 10.3.1), best master selection information is exchanged between PTP Instances of time-aware systems via Announce messages (see 10.5 and 10.6). Each Announce message contains time-synchronization spanning tree vector information that identifies one PTP Instance as the root of the time-synchronization spanning tree and, if the PTP Instance is grandmaster-capable, the grandmaster. Each PTP Instance in turn uses the information contained in the Announce messages it receives, along with its knowledge of itself, to compute which of the PTP Instances that it has knowledge of ought to be the root of the spanning tree and, if grandmaster-capable, the grandmaster. As part of constructing the time-synchronization spanning tree, each port of each PTP Instance is assigned a port state from Table 10-2 by state machines associated with the ports and with the PTP Instance as a whole.

(Source: https://1.ieee802.org/wp-content/uploads/2019/03/802-1AS-rev-d8-0.pdf)

c) In gPTP there are only two types of PTP Instances: PTP End Instances and PTP Relay Instances, while IEEE 1588 has ordinary clocks, boundary clocks, end-to-end transparent clocks, and P2P transparent clocks. A PTP End Instance corresponds to an IEEE 1588 ordinary clock, and a PTP Relay Instance is a type of IEEE 1588 boundary clock where its operation is very tightly defined, so much so that a PTP Relay Instance with Ethernet ports can be shown to be mathematically equivalent to a P2P transparent clock in terms of how synchronization is performed, as shown in

(Source: https://1.ieee802.org/wp-content/uploads/2019/03/802-1AS-rev-d8-0.pdf)

- **Grand Master selection**
  - GM-capable stations advertise themselves via ANNOUNCE messages
  - If a station hears from station with "better" clock, it does not send ANNOUNCE
    - Configurable "Priority" field can override clock quality
    - MAC address is tie breaker
  - Time relays drop all inferior ANNOUNCE messages
    - Forward only the best
  - Last one standing is Grand Master for the domain
    - GM is the root of the 802.1AS timing tree
    - GM periodically sends the current time

(Source: https://avnu.org/wp-content/uploads/2014/05/as-kbstanton-8021AS-tutorial-0714-v01.pdf)

IEEE Std 802.1Q-2018
IEEE Standard for Local and Metropolitan Area Networks—Bridges and Bridged Networks

2. Normative references

The following referenced documents are indispensable for the application of this document (i.e., they must be understood and used, so each referenced document is cited in the text and its relationship to this document is explained). For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments or corrigenda) applies.

ANSI X3.159, American National Standards for Information Systems—Programming Language—C.[5]

IEEE Std 802®, IEEE Standard for Local and metropolitan area networks: Overview and Architecture.[6,7]

IEEE Std 802.1AB™, IEEE Standard for Local and metropolitan area networks—Station and Media Access Control Connectivity Discovery.

IEEE Std 802.1AC™, IEEE Standard for Local and metropolitan area networks—Media Access Control (MAC) Service Definition.

IEEE Std 802.1AE™, IEEE Standard for Local and metropolitan area networks—Media Access Control (MAC) Security.

IEEE Std 802.1AS™, IEEE Standard for Local and metropolitan area networks—Timing and Synchronization for Time-Sensitive Applications in Bridged Local Area Networks.

(Source: IEEE Standard for Local and Metropolitan Area Networks—Bridges and Bridged Networks- IEEE Std 802.1Q™-2018)

8.6.9.4.1 AdminBaseTime

The administrative value of base time, expressed as an IEEE 1588 precision time protocol (PTP) [B24] timescale (see 8.2 of IEEE Std 802.1AS™-2011 [B11]). This value can be changed by management, and is used by the List Config state machine (8.6.9.3) to set the value of OperBaseTime (8.6.9.4.18).

NOTE—Time is expressed in the PTP timescale as the number of seconds, nanoseconds, and fractional nanoseconds that have elapsed since 1 January 1970 00:00:00 TAI.

NOTE 2—If AdminBaseTime is set to the same time in the past in all bridges and end stations, OperBaseTime is always in the past, and all cycles start synchronized. Using AdminBaseTime in the past is appropriate when you can start schedules prior to starting the application that uses the schedules. Use of AdminBaseTime in the future is intended to change a currently running schedule in all bridges and end stations to a new schedule at a future time. Using AdminBaseTime in the future is appropriate when schedules must be changed without stopping the application.

(Source: IEEE Standard for Local and Metropolitan Area Networks—Bridges and Bridged Networks- IEEE Std 802.1Q™-2018)

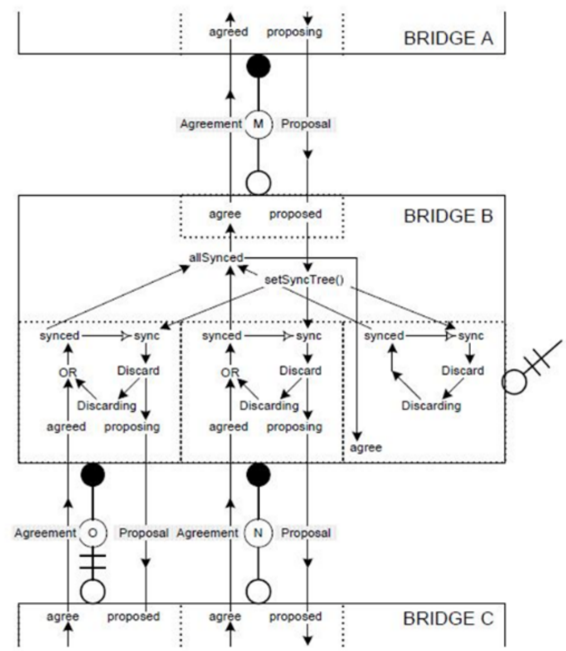

Figure 13-10—Agreements and Proposals

(Source: IEEE Standard for Local and Metropolitan Area Networks—Bridges and Bridged Networks- IEEE Std 802.1Q™-2018)

NOTE 2—Agreements can be generated without prior receipt of a Proposal as soon as the necessary conditions are met. Subsequent receipt of a Proposal serves to elicit a further Agreement. If all other ports have already been synchronized (allSynced in Figure 13-10) and the Proposal's priority vector does not convey worse information, synchronization is maintained and there is no need to transition Designated Ports to Discarding once more, or to transmit further Proposals.

(Source: IEEE Standard for Local and Metropolitan Area Networks—Bridges and Bridged Networks- IEEE Std 802.1Q™-2018)

8.6.8.4 Enhancements for scheduled traffic

A Bridge or an end station may support enhancements that allow transmission from each queue to be scheduled relative to a known timescale. In order to achieve this, a transmission gate is associated with each queue; the state of the transmission gate determines whether or not queued frames can be selected for transmission (see Figure 8-12). For a given queue, the transmission gate can be in one of two states:

a) *Open*: Queued frames are selected for transmission, in accordance with the definition of the transmission selection algorithm associated with the queue.
b) *Closed*: Queued frames are not selected for transmission.

(Source: IEEE Standard for Local and metropolitan area networks— Bridges and Bridged Networks Amendment 25: Enhancements for Scheduled Traffic (IEEE 802.1Qbv-2015))

8.6.8 Transmission selection

For each Port, frames are selected for transmission on the basis of the traffic classes that the Port supports and the operation of the transmission selection algorithms supported by the corresponding queues on that Port. For a given Port and traffic class, frames are selected from the corresponding queue for transmission if and only if

a) The operation of the transmission selection algorithm supported by that queue determines that there is a frame available for transmission; and

b) For each queue corresponding to a numerically higher value of traffic class supported by the Port, the operation of the transmission selection algorithm supported by that queue determines that there is no frame available for transmission.

(Source: IEEE Standard for Local and Metropolitan Area Networks—Bridges and Bridged Networks- IEEE Std 802.1Q™-2018)

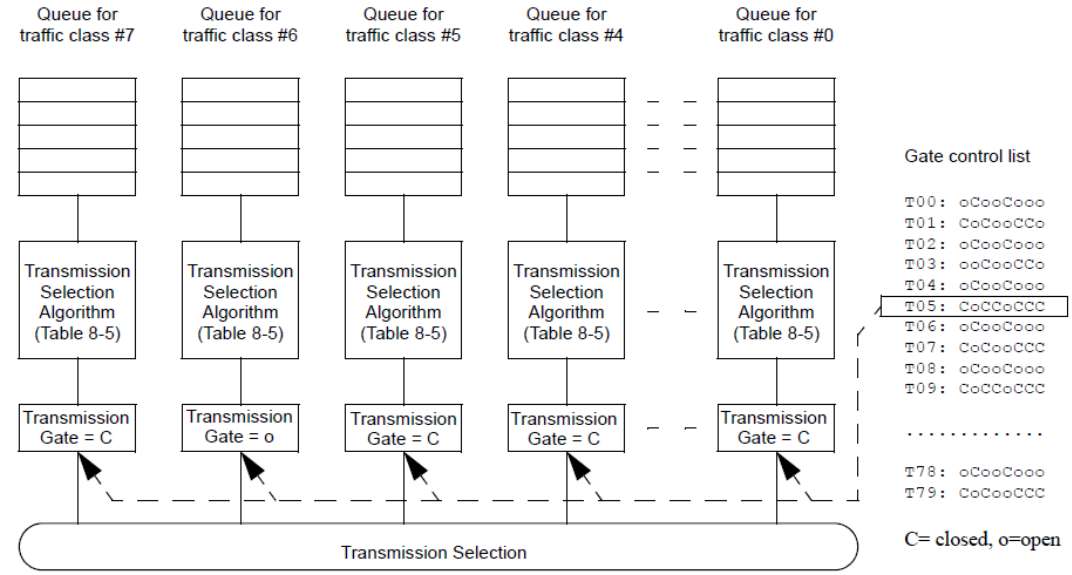

Figure 8-12—Transmission selection with gates

(Source: IEEE Standard for Local and metropolitan area networks— Bridges and Bridged Networks Amendment 25: Enhancements for Scheduled Traffic (IEEE 802.1Qbv-2015))

> A *gate control list* associated with each Port contains an ordered list of gate operations. Each gate operation changes the transmission gate state for the gate associated with each of the Port's traffic class queues. In an implementation that does not support enhancements for scheduled traffic, all gates are assumed to be permanently in the *open* state. Table 8-6 identifies the gate operation types, their parameters, and the actions that result from their execution. The state machines that control the execution of the gate control list, along with their variables and procedures, are specified in 8.6.9.

(Source: IEEE Standard for Local and metropolitan area networks— Bridges and Bridged Networks Amendment 25: Enhancements for Scheduled Traffic (IEEE 802.1Qbv-2015)).

> **3.3 gating cycle:** The period of time over which the sequence of operations in a gate control list repeats.
>
> **3.4 transmission gate:** A gate that connects or disconnects the transmission selection function of the forwarding process from the queue, allowing or preventing it from selecting frames from that queue. The gate has two states, Open and Closed.

(Source: IEEE Standard for Local and metropolitan area networks— Bridges and Bridged Networks Amendment 25: Enhancements for Scheduled Traffic (IEEE 802.1Qbv-2015))

Cyclic queuing and forwarding[53]

T.1 Overview of CQF

Cyclic queuing and forwarding (CQF) is a method of traffic shaping that can deliver deterministic, and easily calculated, latency for time-sensitive traffic streams. As the name implies, the principle underlying CQF is that stream traffic is transmitted and queued for transmission along a network path in a cyclic manner. Time is divided into numbered time intervals *i*, *i*+1, *i*+2, ... *i*+*N*, each of duration *d*. Frames transmitted by a Bridge, *Alice*, during time interval *i* are received by a downstream Bridge, *Bob*, during time interval *i* and are transmitted onwards by *Bob* towards Bridge *Charlie* during time interval *i*+1, and so on. A starting assumption is that, for a given traffic class, all Bridges and all end stations connected to a given bridge have a common understanding (to a known accuracy) of the start time of cycle *i*, and the cycle duration, *d*.

Frames transmitted by *Alice* during interval *i* are transmitted by *Bob* in interval *i*+1; the maximum possible delay experienced by a given frame is from the beginning of *i* to the end of *i*+1, or twice *d*. Similarly, the minimum possible delay experienced is from the end of *i* to the beginning of *i*+1, which is zero. More generally, the maximum delay experienced by a given frame is

$$(h+1) \times d$$

and the minimum delay experienced by a given frame is

$$(h-1) \times d$$

where *h* is the number of hops.

(Source: IEEE Standard for Local and Metropolitan Area Networks—Bridges and Bridged Networks- IEEE Std 802.1Q™-2018)

18. The accused products include a device adapter that is configured to transmit data during at least one of an assigned time phase associated with the device adapter prior to transmission of data from the real-time device by the device adapter, and included in the plurality of assigned time phases, or the free access phase, to refrain from transmitting data during time phases of the plurality of assigned time phases that are not associated with the device adapter, and to be able to determine whether to defer transmission of data during the assigned time phase associated with the device adapter and the free access phase to allow a non-real time device to transmit data. For example, the accused products are configured to be used to implement the IEEE 802.1Q standard. IEEE standard 802.1Q shows that scheduling of ports' transmission gates for transmission of data starts prior to the transmission of real-time data. The functionality

of assigned time phases is achieved using open gates transmitting data packets during scheduled transmission time. Per Clause 8.6.8 of the IEEE Std. 802.1Q, each time phase is assigned to a specific device adapter prior to transmission of real-time data by the specific device adapter. Furthermore, IEEE 802.1Q performs traffic shaping through Per-Stream Filtering and Policing (PSTP). IEEE standard 802.1Q implements a method in which open gates transmit data packets during transmission time and closed gates refrain data packets from transmission. The functionality of assigned time phases is achieved using open gates transmitting data packets during transmission time. The functionality of free access phase is achieved by the gates that are opened for transmission during any time. IEEE Std. 802.1Q supports Forwarding and Queuing Enhancements for Time Sensitive Streams. Thus, one of the plurality of device adaptors is configured to transmit data during at least one of a respective assigned time phase or free access phase, to refrain from transmitting data during time phases not assigned to the respective one of the plurality of device adapters. IEEE Std. 802.1Q provides traffic shaping for various classes of data transmission and determining whether to defer transmission of data during at least one of the assigned time phase or the free access phase to allow a non-real time device to transmit data.

> NOTE 2—If AdminBaseTime is set to the same time in the past in all bridges and end stations, OperBaseTime is always in the past, and all cycles start synchronized. Using AdminBaseTime in the past is appropriate when you can start schedules prior to starting the application that uses the schedules. Use of AdminBaseTime in the future is intended to

(Source: IEEE Standard for Local and metropolitan area networks— Bridges and Bridged Networks Amendment 25: Enhancements for Scheduled Traffic (IEEE 802.1Qbv-2015))

> **1.1 Project Number:** P802.1Qbv
> **1.2 Type of Document:** Standard
> **1.3 Life Cycle:** Full Use
>
> **5.5 Need for the Project:** The credit-based shaper works well in arbitrary networks (i.e., non-engineered). Networks employing scheduled transmissions are able to control real-time processes. This amendment enables those two kinds of networks to be consolidated into a single network, with a significant cost reduction to the user.

(Source: http://www.ieee802.org/1/files/public/docs2014/bv-p802-1Qbv-par-modification-1114.pdf)

8.6.8 Transmission selection

For each Port, frames are selected for transmission on the basis of the traffic classes that the Port supports and the operation of the transmission selection algorithms supported by the corresponding queues on that Port. For a given Port and traffic class, frames are selected from the corresponding queue for transmission if and only if

a) The operation of the transmission selection algorithm supported by that queue determines that there is a frame available for transmission; and

b) For each queue corresponding to a numerically higher value of traffic class supported by the Port, the operation of the transmission selection algorithm supported by that queue determines that there is no frame available for transmission.

(Source: IEEE Standard for Local and Metropolitan Area Networks—Bridges and Bridged Networks- IEEE Std 802.1Q™-2018)

5.4.1.9 Cyclic queuing and forwarding (CQF) requirements

A VLAN Bridge component implementation that conforms to the provisions of this standard for CQF (see Annex T) shall

a) Support the enhancements for scheduled traffic as specified in 8.6.8.4.

b) Support the state machines for scheduled traffic as specified in 8.6.9.
c) Support the state machines for stream gate control as specified in 8.6.10.
d) Support the management entities for scheduled traffic as specified in 12.29.
e) Support the requirements for per-stream filtering and policing (PSFP) as stated in 5.4.1.8.
f) Support the management entities for PSFP as specified in 12.31.

(Source: IEEE Standard for Local and Metropolitan Area Networks—Bridges and Bridged Networks- IEEE Std 802.1Q™-2018)

5.4.1.5 Forwarding and Queuing Enhancements for time-sensitive streams (FQTSS)—requirements

A VLAN Bridge component implementation that conforms to the provisions of this standard for FQTSS shall

a) Support a minimum of two traffic classes on all Ports, of which
   1) A minimum of one traffic class supports the strict priority algorithm for transmission selection (8.6.8.1), and
   2) One traffic class is a stream reservation (SR) class.
b) Support the operation of the credit-based shaper algorithm (8.6.8.2) on all Ports as the transmission selection algorithm used for the SR class.
c) Support SRP domain boundary port priority regeneration override as defined in 6.9.4, and the default priority regeneration override value defined in Table 6-5, for SR class "B."
d) Support the tables and procedures for mapping priorities to traffic classes as defined in 34.5.

SR: Stream Reservation, SRP: Stream Reservation Protocol

(Source: IEEE Standard for Local and Metropolitan Area Networks—Bridges and Bridged Networks- IEEE Std 802.1Q™-2018)

8.6.8.4 Enhancements for scheduled traffic

A Bridge or an end station may support enhancements that allow transmission from each queue to be scheduled relative to a known timescale. In order to achieve this, a transmission gate is associated with each queue; the state of the transmission gate determines whether or not queued frames can be selected for transmission (see Figure 8-12). For a given queue, the transmission gate can be in one of two states:

a) *Open*: Queued frames are selected for transmission, in accordance with the definition of the transmission selection algorithm associated with the queue.
b) *Closed*: Queued frames are not selected for transmission.

(Source: IEEE Standard for Local and metropolitan area networks— Bridges and Bridged Networks Amendment 25: Enhancements for Scheduled Traffic (IEEE 802.1Qbv-2015))

A *gate control list* associated with each Port contains an ordered list of gate operations. Each gate operation changes the transmission gate state for the gate associated with each of the Port's traffic class queues. In an implementation that does not support enhancements for scheduled traffic, all gates are assumed to be permanently in the *open* state. Table 8-6 identifies the gate operation types, their parameters, and the actions that result from their execution. The state machines that control the execution of the gate control list, along with their variables and procedures, are specified in 8.6.9.

(Source: IEEE Standard for Local and metropolitan area networks— Bridges and Bridged Networks Amendment 25: Enhancements for Scheduled Traffic (IEEE 802.1Qbv-2015))

5.4.1.5 Forwarding and Queuing Enhancements for time-sensitive streams (FQTSS)—requirements

A VLAN Bridge component implementation that conforms to the provisions of this standard for FQTSS shall

a) Support a minimum of two traffic classes on all Ports, of which
   1) A minimum of one traffic class supports the strict priority algorithm for transmission selection (8.6.8.1), and
   2) One traffic class is a stream reservation (SR) class.

b) Support the operation of the credit-based shaper algorithm (8.6.8.2) on all Ports as the transmission selection algorithm used for the SR class.

c) Support SRP domain boundary port priority regeneration override as defined in 6.9.4, and the default priority regeneration override value defined in Table 6-5, for SR class "B."

d) Support the tables and procedures for mapping priorities to traffic classes as defined in 34.5.

SR: Stream Reservation, SRP: Stream Reservation Protocol

(Source: IEEE Standard for Local and Metropolitan Area Networks—Bridges and Bridged Networks- IEEE Std 802.1Q™-2018)

5.4.1.6 ETS Bridge requirements

A device supporting ETS shall

a) Support at least 3 traffic classes (37.3).

NOTE—A minimum of 3 traffic classes allows a minimum configuration such that one traffic class contains priorities with PFC enabled, one traffic class contains priorities with PFC disabled, and one traffic class using strict priority.

b) Support bandwidth configuration with a granularity of 1% or finer (37.3).

c) Support bandwidth allocation with a precision of 10% (37.3).

d) Support a transmission selection policy such that if one of the traffic classes does not consume its allocated bandwidth, then any unused bandwidth is available to other traffic classes (37.3).

e) Support DCBX (Clause 38).

(Source: IEEE Standard for Local and Metropolitan Area Networks—Bridges and Bridged Networks- IEEE Std 802.1Q™-2018)

19. ADVA has infringed the '053 Patent by using the accused products and thereby practicing a method that includes transmitting a synchronization signal at regular intervals to synchronize local clocks of each of a plurality of device adapters. For example, the accused products are used by ADVA to implement the IEEE 802.1Q standard. IEEE standard 802.1Q implements a method in which a time aware bridged LAN use 802.1AS base time to synchronize

all the clocks of ports associated with bridges (device adapters) by periodically (regular intervals) sending the Announce messages. Using Best Master Clock Algorithm, the synchronization time signal is transmitted from a grandmaster to other ports via periodic Announce messages. IEEE Std. 802.1AS™-2011 is normative and essential to implement an IEEE Std. 802.1Q Compliant System. IEEE Std. 802.1Q-2018 defines parameters, such as AdminBaseTime and OpenBaseTime, which are used to synchronize the clocks across the network.

1.1 Project Number: P802.1Qbv
1.2 Type of Document: Standard
1.3 Life Cycle: Full Use

2.1 Title: Standard for Local and metropolitan area networks--Media Access Control (MAC) Bridges and Virtual Bridged Local Area Networks Amendment: Enhancements for Scheduled Traffic

5.2.b. Scope of the project: This amendment specifies time-aware queue-draining procedures, managed objects and extensions to existing protocols that enable bridges and end stations to schedule the transmission of frames based on a synchronized time. Virtual Local Area Network (VLAN) tag encoded priority values are allocated allowing simultaneous support of scheduled traffic, credit-based shaper traffic and other bridged traffic over Local Area Networks (LANs).

(Source: http://www.ieee802.org/1/files/public/docs2014/bv-p802-1Qbv-par-modification-1114.pdf)

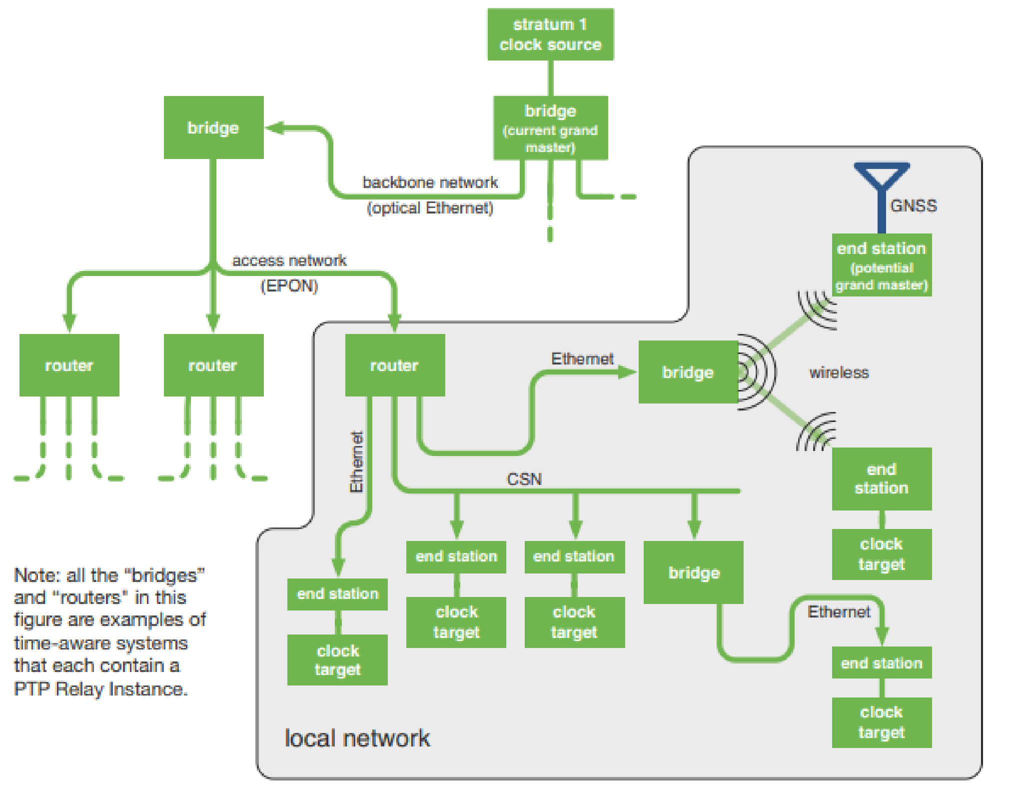

Figure 7-1—Time-aware network example

(Source: https://1.ieee802.org/wp-content/uploads/2019/03/802-1AS-rev-d8-0.pdf)

7.2 Architecture of a time-aware network

7.2.1 General

A time-aware network consists of a number of interconnected time-aware systems that support the gPTP defined within this standard. These time-aware systems can be any networking device, including, for example, bridges, routers, and end stations. A set of time-aware systems that are interconnected by gPTP-capable network elements is called a *gPTP network*. Each instance of gPTP that the time-aware systems support is in one *gPTP domain*, and the instances of gPTP are said to be part of that gPTP domain. A time-aware system can support, and therefore be part of, more than one gPTP domain. The entity of a single time-aware system that executes gPTP in one gPTP domain is called a PTP Instance. A time-aware system can contain multiple PTP Instances, which are each associated with a different gPTP domain. There are two

(Source: https://1.ieee802.org/wp-content/uploads/2019/03/802-1AS-rev-d8-0.pdf)

3.16 PTP End Instance: A PTP Instance that is capable of acting as the source of synchronized time on the network, or destination of synchronized time using the IEEE 802.1AS protocol, or both.

3.17 PTP Instance: A PTP Relay Instance or a PTP End Instance. A PTP Instance implements those portions of this standard indicated as applicable to a PTP Relay Instance or a PTP End Instance. Each PTP Instance operates in exactly one domain.

3.18 PTP Link: Within a domain, a network segment between two PTP Ports using the peer-to-peer delay mechanism of this standard. The peer-to-peer delay mechanism is designed to measure the propagation time over such a link.

NOTE—A PTP Link between PTP Ports of PTP Instances is also a gPTP Communication Path (see 3.9).

3.19 PTP Relay Instance: A PTP Instance that is capable of communicating synchronized time received on one port to other ports, using the IEEE 802.1AS protocol.

NOTE—A PTP Relay Instance could, for example, be contained in a bridge, a router, or a multi-port end station.

(Source: https://1.ieee802.org/wp-content/uploads/2019/03/802-1AS-rev-d8-0.pdf)

7.2.2 Time-aware network consisting of a single gPTP domain

Figure 7-1 illustrates an example time-aware network consisting of a single gPTP domain, using all theabove network technologies (i.e., (c) - (f) of 7.2.1), where end stations on several local networks are connected to a grandmaster on a backbone network via an EPON access network.

Any PTP Instance with clock sourcing capabilities can be a potential grandmaster, so there is a selection method (the *best master clock algorithm*, or BMCA) that ensures that all of the PTP Instances in a gPTP domain use the same grandmaster.[12] The BMCA is largely identical to that used in IEEE Std 1588-2019,

(Source: https://1.ieee802.org/wp-content/uploads/2019/03/802-1AS-rev-d8-0.pdf)

10.3.1.1 Best master clock algorithm overview

In the BMCA (i.e., method (a) of 10.3.1), best master selection information is exchanged between PTP Instances of time-aware systems via Announce messages (see 10.5 and 10.6). Each Announce message contains time-synchronization spanning tree vector information that identifies one PTP Instance as the root of the time-synchronization spanning tree and, if the PTP Instance is grandmaster-capable, the grandmaster. Each PTP Instance in turn uses the information contained in the Announce messages it receives, along with its knowledge of itself, to compute which of the PTP Instances that it has knowledge of ought to be the root of the spanning tree and, if grandmaster-capable, the grandmaster. As part of constructing the time-synchronization spanning tree, each port of each PTP Instance is assigned a port state from Table 10-2 by state machines associated with the ports and with the PTP Instance as a whole.

(Source: https://1.ieee802.org/wp-content/uploads/2019/03/802-1AS-rev-d8-0.pdf)

c) In gPTP there are only two types of PTP Instances: PTP End Instances and PTP Relay Instances, while IEEE 1588 has ordinary clocks, boundary clocks, end-to-end transparent clocks, and P2P transparent clocks. A PTP End Instance corresponds to an IEEE 1588 ordinary clock, and a PTP Relay Instance is a type of IEEE 1588 boundary clock where its operation is very tightly defined, so much so that a PTP Relay Instance with Ethernet ports can be shown to be mathematically equivalent to a P2P transparent clock in terms of how synchronization is performed, as shown in

(Source: https://1.ieee802.org/wp-content/uploads/2019/03/802-1AS-rev-d8-0.pdf)

- **Grand Master selection**
  - GM-capable stations advertise themselves via ANNOUNCE messages
  - If a station hears from station with "better" clock, it does not send ANNOUNCE
    - Configurable "Priority" field can override clock quality
    - MAC address is tie breaker
  - Time relays drop all inferior ANNOUNCE messages
    - Forward only the best
  - Last one standing is Grand Master for the domain
    - GM is the root of the 802.1AS timing tree
    - GM periodically sends the current time

(Source: https://avnu.org/wp-content/uploads/2014/05/as-kbstanton-8021AS-tutorial-0714-v01.pdf)

IEEE Std 802.1Q-2018
IEEE Standard for Local and Metropolitan Area Networks—Bridges and Bridged Networks

2. Normative references

The following referenced documents are indispensable for the application of this document (i.e., they must be understood and used, so each referenced document is cited in the text and its relationship to this document is explained). For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments or corrigenda) applies.

ANSI X3.159, American National Standards for Information Systems—Programming Language—C.[5]

IEEE Std 802®, IEEE Standard for Local and metropolitan area networks: Overview and Architecture.[6,7]

IEEE Std 802.1AB™, IEEE Standard for Local and metropolitan area networks—Station and Media Access Control Connectivity Discovery.

IEEE Std 802.1AC™, IEEE Standard for Local and metropolitan area networks—Media Access Control (MAC) Service Definition.

IEEE Std 802.1AE™, IEEE Standard for Local and metropolitan area networks—Media Access Control (MAC) Security.

IEEE Std 802.1AS™, IEEE Standard for Local and metropolitan area networks—Timing and Synchronization for Time-Sensitive Applications in Bridged Local Area Networks.

(Source: IEEE Standard for Local and metropolitan area networks— Bridges and Bridged Networks Amendment 25: Enhancements for Scheduled Traffic (IEEE 802.1Qbv-2015))

8.6.9.4.1 AdminBaseTime

The administrative value of base time, expressed as an IEEE 1588 precision time protocol (PTP) [B24] timescale (see 8.2 of IEEE Std 802.1AS™-2011 [B11]). This value can be changed by management, and is used by the List Config state machine (8.6.9.3) to set the value of OperBaseTime (8.6.9.4.18).

NOTE—Time is expressed in the PTP timescale as the number of seconds, nanoseconds, and fractional nanoseconds that have elapsed since 1 January 1970 00:00:00 TAI.

NOTE 2—If AdminBaseTime is set to the same time in the past in all bridges and end stations, OperBaseTime is always in the past, and all cycles start synchronized. Using AdminBaseTime in the past is appropriate when you can start schedules prior to starting the application that uses the schedules. Use of AdminBaseTime in the future is intended to change a currently running schedule in all bridges and end stations to a new schedule at a future time. Using AdminBaseTime in the future is appropriate when schedules must be changed without stopping the application.

(Source: IEEE Standard for Local and metropolitan area networks— Bridges and Bridged Networks Amendment 25: Enhancements for Scheduled Traffic (IEEE 802.1Qbv-2015))

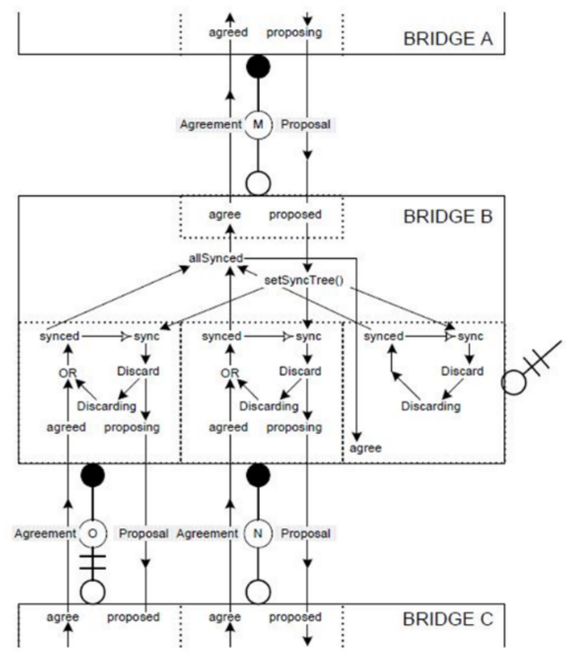

Figure 13-10—Agreements and Proposals

(Source: IEEE Standard for Local and Metropolitan Area Networks—Bridges and Bridged Networks- IEEE Std 802.1Q™-2018)

> NOTE 2—Agreements can be generated without prior receipt of a Proposal as soon as the necessary conditions are met. Subsequent receipt of a Proposal serves to elicit a further Agreement. If all other ports have already been synchronized (allSynced in Figure 13-10) and the Proposal's priority vector does not convey worse information, synchronization is maintained and there is no need to transition Designated Ports to Discarding once more, or to transmit further Proposals.

(Source: IEEE Standard for Local and Metropolitan Area Networks—Bridges and Bridged Networks- IEEE Std 802.1Q™-2018)

20. The methods practiced by ADVA's use of the accused products include maintaining a substantially synchronized time frame among the plurality of device adapters interconnected by a network, the time frame repeating periodically and including a plurality of

assigned time phases and a free access phase. For example, the accused products are used by ADVA to implement the IEEE 802.1Q standard. The time aware bridged LAN uses 802.1AS base time to maintain synchronized time for all the ports in the bridges (device adapters). The bridges containing ports schedule the transmission of traffic based on the synchronized time. Each port associated with a specific set of transmission queues includes a plurality of transmission gates. A transmission gate can be in a closed state or open state. The functionality of assigned time phases is achieved using open gates transmitting data packets during transmission time. The functionality of free access phase is achieved when the gates are opened for transmission during any time. IEEE Std. 802.1Q-2018 supports cyclic queuing and forwarding structures to create synchronized frames and gates which repeat periodically (Annex T).

1.1 Project Number: P802.1Qbv
1.2 Type of Document: Standard
1.3 Life Cycle: Full Use

2.1 Title: Standard for Local and metropolitan area networks--Media Access Control (MAC) Bridges and Virtual Bridged Local Area Networks Amendment: Enhancements for Scheduled Traffic

5.2.b. Scope of the project: This amendment specifies time-aware queue-draining procedures, managed objects and extensions to existing protocols that enable bridges and end stations to schedule the transmission of frames based on a synchronized time. Virtual Local Area Network (VLAN) tag encoded priority values are allocated allowing simultaneous support of scheduled traffic, credit-based shaper traffic and other bridged traffic over Local Area Networks (LANs).

(Source: http://www.ieee802.org/1/files/public/docs2014/bv-p802-1Qbv-par-modification-1114.pdf)

- **Grand Master selection**
  - GM-capable stations advertise themselves via ANNOUNCE messages
  - If a station hears from station with "better" clock, it does not send ANNOUNCE
    - Configurable "Priority" field can override clock quality
    - MAC address is tie breaker
  - Time relays drop all inferior ANNOUNCE messages
    - Forward only the best
  - Last one standing is Grand Master for the domain
    - GM is the root of the 802.1AS timing tree
    - GM periodically sends the current time

(Source: https://avnu.org/wp-content/uploads/2014/05/as-kbstanton-8021AS-tutorial-0714-v01.pdf)

3.16 PTP End Instance: A PTP Instance that is capable of acting as the source of synchronized time on the network, or destination of synchronized time using the IEEE 802.1AS protocol, or both.

3.17 PTP Instance: A PTP Relay Instance or a PTP End Instance. A PTP Instance implements those portions of this standard indicated as applicable to a PTP Relay Instance or a PTP End Instance. Each PTP Instance operates in exactly one domain.

3.18 PTP Link: Within a domain, a network segment between two PTP Ports using the peer-to-peer delay mechanism of this standard. The peer-to-peer delay mechanism is designed to measure the propagation time over such a link.

NOTE—A PTP Link between PTP Ports of PTP Instances is also a gPTP Communication Path (see 3.9).

3.19 PTP Relay Instance: A PTP Instance that is capable of communicating synchronized time received on one port to other ports, using the IEEE 802.1AS protocol.

NOTE—A PTP Relay Instance could, for example, be contained in a bridge, a router, or a multi-port end station.

(Source: https://1.ieee802.org/wp-content/uploads/2019/03/802-1AS-rev-d8-0.pdf)

8.6.8.4 Enhancements for scheduled traffic

A Bridge or an end station may support enhancements that allow transmission from each queue to be scheduled relative to a known timescale. In order to achieve this, a transmission gate is associated with each queue; the state of the transmission gate determines whether or not queued frames can be selected for transmission (see Figure 8-12). For a given queue, the transmission gate can be in one of two states:

a) *Open*: Queued frames are selected for transmission, in accordance with the definition of the transmission selection algorithm associated with the queue.
b) *Closed*: Queued frames are not selected for transmission.

(Source: IEEE Standard for Local and metropolitan area networks— Bridges and Bridged Networks Amendment 25: Enhancements for Scheduled Traffic (IEEE 802.1Qbv-2015))

8.6.8 Transmission selection

For each Port, frames are selected for transmission on the basis of the traffic classes that the Port supports and the operation of the transmission selection algorithms supported by the corresponding queues on that Port. For a given Port and traffic class, frames are selected from the corresponding queue for transmission if and only if

a) The operation of the transmission selection algorithm supported by that queue determines that there is a frame available for transmission; and

b) For each queue corresponding to a numerically higher value of traffic class supported by the Port, the operation of the transmission selection algorithm supported by that queue determines that there is no frame available for transmission.

(Source: IEEE Standard for Local and Metropolitan Area Networks—Bridges and Bridged Networks- IEEE Std 802.1Q™-2018)

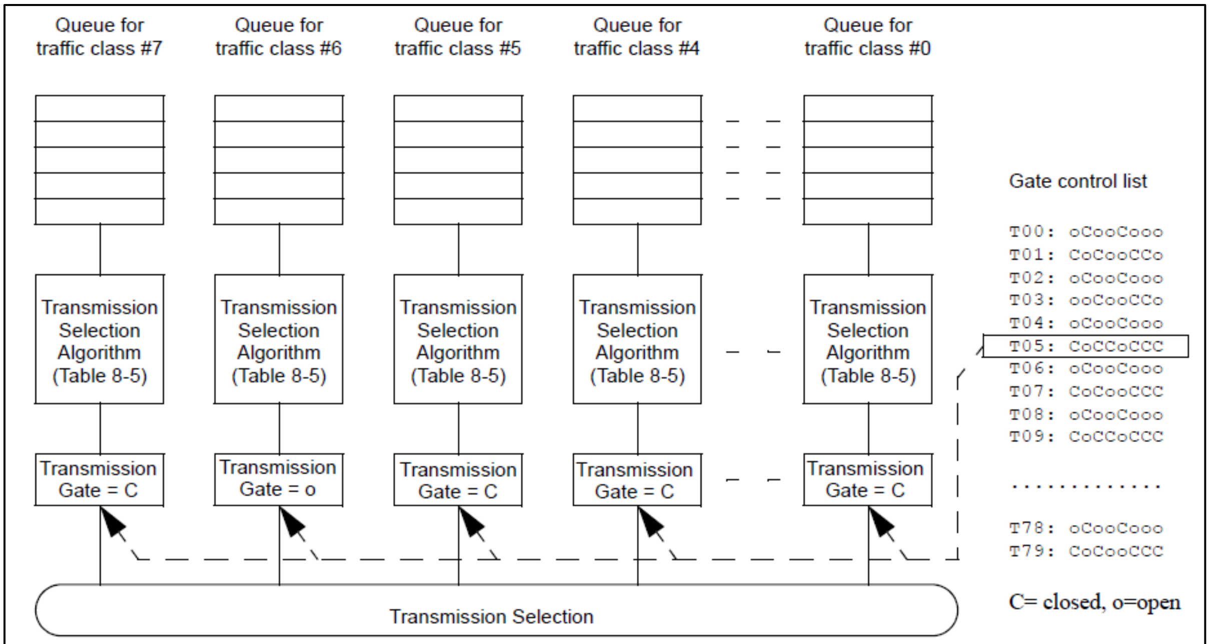

Figure 8-12—Transmission selection with gates

(Source: IEEE Standard for Local and metropolitan area networks— Bridges and Bridged Networks Amendment 25: Enhancements for Scheduled Traffic (IEEE 802.1Qbv-2015))

A *gate control list* associated with each Port contains an ordered list of gate operations. Each gate operation changes the transmission gate state for the gate associated with each of the Port's traffic class queues. In an implementation that does not support enhancements for scheduled traffic, all gates are assumed to be permanently in the *open* state. Table 8-6 identifies the gate operation types, their parameters, and the actions that result from their execution. The state machines that control the execution of the gate control list, along with their variables and procedures, are specified in 8.6.9.

(Source: IEEE Standard for Local and metropolitan area networks— Bridges and Bridged Networks Amendment 25: Enhancements for Scheduled Traffic (IEEE 802.1Qbv-2015))

3.3 gating cycle: The period of time over which the sequence of operations in a gate control list repeats.

3.4 transmission gate: A gate that connects or disconnects the transmission selection function of the forwarding process from the queue, allowing or preventing it from selecting frames from that queue. The gate has two states, Open and Closed.

(Source: IEEE Standard for Local and metropolitan area networks— Bridges and Bridged Networks Amendment 25: Enhancements for Scheduled Traffic (IEEE 802.1Qbv-2015))

Cyclic queuing and forwarding[53]

T.1 Overview of CQF

Cyclic queuing and forwarding (CQF) is a method of traffic shaping that can deliver deterministic, and easily calculated, latency for time-sensitive traffic streams. As the name implies, the principle underlying CQF is that stream traffic is transmitted and queued for transmission along a network path in a cyclic manner. Time is divided into numbered time intervals *i*, *i*+1, *i*+2, ... *i*+*N*, each of duration *d*. Frames transmitted by a Bridge, *Alice*, during time interval *i* are received by a downstream Bridge, *Bob*, during time interval *i* and are transmitted onwards by *Bob* towards Bridge *Charlie* during time interval *i*+1, and so on. A starting assumption is that, for a given traffic class, all Bridges and all end stations connected to a given bridge have a common understanding (to a known accuracy) of the start time of cycle *i*, and the cycle duration, *d*.

Frames transmitted by *Alice* during interval *i* are transmitted by *Bob* in interval *i*+1; the maximum possible delay experienced by a given frame is from the beginning of *i* to the end of *i*+1, or twice *d*. Similarly, the minimum possible delay experienced is from the end of *i* to the beginning of *i*+1, which is zero. More generally, the maximum delay experienced by a given frame is

$$(h+1) \times d$$

and the minimum delay experienced by a given frame is

$$(h-1) \times d$$

where *h* is the number of hops.

(Source: IEEE Standard for Local and Metropolitan Area Networks—Bridges and Bridged Networks- IEEE Std 802.1Q™-2018)

21. The methods practiced by ADVA's use of the accused products include assigning each time phase to a specific device adapter prior to transmission of real-time data by the specific device adapter. For example, the accused products are used by ADVA to implement the IEEE 802.1Q standard. IEEE standard 802.1Q shows that scheduling (assigning) of transmission gates starts prior to the transmission of real-time data. Per clause 8.6.8 of the IEEE Std. 802.1Q, each time phase is assigned to a specific device adapter prior to transmission of real-time data by the specific device adapter. IEEE 802.1Q performs traffic shaping through Per-Stream Filtering and Policing (PSTP).

NOTE 2—If AdminBaseTime is set to the same time in the past in all bridges and end stations, OperBaseTime is always in the past, and all cycles start synchronized. Using AdminBaseTime in the past is appropriate when you can start schedules prior to starting the application that uses the schedules. Use of AdminBaseTime in the future is intended to

(Source: IEEE Standard for Local and metropolitan area networks— Bridges and Bridged Networks Amendment 25: Enhancements for Scheduled Traffic (IEEE 802.1Qbv-2015))

1.1 Project Number: P802.1Qbv
1.2 Type of Document: Standard
1.3 Life Cycle: Full Use

5.5 Need for the Project: The credit-based shaper works well in arbitrary networks (i.e., non-engineered). Networks employing scheduled transmissions are able to control real-time processes. This amendment enables those two kinds of networks to be consolidated into a single network, with a significant cost reduction to the user.

(Source: http://www.ieee802.org/1/files/public/docs2014/bv-p802-1Qbv-par-modification-1114.pdf)

8.6.8 Transmission selection

For each Port, frames are selected for transmission on the basis of the traffic classes that the Port supports and the operation of the transmission selection algorithms supported by the corresponding queues on that Port. For a given Port and traffic class, frames are selected from the corresponding queue for transmission if and only if

a) The operation of the transmission selection algorithm supported by that queue determines that there is a frame available for transmission; and

b) For each queue corresponding to a numerically higher value of traffic class supported by the Port, the operation of the transmission selection algorithm supported by that queue determines that there is no frame available for transmission.

(Source: IEEE Standard for Local and Metropolitan Area Networks—Bridges and Bridged Networks- IEEE Std 802.1Q™-2018)

5.4.1.9 Cyclic queuing and forwarding (CQF) requirements

A VLAN Bridge component implementation that conforms to the provisions of this standard for CQF (see Annex T) shall

a) Support the enhancements for scheduled traffic as specified in 8.6.8.4.

b) Support the state machines for scheduled traffic as specified in 8.6.9.
c) Support the state machines for stream gate control as specified in 8.6.10.
d) Support the management entities for scheduled traffic as specified in 12.29.
e) Support the requirements for per-stream filtering and policing (PSFP) as stated in 5.4.1.8.
f) Support the management entities for PSFP as specified in 12.31.

(Source: IEEE Standard for Local and Metropolitan Area Networks—Bridges and Bridged Networks- IEEE Std 802.1Q™-2018)

5.4.1.5 Forwarding and Queuing Enhancements for time-sensitive streams (FQTSS)—requirements

A VLAN Bridge component implementation that conforms to the provisions of this standard for FQTSS shall

a) Support a minimum of two traffic classes on all Ports, of which
   1) A minimum of one traffic class supports the strict priority algorithm for transmission selection (8.6.8.1), and
   2) One traffic class is a stream reservation (SR) class.
b) Support the operation of the credit-based shaper algorithm (8.6.8.2) on all Ports as the transmission selection algorithm used for the SR class.
c) Support SRP domain boundary port priority regeneration override as defined in 6.9.4, and the default priority regeneration override value defined in Table 6-5, for SR class "B."
d) Support the tables and procedures for mapping priorities to traffic classes as defined in 34.5.

SR: Stream Reservation, SRP: Stream Reservation Protocol

(Source: IEEE Standard for Local and Metropolitan Area Networks—Bridges and Bridged Networks- IEEE Std 802.1Q™-2018)

22. The plurality of device adaptors recited above in connection with ADVA's use of the accused products includes a respective one of the plurality of device adapters that is configured to transmit data during at least one of a respective assigned time phase or the free access phase, to refrain from transmitting data during time phases not assigned to the respective one of the plurality of device adapters, and to determine whether to defer transmission of data during at least one of the assigned time phase or the free access phase to allow a non-real time device to transmit data. For example, the accused products are used by ADVA to implement the IEEE 802.1Q standard. IEEE standard 802.1Q implements a method in which open gates transmit data packets during transmission time and closed gates refrain data packets from transmission. The functionality of assigned time phases is achieved using open gates transmitting data packets during transmission time. The functionality of free access phase is achieved by the gates that are opened for transmission during any time. IEEE Std. 802.1Q supports Forwarding and Queuing Enhancements for Time Sensitive Streams. Thus, one of the plurality of device adaptors is configured to transmit data during at least one of a respective assigned time phase or

free access phase, to refrain from transmitting data during time phases not assigned to the respective one of the plurality of device adapters. IEEE Std. 802.1Q provides traffic shaping for various classes of data transmission and determining whether to defer transmission of data during at least one of the assigned time phase or the free access phase to allow a non-real time device to transmit data.

8.6.8.4 Enhancements for scheduled traffic

A Bridge or an end station may support enhancements that allow transmission from each queue to be scheduled relative to a known timescale. In order to achieve this, a transmission gate is associated with each queue; the state of the transmission gate determines whether or not queued frames can be selected for transmission (see Figure 8-12). For a given queue, the transmission gate can be in one of two states:

a) *Open*: Queued frames are selected for transmission, in accordance with the definition of the transmission selection algorithm associated with the queue.
b) *Closed*: Queued frames are not selected for transmission.

(Source: IEEE Standard for Local and metropolitan area networks— Bridges and Bridged Networks Amendment 25: Enhancements for Scheduled Traffic (IEEE 802.1Qbv-2015))

A *gate control list* associated with each Port contains an ordered list of gate operations. Each gate operation changes the transmission gate state for the gate associated with each of the Port's traffic class queues. In an implementation that does not support enhancements for scheduled traffic, all gates are assumed to be permanently in the *open* state. Table 8-6 identifies the gate operation types, their parameters, and the actions that result from their execution. The state machines that control the execution of the gate control list, along with their variables and procedures, are specified in 8.6.9.

(Source: IEEE Standard for Local and metropolitan area networks— Bridges and Bridged Networks Amendment 25: Enhancements for Scheduled Traffic (IEEE 802.1Qbv-2015))

5.4.1.5 Forwarding and Queuing Enhancements for time-sensitive streams (FQTSS)—requirements

A VLAN Bridge component implementation that conforms to the provisions of this standard for FQTSS shall

a) Support a minimum of two traffic classes on all Ports, of which
   1) A minimum of one traffic class supports the strict priority algorithm for transmission selection (8.6.8.1), and
   2) One traffic class is a stream reservation (SR) class.
b) Support the operation of the credit-based shaper algorithm (8.6.8.2) on all Ports as the transmission selection algorithm used for the SR class.
c) Support SRP domain boundary port priority regeneration override as defined in 6.9.4, and the default priority regeneration override value defined in Table 6-5, for SR class "B."
d) Support the tables and procedures for mapping priorities to traffic classes as defined in 34.5.

SR: Stream Reservation, SRP: Stream Reservation Protocol

(Source: IEEE Standard for Local and Metropolitan Area Networks—Bridges and Bridged Networks- IEEE Std 802.1Q™-2018)

5.4.1.6 ETS Bridge requirements

A device supporting ETS shall

a) Support at least 3 traffic classes (37.3).

NOTE—A minimum of 3 traffic classes allows a minimum configuration such that one traffic class contains priorities with PFC enabled, one traffic class contains priorities with PFC disabled, and one traffic class using strict priority.

b) Support bandwidth configuration with a granularity of 1% or finer (37.3).
c) Support bandwidth allocation with a precision of 10% (37.3).
d) Support a transmission selection policy such that if one of the traffic classes does not consume its allocated bandwidth, then any unused bandwidth is available to other traffic classes (37.3).
e) Support DCBX (Clause 38).

(Source: IEEE Standard for Local and Metropolitan Area Networks—Bridges and Bridged Networks- IEEE Std 802.1Q™-2018)

23. ADVA has had knowledge of the '053 Patent at least as of the date when it was notified of the filing of this action.

24. Far North Patents has been damaged as a result of the infringing conduct by ADVA alleged above. Thus, ADVA is liable to Far North Patents in an amount that adequately compensates it for such infringements, which, by law, cannot be less than a reasonable royalty, together with interest and costs as fixed by this Court under 35 U.S.C. § 284.

25. Far North Patents and/or its predecessors-in-interest have satisfied all statutory obligations required to collect pre-filing damages for the full period allowed by law for infringement of the '053 Patent.

COUNT II

DIRECT INFRINGEMENT OF U.S. PATENT NO. 6,246,702

26. On June 12, 2001, United States Patent No. 6,246,702 ("the '702 Patent") was duly and legally issued by the United States Patent and Trademark Office for an invention entitled "Methods and Apparatus for Providing Quality-of-Service Guarantees in Computer Networks."

27. Far North Patents is the owner of the '702 Patent, with all substantive rights in and to that patent, including the sole and exclusive right to prosecute this action and enforce the '702 Patent against infringers, and to collect damages for all relevant times.

28. ADVA made, had made, used, imported, provided, supplied, distributed, sold, and/or offered for sale products and/or systems including, for example, its ADVA FSP 150-GO102Pro and ADVA FSP 150-GE102Pro families of products that include advanced quality of service capabilities (collectively, "accused products").

FSP 150-GO102Pro Series

Outdoor Carrier Ethernet and IP demarcation

Public outdoor small cells, Wi-Fi and closed circuit TV (CCTV) require connectivity services which end outside a controlled environment. But service providers don't want to invest in expensive and unsightly cabinets. That's why small environmentally sealed network demarcation devices are a game changer.

Communication service providers (CSPs) struggle to cope with a high number of specialized boxes. They need a single demarcation product that can cover a wide range of applications and be effective even under harsh environmental conditions. Our FSP 150-GO102Pro, a member of the market-leading FSP 150 family, makes a real difference. Its small size and low power consumption make it easy to install and simple to configure. It supports a comprehensive set of Carrier Ethernet and IP connectivity services. Automated testing and in-service monitoring protocols simplify any phase of the service lifecycle. What's more, our FSP 150-GO102Pro also provides precise synchronization. Such a unique combination of features makes it the perfect solution for connecting small cell sites.

(Source : Screenshot of PDF downloaded from https://www.adva.com/-/media/adva-main-site/resources/data-sheets/pdfs/fsp-150-go-102-pro-series.ashx?la=de-de&hash=5122080C1CCB4C881E30D8D62F0DF92DF16C098B)

VLAN support

- 4096 VLANs (IEEE 802.1Q customer-tagged) and stacked VLANs (Q-in-Q service provider tagged)
- 2-tag management (push/pop/swap) for c-tag and s-tag
- IEEE 802.1ad provider bridging (c-tag, s-tag)
- Ethertype translation
- Eight Ethernet virtual circuits (EVC)
- 9612 byte-per-frame MTU transparency

Layer 2 traffic management

- Acceptable client frame policy: tagged or untagged
- Service classification based on IEEE 802.1p, 802.1Q and IP-TOS/DSCP
- VLAN tag priority mapping (IEEE 802.1ad PCP encoding)
- MEF-compliant policing (CIR/CBS/EIR/EBS) with three-color marking and eight classes of service
- Port shaping on transmit for both client and network ports
- MEF 10.3 hierarchical policing with token-share envelopes
- DiffServ supporting WFQ/SP mix

(Source : Screenshot of PDF downloaded from https://www.adva.com/-/media/adva-main-site/resources/data-sheets/pdfs/fsp-150-go-102-pro-series.ashx?la=de-de&hash=5122080C1CCB4C881E30D8D62F0DF92DF16C098B)

ADVA today answered the urgent need for small cell backhaul with the launch of the world's smallest cell site gateway device. The ADVA FSP 150-GO102Pro Series has been specifically engineered to be installed in the most challenging locations, enabling the easy deployment of small cells at street level. With its uniquely compact and ruggedized design, it provides multi-layer service demarcation in a wide range of outdoor locations, from walls to poles to lampposts. The ADVA FSP 150-GO102Pro Series also delivers highly precise time and frequency synchronization and features automated testing and in-service monitoring. With the ADVA FSP 150-GO102Pro Series, service providers can easily and cost-effectively introduce next-generation mobile connectivity services for the IoT and 5G era. The new solution is already in customer trials and is generally available from today.

"Our FSP 150-GO102Pro Series is the ultimate outdoor demarcation technology. It ensures the highest quality of service even in the harshest conditions. This phenomenally versatile device empowers operators to deliver reliable, programmable mobile backhaul connectivity without investing in expensive cabinets or power-hungry air conditioning systems," said Stephan Rettenberger, SVP, marketing and investor relations, ADVA. "We worked closely with major wholesale service providers to develop our FSP 150-GO102Pro Series. The solution is specifically engineered to meet their exacting requirements and facilitate their 5G ambitions. It offers full Layer 2 and 3 service demarcation with a complete set of Carrier Ethernet and routing features. The FSP 150-GO102Pro Series even provides highly automated zero touch provisioning for effortless installation and activation."

(Source : https://www.newswiretoday.com/news/168708/)

ADVA™

FSP 150-GE100Pro Series

Programmable Carrier Ethernet and IP demarcation

As complexity increases, network demarcation devices need to continuously extend their capabilities. Communication service provider need one product family for Ethernet and IP, indoor or outdoor, sophisticated security and highly precise synchronization.

Change is the norm. Today, your business customer wants Ethernet connectivity. Tomorrow, it's IP services. Frequency synchronization is no longer sufficient for your mobile network as time synchronization is mandatory for 4G. Meanwhile, your customers decide that they won't accept unencrypted transmission. The one constant is that requirements keep changing – and at an unprecedented pace. Our FSP 150-GE100Pro series belongs to the successful FSP 150 ProNID family. It enables network operators to offer true multi-service access by combining the demarcation of Carrier Ethernet 2.0 and IP services with a rich set of features in a single device. What's more, there's a range of designs from ultra-compact to rack-mountable devices, all aligned with distinct customer demand. The comprehensive FSP 150-GE100Pro series provides the perfect answer to any demarcation requirement.

(Source : Screenshot of PDF downloaded from https://www.adva.com/-/media/adva-main-site/resources/data-sheets/pdfs/fsp-150-ge-100-pro-series.ashx?la=de-DE&hash=46C2728AB543DEB24ECC9B31953C3463C4325AB5)

VLAN support

- 4096 VLANs (IEEE 802.1Q customer-tagged) and stacked VLANs (Q-in-Q service provider tagged)
- 2-tag management (push/pop/swap) for c-tag and s-tag
- IEEE 802.1ad provider bridging (c-tag, s-tag)
- Ethertype translation
- $8^{1-2}/32^{3-5}/64^{6-10}$ Ethernet virtual circuits (EVC)
- 9612 Byte per frame MTU transparency
- EoMPLS encapsulation

Layer 2 traffic management

- Acceptable client frame policy: tagged or untagged
- Service classification based on IEEE 802.1p, 802.1Q and IP-TOS/DSCP
- VLAN tag priority mapping (IEEE 802.1ad PCP encoding)
- MEF-compliant policing (CIR/CBS/EIR/EBS) with three-color marking and eight classes of service
- Port shaping on transmit for both client and network ports
- MEF 10.3 hierarchical policing with token-share envelopes
- DiffServ supporting WFQ/SP mix

(Source : Screenshot of PDF downloaded from https://www.adva.com/-/media/adva-main-site/resources/data-sheets/pdfs/fsp-150-ge-100-pro-series.ashx?la=de-DE&hash=46C2728AB543DEB24ECC9B31953C3463C4325AB5)

29. By doing so, ADVA has directly infringed (literally and/or under the doctrine of equivalents) at least Claim 27 of the '702 Patent.

30. ADVA has infringed the '702 Patent by using the accused products and thereby practicing a method for regulating traffic in an Ethernet network including real-time devices, non-real-time devices, a network medium, and a plurality of device adapters connected between the devices and the network medium, each of the device adapters including a clock. For example, the accused products are used by ADVA to implement the IEEE 802.1Q standard. IEEE standard 802.1Q (Qbv) implements a method for scheduling traffic in time aware Local Area Network (Ethernet network). The time aware network includes multiple end points (devices) and bridges that includes ports (device adapters). The endpoint and bridges are connected via interconnects (network medium). Also, each time aware bridge including port is a boundary clock. The endpoints transmit data that is a mix of time-critical traffic and other traffic,

i.e., real time data and non-real time data. The end point is either a real time device or a non-real time device. IEEE Std. 802.1AS™ is normative and essential to implement an IEEE Std. 802.1Q Compliant System.

1.1 Project Number: P802.1Qbv
1.2 Type of Document: Standard
1.3 Life Cycle: Full Use

2.1 Title: Standard for Local and metropolitan area networks--Media Access Control (MAC) Bridges and Virtual Bridged Local Area Networks Amendment: Enhancements for Scheduled Traffic

5.2.b. Scope of the project: This amendment specifies time-aware queue-draining procedures, managed objects and extensions to existing protocols that enable bridges and end stations to schedule the transmission of frames based on a synchronized time. Virtual Local Area Network (VLAN) tag encoded priority values are allocated allowing simultaneous support of scheduled traffic, credit-based shaper traffic and other bridged traffic over Local Area Networks (LANs).

(Source: http://www.ieee802.org/1/files/public/docs2014/bv-p802-1Qbv-par-modification-1114.pdf)

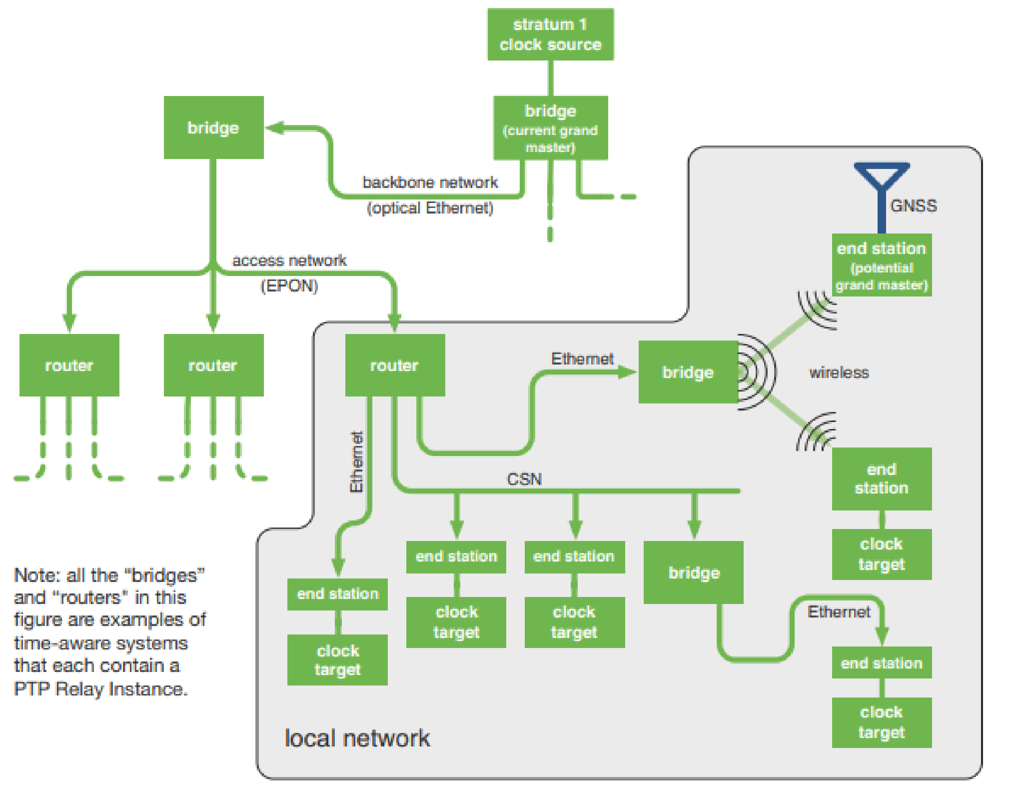

Figure 7-1—Time-aware network example

(Source: https://1.ieee802.org/wp-content/uploads/2019/03/802-1AS-rev-d8-0.pdf)

7.2 Architecture of a time-aware network

7.2.1 General

A time-aware network consists of a number of interconnected time-aware systems that support the gPTP defined within this standard. These time-aware systems can be any networking device, including, for example, bridges, routers, and end stations. A set of time-aware systems that are interconnected by gPTP-capable network elements is called a *gPTP network*. Each instance of gPTP that the time-aware systems support is in one *gPTP domain*, and the instances of gPTP are said to be part of that gPTP domain. A time-aware system can support, and therefore be part of, more than one gPTP domain. The entity of a single time-aware system that executes gPTP in one gPTP domain is called a PTP Instance. A time-aware system can contain multiple PTP Instances, which are each associated with a different gPTP domain. There are two

(Source: https://1.ieee802.org/wp-content/uploads/2019/03/802-1AS-rev-d8-0.pdf)

c) In gPTP there are only two types of PTP Instances: PTP End Instances and PTP Relay Instances, while IEEE 1588 has ordinary clocks, boundary clocks, end-to-end transparent clocks, and P2P transparent clocks. A PTP End Instance corresponds to an IEEE 1588 ordinary clock, and a PTP Relay Instance is a type of IEEE 1588 boundary clock where its operation is very tightly defined, so much so that a PTP Relay Instance with Ethernet ports can be shown to be mathematically equivalent to a P2P transparent clock in terms of how synchronization is performed, as shown in

(Source: https://1.ieee802.org/wp-content/uploads/2019/03/802-1AS-rev-d8-0.pdf)

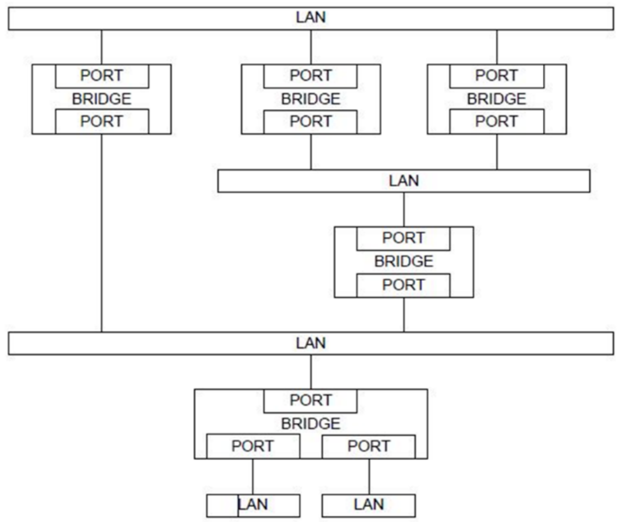

Figure 8-1—A Bridged Network

(Source: IEEE Standard for Local and Metropolitan Area Networks—Bridges and Bridged Networks- IEEE Std 802.1Q™-2018)

Traffic scheduling

This annex provides some background to the mechanisms provided in this standard for traffic scheduling, with the intent of providing some insight into the motivation for the provision of mechanisms for traffic scheduling and some of the ways that the mechanisms might be used.

Q.1 Motivation

Some applications have a need for frame delivery that is highly predictable in terms of the time at which frame transmission will occur, and the overall latency and jitter that will be experienced as the frame is propagated to its destination. Examples include industrial and automotive control applications, where data transmitted over the network is used to feed the parameters of control loops that are critical to the operation of the plant or machinery involved, and where frames carrying control data are transmitted on a repeating time schedule; late delivery of such frames can result in instability, inaccuracy, or failure of the operation of the control loops concerned. In some implementations, this need has been met by the provision of dedicated, highly engineered networks that are used solely for the transmission of time-critical control traffic; however, as the bandwidth occupied by such traffic is often low, and the cost of providing a dedicated control network can be high, it can be desirable to mix time-critical traffic with other classes of traffic in the same network, as long as such mixing can be achieved while still meeting the timing requirements of the time-critical traffic.

(Source: IEEE Standard for Local and metropolitan area networks— Bridges and Bridged Networks Amendment 25: Enhancements for Scheduled Traffic (IEEE 802.1Qbv-2015))

IEEE Std 802.1Q-2018
IEEE Standard for Local and Metropolitan Area Networks—Bridges and Bridged Networks

2. Normative references

The following referenced documents are indispensable for the application of this document (i.e., they must be understood and used, so each referenced document is cited in the text and its relationship to this document is explained). For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments or corrigenda) applies.

ANSI X3.159, American National Standards for Information Systems—Programming Language—C.[5]

IEEE Std 802®, IEEE Standard for Local and metropolitan area networks: Overview and Architecture.[6,7]

IEEE Std 802.1AB™, IEEE Standard for Local and metropolitan area networks—Station and Media Access Control Connectivity Discovery.

IEEE Std 802.1AC™, IEEE Standard for Local and metropolitan area networks—Media Access Control (MAC) Service Definition.

IEEE Std 802.1AE™, IEEE Standard for Local and metropolitan area networks—Media Access Control (MAC) Security.

IEEE Std 802.1AS™, IEEE Standard for Local and metropolitan area networks—Timing and Synchronization for Time-Sensitive Applications in Bridged Local Area Networks.

(Source: IEEE Standard for Local and Metropolitan Area Networks—Bridges and Bridged Networks- IEEE Std 802.1Q™-2018)

31. The methods practiced by ADVA's use of the accused products include defining a common time reference for the device adapters, said common time reference including a frame of time having a plurality of time phases, each of device adapters being uniquely assigned to one of said plurality of time phases, said plurality of time phases including a free-access phase. For example, the accused products are used by ADVA to implement the IEEE 802.1Q standard. The time aware bridged LAN use 802.1AS base time to maintain synchronized time (common time reference) for all the ports in the bridges (device adapters). The bridges containing ports schedule the transmission of traffic based on the synchronized time. Each port associated with a specific set of transmission queues includes a plurality of transmission gates. A transmission gate can be in a closed state or open state. The functionality of assigned time phases is achieved using open

gates transmitting data packets during transmission time. The functionality of free access phase is achieved when the gates are opened for transmission during any time.

1.1 Project Number: P802.1Qbv
1.2 Type of Document: Standard
1.3 Life Cycle: Full Use

2.1 Title: Standard for Local and metropolitan area networks--Media Access Control (MAC) Bridges and Virtual Bridged Local Area Networks Amendment: Enhancements for Scheduled Traffic

5.2.b. Scope of the project: This amendment specifies time-aware queue-draining procedures, managed objects and extensions to existing protocols that enable bridges and end stations to schedule the transmission of frames based on a synchronized time. Virtual Local Area Network (VLAN) tag encoded priority values are allocated allowing simultaneous support of scheduled traffic, credit-based shaper traffic and other bridged traffic over Local Area Networks (LANs).

(Source: http://www.ieee802.org/1/files/public/docs2014/bv-p802-1Qbv-par-modification-1114.pdf)

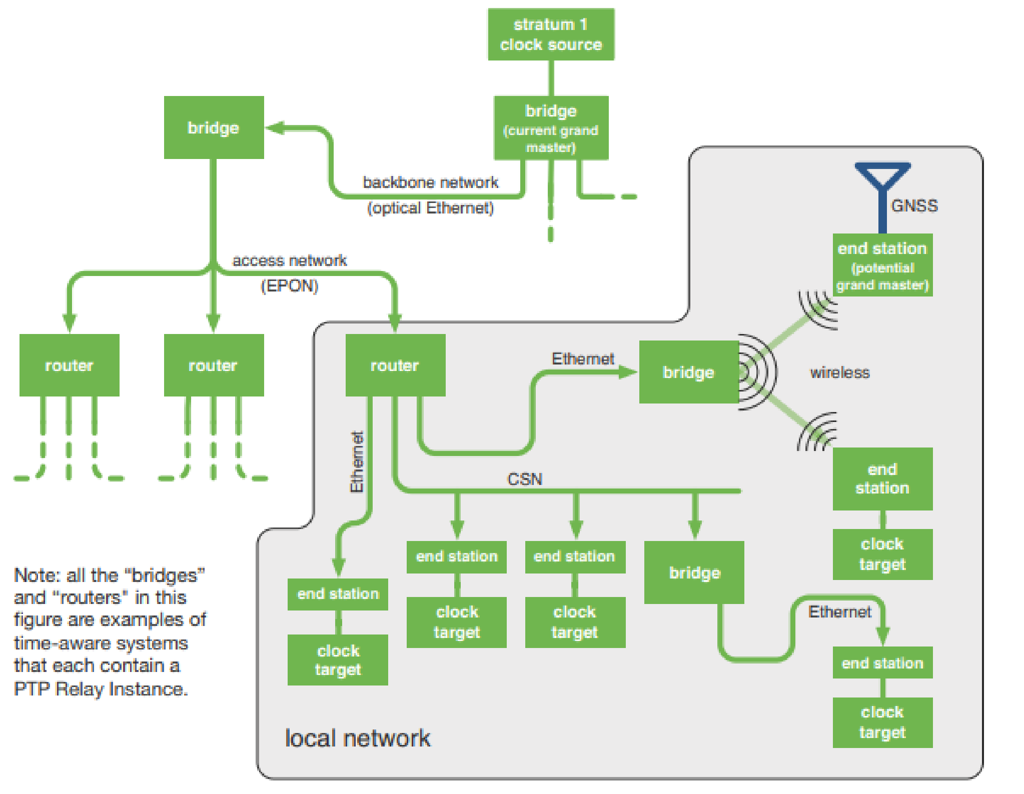

Figure 7-1—Time-aware network example

(Source: https://1.ieee802.org/wp-content/uploads/2019/03/802-1AS-rev-d8-0.pdf)

3.16 PTP End Instance: A PTP Instance that is capable of acting as the source of synchronized time on the network, or destination of synchronized time using the IEEE 802.1AS protocol, or both.

3.17 PTP Instance: A PTP Relay Instance or a PTP End Instance. A PTP Instance implements those portions of this standard indicated as applicable to a PTP Relay Instance or a PTP End Instance. Each PTP Instance operates in exactly one domain.

3.18 PTP Link: Within a domain, a network segment between two PTP Ports using the peer-to-peer delay mechanism of this standard. The peer-to-peer delay mechanism is designed to measure the propagation time over such a link.

NOTE—A PTP Link between PTP Ports of PTP Instances is also a gPTP Communication Path (see 3.9).

3.19 PTP Relay Instance: A PTP Instance that is capable of communicating synchronized time received on one port to other ports, using the IEEE 802.1AS protocol.

NOTE—A PTP Relay Instance could, for example, be contained in a bridge, a router, or a multi-port end station.

(Source: https://1.ieee802.org/wp-content/uploads/2019/03/802-1AS-rev-d8-0.pdf)

8.6.8.4 Enhancements for scheduled traffic

A Bridge or an end station may support enhancements that allow transmission from each queue to be scheduled relative to a known timescale. In order to achieve this, a transmission gate is associated with each queue; the state of the transmission gate determines whether or not queued frames can be selected for transmission (see Figure 8-12). For a given queue, the transmission gate can be in one of two states:

a) *Open*: Queued frames are selected for transmission, in accordance with the definition of the transmission selection algorithm associated with the queue.
b) *Closed*: Queued frames are not selected for transmission.

(Source: IEEE Standard for Local and metropolitan area networks— Bridges and Bridged Networks Amendment 25: Enhancements for Scheduled Traffic (IEEE 802.1Qbv-2015))

8.6.8 Transmission selection

For each Port, frames are selected for transmission on the basis of the traffic classes that the Port supports and the operation of the transmission selection algorithms supported by the corresponding queues on that Port. For a given Port and traffic class, frames are selected from the corresponding queue for transmission if and only if

a) The operation of the transmission selection algorithm supported by that queue determines that there is a frame available for transmission; and

b) For each queue corresponding to a numerically higher value of traffic class supported by the Port, the operation of the transmission selection algorithm supported by that queue determines that there is no frame available for transmission.

(Source: IEEE Standard for Local and Metropolitan Area Networks—Bridges and Bridged Networks- IEEE Std 802.1Q™-2018)

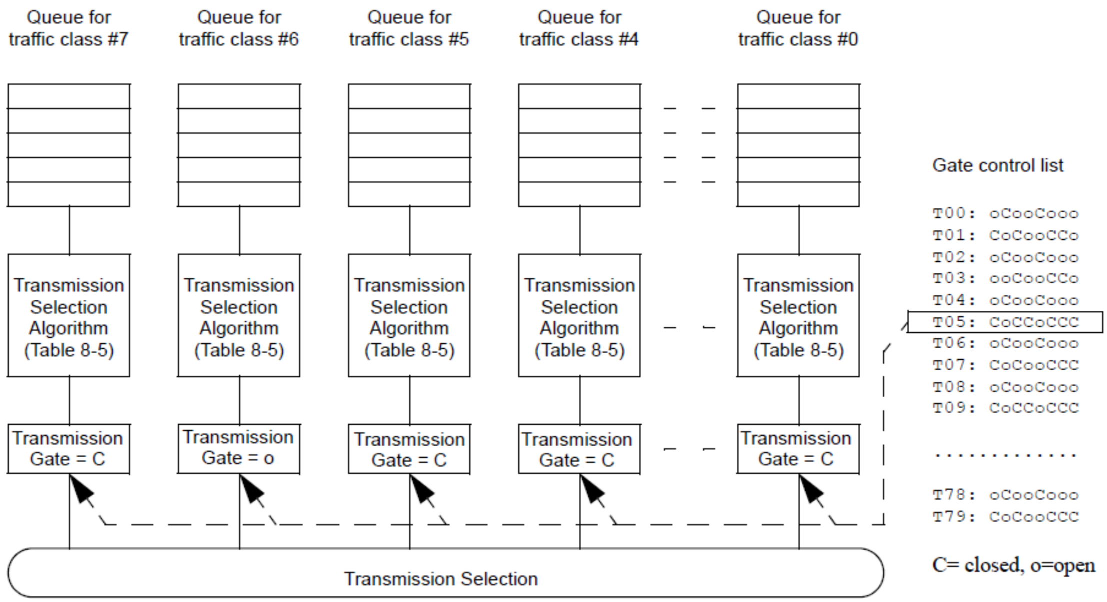

Figure 8-12—Transmission selection with gates

(Source: IEEE Standard for Local and metropolitan area networks— Bridges and Bridged Networks Amendment 25: Enhancements for Scheduled Traffic (IEEE 802.1Qbv-2015))

A *gate control list* associated with each Port contains an ordered list of gate operations. Each gate operation changes the transmission gate state for the gate associated with each of the Port's traffic class queues. In an implementation that does not support enhancements for scheduled traffic, all gates are assumed to be permanently in the *open* state. Table 8-6 identifies the gate operation types, their parameters, and the actions that result from their execution. The state machines that control the execution of the gate control list, along with their variables and procedures, are specified in 8.6.9.

(Source: IEEE Standard for Local and metropolitan area networks— Bridges and Bridged Networks Amendment 25: Enhancements for Scheduled Traffic (IEEE 802.1Qbv-2015))

32. The methods practiced by ADVA's use of the accused products include allowing a device adapter to transmit packets during said time phase uniquely assigned thereto and during said free-access phase. For example, the accused products are used by ADVA to implement the IEEE 802.1Q standard. The open gates assigned to the transmission queue of a port (device adapter) transmit the data packets during the transmission time. The transmission selection algorithm determines the transmission time. If the gates are in permanent open state, the data packets are transmitted from the gates during any time. The functionality of assigned time phases

is achieved using open gates transmitting data packets during transmission time. The functionality of free access phase is achieved when the gates are permanently opened for transmission during any time.

> **8.6.8.4 Enhancements for scheduled traffic**
>
> A Bridge or an end station may support enhancements that allow transmission from each queue to be scheduled relative to a known timescale. In order to achieve this, a transmission gate is associated with each queue; the state of the transmission gate determines whether or not queued frames can be selected for transmission (see Figure 8-12). For a given queue, the transmission gate can be in one of two states:
>
> a) *Open*: Queued frames are selected for transmission, in accordance with the definition of the transmission selection algorithm associated with the queue.
> b) *Closed*: Queued frames are not selected for transmission.

(Source: IEEE Standard for Local and metropolitan area networks— Bridges and Bridged Networks Amendment 25: Enhancements for Scheduled Traffic (IEEE 802.1Qbv-2015))

> **3.4 transmission gate:** A gate that connects or disconnects the transmission selection function of the forwarding process from the queue, allowing or preventing it from selecting frames from that queue. The gate has two states, Open and Closed.

(Source: IEEE Standard for Local and metropolitan area networks— Bridges and Bridged Networks Amendment 25: Enhancements for Scheduled Traffic (IEEE 802.1Qbv-2015))

> A *gate control list* associated with each Port contains an ordered list of gate operations. Each gate operation changes the transmission gate state for the gate associated with each of the Port's traffic class queues. In an implementation that does not support enhancements for scheduled traffic, all gates are assumed to be permanently in the *open* state. Table 8-6 identifies the gate operation types, their parameters, and the actions that result from their execution. The state machines that control the execution of the gate control list, along with their variables and procedures, are specified in 8.6.9.

(Source: IEEE Standard for Local and metropolitan area networks— Bridges and Bridged Networks Amendment 25: Enhancements for Scheduled Traffic (IEEE 802.1Qbv-2015))

33. The methods practiced by ADVA's use of the accused products include designating one of said device adapters as a master timing device. For example, the accused products are used by ADVA to implement the IEEE 802.1Q standard. The ports of the time

aware bridge (device adapter) uses best master clock algorithm (BMCA) to determine a potential grandmaster port (master timing device).

7.2.2 Time-aware network consisting of a single gPTP domain

Figure 7-1 illustrates an example time-aware network consisting of a single gPTP domain, using all theabove network technologies (i.e., (c) - (f) of 7.2.1), where end stations on several local networks are connected to a grandmaster on a backbone network via an EPON access network.

Any PTP Instance with clock sourcing capabilities can be a potential grandmaster, so there is a selection method (the *best master clock algorithm*, or BMCA) that ensures that all of the PTP Instances in a gPTP domain use the same grandmaster.[12] The BMCA is largely identical to that used in IEEE Std 1588-2019,

(Source: https://1.ieee802.org/wp-content/uploads/2019/03/802-1AS-rev-d8-0.pdf)

10.3.1.1 Best master clock algorithm overview

In the BMCA (i.e., method (a) of 10.3.1), best master selection information is exchanged between PTP Instances of time-aware systems via Announce messages (see 10.5 and 10.6). Each Announce message contains time-synchronization spanning tree vector information that identifies one PTP Instance as the root of the time-synchronization spanning tree and, if the PTP Instance is grandmaster-capable, the grandmaster. Each PTP Instance in turn uses the information contained in the Announce messages it receives, along with its knowledge of itself, to compute which of the PTP Instances that it has knowledge of ought to be the root of the spanning tree and, if grandmaster-capable, the grandmaster. As part of constructing the time-synchronization spanning tree, each port of each PTP Instance is assigned a port state from Table 10-2 by state machines associated with the ports and with the PTP Instance as a whole.

(Source: https://1.ieee802.org/wp-content/uploads/2019/03/802-1AS-rev-d8-0.pdf)

11.1.3 Transport of time-synchronization information

The transport of time-synchronization information by a PTP Instance, using Sync and Follow_Up (or just Sync) messages, is illustrated in Figure 11-2. The mechanism is mathematically equivalent to the mechanism described in IEEE Std 1588-2019 for a peer-to-peer transparent clock that is syntonized (see 11.4.5.1, 11.5.1, and 11.5.2.2 of IEEE Std 1588-2019). However, as will be seen shortly, the processes of transporting synchronization by a peer-to-peer transparent clock that is syntonized and by a boundary clock are mathematically and functionally equivalent. The main functional difference between the two types of clocks is that the boundary clock participates in best master selection and invokes the BMCA, while the peer-to-peer transparent clock does not participate in best master selection and does not invoke the BMCA (and implementations of the two types of clocks can be different).

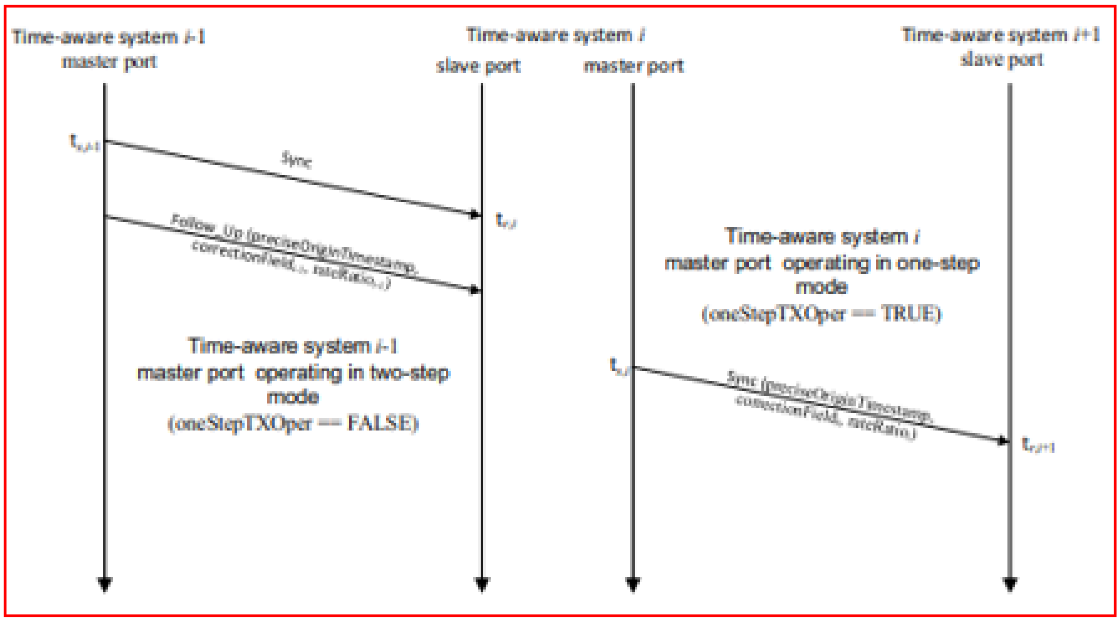

Figure 11-2—Transport of time-synchronization information

(Source: https://1.ieee802.org/wp-content/uploads/2019/03/802-1AS-rev-d8-0.pdf)

c) In gPTP there are only two types of PTP Instances: PTP End Instances and PTP Relay Instances, while IEEE 1588 has ordinary clocks, boundary clocks, end-to-end transparent clocks, and P2P transparent clocks. A PTP End Instance corresponds to an IEEE 1588 ordinary clock, and a PTP Relay Instance is a type of IEEE 1588 boundary clock where its operation is very tightly defined, so much so that a PTP Relay Instance with Ethernet ports can be shown to be mathematically equivalent to a P2P transparent clock in terms of how synchronization is performed, as shown in

(Source: https://1.ieee802.org/wp-content/uploads/2019/03/802-1AS-rev-d8-0.pdf)

34. The methods practiced by ADVA's use of the accused products include synchronizing the clocks of the remaining device adapters with said master timing device. For

example, the accused products are used by ADVA to implement the IEEE 802.1Q standard. The boundary clocks of the slave ports in the time aware bridges (remaining device adapters) are synchronized with the grandmaster boundary clock (master timing device).

c) In gPTP there are only two types of PTP Instances: PTP End Instances and PTP Relay Instances, while IEEE 1588 has ordinary clocks, boundary clocks, end-to-end transparent clocks, and P2P transparent clocks. A PTP End Instance corresponds to an IEEE 1588 ordinary clock, and a PTP Relay Instance is a type of IEEE 1588 boundary clock where its operation is very tightly defined, so much so that a PTP Relay Instance with Ethernet ports can be shown to be mathematically equivalent to a P2P transparent clock in terms of how synchronization is performed, as shown in

(Source: https://1.ieee802.org/wp-content/uploads/2019/03/802-1AS-rev-d8-0.pdf)

3.16 PTP End Instance: A PTP Instance that is capable of acting as the source of synchronized time on the network, or destination of synchronized time using the IEEE 802.1AS protocol, or both.

3.17 PTP Instance: A PTP Relay Instance or a PTP End Instance. A PTP Instance implements those portions of this standard indicated as applicable to a PTP Relay Instance or a PTP End Instance. Each PTP Instance operates in exactly one domain.

3.18 PTP Link: Within a domain, a network segment between two PTP Ports using the peer-to-peer delay mechanism of this standard. The peer-to-peer delay mechanism is designed to measure the propagation time over such a link.

NOTE—A PTP Link between PTP Ports of PTP Instances is also a gPTP Communication Path (see 3.9).

3.19 PTP Relay Instance: A PTP Instance that is capable of communicating synchronized time received on one port to other ports, using the IEEE 802.1AS protocol.

NOTE—A PTP Relay Instance could, for example, be contained in a bridge, a router, or a multi-port end station.

(Source: https://1.ieee802.org/wp-content/uploads/2019/03/802-1AS-rev-d8-0.pdf)

11.1.3 Transport of time-synchronization information

The transport of time-synchronization information by a PTP Instance, using Sync and Follow_Up (or just Sync) messages, is illustrated in Figure 11-2. The mechanism is mathematically equivalent to the mechanism described in IEEE Std 1588-2019 for a peer-to-peer transparent clock that is syntonized (see 11.4.5.1, 11.5.1, and 11.5.2.2 of IEEE Std 1588-2019). However, as will be seen shortly, the processes of transporting synchronization by a peer-to-peer transparent clock that is syntonized and by a boundary clock are mathematically and functionally equivalent. The main functional difference between the two types of clocks is that the boundary clock participates in best master selection and invokes the BMCA, while the peer-to-peer transparent clock does not participate in best master selection and does not invoke the BMCA (and implementations of the two types of clocks can be different).

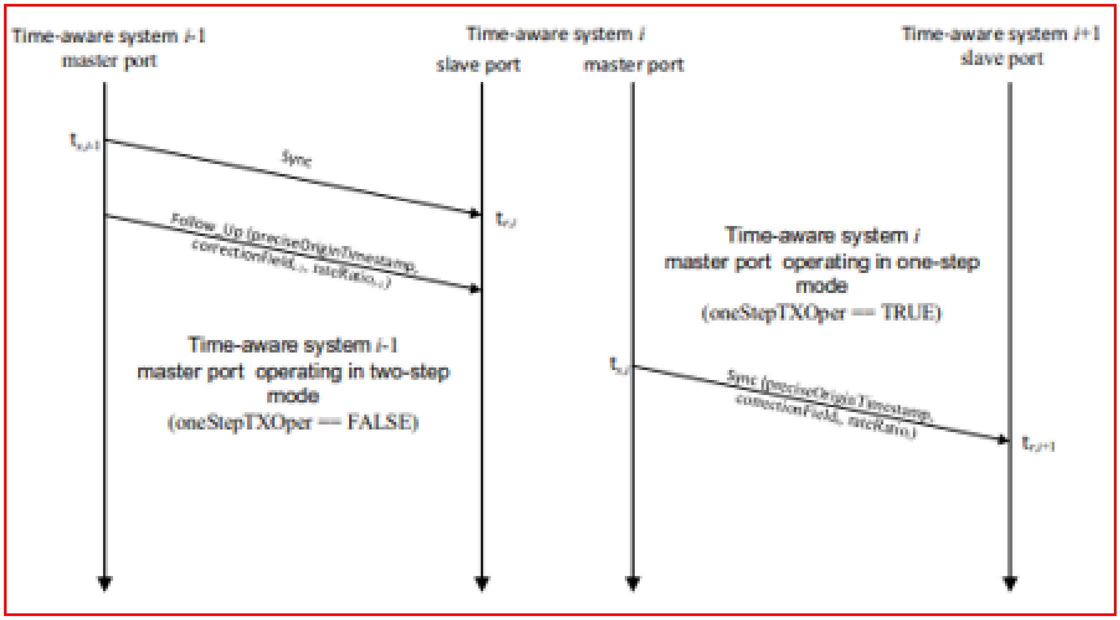

Figure 11-2—Transport of time-synchronization information

(Source: https://1.ieee802.org/wp-content/uploads/2019/03/802-1AS-rev-d8-0.pdf)

35. Far North Patents has been damaged as a result of the infringing conduct by ADVA alleged above. Thus, ADVA is liable to Far North Patents in an amount that adequately compensates it for such infringements, which, by law, cannot be less than a reasonable royalty, together with interest and costs as fixed by this Court under 35 U.S.C. § 284.

36. Far North Patents and/or its predecessors-in-interest have satisfied all statutory obligations required to collect pre-filing damages for the full period allowed by law for infringement of the ‘702 Patent.

COUNT III

DIRECT INFRINGEMENT OF U.S. PATENT NO. 6,215,797

37. On April 10, 2001, United States Patent No. 6,215,797 (“the ‘797 Patent”) was duly and legally issued by the United States Patent and Trademark Office for an invention entitled “Methods and Apparatus for Providing Quality of Service Guarantees in Computer Networks.”

38. Far North Patents is the owner of the ‘797 Patent, with all substantive rights in and to that patent, including the sole and exclusive right to prosecute this action and enforce the ‘797 Patent against infringers, and to collect damages for all relevant times.

39. ADVA made, had made, used, imported, provided, supplied, distributed, sold, and/or offered for sale products and/or systems including, for example, its ADVA FSP 150-GO102Pro and ADVA FSP 150-GE102Pro families of products that include advanced quality of service capabilities (collectively, “accused products”).

ADVA™

FSP 150-GO102Pro Series

Outdoor Carrier Ethernet and IP demarcation

Public outdoor small cells, Wi-Fi and closed circuit TV (CCTV) require connectivity services which end outside a controlled environment. But service providers don't want to invest in expensive and unsightly cabinets. That's why small environmentally sealed network demarcation devices are a game changer.

Communication service providers (CSPs) struggle to cope with a high number of specialized boxes. They need a single demarcation product that can cover a wide range of applications and be effective even under harsh environmental conditions. Our FSP 150-GO102Pro, a member of the market-leading FSP 150 family, makes a real difference. Its small size and low power consumption make it easy to install and simple to configure. It supports a comprehensive set of Carrier Ethernet and IP connectivity services. Automated testing and in-service monitoring protocols simplify any phase of the service lifecycle. What's more, our FSP 150-GO102Pro also provides precise synchronization. Such a unique combination of features makes it the perfect solution for connecting small cell sites.

(Source : Screenshot of PDF downloaded from https://www.adva.com/-/media/adva-main-site/resources/data-sheets/pdfs/fsp-150-go-102-pro-series.ashx?la=de-de&hash=5122080C1CCB4C881E30D8D62F0DF92DF16C098B)

VLAN support

- 4096 VLANs (IEEE 802.1Q customer-tagged) and stacked VLANs (Q-in-Q service provider tagged)
- 2-tag management (push/pop/swap) for c-tag and s-tag
- IEEE 802.1ad provider bridging (c-tag, s-tag)
- Ethertype translation
- Eight Ethernet virtual circuits (EVC)
- 9612 byte-per-frame MTU transparency

Layer 2 traffic management

- Acceptable client frame policy: tagged or untagged
- Service classification based on IEEE 802.1p, 802.1Q and IP-TOS/DSCP
- VLAN tag priority mapping (IEEE 802.1ad PCP encoding)
- MEF-compliant policing (CIR/CBS/EIR/EBS) with three-color marking and eight classes of service
- Port shaping on transmit for both client and network ports
- MEF 10.3 hierarchical policing with token-share envelopes
- DiffServ supporting WFQ/SP mix

(Source : Screenshot of PDF downloaded from https://www.adva.com/-/media/adva-main-site/resources/data-sheets/pdfs/fsp-150-go-102-pro-series.ashx?la=de-de&hash=5122080C1CCB4C881E30D8D62F0DF92DF16C098B)

ADVA today answered the urgent need for small cell backhaul with the launch of the world's smallest cell site gateway device. The ADVA FSP 150-GO102Pro Series has been specifically engineered to be installed in the most challenging locations, enabling the easy deployment of small cells at street level. With its uniquely compact and ruggedized design, it provides multi-layer service demarcation in a wide range of outdoor locations, from walls to poles to lampposts. The ADVA FSP 150-GO102Pro Series also delivers highly precise time and frequency synchronization and features automated testing and in-service monitoring. With the ADVA FSP 150-GO102Pro Series, service providers can easily and cost-effectively introduce next-generation mobile connectivity services for the IoT and 5G era. The new solution is already in customer trials and is generally available from today.

"Our FSP 150-GO102Pro Series is the ultimate outdoor demarcation technology. It ensures the highest quality of service even in the harshest conditions. This phenomenally versatile device empowers operators to deliver reliable, programmable mobile backhaul connectivity without investing in expensive cabinets or power-hungry air conditioning systems," said Stephan Rettenberger, SVP, marketing and investor relations, ADVA. "We worked closely with major wholesale service providers to develop our FSP 150-GO102Pro Series. The solution is specifically engineered to meet their exacting requirements and facilitate their 5G ambitions. It offers full Layer 2 and 3 service demarcation with a complete set of Carrier Ethernet and routing features. The FSP 150-GO102Pro Series even provides highly automated zero touch provisioning for effortless installation and activation."

(Source : https://www.newswiretoday.com/news/168708/)

ADVA™

FSP 150-GE100Pro Series

Programmable Carrier Ethernet and IP demarcation

As complexity increases, network demarcation devices need to continuously extend their capabilities. Communication service provider need one product family for Ethernet and IP, indoor or outdoor, sophisticated security and highly precise synchronization.

Change is the norm. Today, your business customer wants Ethernet connectivity. Tomorrow, it's IP services. Frequency synchronization is no longer sufficient for your mobile network as time synchronization is mandatory for 4G. Meanwhile, your customers decide that they won't accept unencrypted transmission. The one constant is that requirements keep changing – and at an unprecedented pace. Our FSP 150-GE100Pro series belongs to the successful FSP 150 ProNID family. It enables network operators to offer true multi-service access by combining the demarcation of Carrier Ethernet 2.0 and IP services with a rich set of features in a single device. What's more, there's a range of designs from ultra-compact to rack-mountable devices, all aligned with distinct customer demand. The comprehensive FSP 150-GE100Pro series provides the perfect answer to any demarcation requirement.

(Source : Screenshot of PDF downloaded from https://www.adva.com/-/media/adva-main-site/resources/data-sheets/pdfs/fsp-150-ge-100-pro-series.ashx?la=de-DE&hash=46C2728AB543DEB24ECC9B31953C3463C4325AB5)

VLAN support

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- Ethertype translation
- $8^{1-2}/32^{3-5}/64^{6-10}$ Ethernet virtual circuits (EVC)
- 9612 Byte per frame MTU transparency
- EoMPLS encapsulation

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- VLAN tag priority mapping (IEEE 802.1ad PCP encoding)
- MEF-compliant policing (CIR/CBS/EIR/EBS) with three-color marking and eight classes of service
- Port shaping on transmit for both client and network ports
- MEF 10.3 hierarchical policing with token-share envelopes
- DiffServ supporting WFQ/SP mix

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40. By doing so, ADVA has directly infringed (literally and/or under the doctrine of equivalents) at least Claim 30 of the '797 Patent.

41. ADVA has infringed the '797 Patent by using the accused products and thereby practicing a method for regulating traffic in a network including devices for generating packets of data, a network medium for carrying the packets, and a plurality of device adapters connected between the devices and the network medium. For example, the accused products are used by ADVA to implement the IEEE 802.1Q standard. IEEE standard 802.1Q (Qbv) implements a method for scheduling traffic in time aware Local Area Network. The time aware network includes multiple end points that transmit data packets and bridges that includes ports (device adapters). The interconnects (network medium) carry the transmitted data packets. The endpoints and bridges are connected via interconnects.

1.1 Project Number: P802.1Qbv
1.2 Type of Document: Standard
1.3 Life Cycle: Full Use

2.1 Title: Standard for Local and metropolitan area networks--Media Access Control (MAC) Bridges and Virtual Bridged Local Area Networks Amendment: Enhancements for Scheduled Traffic

5.2.b. Scope of the project: This amendment specifies time-aware queue-draining procedures, managed objects and extensions to existing protocols that enable bridges and end stations to schedule the transmission of frames based on a synchronized time. Virtual Local Area Network (VLAN) tag encoded priority values are allocated allowing simultaneous support of scheduled traffic, credit-based shaper traffic and other bridged traffic over Local Area Networks (LANs).

(Source: http://www.ieee802.org/1/files/public/docs2014/bv-p802-1Qbv-par-modification-1114.pdf)

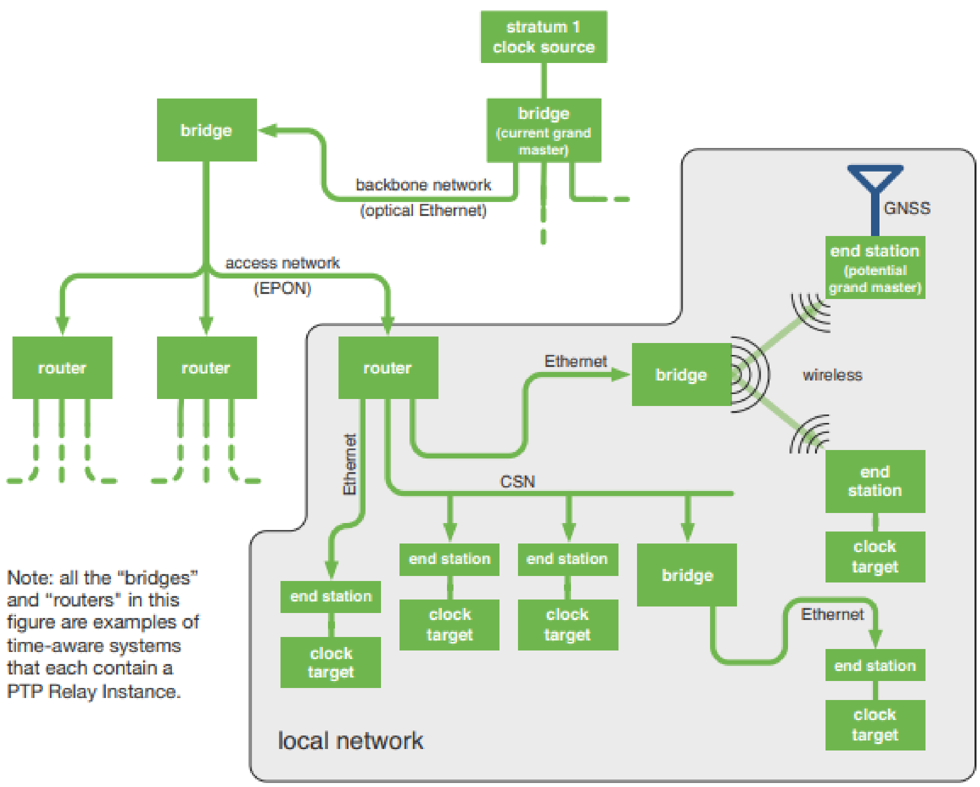

Figure 7-1—Time-aware network example

(Source: https://1.ieee802.org/wp-content/uploads/2019/03/802-1AS-rev-d8-0.pdf)

7.2 Architecture of a time-aware network

7.2.1 General

A time-aware network consists of a number of interconnected time-aware systems that support the gPTP defined within this standard. These time-aware systems can be any networking device, including, for example, bridges, routers, and end stations. A set of time-aware systems that are interconnected by gPTP-capable network elements is called a *gPTP network*. Each instance of gPTP that the time-aware systems support is in one *gPTP domain*, and the instances of gPTP are said to be part of that gPTP domain. A time-aware system can support, and therefore be part of, more than one gPTP domain. The entity of a single time-aware system that executes gPTP in one gPTP domain is called a PTP Instance. A time-aware system can contain multiple PTP Instances, which are each associated with a different gPTP domain. There are two

(Source: https://1.ieee802.org/wp-content/uploads/2019/03/802-1AS-rev-d8-0.pdf)

Traffic scheduling

This annex provides some background to the mechanisms provided in this standard for traffic scheduling, with the intent of providing some insight into the motivation for the provision of mechanisms for traffic scheduling and some of the ways that the mechanisms might be used.

Q.1 Motivation

Some applications have a need for frame delivery that is highly predictable in terms of the time at which frame transmission will occur, and the overall latency and jitter that will be experienced as the frame is propagated to its destination. Examples include industrial and automotive control applications, where data transmitted over the network is used to feed the parameters of control loops that are critical to the operation of the plant or machinery involved, and where frames carrying control data are transmitted on a repeating time schedule; late delivery of such frames can result in instability, inaccuracy, or failure of the operation of the control loops concerned. In some implementations, this need has been met by the provision of dedicated, highly engineered networks that are used solely for the transmission of time-critical control traffic; however, as the bandwidth occupied by such traffic is often low, and the cost of providing a dedicated control network can be high, it can be desirable to mix time-critical traffic with other classes of traffic in the same network, as long as such mixing can be achieved while still meeting the timing requirements of the time-critical traffic.

(Source: IEEE Standard for Local and metropolitan area networks— Bridges and Bridged Networks Amendment 25: Enhancements for Scheduled Traffic (IEEE 802.1Qbv-2015))

b) gPTP specifies a media-independent sublayer that simplifies the integration within a single timing domain of multiple different networking technologies with radically different media access protocols. gPTP specifies a media-dependent sublayer for each medium. The information exchanged between PTP Instances has been generalized to support different packet formats and management schemes appropriate to the particular networking technology. IEEE Std 1588-2019, on the other

(Source: https://1.ieee802.org/wp-content/uploads/2019/03/802-1AS-rev-d8-0.pdf)

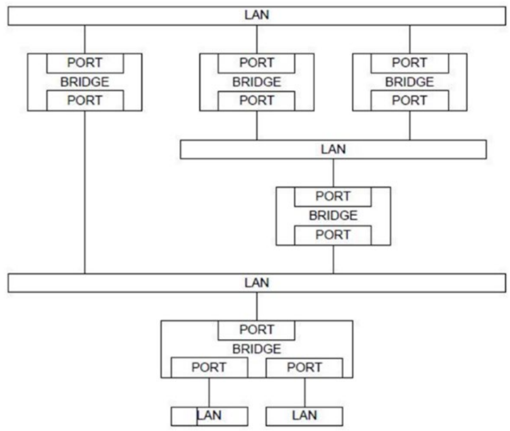

Figure 8-1—A Bridged Network

(Source: IEEE Standard for Local and Metropolitan Area Networks—Bridges and Bridged Networks- IEEE Std 802.1Q™-2018)

42. The methods practiced by ADVA's use of the accused products include defining a common time reference for the device adapters, said common time reference including a frame of time having a plurality of time phases, each device adapter being uniquely assigned to one of said plurality of time phases, said plurality of time phases including a free-access phase. For example, the accused products are used by ADVA to implement the IEEE 802.1Q standard. The time aware bridged LAN uses 802.1AS base time to maintain synchronized time (common time reference) for all the ports in the bridges (device adapters). The bridges containing ports are scheduled for transmission of traffic based on the synchronized time. Each port associated with a specific set of transmission queues includes a plurality of transmission gates. A transmission gate can be in a closed state or open state. The functionality of assigned time phases is achieved using open gates transmitting data packets during transmission time. The functionality of free access phase is achieved when the gates are opened for transmission during any time. IEEE Std. 802.1AS™-2011 is normative and essential to implement an IEEE Std. 802.1Q Compliant System.

1.1 Project Number: P802.1Qbv
1.2 Type of Document: Standard
1.3 Life Cycle: Full Use

2.1 Title: Standard for Local and metropolitan area networks--Media Access Control (MAC) Bridges and Virtual Bridged Local Area Networks Amendment: Enhancements for Scheduled Traffic

5.2.b. Scope of the project: This amendment specifies time-aware queue-draining procedures, managed objects and extensions to existing protocols that enable bridges and end stations to schedule the transmission of frames based on a synchronized time. Virtual Local Area Network (VLAN) tag encoded priority values are allocated allowing simultaneous support of scheduled traffic, credit-based shaper traffic and other bridged traffic over Local Area Networks (LANs).

(Source: http://www.ieee802.org/1/files/public/docs2014/bv-p802-1Qbv-par-modification-1114.pdf)

IEEE Std 802.1Q-2018
IEEE Standard for Local and Metropolitan Area Networks—Bridges and Bridged Networks

2. Normative references

The following referenced documents are indispensable for the application of this document (i.e., they must be understood and used, so each referenced document is cited in the text and its relationship to this document is explained). For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments or corrigenda) applies.

ANSI X3.159, American National Standards for Information Systems—Programming Language—C.[5]

IEEE Std 802®, IEEE Standard for Local and metropolitan area networks: Overview and Architecture.[6,7]

IEEE Std 802.1AB™, IEEE Standard for Local and metropolitan area networks—Station and Media Access Control Connectivity Discovery.

IEEE Std 802.1AC™, IEEE Standard for Local and metropolitan area networks—Media Access Control (MAC) Service Definition.

IEEE Std 802.1AE™, IEEE Standard for Local and metropolitan area networks—Media Access Control (MAC) Security.

IEEE Std 802.1AS™, IEEE Standard for Local and metropolitan area networks—Timing and Synchronization for Time-Sensitive Applications in Bridged Local Area Networks.

(Source: IEEE Standard for Local and Metropolitan Area Networks—Bridges and Bridged Networks- IEEE Std 802.1Q™-2018)

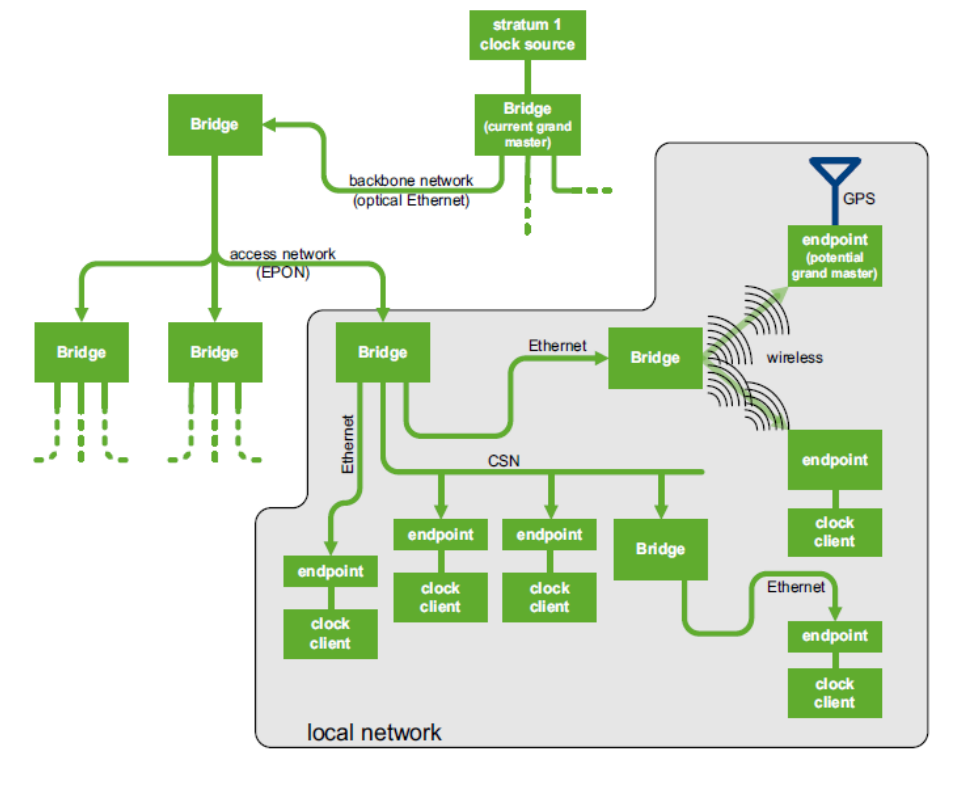

Figure 7-1—Time-aware network example

(Source: IEEE Standard for Local and metropolitan area networks - Timing and Synchronization for Time - Sensitive Applications in Bridged Local Area Networks - IEEE Std 802.1AS™-2011)

3.16 PTP End Instance: A PTP Instance that is capable of acting as the source of synchronized time on the network, or destination of synchronized time using the IEEE 802.1AS protocol, or both.

3.17 PTP Instance: A PTP Relay Instance or a PTP End Instance. A PTP Instance implements those portions of this standard indicated as applicable to a PTP Relay Instance or a PTP End Instance. Each PTP Instance operates in exactly one domain.

3.18 PTP Link: Within a domain, a network segment between two PTP Ports using the peer-to-peer delay mechanism of this standard. The peer-to-peer delay mechanism is designed to measure the propagation time over such a link.

NOTE—A PTP Link between PTP Ports of PTP Instances is also a gPTP Communication Path (see 3.9).

3.19 PTP Relay Instance: A PTP Instance that is capable of communicating synchronized time received on one port to other ports, using the IEEE 802.1AS protocol.

NOTE—A PTP Relay Instance could, for example, be contained in a bridge, a router, or a multi-port end station.

(Source: https://1.ieee802.org/wp-content/uploads/2019/03/802-1AS-rev-d8-0.pdf)

8.6.8.4 Enhancements for scheduled traffic

A Bridge or an end station may support enhancements that allow transmission from each queue to be scheduled relative to a known timescale. In order to achieve this, a transmission gate is associated with each queue; the state of the transmission gate determines whether or not queued frames can be selected for transmission (see Figure 8-12). For a given queue, the transmission gate can be in one of two states:

a) *Open*: Queued frames are selected for transmission, in accordance with the definition of the transmission selection algorithm associated with the queue.
b) *Closed*: Queued frames are not selected for transmission.

(Source: IEEE Standard for Local and metropolitan area networks— Bridges and Bridged Networks Amendment 25: Enhancements for Scheduled Traffic (IEEE 802.1Qbv-2015))

8.6.8 Transmission selection

For each Port, frames are selected for transmission on the basis of the traffic classes that the Port supports and the operation of the transmission selection algorithms supported by the corresponding queues on that Port. For a given Port and traffic class, frames are selected from the corresponding queue for transmission if and only if

a) The operation of the transmission selection algorithm supported by that queue determines that there is a frame available for transmission; and

b) For each queue corresponding to a numerically higher value of traffic class supported by the Port, the operation of the transmission selection algorithm supported by that queue determines that there is no frame available for transmission.

(Source: IEEE Standard for Local and Metropolitan Area Networks—Bridges and Bridged Networks- IEEE Std 802.1Q™-2018)

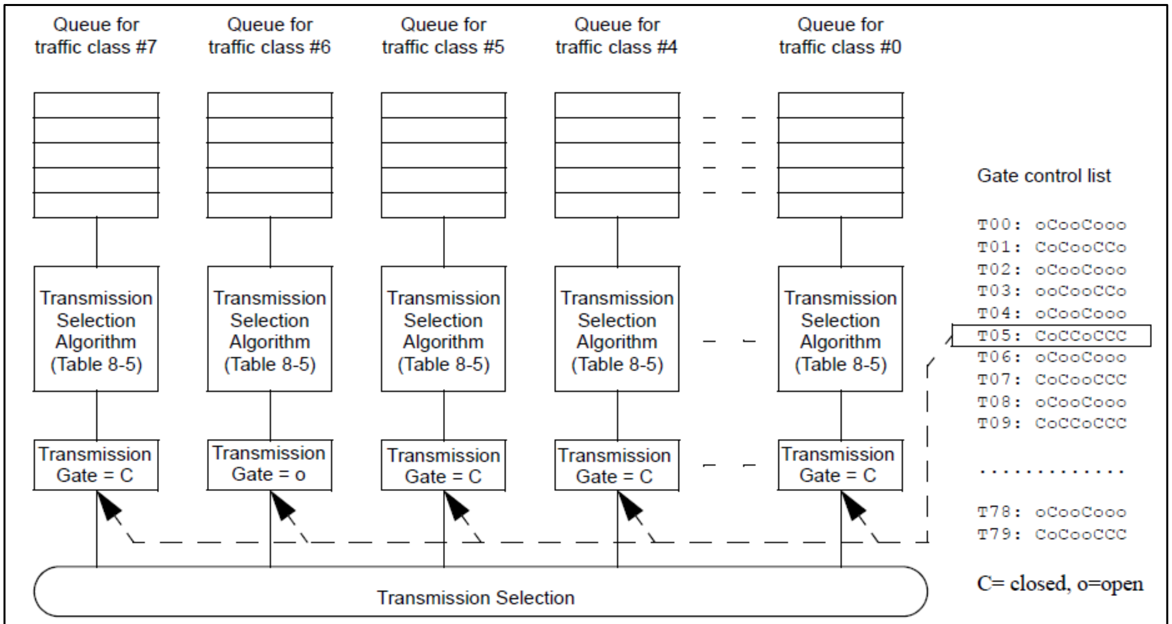

Figure 8-12—Transmission selection with gates

(Source: IEEE Standard for Local and metropolitan area networks— Bridges and Bridged Networks Amendment 25: Enhancements for Scheduled Traffic (IEEE 802.1Qbv-2015))

> A *gate control list* associated with each Port contains an ordered list of gate operations. Each gate operation changes the transmission gate state for the gate associated with each of the Port's traffic class queues. In an implementation that does not support enhancements for scheduled traffic, all gates are assumed to be permanently in the *open* state. Table 8-6 identifies the gate operation types, their parameters, and the actions that result from their execution. The state machines that control the execution of the gate control list, along with their variables and procedures, are specified in 8.6.9.

(Source: IEEE Standard for Local and metropolitan area networks— Bridges and Bridged Networks Amendment 25: Enhancements for Scheduled Traffic (IEEE 802.1Qbv-2015))

43. The methods practiced by ADVA's use of the accused products include allowing a device adapter to transmit packets during said time phase uniquely assigned thereto and during said free-access phase. For example, the accused products are used by ADVA to implement the IEEE 802.1Q standard. The open gates assigned to the transmission queue of a port (device adapter) transmit the data packets during the transmission time. The transmission selection algorithm determines the transmission time. If the gates are in permanent open state, the data packets are transmitted from the gates during any time. The functionality of assigned time phases

is achieved using open gates transmitting data packets during transmission time. The functionality of free access phase is achieved when the gates are permanently opened for transmission during any time.

8.6.8.4 Enhancements for scheduled traffic

A Bridge or an end station may support enhancements that allow transmission from each queue to be scheduled relative to a known timescale. In order to achieve this, a transmission gate is associated with each queue; the state of the transmission gate determines whether or not queued frames can be selected for transmission (see Figure 8-12). For a given queue, the transmission gate can be in one of two states:

a) *Open*: Queued frames are selected for transmission, in accordance with the definition of the transmission selection algorithm associated with the queue.
b) *Closed*: Queued frames are not selected for transmission.

(Source: IEEE Standard for Local and metropolitan area networks— Bridges and Bridged Networks Amendment 25: Enhancements for Scheduled Traffic (IEEE 802.1Qbv-2015))

3.4 transmission gate: A gate that connects or disconnects the transmission selection function of the forwarding process from the queue, allowing or preventing it from selecting frames from that queue. The gate has two states, Open and Closed.

(Source: IEEE Standard for Local and metropolitan area networks— Bridges and Bridged Networks Amendment 25: Enhancements for Scheduled Traffic (IEEE 802.1Qbv-2015))

11.1.3 Transport of time-synchronization information

The transport of time-synchronization information by a PTP Instance, using Sync and Follow_Up (or just Sync) messages, is illustrated in Figure 11-2. The mechanism is mathematically equivalent to the mechanism described in IEEE Std 1588-2019 for a peer-to-peer transparent clock that is syntonized (see 11.4.5.1, 11.5.1, and 11.5.2.2 of IEEE Std 1588-2019). However, as will be seen shortly, the processes of transporting synchronization by a peer-to-peer transparent clock that is syntonized and by a boundary clock are mathematically and functionally equivalent. The main functional difference between the two types of clocks is that the boundary clock participates in best master selection and invokes the BMCA, while the peer-to-peer transparent clock does not participate in best master selection and does not invoke the BMCA (and implementations of the two types of clocks can be different).

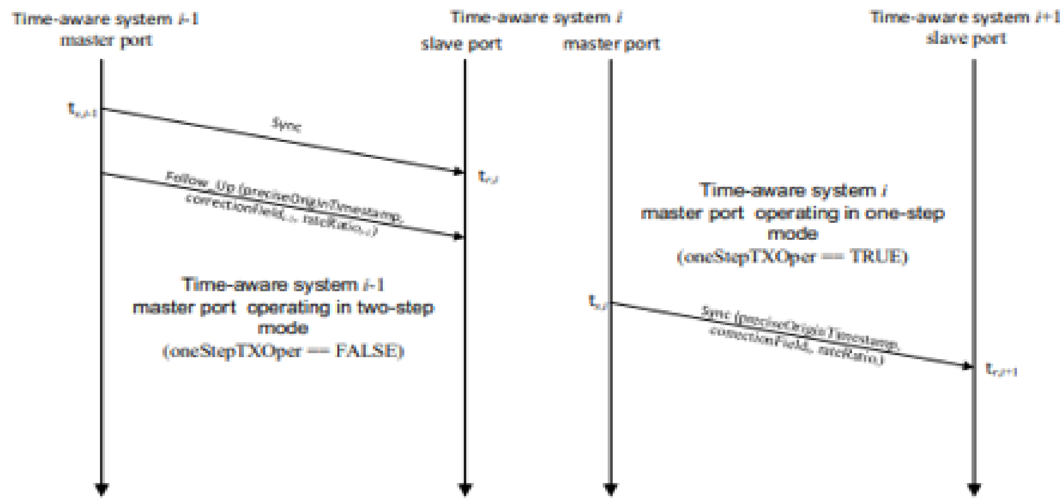

Figure 11-2—Transport of time-synchronization information

(Source: IEEE Standard for Local and metropolitan area networks— Bridges and Bridged Networks Amendment 25: Enhancements for Scheduled Traffic (IEEE 802.1Qbv-2015))

A *gate control list* associated with each Port contains an ordered list of gate operations. Each gate operation changes the transmission gate state for the gate associated with each of the Port's traffic class queues. In an implementation that does not support enhancements for scheduled traffic, all gates are assumed to be permanently in the *open* state. Table 8-6 identifies the gate operation types, their parameters, and the actions that result from their execution. The state machines that control the execution of the gate control list, along with their variables and procedures, are specified in 8.6.9.

(Source: IEEE Standard for Local and metropolitan area networks— Bridges and Bridged Networks Amendment 25: Enhancements for Scheduled Traffic (IEEE 802.1Qbv-2015))

44. The methods practiced by ADVA's use of the accused products include cyclically repeating said frame. For example, the accused products are used by ADVA to implement the

IEEE 802.1Q standard. IEEE Std. 802.1Q-2018 supports cyclic queuing and forwarding structures to create synchronized frames and gates that are repeated periodically (Annex T).

Cyclic queuing and forwarding[53]

T.1 Overview of CQF

Cyclic queuing and forwarding (CQF) is a method of traffic shaping that can deliver deterministic, and easily calculated, latency for time-sensitive traffic streams. As the name implies, the principle underlying CQF is that stream traffic is transmitted and queued for transmission along a network path in a cyclic manner. Time is divided into numbered time intervals i, $i+1$, $i+2$, ... $i+N$, each of duration d. Frames transmitted by a Bridge, *Alice*, during time interval i are received by a downstream Bridge, *Bob*, during time interval i and are transmitted onwards by *Bob* towards Bridge *Charlie* during time interval $i+1$, and so on. A starting assumption is that, for a given traffic class, all Bridges and all end stations connected to a given bridge have a common understanding (to a known accuracy) of the start time of cycle i, and the cycle duration, d.

Frames transmitted by *Alice* during interval i are transmitted by *Bob* in interval $i+1$; the maximum possible delay experienced by a given frame is from the beginning of i to the end of $i+1$, or twice d. Similarly, the minimum possible delay experienced is from the end of i to the beginning of $i+1$, which is zero. More generally, the maximum delay experienced by a given frame is

$$(h+1) \times d$$

and the minimum delay experienced by a given frame is

$$(h-1) \times d$$

where h is the number of hops.

(Source: IEEE Standard for Local and Metropolitan Area Networks—Bridges and Bridged Networks- IEEE Std 802.1Q™-2018)

Traffic scheduling

This annex provides some background to the mechanisms provided in this standard for traffic scheduling, with the intent of providing some insight into the motivation for the provision of mechanisms for traffic scheduling and some of the ways that the mechanisms might be used.

Q.1 Motivation

Some applications have a need for frame delivery that is highly predictable in terms of the time at which frame transmission will occur, and the overall latency and jitter that will be experienced as the frame is propagated to its destination. Examples include industrial and automotive control applications, where data transmitted over the network is used to feed the parameters of control loops that are critical to the operation of the plant or machinery involved, and where frames carrying control data are transmitted on a repeating time schedule; late delivery of such frames can result in instability, inaccuracy, or failure of the operation of the control loops concerned. In some implementations, this need has been met by the provision of dedicated, highly engineered networks that are used solely for the transmission of time-critical control traffic; however, as the bandwidth occupied by such traffic is often low, and the cost of providing a dedicated control network can be high, it can be desirable to mix time-critical traffic with other classes of traffic in the same network, as long as such mixing can be achieved while still meeting the timing requirements of the time-critical traffic.

(Source: IEEE Standard for Local and metropolitan area networks— Bridges and Bridged Networks Amendment 25: Enhancements for Scheduled Traffic (IEEE 802.1Qbv-2015))

45. Far North Patents has been damaged as a result of the infringing conduct by ADVA alleged above. Thus, ADVA is liable to Far North Patents in an amount that adequately compensates it for such infringements, which, by law, cannot be less than a reasonable royalty, together with interest and costs as fixed by this Court under 35 U.S.C. § 284.

46. Far North Patents and/or its predecessors-in-interest have satisfied all statutory obligations required to collect pre-filing damages for the full period allowed by law for infringement of the ‘797 Patent.

COUNT IV

DIRECT INFRINGEMENT OF U.S. PATENT NO. 8,891,504

47. On November 18, 2014, United States Patent No. 8,891,504 ("the '504 Patent") was duly and legally issued by the United States Patent and Trademark Office for an invention entitled "Methods and Apparatus for Providing Quality of Service Guarantees in Computer Networks."

48. Far North Patents is the owner of the '504 Patent, with all substantive rights in and to that patent, including the sole and exclusive right to prosecute this action and enforce the '504 Patent against infringers, and to collect damages for all relevant times.

49. ADVA made, had made, used, imported, provided, supplied, distributed, sold, and/or offered for sale products and/or systems including, for example, its ADVA FSP 150-GO102Pro and ADVA FSP 150-GE102Pro families of products that include advanced quality of service capabilities (collectively, "accused products").

ADVA™

FSP 150-GO102Pro Series

Outdoor Carrier Ethernet and IP demarcation

Public outdoor small cells, Wi-Fi and closed circuit TV (CCTV) require connectivity services which end outside a controlled environment. But service providers don't want to invest in expensive and unsightly cabinets. That's why small environmentally sealed network demarcation devices are a game changer.

Communication service providers (CSPs) struggle to cope with a high number of specialized boxes. They need a single demarcation product that can cover a wide range of applications and be effective even under harsh environmental conditions. Our FSP 150-GO102Pro, a member of the market-leading FSP 150 family, makes a real difference. Its small size and low power consumption make it easy to install and simple to configure. It supports a comprehensive set of Carrier Ethernet and IP connectivity services. Automated testing and in-service monitoring protocols simplify any phase of the service lifecycle. What's more, our FSP 150-GO102Pro also provides precise synchronization. Such a unique combination of features makes it the perfect solution for connecting small cell sites.

(Source : Screenshot of PDF downloaded from https://www.adva.com/-/media/adva-main-site/resources/data-sheets/pdfs/fsp-150-go-102-pro-series.ashx?la=de-de&hash=5122080C1CCB4C881E30D8D62F0DF92DF16C098B)

VLAN support

- 4096 VLANs (IEEE 802.1Q customer-tagged) and stacked VLANs (Q-in-Q service provider tagged)
- 2-tag management (push/pop/swap) for c-tag and s-tag
- IEEE 802.1ad provider bridging (c-tag, s-tag)
- Ethertype translation
- Eight Ethernet virtual circuits (EVC)
- 9612 byte-per-frame MTU transparency

Layer 2 traffic management

- Acceptable client frame policy: tagged or untagged
- Service classification based on IEEE 802.1p, 802.1Q and IP-TOS/DSCP
- VLAN tag priority mapping (IEEE 802.1ad PCP encoding)
- MEF-compliant policing (CIR/CBS/EIR/EBS) with three-color marking and eight classes of service
- Port shaping on transmit for both client and network ports
- MEF 10.3 hierarchical policing with token-share envelopes
- DiffServ supporting WFQ/SP mix

(Source : Screenshot of PDF downloaded from https://www.adva.com/-/media/adva-main-site/resources/data-sheets/pdfs/fsp-150-go-102-pro-series.ashx?la=de-de&hash=5122080C1CCB4C881E30D8D62F0DF92DF16C098B)

ADVA today answered the urgent need for small cell backhaul with the launch of the world's smallest cell site gateway device. The ADVA FSP 150-GO102Pro Series has been specifically engineered to be installed in the most challenging locations, enabling the easy deployment of small cells at street level. With its uniquely compact and ruggedized design, it provides multi-layer service demarcation in a wide range of outdoor locations, from walls to poles to lampposts. The ADVA FSP 150-GO102Pro Series also delivers highly precise time and frequency synchronization and features automated testing and in-service monitoring. With the ADVA FSP 150-GO102Pro Series, service providers can easily and cost-effectively introduce next-generation mobile connectivity services for the IoT and 5G era. The new solution is already in customer trials and is generally available from today.

"Our FSP 150-GO102Pro Series is the ultimate outdoor demarcation technology. It ensures the highest quality of service even in the harshest conditions. This phenomenally versatile device empowers operators to deliver reliable, programmable mobile backhaul connectivity without investing in expensive cabinets or power-hungry air conditioning systems," said Stephan Rettenberger, SVP, marketing and investor relations, ADVA. "We worked closely with major wholesale service providers to develop our FSP 150-GO102Pro Series. The solution is specifically engineered to meet their exacting requirements and facilitate their 5G ambitions. It offers full Layer 2 and 3 service demarcation with a complete set of Carrier Ethernet and routing features. The FSP 150-GO102Pro Series even provides highly automated zero touch provisioning for effortless installation and activation."

(Source : https://www.newswiretoday.com/news/168708/)

ADVA™

FSP 150-GE100Pro Series

Programmable Carrier Ethernet and IP demarcation

As complexity increases, network demarcation devices need to continuously extend their capabilities. Communication service provider need one product family for Ethernet and IP, indoor or outdoor, sophisticated security and highly precise synchronization.

Change is the norm. Today, your business customer wants Ethernet connectivity. Tomorrow, it's IP services. Frequency synchronization is no longer sufficient for your mobile network as time synchronization is mandatory for 4G. Meanwhile, your customers decide that they won't accept unencrypted transmission. The one constant is that requirements keep changing – and at an unprecedented pace. Our FSP 150-GE100Pro series belongs to the successful FSP 150 ProNID family. It enables network operators to offer true multi-service access by combining the demarcation of Carrier Ethernet 2.0 and IP services with a rich set of features in a single device. What's more, there's a range of designs from ultra-compact to rack-mountable devices, all aligned with distinct customer demand. The comprehensive FSP 150-GE100Pro series provides the perfect answer to any demarcation requirement.

(Source : Screenshot of PDF downloaded from https://www.adva.com/-/media/adva-main-site/resources/data-sheets/pdfs/fsp-150-ge-100-pro-series.ashx?la=de-DE&hash=46C2728AB543DEB24ECC9B31953C3463C4325AB5)

VLAN support

- 4096 VLANs (IEEE 802.1Q customer-tagged) and stacked VLANs (Q-in-Q service provider tagged)
- 2-tag management (push/pop/swap) for c-tag and s-tag
- IEEE 802.1ad provider bridging (c-tag, s-tag)
- Ethertype translation
- 8[1-2]/32[3-5]/64[6-10] Ethernet virtual circuits (EVC)
- 9612 Byte per frame MTU transparency
- EoMPLS encapsulation

Layer 2 traffic management

- Acceptable client frame policy: tagged or untagged
- Service classification based on IEEE 802.1p, 802.1Q and IP-TOS/DSCP
- VLAN tag priority mapping (IEEE 802.1ad PCP encoding)
- MEF-compliant policing (CIR/CBS/EIR/EBS) with three-color marking and eight classes of service
- Port shaping on transmit for both client and network ports
- MEF 10.3 hierarchical policing with token-share envelopes
- DiffServ supporting WFQ/SP mix

(Source : Screenshot of PDF downloaded from https://www.adva.com/-/media/adva-main-site/resources/data-sheets/pdfs/fsp-150-ge-100-pro-series.ashx?la=de-DE&hash=46C2728AB543DEB24ECC9B31953C3463C4325AB5)

50. By doing so, ADVA has directly infringed (literally and/or under the doctrine of equivalents) at least Claims 1 and 6 of the '504 Patent.

51. ADVA has infringed the '504 Patent by making, having made, using, importing, providing, supplying, distributing, selling or offering for sale products including a device adapter comprising a transmission unit configured to transmit data from a real time device via a network according to a time frame, wherein the time frame is substantially synchronized in the device adapter and at least one other device adapter, the time frame repeating periodically and including a plurality of assigned time phases and a free access phase. For example, the accused products are configured to be used to implement the IEEE 802.1Q standard. IEEE standard 802.1Q implements a method in which a time aware bridged LAN transmits data from one end point i.e., Precision Time Protocol ("PTP") instance to another. The endpoints transmit data that is a mix of time-critical traffic and other traffic, (i.e., real time data and non-real time data) via PTP

instances such as bridges (device adapters). The end point can be either a real time device or a non-real time device. The bridged network uses 802.1AS base time to synchronize all the clocks of ports associated with bridges (device adapters). Using the Best Master Clock Algorithm, the synchronization time signal is transmitted from a grandmaster to other ports. IEEE Std. 802.1AS™-2011 is normative and essential to implement an IEEE Std. 802.1Q Compliant System. IEEE Std. 802.1Q-2018 defines parameters, such as AdminBaseTime and OpenBaseTime, which are used to synchronize the clocks across the network. The bridges containing ports schedule the transmission of traffic based on the synchronized time. Each port associated with a specific set of transmission queues includes a plurality of transmission gates. A transmission gate can be in a closed state or open state. The functionality of assigned time phases is achieved using open gates transmitting data packets during transmission time. The functionality of a free access phase is achieved when the gates are opened for transmission during any time. IEEE Std. 802.1Q-2018 supports cyclic queuing and forwarding structures to create synchronized frames and gates which repeat periodically (Annex T).

1.1 Project Number: P802.1Qbv
1.2 Type of Document: Standard
1.3 Life Cycle: Full Use

2.1 Title: Standard for Local and metropolitan area networks--Media Access Control (MAC) Bridges and Virtual Bridged Local Area Networks Amendment: Enhancements for Scheduled Traffic

5.2.b. Scope of the project: This amendment specifies time-aware queue-draining procedures, managed objects and extensions to existing protocols that enable bridges and end stations to schedule the transmission of frames based on a synchronized time. Virtual Local Area Network (VLAN) tag encoded priority values are allocated allowing simultaneous support of scheduled traffic, credit-based shaper traffic and other bridged traffic over Local Area Networks (LANs).

(Source: http://www.ieee802.org/1/files/public/docs2014/bv-p802-1Qbv-par-modification-1114.pdf)

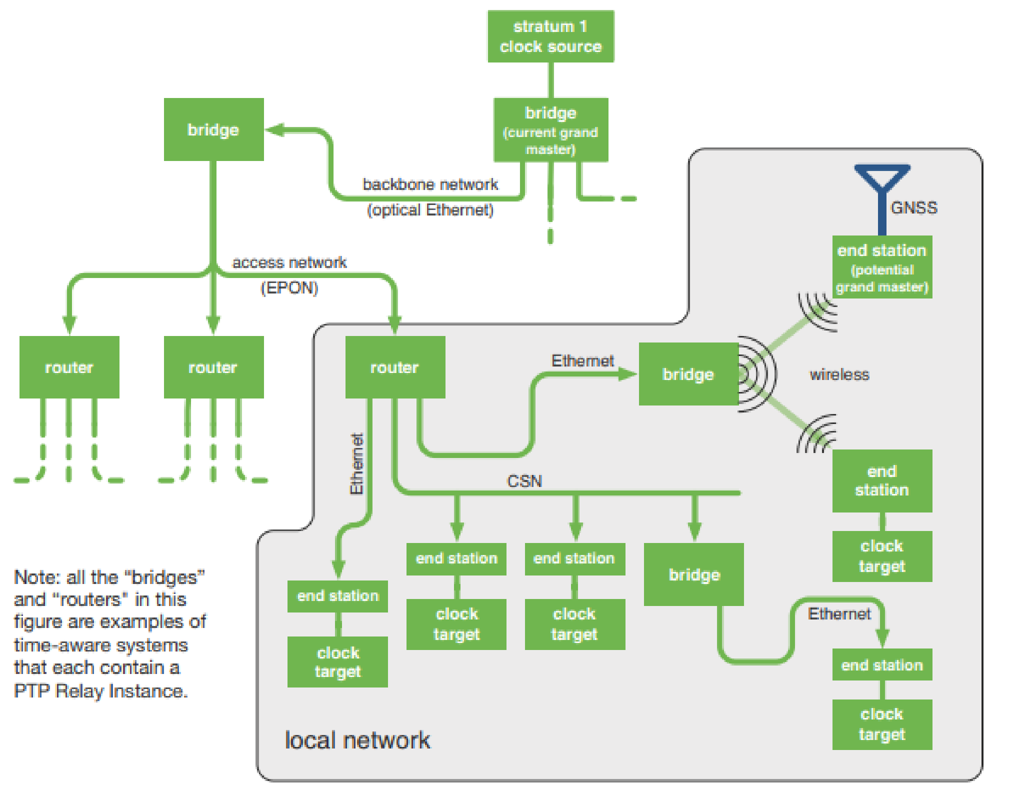

Figure 7-1—Time-aware network example

(Source: https://1.ieee802.org/wp-content/uploads/2019/03/802-1AS-rev-d8-0.pdf)

7.2 Architecture of a time-aware network

7.2.1 General

A time-aware network consists of a number of interconnected time-aware systems that support the gPTP defined within this standard. These time-aware systems can be any networking device, including, for example, bridges, routers, and end stations. A set of time-aware systems that are interconnected by gPTP-capable network elements is called a *gPTP network*. Each instance of gPTP that the time-aware systems support is in one *gPTP domain*, and the instances of gPTP are said to be part of that gPTP domain. A time-aware system can support, and therefore be part of, more than one gPTP domain. The entity of a single time-aware system that executes gPTP in one gPTP domain is called a PTP Instance. A time-aware system can contain multiple PTP Instances, which are each associated with a different gPTP domain. There are two

(Source: https://1.ieee802.org/wp-content/uploads/2019/03/802-1AS-rev-d8-0.pdf)

3.16 PTP End Instance: A PTP Instance that is capable of acting as the source of synchronized time on the network, or destination of synchronized time using the IEEE 802.1AS protocol, or both.

3.17 PTP Instance: A PTP Relay Instance or a PTP End Instance. A PTP Instance implements those portions of this standard indicated as applicable to a PTP Relay Instance or a PTP End Instance. Each PTP Instance operates in exactly one domain.

3.18 PTP Link: Within a domain, a network segment between two PTP Ports using the peer-to-peer delay mechanism of this standard. The peer-to-peer delay mechanism is designed to measure the propagation time over such a link.

NOTE—A PTP Link between PTP Ports of PTP Instances is also a gPTP Communication Path (see 3.9).

3.19 PTP Relay Instance: A PTP Instance that is capable of communicating synchronized time received on one port to other ports, using the IEEE 802.1AS protocol.

NOTE—A PTP Relay Instance could, for example, be contained in a bridge, a router, or a multi-port end station.

(Source: https://1.ieee802.org/wp-content/uploads/2019/03/802-1AS-rev-d8-0.pdf)

Traffic scheduling

This annex provides some background to the mechanisms provided in this standard for traffic scheduling, with the intent of providing some insight into the motivation for the provision of mechanisms for traffic scheduling and some of the ways that the mechanisms might be used.

Q.1 Motivation

Some applications have a need for frame delivery that is highly predictable in terms of the time at which frame transmission will occur, and the overall latency and jitter that will be experienced as the frame is propagated to its destination. Examples include industrial and automotive control applications, where data transmitted over the network is used to feed the parameters of control loops that are critical to the operation of the plant or machinery involved, and where frames carrying control data are transmitted on a repeating time schedule; late delivery of such frames can result in instability, inaccuracy, or failure of the operation of the control loops concerned. In some implementations, this need has been met by the provision of dedicated, highly engineered networks that are used solely for the transmission of time-critical control traffic; however, as the bandwidth occupied by such traffic is often low, and the cost of providing a dedicated control network can be high, it can be desirable to mix time-critical traffic with other classes of traffic in the same network, as long as such mixing can be achieved while still meeting the timing requirements of the time-critical traffic.

(Source: IEEE Standard for Local and metropolitan area networks— Bridges and Bridged Networks Amendment 25: Enhancements for Scheduled Traffic (IEEE 802.1Qbv-2015))

b) gPTP specifies a media-independent sublayer that simplifies the integration within a single timing domain of multiple different networking technologies with radically different media access protocols. gPTP specifies a media-dependent sublayer for each medium. The information exchanged between PTP Instances has been generalized to support different packet formats and management schemes appropriate to the particular networking technology. IEEE Std 1588-2019, on the other

(Source: https://1.ieee802.org/wp-content/uploads/2019/03/802-1AS-rev-d8-0.pdf)

7.2.2 Time-aware network consisting of a single gPTP domain

Figure 7-1 illustrates an example time-aware network consisting of a single gPTP domain, using all theabove network technologies (i.e., (c) - (f) of 7.2.1), where end stations on several local networks are connected to a grandmaster on a backbone network via an EPON access network.

Any PTP Instance with clock sourcing capabilities can be a potential grandmaster, so there is a selection method (the *best master clock algorithm*, or BMCA) that ensures that all of the PTP Instances in a gPTP domain use the same grandmaster.[12] The BMCA is largely identical to that used in IEEE Std 1588-2019,

(Source: https://1.ieee802.org/wp-content/uploads/2019/03/802-1AS-rev-d8-0.pdf)

10.3.1.1 Best master clock algorithm overview

In the BMCA (i.e., method (a) of 10.3.1), best master selection information is exchanged between PTP Instances of time-aware systems via Announce messages (see 10.5 and 10.6). Each Announce message contains time-synchronization spanning tree vector information that identifies one PTP Instance as the root of the time-synchronization spanning tree and, if the PTP Instance is grandmaster-capable, the grandmaster. Each PTP Instance in turn uses the information contained in the Announce messages it receives, along with its knowledge of itself, to compute which of the PTP Instances that it has knowledge of ought to be the root of the spanning tree and, if grandmaster-capable, the grandmaster. As part of constructing the time-synchronization spanning tree, each port of each PTP Instance is assigned a port state from Table 10-2 by state machines associated with the ports and with the PTP Instance as a whole.

(Source: https://1.ieee802.org/wp-content/uploads/2019/03/802-1AS-rev-d8-0.pdf)

c) In gPTP there are only two types of PTP Instances: PTP End Instances and PTP Relay Instances, while IEEE 1588 has ordinary clocks, boundary clocks, end-to-end transparent clocks, and P2P transparent clocks. A PTP End Instance corresponds to an IEEE 1588 ordinary clock, and a PTP Relay Instance is a type of IEEE 1588 boundary clock where its operation is very tightly defined, so much so that a PTP Relay Instance with Ethernet ports can be shown to be mathematically equivalent to a P2P transparent clock in terms of how synchronization is performed, as shown in

(Source: https://1.ieee802.org/wp-content/uploads/2019/03/802-1AS-rev-d8-0.pdf)

- **Grand Master selection**
  - GM-capable stations advertise themselves via ANNOUNCE messages
  - If a station hears from station with "better" clock, it does not send ANNOUNCE
    - Configurable "Priority" field can override clock quality
    - MAC address is tie breaker
  - Time relays drop all inferior ANNOUNCE messages
    - Forward only the best
  - Last one standing is Grand Master for the domain
    - GM is the root of the 802.1AS timing tree
    - GM periodically sends the current time

(Source: https://avnu.org/wp-content/uploads/2014/05/as-kbstanton-8021AS-tutorial-0714-v01.pdf)

IEEE Std 802.1Q-2018
IEEE Standard for Local and Metropolitan Area Networks—Bridges and Bridged Networks

2. Normative references

The following referenced documents are indispensable for the application of this document (i.e., they must be understood and used, so each referenced document is cited in the text and its relationship to this document is explained). For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments or corrigenda) applies.

ANSI X3.159, American National Standards for Information Systems—Programming Language—C.[5]

IEEE Std 802®, IEEE Standard for Local and metropolitan area networks: Overview and Architecture.[6,7]

IEEE Std 802.1AB™, IEEE Standard for Local and metropolitan area networks—Station and Media Access Control Connectivity Discovery.

IEEE Std 802.1AC™, IEEE Standard for Local and metropolitan area networks—Media Access Control (MAC) Service Definition.

IEEE Std 802.1AE™, IEEE Standard for Local and metropolitan area networks—Media Access Control (MAC) Security.

IEEE Std 802.1AS™, IEEE Standard for Local and metropolitan area networks—Timing and Synchronization for Time-Sensitive Applications in Bridged Local Area Networks.

(Source: IEEE Standard for Local and Metropolitan Area Networks—Bridges and Bridged Networks- IEEE Std 802.1Q™-2018)

8.6.9.4.1 AdminBaseTime

The administrative value of base time, expressed as an IEEE 1588 precision time protocol (PTP) [B24] timescale (see 8.2 of IEEE Std 802.1AS™-2011 [B11]). This value can be changed by management, and is used by the List Config state machine (8.6.9.3) to set the value of OperBaseTime (8.6.9.4.18).

NOTE—Time is expressed in the PTP timescale as the number of seconds, nanoseconds, and fractional nanoseconds that have elapsed since 1 January 1970 00:00:00 TAI.

NOTE 2—If AdminBaseTime is set to the same time in the past in all bridges and end stations, OperBaseTime is always in the past, and all cycles start synchronized. Using AdminBaseTime in the past is appropriate when you can start schedules prior to starting the application that uses the schedules. Use of AdminBaseTime in the future is intended to change a currently running schedule in all bridges and end stations to a new schedule at a future time. Using AdminBaseTime in the future is appropriate when schedules must be changed without stopping the application.

(Source: IEEE Standard for Local and Metropolitan Area Networks—Bridges and Bridged Networks- IEEE Std 802.1Q™-2018)

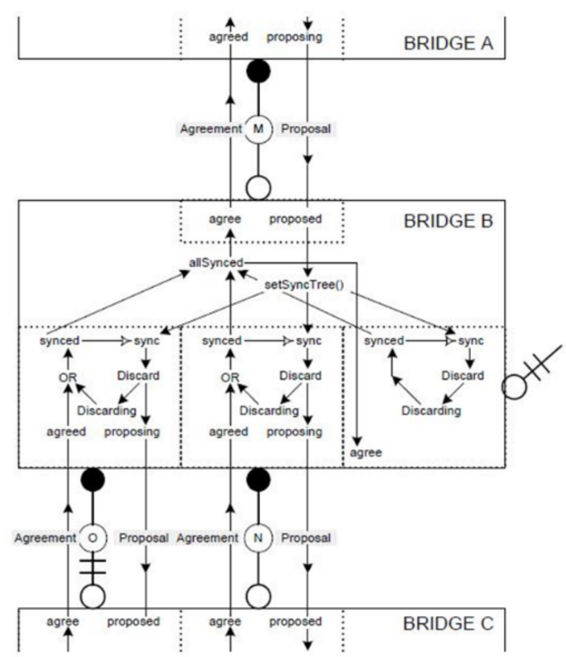

Figure 13-10—Agreements and Proposals

(Source: IEEE Standard for Local and Metropolitan Area Networks—Bridges and Bridged Networks- IEEE Std 802.1Q™-2018)

NOTE 2—Agreements can be generated without prior receipt of a Proposal as soon as the necessary conditions are met. Subsequent receipt of a Proposal serves to elicit a further Agreement. If all other ports have already been synchronized (allSynced in Figure 13-10) and the Proposal's priority vector does not convey worse information, synchronization is maintained and there is no need to transition Designated Ports to Discarding once more, or to transmit further Proposals.

(Source: IEEE Standard for Local and Metropolitan Area Networks—Bridges and Bridged Networks- IEEE Std 802.1Q™-2018)

8.6.8.4 Enhancements for scheduled traffic

A Bridge or an end station may support enhancements that allow transmission from each queue to be scheduled relative to a known timescale. In order to achieve this, a transmission gate is associated with each queue; the state of the transmission gate determines whether or not queued frames can be selected for transmission (see Figure 8-12). For a given queue, the transmission gate can be in one of two states:

a) *Open*: Queued frames are selected for transmission, in accordance with the definition of the transmission selection algorithm associated with the queue.
b) *Closed*: Queued frames are not selected for transmission.

(Source: IEEE Standard for Local and metropolitan area networks— Bridges and Bridged Networks Amendment 25: Enhancements for Scheduled Traffic (IEEE 802.1Qbv-2015))

8.6.8 Transmission selection

For each Port, frames are selected for transmission on the basis of the traffic classes that the Port supports and the operation of the transmission selection algorithms supported by the corresponding queues on that Port. For a given Port and traffic class, frames are selected from the corresponding queue for transmission if and only if

a) The operation of the transmission selection algorithm supported by that queue determines that there is a frame available for transmission; and

b) For each queue corresponding to a numerically higher value of traffic class supported by the Port, the operation of the transmission selection algorithm supported by that queue determines that there is no frame available for transmission.

(Source: IEEE Standard for Local and Metropolitan Area Networks—Bridges and Bridged Networks- IEEE Std 802.1Q™-2018)

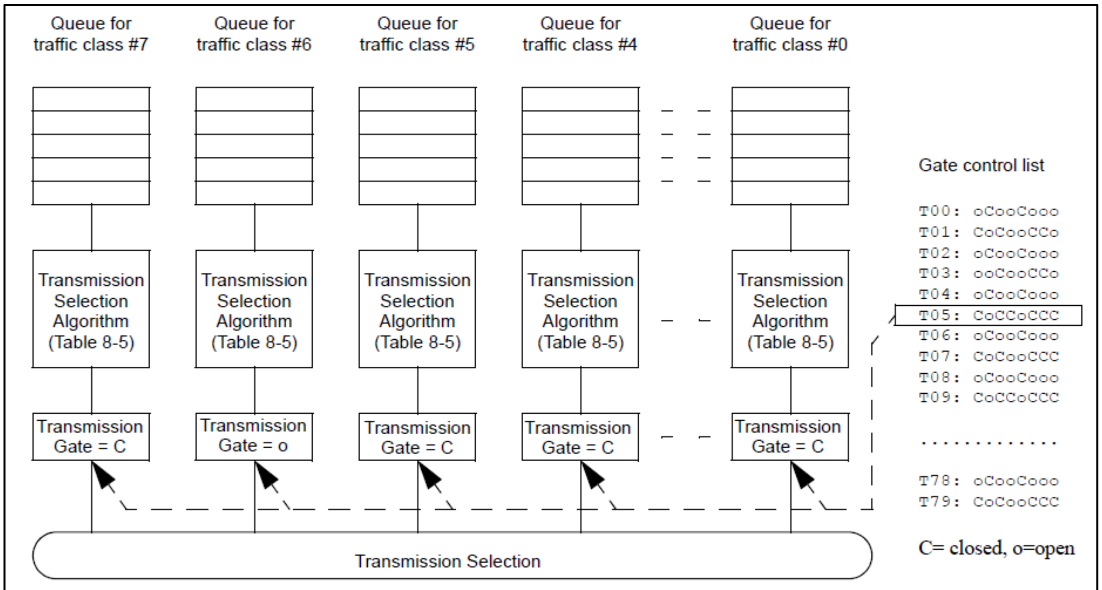

Figure 8-12—Transmission selection with gates

(Source: IEEE Standard for Local and metropolitan area networks— Bridges and Bridged Networks Amendment 25: Enhancements for Scheduled Traffic (IEEE 802.1Qbv-2015))

> A *gate control list* associated with each Port contains an ordered list of gate operations. Each gate operation changes the transmission gate state for the gate associated with each of the Port's traffic class queues. In an implementation that does not support enhancements for scheduled traffic, all gates are assumed to be permanently in the *open* state. Table 8-6 identifies the gate operation types, their parameters, and the actions that result from their execution. The state machines that control the execution of the gate control list, along with their variables and procedures, are specified in 8.6.9.

(Source: IEEE Standard for Local and metropolitan area networks— Bridges and Bridged Networks Amendment 25: Enhancements for Scheduled Traffic (IEEE 802.1Qbv-2015)).

> **3.3 gating cycle:** The period of time over which the sequence of operations in a gate control list repeats.
>
> **3.4 transmission gate:** A gate that connects or disconnects the transmission selection function of the forwarding process from the queue, allowing or preventing it from selecting frames from that queue. The gate has two states, Open and Closed.

(Source: IEEE Standard for Local and metropolitan area networks— Bridges and Bridged Networks Amendment 25: Enhancements for Scheduled Traffic (IEEE 802.1Qbv-2015))

Cyclic queuing and forwarding[53]

T.1 Overview of CQF

Cyclic queuing and forwarding (CQF) is a method of traffic shaping that can deliver deterministic, and easily calculated, latency for time-sensitive traffic streams. As the name implies, the principle underlying CQF is that stream traffic is transmitted and queued for transmission along a network path in a cyclic manner. Time is divided into numbered time intervals i, $i+1$, $i+2$, ... $i+N$, each of duration d. Frames transmitted by a Bridge, *Alice*, during time interval i are received by a downstream Bridge, *Bob*, during time interval i and are transmitted onwards by *Bob* towards Bridge *Charlie* during time interval $i+1$, and so on. A starting assumption is that, for a given traffic class, all Bridges and all end stations connected to a given bridge have a common understanding (to a known accuracy) of the start time of cycle i, and the cycle duration, d.

Frames transmitted by *Alice* during interval i are transmitted by *Bob* in interval $i+1$; the maximum possible delay experienced by a given frame is from the beginning of i to the end of $i+1$, or twice d. Similarly, the minimum possible delay experienced is from the end of i to the beginning of $i+1$, which is zero. More generally, the maximum delay experienced by a given frame is

$$(h+1) \times d$$

and the minimum delay experienced by a given frame is

$$(h-1) \times d$$

where h is the number of hops.

(Source: IEEE Standard for Local and Metropolitan Area Networks—Bridges and Bridged Networks- IEEE Std 802.1Q™-2018)

52. The accused products include a device adapter that is configured to transmit data during at least one of an assigned time phase associated with the device adapter prior to transmission of data from the real-time device by the device adapter, and included in the plurality of assigned time phases, or the free access phase, to refrain from transmitting data during time phases of the plurality of assigned time phases that are not associated with the device adapter, and to be able to determine whether to transmit or defer transmission of data during the assigned time phase associated with the device adapter and the free access phase to allow the another device to transmit data. For example, the accused products are configured to be used to implement the IEEE 802.1Q standard. IEEE standard 802.1Q shows that scheduling of ports' transmission gates for transmission of data starts prior to the transmission of real-time data. The

functionality of assigned time phases is achieved using open gates transmitting data packets during scheduled transmission time. Per Clause 8.6.8 of the IEEE Std. 802.1Q, each time phase is assigned to a specific device adapter prior to transmission of real-time data by the specific device adapter. Furthermore, IEEE 802.1Q performs traffic shaping through Per-Stream Filtering and Policing (PSTP). IEEE standard 802.1Q implements a method in which open gates transmit data packets during transmission time and closed gates refrain data packets from transmission. The functionality of assigned time phases is achieved using open gates transmitting data packets during transmission time. The functionality of free access phase is achieved by the gates that are opened for transmission during any time. IEEE Std. 802.1Q supports Forwarding and Queuing Enhancements for Time Sensitive Streams. Thus, one of the plurality of device adaptors is configured to transmit data during at least one of a respective assigned time phase or free access phase, to refrain from transmitting data during time phases not assigned to the respective one of the plurality of device adapters. IEEE Std. 802.1Q provides traffic shaping for various classes of data transmission and determining whether to transmit or defer transmission of data during at least one of the assigned time phase or the free access phase to allow the another device to transmit data.

NOTE 2—If AdminBaseTime is set to the same time in the past in all bridges and end stations, OperBaseTime is always in the past, and all cycles start synchronized. Using AdminBaseTime in the past is appropriate when you can start schedules prior to starting the application that uses the schedules. Use of AdminBaseTime in the future is intended to

(Source: IEEE Standard for Local and metropolitan area networks— Bridges and Bridged Networks Amendment 25: Enhancements for Scheduled Traffic (IEEE 802.1Qbv-2015))

1.1 Project Number: P802.1Qbv
1.2 Type of Document: Standard
1.3 Life Cycle: Full Use

5.5 Need for the Project: The credit-based shaper works well in arbitrary networks (i.e., non-engineered). Networks employing scheduled transmissions are able to control real-time processes. This amendment enables those two kinds of networks to be consolidated into a single network, with a significant cost reduction to the user.

(Source: http://www.ieee802.org/1/files/public/docs2014/bv-p802-1Qbv-par-modification-1114.pdf)

8.6.8 Transmission selection

For each Port, frames are selected for transmission on the basis of the traffic classes that the Port supports and the operation of the transmission selection algorithms supported by the corresponding queues on that Port. For a given Port and traffic class, frames are selected from the corresponding queue for transmission if and only if

a) The operation of the transmission selection algorithm supported by that queue determines that there is a frame available for transmission; and

b) For each queue corresponding to a numerically higher value of traffic class supported by the Port, the operation of the transmission selection algorithm supported by that queue determines that there is no frame available for transmission.

(Source: IEEE Standard for Local and Metropolitan Area Networks—Bridges and Bridged Networks- IEEE Std 802.1Q™-2018)

5.4.1.9 Cyclic queuing and forwarding (CQF) requirements

A VLAN Bridge component implementation that conforms to the provisions of this standard for CQF (see Annex T) shall

a) Support the enhancements for scheduled traffic as specified in 8.6.8.4.

b) Support the state machines for scheduled traffic as specified in 8.6.9.
c) Support the state machines for stream gate control as specified in 8.6.10.
d) Support the management entities for scheduled traffic as specified in 12.29.
e) Support the requirements for per-stream filtering and policing (PSFP) as stated in 5.4.1.8.
f) Support the management entities for PSFP as specified in 12.31.

(Source: IEEE Standard for Local and Metropolitan Area Networks—Bridges and Bridged Networks- IEEE Std 802.1Q™-2018)

5.4.1.5 Forwarding and Queuing Enhancements for time-sensitive streams (FQTSS)—requirements

A VLAN Bridge component implementation that conforms to the provisions of this standard for FQTSS shall

a) Support a minimum of two traffic classes on all Ports, of which
   1) A minimum of one traffic class supports the strict priority algorithm for transmission selection (8.6.8.1), and
   2) One traffic class is a stream reservation (SR) class.
b) Support the operation of the credit-based shaper algorithm (8.6.8.2) on all Ports as the transmission selection algorithm used for the SR class.
c) Support SRP domain boundary port priority regeneration override as defined in 6.9.4, and the default priority regeneration override value defined in Table 6-5, for SR class "B."
d) Support the tables and procedures for mapping priorities to traffic classes as defined in 34.5.

SR: Stream Reservation, SRP: Stream Reservation Protocol

(Source: IEEE Standard for Local and Metropolitan Area Networks—Bridges and Bridged Networks- IEEE Std 802.1Q™-2018)

8.6.8.4 Enhancements for scheduled traffic

A Bridge or an end station may support enhancements that allow transmission from each queue to be scheduled relative to a known timescale. In order to achieve this, a transmission gate is associated with each queue; the state of the transmission gate determines whether or not queued frames can be selected for transmission (see Figure 8-12). For a given queue, the transmission gate can be in one of two states:

a) *Open*: Queued frames are selected for transmission, in accordance with the definition of the transmission selection algorithm associated with the queue.
b) *Closed*: Queued frames are not selected for transmission.

(Source: IEEE Standard for Local and metropolitan area networks— Bridges and Bridged Networks Amendment 25: Enhancements for Scheduled Traffic (IEEE 802.1Qbv-2015))

A *gate control list* associated with each Port contains an ordered list of gate operations. Each gate operation changes the transmission gate state for the gate associated with each of the Port's traffic class queues. In an implementation that does not support enhancements for scheduled traffic, all gates are assumed to be permanently in the *open* state. Table 8-6 identifies the gate operation types, their parameters, and the actions that result from their execution. The state machines that control the execution of the gate control list, along with their variables and procedures, are specified in 8.6.9.

(Source: IEEE Standard for Local and metropolitan area networks— Bridges and Bridged Networks Amendment 25: Enhancements for Scheduled Traffic (IEEE 802.1Qbv-2015))

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   2) One traffic class is a stream reservation (SR) class.
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d) Support the tables and procedures for mapping priorities to traffic classes as defined in 34.5.

SR: Stream Reservation, SRP: Stream Reservation Protocol

(Source: IEEE Standard for Local and Metropolitan Area Networks—Bridges and Bridged Networks- IEEE Std 802.1Q™-2018)

5.4.1.6 ETS Bridge requirements

A device supporting ETS shall

a) Support at least 3 traffic classes (37.3).

NOTE—A minimum of 3 traffic classes allows a minimum configuration such that one traffic class contains priorities with PFC enabled, one traffic class contains priorities with PFC disabled, and one traffic class using strict priority.

b) Support bandwidth configuration with a granularity of 1% or finer (37.3).
c) Support bandwidth allocation with a precision of 10% (37.3).
d) Support a transmission selection policy such that if one of the traffic classes does not consume its allocated bandwidth, then any unused bandwidth is available to other traffic classes (37.3).
e) Support DCBX (Clause 38).

(Source: IEEE Standard for Local and Metropolitan Area Networks—Bridges and Bridged Networks- IEEE Std 802.1Q™-2018)

53. ADVA has infringed the '504 Patent by using the accused products and thereby practicing a method that includes obtaining, at a device adapter, a substantially synchronized time frame which is maintained among a plurality of device adapters interconnected by a network, the time frame repeating periodically and including a plurality of assigned time phases and a free access phase. For example, the accused products are used by ADVA to implement the

IEEE 802.1Q standard. IEEE standard 802.1Q implements a method in which a time aware bridged LAN transmits data from one end point i.e., Precision Time Protocol (PTP) instance to another. The endpoints transmit data that is a mix of time-critical traffic and other traffic, (i.e., real time data and non-real time data) via PTP instances such as bridges (device adapters). The end point can be either a real time device or a non-real time device. The bridged network uses 802.1AS base time to synchronize all the clocks of ports associated with bridges (device adapters). Using the Best Master Clock Algorithm, the synchronization time signal is transmitted from a grandmaster to other ports. IEEE Std. 802.1AS™-2011 is normative and essential to implement an IEEE Std. 802.1Q Compliant System. IEEE Std. 802.1Q-2018 defines parameters, such as AdminBaseTime and OpenBaseTime, which are used to synchronize the clocks across the network. The bridges containing ports schedule the transmission of traffic based on the synchronized time. Each port associated with a specific set of transmission queries includes a plurality of transmission gates. A transmission gate can be in a closed state or open state. The functionality of assigned time phases is achieved using open gates transmitting data packets during transmission time. The functionality of a free access phase is achieved when the gates are opened for transmission during any time. IEEE Std. 802.1Q-2018 supports cyclic queuing and forwarding structures to create synchronized frames and gates which repeat periodically (Annex T).

1.1 Project Number: P802.1Qbv
1.2 Type of Document: Standard
1.3 Life Cycle: Full Use

2.1 Title: Standard for Local and metropolitan area networks--Media Access Control (MAC) Bridges and Virtual Bridged Local Area Networks Amendment: Enhancements for Scheduled Traffic

5.2.b. Scope of the project: This amendment specifies time-aware queue-draining procedures, managed objects and extensions to existing protocols that enable bridges and end stations to schedule the transmission of frames based on a synchronized time. Virtual Local Area Network (VLAN) tag encoded priority values are allocated allowing simultaneous support of scheduled traffic, credit-based shaper traffic and other bridged traffic over Local Area Networks (LANs).

(Source: http://www.ieee802.org/1/files/public/docs2014/bv-p802-1Qbv-par-modification-1114.pdf)

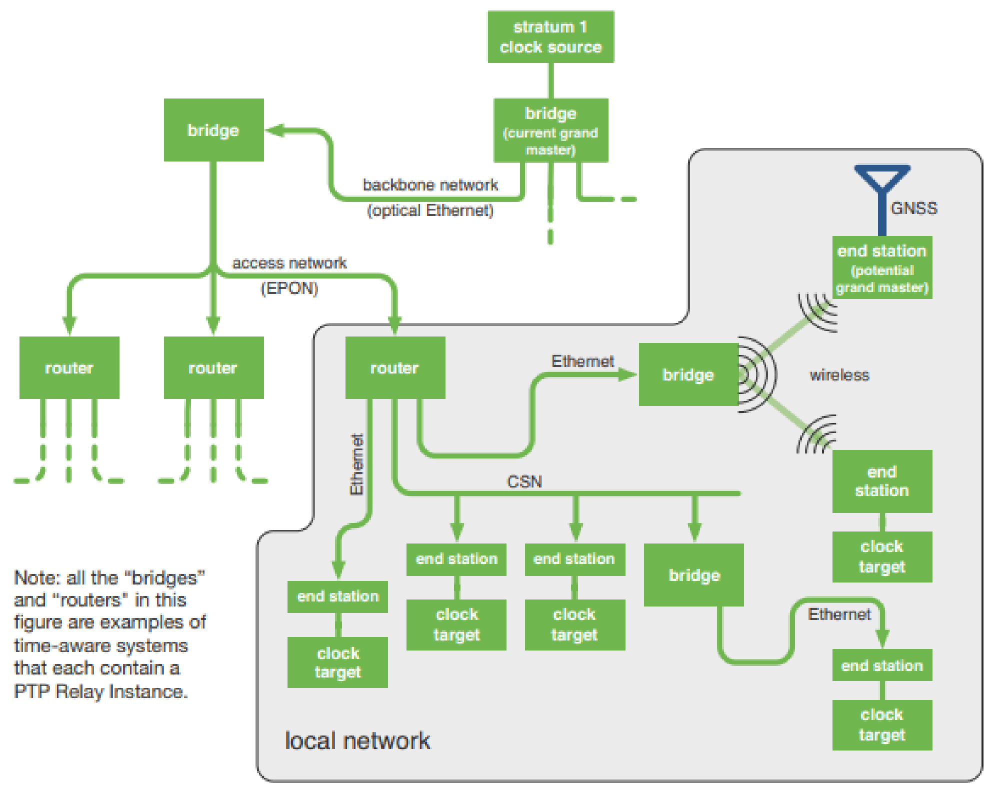

Figure 7-1—Time-aware network example

(Source: https://1.ieee802.org/wp-content/uploads/2019/03/802-1AS-rev-d8-0.pdf)

7.2 Architecture of a time-aware network

7.2.1 General

A time-aware network consists of a number of interconnected time-aware systems that support the gPTP defined within this standard. These time-aware systems can be any networking device, including, for example, bridges, routers, and end stations. A set of time-aware systems that are interconnected by gPTP-capable network elements is called a *gPTP network*. Each instance of gPTP that the time-aware systems support is in one *gPTP domain*, and the instances of gPTP are said to be part of that gPTP domain. A time-aware system can support, and therefore be part of, more than one gPTP domain. The entity of a single time-aware system that executes gPTP in one gPTP domain is called a PTP Instance. A time-aware system can contain multiple PTP Instances, which are each associated with a different gPTP domain. There are two

(Source: https://1.ieee802.org/wp-content/uploads/2019/03/802-1AS-rev-d8-0.pdf)

3.16 PTP End Instance: A PTP Instance that is capable of acting as the source of synchronized time on the network, or destination of synchronized time using the IEEE 802.1AS protocol, or both.

3.17 PTP Instance: A PTP Relay Instance or a PTP End Instance. A PTP Instance implements those portions of this standard indicated as applicable to a PTP Relay Instance or a PTP End Instance. Each PTP Instance operates in exactly one domain.

3.18 PTP Link: Within a domain, a network segment between two PTP Ports using the peer-to-peer delay mechanism of this standard. The peer-to-peer delay mechanism is designed to measure the propagation time over such a link.

NOTE—A PTP Link between PTP Ports of PTP Instances is also a gPTP Communication Path (see 3.9).

3.19 PTP Relay Instance: A PTP Instance that is capable of communicating synchronized time received on one port to other ports, using the IEEE 802.1AS protocol.

NOTE—A PTP Relay Instance could, for example, be contained in a bridge, a router, or a multi-port end station.

(Source: https://1.ieee802.org/wp-content/uploads/2019/03/802-1AS-rev-d8-0.pdf)

Traffic scheduling

This annex provides some background to the mechanisms provided in this standard for traffic scheduling, with the intent of providing some insight into the motivation for the provision of mechanisms for traffic scheduling and some of the ways that the mechanisms might be used.

Q.1 Motivation

Some applications have a need for frame delivery that is highly predictable in terms of the time at which frame transmission will occur, and the overall latency and jitter that will be experienced as the frame is propagated to its destination. Examples include industrial and automotive control applications, where data transmitted over the network is used to feed the parameters of control loops that are critical to the operation of the plant or machinery involved, and where frames carrying control data are transmitted on a repeating time schedule; late delivery of such frames can result in instability, inaccuracy, or failure of the operation of the control loops concerned. In some implementations, this need has been met by the provision of dedicated, highly engineered networks that are used solely for the transmission of time-critical control traffic; however, as the bandwidth occupied by such traffic is often low, and the cost of providing a dedicated control network can be high, it can be desirable to mix time-critical traffic with other classes of traffic in the same network, as long as such mixing can be achieved while still meeting the timing requirements of the time-critical traffic.

(Source: IEEE Standard for Local and metropolitan area networks— Bridges and Bridged Networks Amendment 25: Enhancements for Scheduled Traffic (IEEE 802.1Qbv-2015))

b) gPTP specifies a media-independent sublayer that simplifies the integration within a single timing domain of multiple different networking technologies with radically different media access protocols. gPTP specifies a media-dependent sublayer for each medium. The information exchanged between PTP Instances has been generalized to support different packet formats and management schemes appropriate to the particular networking technology. IEEE Std 1588-2019, on the other

(Source: https://1.ieee802.org/wp-content/uploads/2019/03/802-1AS-rev-d8-0.pdf)

7.2.2 Time-aware network consisting of a single gPTP domain

Figure 7-1 illustrates an example time-aware network consisting of a single gPTP domain, using all theabove network technologies (i.e., (c) - (f) of 7.2.1), where end stations on several local networks are connected to a grandmaster on a backbone network via an EPON access network.

Any PTP Instance with clock sourcing capabilities can be a potential grandmaster, so there is a selection method (the *best master clock algorithm*, or BMCA) that ensures that all of the PTP Instances in a gPTP domain use the same grandmaster.[12] The BMCA is largely identical to that used in IEEE Std 1588-2019,

(Source: https://1.ieee802.org/wp-content/uploads/2019/03/802-1AS-rev-d8-0.pdf)

10.3.1.1 Best master clock algorithm overview

In the BMCA (i.e., method (a) of 10.3.1), best master selection information is exchanged between PTP Instances of time-aware systems via Announce messages (see 10.5 and 10.6). Each Announce message contains time-synchronization spanning tree vector information that identifies one PTP Instance as the root of the time-synchronization spanning tree and, if the PTP Instance is grandmaster-capable, the grandmaster. Each PTP Instance in turn uses the information contained in the Announce messages it receives, along with its knowledge of itself, to compute which of the PTP Instances that it has knowledge of ought to be the root of the spanning tree and, if grandmaster-capable, the grandmaster. As part of constructing the time-synchronization spanning tree, each port of each PTP Instance is assigned a port state from Table 10-2 by state machines associated with the ports and with the PTP Instance as a whole.

(Source: https://1.ieee802.org/wp-content/uploads/2019/03/802-1AS-rev-d8-0.pdf)

c) In gPTP there are only two types of PTP Instances: PTP End Instances and PTP Relay Instances, while IEEE 1588 has ordinary clocks, boundary clocks, end-to-end transparent clocks, and P2P transparent clocks. A PTP End Instance corresponds to an IEEE 1588 ordinary clock, and a PTP Relay Instance is a type of IEEE 1588 boundary clock where its operation is very tightly defined, so much so that a PTP Relay Instance with Ethernet ports can be shown to be mathematically equivalent to a P2P transparent clock in terms of how synchronization is performed, as shown in

(Source: https://1.ieee802.org/wp-content/uploads/2019/03/802-1AS-rev-d8-0.pdf)

- **Grand Master selection**
  - GM-capable stations advertise themselves via ANNOUNCE messages
  - If a station hears from station with “better” clock, it does not send ANNOUNCE
    - Configurable “Priority” field can override clock quality
    - MAC address is tie breaker
  - Time relays drop all inferior ANNOUNCE messages
    - Forward only the best
  - Last one standing is Grand Master for the domain
    - GM is the root of the 802.1AS timing tree
    - GM periodically sends the current time

(Source: https://avnu.org/wp-content/uploads/2014/05/as-kbstanton-8021AS-tutorial-0714-v01.pdf)

IEEE Std 802.1Q-2018
IEEE Standard for Local and Metropolitan Area Networks—Bridges and Bridged Networks

2. Normative references

The following referenced documents are indispensable for the application of this document (i.e., they must be understood and used, so each referenced document is cited in the text and its relationship to this document is explained). For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments or corrigenda) applies.

ANSI X3.159, American National Standards for Information Systems—Programming Language—C.[5]

IEEE Std 802®, IEEE Standard for Local and metropolitan area networks: Overview and Architecture.[6,7]

IEEE Std 802.1AB™, IEEE Standard for Local and metropolitan area networks—Station and Media Access Control Connectivity Discovery.

IEEE Std 802.1AC™, IEEE Standard for Local and metropolitan area networks—Media Access Control (MAC) Service Definition.

IEEE Std 802.1AE™, IEEE Standard for Local and metropolitan area networks—Media Access Control (MAC) Security.

IEEE Std 802.1AS™, IEEE Standard for Local and metropolitan area networks—Timing and Synchronization for Time-Sensitive Applications in Bridged Local Area Networks.

(Source: IEEE Standard for Local and metropolitan area networks— Bridges and Bridged Networks Amendment 25: Enhancements for Scheduled Traffic (IEEE 802.1Qbv-2015))

8.6.9.4.1 AdminBaseTime

The administrative value of base time, expressed as an IEEE 1588 precision time protocol (PTP) [B24] timescale (see 8.2 of IEEE Std 802.1AS™-2011 [B11]). This value can be changed by management, and is used by the List Config state machine (8.6.9.3) to set the value of OperBaseTime (8.6.9.4.18).

NOTE—Time is expressed in the PTP timescale as the number of seconds, nanoseconds, and fractional nanoseconds that have elapsed since 1 January 1970 00:00:00 TAI.

NOTE 2—If AdminBaseTime is set to the same time in the past in all bridges and end stations, OperBaseTime is always in the past, and all cycles start synchronized. Using AdminBaseTime in the past is appropriate when you can start schedules prior to starting the application that uses the schedules. Use of AdminBaseTime in the future is intended to change a currently running schedule in all bridges and end stations to a new schedule at a future time. Using AdminBaseTime in the future is appropriate when schedules must be changed without stopping the application.

(Source: IEEE Standard for Local and metropolitan area networks— Bridges and Bridged Networks Amendment 25: Enhancements for Scheduled Traffic (IEEE 802.1Qbv-2015))

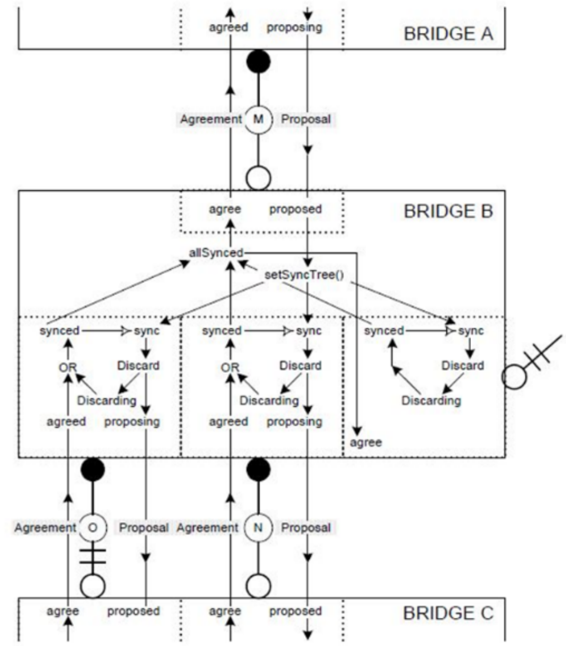

Figure 13-10—Agreements and Proposals

(Source: IEEE Standard for Local and Metropolitan Area Networks—Bridges and Bridged Networks- IEEE Std 802.1Q™-2018)

NOTE 2—Agreements can be generated without prior receipt of a Proposal as soon as the necessary conditions are met. Subsequent receipt of a Proposal serves to elicit a further Agreement. If all other ports have already been synchronized (allSynced in Figure 13-10) and the Proposal's priority vector does not convey worse information, synchronization is maintained and there is no need to transition Designated Ports to Discarding once more, or to transmit further Proposals.

(Source: IEEE Standard for Local and Metropolitan Area Networks—Bridges and Bridged Networks- IEEE Std 802.1Q™-2018)

8.6.8.4 Enhancements for scheduled traffic

A Bridge or an end station may support enhancements that allow transmission from each queue to be scheduled relative to a known timescale. In order to achieve this, a transmission gate is associated with each queue; the state of the transmission gate determines whether or not queued frames can be selected for transmission (see Figure 8-12). For a given queue, the transmission gate can be in one of two states:

a) *Open*: Queued frames are selected for transmission, in accordance with the definition of the transmission selection algorithm associated with the queue.
b) *Closed*: Queued frames are not selected for transmission.

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8.6.8 Transmission selection

For each Port, frames are selected for transmission on the basis of the traffic classes that the Port supports and the operation of the transmission selection algorithms supported by the corresponding queues on that Port. For a given Port and traffic class, frames are selected from the corresponding queue for transmission if and only if

a) The operation of the transmission selection algorithm supported by that queue determines that there is a frame available for transmission; and

b) For each queue corresponding to a numerically higher value of traffic class supported by the Port, the operation of the transmission selection algorithm supported by that queue determines that there is no frame available for transmission.

(Source: IEEE Standard for Local and Metropolitan Area Networks—Bridges and Bridged Networks- IEEE Std 802.1Q™-2018)

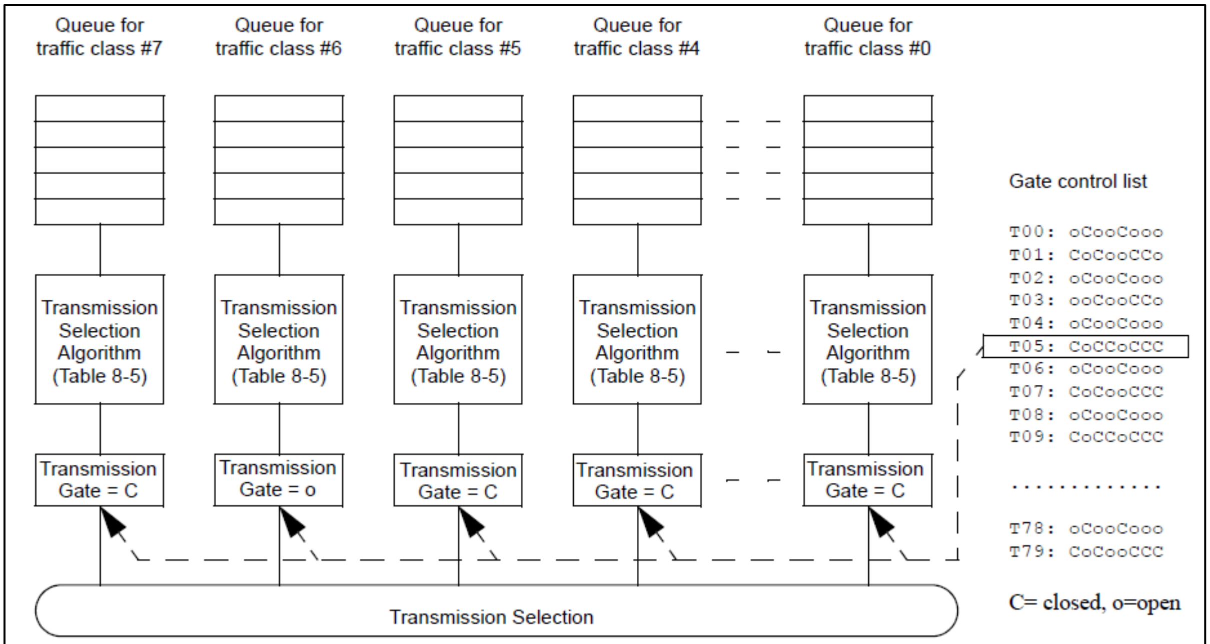

Figure 8-12—Transmission selection with gates

(Source: IEEE Standard for Local and metropolitan area networks— Bridges and Bridged Networks Amendment 25: Enhancements for Scheduled Traffic (IEEE 802.1Qbv-2015))

A *gate control list* associated with each Port contains an ordered list of gate operations. Each gate operation changes the transmission gate state for the gate associated with each of the Port's traffic class queues. In an implementation that does not support enhancements for scheduled traffic, all gates are assumed to be permanently in the *open* state. Table 8-6 identifies the gate operation types, their parameters, and the actions that result from their execution. The state machines that control the execution of the gate control list, along with their variables and procedures, are specified in 8.6.9.

(Source: IEEE Standard for Local and metropolitan area networks— Bridges and Bridged Networks Amendment 25: Enhancements for Scheduled Traffic (IEEE 802.1Qbv-2015))

3.3 gating cycle: The period of time over which the sequence of operations in a gate control list repeats.

3.4 transmission gate: A gate that connects or disconnects the transmission selection function of the forwarding process from the queue, allowing or preventing it from selecting frames from that queue. The gate has two states, Open and Closed.

(Source: IEEE Standard for Local and metropolitan area networks— Bridges and Bridged Networks Amendment 25: Enhancements for Scheduled Traffic (IEEE 802.1Qbv-2015))

Cyclic queuing and forwarding[53]

T.1 Overview of CQF

Cyclic queuing and forwarding (CQF) is a method of traffic shaping that can deliver deterministic, and easily calculated, latency for time-sensitive traffic streams. As the name implies, the principle underlying CQF is that stream traffic is transmitted and queued for transmission along a network path in a cyclic manner. Time is divided into numbered time intervals i, $i+1$, $i+2$, ... $i+N$, each of duration d. Frames transmitted by a Bridge, *Alice*, during time interval i are received by a downstream Bridge, *Bob*, during time interval i and are transmitted onwards by *Bob* towards Bridge *Charlie* during time interval $i+1$, and so on. A starting assumption is that, for a given traffic class, all Bridges and all end stations connected to a given bridge have a common understanding (to a known accuracy) of the start time of cycle i, and the cycle duration, d.

Frames transmitted by *Alice* during interval i are transmitted by *Bob* in interval $i+1$; the maximum possible delay experienced by a given frame is from the beginning of i to the end of $i+1$, or twice d. Similarly, the minimum possible delay experienced is from the end of i to the beginning of $i+1$, which is zero. More generally, the maximum delay experienced by a given frame is

$$(h+1) \times d$$

and the minimum delay experienced by a given frame is

$$(h-1) \times d$$

where h is the number of hops.

(Source: IEEE Standard for Local and Metropolitan Area Networks—Bridges and Bridged Networks- IEEE Std 802.1Q™-2018)

54. The methods practiced by ADVA's use of the accused products include controlling transmission of data during at least one of an assigned time phase assigned to the device adapter prior to transmission of real-time data by the device adapter, and included in the plurality of assigned time phases, or the free access phase. For example, the accused products are used by ADVA to implement the IEEE 802.1Q standard. IEEE standard 802.1Q shows that scheduling (controlling) of transmission gates ports for transmission of data starts prior to the transmission of real-time data. The functionality of assigned time phases is achieved using open gates transmitting data packets during scheduled transmission time. Per Clause 8.6.8 of the IEEE Std. 802.1Q, each time phase is assigned to a specific device adapter prior to transmission of real-time data by the specific device adapter. IEEE 802.1Q performs traffic shaping through

Per-Stream Filtering and Policing (PSFP). In IEEE 802.1Q, open gates transmit data packets during transmission time and closed gates refrain data packets from transmission. The functionality of assigned time phases is achieved using open gates transmitting data packets during transmission time. The functionality of free access phase is achieved by the gates that are opened for transmission during any time. IEEE Std. 802.1Q supports Forwarding and Queuing Enhancements for Time Sensitive Streams. The ports of device adapters are assigned a time for transmission based on priority and credit-based algorithm. So, there will be instances when the transmission of data is refrained based on priority. Thus, one of the plurality of devices is configured to transmit data during at least one of a respective assigned time phase or free access phase, to refrain from transmitting data during time phases not assigned to the respective one of the plurality of device adapters. IEEE Std. 802.1Q provides traffic shaping for various classes of data transmission and determining whether to defer transmission of data during at least one of the assigned time phase or the free access phase to allow a non-real time device to transmit data.

NOTE 2—If AdminBaseTime is set to the same time in the past in all bridges and end stations, OperBaseTime is always in the past, and all cycles start synchronized. Using AdminBaseTime in the past is appropriate when you can start schedules prior to starting the application that uses the schedules. Use of AdminBaseTime in the future is intended to

(Source: IEEE Standard for Local and metropolitan area networks— Bridges and Bridged Networks Amendment 25: Enhancements for Scheduled Traffic (IEEE 802.1Qbv-2015))

1.1 Project Number: P802.1Qbv
1.2 Type of Document: Standard
1.3 Life Cycle: Full Use

5.5 Need for the Project: The credit-based shaper works well in arbitrary networks (i.e., non-engineered). Networks employing scheduled transmissions are able to control real-time processes. This amendment enables those two kinds of networks to be consolidated into a single network, with a significant cost reduction to the user.

(Source: http://www.ieee802.org/1/files/public/docs2014/bv-p802-1Qbv-par-modification-1114.pdf)

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b) For each queue corresponding to a numerically higher value of traffic class supported by the Port, the operation of the transmission selection algorithm supported by that queue determines that there is no frame available for transmission.

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b) Support the state machines for scheduled traffic as specified in 8.6.9.
c) Support the state machines for stream gate control as specified in 8.6.10.
d) Support the management entities for scheduled traffic as specified in 12.29.
e) Support the requirements for per-stream filtering and policing (PSFP) as stated in 5.4.1.8.
f) Support the management entities for PSFP as specified in 12.31.

(Source: IEEE Standard for Local and Metropolitan Area Networks—Bridges and Bridged Networks- IEEE Std 802.1Q™-2018)

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A VLAN Bridge component implementation that conforms to the provisions of this standard for FQTSS shall

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(Source: IEEE Standard for Local and Metropolitan Area Networks—Bridges and Bridged Networks- IEEE Std 802.1Q™-2018)

8.6.8.4 Enhancements for scheduled traffic

A Bridge or an end station may support enhancements that allow transmission from each queue to be scheduled relative to a known timescale. In order to achieve this, a transmission gate is associated with each queue; the state of the transmission gate determines whether or not queued frames can be selected for transmission (see Figure 8-12). For a given queue, the transmission gate can be in one of two states:

a) *Open*: Queued frames are selected for transmission, in accordance with the definition of the transmission selection algorithm associated with the queue.
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(Source: IEEE Standard for Local and metropolitan area networks— Bridges and Bridged Networks Amendment 25: Enhancements for Scheduled Traffic (IEEE 802.1Qbv-2015))

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(Source: IEEE Standard for Local and metropolitan area networks— Bridges and Bridged Networks Amendment 25: Enhancements for Scheduled Traffic (IEEE 802.1Qbv-2015))

5.4.1.6 ETS Bridge requirements

A device supporting ETS shall

a) Support at least 3 traffic classes (37.3).

NOTE—A minimum of 3 traffic classes allows a minimum configuration such that one traffic class contains priorities with PFC enabled, one traffic class contains priorities with PFC disabled, and one traffic class using strict priority.

b) Support bandwidth configuration with a granularity of 1% or finer (37.3).
c) Support bandwidth allocation with a precision of 10% (37.3).
d) Support a transmission selection policy such that if one of the traffic classes does not consume its allocated bandwidth, then any unused bandwidth is available to other traffic classes (37.3).
e) Support DCBX (Clause 38).

(Source: IEEE Standard for Local and Metropolitan Area Networks—Bridges and Bridged Networks- IEEE Std 802.1Q™-2018)

55. The methods practiced by ADVA's use of the accused products include refraining from transmitting data during time phases of the plurality of assigned time phases that are not associated with the device adapter. For example, the accused products are used by ADVA to implement the IEEE 802.1Q standard. IEEE standard 802.1Q performs traffic shaping through Per-Stream Filtering and Policing (PSFP). In IEEE 802.1Q, open gates transmit data packets during transmission time and closed gates refrain data packets from transmission. The functionality of assigned time phases is achieved using open gates transmitting data packets during transmission time. The functionality of free access phase is achieved by the gates that are opened for transmission during any time. IEEE Std. 802.1Q supports Forwarding and Queuing Enhancements for Time Sensitive Streams. The ports of device adapters are assigned a time for transmission based on priority and credit-based algorithm. So, there are instances when the transmission of data is refrained based on priority. Thus, one of the plurality of devices is configured to transmit data during at least one of a respective assigned time phase or free access phase, to refrain from transmitting data during time phases not assigned to the respective one of the plurality of device adapters.

5.4.1.9 Cyclic queuing and forwarding (CQF) requirements

A VLAN Bridge component implementation that conforms to the provisions of this standard for CQF (see Annex T) shall

a) Support the enhancements for scheduled traffic as specified in 8.6.8.4.

b) Support the state machines for scheduled traffic as specified in 8.6.9.
c) Support the state machines for stream gate control as specified in 8.6.10.
d) Support the management entities for scheduled traffic as specified in 12.29.
e) Support the requirements for per-stream filtering and policing (PSFP) as stated in 5.4.1.8.
f) Support the management entities for PSFP as specified in 12.31.

(Source: IEEE Standard for Local and Metropolitan Area Networks—Bridges and Bridged Networks- IEEE Std 802.1Q™-2018)

5.4.1.5 Forwarding and Queuing Enhancements for time-sensitive streams (FQTSS)—requirements

A VLAN Bridge component implementation that conforms to the provisions of this standard for FQTSS shall

a) Support a minimum of two traffic classes on all Ports, of which
   1) A minimum of one traffic class supports the strict priority algorithm for transmission selection (8.6.8.1), and
   2) One traffic class is a stream reservation (SR) class.
b) Support the operation of the credit-based shaper algorithm (8.6.8.2) on all Ports as the transmission selection algorithm used for the SR class.
c) Support SRP domain boundary port priority regeneration override as defined in 6.9.4, and the default priority regeneration override value defined in Table 6-5, for SR class "B."
d) Support the tables and procedures for mapping priorities to traffic classes as defined in 34.5.

SR: Stream Reservation, SRP: Stream Reservation Protocol

(Source: IEEE Standard for Local and Metropolitan Area Networks—Bridges and Bridged Networks- IEEE Std 802.1Q™-2018)

8.6.8.4 Enhancements for scheduled traffic

A Bridge or an end station may support enhancements that allow transmission from each queue to be scheduled relative to a known timescale. In order to achieve this, a transmission gate is associated with each queue; the state of the transmission gate determines whether or not queued frames can be selected for transmission (see Figure 8-12). For a given queue, the transmission gate can be in one of two states:

a) *Open*: Queued frames are selected for transmission, in accordance with the definition of the transmission selection algorithm associated with the queue.
b) *Closed*: Queued frames are not selected for transmission.

(Source: IEEE Standard for Local and metropolitan area networks— Bridges and Bridged Networks Amendment 25: Enhancements for Scheduled Traffic (IEEE 802.1Qbv-2015))

A *gate control list* associated with each Port contains an ordered list of gate operations. Each gate operation changes the transmission gate state for the gate associated with each of the Port's traffic class queues. In an implementation that does not support enhancements for scheduled traffic, all gates are assumed to be permanently in the *open* state. Table 8-6 identifies the gate operation types, their parameters, and the actions that result from their execution. The state machines that control the execution of the gate control list, along with their variables and procedures, are specified in 8.6.9.

(Source: IEEE Standard for Local and metropolitan area networks— Bridges and Bridged Networks Amendment 25: Enhancements for Scheduled Traffic (IEEE 802.1Qbv-2015))

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A VLAN Bridge component implementation that conforms to the provisions of this standard for FQTSS shall

a) Support a minimum of two traffic classes on all Ports, of which
   1) A minimum of one traffic class supports the strict priority algorithm for transmission selection (8.6.8.1), and
   2) One traffic class is a stream reservation (SR) class.
b) Support the operation of the credit-based shaper algorithm (8.6.8.2) on all Ports as the transmission selection algorithm used for the SR class.
c) Support SRP domain boundary port priority regeneration override as defined in 6.9.4, and the default priority regeneration override value defined in Table 6-5, for SR class "B."
d) Support the tables and procedures for mapping priorities to traffic classes as defined in 34.5.

SR: Stream Reservation, SRP: Stream Reservation Protocol

(Source: IEEE Standard for Local and Metropolitan Area Networks—Bridges and Bridged Networks- IEEE Std 802.1Q™-2018)

56. The plurality of device adaptors recited above in connection with ADVA's use of the accused products includes determining whether to defer transmission of data during the assigned time phase assigned to the device adapter if the device adapter has data to transmit during the assigned time phase assigned to the device adapter, to allow another device to transmit data during the assigned time phase assigned to the device adapter; and determining whether to defer transmission of data during the free access phase if the device adapter has data to transmit during the free access phase, to allow the another device to transmit data during the free access phase. For example, the accused products are used by ADVA to implement the IEEE 802.1Q standard. IEEE standard 802.1Q implements a method in which open gates transmit data packets during transmission time and closed gates refrain data packets from transmission. The functionality of assigned time phases is achieved using open gates transmitting data packets during transmission time. The functionality of free access phase is achieved by the gates that are opened for transmission during any time. IEEE Std. 802.1Q supports Forwarding and Queuing Enhancements for Time Sensitive Streams. The ports of device adapters are assigned a time for

transmission based on priority and credit-based algorithm. So, there will be instances when the transmission of data is refrained based on priority. Thus, one of the plurality of devices is configured to transmit data during at least one of a respective assigned time phase or free access phase, to refrain from transmitting data during time phases not assigned to the respective one of the plurality of device adapters. IEEE Std. 802.1Q provides traffic shaping for various classes of data transmission and determining whether to defer transmission of data during at least one of the assigned time phase or the free access phase to allow another device (non-real time device) to transmit data.

8.6.8.4 Enhancements for scheduled traffic

A Bridge or an end station may support enhancements that allow transmission from each queue to be scheduled relative to a known timescale. In order to achieve this, a transmission gate is associated with each queue; the state of the transmission gate determines whether or not queued frames can be selected for transmission (see Figure 8-12). For a given queue, the transmission gate can be in one of two states:

a) *Open*: Queued frames are selected for transmission, in accordance with the definition of the transmission selection algorithm associated with the queue.
b) *Closed*: Queued frames are not selected for transmission.

(Source: IEEE Standard for Local and metropolitan area networks— Bridges and Bridged Networks Amendment 25: Enhancements for Scheduled Traffic (IEEE 802.1Qbv-2015))

A *gate control list* associated with each Port contains an ordered list of gate operations. Each gate operation changes the transmission gate state for the gate associated with each of the Port's traffic class queues. In an implementation that does not support enhancements for scheduled traffic, all gates are assumed to be permanently in the *open* state. Table 8-6 identifies the gate operation types, their parameters, and the actions that result from their execution. The state machines that control the execution of the gate control list, along with their variables and procedures, are specified in 8.6.9.

(Source: IEEE Standard for Local and metropolitan area networks— Bridges and Bridged Networks Amendment 25: Enhancements for Scheduled Traffic (IEEE 802.1Qbv-2015))

5.4.1.5 Forwarding and Queuing Enhancements for time-sensitive streams (FQTSS)—requirements

A VLAN Bridge component implementation that conforms to the provisions of this standard for FQTSS shall

a) Support a minimum of two traffic classes on all Ports, of which
   1) A minimum of one traffic class supports the strict priority algorithm for transmission selection (8.6.8.1), and
   2) One traffic class is a stream reservation (SR) class.
b) Support the operation of the credit-based shaper algorithm (8.6.8.2) on all Ports as the transmission selection algorithm used for the SR class.
c) Support SRP domain boundary port priority regeneration override as defined in 6.9.4, and the default priority regeneration override value defined in Table 6-5, for SR class "B."
d) Support the tables and procedures for mapping priorities to traffic classes as defined in 34.5.

SR: Stream Reservation, SRP: Stream Reservation Protocol

(Source: IEEE Standard for Local and Metropolitan Area Networks—Bridges and Bridged Networks- IEEE Std 802.1Q™-2018)

5.4.1.6 ETS Bridge requirements

A device supporting ETS shall

a) Support at least 3 traffic classes (37.3).

NOTE—A minimum of 3 traffic classes allows a minimum configuration such that one traffic class contains priorities with PFC enabled, one traffic class contains priorities with PFC disabled, and one traffic class using strict priority.

b) Support bandwidth configuration with a granularity of 1% or finer (37.3).
c) Support bandwidth allocation with a precision of 10% (37.3).
d) Support a transmission selection policy such that if one of the traffic classes does not consume its allocated bandwidth, then any unused bandwidth is available to other traffic classes (37.3).
e) Support DCBX (Clause 38).

(Source: IEEE Standard for Local and Metropolitan Area Networks—Bridges and Bridged Networks- IEEE Std 802.1Q™-2018)

57. Far North Patents has been damaged as a result of the infringing conduct by ADVA alleged above. Thus, ADVA is liable to Far North Patents in an amount that adequately compensates it for such infringements, which, by law, cannot be less than a reasonable royalty, together with interest and costs as fixed by this Court under 35 U.S.C. § 284.

58. Far North Patents and/or its predecessors-in-interest have satisfied all statutory obligations required to collect pre-filing damages for the full period allowed by law for infringement of the ‘504 Patent.

COUNT V

DIRECT INFRINGEMENT OF U.S. PATENT NO. 6,661,804

59. On December 9, 2003, United States Patent No. 6,661,804 (“the ‘804 Patent”) was duly and legally issued by the United States Patent and Trademark Office for an invention entitled “Methods and Apparatus for Providing Quality-of-Service Guarantees in Computer Networks.”

60. Far North Patents is the owner of the ‘804 Patent, with all substantive rights in and to that patent, including the sole and exclusive right to prosecute this action and enforce the ‘804 Patent against infringers, and to collect damages for all relevant times.

61. ADVA made, had made, used, imported, provided, supplied, distributed, sold, and/or offered for sale products and/or systems including, for example, its ADVA FSP 150-GO102Pro and ADVA FSP 150-GE102Pro families of products that include advanced quality of service capabilities (collectively, “accused products”).

ADVA™

FSP 150-GO102Pro Series

Outdoor Carrier Ethernet and IP demarcation

Public outdoor small cells, Wi-Fi and closed circuit TV (CCTV) require connectivity services which end outside a controlled environment. But service providers don't want to invest in expensive and unsightly cabinets. That's why small environmentally sealed network demarcation devices are a game changer.

Communication service providers (CSPs) struggle to cope with a high number of specialized boxes. They need a single demarcation product that can cover a wide range of applications and be effective even under harsh environmental conditions. Our FSP 150-GO102Pro, a member of the market-leading FSP 150 family, makes a real difference. Its small size and low power consumption make it easy to install and simple to configure. It supports a comprehensive set of Carrier Ethernet and IP connectivity services. Automated testing and in-service monitoring protocols simplify any phase of the service lifecycle. What's more, our FSP 150-GO102Pro also provides precise synchronization. Such a unique combination of features makes it the perfect solution for connecting small cell sites.

(Source : Screenshot of PDF downloaded from https://www.adva.com/-/media/adva-main-site/resources/data-sheets/pdfs/fsp-150-go-102-pro-series.ashx?la=de-de&hash=5122080C1CCB4C881E30D8D62F0DF92DF16C098B)

VLAN support
- 4096 VLANs (IEEE 802.1Q customer-tagged) and stacked VLANs (Q-in-Q service provider tagged)
- 2-tag management (push/pop/swap) for c-tag and s-tag
- IEEE 802.1ad provider bridging (c-tag, s-tag)
- Ethertype translation
- Eight Ethernet virtual circuits (EVC)
- 9612 byte-per-frame MTU transparency

Layer 2 traffic management
- Acceptable client frame policy: tagged or untagged
- Service classification based on IEEE 802.1p, 802.1Q and IP-TOS/DSCP
- VLAN tag priority mapping (IEEE 802.1ad PCP encoding)
- MEF-compliant policing (CIR/CBS/EIR/EBS) with three-color marking and eight classes of service
- Port shaping on transmit for both client and network ports
- MEF 10.3 hierarchical policing with token-share envelopes
- DiffServ supporting WFQ/SP mix

(Source : Screenshot of PDF downloaded from https://www.adva.com/-/media/adva-main-site/resources/data-sheets/pdfs/fsp-150-go-102-pro-series.ashx?la=de-de&hash=5122080C1CCB4C881E30D8D62F0DF92DF16C098B)

ADVA today answered the urgent need for small cell backhaul with the launch of the world's smallest cell site gateway device. The ADVA FSP 150-GO102Pro Series has been specifically engineered to be installed in the most challenging locations, enabling the easy deployment of small cells at street level. With its uniquely compact and ruggedized design, it provides multi-layer service demarcation in a wide range of outdoor locations, from walls to poles to lampposts. The ADVA FSP 150-GO102Pro Series also delivers highly precise time and frequency synchronization and features automated testing and in-service monitoring. With the ADVA FSP 150-GO102Pro Series, service providers can easily and cost-effectively introduce next-generation mobile connectivity services for the IoT and 5G era. The new solution is already in customer trials and is generally available from today.

"Our FSP 150-GO102Pro Series is the ultimate outdoor demarcation technology. It ensures the highest quality of service even in the harshest conditions. This phenomenally versatile device empowers operators to deliver reliable, programmable mobile backhaul connectivity without investing in expensive cabinets or power-hungry air conditioning systems," said Stephan Rettenberger, SVP, marketing and investor relations, ADVA. "We worked closely with major wholesale service providers to develop our FSP 150-GO102Pro Series. The solution is specifically engineered to meet their exacting requirements and facilitate their 5G ambitions. It offers full Layer 2 and 3 service demarcation with a complete set of Carrier Ethernet and routing features. The FSP 150-GO102Pro Series even provides highly automated zero touch provisioning for effortless installation and activation."

(Source : https://www.newswiretoday.com/news/168708/)

ADVA™

FSP 150-GE100Pro Series

Programmable Carrier Ethernet and IP demarcation

As complexity increases, network demarcation devices need to continuously extend their capabilities. Communication service provider need one product family for Ethernet and IP, indoor or outdoor, sophisticated security and highly precise synchronization.

Change is the norm. Today, your business customer wants Ethernet connectivity. Tomorrow, it's IP services. Frequency synchronization is no longer sufficient for your mobile network as time synchronization is mandatory for 4G. Meanwhile, your customers decide that they won't accept unencrypted transmission. The one constant is that requirements keep changing – and at an unprecedented pace. Our FSP 150-GE100Pro series belongs to the successful FSP 150 ProNID family. It enables network operators to offer true multi-service access by combining the demarcation of Carrier Ethernet 2.0 and IP services with a rich set of features in a single device. What's more, there's a range of designs from ultra-compact to rack-mountable devices, all aligned with distinct customer demand. The comprehensive FSP 150-GE100Pro series provides the perfect answer to any demarcation requirement.

(Source : Screenshot of PDF downloaded from https://www.adva.com/-/media/adva-main-site/resources/data-sheets/pdfs/fsp-150-ge-100-pro-series.ashx?la=de-DE&hash=46C2728AB543DEB24ECC9B31953C3463C4325AB5)

VLAN support
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- IEEE 802.1ad provider bridging (c-tag, s-tag)
- Ethertype translation
- 8[1-2]/32[3-5]/64[6-10] Ethernet virtual circuits (EVC)
- 9612 Byte per frame MTU transparency
- EoMPLS encapsulation

Layer 2 traffic management
- Acceptable client frame policy: tagged or untagged
- Service classification based on IEEE 802.1p, 802.1Q and IP-TOS/DSCP
- VLAN tag priority mapping (IEEE 802.1ad PCP encoding)
- MEF-compliant policing (CIR/CBS/EIR/EBS) with three-color marking and eight classes of service
- Port shaping on transmit for both client and network ports
- MEF 10.3 hierarchical policing with token-share envelopes
- DiffServ supporting WFQ/SP mix

(Source : Screenshot of PDF downloaded from https://www.adva.com/-/media/adva-main-site/resources/data-sheets/pdfs/fsp-150-ge-100-pro-series.ashx?la=de-DE&hash=46C2728AB543DEB24ECC9B31953C3463C4325AB5)

62. By doing so, ADVA has directly infringed (literally and/or under the doctrine of equivalents) at least Claim 22 of the '804 Patent.

63. ADVA has infringed the '804 Patent by using the accused products and thereby practicing a method including defining a common time reference for a plurality of device adapters, said common time reference including a time frame having a plurality of time phases, each of said device adapters capable of being uniquely assigned to at least one of said time phases, said time phases including a free-access phase. For example, the accused products are used by ADVA to implement the IEEE 802.1Q standard. IEEE standard 802.1Q implements a method in which a time aware bridged LAN transmits data from one end point i.e., Precision Time Protocol ("PTP") instance to another. The endpoints transmit data that is a mix of time-critical traffic and other traffic, (i.e., real time data and non-real time data) via PTP instances such as bridges (device adapters). The time aware bridged LAN use 802.1AS base time to

maintain synchronized time (common time reference) for all the ports in the bridges (device adapters). The bridges containing ports schedule the transmission of traffic based on the synchronized time. Each port associated with a specific set of transmission queues includes a plurality of transmission gates. A transmission gate can be in a closed state or open state. The functionality of assigned time phases is achieved using open gates transmitting data packets during transmission time. The functionality of free access phase is achieved when the gates are opened for transmission during any time. IEEE Std. 802.1AS™ is normative and essential to implement an IEEE Std. 802.1Q Compliant System.

1.1 Project Number: P802.1Qbv
1.2 Type of Document: Standard
1.3 Life Cycle: Full Use

2.1 Title: Standard for Local and metropolitan area networks--Media Access Control (MAC) Bridges and Virtual Bridged Local Area Networks Amendment: Enhancements for Scheduled Traffic

5.2.b. Scope of the project: This amendment specifies time-aware queue-draining procedures, managed objects and extensions to existing protocols that enable bridges and end stations to schedule the transmission of frames based on a synchronized time. Virtual Local Area Network (VLAN) tag encoded priority values are allocated allowing simultaneous support of scheduled traffic, credit-based shaper traffic and other bridged traffic over Local Area Networks (LANs).

(Source: http://www.ieee802.org/1/files/public/docs2014/bv-p802-1Qbv-par-modification-1114.pdf)

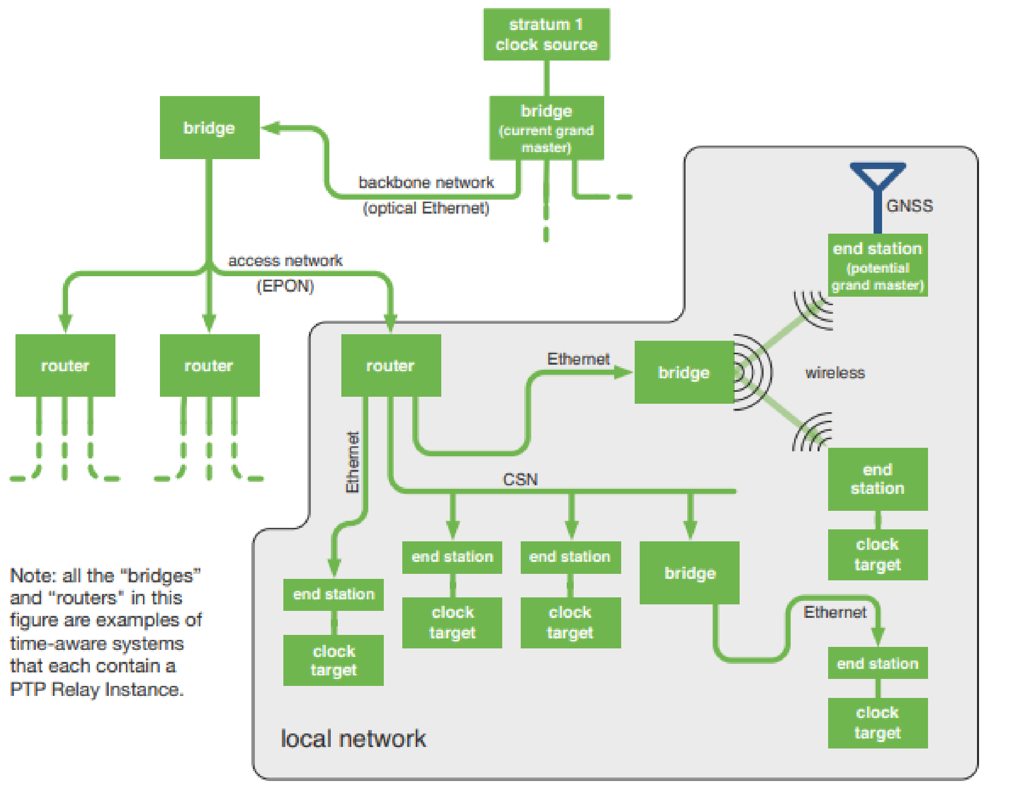

Figure 7-1—Time-aware network example

(Source: https://1.ieee802.org/wp-content/uploads/2019/03/802-1AS-rev-d8-0.pdf)

7.2 Architecture of a time-aware network

7.2.1 General

A time-aware network consists of a number of interconnected time-aware systems that support the gPTP defined within this standard. These time-aware systems can be any networking device, including, for example, bridges, routers, and end stations. A set of time-aware systems that are interconnected by gPTP-capable network elements is called a *gPTP network*. Each instance of gPTP that the time-aware systems support is in one *gPTP domain*, and the instances of gPTP are said to be part of that gPTP domain. A time-aware system can support, and therefore be part of, more than one gPTP domain. The entity of a single time-aware system that executes gPTP in one gPTP domain is called a PTP Instance. A time-aware system can contain multiple PTP Instances, which are each associated with a different gPTP domain. There are two

(Source: https://1.ieee802.org/wp-content/uploads/2019/03/802-1AS-rev-d8-0.pdf)

c) In gPTP there are only two types of PTP Instances: PTP End Instances and PTP Relay Instances, while IEEE 1588 has ordinary clocks, boundary clocks, end-to-end transparent clocks, and P2P transparent clocks. A PTP End Instance corresponds to an IEEE 1588 ordinary clock, and a PTP Relay Instance is a type of IEEE 1588 boundary clock where its operation is very tightly defined, so much so that a PTP Relay Instance with Ethernet ports can be shown to be mathematically equivalent to a P2P transparent clock in terms of how synchronization is performed, as shown in

(Source: https://1.ieee802.org/wp-content/uploads/2019/03/802-1AS-rev-d8-0.pdf)

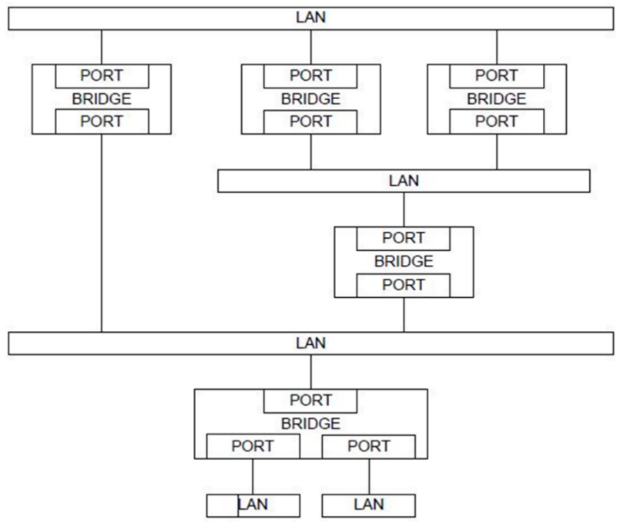

Figure 8-1—A Bridged Network

(Source: IEEE Standard for Local and Metropolitan Area Networks—Bridges and Bridged Networks- IEEE Std 802.1Q™-2018)

Traffic scheduling

This annex provides some background to the mechanisms provided in this standard for traffic scheduling, with the intent of providing some insight into the motivation for the provision of mechanisms for traffic scheduling and some of the ways that the mechanisms might be used.

Q.1 Motivation

Some applications have a need for frame delivery that is highly predictable in terms of the time at which frame transmission will occur, and the overall latency and jitter that will be experienced as the frame is propagated to its destination. Examples include industrial and automotive control applications, where data transmitted over the network is used to feed the parameters of control loops that are critical to the operation of the plant or machinery involved, and where frames carrying control data are transmitted on a repeating time schedule; late delivery of such frames can result in instability, inaccuracy, or failure of the operation of the control loops concerned. In some implementations, this need has been met by the provision of dedicated, highly engineered networks that are used solely for the transmission of time-critical control traffic; however, as the bandwidth occupied by such traffic is often low, and the cost of providing a dedicated control network can be high, it can be desirable to mix time-critical traffic with other classes of traffic in the same network, as long as such mixing can be achieved while still meeting the timing requirements of the time-critical traffic.

(Source: IEEE Standard for Local and metropolitan area networks— Bridges and Bridged Networks Amendment 25: Enhancements for Scheduled Traffic (IEEE 802.1Qbv-2015))

IEEE Std 802.1Q-2018
IEEE Standard for Local and Metropolitan Area Networks—Bridges and Bridged Networks

2. Normative references

The following referenced documents are indispensable for the application of this document (i.e., they must be understood and used, so each referenced document is cited in the text and its relationship to this document is explained). For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments or corrigenda) applies.

ANSI X3.159, American National Standards for Information Systems—Programming Language—C.[5]

IEEE Std 802®, IEEE Standard for Local and metropolitan area networks: Overview and Architecture.[6,7]

IEEE Std 802.1AB™, IEEE Standard for Local and metropolitan area networks—Station and Media Access Control Connectivity Discovery.

IEEE Std 802.1AC™, IEEE Standard for Local and metropolitan area networks—Media Access Control (MAC) Service Definition.

IEEE Std 802.1AE™, IEEE Standard for Local and metropolitan area networks—Media Access Control (MAC) Security.

IEEE Std 802.1AS™, IEEE Standard for Local and metropolitan area networks—Timing and Synchronization for Time-Sensitive Applications in Bridged Local Area Networks.

(Source: IEEE Standard for Local and Metropolitan Area Networks—Bridges and Bridged Networks- IEEE Std 802.1Q™-2018)

3.16 PTP End Instance: A PTP Instance that is capable of acting as the source of synchronized time on the network, or destination of synchronized time using the IEEE 802.1AS protocol, or both.

3.17 PTP Instance: A PTP Relay Instance or a PTP End Instance. A PTP Instance implements those portions of this standard indicated as applicable to a PTP Relay Instance or a PTP End Instance. Each PTP Instance operates in exactly one domain.

3.18 PTP Link: Within a domain, a network segment between two PTP Ports using the peer-to-peer delay mechanism of this standard. The peer-to-peer delay mechanism is designed to measure the propagation time over such a link.

NOTE—A PTP Link between PTP Ports of PTP Instances is also a gPTP Communication Path (see 3.9).

3.19 PTP Relay Instance: A PTP Instance that is capable of communicating synchronized time received on one port to other ports, using the IEEE 802.1AS protocol.

NOTE—A PTP Relay Instance could, for example, be contained in a bridge, a router, or a multi-port end station.

(Source: https://1.ieee802.org/wp-content/uploads/2019/03/802-1AS-rev-d8-0.pdf)

8.6.8.4 Enhancements for scheduled traffic

A Bridge or an end station may support enhancements that allow transmission from each queue to be scheduled relative to a known timescale. In order to achieve this, a transmission gate is associated with each queue; the state of the transmission gate determines whether or not queued frames can be selected for transmission (see Figure 8-12). For a given queue, the transmission gate can be in one of two states:

a) *Open*: Queued frames are selected for transmission, in accordance with the definition of the transmission selection algorithm associated with the queue.
b) *Closed*: Queued frames are not selected for transmission.

(Source: IEEE Standard for Local and metropolitan area networks— Bridges and Bridged Networks Amendment 25: Enhancements for Scheduled Traffic (IEEE 802.1Qbv-2015))

8.6.8 Transmission selection

For each Port, frames are selected for transmission on the basis of the traffic classes that the Port supports and the operation of the transmission selection algorithms supported by the corresponding queues on that Port. For a given Port and traffic class, frames are selected from the corresponding queue for transmission if and only if

a) The operation of the transmission selection algorithm supported by that queue determines that there is a frame available for transmission; and

b) For each queue corresponding to a numerically higher value of traffic class supported by the Port, the operation of the transmission selection algorithm supported by that queue determines that there is no frame available for transmission.

(Source: IEEE Standard for Local and Metropolitan Area Networks—Bridges and Bridged Networks- IEEE Std 802.1Q™-2018)

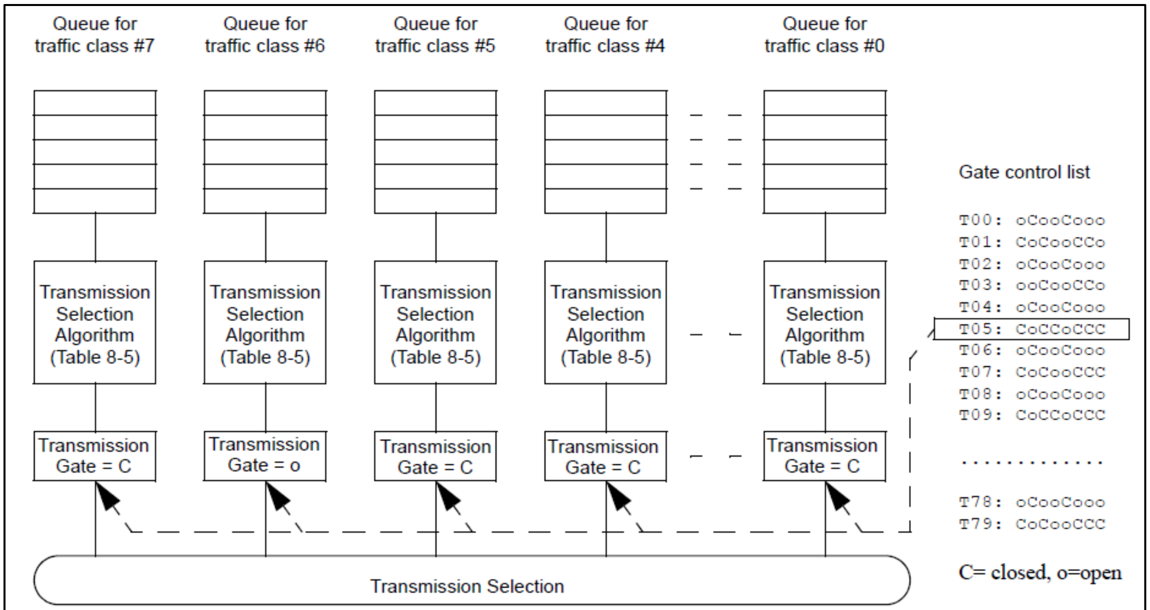

Figure 8-12—Transmission selection with gates

(Source: IEEE Standard for Local and metropolitan area networks— Bridges and Bridged Networks Amendment 25: Enhancements for Scheduled Traffic (IEEE 802.1Qbv-2015))

> A *gate control list* associated with each Port contains an ordered list of gate operations. Each gate operation changes the transmission gate state for the gate associated with each of the Port's traffic class queues. In an implementation that does not support enhancements for scheduled traffic, all gates are assumed to be permanently in the *open* state. Table 8-6 identifies the gate operation types, their parameters, and the actions that result from their execution. The state machines that control the execution of the gate control list, along with their variables and procedures, are specified in 8.6.9.

(Source: IEEE Standard for Local and metropolitan area networks— Bridges and Bridged Networks Amendment 25: Enhancements for Scheduled Traffic (IEEE 802.1Qbv-2015))

64. The methods practiced by ADVA's use of the accused products include allowing a specified device adapter to transmit packets during time phase uniquely assigned to the specified device adapter and during said free-access phase. For example, the accused products are used by ADVA to implement the IEEE 802.1Q standard. The open gates assigned to the transmission queue of a port (device adapter) transmit the data packets during the transmission time. The transmission selection algorithm determines the transmission time. If the gates are in permanent open state, the data packets are transmitted from the gates during any time. The

functionality of assigned time phases is achieved using open gates transmitting data packets during transmission time. The functionality of free access phase is achieved when the gates are permanently opened for transmission during any time.

8.6.8.4 Enhancements for scheduled traffic

A Bridge or an end station may support enhancements that allow transmission from each queue to be scheduled relative to a known timescale. In order to achieve this, a transmission gate is associated with each queue; the state of the transmission gate determines whether or not queued frames can be selected for transmission (see Figure 8-12). For a given queue, the transmission gate can be in one of two states:

a) *Open*: Queued frames are selected for transmission, in accordance with the definition of the transmission selection algorithm associated with the queue.
b) *Closed*: Queued frames are not selected for transmission.

(Source: IEEE Standard for Local and metropolitan area networks— Bridges and Bridged Networks Amendment 25: Enhancements for Scheduled Traffic (IEEE 802.1Qbv-2015))

3.4 transmission gate: A gate that connects or disconnects the transmission selection function of the forwarding process from the queue, allowing or preventing it from selecting frames from that queue. The gate has two states, Open and Closed.

(Source: IEEE Standard for Local and metropolitan area networks— Bridges and Bridged Networks Amendment 25: Enhancements for Scheduled Traffic (IEEE 802.1Qbv-2015))

A *gate control list* associated with each Port contains an ordered list of gate operations. Each gate operation changes the transmission gate state for the gate associated with each of the Port's traffic class queues. In an implementation that does not support enhancements for scheduled traffic, all gates are assumed to be permanently in the *open* state. Table 8-6 identifies the gate operation types, their parameters, and the actions that result from their execution. The state machines that control the execution of the gate control list, along with their variables and procedures, are specified in 8.6.9.

(Source: IEEE Standard for Local and metropolitan area networks— Bridges and Bridged Networks Amendment 25: Enhancements for Scheduled Traffic (IEEE 802.1Qbv-2015))

65. The methods practiced by ADVA's use of the accused products include designating one of said device adapters as a master timing device. For example, the accused products are used by ADVA to implement the IEEE 802.1Q standard. IEEE standard 802.1Q implements a method in which a time aware bridged LAN transmits data from one Precision

Time Protocol (PTP) instance (device adapter) to another. The ports of the time aware bridge use best master clock algorithm (BMCA) to determine a potential grandmaster port (master timing device).

7.2.2 Time-aware network consisting of a single gPTP domain

Figure 7-1 illustrates an example time-aware network consisting of a single gPTP domain, using all theabove network technologies (i.e., (c) - (f) of 7.2.1), where end stations on several local networks are connected to a grandmaster on a backbone network via an EPON access network.

Any PTP Instance with clock sourcing capabilities can be a potential grandmaster, so there is a selection method (the *best master clock algorithm*, or BMCA) that ensures that all of the PTP Instances in a gPTP domain use the same grandmaster.[12] The BMCA is largely identical to that used in IEEE Std 1588-2019,

(Source: https://1.ieee802.org/wp-content/uploads/2019/03/802-1AS-rev-d8-0.pdf)

10.3.1.1 Best master clock algorithm overview

In the BMCA (i.e., method (a) of 10.3.1), best master selection information is exchanged between PTP Instances of time-aware systems via Announce messages (see 10.5 and 10.6). Each Announce message contains time-synchronization spanning tree vector information that identifies one PTP Instance as the root of the time-synchronization spanning tree and, if the PTP Instance is grandmaster-capable, the grandmaster. Each PTP Instance in turn uses the information contained in the Announce messages it receives, along with its knowledge of itself, to compute which of the PTP Instances that it has knowledge of ought to be the root of the spanning tree and, if grandmaster-capable, the grandmaster. As part of constructing the time-synchronization spanning tree, each port of each PTP Instance is assigned a port state from Table 10-2 by state machines associated with the ports and with the PTP Instance as a whole.

(Source: https://1.ieee802.org/wp-content/uploads/2019/03/802-1AS-rev-d8-0.pdf)

11.1.3 Transport of time-synchronization information

The transport of time-synchronization information by a PTP Instance, using Sync and Follow_Up (or just Sync) messages, is illustrated in Figure 11-2. The mechanism is mathematically equivalent to the mechanism described in IEEE Std 1588-2019 for a peer-to-peer transparent clock that is syntonized (see 11.4.5.1, 11.5.1, and 11.5.2.2 of IEEE Std 1588-2019). However, as will be seen shortly, the processes of transporting synchronization by a peer-to-peer transparent clock that is syntonized and by a boundary clock are mathematically and functionally equivalent. The main functional difference between the two types of clocks is that the boundary clock participates in best master selection and invokes the BMCA, while the peer-to-peer transparent clock does not participate in best master selection and does not invoke the BMCA (and implementations of the two types of clocks can be different).

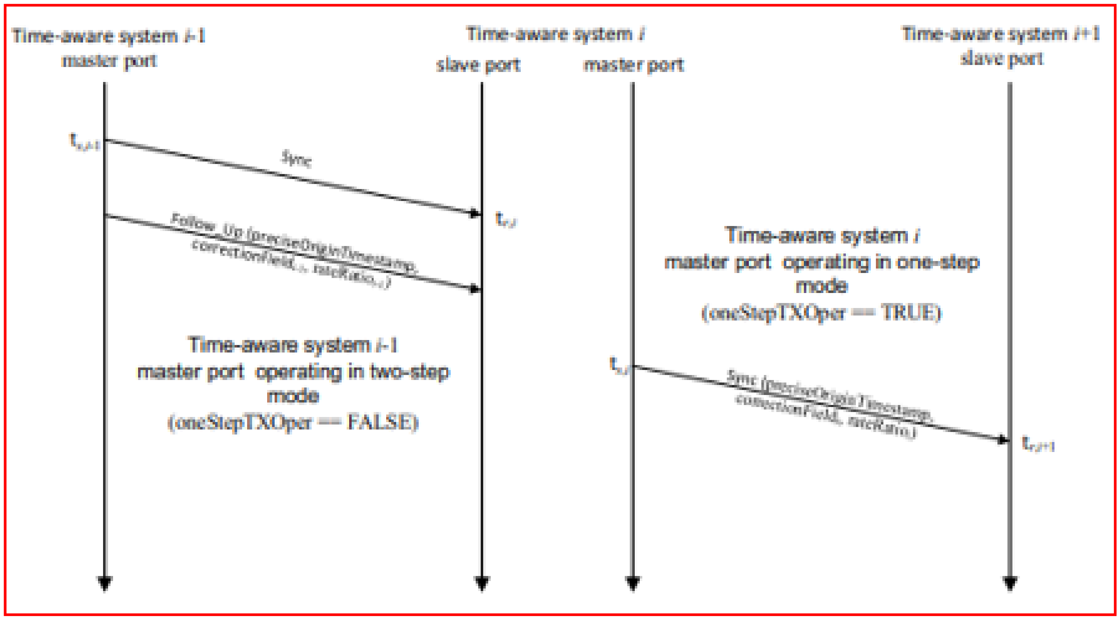

Figure 11-2—Transport of time-synchronization information

(Source: https://1.ieee802.org/wp-content/uploads/2019/03/802-1AS-rev-d8-0.pdf)

c) In gPTP there are only two types of PTP Instances: PTP End Instances and PTP Relay Instances, while IEEE 1588 has ordinary clocks, boundary clocks, end-to-end transparent clocks, and P2P transparent clocks. A PTP End Instance corresponds to an IEEE 1588 ordinary clock, and a PTP Relay Instance is a type of IEEE 1588 boundary clock where its operation is very tightly defined, so much so that a PTP Relay Instance with Ethernet ports can be shown to be mathematically equivalent to a P2P transparent clock in terms of how synchronization is performed, as shown in

(Source: https://1.ieee802.org/wp-content/uploads/2019/03/802-1AS-rev-d8-0.pdf)

66. The methods practiced by ADVA's use of the accused products include synchronizing the remaining device adapters with the designated master timing device. For

example, the accused products are used by ADVA to implement the IEEE 802.1Q standard. The boundary clocks of the slave ports in the time aware bridges (remaining device adapters) are synchronized with the grandmaster boundary clock (master timing device).

c) In gPTP there are only two types of PTP Instances: PTP End Instances and PTP Relay Instances, while IEEE 1588 has ordinary clocks, boundary clocks, end-to-end transparent clocks, and P2P transparent clocks. A PTP End Instance corresponds to an IEEE 1588 ordinary clock, and a PTP Relay Instance is a type of IEEE 1588 boundary clock where its operation is very tightly defined, so much so that a PTP Relay Instance with Ethernet ports can be shown to be mathematically equivalent to a P2P transparent clock in terms of how synchronization is performed, as shown in

(Source: https://1.ieee802.org/wp-content/uploads/2019/03/802-1AS-rev-d8-0.pdf)

3.16 PTP End Instance: A PTP Instance that is capable of acting as the source of synchronized time on the network, or destination of synchronized time using the IEEE 802.1AS protocol, or both.

3.17 PTP Instance: A PTP Relay Instance or a PTP End Instance. A PTP Instance implements those portions of this standard indicated as applicable to a PTP Relay Instance or a PTP End Instance. Each PTP Instance operates in exactly one domain.

3.18 PTP Link: Within a domain, a network segment between two PTP Ports using the peer-to-peer delay mechanism of this standard. The peer-to-peer delay mechanism is designed to measure the propagation time over such a link.

NOTE—A PTP Link between PTP Ports of PTP Instances is also a gPTP Communication Path (see 3.9).

3.19 PTP Relay Instance: A PTP Instance that is capable of communicating synchronized time received on one port to other ports, using the IEEE 802.1AS protocol.

NOTE—A PTP Relay Instance could, for example, be contained in a bridge, a router, or a multi-port end station.

(Source: https://1.ieee802.org/wp-content/uploads/2019/03/802-1AS-rev-d8-0.pdf)

11.1.3 Transport of time-synchronization information

The transport of time-synchronization information by a PTP Instance, using Sync and Follow_Up (or just Sync) messages, is illustrated in Figure 11-2. The mechanism is mathematically equivalent to the mechanism described in IEEE Std 1588-2019 for a peer-to-peer transparent clock that is syntonized (see 11.4.5.1, 11.5.1, and 11.5.2.2 of IEEE Std 1588-2019). However, as will be seen shortly, the processes of transporting synchronization by a peer-to-peer transparent clock that is syntonized and by a boundary clock are mathematically and functionally equivalent. The main functional difference between the two types of clocks is that the boundary clock participates in best master selection and invokes the BMCA, while the peer-to-peer transparent clock does not participate in best master selection and does not invoke the BMCA (and implementations of the two types of clocks can be different).

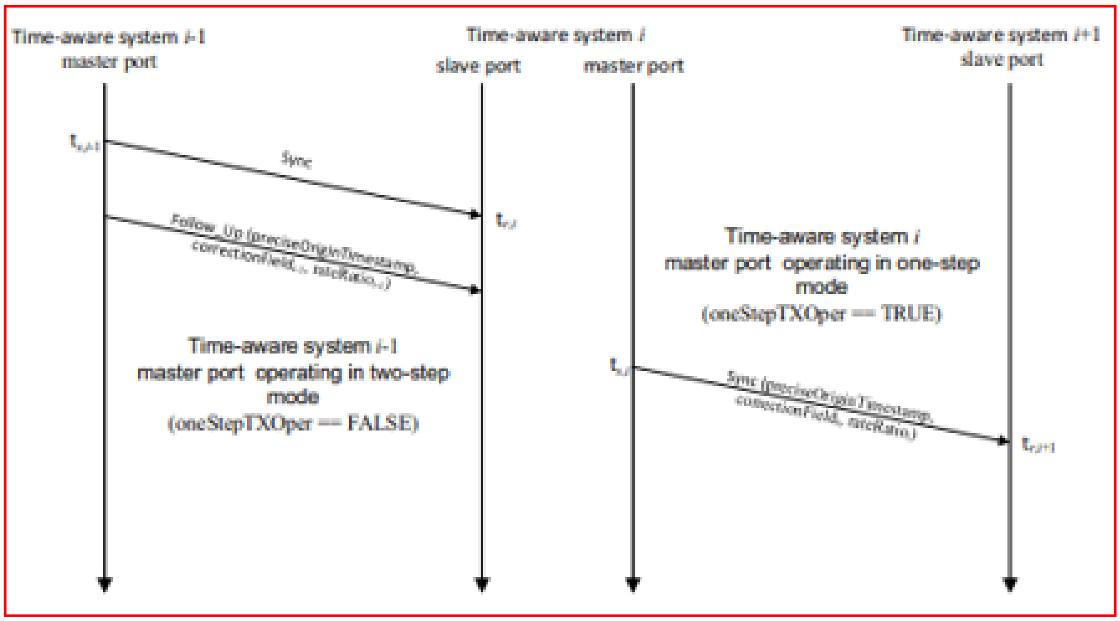

Figure 11-2—Transport of time-synchronization information

(Source: https://1.ieee802.org/wp-content/uploads/2019/03/802-1AS-rev-d8-0.pdf)

67. Far North Patents has been damaged as a result of the infringing conduct by ADVA alleged above. Thus, ADVA is liable to Far North Patents in an amount that adequately compensates it for such infringements, which, by law, cannot be less than a reasonable royalty, together with interest and costs as fixed by this Court under 35 U.S.C. § 284.

68. Far North Patents and/or its predecessors-in-interest have satisfied all statutory obligations required to collect pre-filing damages for the full period allowed by law for infringement of the ‘804 Patent.

ADDITIONAL ALLEGATIONS REGARDING INFRINGEMENT

69. ADVA has also indirectly infringed the ‘053 Patent, the ‘702 Patent, the ‘797 Patent, the ‘504 Patent, and the ‘804 Patent by inducing others to directly infringe the ‘053 Patent, the ‘702 Patent, the ‘797 Patent, the ‘504 Patent, and the ‘804 Patent. ADVA has induced the end-users, ADVA’s customers, to directly infringe (literally and/or under the doctrine of equivalents) the ‘053 Patent, the ‘702 Patent, the ‘797 Patent, the ‘504 Patent, and the ‘804 Patent by using the accused products.

70. ADVA took active steps, directly and/or through contractual relationships with others, with the specific intent to cause them to use the accused products in a manner that infringes one or more claims of the patents-in-suit, including, for example, Claims 1 and 14 of the ‘053 Patent, Claim 27 of the ‘702 Patent, Claim 30 of the ‘797 Patent, Claims 1 and 6 of the ‘504 Patent, and Claim 22 of the ‘804 Patent.

71. Such steps by ADVA included, among other things, advising or directing customers and end-users to use the accused products in an infringing manner; advertising and promoting the use of the accused products in an infringing manner; and/or distributing instructions that guide users to use the accused products in an infringing manner.

72. ADVA has performed these steps, which constitute induced infringement, with the knowledge of the ‘053 Patent, the ‘702 Patent, the ‘797 Patent, the ‘504 Patent, and the ‘804 Patent and with the knowledge that the induced acts constitute infringement.

73. ADVA was and is aware that the normal and customary use of the accused products by ADVA's customers would infringe the '053 Patent, the '702 Patent, the '797 Patent, the '504 Patent, and the '804 Patent. ADVA's inducement is ongoing.

74. ADVA has also induced its affiliates, or third-party manufacturers, shippers, distributors, retailers, or other persons acting on its or its affiliates' behalf, to directly infringe (literally and/or under the doctrine of equivalents) the '053 Patent, the '702 Patent, the '797 Patent, the '504 Patent, and the '804 Patent by importing, selling or offering to sell the accused products.

75. ADVA has at least a significant role in placing the accused products in the stream of commerce in Texas and elsewhere in the United States.

76. ADVA directs or controls the making of accused products and their shipment to the United States, using established distribution channels, for sale in Texas and elsewhere within the United States. For example, ADVA uses at least Sanmina-Sci (Shenzhen) Ltd and ADVA Optical Networking North America, Inc. to ship the accused products and to distribute the accused products within the United States.

77. ADVA directs or controls the sale of the accused products into established United States distribution channels, including sales to nationwide retailers.

78. ADVA's established United States distribution channels include one or more United States based affiliates (e.g., at least ADVA Optical Networking North America, Inc.).

79. ADVA directs or controls the sale of the accused products nationwide through its own websites, including for sale in Texas and elsewhere in the United States, and expects and intends that the accused products will be so sold.

80. ADVA took active steps, directly and/or through contractual relationships with others, with the specific intent to cause such persons to import, sell, or offer to sell the accused products in a manner that infringes one or more claims of the patents-in-suit, including, for example, Claims 1 and 14 of the '053 Patent, Claim 27 of the '702 Patent, Claim 30 of the '797 Patent, Claims 1 and 6 of the '504 Patent, and Claim 22 of the '804 Patent.

81. Such steps by ADVA included, among other things, making or selling the accused products outside of the United States for importation into or sale in the United States, or knowing that such importation or sale would occur; and directing, facilitating, or influencing its affiliates, or third-party manufacturers, shippers, distributors, retailers, or other persons acting on its or their behalf, to import, sell, or offer to sell the accused products in an infringing manner.

82. ADVA performed these steps, which constitute induced infringement, with the knowledge of the '053 Patent, the '702 Patent, the '797 Patent, the '504 Patent, and the '804 Patent and with the knowledge that the induced acts would constitute infringement.

83. ADVA performed such steps in order to profit from the eventual sale of the accused products in the United States.

84. ADVA's inducement is ongoing.

85. ADVA has also indirectly infringed by contributing to the infringement of the '053 Patent, the '702 Patent, the '797 Patent, the '504 Patent, and the '804 Patent. ADVA has contributed to the direct infringement of the '053 Patent, the '702 Patent, the '797 Patent, the '504 Patent, and the '804 Patent by the end-user of the accused products.

86. The accused products have special features that are specially designed to be used in an infringing way and that have no substantial uses other than ones that infringe the '053 Patent, the '702 Patent, the '797 Patent, the '504 Patent, and the '804 Patent, including, for

example, Claims 1 and 14 of the ‘053 Patent, Claim 27 of the ‘702 Patent, Claim 30 of the ‘797 Patent, Claims 1 and 6 of the ‘504 Patent, and Claim 22 of the ‘804 Patent.

87. The special features include advanced quality of service capabilities, used in a manner that infringes the ‘053 Patent, the ‘702 Patent, the ‘797 Patent, the ‘504 Patent, and the ‘804 Patent.

88. The special features constitute a material part of the invention of one or more of the claims of the ‘053 Patent, the ‘702 Patent, the ‘797 Patent, the ‘504 Patent, and the ‘804 Patent and are not staple articles of commerce suitable for substantial non-infringing use.

89. ADVA’s contributory infringement is ongoing.

90. Furthermore, ADVA has a policy or practice of not reviewing the patents of others (including instructing its employees to not review the patents of others), and thus has been willfully blind of Far North Patents’ patent rights. *See, e.g.*, M. Lemley, “Ignoring Patents,” 2008 Mich. St. L. Rev. 19 (2008).

91. ADVA’s actions are at least objectively reckless as to the risk of infringing valid patents and this objective risk was either known or should have been known by ADVA.

92. ADVA has knowledge (at least constructively through its willful blindness) of the ‘053 Patent, the ‘702 Patent, the ‘797 Patent, the ‘504 Patent, and the ‘804 Patent.

93. ADVA’s customers have infringed the ‘053 Patent, the ‘702 Patent, the ‘797 Patent, the ‘504 Patent, and the ‘804 Patent.

94. ADVA encouraged its customers’ infringement.

95. ADVA’s direct and indirect infringement of the ‘053 Patent, the ‘702 Patent, the ‘797 Patent, the ‘504 Patent, and the ‘804 Patent is, has been, and/or continues to be willful,

intentional, deliberate, and/or in conscious disregard of Far North Patents' rights under the patents.

96. Far North Patents has been damaged as a result of the infringing conduct by ADVA alleged above. Thus, ADVA is liable to Far North Patents in an amount that adequately compensates it for such infringements, which, by law, cannot be less than a reasonable royalty, together with interest and costs as fixed by this Court under 35 U.S.C. § 284.

JURY DEMAND

Far North Patents hereby requests a trial by jury on all issues so triable by right.

PRAYER FOR RELIEF

Far North Patents requests that the Court find in its favor and against ADVA, and that the Court grant Far North Patents the following relief:

a. Judgment that one or more claims of the '053 Patent, the '702 Patent, the '797 Patent, the '504 Patent, and the '804 Patent have been infringed, either literally and/or under the doctrine of equivalents, by ADVA and/or all others acting in concert therewith;

b. A permanent injunction enjoining ADVA and its officers, directors, agents, servants, affiliates, employees, divisions, branches, subsidiaries, parents, and all others acting in concert therewith from infringement of the '053 Patent; or, in the alternative, an award of a reasonable ongoing royalty for future infringement of the '053 Patent by such entities;

c. Judgment that ADVA account for and pay to Far North Patents all damages to and costs incurred by Far North Patents because of ADVA's infringing activities and other conduct complained of herein, including an award of all increased damages to which Far North Patents is entitled under 35 U.S.C. § 284;

d. That Far North Patents be granted pre-judgment and post-judgment interest on the damages caused by ADVA's infringing activities and other conduct complained of herein;

e. That this Court declare this an exceptional case and award Far North Patents its reasonable attorney's fees and costs in accordance with 35 U.S.C. § 285; and

f. That Far North Patents be granted such other and further relief as the Court may deem just and proper under the circumstances.

Dated: March 25, 2020

Respectfully submitted,

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