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ANSI/IEEE Std 802.1G

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1998-03-13

Information technology — Telecommunications and information exchange between systems — Local and metropolitan area networks — Common specifications —

Part 5:
Remote Media Access Control (MAC) bridging

Technologies de l'information — Télécommunications et échange d'information entre systèmes — Réseaux locaux et métropolitains — Spécifications communes —

Partie 5: Pontage pour le controle d'accès aux supports (MAC) à distance

Reference number
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Std 802.1G, 1998 edition

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Abstract: Extensions to the behavior of ISO/IEC 10038 (IEEE 802.1D) media access control (MAC) bridges, including the aspects of operation of remote MAC bridges that are observable on the interconnected LANs, are specified. A protocol for (optional) use between remote MAC bridges, across the non-LAN communications equipment that interconnects them, to configure the remote bridges within the bridged LAN in accordance with the spanning tree algorithm of ISO/IEC 10038: 1993, is also provided.
Keywords: bridge management, local area network (LAN), local bridge, logical link control, media access control (MAC) bridges, remote bridge, spanning tree algorithm, spanning tree protocol

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ANSI/IEEE Std 802.1G, 1998 Edition

Information technology—Telecommunications and information exchange between systems—Local and metropolitan area networks—Common specifications—

Part 5: Remote Media Access Control (MAC) bridging

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International Standard ISO/IEC 15802-5: 1998

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In the field of information technology, ISO and IEC have established a joint technical committee, ISO/IEC JTC1. Draft International Standards adopted by the joint technical committee are circulated to national bodies for voting. Publication as an International Standard requires approval by at least 75% of the national bodies casting a vote.

International Standard ISO/IEC 15802-5 was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology, Subcommittee SC 6, Telecommunications and information exchange between systems*.

ISO/IEC 15802 consists of the following parts, under the general title *Information technology—Telecommunications and information exchange between systems—Local and metropolitan area networks—Common specifications*.

— *Part 1: Medium Access Control (MAC) service definition*
— *Part 2: LAN/MAN management*
— *Part 3: Media Access Control (MAC) bridges*
— *Part 4: System load protocol*
— *Part 5: Remote Media Access Control (MAC) bridging*

Annexes A and B form an integral part of this part of ISO/IEC 15802. Annexes C and D are for information only.

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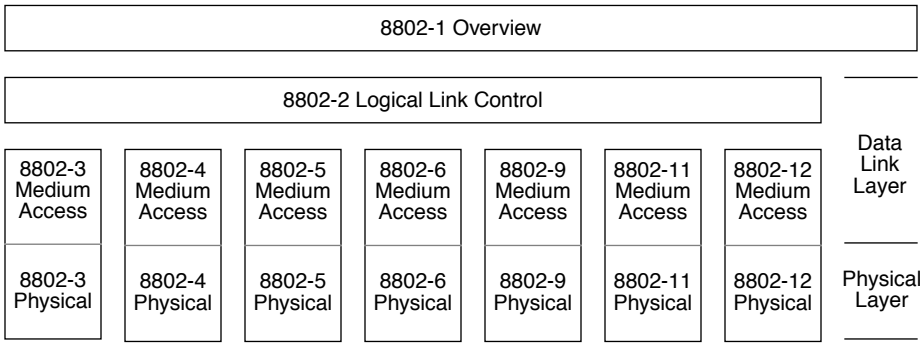
Foreword to International Standard ISO/IEC 15802-5: 1998

This International Standard is part of a family of International Standards for Local and Metropolitan Area Networks. The relationship between this International Standard, which provides extensions to the behavior of ISO/IEC 10038, and the other members of the family is shown below. (The numbers in the figure refer to ISO/IEC Standard numbers.)



This family of International Standards deals with the Physical and Data Link layers as defined by the ISO Open Systems Interconnection (OSI) Basic Reference Model (ISO/IEC 7498-1: 1994). The access standards define seven types of medium access technologies and associated physical media, each appropriate for particular applications or system objectives. Other types are under investigation.

The International Standards defining the access technologies are as follows:

a) ISO/IEC 8802-3, utilizing carrier sense multiple access with collision detection (CSMA/CD) as the access method.
b) ISO/IEC 8802-4, utilizing token passing bus as the access method.
c) ISO/IEC 8802-5, utilizing token passing ring as the access method.
d) ISO/IEC 8802-6, utilizing distributed queuing dual bus as the access method.
e) ISO/IEC 8802-9, a unified access method offering integrated services for backbone networks.
f) ISO/IEC DIS 8802-11, a wireless LAN utilizing carrier sense multiple access with collision avoidance (CSMA/CA) as the access method.
g) ISO/IEC DIS 8802-12, utilizing Demand Priority as the access method.

ISO/IEC TR 8802-1, *Overview of Local Area Network Standards,* provides an overview of the series of ISO/IEC 8802 standards.

ISO/IEC 8802-2, *Logical Link Control*, is used in conjunction with the medium access standards to provide the data link layer service to network layer protocols.

ISO/IEC 15802-1, *Medium Access Control (MAC) service definition,* specifies the characteristics of the common MAC Service provided by all IEEE 802 LAN MACs. The service is defined in terms of primitives that can be passed between peer service users, their parameters, their interrelationship and valid sequences, and the associated events of the service.

ISO/IEC 15802-2, *LAN/MAN Management*, defines an OSI management-compatible architecture, and services and protocol elements for use in a LAN/MAN environment for performing remote management.

ISO/IEC 10038, *Media Access Control (MAC) bridges*, specifies an architecture and protocol for the interconnection of IEEE 802 LANs below the level of the logical link control protocol (to be renumbered 15802-3).

ISO/IEC 15802-4, *System Load Protocol*, specifies a set of services and protocol for those aspects of management concerned with the loading of systems on IEEE 802 LANs.

ISO/IEC 15802-5, *Remote Media Access Control (MAC) bridging*, specifies extensions for the interconnection, using non-LAN communication technologies, of geographically separated IEEE 802 LANs below the level of the logical link control protocol.

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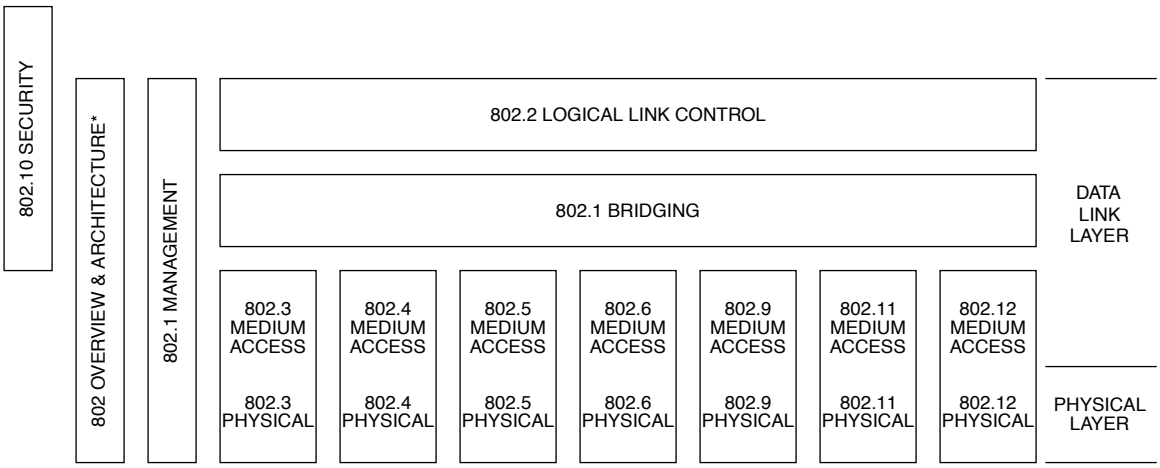
Introduction to ANSI/IEEE Std 802.1G, 1998 Edition

(This introduction is not a part of ANSI/IEEE Std 802.1G, 1998 Edition or of ISO/IEC 15802-5: 1998.)

This standard is part of a family of standards for local and metropolitan area networks. The relationship between the standard and other members of the family is shown below. (The numbers in the figure refer to IEEE standard numbers.)



* Formerly IEEE Std 802.1A.

This family of standards deals with the Physical and Data Link layers as defined by the International Organization for Standardization (ISO) Open Systems Interconnection (OSI) Basic Reference Model (ISO/IEC 7498-1: 1994). The access standards define seven types of medium access technologies and associated physical media, each appropriate for particular applications or system objectives. Other types are under investigation.

The standards defining the access technologies are as follows:

- IEEE Std 802 — *Overview and Architecture*. This standard provides an overview to the family of IEEE 802 Standards.
- ANSI/IEEE Std 802.1B and 802.1k [ISO/IEC 15802-2] — *LAN/MAN Management*. Defines an OSI management-compatible architecture, and services and protocol elements for use in a LAN/MAN environment for performing remote management.
- ANSI/IEEE Std 802.1D [ISO/IEC 10038] — *Media Access Control (MAC) Bridges*. Specifies an architecture and protocol for the interconnection of IEEE 802 LANs below the MAC service boundary.
- ANSI/IEEE Std 802.1E [ISO/IEC 15802-4] — *System Load Protocol*. Specifies a set of services and protocol for those aspects of management concerned with the loading of systems on IEEE 802 LANs.
- ANSI/IEEE Std 802.1G [ISO/IEC 15802-5] — *Remote Media Access Control (MAC) Bridging*. Specifies extensions for the interconnection, using non-LAN communication technologies, of geographically separated IEEE 802 LANs below the level of the logical link control protocol.
- ANSI/IEEE Std 802.2 [ISO/IEC 8802-2] — *Logical Link Control*
- ANSI/IEEE Std 802.3 [ISO/IEC 8802-3] — *CSMA/CD Access Method and Physical Layer Specifications*

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- ANSI/IEEE Std 802.4 [ISO/IEC 8802-4] — *Token Passing Bus Access Method and Physical Layer Specifications*
- ANSI/IEEE Std 802.5 [ISO/IEC 8802-5] — *Token Ring Access Method and Physical Layer Specifications*
- ANSI/IEEE Std 802.6 [ISO/IEC 8802-6] — *Distributed Queue Dual Bus Access Method and Physical Layer Specifications*
- ANSI/IEEE Std 802.9 [ISO/IEC 8802-9] — *Integrated Services (IS) LAN Interface at the Medium Access Control (MAC) and Physical (PHY) Layers*
- ANSI/IEEE Std 802.10 — *Interoperable LAN/MAN Security*
- IEEE Std 802.11 [ISO/IEC DIS 8802-11] — *Wireless LAN Medium Access Control (MAC) and Physical Layer Specifications*
- ANSI/IEEE Std 802.12 [ISO/IEC DIS 8802-12] — *Demand Priority Access Method, Physical Layer and Repeater Specifications*

In addition to the family of standards, the following is a recommended practice for a common Physical Layer technology:

- IEEE Std 802.7 — *IEEE Recommended Practice for Broadband Local Area Networks*

The following additional working group has authorized standards projects under development:

- IEEE 802.14 — *Standard Protocol for Cable-TV Based Broadband Communication Network*

Conformance test methodology

An additional standards series, identified by the number 1802, has been established to identify the conformance test methodology documents for the 802 family of standards. Thus the conformance test documents for 802.3 are numbered 1802.3.

ANSI/IEEE Std 802.1G, 1998 Edition [ISO/IEC 15802-5: 1998]

This standard specifies extensions to the architecture and protocol of ISO/IEC 10038 that provide for the interconnection, using non-LAN communication technologies, of geographically separated IEEE 802 LANs below the level of the logical link control protocol.

This standard contains state-of-the-art material. The area covered by this standard is undergoing evolution. Revisions are possible within the next few years to clarify existing material, to correct possible errors, and to incorporate new related material. Information on the current revision state of this and other IEEE 802 standards may be obtained from

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Information technology—
Telecommunications and information exchange between systems—
Local and metropolitan area networks—Common specifications—

Part 5: Remote Media Access Control (MAC) bridging

1. Scope

ISO/IEC 8802 local area networks (LANs) of all types can be connected together using MAC bridges. Each individual LAN has its own independent MAC. The bridged LAN created allows the interconnection of stations as if they were attached to a single LAN, although they are in fact attached to separate LANs each with its own MAC. A MAC bridge operates below the MAC service boundary, and is largely transparent to protocols operating above this boundary, in the Logical Link Control (LLC) sublayer or Network layer. The presence of one or more MAC bridges can lead to differences in the quality of service provided by the MAC sublayer; it is only because of such differences that MAC bridge operation is not fully transparent.

A bridged LAN can provide for

— The interconnection of stations attached to LANs of different MAC types.
— An effective increase in the physical extent, the number of permissible attachments, or the total performance of a LAN.
— Partitioning of the physical LAN for administrative or maintenance reasons.

Local MAC bridges interconnect separate LANs, at geographically close points of attachment. Remote MAC bridges, which can be geographically separated, interconnect LANs sited locally to the individual remote MAC bridges, using non-LAN technologies for communication among the remote bridges. A given piece of equipment can be a local MAC bridge or remote MAC bridge, only, or it can combine the functions of a local MAC bridge and a remote MAC bridge.

This International Standard extends ISO/IEC 10038: 1993,[1] which specifies the operation of local MAC bridges, by specifying

— The aspects of operation of remote MAC bridges that are observable on the interconnected LANs, and
— A protocol for (optional) use between remote MAC bridges, across the non-LAN communications equipment that interconnects them, to configure the remote bridges within the bridged LAN in accordance with the Spanning Tree Algorithm of ISO/IEC 10038: 1993.

To this end, it

a) Extends the ISO/IEC 10038: 1993 architectural description of the MAC sublayer bridging function to cover interconnection of LANs by remote bridges (5.1).

b) States the principles of operation of remote bridges in terms of the support and preservation of the MAC service, and of maintenance of quality of service (5.1, 5.2, 5.3).

c) Extends the ISO/IEC 10038: 1993 definition of the MAC Internal Sublayer Service to apply to provision of the service by the non-LAN communications equipment that interconnects remote bridges (in addition to provision of the service by LANs, as covered in ISO/IEC 10038: 1993) (5.4).

[1] Information on references can be found in Clause 2.

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d) Extends the ISO/IEC 10038: 1993 model of the internal operation of a bridge to apply to remote bridges, and provides a related model for their interconnection (Clause 6).

e) Specifies the behavior of remote bridges as observed on the LANs to which they are attached, both in relaying MAC frames between LANs and in supporting the Spanning Tree Protocol (Clauses 7 and 8).

f) Specifies the requirements for provision of the MAC Internal Sublayer Service by the non-LAN communications equipment (5.6, Clause 8).

g) Identifies managed objects for remote bridges, and defines the management operations on these objects (Clauses 9 and 10).

h) Specifies performance requirements for remote bridges, and recommends default values and applicable ranges for operational parameters (7.10, Clause 11).

i) Specifies an extension of the Spanning Tree Protocol for optional use over the non-LAN communications equipment that interconnects remote bridges (Clauses 12 and 13).

j) Specifies requirements on the non-LAN communications equipment relating to support of the optional Extended Spanning Tree Protocol, in terms of an abstract subnetwork service that is to be provided by the non-LAN communications (12.2).

k) Specifies the requirements to be satisfied by equipment claiming conformance to this International Standard (Clause 4).

l) Provides the protocol implementation conformance statement (PICS) proforma in compliance with the relevant requirements, and in accordance with the relevant guidance, given in ISO/IEC 9646-7: 1995 (Annex A).

Detailed specification of protocols and procedures to support either the MAC Internal Sublayer Service or the subnetwork service for support of the Extended Spanning Tree Protocol, over particular non-LAN communication technologies, is outside the scope of this International Standard.

Annex B summarizes the object identifier values allocated by this International Standard.

Annex C contains additional explanatory and tutorial material, intended to aid the reader in understanding a number of aspects of remote MAC bridging that were highlighted during the development of this International Standard.

Annex D summarizes the relationship of the material in this International Standard to ISO/IEC 10038: 1993.

NOTE—This International Standard is closely based upon the specification for local MAC bridging in ISO/IEC 10038: 1993, and the text largely follows the organization of that parent standard. However, dealing with remote bridging introduces the need for a number of new concepts, with associated protocol parameters and mechanisms, etc. Annex D identifies—at clause and subclause level, and occasionally still more precisely—the correspondences and differences between this International Standard and ISO/IEC 10038: 1993. In particular, it lists subclauses that contain significant new or modified requirements specific to remote MAC bridging.

2. References

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards listed below.

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IEEE Std 802-1990, IEEE Standards for Local and Metropolitan Area Networks: Overview and Architecture (ANSI).[2]

IEEE Std 802.1j-1996 (Supplement to IEEE Std 802.1D-1990 [ISO/IEC 10038: 1993]), Supplement to Information technology—Telecommunications and information exchange between systems—Local area networks—Media access control (MAC) bridges: Managed objects for MAC bridges (ANSI).

ISO/IEC 7498-1: 1994, Information technology—Open Systems Interconnection—Basic Reference Model: The Basic Model.[3]

ISO/IEC 8802-2: 1994 [ANSI/IEEE Std 802.2, 1994 Edition], Information technology—Telecommunications and information exchange between systems—Local and metropolitan area networks—Specific requirements—Part 2: Logical link control.

ISO/IEC 9596-1: 1991, Information technology—Open Systems Interconnection—Common management information protocol—Part 1: Specification.

ISO/IEC 9646-7: 1995, Information technology—Open Systems Interconnection—Conformance testing methodology and framework—Part 7: Implementation Conformance Statements.

ISO/IEC 10038: 1993 (ANSI/IEEE Std 802.1D, 1993 Edition), Information technology—Telecommunications and information exchange between systems—Local area networks—Media access control (MAC) bridges.

ISO/IEC 10165-2: 1992, Information technology—Open Systems Interconnection—Structure of management information: Definition of management information.

ISO/IEC 10165-4: 1992, Information technology—Open Systems Interconnection—Structure of management information: Guidelines for the definition of managed objects.

ISO/IEC 10731: 1994, Information technology—Open Systems Interconnection—Basic Reference Model—Conventions for the definition of OSI services.

ISO/IEC 10742: 1994, Information technology—Telecommunications and information exchange between systems—Elements of management information related to OSI Data Link Layer standards.

ISO/IEC 15802-1: 1995, Information technology—Telecommunications and information exchange between systems—Local and metropolitan area networks—Common specifications—Part 1: Medium Access Control (MAC) service definition.

ISO/IEC 15802-2: 1995 (ANSI/IEEE Std 802.1B, 1995 Edition), Information technology—Telecommunications and information exchange between systems—Local and metropolitan area networks—Common specifications—Part 2: LAN/MAN management.

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[2]IEEE publications are available from the Institute of Electrical and Electronics Engineers, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331, USA.

[3]ISO/IEC publications are available from the ISO Central Secretariat, Case Postale 56, 1 Rue de Varembé, CH-1211, Genève 20, Switzerland/Suisse. ISO/IEC publications are also available in the United States from the Sales Department, American National Standards Institute, 11 West 42nd Street, 13th Floor, New York, NY 10036, USA.

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3. Definitions

3.1 Definitions related to MAC bridging

The following definition from ISO/IEC 10038: 1993 applies, unchanged, to this International Standard.

3.1.1 bridged local area network: A concatenation of individual local area networks interconnected by MAC bridges.

The following terms specific to MAC bridging are defined in the body of ISO/IEC 10038: 1993. This International Standard extends the application of these terms to remote MAC bridging.

3.1.2 active topology: At any time, the set of communication paths in a bridged local area network that can be used in transferring data between end stations on the LANs.

3.1.3 Spanning Tree Algorithm: The abstract distributed algorithm that determines the active topology of an ISO/IEC 10038 bridged local area network.

3.1.4 Spanning Tree Protocol: The protocol that MAC bridges use in exchanging information across local area networks, in order to compute the active topology of a bridged LAN in accordance with the Spanning Tree Algorithm.

3.2 Definitions specific to remote MAC bridging

The following definitions are specific to this International Standard among the family of IEEE 802 standards. Other terms specific to remote MAC bridging are defined in the body of this International Standard.

3.2.1 adjacent bridges: Two local or remote bridges that are both attached to the same LAN or remote bridge group.

3.2.2 attach: The term used consistently to express the relationship between an end station, a bridge, or a bridge port and the physical or logical communications elements by which it is interconnected with the other bridges in a bridged LAN.

NOTE—In particular: an end station, a local bridge, or a LAN port is said to attach to a LAN; a remote bridge is said to attach to a LAN, a group, or a cluster; a virtual port is said to attach to a group, a subgroup, or a cluster. Where other uses are encountered, they are to be interpreted in a similar sense. The definitions following contain a number of examples.

3.2.3 bridge port: A LAN port or virtual port.

3.2.4 cluster: *See:* **remote bridge cluster.**

3.2.5 connect: The term used consistently to express the capability for communication, across a group or LAN, between adjacent bridges, or between the bridge ports of adjacent bridges. *Contrast:* **attach.**

3.2.6 Extended Spanning Tree Protocol: The protocol specified (in Clauses 12 and 13 of this International Standard) for optional use among the remote bridges of a group in determining how the virtual ports attaching them to the group are to participate in the active topology.

3.2.7 frame: *See:* **MAC frame.**

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3.2.8 group: *See:* **remote bridge group.**

3.2.9 individual virtual port: A subgroup port that represents the capability for communication with one other remote bridge in the remote bridge group to which the port attaches.

NOTE—An individual virtual port always has another individual virtual port as its peer port; the two ports connect their respective remote bridges in a two-member subgroup.

3.2.10 LAN port: A MAC-sublayer point of attachment of a bridge to a local area network.

NOTE—This definition is equivalent to that of bridge port in ISO/IEC 10038: 1993, as applied to local MAC bridges.

3.2.11 local MAC bridge, local bridge: A MAC bridge that interconnects only local area networks to which it attaches directly as specified in the relevant MAC standards.

3.2.12 locally bridged local area network: A bridged local area network interconnected by local bridges only; a single LAN is also considered as (a degenerate case of) a locally bridged LAN.

3.2.13 MAC frame: Except where explicitly stated otherwise (in 5.4), a MAC frame conveying MAC user data across a LAN, or a representation of such a MAC frame within a MAC bridge or on the non-LAN communications equipment of a remote bridge group.

3.2.14 MAC service: The unconfirmed connectionless-mode MAC service defined in ISO/IEC 15802-1: 1995, as an abstraction of the features common to a number of specific MAC services for local area networks.

3.2.15 mixed-configuration group: A group to which the member remote bridges attach by a mixture of individual virtual ports and multipeer virtual ports.

NOTE—It is possible for some members of a mixed-configuration group to attach only by individual virtual ports.

3.2.16 multipeer virtual port: A subgroup port that represents the capability for communication with more than one other remote bridge in the remote bridge group to which the port attaches.

NOTE—A multipeer virtual port always has multipeer virtual ports as its peer ports.

3.2.17 peer port (of a virtual port): A virtual port is a peer (virtual) port of a given virtual port when both virtual ports attach to the same group and both represent the capability for communication between the remote bridges to which they belong.

3.2.18 port: *See:* **bridge port.**

3.2.19 remote bridge: *See:* **remote MAC bridge.**

3.2.20 remote bridge cluster: A subset of the remote bridges in a single group, all of which are providing, or preparing to provide, MAC-sublayer interconnection of the attached locally bridged local area networks and other groups. A remote bridge cluster is fully connected, i.e., it supports communication between any pair of the remote bridges that belong to it. Membership of a remote bridge cluster is determined dynamically through protocols operating in support of the Spanning Tree Algorithm. (See 6.13.4, 7.3.1.1, 7.3.2.4, 7.3.4.5, and 7.3.8 for fuller specification; 6.13.6 and C.7.3 for examples.)

NOTE—A cluster can—and often will—consist of all the remote bridges in the relevant group.

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3.2.21 remote bridge group: A set of remote bridges, capable of communicating with each other over non-LAN communications equipment, which cooperate in providing actual or potential MAC-sublayer interconnection among all the attached locally bridged local area networks and other attached groups. Membership of a remote bridge group is determined statically, as an aspect of the configuration of the remotely bridged LAN. (See 6.13.3 and 6.13.6 for fuller specification and examples.)

NOTE—A remotely bridged LAN can contain more than one remote bridge group.

3.2.22 remote bridge subgroup: A set of remote bridges belonging to one group, such that each remote bridge in the subgroup has a single virtual port representing its communication with all the other remote bridges in the subgroup, and with no others (see 6.13.3, 6.13.6). Membership of a subgroup is determined statically, as an aspect of the configuration of the group.

3.2.23 remote MAC bridge: A MAC bridge interconnecting a locally bridged local area network and the non-LAN communications equipment of a remotely bridged LAN.

3.2.24 remotely bridged local area network: A bridged local area network of two or more locally bridged LANs interconnected using non-LAN communication technologies, and providing MAC-sublayer interworking between end stations attached to any of the LANs.

3.2.25 specific MAC service: The service provided by the MAC protocol and procedures of a specific local area network technology (which can contain features not present in other specific MAC services or in the ISO/IEC 15802-1 MAC service).

3.2.26 subgroup: *See:* **remote bridge subgroup.**

3.2.27 subgroup port: A virtual port by which a remote bridge attaches to a group consisting of two or more subgroups.

NOTE—Every virtual port is either a virtual LAN port or a subgroup port. In a group that is not a virtual LAN, every bridge attaches to the group by at least two subgroup ports.

3.2.28 virtual LAN: A group to which each member remote bridge attaches by a single virtual port (see 6.13.6.1).

NOTE—Each virtual LAN comprises a single subgroup.

3.2.29 virtual LAN port: A virtual port by which a remote bridge attaches to a virtual LAN.

3.2.30 virtual mesh: A group to which each member remote bridge attaches by a set of individual virtual ports, one for each other remote bridge in the group (see 6.13.6.1).

NOTE—A virtual mesh comprises $n \times (n-1)/2$ two-member subgroups, where n is the number of bridges in the group.

3.2.31 virtual port: An abstraction of a remote bridge's point(s) of attachment to the non-LAN communications equipment of a single group. A virtual port represents the capability for bidirectional communication with one, some, or all of the other remote bridges in that group.

NOTE—A bridge can attach by two or more virtual ports to a single group. (See 6.13.3 and 6.13.6 for fuller specification and examples.)

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3.3 Acronyms and abbreviations

BPDU	bridge protocol data unit
Conf	confirm (primitive)
CSMA/CD	carrier sense multiple access with collision detection
DLE	Data Link entity
FCS	frame check sequence
Ind	indication (primitive)
LAN	local area network
LB-LAN	locally bridged local area network
LLC	logical link control
LMMS	LAN/MAN management service
MAC	media access control
MSDU	MAC service data unit
PICS	protocol implementation conformance statement
QOS	quality of service
RB	remote bridge
RB-LAN	remotely bridged local area network
Req	request (primitive)
Rsp	response (primitive)
SDU	service data unit

4. Conformance

4.1 Static conformance requirements

A remote MAC bridge for which conformance to this International Standard is claimed shall

a) Conform to the relevant MAC standards for the MAC technology or technologies implemented at its LAN ports, as specified (by reference to ISO/IEC 10038: 1993) in 5.5.

b) Conform to ISO/IEC 8802-2: 1994 for the implementation of a class of LLC supporting Type 1 operation as required by 6.3.

c) As specified in 6.7.2, support either

— Filtering of all frames with equal source and destination MAC addresses, or
— Forwarding (subject to the forwarding conditions) of all frames with equal source and destination MAC addresses.

d) Maintain the information required to make frame filtering decisions as specified in 6.7.1, 6.8, and 6.9.

e) Use stated values of the following parameters of the filtering database (6.9):

— Filtering Database Size (the maximum number of entries that can be held in the filtering database).
— Permanent Database Size (the maximum number of entries that can be held in the permanent database).

f) Support 48-bit universally administered MAC addresses, or 48-bit locally administered MAC addresses, or both.

g) Conform to the provisions for addressing specified (by reference to ISO/IEC 10038: 1993) in 6.12.

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h) Support operation within at least one of the following classes of configuration specified in 6.13.3.2:

— Virtual LAN
— Virtual mesh
— Mixed-configuration group

i) Provide

— A means of assigning a group MAC address to identify the bridge protocol entity if 48-bit locally administered MAC addresses are used, and
— A distinct port identifier for each LAN port and virtual port of the remote bridge, as specified in 7.5.4.1.1,

as required for support of the Spanning Tree Algorithm (by reference to ISO/IEC 10038: 1993) by 7.2.

j) Implement the Spanning Tree Algorithm and operation of the associated Spanning Tree Protocol over its LAN ports as specified in 7.5 through 7.8.

k) Encode transmitted BPDUs and validate received BPDUs, at its LAN ports, as specified (by reference to ISO/IEC 10038: 1993) in 7.9.

l) Not exceed the values specified (by reference to ISO/IEC 10038: 1993) in 7.10 for the following parameters:

— Maximum bridge transit delay
— Maximum Message Age increment overestimate
— Maximum BPDU transmission delay

m) Use the value specified (by reference to ISO/IEC 10038: 1993) in 7.10 for the Hold Time parameter.

n) Not exceed the values specified in 7.10.4 for the following parameters:

— Group maximum bridge transit delay
— Group maximum message propagation delay
— Group maximum Message Age increment overestimate

o) Support relaying of frames (subject to the forwarding conditions in 6.7.1) to and from any other active remote bridges in the groups to which the remote MAC bridge belongs, in accordance with the requirements specified in Clause 8.

p) Use stated values of the time to detect a failure of the relaying connectivity requirement (8.1) and the time to detect a failure of the group connectivity requirement (12.2.2).

q) — Specify a Guaranteed Port Filtering Rate for each LAN port, a Guaranteed Bridge Relaying Rate for the bridge, and the related time intervals T_F and T_R as specified (by reference to ISO/IEC 10038: 1993) in Clause 11.
— Not violate any of the other conformance provisions of this International Standard when operating within the parameters specified.

4.2 Options

A remote MAC bridge for which conformance to this International Standard is claimed may

a) Provide the capability to control the mapping of the priority of forwarded frames as specified in 6.7.4.

b) Provide the capability to read and update the filtering databases as specified in 6.9.

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c) Support the exchange of filtering information with other remote bridges in one or more of the groups to which the remote MAC bridge belongs, as permitted in 6.9.

d) Implement the optional provisions for addressing bridge management, for associating the bridge address with a LAN port, and for configuring additional addresses in the permanent database, as specified (by reference to ISO/IEC 10038: 1993) in 6.12.

e) Provide the capability to assign values, in accordance with the ranges of values specified (by reference to ISO/IEC 10038: 1993) in 7.10, to the following parameters, to allow configuring of the spanning tree active topology as described in 7.2:

— Bridge Priority
— Port Priority
— Path Cost

f) Provide the capability to set the values, in accordance with the ranges of values specified (by reference to ISO/IEC 10038: 1993) in 7.10, of the following parameters of the Spanning Tree Algorithm and Protocol:

— Bridge Max Age
— Bridge Hello Time
— Bridge Forward Delay

g) Provide the capability to set the value of the Primary Reclustering Delay parameter for each non-virtual-LAN group to which the bridge belongs, in accordance with the range of values specified in 7.10.5.

h) Support use of a priority mechanism, with up to eight levels of priority, applicable to relaying of frames to or from other active remote bridges in one or more of the groups to which the remote MAC bridge belongs, as specified in 8.2.6.

i) Support management of the remote bridge: a remote bridge claiming to support management shall support all the managed objects and definitions specified in Clause 9.

j) Support IEEE 802.1 remote management: a bridge claiming to support such remote management shall

— Conform to ISO/IEC 15802-2: 1995, and
— Support remote management by use of the network management operations and encodings specified in Clause 10.

k) Support the Extended Spanning Tree Protocol in one or more of the groups to which the bridge belongs, as specified in Clauses 12 and 13.

4.3 Protocol implementation conformance statement (PICS)

The supplier of an implementation that is claimed to conform to this International Standard shall complete a copy of the PICS proforma provided in Annex A, including the information necessary to identify fully both the supplier and the implementation.

5. Support of the MAC service

MAC bridges interconnect the separate LANs that comprise a bridged LAN by relaying frames between the separate MACs of the bridged LANs. A single local MAC bridge interconnects two LANs directly for any instance of relaying, as described in ISO/IEC 10038: 1993. A remote MAC bridge interconnects two LANs indirectly, via non-LAN communications equipment and one or more further remote bridges, for any instance of relaying (see 5.1, Figures 5-3 and 5-4).

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This clause discusses

— Provision of the MAC service to end stations.
— Support of the MAC service by remote bridges and the non-LAN communications equipment that interconnects them.
— Preservation of the MAC service offered by the bridged LAN.
— Maintenance of quality of service in the bridged LAN.
— The Internal Sublayer Service offered to the remote bridges themselves to enable them to interconnect individual LANs.

5.1 Provision and support of the MAC service

The MAC service provided to end stations attached to a bridged LAN is the (unconfirmed) connectionless-mode MAC service defined in ISO/IEC 15802-1: 1995. The MAC service is defined as an abstraction of the features common to a number of specific MAC services; it describes the transfer of user data between source and destination end stations, via MA-UNITDATA request primitives and corresponding MA-UNITDATA indication primitives issued at MAC service access points. Each MA-UNITDATA request and indication primitive has four parameters: Destination Address, Source Address, MAC service data unit (MSDU), and Priority.

The model for provision of the MAC service is the simple service-provider / service-user model shown in Figure 5-1. For a pair of end stations attached to a single LAN, the MAC service is supported by implementations of the specific MAC service for the LAN in the two end stations, and by the LAN communications media and any Physical-layer relaying equipment. This support relates to the service-provider model in a straightforward way, with the specific MAC procedures being associated with the MAC service access points (see Figure 5-2).

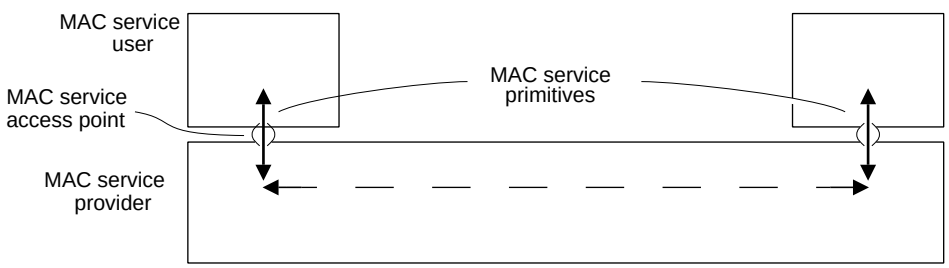

Figure 5-1—Model for provision of the MAC service

When MAC-sublayer communication is relayed through remote bridges, a more complicated representation for support of the MAC service throughout the MAC sublayer is needed. First, this has to take account of the presence of a specific MAC entity associated with each LAN port; second, it has to represent the conveying of the MAC service semantics across the non-LAN communications equipment; and finally, it has to represent the relaying of the MAC service semantics by bridges.

NOTE 1—An important distinction is made between *provision* of a service, according to the “black box” service provider model such as is shown in Figure 5-1, and *support* of the service, dealing with structure and functions within the interior of the box. This same distinction applies, below, to provision and support of the Internal Sublayer Service.

Figures 5-3 and 5-4 show the structure of the MAC sublayer support for remote bridging, in relation to the service-provider model. Figure 5-3 shows the simplest case, where relaying is via two remote bridges connected across a single remote bridge cluster. Figure 5-4 shows the case of relaying between two clusters by an additional remote bridge (the two clusters belong to different groups—see 6.13.3 and 6.7.1). The

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parts of Figures 5-3 and 5-4 labeled "MAC" represent the specific MAC entities for the LANs. The parts marked "MAC service support" represent the functions in the remote bridges that perform the equivalent communication of the MAC service semantics across the non-LAN equipment.

NOTE 2—Figures 5-1 through 5-4 illustrate MAC sublayer support as it applies to the communication path between a single given pair of LAN end stations. In general, a remote bridge is attached to one or more LANs. It offers multiple end stations the capability of communicating via remote bridge groups with end stations attached to other LANs. Instances of communication between different pairs of end stations can involve different sets of remote bridges and remote bridge groups. The central remote bridge in Figure 5-4 would attach to at least one LAN, which is not shown since it is not on the communication path between the two end stations being considered.

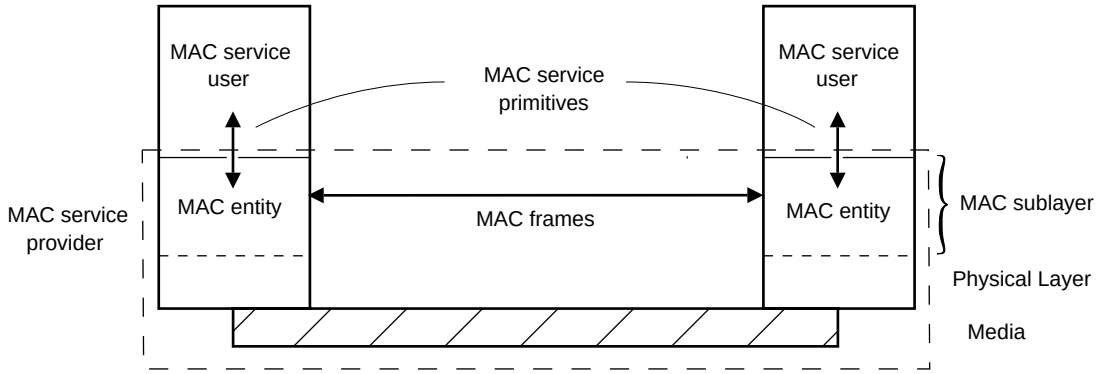

Figure 5-2—Support of the MAC service on a single LAN

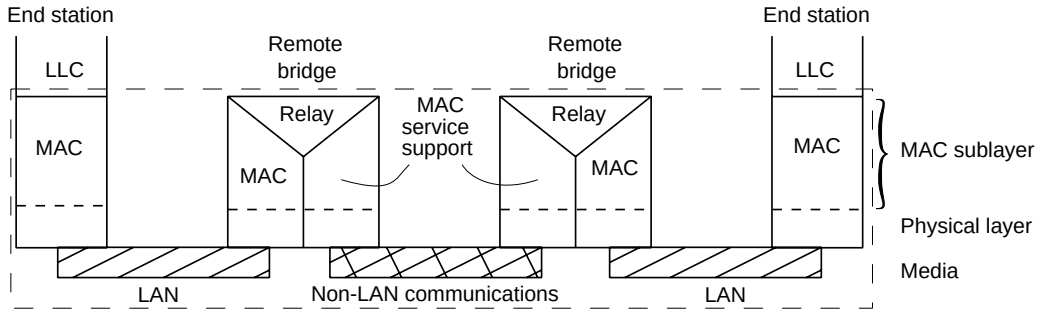

Figure 5-3—MAC service with remote bridging

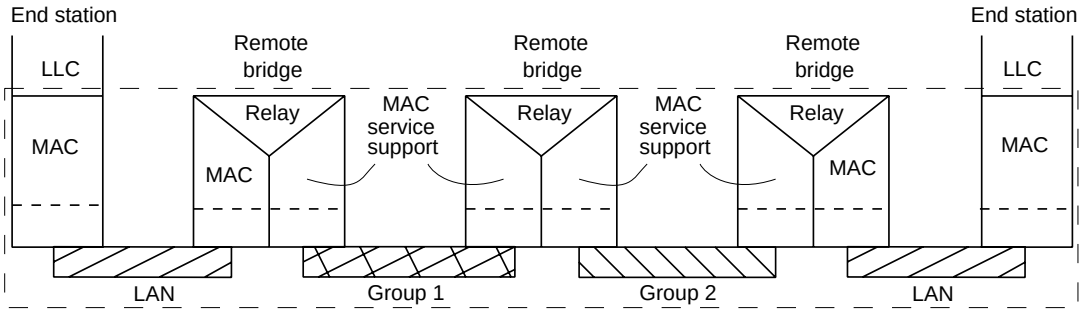

Figure 5-4—MAC service with remote bridging: multiple groups

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5.2 Preservation of the MAC service

The MAC service offered by a remotely bridged LAN is similar (see 5.3) to that offered by a single LAN. In consequence

a) A bridge is not directly addressed by communicating end stations, except as an end station for management purposes: frames transmitted between end stations carry the MAC address of the peer end station in their Destination Address fields, not the MAC address, if any, of a bridge.

b) All MAC addresses are unique and addressable within the bridged LAN.

c) The MAC addresses of end stations are not restricted by the topology and configuration of the bridged LAN.

5.3 Quality of service (QOS) maintenance

As with local MAC bridges (ISO/IEC 10038), remote bridges should not significantly degrade the QOS relative to that provided on a single LAN. However, remote bridges often use intermediate-link technologies that offer lower data rates and longer delays than LANs; hence the degradation of service from a remote bridge can be greater than that introduced by a local bridge. A remote bridge does not violate MAC service invariants such as frame ordering and non-duplication; however, performance characteristics can be degraded from those provided by either a single LAN or a locally bridged LAN.

The QOS parameters to be considered are those relating to

a) Service availability
b) Frame loss
c) Frame misordering
d) Frame duplication
e) The transit delay experienced by frames
f) Frame lifetime
g) The undetected frame error rate
h) Maximum service data unit size supported
i) User priority
j) Throughput

A discussion of how the presence of remote bridges can affect the QOS provided to LAN end stations is presented in C.5.3. The following requirements apply to the operation of bridges in general; other requirements relating to maintenance of QOS are specified in 6.7, 7.10, and 8.2. (See C.5.3 for more detailed references.)

5.3.1 Undetected error rate

For frames relayed between LANs of the same MAC type, remote bridges shall not introduce an undetected frame error rate greater than that which would be achieved by preserving the frame check sequence (FCS). For frames relayed between LANs of different MAC types, remote bridges shall not increase the undetected frame error rate above 5×10^{-14} per octet of MSDU length.

5.4 Internal Sublayer Service provided within the remote MAC bridge

The Internal Sublayer Service provided by a MAC entity to the MAC relay entity within a remote bridge is that provided by the individual MAC for the LAN port. This observes the appropriate MAC procedures and protocol for the LAN to which it attaches. No control frames (i.e., MAC frames that do not convey MAC user data) are forwarded on any LAN other than that on which they originated.

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In a remote bridge group, the same Internal Sublayer Service is provided to the MAC relay entities by the non-LAN access functions of the virtual ports. This International Standard does not specify any mechanisms (protocols, procedures, communications technologies, etc.) by which the Internal Sublayer Service is supported in a group. The operation of such mechanisms—whatever they may be—is modeled as the MAC service support function, which maps the Internal Sublayer Service onto the associated non-LAN communications.

The Internal Sublayer Service excludes specific features and procedures of individual LAN MAC methods, or of particular non-LAN communications technologies.

The primitives and parameters that describe the Internal Sublayer Service are as follows:

```
M-UNITDATA request      (
                        frame_type,
                        mac_action,
                        destination_address,
                        source_address,
                        mac_service_data_unit,
                        user_priority,
                        access_priority,
                        frame_check_sequence,
                        cluster_id
                        )

M-UNITDATA indication   (
                        frame_type,
                        mac_action,
                        destination_address,
                        source_address,
                        mac_service_data_unit,
                        user_priority,
                        frame_check_sequence,
                        cluster_id
                        )
```

For provision of the service by LANs, invocation of the primitives and assignment of values to their parameters are exactly as defined in ISO/IEC 10038: 1993, with the cluster_id parameter considered always to take the null value. The identification of the LAN to which a frame is to be transmitted is a local matter and is not expressed as a parameter of the service primitive.

For provision of the service within a remote bridge group,

a) Each M-UNITDATA indication primitive invoked corresponds to receipt, from the non-LAN communications equipment, of the complete information corresponding to a single relayed MAC frame.

b) An M-UNITDATA request primitive is invoked to transmit a frame across the non-LAN communications equipment.

c) Every primitive has the frame_type parameter value user_data_frame.

d) Every primitive has the mac_action parameter value request_with_no_response.

e) The access_priority parameter in a request primitive is the priority requested of the local MAC service support functions (those functions can include a priority mechanism for use across the non-LAN communications media).

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f) The destination_address, source_address, mac_service_data_unit, and user_priority parameters are those of the relayed MAC frame.

g) The frame_check_sequence is either that of the relayed MAC frame together with an indication of the MAC type of the relevant LAN, or is absent.

h) The cluster_id parameter of an M-UNITDATA request identifies the remote bridge cluster to which the virtual port at which the primitive is issued is attached; the cluster_id parameter of an M-UNITDATA indication has the same value as in the corresponding M-UNITDATA request (see 6.5, 8.3).

Refer to ISO/IEC 10038: 1993 for full definitions of items a) through f) above.

5.5 Support of the Internal Sublayer Service by specific MAC procedures

The mapping of the Internal Sublayer Service to the MAC protocol and procedures of each individual LAN type, and the encoding of the parameters of the service in MAC frames, at each LAN port of a remote bridge shall be as specified in ISO/IEC 10038: 1993.

5.6 Support of the Internal Sublayer Service in remote bridge groups

Detailed mechanisms for support of the Internal Sublayer Service by specific non-LAN communications technologies are outside the scope of this International Standard. Any such mechanisms shall meet the requirements specified in Clause 8. (See also 6.2.4, and related subclauses of Annex C.)

6. Principles of operation

This clause establishes the principles of operation of a remote bridge, by reference to a model of that operation. It complements, and is compatible with, the specification for local bridges in ISO/IEC 10038: 1993. In addition, this clause establishes a model for the interconnection of remote bridges (6.13).

6.1 Remote bridge operation

The principal elements of remote bridge operation, as for local bridges, are

— Relay and filtering of frames.
— Maintenance of the information required to make frame filtering and relaying decisions.
— Management of the above.

6.1.1 Relay

A remote bridge relays MAC user data frames between the MACs of the LB-LANs attached to its LAN ports and the MAC service support functions associated with its virtual ports. A remote bridge that belongs to two or more remote bridge groups also relays MAC user data frames between the MAC service support functions associated with two or more of its virtual ports attaching to different groups. A remote bridge that attaches to two or more LANs relays MAC user data frames between the MACs of the LB-LANs attached to its LAN ports.

The functions that support the relaying of frames and maintain the QOS supported by the remote bridge are

a) Frame reception, on LAN ports and virtual ports.

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b) Discard on received frame in error (see 5.3, C.5.3.2).

c) Frame discard if the frame_type is not user_data_frame, or if the mac_action is not request_with_no_response (see 5.4).

d) Frame discard following the application of filtering information.

e) Frame discard on transmittable MSDU size exceeded (see 5.3, C.5.3.8).

f) Forwarding of received frames to other LAN ports or virtual ports.

g) Frame discard to ensure that a maximum bridge transit delay or maximum cluster transit delay is not exceeded (see 5.3, C.5.3.6).

h) Selection of access priority for forwarded frames (see 5.3, C.5.3.9).

i) Recalculation of FCS, if necessary (see 5.3, C.5.3.7).

j) For frames transferred through virtual ports, mapping between M-UNITDATA primitives and the underlying MAC service support functions, including any cluster-specific error detection and correction mechanisms (see 5.3, C.5.3.7).

k) Frame transmission, onto LANs and/or clusters.

6.1.2 Filtering Information

A remote bridge filters frames to prevent duplication (see 5.3, C.5.3.4) and to localize traffic (see 5.3, C.5.3.10). The filtering functions that support the use and maintenance of filtering information in a remote bridge are

a) Permanent configuration of reserved addresses.

b) Explicit configuration of static filtering information.

c) Automatic learning of dynamic filtering information through observation of bridged LAN traffic.

d) Ageing out of filtering information that has been automatically learned.

e) Calculation and configuration of bridged LAN topology.

f) Optionally, exchange of dynamic filtering information with other remote bridges.

NOTE—Item f) is specific to remote bridge operation; the others are common to local bridges and remote bridges.

6.1.3 Bridge management

Relay and filtering of frames, and the maintenance of filtering information, are controlled and monitored using functions that support management of a remote bridge: these management functions are specified in Clause 9.

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6.2 Remote bridge architecture

6.2.1 Architectural model of a remote bridge

Figure 6-1 illustrates a remote bridge with one LAN port and one virtual port, and Figure 6-2 illustrates the architecture of such a remote bridge. A remote bridge is modeled as consisting of

— A MAC relay entity that interconnects the bridge's ports
— At least one LAN port
— At least one virtual port
— One or more group communications entities, associated with the virtual ports
— Higher layer entities, including at least a bridge protocol entity

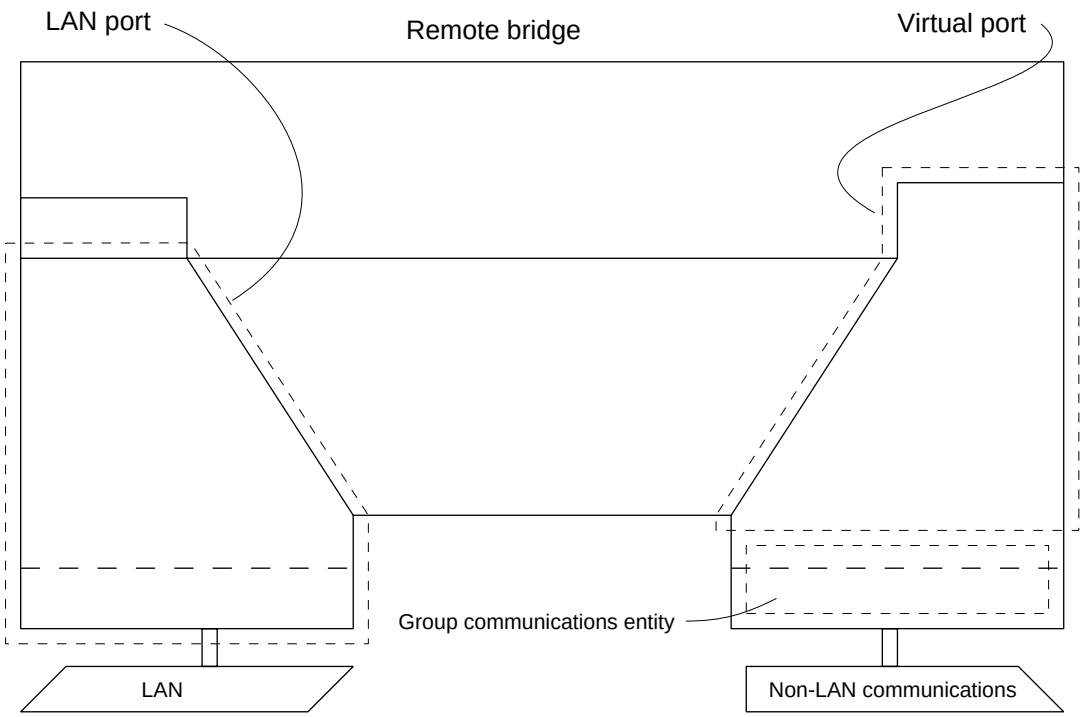

Figure 6-1—Remote bridge ports

6.2.2 MAC relay entity

The MAC relay entity handles the Media Access method independent functions of relaying frames between ports, filtering frames, and learning filtering information. It uses the Internal Sublayer Service provided by the separate MAC entities for each LAN port and by the MAC service support functions for each virtual port. (The Internal Sublayer Service and its support are described in 5.4 and 5.5.)

Frames are relayed between LAN ports and virtual ports (i.e., LAN to cluster or cluster to LAN), or between virtual ports attached to different clusters (inter-group relaying), or between LAN ports attached to different LANs.

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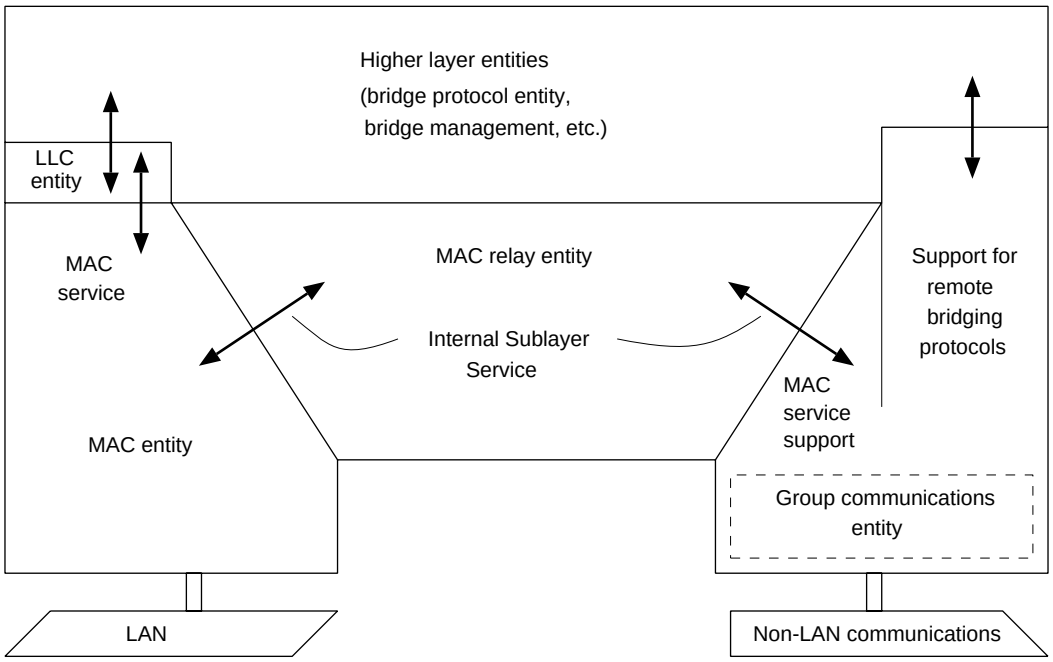

Figure 6-2—Remote bridge architecture

6.2.3 Ports

Each LAN port transmits and receives frames to and from the LAN to which it is attached. An individual MAC entity permanently associated with the LAN port provides the Internal Sublayer Service used for frame transmission and reception. The MAC entity handles all the Media Access method dependent functions (MAC protocol and procedures) as specified in the relevant standard for that MAC technology.

Each virtual port transmits and receives relayed MAC frames to and from the remote bridge cluster to which it attaches. Appropriate MAC service support functions map the Internal Sublayer Service to the non-LAN communications equipment. Transmission and reception of information exchanged between the remote bridges of a group are also modeled as occurring through virtual ports (see 6.13.3.1).

6.2.4 Group communications entity

The group communications entity provides an explicit recognition of the following two aspects of communication underlying the virtual ports:

a) The abstract communication functionality represented by virtual ports is supported by real communications equipment, and by protocols and procedures (outside the scope of this International Standard) that map the virtual-port-level communications to that real equipment.

b) The operation of some groups can require a remote bridge to communicate with others in the group, in ways that do not directly support communication represented at the virtual port level (e.g., in support of the requirements of 8.1 and 12.2.2).

(See C.6.13 for further discussion, and examples, of the group communications entity's role.)

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6.2.5 Higher layer entities

The bridge protocol entity handles calculation and configuration of bridged LAN topology.

For communication over a LAN, via a LAN port, the bridge protocol entity and other higher layer protocol users, such as bridge management, make use of LLC procedures. These procedures are provided separately for each LAN port, and use the MAC service provided by the individual MAC entities.

For communication within a remote bridge group, via a virtual port, the bridge protocol entity and other higher layer protocol users make use of the group's communications through protocol support mechanisms whose details are outside the scope of this International Standard. (See 12.2.1 for a definition of the service to be provided by such mechanisms for use by the bridge protocol entity, if that operates the optional Extended Spanning Tree Protocol).

NOTE—These mechanisms could be the same, or partly the same, as those for the MAC service support function, or they could involve quite separate communications support. For the purposes of modeling the functions present in a remote bridge, such details are unimportant: virtual ports represent the abstraction, independent of those details, of the fact that communication occurs between remote bridges, relating to support both for relaying MAC frames and for use of higher-layer protocols.

6.3 Model of operation of a single remote bridge

The MAC relay entity's use of the Internal Sublayer Service is specified in 6.5 and 6.6. State information associated with each LAN port and virtual port, and cluster identification information associated with virtual ports and with the bridge's membership of groups, govern the ports' participation in the RB-LAN. (Port states are specified in detail in 7.4.)

Frames are accepted for transmission and delivered on reception to and from processes and entities which model the operation of the MAC relay entity in a remote bridge. These are

a) The forwarding process (6.7), which forwards received frames that are to be relayed through other ports, filtering frames on the basis of information contained in the filtering database (6.9) and on the states of the ports.

b) The learning process (6.8), which by observing the source MAC addresses of frames received on each port updates the filtering database (6.9), conditionally upon the port state.

c) The filtering database (6.9), which holds filtering information and supports queries by the forwarding process as to whether frames with given values of the destination MAC address field should be forwarded to a given port.

Each LAN port also functions as an end station providing the MAC service to LLC, which in turn supports operation of the bridge protocol entity (6.10) and of other possible users of LLC such as protocols providing bridge management (6.11). Each virtual port provides similar functions that support communication between bridge protocol entities in remote bridges belonging to the same remote bridge group (see also 6.2.1 and 6.2.3).

Figures 6-3 and 6-4 each illustrate a single instance of relaying a frame between two ports of a remote bridge, for frame reception on a LAN port and a virtual port, respectively (the cases of relaying between two virtual ports, and of relaying between two LAN ports, are similar). The forwarding process uses port state information and filtering database information to determine to which ports, if any, the received frame is to be forwarded.

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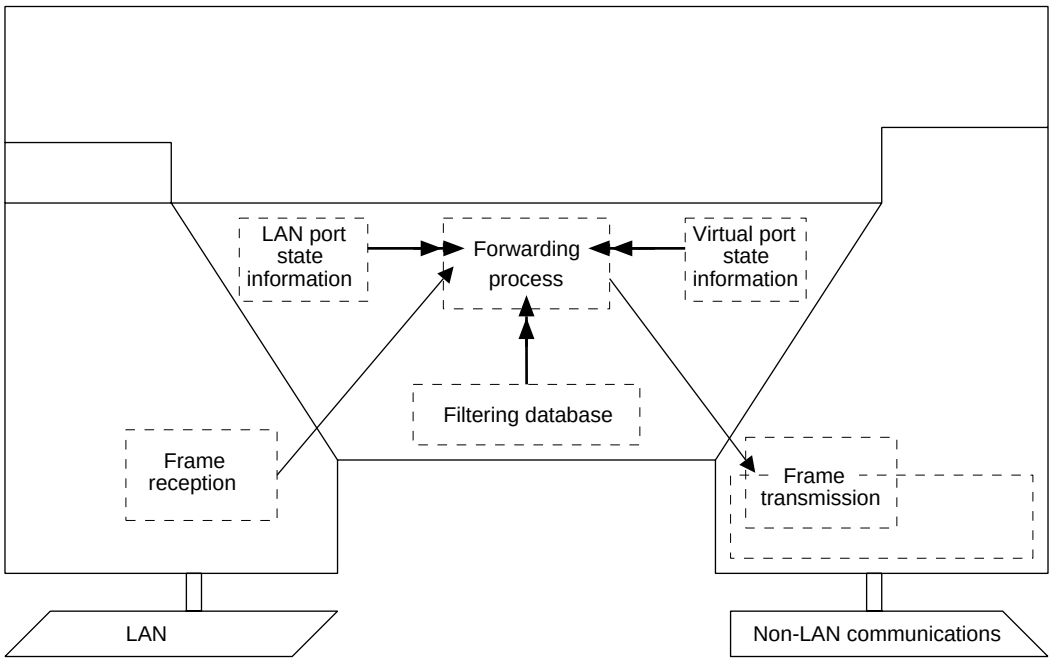

Figure 6-3—Remote bridge relaying, LAN port to virtual port

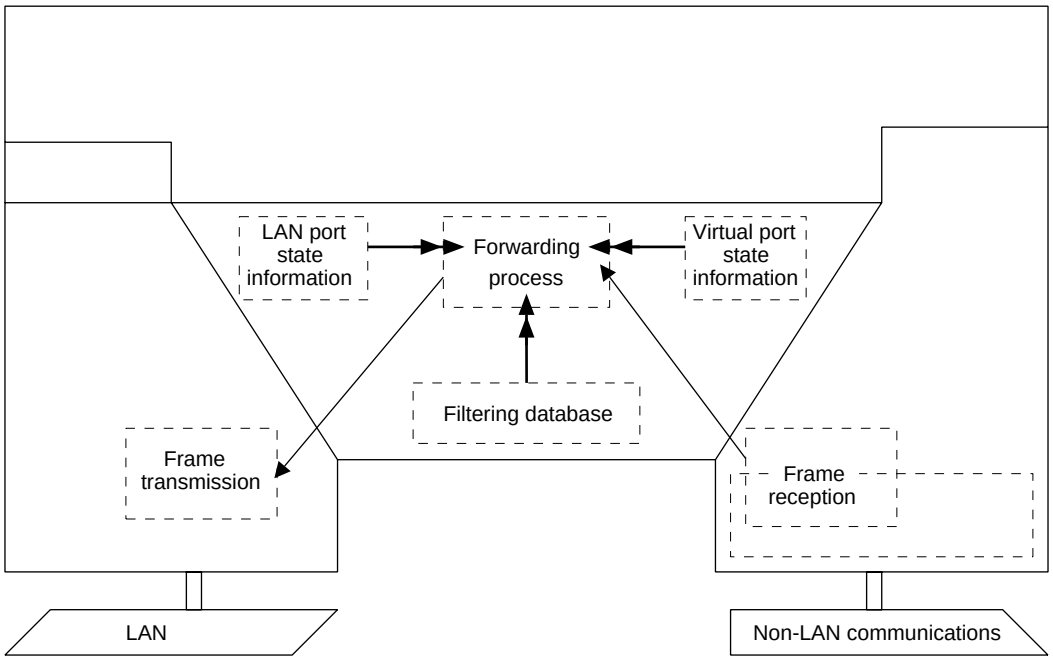

Figure 6-4—Remote bridge relaying, virtual port to LAN port

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Figures 6-5 and 6-6 illustrate, similarly, the incorporation into the filtering database of station location information carried by a single received frame; port state information for the receiving port is used to determine whether or not the information is to be incorporated.

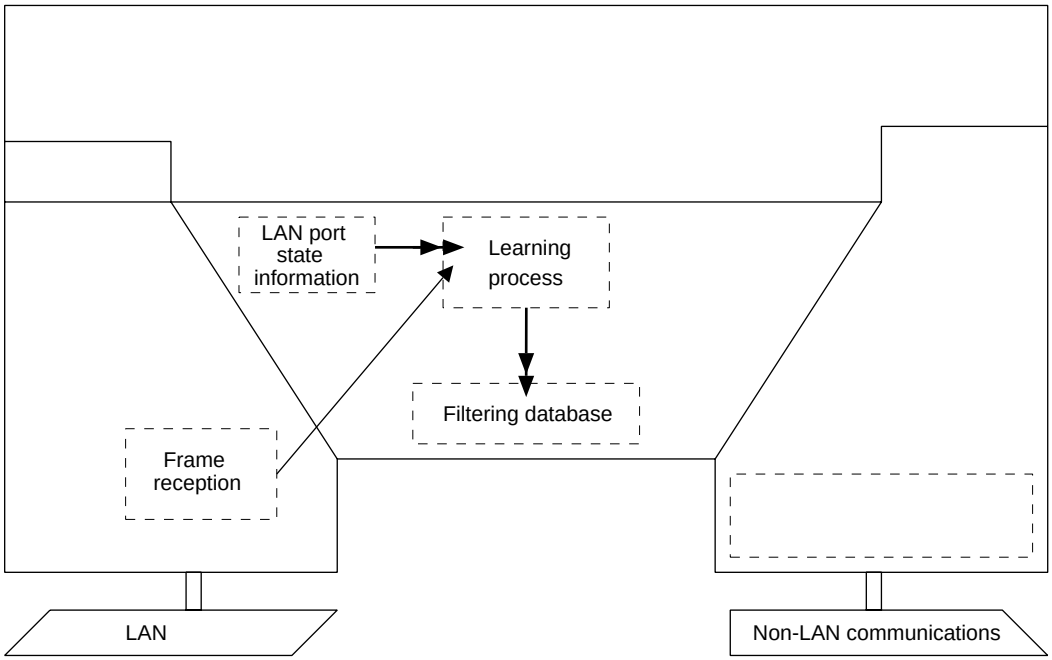

Figure 6-5—Observation of network traffic received on a LAN port

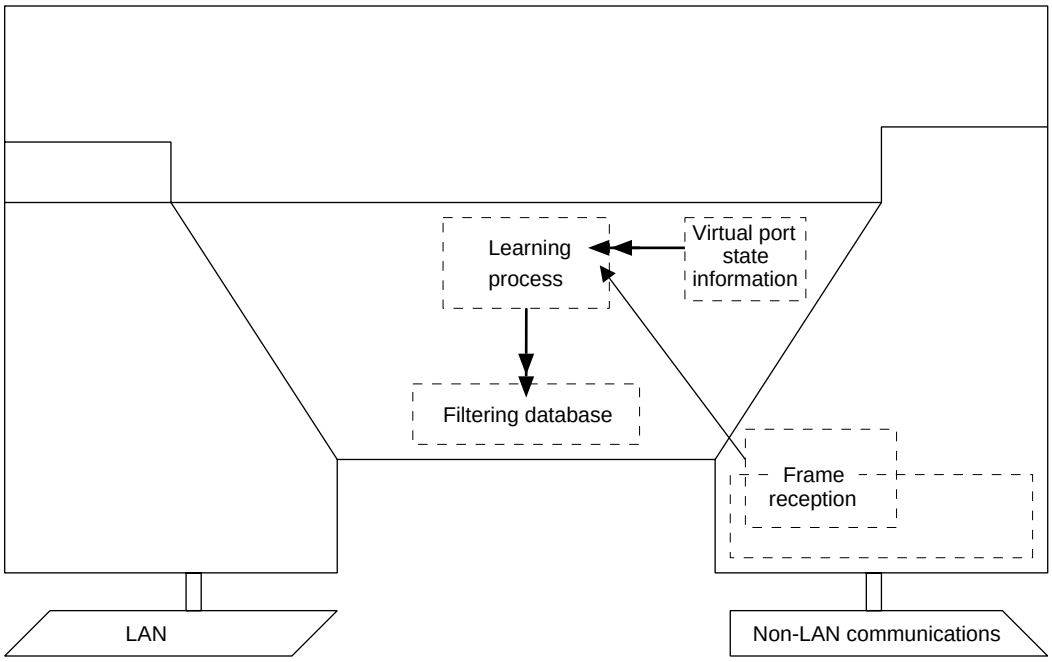

Figure 6-6—Observation of network traffic received on a virtual port

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Figure 6-7 illustrates the bridge protocol entity operating the Spanning Tree Protocol in a remote bridge: this includes its reception and transmission of bridge protocol data units via a LAN port, and of the equivalent information via a virtual port; and modification of port state information to select the active topology of the RB-LAN. The bridge protocol entity is shown divided into three parts corresponding to these functions. If the optional Extended Spanning Tree Protocol is used within the group, the interface between the bridge protocol entity and the functions that support remote bridging protocols is the RB-Protocol Subnetwork Service specified in 12.2.1.

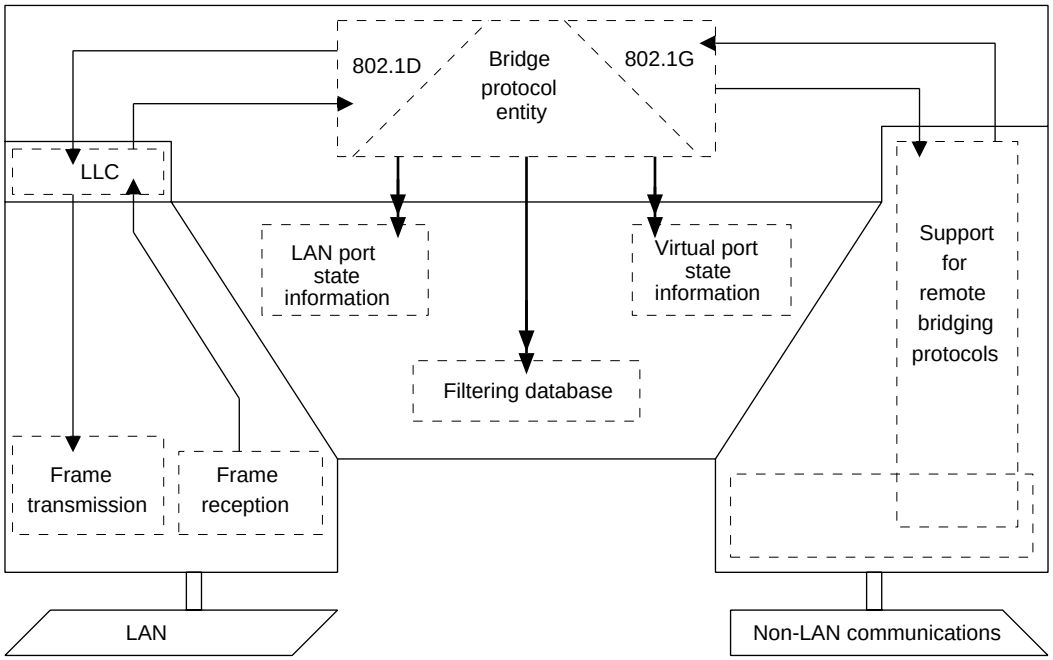

Figure 6-7—Operation of bridge-to-bridge protocols in a remote bridge

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Figures 6-8 through 6-10 illustrate reception and transmission of frames by the bridge management entity via the LLC entity. Figure 6-8 shows the straightforward cases, of frames received and transmitted at a LAN port with which the bridge management entity is associated.

Figure 6-9 shows reception of a frame via a virtual port and the forwarding process, and Figure 6-10 shows the complementary transmission of a frame by the bridge management entity back through the forwarding process and the virtual port. In each of these scenarios, transmission to the LAN may be suppressed, as an optimization, if the frame has an individual destination MAC address (see 6.7.5).

NOTES

1—It is emphasized that these figures illustrate only a modeling of information flows, not the structure of an implementation. The model in Figures 6-8 through 6-10 applies to bridge management information carried over LLC, in MAC frames addressed to the MAC addresses of LAN ports. Considering the implementation of the flow illustrated in Figure 6-9 within a real remote bridge, the fact that a frame is addressed to the MAC address of the LAN port does not mean that it has to go to the port's adapter card, or equivalent, before re-entering the bridge.

2—Communications support for bridge management may be provided by non-LLC mechanisms; such support falls outside the scope of these illustrations.

3—The information flows shown in Figures 6-9 and 6-10 never apply to BPDUs of the Extended Spanning Tree Protocol, since these are not conveyed in MAC frames.

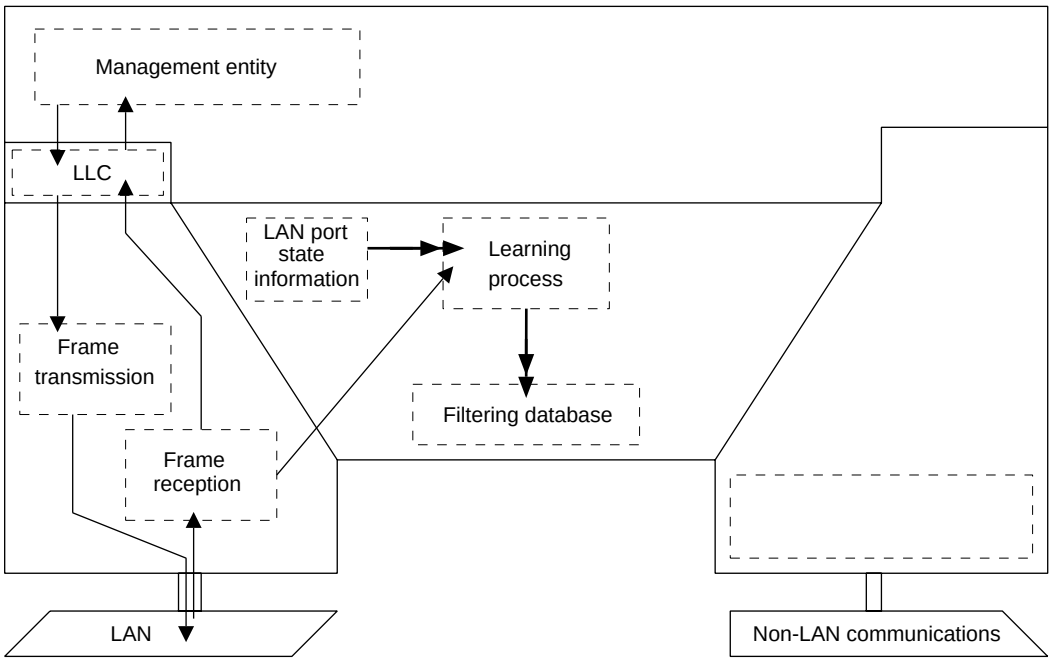

Figure 6-8—Reception and transmission of bridge management information at a LAN port of a remote bridge

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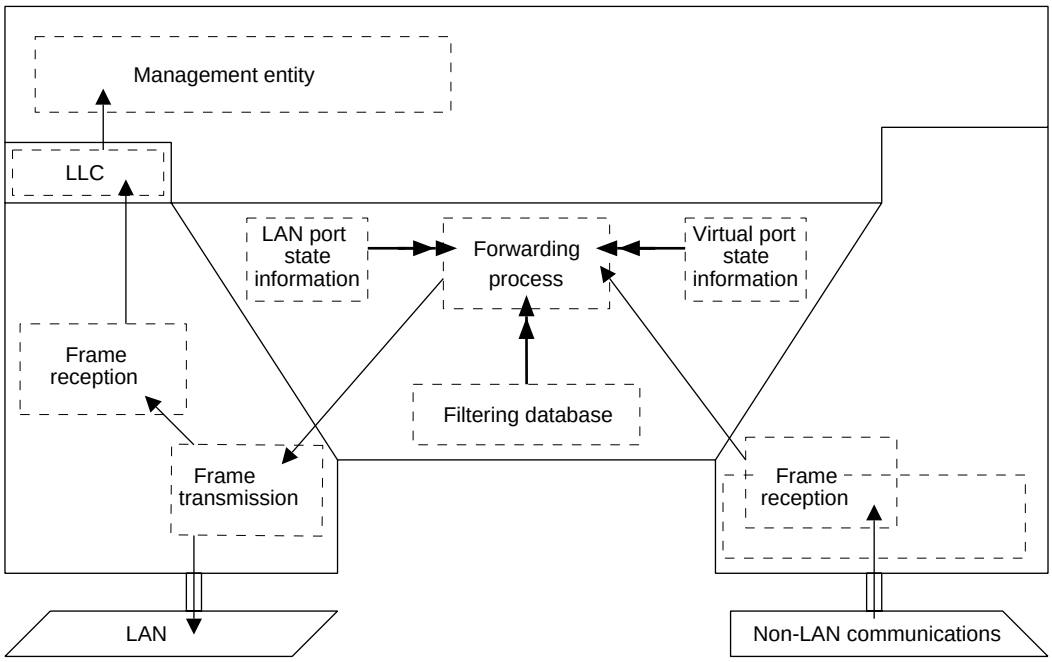

Figure 6-9—Reception of bridge management information at a virtual port of a remote bridge

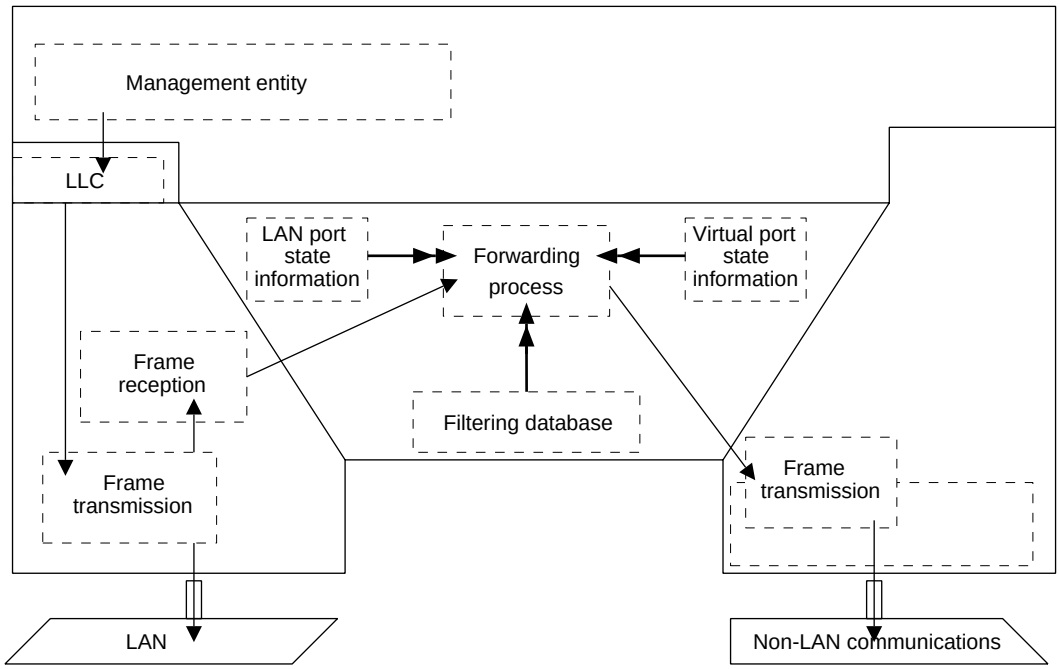

Figure 6-10—Transmission of bridge management Information through a virtual port of a remote bridge

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6.4 Port states, active ports, and the active topology

State information associated with each bridge port governs whether or not it participates in relaying MAC frames. A port can be disabled by management, in which case it plays no part in the operation of the RB-LAN; a port that is not disabled can be dynamically excluded from participation in frame relaying by operation of the Spanning Tree Algorithm. If neither of these applies to a port, it is described as *forwarding*.

The *active topology* of an RB-LAN at any time is the set of communication paths formed by interconnecting the LANs, bridges, and group communications equipment by the forwarding ports. The function of the distributed Spanning Tree Algorithm is to construct an active topology that is simply connected relative to communication between any given pair of MAC addresses used to address end stations on the LANs.

Figure 6-7 illustrates the operation of the bridge protocol entity, which operates the Spanning Tree Algorithm and its related protocols, and its modification of port state information as part of determining the active topology of the RB-LAN. The port states associated with that determination of the active topology are specified in detail in 7.3.7 and 7.4.

Figure 6-4 illustrates the forwarding process's use of port state information: first, for a port receiving a frame, in order to determine whether the received frame is to be relayed through any other ports; and second, for another port in order to determine whether the frame is to be forwarded through that particular port.

The incorporation of end-station location information in the filtering database by the learning process also depends upon port states assigned as part of determining the active topology. If information associated with frames received on a port is to be incorporated in the filtering database, the port is described as being in a learning state; otherwise, it is in a non-learning state. Figures 6-5 and 6-6 illustrate the learning process's use of the port state information for a LAN port and a virtual port, respectively, in order to determine whether the station location information in received frames is to be incorporated in the filtering database.

6.5 Frame reception

Frames received on a LAN port of a remote bridge shall be discarded, or submitted to the forwarding process and/or learning process and/or LLC, as specified in ISO/IEC 10038: 1993.

Frames received, as M-UNITDATA indication primitives, on a virtual port of a remote bridge

a) Shall be discarded if their cluster_id parameters do not identify the remote bridge cluster to which the receiving port attaches; or

b) May be discarded if it is determined (from the parameters of the M-UNITDATA primitives) that they have been damaged so that they cannot be successfully delivered; or

c) If not discarded as in a) or b), shall be submitted to the forwarding process and the learning process.

NOTE—Discarding of frames from other clusters as in a) is necessary in order to preserve the simply connected active topology (6.4, 6.13.1, 6.13.4). Whether such frames can ever actually be received at a given real remote bridge is, in general, implementation-dependent; the statement in a), which is about the abstract model for any implementation, is needed in order to cover the full range of possible implementations. See also 8.3, C.7.3.4, and C.7.3.6.

6.6 Frame transmission

Frames are transmitted onto a LAN via a LAN port as specified in ISO/IEC 10038: 1993, by the individual MAC entity associated with the LAN port.

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Similarly, the MAC service support function associated with each virtual port transmits the information corresponding to frames submitted to it, as M-UNITDATA request primitives, by the MAC relay entity.

6.7 Frame forwarding

The forwarding process forwards received frames to other ports, filtering them on the basis both of information contained in the filtering database, and of the states of the ports.

6.7.1 Forwarding conditions

A frame received on a LAN port or a virtual port and submitted to the forwarding process shall not be forwarded to any other port unless the receiving port is in Forwarding state (7.4).

Each frame received on a port that is in Forwarding state shall be submitted to the forwarding process, and queued for transmission on each port, and on no others, for which

a) The transmission port is in Forwarding state (7.4); and

b) The receiving and transmission ports are not both virtual ports attached to the same remote bridge group; and

c) either

   1) The filtering database indicates that frames with this value of the destination MAC address are to be forwarded through the transmission port; or

   2) The values of the source and destination MAC addresses are the same, and the bridge is configured to forward such frames;

except that

d) A frame shall not be queued for transmission on a LAN port if it conveys an MSDU of size greater than the maximum MSDU size supported by the LAN; and

e) A frame is not required to be queued for transmission on a virtual port if it conveys an MSDU of size greater than the maximum MSDU size supported by any of the destination remote bridges in the remote bridge cluster to which the virtual port is attached.

NOTES

1—The maximum MSDU size supported by a remote bridge can be greater than the maximum MSDU size supported by any of the LANs to which its LAN ports attach, if the bridge supports relaying between virtual ports belonging to two or more different groups.

2—One case of condition c)1) arises when a frame's destination MAC address is not in the filtering database (i.e., the destination MAC address is not known to the bridge). Such a frame is queued for transmission on all forwarding ports, apart from the receiving port and any subgroup ports attaching to the same group as the receiving port.

6.7.2 LLC duplicate address check

Like a local bridge, a remote bridge shall either

a) Filter frames whose source and destination MAC addresses have the same value, in order to localize traffic; or

b) Forward such frames, in order to support the optional LLC duplicate address check function.

The choice shall apply consistently to all LAN ports and virtual ports of a given remote bridge.

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6.7.3 Queued frames

The forwarding process provides storage for queued frames, awaiting an opportunity to submit them for transmission to the MAC entity or MAC service support functions associated with each port. The order of queued frames shall be maintained for each user priority and each pair of source and destination MAC address values.

A frame queued by the forwarding process for transmission on a port shall be removed from that queue on submission for transmission on that port; no further attempt shall be made by the forwarding process to transmit the frame on that port even if the transmission is known to have failed. (Note that this does not preclude the use of retransmission for error recovery as part of the MAC service support functions over non-LAN communications equipment.)

A frame queued by the forwarding process for transmission on a port may be removed from that queue, and not subsequently transmitted, if the time for which buffering is guaranteed has been exceeded for that frame.

A frame queued by the forwarding process for transmission on a port shall be removed from that queue, and not subsequently submitted for transmission on that port, if that is necessary to ensure that the maximum bridge transit delay (see 5.3, C.5.3.6) will not be exceeded at the time at which the frame would be subsequently transmitted.

A frame queued for transmission on a port shall be removed from that queue if the associated port leaves the Forwarding state.

A frame queued for transmission on a port may be removed from that queue if it becomes known that the destination is not reachable.

Removal of a frame from a queue for transmission on any particular port does not of itself imply that it shall be removed from a queue for transmission on any other port.

6.7.4 Priority mapping

The forwarding process performs the mapping of the priority of forwarded frames (see 5.3, C.5.3.9) by determining the values of the user_priority and access_priority parameters in the M-UNITDATA request primitives used to relay frames.

The user_priority parameter in an M-UNITDATA request primitive (5.4) shall be either

— Equal to the value of the user_priority of the corresponding M-UNITDATA indication primitive, if that value was specified (e.g., if the frame was received on a virtual port, or on a LAN port using the token-passing bus or a token-passing ring access method); or

— Set to the value of the Outbound User Priority parameter for the transmission port, if the value in the corresponding M-UNITDATA indication primitive was unspecified (e.g., if the frame was received on a LAN port for a LAN using the CSMA/CD access method).

The access_priority parameter in an M-UNITDATA request primitive (5.4) shall be either

— Equal to the value of the user_priority parameter in the corresponding M-UNITDATA indication primitive; or

— Set to the value of the Outbound Access Priority parameter for the transmission port.

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If bridge management is supported, the values of the Outbound User Priority and Outbound Access Priority parameters shall be capable of being set independently for each transmission port. The remote bridge shall have the capability to use the full range of values specified in Tables 3-1 and 3-2 of ISO/IEC 10038: 1993 for LAN ports, and all values in the range 0–7 for virtual ports. If bridge management is not supported, the remote bridge shall use the default values specified in Tables 3-1 and 3-2 of ISO/IEC 10038: 1993 for LAN ports, and the default value zero for each parameter of a virtual port.

NOTE—Some LAN access methods treat all values of access_priority equally and do not convey user_priority; virtual ports (see 5.6) can similarly limit support for one or both of these parameters. The Outbound User Priority and Outbound Access Priority parameters are still specified for these cases, to allow a consistent approach to the management both of virtual ports and of LAN ports of different MAC types.

6.7.5 Frames addressed to the remote bridge

When the MAC relay entity forwards a frame to a LAN port, and the frame's destination MAC address matches an individual MAC address associated with the port, the frame may be transmitted on the LAN. Alternatively, the physical transmission of the frame on the LAN may be suppressed. In either case, an MA_UNITDATA indication primitive shall be issued to the LLC entity associated with the LAN port, as though the frame had been received on the port.

When a frame is forwarded to a LAN port, and the frame's destination MAC address matches a group MAC address associated with the LAN port, the frame shall be transmitted on the LAN in the normal way. An MA_UNITDATA indication primitive shall be issued to the LLC entity associated with the LAN port, as though the frame had been received on the port.

NOTES

1—In each case (individual MAC address or group MAC address), the normal behavior of the MAC entity for the port will be to ensure that the LLC entity receives the frame, as required above. This is because the MAC service, ISO/IEC 15802-1: 1995, specifies that an MA_UNITDATA request containing a MAC address designating the MAC service access point at which the request is invoked shall result in an MA_UNITDATA indication at that MAC service access point.

2—The above never applies to MAC frames containing BPDUs. Such frames are never forwarded by a bridge's MAC relay entity.

6.8 The learning process

The learning process observes the source MAC addresses of frames received on each port and updates the filtering database conditionally on the state of the receiving port.

Frames received on ports are submitted to the learning process as specified in 6.5. When a frame is submitted, the learning process shall update a dynamic entry if one exists in the filtering database, and otherwise may create a dynamic entry, associating the port on which the frame was received with the source MAC address of the frame, if and only if

a) The port on which the frame was received is in a state that allows learning (7.4).

b) The frame's source MAC address is an individual MAC address.

c) No static entry for the MAC address already exists.

d) The resulting number of entries would not exceed the capacity of the filtering database.

If the filtering database is already filled up to capacity but a newly created entry would otherwise be made, an existing entry may be removed to make room for the new entry.

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Figure 6-6 illustrates the operation of the learning process in including the station location information carried by a single frame, received on a virtual port, into the filtering database.

6.9 The filtering database

The filtering database holds filtering information which is either explicitly configured by management action or automatically entered. It supports queries by the forwarding process as to whether frames with given values of destination MAC address are to be forwarded to a given port. The specification given here is equivalent to that for local bridges in ISO/IEC 10038: 1993, extended to include all virtual ports within the scope of the filtering function.

Information is entered automatically into the filtering database by the learning process, and may also be entered automatically to reflect location information acquired by the learning processes in other remote bridges belonging to the same remote bridge cluster.

NOTE—The latter possibility can be viewed as allowing a cluster to implement a partially distributed filtering database. This can result in a reduction in the traffic conveyed across clusters (e.g., by avoiding flooding by one remote bridge which has timed out information, when other bridges retain current information because of traffic among them). This International Standard does not specify methods for performing such remote learning and updates.

The filtering database shall contain static entries (6.9.1), and shall be capable of containing dynamic entries (6.9.2). At most one type of entry shall exist for a given MAC address: a dynamic entry shall not be created if a static entry already exists for the same MAC address; and creation of a static entry shall cause the deletion of any dynamic entry for the same address.

When management of the remote bridge is supported, the filtering database shall be capable of being interrogated and updated by management using the operations specified in Clause 9. Alternatively, or additionally, interrogation and updating of the filtering database may be supported by local or private mechanisms.

6.9.1 Static entries

Static entries may be added to and removed from the filtering database under explicit management control. They are not automatically removed by any timeout mechanism.

A static entry specifies

a) The MAC address for which filtering is specified.

b) For each inbound LAN port and virtual port on which frames are received, a port map that specifies whether frames are to be filtered or forwarded to each outbound port.

The MAC addresses that can be specified shall include group addresses and the broadcast address.

6.9.2 Dynamic entries

Dynamic entries are created and updated by the learning process as described in 6.8. They may also be created and updated as a result of operations by the learning processes in other remote bridges, as described in 6.9.

A dynamic entry shall be removed after a specified time—the *ageing time*—has elapsed since the entry was created or last updated. A remote bridge's support for timeout values shall be as specified for local bridges in ISO/IEC 10038: 1993.

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NOTE—Use of a short timeout value is specified in Clause 7, when the Spanning Tree Protocol is used to notify all bridges in an RB-LAN of topology changes. This allows the normal ageing time timeout, applicable when the topology does not change, to be long enough to cope with periods when end stations do not generate frames themselves, while not sacrificing the ability of the RB-LAN to continue to provide a service after automatic reconfiguration.

A dynamic entry specifies

a) The MAC address for which filtering is specified.

b) A port number.

Frames with the specified destination MAC address shall be forwarded only to the specified port. Only individual MAC addresses shall be present in dynamic entries.

6.9.3 Permanent database

The filtering database shall contain a permanent database, providing fixed storage for static entries; the filtering database shall be initialized with these static entries.

Static entries may be added to and removed from the permanent database by explicit management action.

6.10 Bridge protocol entity

The bridge protocol entity operates the Spanning Tree Protocol on the LANs to which a remote bridge's LAN ports are attached, and performs equivalent interchanges of information with other remote bridges in the same remote bridge group.

The bridge protocol entities of bridges attached to a given individual LAN in an RB-LAN communicate by exchanging bridge protocol data units (BPDUs), as specified in ISO/IEC 10038: 1993.

The bridge protocol entities of bridges belonging to the same group may communicate by exchanging BPDUs in accordance with the optional Extended Spanning Tree Protocol specified in Clauses 12 and 13; or they may use other means of achieving equivalent support of the Spanning Tree Algorithm across the group.

Figure 6-7 illustrates the operation of the bridge protocol entity including the reception and transmission of frames containing BPDUs, the reception and transmission of corresponding information (in BPDUs, or otherwise) over the non-LAN communications equipment of the group, the modification of the state information for individual ports, and notification of changes in active topology to the filtering database.

6.11 Bridge management

The remote bridge may provide facilities for management; these facilities and the operations that support them are specified in Clause 9.

Invocation of the management operations may be carried out by local or private means, or by use of standard management protocols. When ISO/IEC 15802-2: 1995 LAN/MAN Management is used, the protocol operations, identifiers, and values to be used in realizing the management operations shall be as specified in Clause 10 of this International Standard.

Bridge management is modeled as being performed by means of the bridge management entity. Figures 6-8 through 6-10 illustrate use of the MAC service in support of (standard or private) protocols for communicating with the bridge management entity. Communication both via a LAN port and via a virtual port is illustrated.

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6.12 Addressing

Use of MAC addresses in frames transmitted and received on the LANs to which the LAN ports of a remote bridge are attached shall be as specified in ISO/IEC 10038: 1993. The reserved LLC Address (Standard LSAP) assigned to the Bridge Spanning Tree Protocol shall be used, as specified in ISO/IEC 10038: 1993, in the LLC PDUs used to convey BPDUs transmitted over a LAN by the bridge protocol entity of a remote bridge.

Where a remote bridge's bridge management entity is addressed by one or more specific MAC addresses associated with LAN ports of the remote bridge, as specified in ISO/IEC 10038: 1993, frames received on a forwarding virtual port and addressed to the bridge management entity shall be forwarded to the addressed LAN port in accordance with the forwarding conditions in 6.7. When such forwarding occurs, the frame is submitted to the LLC entity that supports the bridge management entity (the frame is not necessarily transmitted on the LAN to which the port attaches; see 6.7.5).

Similarly, a management request conveyed in a frame received on a forwarding virtual port and carrying the All LANs Bridge Management Group Address specified in ISO/IEC 10038: 1993 shall be forwarded to the remote bridge's LAN ports in accordance with the forwarding conditions in 6.7. One instance of the frame is submitted to the bridge management entity for each LAN port to which it is forwarded and which has a specific MAC address by which the bridge management entity is reachable.

Use of addresses for protocol functions within a remote bridge group is outside the scope of this International Standard.

6.13 Model of remote bridge interconnection

6.13.1 Roles and objectives of the model

The interconnection model has three roles:

— As an aid to describing and understanding the operation of a set of intercommunicating remote bridges.
— As a basis for establishing a structure for management of remote bridges and RB-LANs.
— As a framework for operation of the optional Extended Spanning Tree Protocol.

The objectives of the model are to

a) Accommodate the full variance in, and to allow the best use of, applicable non-LAN communications technologies.

b) Allow a range of sizes and complexities of remote bridges, and in particular to allow simple remote bridges to be interconnected with more complex remote bridges.

c) Provide for manageability of real RB-LAN implementations, by compatible extension of the corresponding features of ISO/IEC 10038: 1993; in particular, to

   1) Provide for control of the spanning tree's configuration, across a complete RB-LAN; and

   2) Provide for control of the filtering of user traffic within the RB-LAN.

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6.13.2 Elements of the model

Interconnection of remote bridges is modeled in terms of *virtual ports*, *remote bridge groups*, and *remote bridge clusters*. Remote bridge groups and remote bridge clusters express, respectively, static and dynamic aspects of the configuration of a set of remote bridges cooperating in support of the MAC service. Virtual ports are abstractions of the communications functions between remote bridges, and are used in expressing the peer-to-peer communication between remote bridges in a group or cluster. The logical interconnection of a group's remote bridges by their virtual ports is described in terms of *subgroups*.

NOTE—It is important to note that virtual ports and subgroups are logical, abstract representations of the capability for communication among remote bridges. Virtual ports do not represent points of attachment to particular physical communications links, nor do subgroups represent discrete sets of such links. (See 6.13.5, 6.13.6, and Annex C.)

The modeling principles for the static and dynamic aspects of group configuration are described in 6.13.3 and 6.13.4, respectively. The functions of virtual ports in the overall model of remote bridge interconnection are described in 6.13.5, and basic examples of the model are provided in 6.13.6.

6.13.3 Static configuration: remote bridge groups, virtual ports, and subgroups

6.13.3.1 Virtual ports and subgroups

A remote bridge attaches to a remote bridge group through one or more virtual ports. A remote bridge may be attached to more than one group; in this case, each virtual port attaches to one and only one of the groups.

Each virtual port represents a remote bridge's ability to communicate with a particular, configured set of the other remote bridges in the group to which the port attaches. Such a set of remote bridges is termed a *subgroup*. The interconnection structure of the group is constrained so that each remote bridge in a subgroup has a single virtual port representing its ability to communicate with all the other bridges in the subgroup, and with no others.

NOTE—The above constraint means that a subgroup is fully connected, and simply connected, via the attaching virtual ports. It is fully connected because each member of the subgroup can communicate with every other member; and it is simply connected because there is a unique pair of virtual ports representing communication between any given pair of members.

A subgroup does not provide a means for a bridge belonging to it to discriminate between the other bridges with which it communicates: information transmitted via a virtual port is capable of being received at all the peer virtual ports in the subgroup. The part of the group's communications functions corresponding to a subgroup therefore interconnects the subgroup members to provide communication among them that has similar properties to those of the communication provided by a LAN. The support for this LAN-like interconnection is referred to as the *subgroup communications capability*.

6.13.3.2 Groups and subgroups

A group as a whole is also required to be fully and simply connected: that is, each remote bridge attached to a given group shall belong to one or more subgroups, such that each other remote bridge in the group belongs to exactly one of those subgroups.

In a given group, communication takes place between all the bridges' bridge protocol entities, except for those that have had their virtual ports disabled.

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This International Standard constrains the interconnection structure of a group only to the extent that any group shall be fully and simply connected via its virtual ports, as described above. The detailed capabilities of any remote bridge, or of any set of remote bridges that can form a group, are at the implementors' choice in terms of, for example,

— The maximum number of virtual ports by which a given remote bridge can attach to a group.
— The maximum size of group in which a given remote bridge can participate.
— The variety of ways in which a group can be structured in terms of subgroups.

An important special case of the possible subgroup structures for a group is that where there is just one subgroup, with each remote bridge attaching to the group by just one virtual port. A group configured in this way is termed a *virtual LAN*. A virtual port that attaches to a virtual LAN is termed a *virtual LAN port.*

When a remote bridge attaches to a group that is not a virtual LAN (i.e., when each remote bridge has multiple virtual ports, and the group consists of multiple subgroups), each of its virtual ports is termed a *subgroup port*. When a subgroup port represents the capability for communication with just one other remote bridge, it is termed an *individual virtual port*. A group in which every remote bridge is attached only by individual virtual ports is termed a *virtual mesh*.
When a subgroup port represents the capability for communication with two or more other remote bridges, it is termed a *multipeer virtual port*. A group containing remote bridges attached by multipeer virtual ports is termed a *mixed-configuration group*.

NOTES

1—A number of the properties of remote bridges that attach to virtual LANs are simpler than those for remote bridges interconnected by multiple subgroups. The requirements in this International Standard therefore frequently distinguish between the virtual LAN case and the other, more general, structures.

2—The following are consequences of the definitions just given:

a) Every virtual port is either a virtual LAN port or a subgroup port.

b) A group containing only two remote bridges is a virtual LAN.

c) An individual virtual port always connects to another individual virtual port, because of the fully and simply connected structure of subgroups; the ports therefore connect their bridges in a two-member subgroup.

d) A mixed-configuration group always contains some individual virtual ports as well as at least one multipeer virtual port.

3—Groups and their virtual port attachments define the static configuration of an RB-LAN. This definition—of how remote bridges are associated together in groups, and of each remote bridge's configuration of virtual ports, including subgroup membership—is essentially an administrative matter, subject of course to any limitations imposed by the technical capabilities of the equipment to be used, and subject to the full-connectivity requirements on subgroups.

4—For a given set of more than two remote bridges and their interconnecting communications equipment, there is not in general a unique configuration either of groups or of virtual ports: actual configurations, and the ranges of possible configurations, depend upon user requirements and upon implementation capabilities, including those for RB-LAN management. (See Annex C for examples.)

6.13.4 The active topology and remote bridge clusters

As defined in 6.4, the active topology of an RB-LAN at any time is the set of communication paths formed by interconnecting the LANs, bridges, and group communications equipment by the forwarding ports. The function of the distributed Spanning Tree Algorithm is to construct an active topology that is simply connected relative to communication between any pair of LAN end stations using given MAC addresses. When a group belongs to an RB-LAN containing other external communication paths between two or more of the remote bridges in the group, it is sometimes necessary to partition the group in order to construct the simply connected active topology.

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Dynamic aspects of the configuration of remote bridge groups in an RB-LAN, relating to the selection of virtual ports to be forwarding, are expressed in terms of remote bridge clusters. The Spanning Tree Algorithm and the associated cluster-formation rules (see 7.3) configure the remote bridges of a given group into one or more disjoint subsets. Such a subset is

a) An active cluster consisting of two or more remote bridges, each of which either is relaying frames to the other bridges in the cluster, through its virtual ports that have been selected to be forwarding, or is preparing to perform such relaying following a configuration change; or

b) A degenerate cluster, containing a single isolated remote bridge with one or more virtual ports selected to be forwarding, but with none of its peer virtual ports on other bridges belonging to the same cluster; or

c) A single isolated remote bridge that is not relaying frames, or preparing to relay frames, to any other bridge in the group.

No remote bridge belongs to two clusters of the same group. Consequently, in any group, no relaying of frames occurs through pairs of remote bridges belonging to different clusters of that group.

NOTES

1—This last property, which is a consequence of the Spanning Tree Algorithm and cluster-formation rules, ensures that the active topology for end-station to end-station frame transfer is simply connected.

2—A cluster can, and often will, consist of all the remote bridges in a given group. In particular, this will be the case when there are no better communication paths, external to the group, between any members of the group. The distinction between groups and clusters is necessary only in order to handle the possibility of such external paths.

3—In a mixed-configuration group (neither a virtual LAN nor a virtual mesh), the active topology for relaying of frames is determined by the clusters, rather than by the selection of virtual ports to be forwarding or blocking. It is possible for peer subgroup ports to belong to different clusters, and so to be selected as forwarding; however, frames are never relayed through the two bridges connected by such ports—see 6.5 a), 5.4 h), 8.1, and 8.3. In virtual LAN and virtual mesh configurations, the active topology determined by the clusters in fact corresponds to that determined by the selection of virtual ports to be forwarding or blocking. In any configuration, it is possible that degenerate clusters as in b) will occur; it is an implementation choice whether or not there should be mechanisms to detect this and to suppress the actual transmission of frames across the group, since any frames transmitted will only be discarded on receipt.

4—The fact that a cluster is fully connected, as stated in a), does not mean that direct communication paths are required between each pair of remote bridges, but only that the cluster provides some path between each pair. This would be modeled as a function of the group communications entity (see 6.2.4, and Annex C).

5—A remote bridge that is isolated within one group as in b) or c) could be a member of an active cluster in another group to which it is attached.

6—A remote bridge that belongs to two or more groups can belong to two or more clusters, in different groups, and relays frames between those clusters as necessary.

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