**IEEE Std 802.5c-1991**
**(Supplement to IEEE Std 802.5-1989)**

IEEE Standards for
Local and Metropolitan Area Networks:

**Supplement to Token Ring Access Method and Physical Layer Specifications**

# Recommended Practice for Dual Ring Operation with Wrapback Reconfiguration

Sponsor

**Technical Committee on Computer Communications
of the
IEEE Computer Society**

Approved March 21, 1991

**IEEE Standards Board**

**Abstract:** Extensions to the IEEE 802.5 Token-Passing Ring standard are defined. These extensions implement a Dual Ring local area network (LAN) topology that provides full interoperability between stations conforming to IEEE Std 802.5, including coexistence on the same ring, and recovery from all single media failures with full capability restored. The Dual Ring topology and operation described are intended for applications that require very high availability and recovery from media and station failures.

The Institute of Electrical and Electronics Engineers, Inc.
345 East 47th Street, New York, NY 10017-2394, USA



**Library of Congress Cataloging in Publication Data
will be found on the following page.**



*September 18, 1991* *SH14290*

**IEEE Standards** documents are developed within the Technical Committees of the IEEE Societies and the Standards Coordinating Committees of the IEEE Standards Board. Members of the committees serve voluntarily and without compensation. They are not necessarily members of the Institute. The standards developed within IEEE represent a consensus of the broad expertise on the subject within the Institute as well as those activities outside of IEEE which have expressed an interest in participating in the development of the standard.

Use of an IEEE Standard is wholly voluntary. The existence of an IEEE Standard does not imply that there are no other ways to produce, test, measure, purchase, market, or provide other goods and services related to the scope of the IEEE Standard. Furthermore, the viewpoint expressed at the time a standard is approved and issued is subject to change brought about through developments in the state of the art and comments received from users of the standard. Every IEEE Standard is subjected to review at least once every five years for revision or reaffirmation. When a document is more than five years old, and has not been reaffirmed, it is reasonable to conclude that its contents, although still of some value, do not wholly reflect the present state of the art. Users are cautioned to check to determine that they have the latest edition of any IEEE Standard.

Comments for revision of IEEE Standards are welcome from any interested party, regardless of membership affiliation with IEEE. Suggestions for changes in documents should be in the form of a proposed change of text, together with appropriate supporting comments.

Interpretations: Occasionally questions may arise regarding the meaning of portions of standards as they relate to specific applications. When the need for interpretations is brought to the attention of IEEE, the Institute will initiate action to prepare appropriate responses. Since IEEE Standards represent a consensus of all concerned interests, it is important to ensure that any interpretation has also received the concurrence of a balance of interests. For this reason IEEE and the members of its technical committees are not able to provide an instant response to interpretation requests except in those cases where the matter has previously received formal consideration.

Comments on standards and requests for interpretations should be addressed to:

Secretary, IEEE Standards Board
445 Hoes Lane, P.O. Box 1331
Piscataway, NJ 08855-1331
USA



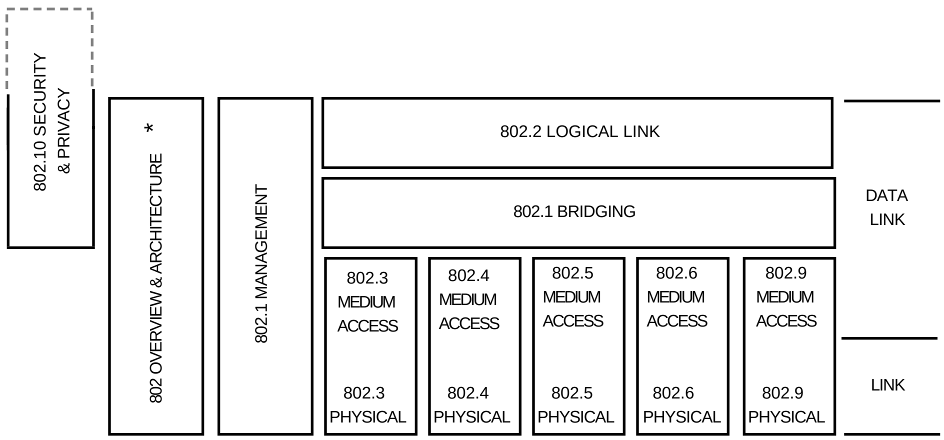
*Library of Congress Cataloging-in-Publication Data*

IEEE Standards Board.
Recommended practice with dual ring operation with wrapback reconfiguration : IEEE standards for local and metropolitan area networks : supplement to Token ring access method and physical layer specifications / sponsor, Technical Committee on Computer Communications of the IEEE Computer Society.
p. cm.
"IEEE Std 802.5c-1991"
"Approved March 21, 1991, IEEE Standards Board".
ISBN 1-55937-117-X
1. Local area networks (Computer networks)—Standards—United States. 2. Ring networks (Computer networks)—Standards—United States. I. IEEE Computer Society. Technical Committee on Computer Communications. II. Title: Token ring access method and physical layer specifications.
TK5105.7.I33 1991
004.6'2—dc20 91-29969
CIP

## Foreword

(This Foreword is not a part of IEEE Std 802.5c-1991, Recommended Practice for Dual Ring Operation with Wrapback Reconfiguration.)

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 ISO Open Systems Interconnection Basic Reference Model (ISO 7498:1984). The access standards define several 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 these technologies are as follows:

- IEEE Std 802† : Overview and Architecture. This standard provides an overview to the family of IEEE 802 Standards. It is a part of the 802.1 scope of work.
- IEEE Std 802.1D: MAC Bridging. Specifies an architecture and protocol for the interconnection of IEEE 802 LANs below the MAC service boundary.

† The 802 Architecture and Overview Specification, originally known as IEEE Std 802.1A, has been renumbered as IEEE Std 802. This has been done to accommodate recognition of the base standard in a family of standards. References to IEEE Std 802.1A should be considered as references to IEEE Std 802.

- IEEE Std 802.1E: 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 8802-2 [ANSI/IEEE Std 802.2]: Logical Link Control.
- ISO/IEC 8802-3 [ANSI/IEEE Std 802.3]: CSMA/CD Access Method and Physsical Layer Specifications.
- ISO/IEC 8802-4 [ANSI/IEEE Std 802.4]: Token Bus Access Method and Physsical Layer Specifications.
- IEEE Std 802.5: Token Ring Access Method and Physical Layer Specifications.
- IEEE Std 802.6: Metropolitan Area Network Access Method and Physical Layer Specifications.

In addition to the family of standards are technical advisory groups as follows:

- IEEE Std 802.7: Broadband Technical Advisory and Physical Layer Topics and Recommended Practices.
- P802.8: Fiber Optic Technical Advisory and Physical Layer Topics.

The reader of this document is urged to become familiar with the complete family of standards.

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

Secretary, IEEE Standards Board
Institute of Electrical and Electronics Engineers, Inc
PO Box 1331, 445 Hoes Lane
Piscataway, NJ 08855-1331
USA

When the IEEE 802.5 Working Group approved IEEE Std 802.5c-1991, it had the following membership:

**Robert A. Donnan,** *Chair*

Don Aelmore
Charles Amann
Rey Bautista
Alan Beardsley
Steve Belisle
Philip Brownlee
Patrik Bulteel
Robert R Campbell
Hsin-Hwai Chen
Thomas Coradetti
Rick Downs
Hanoch Eldar
Farzin Firoozmand
Gunnar Forsberg
Nathan Fritts
Harry Gold
Tom Gulick
Sharam Hakimi
James Harrer
Carl G. Hayssen
Tricia Hill
Paul Hittel
Tom Hogan
Clarence C. Joh
Arthur D. Jopling
Dave Juhre
Lisa Kelley
Bryan B. Kim
David M. Kollm
William F. Kous
Katie D. Lee
Robert D. Love
Carl Madison
Alan C. Marshall
Kelly P. McClellan
Colin Mick
Arthur Miller
John E. Montague
Steven Moustakas
Bilal Murtaza
Andrew Norton
Brian O'Connell
Dave Pearce
Thanh Pham
Richard Podgalsky
Kirk Preiss
Ivan Reede
Everett O. Rigsbee III
Andrew L. Ringwald
Bob Ross
Jacques A. Roth
Mike Rubera
Howard Rubin
Haig A. Sarkissian
David Sheehy
Marc Shoquist
Somsubhra Sikdar
Raymond Sit
Bob Smith
Robert Snyder
Bob Southard
Louis Stankaitas
Leo Staschover
Ed Sterling
Richard Sweatt
Andre Szczepanek
Hidenori Takahashi
Lars Thernsjo
Scott Thomas
Jeff Tong
Akihisa Toyooka
John Trites
Chang-Jung Wang
Peter Williams

Significant contributions to the development of this document were made by the following people:

Steve Anderson
Nicholas Beale
Jacalyn L. Winkler (Fratz)
Harry Gold
Jiro Kashio
Jeffry Marshik
John Messenger

The following persons were on the balloting committee that approved this document for submission to the IEEE Standards Board:

Bandula W. Abeysundara
William B. Adams
Don Aelmore
Hasan S. Alkhatib
Jonathan Allan
Kit Athul
Michael Atkinson
William E. Ayen
Yong Myung Baeg
Tim Batten
Subhash Bhatia
Alan L. Bridges
Richard Caasi
Mehmet U. Caglayan
George S. Carson
Brian J. Casey
Alex Castaldo
George C. Chachis
Chih-Tsai Chen
Robert A. Ciampa
Gerald W. Cichanowski
Michael H. Coden
Keith Collins
Bernard Cousin
Robert Crowder
Jose A. Cueto
R. T. Denton
Ashwani K. Dhawan
Siyi Terry Dong
Robert Donnan
Mitchell G. Duncan
Andrew M. Dunn
Sourav Dutta
Ted Dzik
Judith A. Edwards
John E. Emrich
Richard G. Estock
Changxin Fan
John W. Fendrich
Samuel Fineberg
Ernest L. Fogle
Harold C. Folts
Sandra J. Forney
Harvey A. Freeman
Robert Gagliano
Thomas F. Gannon III
Isaac Ghansah
Patrick Gonia
Abraham Grund
Crag Guarnieri
Sandor V. Halasz
Nobuhiro Hamada
Joseph L. Hammond
R. Harish
J. Scott Haugdahl
Lee A. Hollaar
Anne B. Horton
Ivy P. Hsu
Wing Huen
Bob Jacobsen
Raj Jain
Thomas J. Jasinski
Jack R. Johnson
Reijo Juvonen
Julian Kateley
Robert W. Klessig
Jens Kolind
Vijaya Konangi
Jon Kramp
Stephen B. Kruger
Thomas M. Kurihara
Anthony B. Lake
Glen Langdon
Mike Lawler
John E. Lecky
Jaiyong Lee
Lewis E. Leinenweber
Kin Fun Li
F. C. Lim
Ping Lin
Randolph S. Little
William D. Livingston
Mauro Lolli
Wayne M. Loucks
Donald Loughry
Nam C. Low
Andy J. Luque
Kenneth Majithia
Eduardo G. Marmol
Gerald M. Masson
Kelly C. McDonald
Michael J. McGuire
Richard H. Miller
David S. Millman
C. B. M. Mishra
Wen Hsien Lim Moh
John E. Montague
Kinji Mori
Gerald Moseley
K. R. S. Murthy
Gerald Neblock
Ruth Nelson
Arne A. Nilsson
Donal O'Mahony
Attila Ozgit
Jeffrey L. Paige
Richard J. Paroline
Andreas Pfitzmann
Rafat Pirzada
Udo W. Pooch
Hardy J. Pottinger
Sudha Ram
Thad L. D. Regulinski
Francisco J. Restivo
John R. Riganati
Saber Rizk
Philip T. Robinson
Gary S. Robinson
Daniel Rosich
Floyd E. Ross
John Rovner
Victor Rozentouler
Chiseki Sagawa
Mark S. Sanders
Ravi Sankar
Julio Gonzalez Sanz
Ambatipudi Sastry
Vidyadhar S. Savant
Manoj Kunar Saxena
Lorne H. Schachter
Norman Schneidewind
Jeffrey R. Schwab
Adarshpal S. Sethi
David M. Siefert
Surinder Singh
Ing. Alex. Soceanu
Robert K. Southard
James Sterbenz
Benjamin J. Stoppe, Jr.
Fred J. Strauss
Efstathios D. Sykas
Gregory M. Sylvain
Daniel Sze
Nhi P. Ta
Hassan Tabaie
Hao Tang
Ahmed N. Tantawi
Steven R. Taylor
Geoffrey O. Thompson
Nathal Tobol
Robert Tripi
L. David Umbaugh
Thomas A. Varetoni
James T. Vorhies
Richard S. Walker
Donald J. Ware
Donald F. Weir
Raymond Wenig
Thomas P. Wiggen
Michael Willett
Paul A. Willis
George B. Wright
Oren Yuen
Wei Zhao
Jen-Kun Yang

## Contents

IEEE Standards for
Local and Metropolitan Area Networks:

**Supplement to Token Ring Access Method and Physical Layer Specifications**

# Recommended Practice for Dual Ring Operation with Wrapback Reconfiguration

## 1. Overview

This document defines extensions to IEEE Std 802.5, IEEE Standards for Local and Metropolitan Area Networks: Token Ring Access Method and Physical Layer Specifications, which implements a Dual Ring LAN topology having the following features:

(1) Full interoperability between stations conforming to IEEE Std 802.5, including coexistence on the same ring.
(2) Recovery from all single media failures with full capability restored.

**1.1 Introduction.** The Dual Ring topology and operation described within this document is intended for applications that require very high availability and recovery from media and station failures.

The Dual Ring topology is illustrated in Fig 1-1. Two individual (counter-rotating) Token-Passing Rings provide the interconnection for both Dual Ring and Single Ring stations. Counter-rotating rings are defined where the upstream neighbor of a station on one ring is the downstream neighbor of that station on the other ring. One of the Token-Passing Rings is designated as the Primary Ring and the other is designated as the Secondary Ring.

The Primary Ring is normally the operational ring.When the Primary Ring is operational, no data other than Medium Access Control (MAC) frames can flow on the Secondary Ring. Also, recovery requiring reconfiguration is not initiated for a failure on the Secondary Ring if the Primary Ring is operational.

Single Ring stations can only be connected to the Primary Ring through a Trunk Coupling Unit (TCU) and operate exactly as specified in IEEE Std 802.5.

Dual Ring stations are connected to their neighboring Dual Ring stations on both the Primary and Secondary Rings through two TCUs. Generally, each Dual Ring station contains two complete IEEE Std 802.5 interfaces and a Crosspoint Switching function controlled by a Dual Ring Management function.

Dual Ring reconfiguration employs “Wrapback” to provide for recovery from all forms of signal loss failures and from trunk line media failures

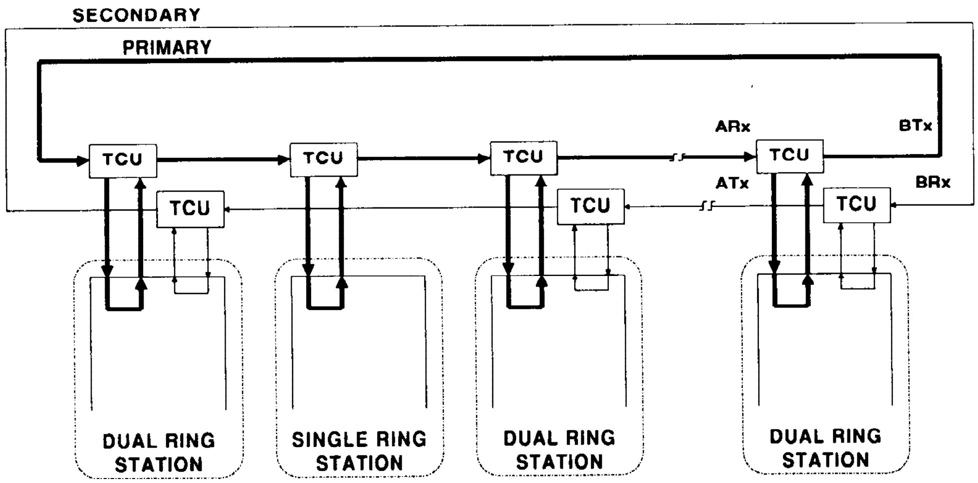



**Fig 1-1**
**Dual Ring Architecture**

not covered by IEEE Std 802.5-1989. (These failures are referred to as "Break Conditions" in this document.) The secondary MAC never transmits LLC frames in any of the Dual Ring configurations; thus, extensions such as bridging are not affected by Dual Ring operation. The Wrapback method restores normal operation by interconnecting the two rings on each side of the failure (see Fig 1-2). This results in a single ring being formed from the remaining good parts of the original two rings (but with the failed link, or node, absent). A reconfigured ring is comprised of the following:

(1) One station in WRAPA (Primary Receive (ARx) connected to the Secondary Transmit (ATx)).

(2) One station in WRAPB (Secondary Receive (BRx) connected to the Primary Transmit (BTx)).

(3) The remaining intervening stations in Normal (Primary and Second-ary Receive (ARx, BRx) connected to the Primary and Secondary Transmit (BTx, ATx), respectively).

**1.2 Definitions.** The following definitions, in addition to those contained in IEEE Std 802.5, are used in this recommended practice:

**Beacon Reconfigure (BNR).** A beacon (Type 1) used in the reconfiguration protocols.

**Break Indication.** The state where the Physical Layer (PHY) is unable to recover data from the incoming signal, or the incoming signal power level is less than a defined threshold.

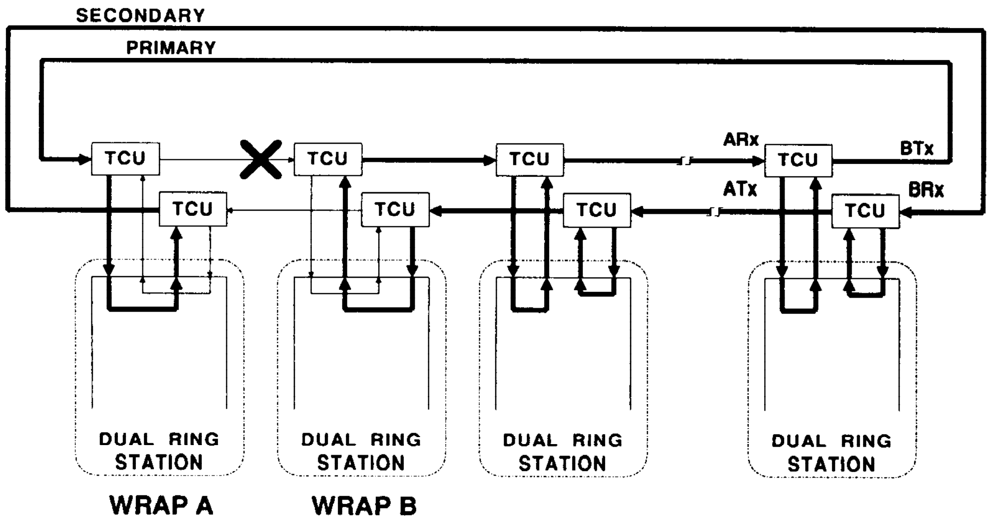



**Fig 1-2**
**Failure Recovery by Wrapback**

**Crosspoint Switch.** A switching function that provides normal connections, wrap connections, breaks in the transmit, and local loopback for lobe testing in the wrap mode.

**Dual Ring.** A topology (such as that shown in Fig 1-1) in which stations are linked by link pairs and, from any one station to another, there are exactly two distinct paths, where a path is defined as a sequence of consecutive links in which no link pair is traversed more than once.

**Dual Ring Management.** The management functions of a Dual Ring station responsible for Dual Ring reconfiguration.

**Dual Ring station.** A station that attaches link pairs that have opposite directions of data flow with respect to the adjacent Dual Ring stations. It consists of two MACs, a crosspoint function, and Dual Ring Management. It may have other attachments.

**link.** A unidirectional physical and media connection between two stations.

**link pair.** A pair of links going in opposite directions between two stations.

**merging.** Reconfiguration function that involves Dual Ring stations ceasing to use contra-rotating links in favor of a restored link or station.

**Primary Ring.** In a Dual Ring, this is the ring over which application data (LLC frames) are exchanged during normal operation. MAC1, which transmits the application data, is attached to the Primary Ring. When a Dual

Ring station is in either WRAPA or WRAPB, MAC1 is switched to remain in the operational section of the wrapped ring. The Primary Ring uses the links ARx and BTx in each Dual Ring station.

**reconfiguration.** A change of the path around which the token that is used for normal data transfer circulates.

**Reconfiguration Management.** The management functions responsible for reconfiguration.This includes both Dual Ring Management and any other management required for reconfiguration.

**Secondary Ring.** The alternate paths of the Dual Ring that are not normally connected to MAC1. It uses links BRx and ATx. Application data may be transmitted on this ring, but not when the Primary Ring is being used for transmitting application data.

**Single Ring station.** A station that offers one attachment to the network on the Primary Ring.

**Wrapping.** Reconfiguration function that involves Dual Ring stations using contra-rotating links to avoid a failed link or node.

**1.3 Abbreviations and Symbols**. The following abbreviations and symbols, in addition to those contained in IEEE Std 802.5, are used in this recommended practice. The underlined x indicates that the x shall be replaced by the appropriate numerical value:

| | |
|---|---|
| AMP<u>x</u> | MAC(1 or 2) generated Active Monitor Present signal |
| BCN | Any beacon (Type 1, 2, 3, or 4) |
| BNN | Beacon Normal (Type 2, 3, or 4) |
| BNR | Beacon Reconfigure (Type 1) |
| DRCF | Dual Ring Crosspoint function |
| DRFSM | Dual Ring Finite State Machine |
| D<u>x</u> | Dual Ring Finite State Machine state |
| FSM | Finite State Machine |
| MAC<u>x</u> I | MAC(1 or 2) generated insert signal |
| MBF<u>x</u> | MAC Break Flag (MAC1 or 2) |
| MIF | Management Interlock Flag |
| MPF | Merge Permission Flag |
| RBNN<u>x</u> | MAC(1 or 2) Receive Beacon Normal |
| RBNR<u>x</u> | MAC(1 or 2) Receive Beacon Reconfigure |
| RBPWRS | Repeat BNRs on Primary and wait for reconfiguration to stabilize |
| TBNN<u>x</u> | MAC(1 or 2) generated Transmit Beacon Normal |
| TBNR<u>x</u> | MAC(1 or 2) generated Transmit Beacon Reconfigure |
| TCLT<u>x</u> | MAC(1 or 2) generated Transmit Claim Token |
| TBF<u>x</u> | MAC Transmit BNR Enable Flag |
| TB<u>x</u> | TCU Bypass Insert signal, Primary (1) and Secondary (2) |
| TD<u>x</u> | Timer, Dual Ring, State D<u>x</u> |

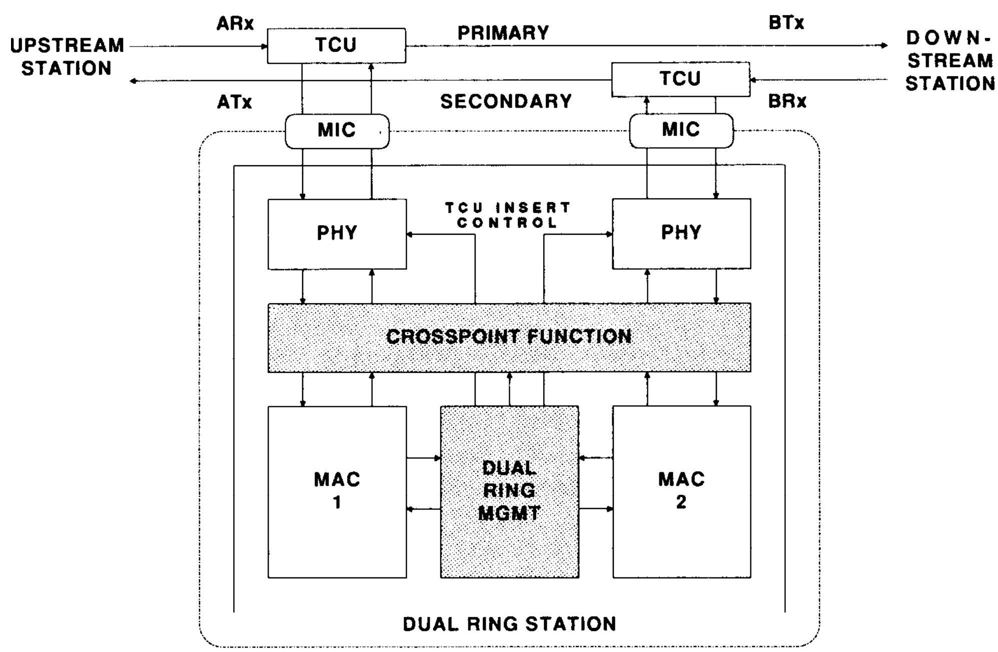
| | |
|---|---|
| Time_TDx | Time interval for Timer, Dual Ring, State Dx |
| TPWBNR | Transmit BNR on Primary and wait for BNR |
| TSWBNR | Transmit BNR on Secondary and wait for BNR |
| XA | Break, Primary Ring receive |
| XB | Break, Secondary Ring receive |

# 2. Dual Ring Station Definition

This section defines the functional elements of the Dual Ring station and their interrelationships. The functional architecture of the Dual Ring station is illustrated in Fig 2-1.

A Dual Ring station is connected to its neighboring Dual Ring stations on both the Primary and Secondary Rings. The connection to either neighboring Dual Ring station is defined as a link pair. The "A" link pair contains the Primary Ring Receive (ARx) from, and Secondary Ring Transmit (ATx) to, the upstream neighbor. The "B" link pair contains the Primary Ring Transmit (BTx) to, and the Secondary Ring Receive (BRx) from, the downstream neighbor. Upstream or downstream is defined with respect to the direction of signals transmitted on the Primary Ring.

**Fig 2-1**
**Dual Ring Station Functional Partitioning**



A Dual Ring station contains the following functional components:

(1) *Trunk Coupling Unit (TCU)*. Each Dual Ring station contains two TCUs; one for the Primary Ring and another for the Secondary Ring. Each TCU operates as an independent bypass function (as defined in IEEE Std 802.5) with Insert/De-insert signals provided by the Physical Layer (PHY) of the Dual Ring station. The TCUs are not required to be physically part of the station and the MIC interface of IEEE Std 802.5 is unchanged.

(2) *Physical Layer (PHY)*. Each Dual Ring station contains two IEEE Std 802.5 Physical Layers; one for the Primary Ring and one for the Secondary Ring.

(3) *Dual Ring Crosspoint Function (DRCF)*. The Dual Ring Crosspoint function is controlled by the state of the Dual Ring Management Function Finite State Machine and provides connections between the Media Access Controllers and the Physical Layers (PHYs) as shown in Fig 2-2. The settings of the DRCF for State WRAPA is shown in Fig 2-3. The Crosspoint function has three subfunctions:

(a) *Wrap Switches*. Allow for normal connections of the MACs and the ring signals or two modes of Wrapping:

| | | |
|---|---|---|
| Normal | ARx > MAC1 > BTx | BRx > MAC2 > ATx |
| WRAPA | ARx > MAC1 > ATx | BRx > MAC2 > BTx |
| WRAPB | BRx > MAC1 > BTx | ARx > MAC2 > ATx |

(b) *Break Switch*. Allows for independent breaking of the Secondary Ring Transmit (ATx) data path.

(c) *Internal Bypass Switches*. Allow for local loopback to the MAC when it enters the bypass state and performs a subsequent lobe test. This capability of the DRCF is not specifically required for compatibility with the IEEE Std 802.5 Active and Standby Monitor state machines. The bypass function, which continues the received signal to the output, is not necessary for the Dual Ring operation.

(4) *Media Access Control (MACx)*. Each Dual Ring station contains two complete IEEE Std 802.5 Media Access Control (MAC) functions with modifications as defined in this document. MAC1 performs the normal functions of data transfer. MAC2 provides a means of transferring suitable signals along the links not used by MAC1 for the purpose of Dual Ring failure detection and recovery.

(5) *Dual Ring Management (DRM)*. Each Dual Ring station contains one Dual Ring Management function. This function provides for Break Detection on both the Primary (ARx) and Secondary (BRx) rings. It responds to detected Break Conditions or ring beaconing conditions and, if necessary, utilizes the Crosspoint function to invoke the WRAPx recovery procedures.

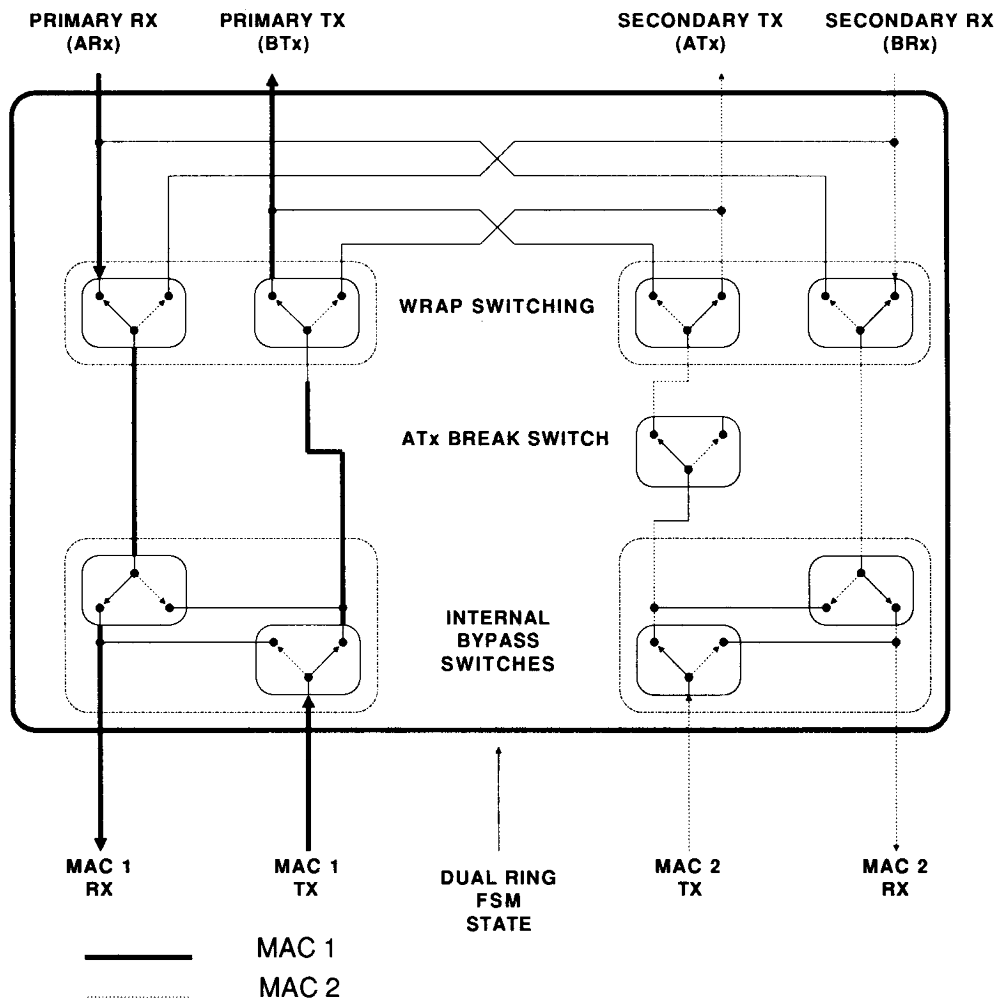



**Fig 2-2**
**Dual Ring Crosspoint Function Abstract Definition**

It should be noted that this functional architecture does not constrain the actual implementation to utilizing two physical MACs or to providing separate Dual Ring Management function. The implementation of the Dual Ring station is dependent upon the signal transmission paths that are provided.

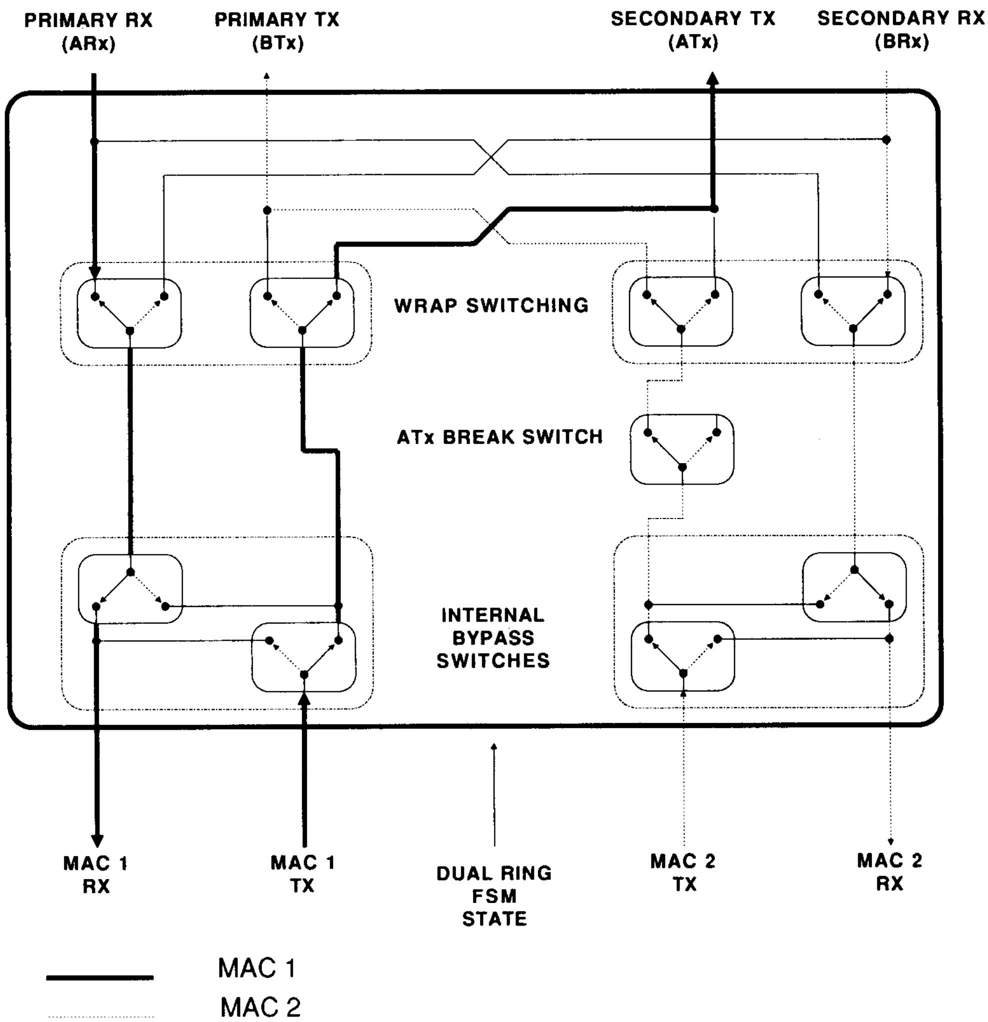



**Fig 2-3**
**Dual Ring Crosspoint Function Abstract Definition in WRAPA State**

# 3. Dual Ring Reconfiguration

During normal operation in a Dual Ring system, data is passed on the Primary Ring. The Secondary Ring is operational with tokens circulating. The Primary and Secondary Rings should not be used simultaneously for data transmission unless two Dual Ring stations are in the wrapped state (i.e., a break has been detected on the Primary Ring).

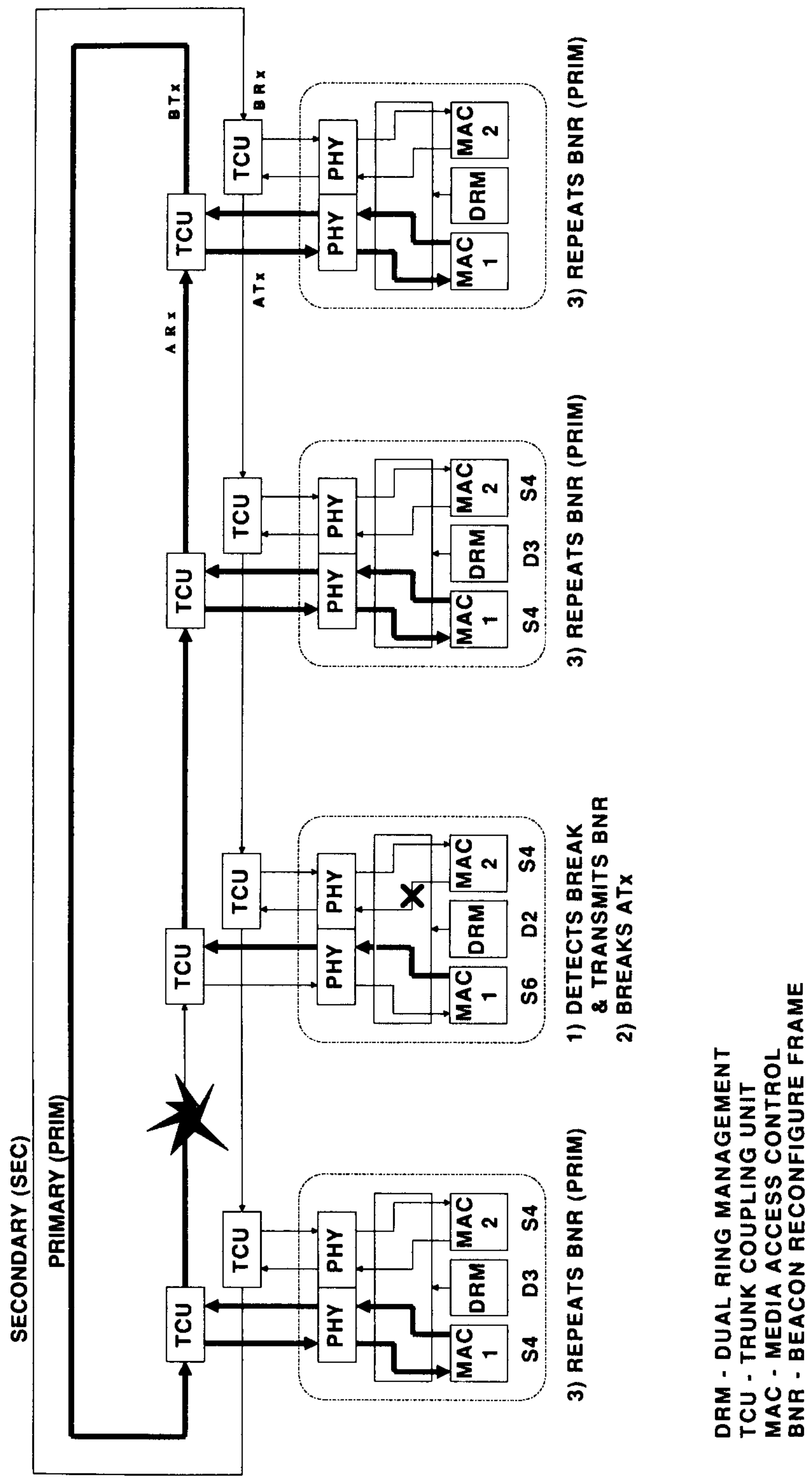
If any failure occurs on the Secondary Ring (while the Primary Ring is still operational), the existing IEEE Std 802.5 MAC layer recovery procedures are in effect. If the failure was due to a lobe, Physical Layer (PHY), or MAC fault, then normal IEEE Std 802.5 recovery procedures will result in removal of the faulted station and full recovery of the Secondary Ring. Otherwise, the Secondary Ring will continue to Beacon. (MAC Layer Management reports this condition.)

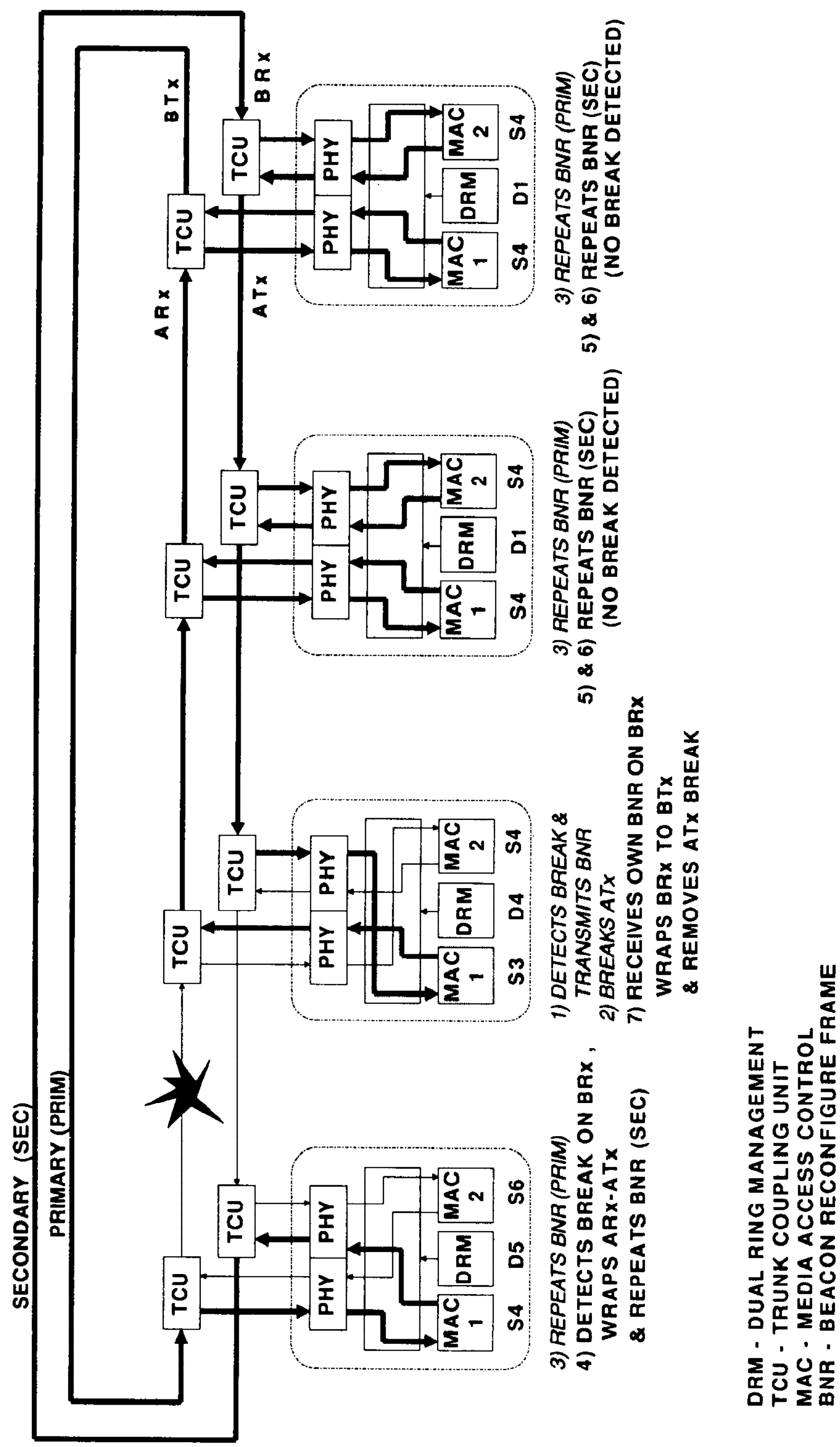
All Primary Ring failures, except Break and Claim Token Failure, are handled by the existing IEEE Std 802.5 MAC Layer recovery procedures. Break and Claim Token Failure cause the Dual Ring Management function to leave the Normal (Idle) state. If one of these failures occurs on the Primary Ring, the Dual Ring Management functions will be invoked to reconfigure the network. A simplified description of how the Dual Ring Management algorithm recovers from a Break Condition is illustrated in the following narrative (subparagraph numbers are keyed to Fig 3-1 in which FSM states and the important state transitions are shown):

(1) The Dual Ring station that either detects the Break Condition or receives Beacon Normal (BNN) Frames begins transmitting Beacon Reconfigure (BNR) frames on the Primary Ring. Beacon normal (BNN) frames would be received by the station if the upstream station were either a Single Ring station or a Dual Ring station that was already in a wrapped state. These frames notify the downstream stations that a failure has occurred that requires Wrapback reconfiguration.

(2) The Dual Ring station that detected the Break Condition also induces a break on the Secondary Ring at its transmitter (ATx). This Break Condition and the receipt of Beacon Reconfigure frames on the Primary Ring will ultimately trigger the upstream station to enter the WRAPA state.

(3) The Beacon Reconfigure frames on the Primary Ring will be repeated by each station. This feature is implemented by the current IEEE Std 802.5 Standby/Active Monitor Finite State Machines (FSMs).


SECONDARY (SEC)
PRIMARY (PRIM)
TCU
PHY
MAC 1
MAC 2
DRM
ARx
ATx
BTx
BRx
S4 D3 S4
S6 D2 S4
3) REPEATS BNR (PRIM)
1) DETECTS BREAK
& TRANSMITS BNR
2) BREAKS ATx
3) REPEATS BNR (PRIM)
3) REPEATS BNR (PRIM)
DRM - DUAL RING MANAGEMENT
TCU - TRUNK COUPLING UNIT
MAC - MEDIA ACCESS CONTROL
BNR - BEACON RECONFIGURE FRAME


SECONDARY (SEC)
PRIMARY (PRIM)
A Rx
B Tx
A Tx
B Rx
TCU
PHY
MAC 1
MAC 2
DRM
S4 D5 S6
S3 D4 S4
S4 D1 S4
S4 D1 S4
3) REPEATS BNR (PRIM)
4) DETECTS BREAK ON BRx ,
WRAPS ARx-ATx
& REPEATS BNR (SEC)
1) DETECTS BREAK &
TRANSMITS BNR
2) BREAKS ATx
7) RECEIVES OWN BNR ON BRx
WRAPS BRx TO BTx
& REMOVES ATx BREAK
3) REPEATS BNR (PRIM)
5) & 6) REPEATS BNR (SEC)
(NO BREAK DETECTED)
3) REPEATS BNR (PRIM)
5) & 6) REPEATS BNR (SEC)
(NO BREAK DETECTED)
DRM - DUAL RING MANAGEMENT
TCU - TRUNK COUPLING UNIT
MAC - MEDIA ACCESS CONTROL
BNR - BEACON RECONFIGURE FRAME

(4) When a station receives Beacon Reconfigure frames on the Primary Ring and also has a Break Condition present on the Secondary Ring, it will enter the WRAPA state. In this state, the Primary Ring receive is coupled to the Secondary Ring transmit (ARx > MAC1 > ATx) thus providing a Wrapping path. The Beacon Reconfigure frames being received on the Primary Ring are then repeated through the WRAPA onto the Secondary Ring. This station also attaches MAC2 to the Secondary Ring receive and the Primary Ring transmit (BRx > MAC2 > BTx) for the purpose of monitoring for recovery from the break on the Secondary Ring.

When a station receives Beacon Reconfigure frames on the Primary Ring and has not detected a Break Condition on the Secondary Ring, then after a timeout, the station transmits Beacon Reconfigure frames on the Secondary Ring to identify the WRAPA station. When the WRAPA station is identified, then that station enters WRAPA.

(5) The Beacon Reconfigure frames, now present on the Secondary Ring (due to the WRAPA condition), will be repeated by each station.

(6) Stations that do not detect a Break Condition on the Secondary Ring do not go into WRAPA, since these stations are not adjacent to the failure.

(7) When the station originating the Beacon Reconfigure frames detects the return of these frames (Beacon Source address matches this station's MAC1 address) on the Secondary Ring, it will enter into the WRAPB state. In this state, the Secondary Receive is coupled through MAC1 to the Primary Transmit (BRx > MAC1 > BTx) which results in a closed ring made up of the good Primary and Secondary Ring segments. At this point, the existing IEEE Std 802.5 MAC Layer recovery procedures will restablish an operational ring. The WRAPB station also removes the Break Condition on its ATx and attaches the Primary Ring receive through MAC2 to the Secondary Ring transmit (ARx > MAC2 > ATx) for the purpose of monitoring for the recovery from the Break Condition on the Primary Ring.

If the media failure is subsequently repaired, then the normal IEEE Std 802.5 MAC Layer recovery procedures will result in the formation of a working ring between the two Wrapping stations. If the Merge Permission Flag (MPF) is set, the Dual Ring Management function will return the Crosspoint function to the unwrapped state. The MPF that authorizes the two wrapped stations to unwrap is controlled by Station Management.

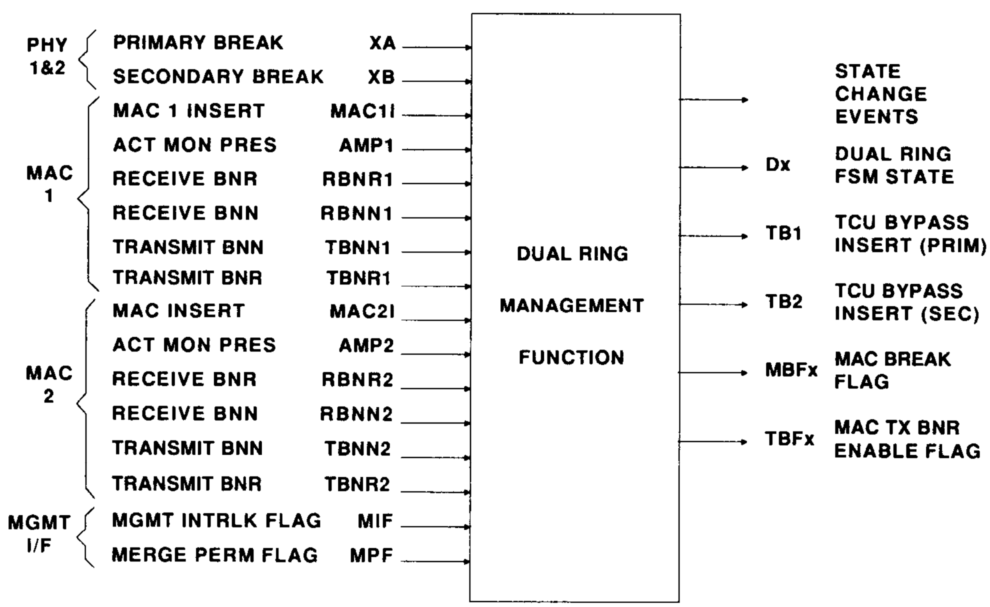
Claim Token Failures are handled similarily, with the exception that the failure condition is localized to the failed link before reconfiguring.

Multiple failures will cause additional Wrapbacks, but in all cases the Wrapback reconfiguration method constructs the largest possible operating ring. Subrings may arise when the Primary and Secondary Rings have breaks that are in nonaligned segments. Communication does not occur between subrings, but communication is normal for all stations in any single subring.

# 4. Dual Ring Management Function

The Dual Ring Management function (see Fig 4-1) accepts Management, MAC Beacon/AMP Indication, and Physical Break Indication inputs. These inputs, along with internal timers, states, and variables in the Dual Ring Management function, drive the Dual Ring Finite State Machine (DRFSM) that generates control signals for the Crosspoint function and the TCU Bypass functions. These controls provide for lobe testing and attachment of the MAC functions to the Primary and Secondary Ring segments. MAC1 is always connected to the ring on which data is being transferred. MAC2 provides a means of transferring signals along the other links.

**Fig 4-1**
**DRFSM Inputs/Outputs**



The operation of the Dual Ring Management function is described in the following five separate sections:

(1) Dual Ring Management Function Inputs (4.1).
(2) Dual Ring Management Function Variables (4.2).
(3) Dual Ring Management Function Timers (4.3).
(4) Dual Ring Management Function FSM (4.4).
(5) Dual Ring Management Function Outputs (4.5).

**4.1 Dual Ring Management Function Inputs.** The Dual Ring Management function receives the following inputs:

(1) Break Indication (XA, XB)
(2) MAC Insert Indication (MAC<u>x</u>I)
(3) Active Monitor Present Indication (AMP<u>x</u>)
(4) Receive Beacon Reconfigure Indication (RBNR<u>x</u>)
(5) Receive Beacon Normal Indication (RBNN<u>x</u>)
(6) Transmit Beacon Normal Indication (TBNN<u>x</u>)
(7) Transmit Beacon Reconfigure Indication (TBNR<u>x</u>)
(8) Management Interlock Flag (MIF) Value
(9) Merge Permission Flag (MPF) Value

**4.1.1 Break Indication.** The DRFSM can recover from failures with or without detecting breaks on the ring. If fast recovery is not required, the features already present in IEEE Std 802.5 may be used to detect failures on the ring. If fast recovery is required, the following Break Detection mechanism should be used.

The Break Indication initiates the Dual Ring reconfiguration actions if permitted by the Management Entity. A Break Indication may be detected on either the Primary Ring (XA) or the Secondary Ring (XB). Although the Break Indication is identified as part of the PHY Layer, additional logic required for this function is part of the Dual Ring implemention.

A wide variety of specific implementations for Break Detection are possible, depending on the level of technology applied, and the required responsiveness of the application. In this document, one set of Break Indication criteria and its timing requirements are defined. Since almost all breaks are eventually indicated by protocol errors at the MAC level, a specific implementation may choose to “enhance” this Break Indication with other information. Other implementations which provide faster or more precise Break Detection should be interoperable with this recommended practice.

The Break Indication is defined as the state where the Physical Layer (PHY) is unable to recover data from the incoming signal or the incoming signal power level is less than a defined threshold.

Specifically, the Break Indication is defined by the following formula:

XA, XB = FREQ_HIGH & TBTDR_EXP | FREQ_LOW & TBTDR_EXP | THRESH_VIOL & TBTDR_EXP

where

FREQ_HIGH = Indication that the frequency of the incoming signal exceeds the allowed upper limit shown in Fig 4-2. The FREQ_HIGH Indication is guaranteed to be active if more than 256 rising transitions are detected in the received signal in any 64-bit time period (this corresponds to a frequency of 4 times the data rate (R)). The FREQ_HIGH Indication is guaranteed to be inactive if less than 128 rising transitions are detected in the received signal in any 64-bit time period (this corresponds to a frequency of 2R). For situations where the number of rising transitions is in the range of 128 to 256, the FREQ_HIGH Indication state may be active or inactive.

FREQ_LOW = Indication that the frequency of the incoming signal is less than the allowed lower limit as shown in Fig 4-2. The FREQ_LOW Indication is guaranteed to be active if less than 4 rising transitions are detected in the received signal in any 64-bit time period (this corresponds to a frequency of 0.0625R). The FREQ_ _LOW Indication is guaranteed to be inactive if more than 24 rising transitions are detected in the received signal in any 64-bit time period (this corresponds) to a frequency of 0.375R). For situations where the number of rising transition is in the range of 4 to 24, the FREQ_LOW Indication state may be active or inactive.

THRESH_VIOL = Indication that the incoming signal power level is less than the minimum acceptable power threshold established for Dual Ring operation. The defined range for operation of the threshold detector assumes a 150 Ω receiver impedance with input power levels as follows:

| Data Rate | Ptdmax | Ptdmin |
|---|---|---|
| 4 Mb/s | –15 dBm | –27 dBm |
| 16 Mb/s | –6 dBm | –18 dBm |

where

Ptdmax = The threshold violation detector may indicate a violation for power levels below Ptdmax and above Ptdmin.

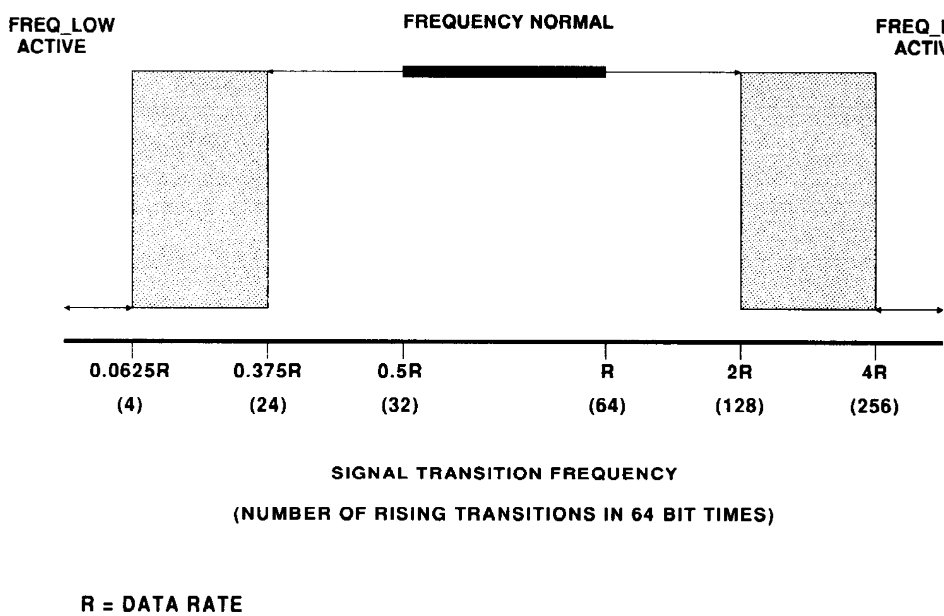
Ptdmin = The threshold violation detector must indicate a violation at, or below, this input power level.

TBTDR_EXP = Indication that Timer Break_Time_Dual_Ring (TBTDR) has expired. TBTDR is loaded and started whenever FREQ_HIGH, FREQ_LOW, or THRESH_VIOL go from inactive to active and the timer is not already counting. This timer is disabled when FREQ_HIGH, FREQ_LOW, or THRESH_VIOL are all inactive.

In order to define the system response time to Break Indications, the threshold Break_Time_Dual_Ring is associated with TBTDR. Break_Time_Dual_Ring is initialized to a value of 10 ms. This value may be changed through the Management Interface to the Dual Ring function subject to the constraint that the value requested should be within the range supported by that particular implementation.

**4.1.2 MAC Insert Control Indication.** The MACx Insert Indication (MACxI) occurs when a MAC wishes to be inserted into the active ring. The underlined x identifies which MAC(1 or 2) is being inserted into the active ring. This function of the MAC is not strictly defined by IEEE Std 802.5, but is included in this recommended practice because it is recognized as a generally accepted practice.

**Fig 4-2**
**Frequency Error Detection Criteria**



**4.1.3 Active Monitor Present Indication.** The Dual Ring Management function utilizes the Active Monitor Present (AMPx) Indication to signal that the MAC is participating on a functional ring with at least itself present on that ring. This indication is reported to the Dual Ring Management function by each MAC. It signifies that a good set of MAC(s) exist in a closed ring configuration. Normal transitions of the individual station FSMs have caused AMP and SMP frames to circulate on the ring. The underlined x identifies which MAC(1 or 2) is receiving the Active Monitor Present frame.

**4.1.4 Receive Beacon Reconfigure Indication**. The Receive Beacon Reconfigure MACx Indication (RBNRx) occurs when a MAC Beacon Frame of Type 1 (used by Dual Ring stations) for reconfiguration is received. Beacon Reconfigure is transmitted by a Dual Ring station on the Primary Ring to inform downstream stations (with respect to the Primary Ring) that a serious ring failure has been detected and reconfiguration is required. Beacon Reconfigure is transmitted on the Secondary Ring to inform upstream stations (with respect to the Primary Ring) that there is a functioning downstream station. The subscript x identifies which MAC(1 or 2) is receiving the Beacon Reconfigure frame.

**4.1.5 Receive Beacon Normal Indication**. The Receive Beacon Normal MACx Indication (RBNNx) occurs when a MAC Beacon Frame of Type 2, 3, or 4 is received. Beacon Normal is the standard IEEE Std 802.5 frame transmitted by a Single Ring station (or a Dual Ring station with the MIF reset) to inform downstream stations that a serious ring failure has been detected and reconfiguration is required. Beacon Normal may occur on either the Primary or Secondary Ring. When it occurs in the Primary Ring, the first Dual Ring station that has its MIF set will transmit Beacon Reconfigure frames. (This is done in the MAC FSMs). This station will also become the WRAPB station when the Dual Ring reconfiguration is completed. The subscript x identifies which MAC(1 or 2) is receiving the Beacon Normal frame.

**4.1.6 Transmit Beacon Reconfigure Indication**. The Transmit Beacon Reconfigure Indication (TBNRx) occurs when a MAC is transmitting a Beacon Frame of Type 1. Beacon Reconfigure is transmitted by a Dual Ring station with the MIF set to inform downstream stations that a serious ring failure has been detected and reconfiguration is required. Beacon Reconfigure may be transmitted on either the Primary or Secondary Ring. The subscript x identifies which MAC(1 or 2) is transmitting the Beacon Reconfigure frame.

**4.1.7 Management Interlock Flag (MIF) Value**. The MIF Value is provided to the Dual Ring Management function through the Management Interface and stored in the local variable MIF. The Dual Ring Management function also senses changes in MIF (MIF_RST and MIF_SET). If MIF is set and the relevant Break Indication occurs, the reconfiguration process will be allowed to proceed. If the MIF is reset in states D5, D6, or D7, the DRFSM will return to State D1: NORMal.

**4.1.8 Merge Permission Flag (MPF) Value.** The MPF Value is provided to the Dual Ring Management function through the Management Interface. The Dual Ring Management function retains the MPF Value in the local variable

MPF. If the MPF is set, and the relevant Active Monitor Present Indication occurs, the merge process will be allowed to proceed.

**4.2 Dual Ring Management Function Variables.** The Dual Ring Management function employs the following internal variables:

(1) *Management Interlock Flag (MIF).* MIF is controlled via the Management Interface. When this flag is set it is permissible for the Dual Ring Management function to perform reconfiguration to either the WRAP or ISOLated states. MIF will initialize to the Reset (0) state upon Master Clear and remain in that state until changed by an LM_SET_VALUE commmand received from the Management Interface.

(2) *Merge Permission Flag (MPF).* MPF is controlled via the Management Interface. When this flag is set, it is permissible for the Dual Ring Management function to perform a merge from ISOLated to WRAPx or WRAPx to NORMal states. MPF will initialize to the Reset (0) state upon Master Clear and remain in that state until changed by an LM_SET_VALUE commmand received at the Management Interface.

**4.3 Dual Ring Management Function Timers.** The Dual Ring Management Function Timers defined in this section are part of the Dual Ring Management function. Each is defined as a countdown timer that can be loaded with an initial value from which it will count down to 0. When the timer count reaches 0, the timer ceases counting and indicates that it has “expired.” The expired condition is generated by the transition from a count of 1 to a count of 0, not by the existence of a 0 value in the counter. Resetting a counter will not cause an “expired condition.” Each timer is identified by the state in which it may be active (TDx—where x is the DRFSM state). Each timer has the following states associated with it:

(1) TDx_DIS. Indicates that Timer TDx is at the zero count. This is the condition that exists when a timer is reset or when a timer has expired.

(2) TDx_ACT. Indicates that Timer TDx is actively counting and has not expired.

(3) TDx_EXP. Indicates that Timer TDx has transitioned from a count of 1 to a count of 0 and therefore expired.

The timer states are internal inputs to the Dual Ring Management function. It should be noted that a real implementation might only implement one counting device since only one of these timers is active at any time. The following timers are defined for the DRFSM.

NOTE: The recommended values for the timers are for fast reconfiguration. In some applications, other values may be more suitable.

(a) TD1A. Timer TD1A is used to hold the DRFSM in State D1 until sufficient time has elapsed for the farthest upstream station to begin transmitting Beacon Reconfigure frames. The initial value to which it is set should be [Time_TD1A]. The recommended value for [Time_TD1A] is 20 ms.

(b) TD1B. Timer TD1B is used to hold the DRFSM in State D1 after it has returned from State D3. This prevents oscillation between States D1 and D3. The initial value to which it is set should be [Time_TD1B]. It is recommended that [Time_TD1B] > the anticipated worst-case reconfiguration time. The recommended value for [Time_TD1B] is 5000 ms.

(c) TD2. Timer TD2 controls the amount of time which the Beaconing station waits for a downstream station to communicate with it ( i.e., for a downstream station to enter into WRAPA and return the Beacon Reconfigure frames on the Secondary Ring). TD2 is initialized to [Time_TD2] upon entry into State D2. The recommended value for [Time_TD2] is 120 ms.

(d) TD3. Timer TD3 controls the amount of time which stations receiving Beacon Reconfigure frames on the Primary will wait for the farthest upstream station to begin transmitting Beacon Reconfigure Frames. When this timer expires the station assumes that the farthest upstream station has entered State D2: TPWBNR. The station then enters State D4:TSWBNR. TD3 is initialized to [Time_TD3] upon entry into State D3.It is recommended that [Time_TD3] be set to approximately twice [Time_TD1A]. The recommended value for [Time_TD3] is 40 ms.

(e) TD4. Timer TD4 controls the amount of time which stations receiving Beacon Reconfigure frames on the Primary will wait for a Secondary Ring Break or Secondary Ring Beacon Reconfigure Receive condition. When this timer expires the station assumes that it is the dual attachment station nearest to the Primary Ring Break on the upstream side. The station then enters State D6: WRAPA. TD4 is initialized to [Time_TD4] upon entry into State D4. The recommended value for [Time_TD4] is 20 ms.

(f) TD5. Timer TD5 is used to detect a MAC level failure of the downstream neighbor link (with respect to the Primary Ring) when the station is in WRAPB. This timer is loaded and started if it is not already active and a Beacon Normal (BNN) frame is received by MAC1. If this timer expires the remaining active ring is broken and the DRFSM enters the ISOLated state. The initial value of this timer is [Time_TD5]. It is recommended that [Time_TD5] = [Time_TD6]. The recommended value for [Time_TD5] is 120 ms.

(g) TD6. Timer TD6 is used to detect a MAC level failure of the upstream neighbor link (with respect to the Secondary Ring) when the station is in WRAPA. This timer is loaded and started if it is not already active and a Beacon Normal (BNN) frame is received by MAC1. If this timer expires there maining active ring is broken and the DRFSM enters the ISOLated state.The initial value of this timer is [Time_TD6]. The recommended value for [Time_TD6] is 120 ms.

(h) TBTDR. Timer Break Time Dual Ring is is loaded and started whenever FREQ_HIGH, FREQ_LOW, or THRESH_VIOL go from inactive to active and the timer is not already counting. This timer is disabled when FREQ_HIGH, FREQ_LOW, or THRESH_VIOL are all inactive. When TBTDR expires, a Break Condition is generated. Since TBTDR can be active in any state, the standard naming convention is not used. The initial value of TBTDR is Break_Time_Dual_Ring. The recommended value for Break_Time_Dual_Ring is 10 ms.

**4.4 Dual Ring Management Function Finite State Machine**. The DRFSM is shown in Fig 4-3. The legend for Fig 4-3 is provided in Table 4-1. The description of this state machine is provided in the following paragraphs. States are identified by labels of Dx where the x identifies the state number. State transitions use the following labeling conventions:

D(xyz)

where

D = a DRFSM transition
x = the current state
y = the next state
z = a sub-vector alpha discriminator used to differentiate between transitions between the same two states

The Dual Ring Management MAC Break Flag and MAC Transmit Beacon Reconfigure Flag outputs (defined in 4.5) are derived from the DRFSM states. The value of these flags in each state are provided in Fig 4-3 for clarity. The following convention is used in the figure:

[MBF1, MBF2, TBFx]

where

MBF1 = the value of MBF1
MBF2 = the value of MBF2
TBFx = the value of TBF1 and TBF2

An example of this convention is the following, which are the values of these flags for State D1:

[XA & MIF, XB & MIF, MIF]

When MIF is set, the value of MBF1 is the state of the Break Indication on the Primary Ring. The value of MBF2 is the state of the Break Indication on the Secondary Ring. The value of TBF1 and TBF2 is one. When MIF is not set, the value of MPF1, MBF2, TBF1, and TBF2 is zero.

**4.4.1 State D0: PASS.** State D0 is the PASS state. It is entered when the station power is off, the station has a fatal internal fault, or is performing self-tests. The DRFSM unconditionally deactivates the TCU Bypass function

**Table 4-1**
**DRFSM Transition Diagram Legend**

| Symbol | Definition |
|---|---|
| ACT | Timer Counting |
| EXP | Timer Expired |
| LS | Load and Start |
| MAC | Media Access Control |
| MIF | Management Interlock Flag |
| MPF | Merge Permission Flag |
| RBNN | Receive Beacon Normal |
| RBNR | Receive Beacon Reconfigure |
| RST | Reset |
| SA | Source Address |
| TBNN | Transmit Beacon Normal |
| TBNR | Transmit Beacon Reconfigure |
| TDx | Timer, Dual Ring State x |
| XA | Break, Primary Ring |
| XB | Break, Secondary Ring |
| / | Logical "INVERT" |
| & | Logical "AND" |
| v | Logical "OR" |

(causing station bypass) in this state so that neither MAC1 nor MAC2 interfere with the signals on either the Primary or Secondary Rings. Signals received from ARx are passed directly to BTx and signals received from BRx are passed directly to ATx through their respective TCUs. The station local tests must pass in order to leave this state. State transitions out of State D0 should occur as follows:

(D01a): If all local tests pass, then a transition is made to State D1: NORMal. Timers TD1A and TD1B are reset.

**4.4.2 State D1: NORMal.** State D1 is the NORMal (non-wrapped) operating state of the DRFSM. When the DRFSM is in this state, the Crosspoint function connects MAC1 to the Primary Ring (ARx > MAC1 > BTX) and MAC2 to the Secondary Ring (BRx > MAC2 > ATx).

NOTE: When transitions D11a, D12a, and D12b occur, MAC1 is transmitting BNR on the Primary Ring (BTx) because the MAC Standby Monitor FSM will have transitioned to State S6.

State transitions should occur as follows:

(D11a) If a Transmit Beacon Reconfigure MAC1 (TBNR1) Indication or a Receive Beacon Normal MAC1 (RBNN1) Indication occurs and TD1A is disabled and MIF is set, then TD1A should be loaded with [Time_TD1A] and started. The station should remain in State D1:NORMal. TD1A allows time for the upstream stations to recognize the Break Condition and begin transmitting BNRs.

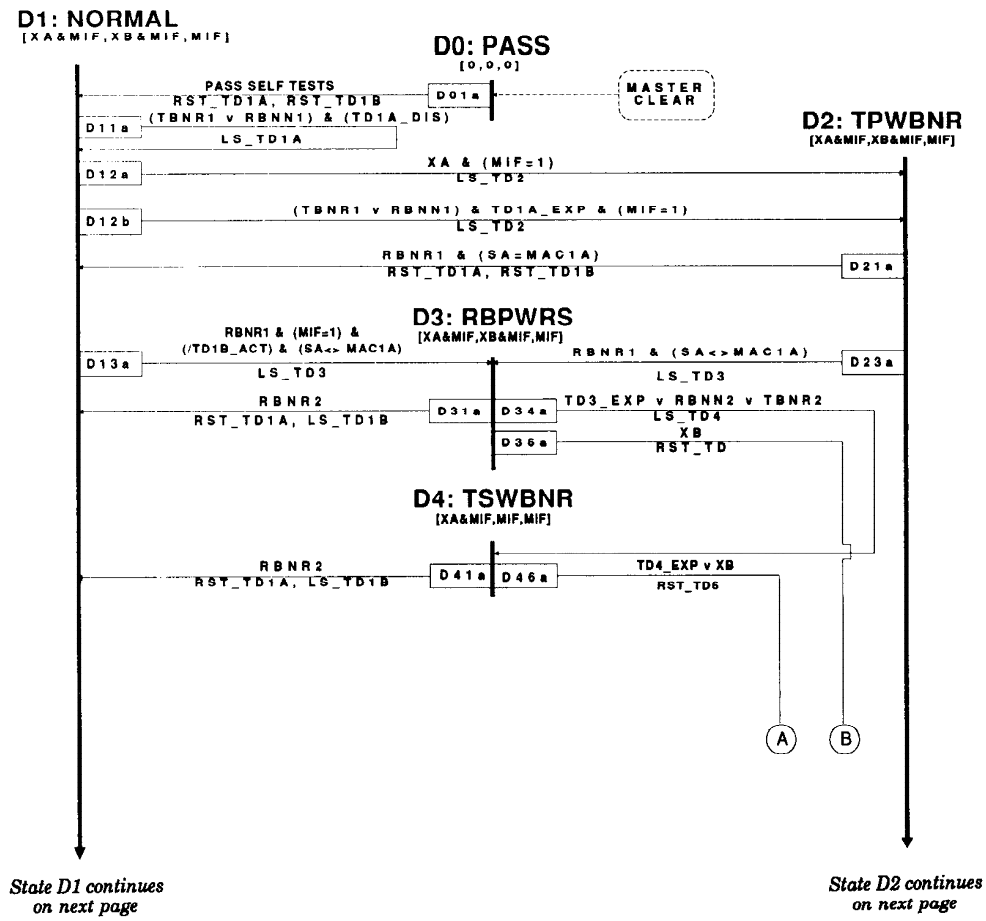



**Fig 4-3**
**DRFSM Transition Diagram (page 1 of 2)**

(D12a): If a Break Indication is received for ARx (XA) and MIF is set, then a transition should be made to State D2: TPWBNR. Timer TD2 should be loaded with [Time_TD2] and started.

(D12b): If a Transmit Beacon Reconfigure MAC1 (TBNR1) Indication or a Receive Beacon Normal MAC1 (RBNN1) Indication occurs, TD1A has expired, and MIF is set, then the station should transition to State D2: TPWBNR. Timer TD2 should be loaded with [Time_TD2] and started.

(D13a): If a Receive Beacon Reconfigure MAC1 (RBNR1) Indication occurs, MIF is set, Timer TD1B is not active, and the source address in the BNR frame is not the MAC1 address, then a transition should be made to State D3: RBPWRS. Timer TD3 should be loaded with [Time_TD3] and started.

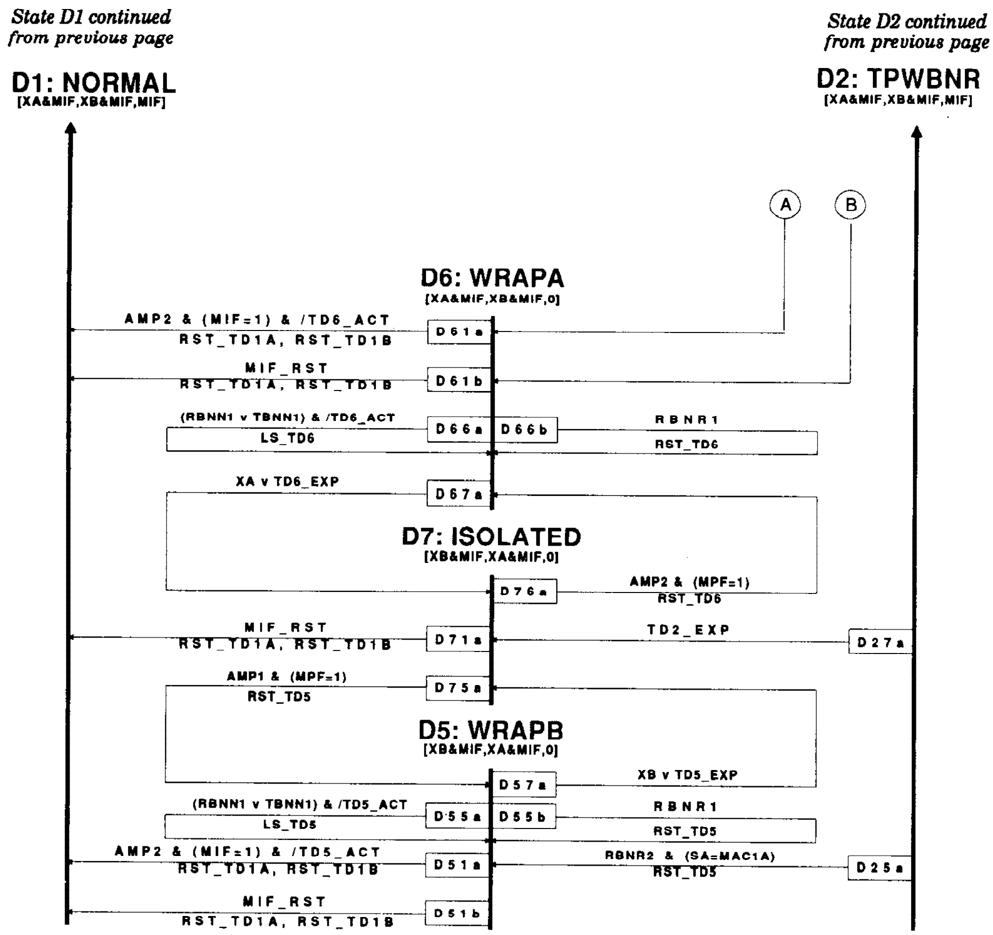



**Fig 4-3**
**DRFSM Transition Diagram (page 2 of 2)**

**4.4.3 State D2: TPWBNR.** In the Transmit BNR on Primary and Wait for BNR (TPWBNR) state, the DRFSM will continually transmit a BNR frame on BTx to notify all other stations on the ring that a serious ring problem in need of reconfiguration has been detected. The Crosspoint function connections for MAC1 remain the same as in State D1 (ARx > MAC1 > BTX). MAC2 is still connected to BRx and ATx (BRx >MAC2 > ATx) but whenever State D2 is active *a break is induced in the ATx path*. The break induced on ATx will signal to the upstream station (with respect to the Primary Ring) that a problem has been detected on the Primary that requires Dual Ring reconfiguration. The station will wait in this state for TD2 [set to Time_TD2] for a downstream station to enter into the WRAPA state and return the BNR frames on the Secondary Ring. While in State D2, a request by management to clear MIF will be processed but no transition to another state occurs. Transitions should occur as follows:

(D21a): If a Receive Beacon Reconfigure MAC1 (RBNR1) Indication occurs with the Source Address field equal to this station's MAC1 address (SA = MAC1A), then a transition should be made to State D1: NORMal. Timers TD1A and TD1B should be reset. An example of this situation would be a temporary break that is repaired by a station removing itself from the Primary Ring.

(D23a): If a Receive Beacon Reconfigure MAC1 (RBNR1) Indication occurs with the Source Address field not equal to this station's MAC1 address (SA <> MAC1A), then a transition should be made to State D3: RBPWRS. Timer TD3 should be loaded with [Time_TD3] and started.

(D25a): If a Receive Beacon Reconfigure MAC2 (RBNR2) Indication occurs with the Source Address field equal to the MAC1 Address (SA = MAC1A), then the downstream wrap (WRAPA) has successfully been performed. This DRFSM should transition to State D5: WRAPB. Timer TD5 should be reset.

(D27a): If a TD2-expired event occurs, then the DRFSM assumes there is no Dual Ring station downstream with which to communicate. Therefore, a transition should be made to State D7: ISOLated.

**4.4.4 State D3: RBPWRS**. In the Repeat BNR on Primary and wait for the reconfiguration to stabilize (RBPWRS) state, the DRFSM will wait for sufficient time for the farthest upstream station to enter State D2:TPWBNR. The DRFSM waits in this state for either a Break Indication on the Secondary (XB) or for TD3 to expire. The Break signals that this station is upstream of the fault on the Primary and it will enter WRAPA. The expiration of TD3 indicates that reconfiguration has stabilized and the farthest upstream station has inserted a break on the secondary and begun transmitting Beacon Reconfigure frames on the primary. This station enters TSWBNR in order to localize the WRAPA station. Receipt of a BNR on the secondary indicates that another station exists downstream (with respect to the Primary) that is capable of entering WRAPA, and this station can return to NORMal. The Crosspoint function connections are the same as in State D1 (ARx > MAC1 > BTX and BRx > MAC2 > ATx). While in State D3, a request by management to clear MIF will be processed, but no transition to another state occurs. State transitions should occur as follows:

(D31a): If a Receive Beacon Reconfigure MAC2 (RBNR2) Indication occurs, then a functioning downstream Dual Ring station has detected either the BNR frames on the Primary or an induced break on ATx (from it's downstream neighbor) and entered the WRAPA state. In this case, the local station is an intermediate Dual Ring station that does not have to perform a WRAPA or WRAPB action. Therefore, a transition should be made to State D1: NORMal. Timer TD1A should be reset. Timer TD1B should be loaded with [Time_TD1B] and started.

(D34a): If a TD3-expired event occurs, a Receive Beacon Normal MAC2 (RBNN2) indication occurs, or a Transmit Beacon Reconfigure MAC2 (TBNR2) indication occurs, a transition should be made to State D4: TSWBNR. Timer TD4 should beloaded with [Time_TD4] and started.

(D36a): If a Break Indication is detected on BRx (XB), a transition should be made to State D6: WRAPA. Timer TD6 should be reset.

**4.4.5 State D4: TSWBNR.** In the Transmit BNR on Secondary and Wait for BNR (TSWBNR) state, the DRFSM will force a Break Condition on the MAC2 FSM by activating the MAC2 Break Flag (MBF2). This flag is an input to MAC2. Setting MBF2 causes MAC2 to enter State S6 and transmit Beacon Reconfigure frames on the Secondary Ring if MAC2 is not already transmitting Beacon Reconfigure Frames.

NOTE: MAC2 is still able to receive any signal from BRx.

This action signals to the upstream stations (with respect to the Primary) that this station is receiving Beacon Reconfigure frames on the Primary Ring. The DRFSM waits in this state for either a Break Indication on the Secondary (XB) or for TD4 to expire. The Break signals that this station is upstream of the fault on the Primary and it will enter WRAPA. The expiration of TD4 indicates that there is no other station downstream (with respect to the Primary Ring) that is capable of initiating a WRAPA to repair the Dual Ring. Receipt of a BNR on the secondary indicates that another station exists downstream (with respect to the Primary) that is capable of entering WRAPA and this station can return to NORMal. The Crosspoint function connections are the same as in State D1 (ARx > MAC1 > BTX and BRx > MAC2 > ATx). While in State D4, a request by management to clear MIF will be processed, but no transition to another state occurs. State transitions should occur as follows:

(D41a): If a Receive Beacon Reconfigure MAC2 (RBNR2) Indication occurs, then a functioning downstream Dual Ring station has detected either the BNR frames on the Primary or an induced break on ATx (from it's downstream neighbor) and entered the WRAPA state. In this case the local station is an intermediate Dual Ring station that does not have to perform a WRAPA or WRAPB action. Therefore, a transition should be made to State D1: NORMal. Timer TD1A should be reset. Timer TD1B should be loaded with [Time_TD1B] and started.

(D46a): If a TD4-expired event occurs or a Break Indication is detected on BRx (XB), a transition should be made to State D6: WRAPA. Timer TD6 should be reset.

**4.4.6 State D5: WRAPB.** In the WRAPB state, the station receives data from BRx and transmits data via BTx. In the WRAPB state, the Crosspoint function connections are ATx > MAC2 > ARx and BRx > MAC1 > BTx. If the DRFSM receives a Break Indication on BRx (XB) or a MAC level failure indication, then a transition is made to the ISOLated state as detailed below. MAC level failure is defined as reception or transmission of Beacon Normal (BNN) frames not followed by reception of a Beacon Reconfigure (BNR) frame within [Time_TD5]. State transitions occur as follows:

(D51a): When an Active Monitor Present MAC2 (AMP2) Indication occurs, a good link to the upstream neighbor exists (relative to the Primary Ring). If the MPF is set and Timer TD5 is not active, then a transition should be made to State D1: NORMal. Timers TD1A and TD1B should be reset.

(D51b): If the MIF is reset (MIF_RST) when the DRFSM is in State 5, then a transition should be made to State D1: NORMal. Timers TD1A and TD1B should be reset.

(D55a): If a Receive Beacon Normal MAC1 (RBNN1) Indication is received, or if MAC1 enters the Transmit Beacon Normal (TBNN1) state (State S5), then a MAC level failure is occurring. If Timer TD5 is not active, then Timer TD5 should be loaded with [Time_TD5] and started. The DRFSM should remain in State D5: WRAPB. In this case the DRFSM is allowing sufficient time for the MAC level recovery procedures to take effect, or for other Dual Attachment stations to remove the problem by Wrapping.

(D55b): If a Receive Beacon Reconfigure MAC1 (RBNR1) Indication occurs, then a reconfiguration event is occurring on the wrapped ring. Normal MAC level procedures will reestablish the Token and Active Monitor. Timer TD5 should be reset and the DRFSM should remain in State D5: WRAPB.

(D57a): If a Break BRx (XB) Indication occurs, or if a TD5-expired condition occurs, then the last remaining link has failed and a transition should be made to State D7: ISOLated.

**4.4.7 State D6: WRAPA**. In the WRAPA state, the station receives data from ARx and transmits data via ATx. The Crosspoint function connections are ATx > MAC1 > ARx and BRx > MAC2 > BTx. If the DRFSM receives a Break Indication from MAC1, then a transition is made to ISOLated state as detailed below. MAC level failure is defined as reception or transmission of Beacon Normal (BNN) frames not followed by reception of a Beacon Reconfigure (BNR) frame within [Time_TD6]. State transitions occur as follows:

(D61a): When an Active Monitor Present MAC2 (AMP2) Indication occurs, then a good link to the downstream neighbor exists (relative to the Primary Ring). If the MPF is set and Timer TD6 is not active, then a transition should be made to State D1: NORMal. Timers TD1A and TD1B should be reset.

(D61b): If the MIF is reset (MIF_RST) when the DRFSM is in State 6, then a transition should be made to State D1: NORMal. Timers TD1A and TD1B should be reset.

(D66a): If a Receive Beacon Normal (RBNN1) Indication is received from MAC1, or if MAC1 enters Transmit Beacon Normal (TBNN1) state (State S6), then a MAC level failure is occurring. If Timer TD6 is not active, then Timer TD6 should be loaded with [Time_TD6] and started. The DRFSM should remain in State D6: WRAPA. In this case the DRFSM is allowing sufficient time for the MAC level recovery procedures to take effect, or for other Dual Ring stations to remove the problem by Wrapping.

(D66b): If a Receive Beacon Reconfigure MAC1 (RBNR1) Indication occurs, then a reconfiguration event is occurring. Normal MAC level procedures will reestablish the Token and Active Monitor. Timer TD6 should be reset and the DRFSM should remain in State D6: WRAPA.

(D67a): If a Break ARx (XA) Indication occurs, or if a TD6-expired condition occurs, then the last remaining link has failed and a transition should be made to State D7: ISOLated.

**4.4.8 State D7: ISOLated.** In the ISOLated state the Crosspoint function connections are the same as for State D5: WRAPB (BRx > MAC1 > BTx and ARx > MAC2 > ATx).

NOTE: When a break is repaired, the Standby Monitor FSM will execute the existing IEEE Std 802.5 recovery procedures which will culminate with an Active Monitor Present MAC frame being issued on the repaired ring. The DRFSM waits for an Active Monitor Present MACx (AMP x) Indication from either MAC.

State transitions occur as follows:

(D75a): When an Active Monitor Present MAC1 (AMP1) Indication occurs and the MPF is set, then a transition should be made to State D5: WRAPB. Timer TD5 should be reset. This situation arises when a downstream station (with respect to the Primary Ring) is active and has established a ring.

(D76a): When an Active Monitor Present MAC2 (AMP2) Indication occurs and the MPF is set, then a transition should be made to State D6: WRAPA. Timer TD6 should be reset. This situation arises when an upstream station (with respect to the Primary Ring) is active and has established a ring.

(D71a): If the MIF is reset (MIF_RST) when the DRFSM is in State 7, then a transition should be made to State D1:NORMal. Timers TD1A and TD1B should be reset.

**4.5 Dual Ring Management Function Outputs.** The DRFSM generates the following outputs:

(1) DRFSM state (input to the Crosspoint function)
(2) TCU Bypass Control signal
(3) MAC Break Flags (input to each MAC (MBF1 and MBF2))
(4) MAC Transmit BNR Enable Flags (TBF1 and TBF2)

The Crosspoint function configuration and TCU Bypass Control function are related directly to the DRFSM internal states as shown in Table 4-2.

The MACx Break Flags are derived from the DRFSM Break Indications and the DRFSM state as follows:

MBF1 = [XA & MIF & (D1 | D2 | D3 | D4 | D6)] |
[XB & MIF & (D5 | D7)]

MBF2 = [XB & MIF & (D1 | D2 | D3 | D6)] |
[D4 & MIF] |
[XA & MIF & (D5 | D7)]

The MAC Transmit BNR Enable Flag is derived from the MIF as follows:

TBF1 = MIF & (D1 | D2 | D3 | D4)

TBF2 = MIF & (D1 | D2 | D3 | D4)

This prevents transmission of Beacon Reconfigure frames by a Dual Ring station when it is in the wrapped mode.

NOTE: The equations for TBF are the same for both MACs.

**Table 4-2**
**DRFSM Outputs**

| | DRFSM State | Crosspoint Function Connections | | | | INTx Bypass | TCUx Bypass |
|---|---|---|---|---|---|---|---|
| | | MAC1 | | MAC2 | | | |
| 0 | PASS | ARx | BTx | BRx | ATx | Inserted | Bypassed |
| 1 | NORMAL | ARx | BTx | BRx | ATx | Inserted | MACxI |
| 2 | TPWBNR | ARx | BTx | BRx | XTA | MACxI | Inserted |
| 3 | RBPWRS | ARx | BTx | BRx | ATx | MACxI | Inserted |
| 4 | TSWBNR | ARx | BTx | BRx | ATx | MACxI | Inserted |
| 5 | WRAPB | BRx | BTx | ARx | ATx | MACxI | Inserted |
| 6 | WRAPA | ARx | ATx | BRx | BTx | MACxI | Inserted |
| 7 | ISOLated | BRx | BTx | ARx | ATx | MACxI | Inserted |

KEY:
TCUx = TCU Insert Control signal state for Primary and Secondary Rings
INTx = Internal Bypass Insert Control signal for MAC1 or 2
MACxI = MAC x Insert Control Signal state
XTA = Break Condition on the ATx line

# 5. Management Interface

**5.1 Station Management Interface**. The following parameters and events, defined in the following subsections, constitute the Dual Ring Management Function Management Interface.These parameters provide for Dual Ring operation and allow passing of ring parameters from the primary MAC to the secondary MAC.

### 5.1.1 Parameters

```
ReconParameters ::= CHOICE {
    ManagementInterlockFlag   (20)   IMPLICIT   BOOLEAN,
    MergePermissionFlag       (21)   IMPLICIT   BOOLEAN,
    BreakTimeDualRing         (22)   IMPLICIT   MTimeValue,
    TimeTD1A                  (23)   IMPLICIT   MTimeValue,
    TimeTD1B                  (24)   IMPLICIT   MTimeValue,
    TimeTD2                   (25)   IMPLICIT   MTimeValue,
    TimeTD3                   (26)   IMPLICIT   MTimeValue,
    TimeTD4                   (27)   IMPLICIT   MTimeValue,
    TimeTD5                   (28)   IMPLICIT   MTimeValue,
    TimeTD6                   (29)   IMPLICIT   MTimeValue,
    DualRingState             (30)   IMPLICIT   DRStateInfo }

MTimeValue ::= INTEGER -- time in milliseconds

DRStateInfo ::= INTEGER {  PASS       (0),
                           NORMAL     (1),
                           TPWBNR     (2),
                           RBPWRS     (3),
                           TSWBNR     (4),
                           WRAPB      (5),
                           WRAPA      (6),
                           ISOLATED   (7) }

RingParameters ::= SEQUENCE {
    ringNumber                [0]   IMPLICIT OCTET STRING,
    errorTimer                [1]   IMPLICIT OCTET STRING,
    authorizedFunctionClass   [2]   IMPLICIT OCTET STRING,
    authorizedAccessPriority  [3]   IMPLICIT INTEGER,
    physicalDrop              [4]   ANY  }
```

### 5.1.2 Events

```
ReconEventInfo ::= INTEGER {  PASS        (0),
                              NORMAL      (1),
                              TPWBNR      (2),
                              RBPWRS      (3),
                              TSWBNR      (4),
                              WRAPB       (5),
                              WRAPA       (6),
                              ISOLATED    (7) }

ReceiveRingParams ::=  SEQUENCE {
    ringNumber                   [0]   IMPLICIT OCTET STRING,
    errorTimer                   [1]   IMPLICIT OCTET STRING,
    authorizedFunctionClass      [2]   IMPLICIT OCTET STRING,
    authorizedAccessPriority     [3]   IMPLICIT INTEGER,
    physicalDrop                 [4]   ANY  }
```

# 6. IEEE Std 802.5 MAC Finite State Machine (FSM) Changes for Dual Ring Stations

In order to incorporate Dual Ring operation, as specified in this document, and also in a manner that is backward compatible with IEEE Std 802.5, the changes identified in the following paragraphs are necessary for Dual Ring operation. These changes allow a MAC to transmit and receive Beacon Type 1 (Beacon Reconfigure) frames.

Backward compatibility is achieved by nulling out the Dual Ring specific operational characteristics when the DRFSM MIF is set to 0.

## 6.1 MAC Inputs

**6.1.1 MAC Break Flag.** The MAC Break Flag (MBF) is controlled by the DRFSM and indicates to the MAC that a Break Condition exists on its receive path. The MAC FSM should make state transitions as defined below when the MAC Break Indication is received. If the optional Break Detection logic is used, this flag must be implemented by the MAC function and must be accessible at the MAC Layer Management Interface for the purpose of setting or clearing it.

**6.1.2 MAC Transmit BNR Enable Flag**. The MAC Transmit BNR Enable Flag (TBF) authorizes the MAC to enter State S6 for the purpose of transmitting Beacon Reconfigure frames during serious ring failure conditions. This flag must be implemented by the MAC function and must be accessible at the MAC Layer Management Interface for the purpose of setting or clearing it.

## 6.2 Changes to the Standby Monitor FSM

### 6.2.1 Additional Standby Monitor State/Variable

**6.2.1.1 Additional Standby Monitor State.** The Standby Monitor FSM requires one additional State S6: Transmit Beacon Reconfigure (TX BNR). In this state, the MAC will continuously transmit Beacon Reconfigure (BNR) frames until Beacon Reconfigure frames are being received, or until TBF becomes reset.

**6.2.1.2 Additional Standby Monitor Variable.** The Standby Monitor FSM requires one variable: The Duplicate Address Test Completed (DAC) Flag. The DAC Flag indicates that the duplicate address test has been completed. This flag ensures that stations being inserted into a beaconing ring and stations in a wrapped ring perform the duplicate address test.

**6.2.2 New/Modified Standby Monitor FSM State Transitions**. The modified/new transitions to the IEEE Std 802.5 MAC Standby Monitor FSM are shown in Fig 6-1. Optional transitions for Break Detection logic are identified as optional in the text and are shaded in the figure. The following transitions have been added to the IEEE Std 802.5 Standby Monitor FSM:

(S14): (optional) If a Break Indication (MBF) occurs and TBF is set, the Standby Monitor FSM should transition to State S6: Transmit Beacon Reconfigure.

(S15): (optional) If a Break Indication (MBF) occurs and TBF is not set, then Timer TBT is reset and the Standby Monitor FSM should transition to State S5: Transmit Beacon Normal.

(S23): (optional) If a Break Indication (MBF) occurs and TBF is not set, the Standby Monitor FSM should transition to State S6: Transmit Beacon Reconfigure.

(S24): (optional) If a Break Indication (MBF) occurs and TBF is set, then Timer TBT is reset and the Standby Monitor FSM should transition to State S5: Transmit Beacon Normal.

(S25): If a Beacon Frame is received and TBF is set, then timers TNT and TSM should be reset and the Standby Monitor FSM should transition to State S4: Standby.

(S36): (optional) If a Break Indication (MBF) occurs and TBF is set, the Standby Monitor FSM should transition to State S6: Transmit Beacon Reconfigure.

(S37): (optional) If a Break Indication (MBF) occurs and TBF is not set, then Timer TBT is reset and the Standby Monitor FSM should transition to State S5: Transmit Beacon Normal.

(S35): If Timer TNT expires, and TBF is set, then the Standby Monitor FSM should transition to State S6: Transmit Beacon Reconfigure.

(S43): (optional) If a Break Indication (MBF) occurs and TBF is set, the Standby Monitor FSM should transition to State S6: Transmit Beacon Reconfigure.

(S44): If a Beacon frame is received which is not of Type 1 and TBF is set, the Standby Monitor FSM should transition to State S6: Transmit Beacon Reconfigure.

(S45): (optional) If a Break Indication (MBF) occurs and TBF is not set, then Timer TBT is reset and the Standby Monitor FSM should transition to State S5: Transmit Beacon Normal.

(S46): If an Active Monitor Present Frame is received and the DAC Flag is not set and TBF is set (TBF = 1), then Timer TSM should be reset, a Duplicate Address Test Flag queued for transmission awaiting a usable token, and the Standby Monitor FSM should transition to State S2: Initialize.

(S4X): If a Beacon Type 1 frame is received and TBF is set (TBF =1), then the DAC Flag should be reset (DAC = 0) and the Standby Monitor FSM should remain in State S4: Standby.

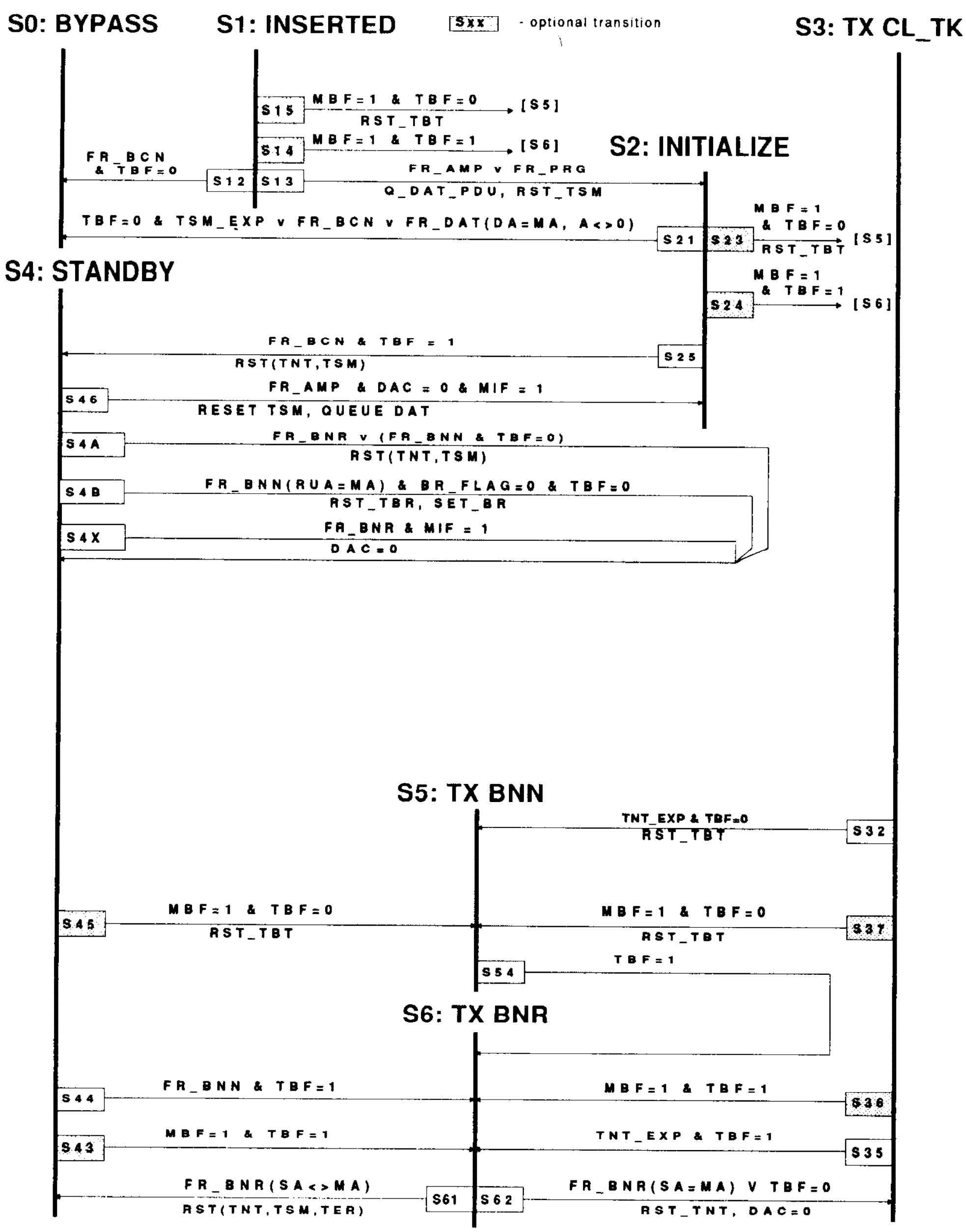



**Fig 6-1**
**Modified/New Standby Monitor FSM Transitions**

(S54): If the Transmit Beacon Reconfigure Enable Flag becomes set (TBF = 1), then the Standby Monitor FSM should transition to State S6: Transmit Beacon Reconfigure.

(S61): If a Beacon Type 1 frame is received in which the Source Address does not equal the station's own address (SA <> MA), Timers TNT, TSM, and TER should be reset and the Standby Monitor FSM should transition to State S4: Standby.

(S62): If a Beacon Type 1 frame is received in which the Source Address equals the station's own address (SA = MA), or if the Transmit Beacon Reconfigure Enable Flag becomes reset (TBF =0), then Timer TNT should be reset, the DAC Flag should be reset (DAC = 0), and the Standby Monitor FSM should transition to State S3: Transmit Claim Token. When reconfiguration completes the DRFSM makes a transition into WRAP or ISOLATED and therefore stops transmitting Beacon Reconfigure frames.

The following transitions have been altered in the IEEE Std 802.5 Standby Monitor FSM:

(S12): If a Beacon Frame of any type is received, and TBF is not set, then a transition should be made to State S0: Bypass.

(S21): If either Beacon Frame of any type is received, if Timer TSM expires and TBF is not set, or if a Duplicate Address Test Frame is received in which the A bit is set and the destination address is equal to the station's own address, then the Standby Monitor FSM should transition to State S0: Bypass.

(S32): If Timer TNT expires, and TBF is not set, then Timer TBT should be reset and the Standby Monitor FSM should transition to State S5: Transmit Beacon Normal.

(S4A): If a Beacon Frame is received that is not of Type 1, andTBF is not set, or if a Beacon Type 1 frame is received, thenTimers TNT and TSM should be reset and the Standby Monitor FSM should remain in State S4: Standby.

(S4B): If a Beacon Frame is received that is not of Type 1, the SUA equals MA, the BR Flag is not set, and TBF is not set, then Timer TBR should be reset, the BR Flag should be set, and the Standby Monitor FSM should remain in State S4:Standby.

**6.3 Changes to the Active Monitor FSM.** The modified/new transitions to the IEEE Std 802.5 MAC Active Monitor FSM are shown in Fig 6-2. Optional transitions for Break Detection logic are identified as optional in the text and are shaded in the figure. The modified IEEE Std 802.5 Active Monitor FSM requires the following additional state transitions:

(A06): (optional) If a Break Indication (MBF) occurs and TBF is not set, the latency buffer should be deleted and the Active Monitor FSM should transition to the Standby Monitor State S5: Transmit Beacon Normal.

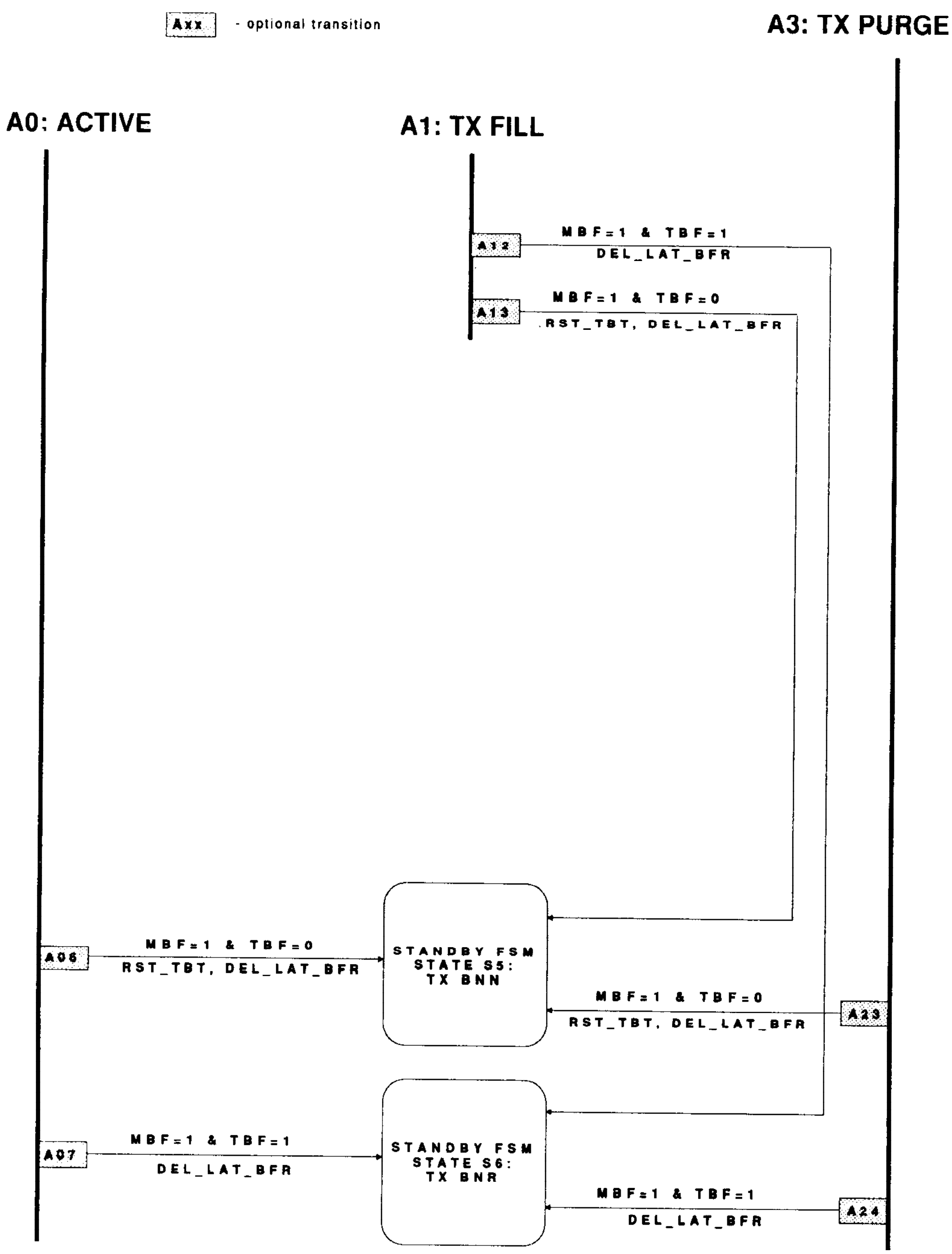



**Fig 6-2**
**Modified/New Active Monitor FSM Transitions**

(A07): (optional) If a Break Indication (MBF) occurs and TBF is set, the latency buffer should be deleted and the Active Monitor FSM should transition to the Standby Monitor State S6: Transmit Beacon Reconfigure.

(A12): (optional) If a Break Indication (MBF) occurs and TBF is set, the latency buffer should be deleted and the Active Monitor FSM should transition to the Standby Monitor State S6: Transmit Beacon Reconfigure.

(A13): (optional) If a Break Indication (MBF) occurs and TBF is not set, then the latency buffer should be deleted, Timer TBT is reset and the Active Monitor FSM should transition to the Standby Monitor State S5: Transmit Beacon Normal.

(A23): (optional) If a Break Indication (MBF) occurs and TBF is not set, the latency buffer should be deleted and the Active Monitor FSM should transition to the Standby Monitor State S5: Transmit Beacon Normal.

(A24): (optional) If a Break Indication (MBF) occurs and TBF is set, the latency buffer should be deleted and the Active Monitor FSM should transition to the Standby Monitor State S6: Transmit Beacon Reconfigure.

*State D1 continues
on next page*

*State D2 continues
on next page*

*State D1 continued
from previous page*

*State D2 continued
from previous page*

*State D1 continues
on next page*

*State D2 continues
on next page*

*State D1 continued
from previous page*

*State D2 continued
from previous page*