ISA and MicroChannel Host Software Programmers Guide for the DP8025 TROPIC™ (Token-Ring Protocol Interface Controller)

National Semiconductor
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INTRODUCTION

The Token-Ring Protocol Interface Controller (TROPIC) is a microCMOS VLSI device designed for easy implementation of IEEE 802.5 Token-Ring LAN interface adapters. The TROPIC chip includes integrated Analog and Digital Token-Ring interfaces and bus interface support for ISA and Micro-Channel hosts.

This document addresses programming issues for TROPIC-based adapters used in ISA or MicroChannel hosts.

In this document, any reference to "adapter", without a specific reference to a particular bus, applies to both ISA and MicroChannel TROPIC-based Token-Ring adapters.

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1.0 TROPIC ADAPTER INTERFACE SUMMARY

The interface provided by TROPIC-based adapters allows Host software to communicate with the adapter hardware and software. Host software uses the hardware interface to issue commands, store and retrieve data, receive commands, use timing facilities, and identify the adapter.

TROPIC Token-Ring adapters contain several areas that allow communication between Host software and the adapter. These areas include:

- Programmed I/O (PIO)
- Memory Mapped I/O (MMIO)
- Shared RAM
- Basic Input/Output System (BIOS).

The PIO areas are accessed using IN (Read) and OUT (Write) I/O instructions. The MMIO and shared RAM areas are accessed using memory instructions. The BIOS area, which is read only, can contain an optional program that is executed by the Host during power-on.

Host Transmit and Receive buffers and control blocks are provided through the Shared RAM interface, which is managed by a TROPIC integral controller. The control blocks are used to pass commands and messages between the Host system and TROPIC.

Host software must perform the control functions and interrupt handling for the adapter. The Host software must load commands and parameters into the shared RAM and control interrupt bits in the adapter MMIO domain where the interrupt status registers are located. The Host software must then interrogate control blocks and registers when the adapter has updated shared RAM.

This document describes in detail the sequence of operations, shared RAM assignments, the process of initializing the adapter, and related responses.

Overview of Adapter Interface Areas

This section briefly describes the adapter interface areas. Detailed mappings are provided in a later section.

PIO

The PIO area is used for adapter configuration information and control. The PIO area uses I/O addresses that range from:

- x0A20 to x0A27 for both the ISA Bus Adapter and the MicroChannel Bus Adapter
- x02F0 to x02F7 for the ISA Bus Adapter only.

These addresses are used to obtain the MMIO address and interrupt level used by the adapter and provide the ability to reset and release the adapter. For the MicroChannel Bus Adapter, they are also used to obtain the shared RAM address for the adapter.

MMIO

The MMIO area is a movable section of memory mapped I/O that is 512 bytes and consists of the following:

- **ACA:** The Attachment Control Area contains registers for adapter operations control. These registers include:

  RRR: The shared RAM relocation register (RRR) is used to get information for the shared RAM on the adapter. For ISA Host adapters, it is also used to set the shared RAM address in Host memory.

  WRBR/WWOR/WWCR: The write region base register (WRBR), write window open register (WWOR), and the write window close register (WWCR) are used to control the read/write access to the shared RAM on the adapter. The R/O access is used to protect the Token-Ring Network parameters. The R/W areas are used to pass data to the adapter.

  HISR/TISR: The Host interrupt status register (HISR) and the TROPIC interrupt status register (TISR) are used for the main communication between the adapter and the Host.

- TROPIC's Host Programmable Timer is a general purpose timer for use by the Host software. The offset addresses of the timer registers are x1E0C and x1E0D within the BIOS/MMIO segment.

- The adapter ID PROM (AIP) is used to provide the adapter type and the adapter's encoded address.

Shared RAM

The shared RAM is a movable section of memory and can be 8 kB, 16 kB, 32 kB, or 64 kB. It is used for data transfer and control blocks. Shared RAM is where data and all of the software commands are stored.

BIOS

TROPIC has an optional BIOS area that is a movable 7.5 kB section of mapped memory. This area can be used for initialization code that is executed at power-on.

Data Transfer

Data can be obtained from three general adapter sections:

- PIO area (8 bits wide). Byte read and write I/O instructions can be used.
- MMIO area (8 bits wide). Both byte and word read and write memory instructions can be used except when accessing the AIP. The AIP is 8 bits wide, but only 4 bits are valid and should be accessed using a byte read memory instruction to an even address.
- Shared RAM area (8 or 16 bits wide for ISA Adapter and 16 bits wide for MicroChannel Adapter). Both byte and word read and write memory instructions can be used.

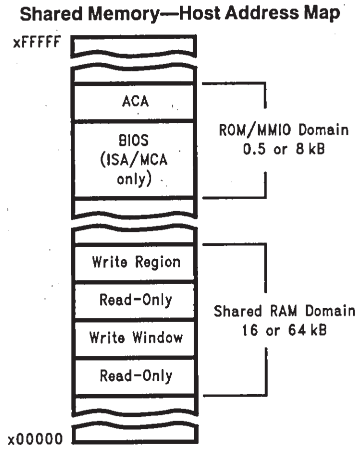
Using Interrupts

TROPIC uses interrupts to alert Host software that events have occurred on the adapter. Host software uses TROPIC interrupts to communicate with TROPIC's MPU.

2.0 HOST ADDRESS SPACE STRUCTURE

A TROPIC adapter's Host Address Space is divided into two domains: the Shared RAM domain and the ROM/MMIO domain, as shown below:

Shared Memory—Host Address Map



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Shared RAM Domain

As discussed in Section 1.0, transmission and reception data and control blocks are transferred between TROPIC and the Host via the TROPIC Shared RAM area. This area can be either 16 kB or 64 kB, depending on the Host's upper memory area usage; its size and initial base address are configured during Reset initialization.

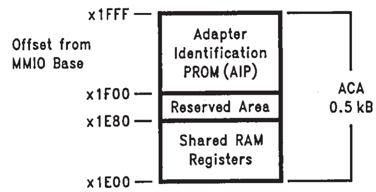
During operation, Shared RAM can be relocated and paged. Location and paging status are available through the Shared RAM address parameters defined in the RAM Relocation Register (RRR) and Shared RAM Paging Register (SRPR), as described in Section 3.0.

Mapping of the buffers and control blocks in Shared RAM is controlled by microcode. Buffer management and handshaking are summarized in Section 5.0.

ROM/MMIO Domain

For MicroChannel and ISA Hosts, the ROM/MMIO domain is 8k and includes 7.5k for BIOS and 0.5k for an area called the Attachment Control Area (ACA).

Attachment Control Area (ACA)



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The Adapter Identification PROM (AIP) area is a read-only region that contains unique adapter parameters, such as the IEEE node address and serial number. The area from x1E80 to x1EFF is reserved and *should not* be accessed by the Host.

The MMIO Registers (discussed in Section 3.0) serve as important status and control registers that are accessible to the Host during operation. Note that these registers are accessed by both TROPIC and the Host. The Host cannot "lock" a register to prevent TROPIC access.

Addressing The ROM/MMIO Domain

The address driven to TROPIC by the Host contains several fields when used in the MMIO area.

Host Address Bits

A23	8 7	6 5	4 A0
MMIO region address	Area	CMD	Reg #

Bits 23 through 9 select the MMIO region.

Bits 8 and 7 select the 128-byte area within the region, as follows:

b00 The attachment control area.

b01 No access. This is a reserved area.

b10 The adapter identification area A.

b11 The adapter identification area B.

Bits 6 and 5 select the specific MMIO command (CMD) to be performed.

Bits 4 through 0 select the specific register (Reg #) and byte.

With the BIOS/MMIO domain address from the setup information obtained by using the PIO instructions, MMIO read or write instructions can be used to put data into or read data from the adapter registers. Four MMIO commands are used. These four commands are controlled by the specific address used, as follows:

READ Read the contents of an adapter control register into the Host register. A READ is performed by issuing a read instruction in the Host with an address pointing to the appropriate MMIO register of the adapter.

WRITE Transfer the contents of a Host register directly into the selected adapter register. A WRITE is performed by issuing a write instruction in the Host with an address pointing to the appropriate MMIO register of the adapter with the 2 bits in the address assigned as CMD being set to b00.

OR OR the contents of a Host register into the selected adapter register. An OR is performed by issuing a write instruction in the Host with an address pointing to the appropriate MMIO register of the adapter with the 2 bits in the address assigned as CMD being set to b10.

AND AND the contents of a Host register into the selected adapter register. An AND is performed by issuing a write instruction in the Host with an address pointing to the appropriate MMIO register of the adapter with the 2 bits in the address assigned as CMD being set to b01.

All but the last 512 bytes of the BIOS/MMIO domain are reserved for Host BIOS program storage.

The MMIO region is structured as follows:

ROM/MMIO Layout

Offset from ROM/MMIO Segment	
x1F00	AIP, 256 bytes (read only access)
x1E80	Reserved, 128 bytes (do not access)
x1E00	Attachment Control Area, 128 bytes
x1DFF	Reserved for BIOS
x0000	

AIP (Adapter Identification PROM) Area Structure

This section describes the AIP fields, which are used to identify the adapter and provide information on supported hardware functions. Only *even* addresses are valid, and only the lower four bits of each even location are defined. The upper four bits of each byte should *always* be masked off (because these bits are not guaranteed to be zero). AIP contents can vary. A typical AIP might have the contents shown in the table below (as seen from the Host).

Example of a Typical AIP

ROM/MMIO Offset Address	AIP Contents															
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**A**	**B**	**C**	**D**	**E**	**F**
1F00	01	00	00	00	00	00	00	00	05	00	0A	00	02	00	00	00
1F10	00	00	01	00	0E	00	03	00	0E	00	0F	00	0F	00	0F	00
1F20	0A	00	05	00	0D	00	0F	00	0F	00	0E	00	01	00	0C	00
1F30	04	00	0D	00	04	00	01	00	05	00	02	00	05	00	03	00
1F40	03	00	06	00	03	00	03	00	05	00	08	00	03	00	04	00
1F50	03	00	05	00	03	00	01	00	03	00	08	00	02	00	00	00
1F60	0B	00	0F	00	0F	00	0F	00	0F	00	0F	00	0F	00	0F	00
1F70	0F	00	0F	00	0F	00	0F	00	0F	00	0F	00	0F	00	0F	00
1F80	00	00	02	00	04	00	06	00	08	00	0A	00	0C	00	0E	00
1F90	0F	00	0D	00	0B	00	09	00	07	00	05	00	03	00	01	00
1FA0	0F	00	0F	00	0F	00	0F	00	0F	00	0F	00	0F	00	0F	00
1FB0	0F	00	0F	00	0F	00	0F	00	0F	00	0F	00	0F	00	0F	00
1FC0	0F	00	0F	00	0F	00	0F	00	0F	00	0F	00	0F	00	0F	00
1FD0	0F	00	0F	00	0F	00	0F	00	0F	00	0F	00	0F	00	0F	00
1FE0	0F	00	0F	00	0F	00	0F	00	0F	00	0F	00	0F	00	0F	00
1FF0	0F	00	0F	00	0F	00	0F	00	0F	00	0F	00	0F	00	0F	00

A brief description of all AIP fields follows.

Adapter's Encoded Address

Stored in the Host even locations from x1F00 to x1F16, this field contains a 48-bit universally administered address as defined by the IEEE 802 committee on local area networks. Each IBM Token-Ring Network adapter is programmed with its own unique address in this field. This address will be used as the adapter's node address unless specifically overridden.

The format is 12 nibbles from the even bytes with each nibble representing a hexadecimal digit. The most significant nibble (MSN) is the nibble at x1F00, and the least significant nibble (LSN) is at x1F16. For example, from the sample AIP above, read the even bytes from x1F00 to x1F16 as x1, x0, x0, x0, x5, xA, x2, x0, x0, x1, xE, x3. The resulting address is x10005A2001E3.

One's Complement of the Adapter Encoded Address

The method for determining this value is the same as for the address, but using the even locations x1F18 to x1F2E. x1F18 is the MSN and x1F2E is the LSN. In the typical AIP above, read xE, xF, xF, xF, xA, x5, xD, xF, xF, xE, x1, xC for a one's complement address of xEFFFA5DFFE1C.

This field contains the one's complement of the universally administered address as defined above.

Channel Identifier

This field determines whether the adapter is an ISA Bus Adapter or a MicroChannel Bus Adapter. It uses Host even locations from x1F30 to x1F5E. The format is 24 nibbles from the even bytes with each nibble representing a hexadecimal digit. The MSN is the nibble at x1F30, and the LSN is at x1F5E.

In the sample AIP above, you would read:

x4, xD, x4, x1, x5, x2, x5, x3, x3, x6, x3, x3, x5, x8, x3, x4, x3, x5, x3, x1, x3, x8, x2, x0

for a value of x4D41 5253 3633 5834 3531 3820.

The two channel identifiers are:

- x5049 434F 3631 3130 3939 3020 for ISA Bus.
- x4D41 5253 3633 5834 3531 3820 for MicroChannel Bus.

AIP Checksum #1

The checksum is a Host even location of x1F60. The format is a hexadecimal nibble.

This field contains the first checksum for the AIP. If a 4-bit checksum (addition) of all valid (even) locations from 1F00 up to and including 1F60 is calculated, the result should be zero. This checksum is used to validate the encoded address and channel identifier. If an invalid checksum is obtained (non-zero value), then the previous values should be considered inaccurate.

Test Pattern

This field contains a test pattern for use during adapter diagnostics. The test pattern is Host even and odd locations x1F80 to x1F9F. The format is 32 nibbles from all bytes with each nibble representing a hexadecimal digit. In the sample AIP above read:

x0, x0, x2, x0, x4, x0, x6, x0,
x8, x0, xA, x0, xC, x0, xE, x0,
xF, x0, xD, x0, xB, x0, x9, x0,
x7, x0, x5, x0, x3, x0, x1, x0.

Supported Functions Identifiers

These identifiers are Host even locations from x1FA0 to x1FEE. The format is a hexadecimal nibble from the even bytes. The sample AIP above reads xF, xF, xF . . .

These nibbles should be used to determine what functions the adapter supports. The Host software should read these nibbles to determine the capabilities of each specific adapter. The nibbles from the hexadecimal locations are defined as follows:

x1FA0 Adapter Type where P=1st, E=2nd, D=3rd, . . . 0=16th.

Used to identify different adapters within a given I/O bus or channel type. The sample above uses xF.

x1FA2 Data Rate where F=4 Mbps, E=16 Mbps, D=4 Mbps and 16 Mbps, C to 0=reserve.

Used to identify data rates supported by the adapter.

x1FA4 Early Token Release where F=No, E=4 Mbps, D=16 Mbps. C=4/16 Mbps, B to 0=reserved.

Used to identify which data rates support early token release.

x1FA6 Total available shared RAM where F=use RRR(11,10), E=8 kB, D=16 kB, C=32 kB, B=64 kB (top 512 reserved and must be set to zero), A=64 kB (top 512 usable) 9 to 0=reserved.

Used to identify total shared RAM installed on the adapter. Use either the encoded value in the RRR register, or the specified value in the AIP. For value "B", the last 512 bytes (offset address FE00–FFFF) are reserved and must be set to 0 during adapter initialization in order to set RAM parity bits.

x1FA8 Shared RAM paging where F=No, E=16 kB page, D=32 kB page, C=16 kB and 32 kB page, B to 0=reserved.

Used to identify whether or not the adapter supports shared RAM paging and if so, at which page sizes.

x1FAA The Transmit Buffer size available at 4 Mbps where F=2048, E=4096, D=4464, C to 0=reserved.

Used to identify the maximum Transmit Buffer size at a 4 Mbps data rate (not applicable if adapter does not support 4 Mbps).

x1FAC The Transmit Buffer size available at 16 Mbps where F=2048, E=4096, D=8192, C=16384, B=17960, A to 0=reserved.

Used to identify the maximum Transmit Buffer size at a 16 Mbps data rate (not applicable if adapter does not support 16 Mbps).

x1FAE to x1FEE These locations are reserved.

AIP Checksum #2

This field is stored at Host even location x1FF0. The format is a hexadecimal nibble.

This field contains the second checksum for the AIP. If a 4-bit checksum (addition) of all valid (even) locations from 1F00 up to and including 1FF0 is calculated, the result should be 0. This checksum is used to validate all defined areas of the AIP. If an invalid checksum is obtained (non-zero value), then the previous values should be considered inaccurate. If an incorrect value is encountered, the only values used should be "default" values for the type of adapter identified by the channel identifier field.

Reserved

All undefined locations (both even and odd) are reserved and should not be used.

3.0 REGISTERS

The Host communicates with and controls TROPIC using three methods: Shared RAM, interrupts, and registers.

TROPIC supports three register areas:

- **MMIO Registers**—these are used by all Host bus types
- **Programmed I/O (PIO) Registers**—these are used by all Host bus types and are decoded during normal operation
- **MicroChannel Standard POS Registers**—these are used only by MicroChannel hosts and are decoded *only* during Setup

Note: POS Registers reside in PIO space, but are treated separately because they are only decoded during Setup.

Register Usage and Location by Bus Type

Register usage varies by bus type, as shown below.

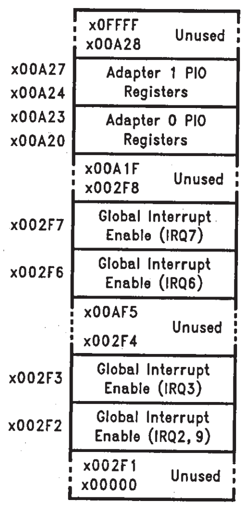
Register Usage by Bus Type

Bus Type	MMIO Registers	PIO Registers	MicroChannel POS Registers
MicroChannel	Yes	Yes	Yes
ISA	Yes	Yes	No

Memory allocation of registers is shown below.

Register Location by Bus Type

PIO Space (ISA)



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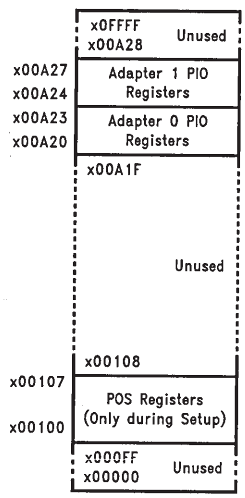
PIO Space (MicroChannel)



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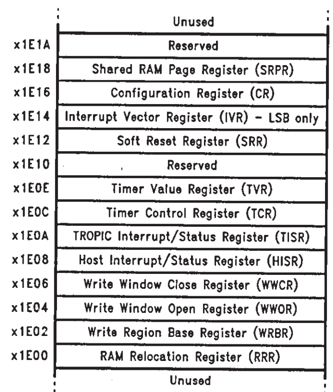
MMIO Space (All Buses)



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MMIO Registers—General

The MMIO Registers are used by all bus types and are located within the ACA Host Address Space area. They include mostly read-only status registers, with a few Read/Write control registers. Some of these registers are replicated in the PIO Registers; in such cases, one register is usually read-only while the alternative location is read/write.

All of the MMIO Registers consist of two-byte (word) registers, each having its low order byte at an even address and its high order byte at the following odd address. Note that addresses are relative to the ROM/MMIO Base Address.

RAM Relocation Register (RRR)

This register is used to relocate the Shared RAM region and indicate its page size and location. It also contains bits used to control different TROPIC operating modes.

Warning: Reserved bits (indicated by "—"), though readable, are controlled by TROPIC. These bits should not be changed.

ISA BUS MODE:

x1E01								x1E00							
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
—	—	—	—	RAM Size		—	—	AB19	AB18	AB17	AB16	AB15	AB14	AB13 (=0)	—

MicroChannel BUS MODE:

x1E01								x1E00							
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
—	—	—	—	RAM Size		—	—	—	—	—	—	—	—	—	—

Bit(s)	Description
15–12	Reserved.
11–10	**Shared RAM Page Size (READ ONLY):** Displays the shared RAM page (window) size, i.e., the amount of the Host's memory space that was allocated to shared RAM during initialization. These bits are coded as follows: 11 / 10 / Page Size 0 0 8 kB 0 1 16 kB 1 0 32 kB 1 1 64 kB This shared RAM page size may not be the total amount of shared RAM on the adapter; instead, this value indicates the amount of shared RAM for the Host to map into its memory. For example, an adapter with 64 kB of available shared RAM can be set for a 16 kB page size to allow shared RAM paging. If the RRR bit 11 is set to 0 and bit 10 is set to 1, this would indicate 16 kB of shared RAM in the Host's memory map. **Note:** To use Shared RAM paging, Host software must use the SRPR (Shared RAM Paging Register) correctly. See the later SRPR description for details.
9–8	Reserved.
7–1	**(FOR MicroChannel BUS MODE) Reserved.** **(FOR ISA BUS MODE) Shared RAM Host Base Address:** For TROPIC adapters in ISA I/O Bus mode, bits 7 through 1 of the RRR register are used to set the shared RAM starting address. This location must be set before the Shared RAM can be accessed and must be set to a location in the memory map that does not cause a conflict. These register bits default to zero on power-up or after an adapter reset. If the register contains zero, the shared RAM is not mapped into the memory map. This register must be set to a correct address boundary as follows: • 8 kB shared RAM page should be on an 8 kB address boundary. • 16 kB shared RAM page should be on a 16 kB address boundary. • 32 kB shared RAM page should be on a 32 kB address boundary. • 64 kB shared RAM page should be on a 64 kB address boundary. For shared RAM paging, the address boundary can be on a 16 kB boundary since only 16 kB of PC address space is used. **Note:** To select a valid address boundary, RRR Bit 1 (AB13) should always be set to 0.
0	Reserved.

Write Region Base Register (WRBR)—READ ONLY

Write Window Open Register (WWOR)—READ ONLY

Write Window Close Register (WWCR)—READ ONLY

The WRBR register indicates the base address of the primary Host write region in Shared RAM. The WWOR and WWCR registers together define the starting and ending addresses of a secondary Host write region. TROPIC uses all three registers to dynamically control the Host write access areas of Shared RAM, which are used to pass commands and data to TROPIC.

WRBR (Read Only):

x1E03								x1E02							
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
LSB (Least Significant Byte) WRBR								MSB (Most Significant Byte) WRBR							

WWOR (Read Only):

x1E05								x1E04							
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
LSB (Least Significant Byte) WWOR								MSB (Most Significant Byte) WWOR							

WWCR (Read Only):

x1E07								x1E06							
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
LSB (Least Significant Byte) WWCR								MSB (Most Significant Byte) WWCR							

These management register pairs specify an offset into shared RAM. The offsets are 16-bit values. The even register contains the most significant byte of this value. For example:

WRBR(15–8) at x1E03 = 24 (LSB)

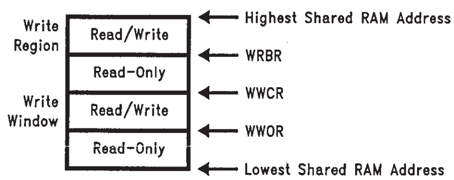
WRBR(7–0) at x1E02 = 47 (MSB)

WRBR full register value = 2447

In this example, a 16-bit Read of the WRBR (at x1E02) returns 2447; however, the logical (useable) address value is 4724.

IMPORTANT: To obtain a usable address, Host software **must** perform a byte-swap on 16-bit Reads from the WRBR, WWOR, and WWCR registers.

As illustrated below, TROPIC can concurrently define two separate and independent computer write areas within the Shared RAM domain: the *write region* and the *write window.* The size of each of these areas can be individually defined in word (2-byte) increments from 2 bytes to the maximum size of the shared RAM domain.



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The two areas differ only in how they are bound. The write region always extends from the highest address of the shared RAM domain down to a variable origin specified by the WRBR. The write window extends from a variable base defined by the WWOR pair to a variable limit defined by the WWCR pair. Also, the low-order bit in each odd register is zero since all write boundaries are word (2-byte) aligned.

Any address in the shared RAM not given specific Host write access by the shared RAM management registers is given Host read-only access. A Host write to any of these read-only memory addresses or to any shared RAM management register MMIO address will not be completed and will activate the Host Access error interrupt condition (HISR bit 2). Since the origin of the write region (WRBR) and the write window (WWOR) must be greater than zero if either write area is to be defined, the first 2 bytes of the shared RAM domain are always read-only to the Host.

The interface mechanism allows the Host read-only access to the entire shared RAM domain until TROPIC is initialized and Host write-access areas are defined by TROPIC.

The WRBR contains either zero or the offset of the beginning of the write region. When this field is zero, no write region is available. The WWOR contains either zero or the offset of the beginning of the write window. This field contains zero until TROPIC is opened, and when it is zero, no write window is available. The WWCR contains either zero or the first offset after the last writeable offset. This field is reserved until TROPIC is opened, and when it is zero, no write window is available.

Host Interrupt/Status Register (HISR)

This read/write register contains interrupt and control bits to allow TROPIC to issue interrupts to Host software. For ISA and MicroChannel Hosts, this register also indicates which PIO addresses (x0A20 to x0A23 or x0A24 to x0A27) select the PIO addressable registers.

x1E09								x1E08							
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
—	TCHK	SRBR	ASBF	ARBC	SSBR	BFFC	—	CH/IR	INTE	—	TINT	EINT	AINT	IBLK	PR/AL

Bit(s)	Description
15	Reserved.
14	**TROPIC Check (TCHK):** TROPIC has encountered an unrecoverable error and is closed. The reason for the check may be read from the shared RAM using the address in the write window close management register pair in the attachment control area of the MMIO region.
13	**SRB Response (SRBR):** TROPIC has recognized an SRB request and has set the return code in the SRB. A return code of: x00: Indicates successful completion of the SRB request. x01–xFD: Indicates unsuccessful completion of the SRB request. xFF: Indicates that the request has been accepted and is in process. A subsequent SSB response will be issued at the command completion. This interrupt bit is set for this return code only if the Host has set the "SRB Free Request" bit in the TISR.
12	**ASB Free (ASBF):** TROPIC has read the response provided in the ASB, and the ASB is available for another response. This interrupt bit is set only if the Host has set the "ASB Free Request" bit in the TISR or if an error has been detected in the response.
11	**ARB Command (ARBC):** The ARB contains a command for the Host to act on.
10	**SSB Response (SSBR):** The SSB contains a response to a previous SRB command from the Host.
9	**Bridge Frame Forward Complete (BRFC):** TROPIC has completed transmitting a frame forwarded by the bridge Host software.
8	Reserved.
7	**CHCK/IRQ Steering Control (CH/IR):** This bit is used to control error interrupts. If 0, TROPIC will issue a CHCK. If 1, TROPIC will issue IRQ. CHCK is not supported in ISA and MicroChannel bus modes and, for those modes, this bit must be set to 1.
6	**Interrupt Enable (INTE):** When this bit is on, interrupt requests will be presented to the Host. When this bit is off, all interrupts are masked off. The bit can be set by either TROPIC or the Host.
5	Reserved.
4	**Timer Interrupt (TINT):** When this bit is on, the TVR (7–0) has expired.
3	**Error Interrupt (EINT):** TROPIC has had a machine check occur, the TROPIC deadman timer expire, or the TROPIC timer overrun.
2	**Access Interrupt (AINT):** When this bit is on, it indicates that a shared RAM access violation or an illegal MMIO operation by the Host to an Attachment Control Area register pair has occurred. The following conditions will set this bit: • Any Host write to a write-protected location in the shared RAM domain • Any Host write to a shared RAM management (WRBR, WWCR, WWOR) register • Any Host write to HISR(7–0) • Any Host write to a nonzero interrupt field of TISR(15–8) or HISR(15–8). Nonzero interrupt fields of TISR(15–8) and HISR(15-8) must be manipulated using OR and AND MMIO commands.
1	**ISA Bus Mode ONLY** **Interrupt Block Bit (IBLK):** Set by TROPIC to prevent interrupts until interrupts are re-enabled.
0	**Primary/Alternate Address (PR/AL):** This bit reflects the setting of the TROPIC primary/alternate setup information. If this bit is off, the primary adapter address is selected. If this bit is on, the alternate adapter address is selected.

TROPIC Interrupt/Status Register (TISR)

This read/write register provides interrupts (for Shared RAM management, errors, timeouts, and other events) and control values that allow Host software to issue interrupts to TROPIC (letting the Host and TROPIC communicate asynchronously). The Host software sets bits in TISR(14–8) to interrupt TROPIC.

x1E0B								x1E0A							
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
—	BFFR	CSRB	RASB	SRBFR	ASBFR	ARBF	SSBF	IPE	TINTT	AINTT	DTEXP	TCHKT	—	THIM	TSIM

Bit(s)	Description
15	Reserved.
14	**Bridge Frame Forward Request (BRFR):** The Host software has placed a frame in the bridge transmit buffers and is requesting that the frame be forwarded.
13	**Command In SRB (CSRB):** The Host software has placed a command in the SRB and is informing TROPIC.
12	**Response In ASB (RASB):** The Host software has placed a response to an ARB request in the ASB and is informing TROPIC.
11	**SRB Free Request (SRBFR):** The Host software wants to use the SRB, but a previous request is still being processed by TROPIC. TROPIC will return an "SRB free" interrupt when the SRB return code field has been set.
10	**ASB Free Request (ASBFR):** The Host software wants to use the ASB, but a previous response is still being processed by TROPIC. TROPIC will return an "ASB free" interrupt when the ASB return code field has been set.
9	**ARB Free (ARBF):** The command in the ARB has been read by the Host software and the ARB is available. If the command requires a response from the Host software (receive and transmit only), it will be provided in the ASB later.
8	**SSB Free (SSBF):** The response in the SSB has been read by the Host software and the SSB is available.
7	**Internal Parity Error (IPE):** If this bit was on, there was a parity error on TROPIC's internal bus.
6	**Timer Interrupt—TROPIC (TINTT):** At least one of the TCR(15–8) timers has an interrupt to present to TROPIC.
5	**Access Interrupt—TROPIC (AINTT):** When this bit is on, it indicates that a shared RAM access violation or an illegal MMIO operation by TROPIC to an Attachment Control Area register has occurred.
4	**Deadman Timer Expired (DTEXP):** The deadman timer has expired, indicating an adapter microcode problem. This bit is one of the conditions that can set HISR bit 3.
3	**TROPIC Processor Check—TROPIC (TCHKT):** This bit does not latch on but follows the state of the TROPIC processor machine check indication. This bit is one of the conditions that can set HISR bit 3.
2	Reserved.
1	**TROPIC Hardware Interrupt Mask (THIM):** When this bit is on, it prevents adapter hardware interrupts (TISR bits 7 and 5) from being presented to the TROPIC processor.
0	**TROPIC Software Interrupt Mask (TSIM):** When this bit is on, it prevents Host software interrupts (TISR bits 14–8) from being presented to the TROPIC processor.

Timer Control Register (TCR)

This register controls both Host and ring timing. TCR(7–0) is used with the TVR register to control the Host programmable timer. TCR(15–8) controls the fixed-duration timers used by TROPIC's microcode timing routines, and is reserved.

x1E0D								x1E0C							
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
—	—	—	—	—	—	—	—	PTIM	PTRM	PTCG	PTOS	PTCS	HLCK	—	—

Bit(s)	Description
15–8	Reserved (TROPIC MPU timer control).
7	**Host Programmable Timer Interrupt Mask (PTIM):** This bit controls the timer interrupt operation. When this bit is on, the timer interrupts the Host when the programmable count expires. When the bit is off, the timer will not interrupt the Host, and the timer status must be obtained by polling either HISR bit 4 or TVR(7–0). The timer interrupt, like all Host interrupts, is also subject to the interrupt enable bit (HISR bit 6).
6	**Host Programmable Timer Reload Mode (PTRM):** If this bit is on, the timer automatically reloads from TVR(15–8) when the countdown expires (reaches zero). When this bit is off, the timer must be reprogrammed or restarted after each countdown. Setting bit 6 while the count is counting reloads TVR(0–7) with the initial count in TVR(15–8).
5	**Host Programmable Timer Count Gate (PTCG):** This bit enables/disables timer counting and also allows reloading of the initial countdown from TVR(15–8). Setting the bit to 1 enables the timer and starts counting. Resetting to 0 disables the timer and halts decrementing of the timer count. The countdown may be resumed by writing a 1 back to this bit, since the count contained in the timer is not changed when the gate bit is cleared. However, if a gate set is received when the gate bit is already on and timer count is 0, the countdown value reloads from TVR(15–8) and a full countdown begins.
4	**Host Programmable Timer Overrun Status (PTOS):** This bit is set when an overrun condition is detected with the Host timer interrupt. If the timer interrupt has not been reset before the end of the next timing period, the overrun bit is set at the end of that period. Once set, this status bit remains active until reset to zero by the Host.
3	**Host Programmable Timer Count Status (PTCS):** This bit is **Host Read-only** and is set by TROPIC when the timer contains a nonzero countdown value (the timer is loaded but not necessarily counting). If this bit is 1, the nonzero timer counter value can be obtained by reading TVR(7–0). Otherwise, reads to the TVR(7–0) return zeroes. When the timer countdown is halted by clearing of TCR bit 5 and the count value is not zero, this bit will remain active (set to 1).
2	**Host Interlock (HLCK):** This interlock allows TROPIC's internal diagnostic routine to check the functional capability of the Host timing facility without interference from the Host. When set to 1, this bit prevents Host MMIO writes from updating the contents of the TVR register and the Host portion (except this bit) of TCR(7–0). This bit will be set only when TROPIC's internal diagnostic procedures require exclusive use of the Host programmable timer.
1–0	Reserved.

Timer Value Register (TVR)

This register contains the Host timer initial countdown value in TVR(15–8) and the current Host timer count in TVR(7–0) (referred to as "the timer"). Reading TVR(15–8) always returns the last value written to it (zero following initial power-on). Both TVR(15–8) and TVR(7–0) are cleared after power-on reset. For each byte, possible values range from 10 ms (x01) to 2.55 seconds (xFF) in 10 ms increments.

If the timer contains zeros, writing a byte to TVR(15–8) transfers that value to the timer. Counting is then subject to the state of the TCR(5) gate bit. A read of TVR(7–0) returns the actual contents of the Host timer counter at the time the read is received by TROPIC. Writes to TVR(7–0) are ignored.

If the counter is loaded (nonzero), a write to the TVR(15–8) register will not cause the timer to be reloaded. The loading of the new TVR(15–8) value to the timer is governed by the state of the TCR gate and reload bits (TCR bits 5 and 6).

The TCR(3) count status bit and the TCR(5) gate bit are used with TVR(7–0). When the timer is loaded (the TCR(3) count status bit is 1), the value returned from TVR(7–0) is the actual timer count at the time of the read. If the TCR(3) gate bit is 1, then the counter will be counting and the value returned will reflect the current instantaneous counting state.

x1E0F								x1E0E							
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Timer Initial Count (TINIT)								Timer Current Count (TCUR)							

Bit(s)	Description
15–8	**Host Programmable Timer Initial Count (TINIT):** See description above.
7–0	**Host Programmable Timer Current Count (TCUR):** See description above.

Shared RAM Page Register (SRPR)

Through the SRPR register, TROPIC allows the Host system to use memory paging schemes to allocate a smaller Shared RAM domain (in the Host memory space) than the actual physical Shared RAM size on the TROPIC adapter. For example, if the adapter needs 64k of Shared RAM, but the Host system can allocate only 16k, the 64k adapter RAM can be mapped to the 16k Host space as four separate 16k pages, any one of which is "visible" at a given moment. Note that TROPIC always has full access to the entire 64k space even if the Host is using a smaller page size.

The SRPR register is only valid in Host bus modes that support RAM paging. It is used before initialization to communicate to TROPIC's microcode the total amount of RAM to use, and is also used after initialization to "page" the shared RAM into the Host's memory map.

Before TROPIC is initialized, the Host's software must write the appropriate value to the SRPR to communicate to TROPIC's microcode how much total shared RAM to use. If a value of x0000 is written to the SRPR, TROPIC uses only the amount of RAM indicated by the Shared RAM size bits in the RRR register (bits 10 and 11). If the RRR Shared RAM size bits are set to the page size indicated in the ID PROM under the RAM paging function, the Host software can write x00C0 to the SRPR, (i.e., set bits 6 and 7 to a "11") and TROPIC's microcode will use all 64 kB of Shared RAM. The Host software can then access the entire 64 kB of shared RAM using RAM paging.

If RAM paging is selected, the SRPR can be used to "page" the Host "window" into the full 64 kB of Shared RAM after TROPIC is initialized. See Section 4.0 for more details on Shared RAM layout and usage.

x1E19								x1E18							
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
—	—	—	—	—	—	—	—	PS1	PS0	—	—	—	—	—	—

Bit(s)	Description
15–8	Reserved.
7	**Page Select Bit 1 (PS1):** *Before initialization,* this bit and bit 6 indicate whether RAM Paging should be used, as follows: Value (PS1,PS0) — Meaning 00 — Use RRR (10,11) as total RAM, no paging 01 — Reserved 10 — Reserved 11 — Use 64k as total RAM, use paging *After initialization,* this bit and bit 6 are used to select the desired memory page, as follows: Value (PS1,PS0) — Meaning 00 — Map Page 1 into Host Memory Map 01 — Map Page 2 into Host Memory Map 10 — Map Page 3 into Host Memory Map 11 — Map Page 4 into Host Memory Map
6	**Page Select Bit 0 (PS0):** See PS1 above.
5–0	Reserved.

PIO Registers (ISA and MicroChannel)

The PIO Registers provide access to certain MMIO Register data or controls that are unavailable to ISA and MicroChannel Hosts via the MMIO Registers. This includes Configuration Register information, Soft Reset Control, and ROM/MMIO Address information. The PIO registers also provide Shared RAM Address information for MicroChannel bus Hosts and Global Interrupt Enable registers for ISA bus Hosts.

There are four I/O addresses dedicated for PIO operations to each possible adapter type (primary or alternate). Read (IN) or write (OUT) operations to these addresses either cause an action or transfer data. The same address has different definitions based on whether Read or Write access is used, as described in the table below.

Note: The MicroChannel POS Registers also appear in Host I/O space, but are discussed separately in the next section.

PIO Registers (ISA)

Address	Read	Write	
x00A27	Reserved	Interrupt Enable	Secondary Adapter
x00A26	Reserved	Reset Release	
x00A25	Reserved	Reset Latch	
x00A24	Setup Read 1	Reserved	
x00A23	Reserved	Interrupt Enable	Primary Adapter
x00A22	Reserved	Reset Release	
x00A21	Reserved	Reset Latch	
x00A20	Setup Read 1	Reserved	
x00A1F … x002F8	Unused		
x002F7	Reserved	IRQ7	Global Interrupt Enable
x002F6	Reserved	IRQ6	
x002F5 … x002F4	Unused		
x002F3	Reserved	IRQ3	
x002F2	Reserved	IRQ2	

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For ISA Bus mode, an I/O Write (OUT) to x002Fn issues a global interrupt enable. This resets interrupt generating circuits in *all* adapters sharing the Host interrupt facilities. The specific IRQ level is defined by the value of "n", as follows:

Write to	Enables
x0002F7	IRQ7
x0002F6	IRQ6
x0002F3	IRQ3
x0002F2	IRQ2,9

This command performs no function for MicroChannel Bus mode.

PIO Registers (MicroChannel)

Address	Read	Write	
x00A27	Reserved	Reserved	Secondary Adapter
x00A26	Setup Read 2	Reset Release	
x00A25	Reserved	Reset Latch	
x00A24	Setup Read 1	Reserved	
x00A23	Reserved	Reserved	Primary Adapter
x00A22	Setup Read 2	Reset Release	
x00A21	Reserved	Reset Latch	
x00A20	Setup Read 1	Reserved	

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Global Interrupt Enable (IRQn) **x0002F7 (WRITE)**
x0002F6 (WRITE)
x0002F3 (WRITE)
x0002F2 (WRITE)

Setup Read 1 **x00A20 (x00A24) READ** **ISA/MicroChannel**

A read to this register returns all but the high-order bit of the 1 byte ROM/MMIO domain base address (in Host's memory space) and 2 bits of interrupt level information.

For MicroChannel Host bus adapters, this information must have been set during the setup function of POST. The address specifies where, in a 512 kB portion of 1 MB of MicroChannel Host-addressable memory, TROPIC registers will be located.

For ISA Host bus adapters, this information must be set (by jumpers, switches, etc.) when the adapter is installed, or using a proprietary software downloading scheme, to define where in the Host-addressable memory TROPIC registers will reside.

x00A20 (x00A24) READ

7	6	5	4	3	2	1	0
RAB18	RAB17	RAB16	RAB15	RAB14	RAB13	Encoded IRQ	

Bit(s)	Description
7–2	**ROM/MMIO Host Base Address:** (Address Bits 18–13, respectively): Used to determine all but the high order bit of the ROM/MMIO starting address, usually as part of initialization handshaking (see Section 7.0), as follows:

Setup Read 1 Bit	Boundary	ROM/MMIO Address Bit
7	256 kB	18
6	128 kB	17
5	64 kB	16
4	32 kB	15
3	16 kB	14
2	8 kB	13

The ROM/MMIO domain is mapped to any contiguous 8 kB block within a 1 MB Host address space. If an optional BIOS module is installed on the adapter that executes at power-on time, the ROM/MIO domain must be limited to the 96 kB of BIOS space in the Host (x0C8000–0DFFFF).

Note: *For MicroChannel Host:* See bit 0 of Setup Read 2 Register at x0A22 (x0A26) for the value of address bit 19 (512 kB).

For ISA Host: Bit 19 is always equal to 1.

Bit(s)	Description
1–0	Encoded IRQ Level: Indicates interrupt level selected for adapter, as follows:

Bit 1	Bit 0	ISA Bus Mode	MicroChannel Bus Mode
0	0	IRQ2	IRQ2
0	1	IRQ3	IRQ3
1	0	IRQ6	IRQ10
1	1	IRQ7	IRQ11

TROPIC Reset Latch **x00A21 (x00A25) WRITE** **ISA/MicroChannel**

A Write to this register causes an unconditional TROPIC reset to be latched on. The entire TROPIC is held reset until a TROPIC Reset Release is received from the Host. The TROPIC reset state is similar to a power-on reset and is used to start TROPIC in a known state. While TROPIC is held reset, the Host cannot access either the Shared RAM or the MMIO region (except for the BIOS area).

TROPIC Reset Release **x00A22 (x00A26) WRITE** **ISA/MicroChannel**

A Write to this register turns off a TROPIC reset condition previously latched on by a TROPIC Reset Latch from the Host. Before TROPIC can be fully reset, at least 50 ms must elapse between a TROPIC Reset Latch and TROPIC Reset Release instruction. If TROPIC is not latched in a reset condition, the command is ignored.

Setup Read 2 **x00A22 (x00A26) READ** **MicroChannel ONLY**

For MicroChannel Hosts only, a read to this register returns a 1 byte value containing the Shared RAM address *plus* the high-order bit of the ROM/MMIO domain base address. This information must have been set during the setup function of POST. The address specifies where, in a 1M space of MicroChannel Host-addressable memory, the Shared RAM on the adapter will be located. The ROM/MMIO address bit specifies which 512 kB portion of 1 MB MicroChannel Host-addressable memory the ROM/MMIO domain is in.

Note: For ISA Hosts, the Shared RAM domain is set by Host software using the RRR register (see earlier discussion of MMIO Registers).

x00A22 (x00A26) READ—MicroChannel ONLY

7	6	5	4	3	2	1	0
SAB19	SAB18	SAB17	SAB16	SAB15	SAB14	SAB13	RAB19

Bit(s)	Description
7–1	**MicroChannel Hosts Only** **Shared RAM Host Base Address:** (Address Bits 19–13, respectively): Used by MicroChannel Hosts to determine the Shared RAM starting address, usually as part of Initialization handshaking (see Section 7.0), as follows: Setup Read 2 Bit / Boundary / Shared RAM Address Bit 7 / 512 kB / 19 6 / 256 kB / 18 5 / 128 kB / 17 4 / 64 kB / 16 3 / 32 kB / 15 2 / 16 kB / 14 1 / 8 kB / 13
0	**MicroChannel Hosts Only** **ROM/MMIO Host Base Address: Bit 19:** Used by MicroChannel Hosts to determine bit 19 of the ROM/MMIO domain base address (see Setup Read 1 Register above for more information).

Adapter Interrupt Enable **x00A23 (x00A27) WRITE** **ISA ONLY**

A Write to this register Resets and re-enables only the TROPIC-based adapter's interrupt generation circuitry. Since this leaves all other Host adapters disabled, the TROPIC adapter is able to monopolize the interrupt facilities.

MicroChannel POS Registers (MicroChannel Only)

During Setup *only*, TROPIC provides PIO-addressable POS registers for polling and initializing adapters in MicroChannel Hosts, in keeping with MicroChannel architecture, these registers let configuration information be written from the non-volatile POS memory on the MicroChannel motherboard to TROPIC during Setup. However, these registers *are not* available during TROPIC operations after Setup. (During normal operation, refer instead to the Setup Read1 and Setup Read 2 PIO Registers for adapter information.) The POS Register region of PIO space has the following structure:

MicroChannel POS Register Locations (only available during Setup)

x00107	Channel Check/Status Register (High Byte)—READ ONLY
x00106	Channel Check/Status Register (Low Byte)—READ ONLY
x00105	Status/Check Register
x00104	Configuration Register (High Byte)
x00103	Configuration Register (Low Byte)
x00102	Card Enable
x00101	MicroChannel Card ID (High Byte)—READ ONLY
x00100	MicroChannel Card ID (Low Byte)—READ ONLY

MicroChannel Card ID Register Pair (Read Only)

This read-only register pair provides the unique MicroChannel Card ID (as stored in the Adapter Identification PROM). Bits 15–4 of the ID are always set at xE00, so the range of unique Card ID values are xE000 to xE00F.

x00101								x00100							
15	**14**	**13**	**12**	**11**	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
CARD ID High Byte (Hardwired to xE0)								Upper 4 Bits of CARD ID Low Byte (Hardwired to x0)				Lower 4 Bits of CARD ID Low Byte (Unique to Adapter)			

Bit(s)	Description
15–8	**Card ID High Byte:** This is always "hardwired" to xE0.
7–4	**Card ID Low Byte (Most Significant 4 bits):** This is always "hardwired" to x0.
3–0	**Card ID Low Byte (Least Significant 4 bits):** These bits are card-specific.

Card Enable Register

This register contains the MicroChannel Card Enable bit and the Shared RAM Base Address (which is loaded from Configuration Register bits 15–9 during RESET).

x00102

7	6	5	4	3	2	1	0
AB19	AB18	AB17	AB16	AB15	AB14	AB13 (=0)	CENA

Bit(s)	Description
7–1	**Shared RAM Host Base Address:** (Address Bits 19–13): Used to set the shared RAM page starting address during Setup. This location must be set before the Shared RAM can be accessed and must be set to a location in the memory map that does not cause a conflict. These register bits default to the same setting as Configuration Register Bits 15–9 on power-up or after an adapter reset. If the register contains this value, the shared RAM page is not mapped into the memory map. This register must be set to a correct address boundary as follows: • 8 kB shared RAM page should be on an 8 kB address boundary. • 16 kB shared RAM page should be on a 16 kB address boundary. • 32 kB shared RAM page should be on a 32 kB address boundary. • 64 kB shared RAM page should be on a 64 kB address boundary. For RAM paging, the address boundary can be on a 16 kB boundary since only 16 kB of PC address space is used. **Note:** To select a valid address boundary, RRR Bit 1 (AB13) should always be set to 0.
0	**Card Enable Bit (CENA):** This bit, when set to 1, enables all MMIO and PIO operations along with the card Data Bus and return signal drivers. If set to 0, the card is disabled.

Configuration Register Pair

This register pair provides an alternative to hardware jumpers at Setup.

x00104								x00103							
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RMA19	RMA18	RMA17	RMA16	RMA15	RMA14	RMA13	Encoded IRQ Level		—	—	—	RAM Size		RATE	PR/AL

Bit(s)	Description
15–9	**ROM/MMIO Host Base Address:** (Address Bits 19–13): Used to set the ROM/MMIO starting address during Setup. This location must be set before the ROM/MMIO can be accessed and must be set to a location in the memory map that does not cause a conflict. The ROM/MMIO domain is mapped to any contiguous 8 kB block within a 1 MB Host address space.
8–7	**Encoded IRQ Level:** Selects interrupt level for adapter, as follows: Bit 8 / Bit 7 / Selected IRQ 0 0 IRQ2 0 1 IRQ3 1 0 IRQ10 1 1 IRQ11
6–4	Reserved.
3–2	**Shared RAM Page Size:** Bits 3 and 2 select the shared RAM page (window) size, i.e., the amount of the Host's memory space that is allocated to shared RAM. These bits are coded as follows: Bit 3 / Bit 2 / Page Size 0 0 8 kB 0 1 16 kB 1 0 32 kB 1 1 64 kB This shared RAM page size may not be the total amount of shared RAM on the adapter. For example, an adapter with 64 kB of available shared RAM can be set for a 16 kB page size to allow shared RAM paging. If bit 3 is set to 1 and bit 2 is set to 0, this would indicate 16 kB of shared RAM in the Host's memory map.
1	**TROPIC Data Rate:** 0 = 4 Mbps, 1 = 16 Mbps
0	**Primary/Alternate Adapter Selection Bit:** 0 = Primary, 1 = Alternate

Status/Check Register

This register contains the MicroChannel Status and I/O Channel Check indicator bits.

x00105							
7	6	5	4	3	2	1	0
CHCK	CSTAT	—	—	—	—	—	—

Bit(s)	Description
7	**Channel Check:** Reflects the true value of —CHCK, TROPIC's I/O Channel Check Signal (0 = Active, 1 = Inactive).
6	**Channel Check Status:** Only valid if Channel Check is active (0 = Present, 1 = Not Present).
5–0	Reserved.

Channel Check Status Registers (Read Only)

This read-only register pair holds the MicroChannel Channel Check Status bits. It should be considered a reserved area.

4.0 SHARED RAM LAYOUT AND USAGE

Communication and control between the TROPIC adapter and the Host is by means of control blocks and buffers in the shared RAM and interrupts initiated in registers in the MMIO region.

Shared RAM Control Blocks

One use of Shared RAM is to provide buffers for passing Token-Ring data between TROPIC and the Host. A second, equally important use of the Shared RAM is to allow the passing of specialized data between TROPIC and the Host software in *Control Blocks*. Control Blocks are used to pass *Commands* (i.e., requests), and the status of requests between TROPIC and the Host software.

The Control Blocks are used in conjunction with interrupts to provide event-driven, asynchronous operation of TROPIC, as described later.

Control Block Commands include high level requests from the Host software to TROPIC for MAC (Media Access Control) and LLC (Logical Link Control) services, which are provided within TROPIC by its MPU and Protocol Handler. The Host software is therefore relieved from having to manage MAC, or LLC services, greatly reducing Host program size and complexity.

There are four Control Blocks, described next.

System Request Block (SRB)

The SRB is used to pass a command from the Host to the adapter. When the SRB is "filled in", the return code field must be set to xFE by the Host. If the command is completed upon receipt by the adapter, either successfully or with an error, the return code for the command is passed back to the Host in the SRB with an interrupt raised. If further processing is required by the adapter, a return code of xFF and a command correlator (which identifies a particular command in process) is placed in the SRB, but no interrupt to the Host will result unless the SRB free request is set. The adapter will later update the system status block (SSB) with status related to that command and interrupt the Host.

The SRB can be initially located by using the address in the write region base register (WRBR) in the attachment control area of the MMIO domain. When the adapter is opened, the future SRB location is indicated by the SRB response to a successful OPEN.ADAPTER SRB. The following four commands change the SRB location:

DIR.CLOSE.ADAPTER,

DIR.CONFIG.BRIDGE.RAM,

DIR.CONFIG.FAST.PATH.RAM,

and DIR.OPEN.ADAPTER.

The SRB address is also changed if the adapter closes automatically due to an error condition.

Initially, the SRB is large enough to contain the 60 bytes (x3C) needed to issue a DIR.OPEN.ADAPTER command but is thereafter only 28 bytes (x1C) long. The SRB location after a DIR.OPEN.ADAPTER command is issued is returned in the SRB upon completion of the DIR.OPEN.ADAPTER command.

System Status Block (SSB)

The SSB passes the results of an SRB command to the Host when the SRB has been returned initially with an in-process return code xFF. If multiple commands of the same type are pending, the station ID and command correlator provided in the SRB with the xFF return code can be used to identify the commands being completed.

The SSB location is returned by the adapter in the SRB upon completion of a DIR.OPEN.ADAPTER command.

Adapter Request Block (ARB)

The ARB is used by the adapter to pass information or issue a command to the Host.

If information is passed with the ARB, no response is expected other than an indication that the information has been read and the ARB is available for reuse by TROPIC.

If a command is passed with the ARB, a response is expected from the Host in the adapter status block (ASB) when the command is complete.

The ARB location is returned by the adapter in the SRB upon completion of a DIR.OPEN.ADAPTER command.

The Adapter Status Block (ASB)

The ASB is used by the Host to respond to a command received from the adapter in the ARB. The response can indicate either that the command has been successfully completed or that an error has occurred.

The location of the ASB is returned by the adapter in the SRB upon completion of a DIR.OPEN.ADAPTER command. The return code field of the ASB is initialized to xFF by the adapter when the DIR.OPEN.ADAPTER command is completed.

Shared RAM Buffers

Shared RAM includes two types of buffers for passing Token-Ring data between TROPIC and the Host:

- Transmit Buffers (also called Data Holding Buffers, or DHBs)
- Receive Buffers

Transmit Buffers (DHBs)

TROPIC assembles and transmits frame data from the Transmit Buffers (based on transmit commands issued through the SRB [System Request Block] by the Host software).

The number and size of the Transmit Buffers is determined when TROPIC is issued an Open Adapter command or a DIR.CONFIG.FAST.PATH.RAM command (as described later).

Fast Path Interface

The Fast Path interface provides a pool of Transmit Buffers that Host software can fill asynchronously to the TROPIC MPU's processing. Host software moves Transmit commands and related data *together* to these buffers and then signals TROPIC that the pools have been updated. TROPIC then processes frames according to each data block's associated command.

The Fast Path transmit interface is activated by issuing a "DIR.CONFIG.FAST.PATH.RAM" SRB command to TROPIC. TROPIC subsequently processes transmit commands based on Fast Path interface procedures. See Section 6.0 for further details.

Receive Buffers

TROPIC takes frame data from the Token-Ring and writes it into Receive Buffers in Shared RAM. It then places a Receive command in the ARB and issues an interrupt to the Host software. Among other things, the Receive command information will include the starting address of the Receive buffer.

The total size of the Receive Buffers is determined indirectly when TROPIC is issued an Open Adapter command (described later); all Shared RAM that is not needed for work areas, control blocks, communication areas, and Transmit Buffers is configured as Receive Buffers. Multiple Receive Buffers may be chained together to hold a complete frame, in which case each buffer will contain a pointer to the next buffer in the chain (and the Receive command will indicate the starting address of the first Receive Buffer).

TROPIC assigns locations in shared RAM when the adapter is initialized and opened. From TROPIC's perspective, these consist of three main areas, as follows:

Start of Shared RAM (as seen from TROPIC)

Host Read-Only Address Space	
Adapter Private Variables and Work Areas	Length: 1496 bytes
System Status Block (SSB)	Length: 20 bytes
Adapter Request Block (ARB)	Length: 28 bytes
Receive Buffers	Length: space remaining after all SAPs/stations are defined
SAP and Link Station Control Blocks	Length: as defined by maximum number of SAPs/stations
Host Read/Write Address Space	
Data Holding Buffer (DHB)	Length: as specified at open adapter time. There may be one or more DHBs.
System Request Block (SRB)	Length: 28 bytes
Adapter Status Block (ASB)	Length: 12 bytes
Reserved Area on 64 kB Shared RAM Adapters	
Reserved	Length: 512 bytes

End of Shared RAM (as seen from TROPIC)

Note: On 64 kB adapters, the 512 bytes at the end are reserved.

If the bridge function is used, shared RAM is formatted with an additional area. See the Bridge Operation discussion later in this document for shared RAM layout and a description of the bridge functions available.

Shared RAM Paging

Shared RAM paging is a technique that allows the Host software to access all the RAM on the adapter, without having to map the entire shared RAM into the Host's memory map. The shared RAM on the adapter is paged into the Host's memory map one area at a time.

Shared RAM paging is only available on adapters that indicate that function within their ID PROM and only when they have the indicated amount of shared RAM mapped into the Host memory map. Shared RAM paging is controlled by the Host software using the Shared RAM Page Register (SRPR).

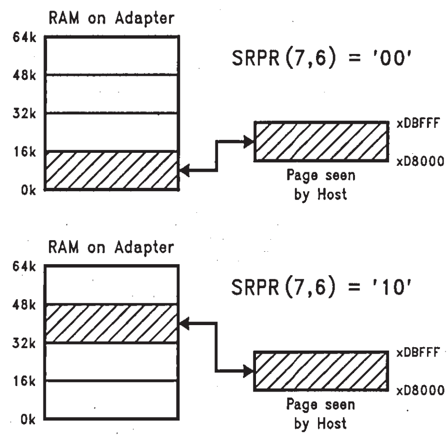
The Host software must follow these steps in order to use RAM paging:

1. Determine if the adapter has the appropriate amount of shared RAM mapped into the Host's memory map using information in the ID PROM and the RRR register shared RAM size bits (bits 11 and 10).
2. Using PIO, reset the adapter.
3. Set the SRPR bits to the desired value (xC0 for paging) before initializing TROPIC.
4. Initialize TROPIC (as described in the next section) to indicate to the TROPIC microcode the desired amount of total shared RAM to use.

   The adapter's microcode uses the total shared RAM to determine where buffers, control blocks, and other pieces of information are placed in the adapter's shared RAM. Notice, however, that Receive and Fast Path RAM buffers will not cross page boundaries.
5. Use the SRPR to page to the desired section of shared RAM as required for operation.

Once the adapter has been initialized for RAM paging, the SRPR Page Select Bits (7 and 6) should be used to page the Host's mapped memory into the appropriate area of shared RAM. The figures below illustrate how the SRPR setting affects mapping of 64k of physical Shared RAM into a 16k Host memory paging window (which, in this example, is located at Host memory address xD8000).

Examples of Shared RAM Paging Using SRPR (After Initialization)



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Uninitialized Shared RAM

All adapters that offer 64 kB of shared RAM and indicate in their AIP a "Total available shared RAM = B" need a portion of the shared RAM initialized to all zeros. The area of uninitialized shared RAM is from address xFE00 to xFFFF. These 512 bytes must be written to all zeros after initialization to set RAM parity bits.

5.0 SOFTWARE OPERATION OF TROPIC

As mentioned earlier, once TROPIC initialization is complete, the Host software communicates with and controls TROPIC through three methods: Shared RAM, interrupts, and registers. This section describes procedures for using those methods to operate TROPIC.

The adapter must be enabled and initialized before any commands can be processed. Initializing the adapter is performed using PIO and MMIO operations. Subsequent commands are performed using read and write memory instructions.

Initialization Handshaking

Before beginning an operating session with TROPIC, the Host software must first perform an initialization to ensure a known starting point. The typical method is as follows:

1. Invoke a Reset condition on TROPIC (using an Adapter Reset PIO Register access for MicroChannel and ISA).
2. Delay for at least 50 ms.
3. Invoke a Reset Release (using a Reset Release PIO Register access for MicroChannel and ISA).
4. If Shared RAM is to be paged, request paging by writing xC0 to SRPR (Shared RAM Page Register).
5. Set the Enable Interrupt bit of the HISR register (Host Interrupt/Status Register).
6. Wait for 1 to 3 seconds until TROPIC sets the "SRB Response" bit of the HISR register (indicating initialization and TROPIC's Adapter Diagnostics Program are complete).
7. Read the WRBR (Write Region Base Register). Use the offset in the WRBR and the Shared RAM Segment Address to calculate the initial SRB location where TROPIC has posted the results of the initialization (including any diagnostics failure messages).
8. Read and evaluate the results in the SRB (described below) and store important parameters. If diagnostics code indicates successful completion, proceed with operations.
9. If Fast Path Transmission will be used, fill out the SRB with CONFIG.FAST.PATH.RAM command information and interrupt TROPIC. Read the response in the SRB to get the new SRB address.

Initialization SRB Response

In response to a Reset as described above, the SRB will contain the following:

Offset	Parameter Name	Byte Length	Description
0	COMMAND	1	x80, Initialization Complete
1	INIT_STATUS	1	Initialization Status
2		4	Reserved
6	BRING_UP_CODE	2	The Bring-Up Diagnostics Result Code
8	ENCODED_ADDRESS	2	Shared RAM Address Offset of the Adapter's Encoded Address
10	LEVEL_ADDRESS	2	Shared RAM Offset to the Adapter Microcode Level
12	ADAPTER_ADDRESS	2	Shared RAM Address Offset of the Adapter Addresses
14	PARMS_ADDRESS	2	Shared RAM Address Offset of the Adapter Parameters
16	MAC_ADDRESS	2	Shared RAM Address Offset of the Adapter MAC Buffer

INIT_STATUS

The bits of this INIT_STATUS byte have the following meanings.

Bits 7–6	**Reserved**	
Bit 5	**Fast Path**	If on, indicates Fast Path Transmit is supported.
Bits 4–2	**Reserved**	
Bit 1	**Remote Program Load Option**	If on, indicates open option bit 13 (Remote Program Load) is supported by this adapter (see DIR.OPEN.ADAPTER)
Bit 0	**Adapter Data Rate**	If bit 0 is 0, the adapter data rate is 4 Mbps, and if it is 1, the data rate is 16 Mbps.

The INIT_STATUS byte is only valid if the bring-up code is zero.

BRING_UP_CODE

One of the following codes will be provided to indicate the results of the bring-up tests.

Code	8086 Type	Meaning
0000	DW	Good Return Code
0020	DW	Diagnostics could not be Executed
0022	DW	ROM (ROS) Diagnostics Failed
0024	DW	Shared RAM Diagnostics Failed
0026	DW	Processor Instruction Test Failed
0028	DW	Processor Interrupt Test Failed
002A	DW	Shared RAM Interface Register Diagnostics Failed
002C	DW	Protocol-Handler Diagnostics Failed

ADAPTER_ADDRESS

This parameter provides the shared RAM offset to the following information. The NODE_ADDRESS is accessible as long as the adapter is initialized or open. The GROUP_ADDRESS and FUNCTIONAL_ADDR are invalid until the adapter is open.

Offset	Parameter Name	Byte Length	Description
0	NODE ADDRESS	6	Adapter Node Address
6	GROUP_ADDRESS	4	Adapter Group Address
10	FUNCTIONAL_ADDR	4	Adapter Functional Address

PARMS_ADDRESS

This parameter provides the shared RAM offset to the following information. This information is accessible as long as the adapter is initialized or open.

Offset	Parameter Name	Byte Length	Description
0	PHYS_ADDR	4	Adapter Physical Address
4	UP_NODE_ADDR	6	Next Active Upstream Node Address
10	UP_PHYS_ADDR	4	Next Active Upstream Physical Address
14	POLL_ADDR	6	Last Poll Address
20		2	Reserved
22	ACC_PRIORITY	2	Transmit Access Priority
24	SOURCE_CLASS	2	Source Class Authorization
26	ATT_CODE	2	Last Attention Code
28	SOURCE_ADDR	6	Last Source Address
34	BEACON_TYPE	2	Last Beacon Type
36	MAJOR_VECTOR	2	Last Major Vector
38	NETW_STATUS	2	Network Status
40	SOFT_ERROR	2	Soft Error Timer Value
42	FE_ERROR	2	Front End Error Counter
44	LOCAL_RING	2	Ring Number
46	MON_ERROR	2	Monitor Error Code
48	BEACON_TRANSMIT	2	Beacon Transmit Type
50	BEACON_RECEIVE	2	Beacon Receive Type
52	FRAME_CORREL	2	Frame Correlator Save
54	BEACON_NAUN	6	Beaconing Station NAUN
60		4	Reserved
64	BEACON_PHYS	4	Beaconing Station Physical Address

Host-to-TROPIC Command Handshaking

Commands that Host software can issue to TROPIC using the SRB are summarized later in this section. The general procedure for issuing a command to TROPIC is:

1. Host software writes the appropriate Command code and related parameters into the SRB.
2. Host software sets the TISR register's "Command in SRB" bit to issue an interrupt to TROPIC.
3. TROPIC checks the validity of the SRB contents and either:
   - completely processes the command, sets a return code other than xFF in the SRB, and issues an interrupt to the Host software (by setting the HISR register's "Response in SRB" bit).
   - performs initial processing only, sets the return code to xFF in the SRB, and provides a "command correlator." TROPIC issues an interrupt to the Host software (by setting the HISR register's "Response in SRB" bit) *only* if an SRB Free Request Interrupt is issued by the Host software (by setting the TISR register's "SRB Free Request" bit).
4. Depending on the command, TROPIC may request more data using the ARB (Adapter Request Block) and DHB (i.e., the Transmit Buffer). The Host software uses the ASB (Adapter Status Block) to indicate that the requested data has been moved to the appropriate Shared RAM location. After reading the ARB, the Host software interrupts TROPIC by setting the TISR "ARB Free" bit.
5. When processing is completed for a command in process (i.e., return code is xFF in Step 3), TROPIC puts the final return code in the SSB (System Status Block) and interrupts the Host software by setting HISR "SSB Response" bit).
6. After the Host software reads the return code from the SSB, it interrupts TROPIC by setting the TISR "SSB Free" bit.

TROPIC-to-Host Command Handshaking

The commands which can be issued from TROPIC to the Host software using the ARB are summarized in a table later in this section. The general procedure for issuing a command to the Host software is as follows:

1. TROPIC writes the appropriate Command code and related parameters into the ARB.
2. TROPIC sets the HISR register's "ARB Command" bit to issue an interrupt to the Host software.
3. The Host software reads the ARB contents and issues an interrupt to TROPIC by setting the TISR register's "ARB Free" bit (to acknowledge command receipt and to indicate that TROPIC can re-use the ARB).
4. If a response is required based on the command, the Host software writes the response information into the ASB (Adapter Status Block) and issues an interrupt to TROPIC by setting the TISR register's "Response in ASB" bit.
5. After TROPIC reads the ASB response, it either:
   - sets a return code of xFF in the SRB, and issues an interrupt to the Host software by setting the HISR register's "ASB Free" bit *only* if the "ASB Free Request" interrupt bit is set.
   - sets an error return code indicating that an error has been detected, and issues an interrupt to the Host software by setting the HISR register's "ASB Free" bit, regardless of the status of the "ASB Free Request" interrupt bit.

6.0 SRB (HOST-TO-TROPIC) COMMANDS

There are three general categories of Host-to-TROPIC commands:

- Direct
- DLC (IEEE 802.2 SAP and station interfaces)
- Data transmission.

These commands have certain qualities in common:

- The command request is made by loading information in the SRB and setting TISR(13).
- The adapter checks the validity of the SRB contents and either:
  - completely processes the command, sets a return code other than xFF, and interrupts the Host by setting HISR (13)
  - performs initial processing only, sets the return code to xFF, and provides a command correlator. HISR(13) will be set only if an SRB Free Request Interrupt is initiated by the Host setting TISR(11).
- Depending on the command the adapter may request further data using the ARB and DHB. The Host will use the ASB to indicate that the requested data has been moved.
- When processing for a request that is in process (return code = xFF) is complete, the adapter will put the final return code in the SSB and interrupt the Host by setting HISR(10).
- After the Host has read the return code from the SSB, it interrupts the adapter by setting TISR(8).

SRB Conventions for Address and Two-Byte Integer Values

In the following command descriptions, whenever a Shared RAM address or a two-byte Integer value is specified, a byte-swap may be required to use the value. The even addressed byte is the most significant byte (MSB) and the odd addressed byte is the least significant byte (LSB). This byte ordering is the *reverse* of normal 8086 memory word access byte ordering.

For example, the TROPIC response to a DIR.OPEN.ADAPTER Host command contains a field that specifies the Shared RAM offset of the new SRB location. The byte at the current SRB offset 10 contains the most significant byte of the new SRB location and the byte at the current SRB offset 11 contains the least significant byte of the new SRB location. Consider:

If Current SRB Offset 10 = x0E8
and Current SRB Offset 11 = x024
then Shared RAM Offset to New SRB = xE824
(*not* x24E8)

If 16k Pages are being used to map into the adapter's 64k memory, then the correct Memory Page must be selected, and the new SRB address offset must be adjusted for the correct offset into that Page. In this example (xE824 offset into the 64k adapter RAM), the Shared RAM Page Register

(SRPR) must be loaded with the value xC0 to select the Memory Page for addresses xC000 through xFFFF (Page 4). The offset into this Page is then:

xE824 − xC000 = x2824

For this example, then, to request a DIR.READ.LOG SRB (Command code = x08) under DOS using the instruction:

```
mov    es:[di].command,a1
```

the registers must be set up as follows:

ES= Shared RAM address segment value = xD800
DI= Offset into Page to new SRB = x2824
AL= Command to be stored in SRB = x08

Direct Interface Commands

These commands affect TROPIC as a whole, rather than specific SAPs (Service Access Points) or link stations, and do not involve LLC processing.

The adapter must have been successfully initialized before any of these commands can be performed. After initialization, or a successful DIR.CLOSE.ADAPTER command, the only acceptable commands are:

DIR.OPEN.ADAPTER, DIR.CLOSE.ADAPTER, DIR.INTERRUPT, DIR.CONFIG.FAST.PATH.RAM, and DIR.CONFIG.BRIDGE RAM.

After successful completion of a DIR.OPEN.ADAPTER, any of the other direct interface commands can be issued.

All direct interface commands will be returned with HISR(13) set and return information located in the SRB. Return code xFF (in process) is never set for these commands.

Command Name	Code (Hex)	Description
DIR.CLOSE.ADAPTER	04	Closes the adapter, terminating all Ring communications (or Open Wrap test, if in process)
DIR.CONFIG.FAST.PATH.RAM	12	Tells adapter to use Fast Path interface techniques and sets values for the amount of shared RAM to allocate for the transmit interface and the size of the Fast Path buffers to be used; this command can only be issued when the adapter is in a Closed state
DIR.INTERRUPT	00	Forces a TROPIC interrupt; has no effect on Ring communications
DIR.MODIFY.OPEN.PARMS	01	Modifies adapter options previously set by DIR.OPEN.ADAPTER
DIR.OPEN.ADAPTER	03	Opens adapter with specified options, preparing adapter for normal ring operations (in automatic receive mode) or adapter wrap test
DIR.READ.LOG	08	Reads and resets adapter error counters
DIR.RESTORE.OPEN.PARMS	02	Modifies adapter options set by DIR.OPEN.ADAPTER
DIR.SET.FUNCT.ADDRESS	07	Sets the functional address for the adapter to receive Ring messages
DIR.SET.GROUP.ADDRESS	06	Sets the Group address for the adapter to receive Ring messages

A description of the SRB content for each of the commands follows. The command is explained and the fields provided by the Host and those returned by the adapter are shown.

See the Bridge Functions discussion later in this document for the direct interface commands used for bridge functions.

DIR.CLOSE.ADAPTER x04

SUMMARY: Close the adapter and terminate all ring communication or the "open wrap test".

This command is accepted anytime after the adapter has been initialized. Commands that have been accepted by the adapter and not completed remain incomplete and are not returned to the Host. The adapter is removed from the ring, if it was active, and the write region base register (WRBR) is reset to the value set before the DIR.OPEN.ADAPTER command was issued.

Offset	Parameter Name	Byte Length	Description
0	COMMAND	1	x04, DIR.CLOSE.ADAPTER
1		1	Reserved
2	RETCODE	1	Set by the adapter upon return

When the adapter completes the operation, it sets the return code in the SRB and interrupts the Host by setting HISR(13).

Valid Return Codes

x00 Operation completed successfully

x01 Invalid command code.

4

DIR.CONFIG.FAST.PATH.RAM x12

SUMMARY: Used to activate Fast Path interface option and configure Fast Path RAM and buffers.

The Configure Fast Path RAM SRB command is used to select TROPIC's Fast Path interface option. Parameters of the command select the amount of RAM to be reserved for the transmit interface and the size of buffers to configure. This command can only be issued when the adapter is closed because it controls the configuration of the adapter's RAM during the open process. When the Host software issues a subsequent Open command to the adapter, the area reserved will be formatted into a Fast Path Transmit Control Area and a set of buffers to be used for transmissions (for more details, see the Transmit Command discussions later in this section).

During processing of the DIR.OPEN.ADAPTER command the adapter will configure the Fast Path RAM area into a 16 byte control area and a set of link-listed buffers. The buffer pool will be checked to verify that there is enough data area to hold at least one maximum size frame. This check is performed according to the formula:

$$\text{DHB\_SIZE} - 6 \le (\text{\# of Fast Path Buffers} - 1) * (\text{Fast Path Buffer Size} - 22)$$

If this is False the open command will be terminated with an error.

Offset	Parameter Name	Byte Length	Description
0	COMMAND	1	x12, DIR.CONFIG.FAST.PATH.RAM
1		1	Reserved
2	RETCODE	1	Set by the Adapter Upon Return
3		5	Reserved
8	RAM_SIZE	2	RAM Size to Allocate
10	BUFFER_SIZE	2	Size of Transmit Buffers

RAM_SIZE

This parameter specifies to TROPIC the number of *eight-byte blocks* of shared RAM to be allocated for the Fast Path interface. This RAM will be used for the Fast Path Transmit Control Area and the Fast Path Buffer Pool (described in detail later). The Transmit Control Area is *sixteen bytes* and the buffers are configured to the size in the BUFFER_SIZE parameter.

BUFFER_SIZE

This parameter specifies to TROPIC the size to configure each Fast Path Transmit Buffer. When configured, buffers will not cross the 16k (Page) boundaries in the Shared RAM. Each buffer has a 22-byte header for command passing and buffer management. The rest of the buffer is used for data. This parameter must be a multiple of 8 bytes, with a maximum value of 2048 bytes. The *recommended buffer size* is 512 bytes.

SRB Response

After the adapter processes this command, it sets bytes 8 through 11 in the SRB with return parameters and sets a return code in the RETCODE field. The adapter then interrupts the Host by setting HISR(13). The SRB content will then be as follows.

Offset	Parameter Name	Byte Length	Description
0	COMMAND	1	x12, DIR.CONFIG.FAST.PATH.RAM
1		1	Reserved
2	RETCODE	1	Return Code, see Below
3		5	Reserved
8	FAST_PATH_XMIT	2	Offset to Transmit Control Area
10	SRB_ADDRESS	2	Offset to the Beginning of the SRB

Valid Return Codes

x00 Operation completed successfully
x01 Invalid (unrecognized) command code
x03 Adapter open, should be closed
x06 Option(s) missing, invalid, or incomplete

FAST_PATH_XMIT

This is the offset from the start of Shared RAM where the Fast Path Transmit Control Area will be located. This parameter is only valid if the return code is x00.

SRB_ADDRESS

This is the offset from the start of Shared RAM where the adapter will expect subsequent SRB commands to be located. This parameter is only valid if the return code is x00.

DIR.INTERRUPT x00

SUMMARY: Force an adapter interrupt.

This command performs no function. The adapter must have been initialized but does not have to be opened for this command to be accepted.

Offset	Parameter Name	Byte Length	Description
0	COMMAND	1	x00, DIR.INTERRUPT
1		1	Reserved
2	RETCODE	1	Set by the Adapter Upon Return

When the adapter completes the operation, it sets the return code in the SRB and interrupts the Host by setting HISR(13).

Valid Return Codes

x00 Operation completed successfully
x01 Invalid command code

DIR.MODIFY.OPEN.PARMS x01

SUMMARY: Used to modify the OPEN_OPTIONS set by the DIR.OPEN.ADAPTER command.

The wrap option, remote program load, and token release bits will be ignored.

Offset	Parameter Name	Byte Length	Description
0	COMMAND	1	x01, DIR.MODIFY.OPEN.PARMS
1		1	Reserved
2	RETCODE	1	Set by the Adapter Upon Return
3		1	Reserved
4	OPEN_OPTIONS	2	New Options (Wrap Bit Left Unaltered in Adapter)

See the DIR.OPEN.ADAPTER command for a description of the OPEN_OPTIONS parameter.

When the adapter completes the operation, it sets the return code in the SRB and interrupts the Host by setting HISR(13).

Valid Return Codes

x00 Operation completed successfully
x01 Invalid command code
x04 Adapter closed, should be open

DIR.OPEN.ADAPTER x03

SUMMARY: Prepare the adapter for either normal ring communication or an adapter wrap test.

This command is accepted after successful initialization of the adapter. Once an open adapter command has been completed successfully, the adapter must be closed or reset before another open adapter command will be accepted. After this command has been returned with a x00 return code, the adapter is in automatic receive mode and frames can be transmitted and received using the direct interface. DLC interface commands can also be issued.

The information provided along with this command is used to configure shared RAM (see Section 4.0). Space is allocated for:

- The adapter work areas
- The communication areas
- The requested individual and group SAP control blocks
- The requested link station control blocks
- The requested number of DHBs

The remaining shared RAM space is configured as receive buffers using the supplied receive buffer length parameter. The adapter then checks that the number of available receive buffers is equal to or greater than the number requested. If the number of receive buffers is inadequate, the open adapter command is rejected.

Length of SRB

The SRB in shared RAM is defined as 28 bytes in length and all Host commands to the adapter except the DIR.OPEN.ADAPTER require 28 or fewer bytes. The SRB after initialization and before an open command has been completed can accept enough information for the open parameters.

Offset	Parameter Name	Byte Length	Description
0	COMMAND	1	x03, DIR.OPEN.ADAPTER
1		7	Reserved
8	OPEN_OPTIONS	2	Open Options, see Description
10	NODE_ADDRESS	6	This Adapter's Ring Address
16	GROUP_ADDRESS	4	The Group Address to Set
20	FUNCT_ADDRESS	4	The Functional Address to Set
24	NUM_RCV_BUF	2	Number of Receive Buffers
26	RCV_BUF_LEN	2	Length of Receive Buffers
28	DHB_LENGTH	2	Length of Transmit Buffers
30	NUM_DHB	1	Number of DHBs
31		1	Reserved
32	DLC_MAX_SAP	1	Maximum Number of SAPs
33	DLC_MAX_STA	1	Maximum Number of Link Stations
34	DLC_MAX_GSAP	1	Maximum Number of Group SAPs
35	DLC_MAX_GMEM	1	Maximum Members per Group SAP
36	DLC_T1_TICK_1	1	DLC Timer T1 Interval, Group One
37	DLC_T2_TICK_1	1	DLC Timer T2 Interval, Group One
38	DLC_TI_TICK_1	1	DLC Timer Ti Interval, Group One
39	DLC_T1_TICK_2	1	DLC Timer T1 Interval, Group Two
40	DLC_T2_TICK_2	1	DLC Timer T2 Interval, Group Two
41	DLC_TI_TICK_2	1	DLC Timer Ti Interval, Group Two
42	PRODUCT_ID	18	Product Identification

OPEN_OPTIONS

Several options are each defined by a bit. A bit set to 1 selects an option for use. Bit 15 is the high-order (leftmost) bit.

Bit 15	**Pass Beacon MAC Frames**	Passes, as direct interface data to the Host, the first beacon MAC frame and all subsequent beacon MAC frames that have a change in the source address or the beacon type.
Bit 14	**Reserved**	Should be zero but is not checked.
Bit 13	**Remote Program Load**	This bit is only implemented in 16/4 adapters. It prevents the adapter from becoming a monitor during the open process. If this bit is on, the adapter will fail the open process if there is no other adapter on the ring when it attempts to insert on the ring.
Bit 12	**Token Release**	This bit is only available when operating at 16 Mbps. If not set, 16 Mbps adapters will get early token release as a default. Setting this bit on selects no early token release for an adapter at 16 Mbps.
Bits 11–8	**Reserved**	Should be zero, but the bits are not checked.
Bit 7	**Wrap Interface**	The adapter will not attach itself to the network. Instead it causes all user-transmitted data to be wrapped as received data.
Bit 6	**Disable Hard Error**	Prevents network status changes involving "Hard Error" and "Transmit Beacon" bits from causing interrupts.
Bit 5	**Disable Soft Errors**	Prevents network status changes involving the "Soft Error" bit from causing interrupts.
Bit 4	**Pass Adapter MAC Frames**	Passes, as direct interface data to the Host, all adapter class MAC frames that are received but not supported by the adapter. If this bit is off, these frames are ignored.
Bit 3	**Pass Attention MAC Frames**	Passes, as direct interface data to the Host, all attention MAC frames that are not the same as the last received attention MAC frame. If this option is off, these frames are not passed to the Host software.
Bit 2	**Reserved**	Should be zero, but is not checked.
Bit 0	**Contender**	When the contender bit is on, the adapter participates in monitor contention (claim token) if the opportunity occurs. When the contender bit is off, and the need is detected by another adapter, this adapter will not participate. If this adapter detects the need for a new active monitor, monitor contention (claim token) processing will be initiated by this adapter in either case.

NODE_ADDRESS

The 6-byte specific node address of this station on the ring. The high-order (leftmost) bit must he zero. If the value is zero, the adapter's encoded address will be the node address by default.

GROUP_ADDRESS

Sets the group address that the adapter will receive messages for. If the value is zero, no group address is set. The group address can also be set, or changed, by a SET.GROUP.ADDRESS command. The two high-order bytes of the group address, before these four bytes, will be set to xC000.

FUNCT_ADDRESS

Sets the functional address that the adapter will receive messages for. Bits 31, 1, and 0 are ignored. If the value is zero, no functional address is set. The functional address can also be set, or changed, by a DIR.SET.FUNCT.ADDRESS command. The functional address is also affected by the DIR.CONFIG.BRIDGE.RAM command. The two high-order bytes of the functional address will be set to xC000.

NUM_RCV_BUF

The number of receive buffers in shared RAM needed for the adapter to open. The adapter will configure as receive buffers all remaining shared RAM after other memory requirements have been met. If the number available is less than the number requested, the DIR.OPEN.ADAPTER command fails. If the number available is greater than the number requested, no action will occur. If this value is less than 2, the default of 8 is used.

RCV_BUF_LEN

The length of each of the receive buffers in the shared RAM. Receive buffers will be chained together to hold a frame that is too long for one buffer. However, only one frame will be put into a single buffer.

The value must be a multiple of 8; 96 is the minimum and 2048 is the maximum. If the value is zero, the default of 112 is used. Each buffer holds 8 fewer bytes of data than the specified size. Therefore, a buffer defined as 112 bytes long can hold only 104 bytes of data. The 8 bytes are overhead needed by the adapter.

DHB_LENGTH

The length of each of the transmit buffers in the shared RAM. Only one buffer is used to hold transmit data, including header information, for a given frame for the direct interface and SAP interface. For the link station interface, this length applies to the information field of I frames. The value must be a multiple of 8 with 96 as minimum. For adapters operating at 4 Mbps, the maximum DHB size is 4464 bytes. For adapters operating at 16 Mbps, the maximum DHB size is 17960 bytes.

If the value is zero, the default of 600 is used. Each buffer holds 6 fewer bytes of data than the specified size. Therefore, a buffer defined as 600 can hold only 594 bytes.

Note: If a size greater than 2048 is used, it is important to make sure that all adapters receiving these frames can also handle the larger size.

NUM_DHB

This defines the number of transmit buffers in the adapter shared RAM in which the data from the Host can be stored. The adapter accepts any value between 0 and 255, but the integrity of adapter operation cannot be guaranteed if the value is greater than 2. Requesting two buffers may improve adapter performance by allowing a frame to be moved into the second buffer while the adapter is transmitting from the first. However, this reduces the storage available for receive buffers. If the value is zero, the default of 1 is used.

DLC_MAX_SAP

The maximum number of individual SAPs that can be opened at one time. The maximum value allowed is 126. Each individual SAP control block requires 64 bytes of shared RAM. If this parameter is set to zero, no open SAP commands will be accepted and the DLC SAP and the DLC link station interfaces will not be available. However, the null and the global SAPs are activated.

DLC_MAX_STA

The maximum number of link stations that can be opened at one time. It does not determine the number of link stations that can be open for any one SAP. Each link station control block requires 144 bytes of shared RAM. If this parameter is not zero, the DLC_MAX_SAP parameter must not be zero.

DLC_MAX_GSAP

The maximum number of group SAPs that can be opened at one time. Each group SAP control block requires 14 bytes plus two times the DLC_MAX_GMEM parameter value in shared RAM. If the value is zero, no group SAPs are allowed, but the global SAP will be activated. The corresponding individual SAP control block, requiring 64 bytes, is required in order to open a group SAP. That is, group SAP x05 requires that individual SAP x04 must also be allocated.

DLC_MAX_GMEM

The maximum number of SAPs that can be assigned to any given group. This parameter is ignored if the DEC_MAX_GSAP parameter is zero and cannot be zero if that field is not zero.

Timer Parameters Note: The next six parameters, **DLC_TI_TICK_1** through **DLCTI_TICK_2**, are timer parameters that are referenced by the DLC.OPEN.SAP and DLC.MODIFY commands.

DLC_T1_TICK_1

The number of 40 ms intervals that make up a "tick" for DLC Wait For Response Timer, T1 (T1 timer values 1–5). If the value is zero, the default of 5 (200 ms) is used.

DLC_T2_TICK_1

The number of 40 ms intervals between timer "ticks" for DLC Send an Acknowledgement Timer, T2 (T2 timer values 1–5). If the value is zero, the default of 1 (40–80 ms) is used.

DLC_TI_TICK_1

The number of 40 ms intervals between timer "ticks" for DLC Inactivity Timer, Ti (Ti timer values 1–5). If the value is zero, the default of 25 (1 second) is used.

DLC_T1_TICK_2

The number of 40 ms intervals between timer "ticks" for DLC timer T1 (timer values 6–10). If the value is zero, the default of 25 (1 second) is used.

DLC_T2_TICK_2

The number of 40 ms intervals between timer "ticks" for DLC timer T2 (timer values 6–10). If the value is zero, the default of 10 (400 ms) is used.

DLC_TI_TICK_2

The number of 40 ms intervals between timer "ticks" for DLC timer Ti (timer values 6–10). If the value is zero, the default of 125 (5 seconds) is used.

PRODUCT_ID

This is the Host 18-byte product ID.

SRB Response

When the adapter completes the open command, bytes 6 through 15 in the SRB are set with return parameters, and the return code is placed in the RETCODE field. The adapter then interrupts the Host by setting HISR(13). The SRB content will then be as follows.

Offset	Parameter Name	Byte Length	Description
0	COMMAND	1	x03, DIR.OPEN.ADAPTER
1		1	Reserved
2	RETCODE	1	Return Code, see Below
3		4	Reserved
7	OPEN_ERROR_CODE	1	Valid if RETCODE is x07. See the "Adapter Open Errors" Table in Section 8.0.
8	ASB_ADDRESS	2	Offset to the Beginning of the ASB
10	SRB_ADDRESS	2	Offset to the Beginning of the SRB
12	ARB_ADDRESS	2	Offset to the Beginning of the ARB
14	SSB_ADDRESS	2	Offset to the Beginning of the SSB

Valid Return Codes

x00 Operation completed successfully
x01 Invalid command code
x03 Adapter open, should be closed
x05 Required parameters not provided
x07 Command canceled, unrecoverable failure
x30 Inadequate receive buffers for adapter to open
x32 Invalid NODE_ADDRESS
x33 Invalid adapter receive buffer length defined
x34 Invalid adapter transmit buffer length defined

DIR.READ.LOG x08

SUMMARY: Read and reset the adapter error counters.

This command should be issued if a ring status change ARB is received with the counter overflow set. This ARB is issued if one of the adapter error counters reaches a count of 255. The adapter will accept this command anytime after the adapter is opened and before a close adapter command is issued.

Offset	Parameter Name	Byte Length	Description
0	COMMAND	1	x08, DIR.READ.LOG
1		1	Reserved
2	RETCODE	1	Set by the Adapter Upon Return
3		3	Reserved
6	LOG_DATA	14	14 Bytes of Log Data Set by the Adapter

Adapter Error Counters

Refer to the *IBM Token-Ring Network Architecture Reference* for more about these error counters.

Byte	Meaning
0	Line Errors
1	Internal Errors
2	Burst Errors
3	A/C Errors
4	Abort Delimiters
5	Reserved
6	Lost Frames
7	Receive Congestion Count
8	Frame Copied Errors
9	Frequency Errors
10	Token Errors
11	Reserved
12	Reserved
13	Reserved

When the adapter completes the operation, it sets the return code in the SRB and interrupts the Host by setting HISR(13).

Valid Return Codes

x00 Operation completed successfully
x01 Invalid command code
x04 Adapter closed, should be open.

DIR.RESTORE.OPEN.PARMS x02

SUMMARY: Used to modify the OPEN_OPTIONS set by the DIR.OPEN.ADAPTER command.
The wrap option, remote program load, and modified token release bits will be ignored.

Offset	Parameter Name	Byte Length	Description
0	COMMAND	1	x02, DIR.RESTORE.OPEN.PARMS
1		1	Reserved
2	RETCODE	1	Set by the Adapter Upon Return
3		1	Reserved
4	OPEN_OPTIONS	2	New Options (Wrap Bit Left Unaltered in Adapter)

See the DIR.OPEN.ADAPTER command for a description of the OPEN_OPTIONS parameter.
When the adapter completes the operation, it sets the return code in the SRB and interrupts the Host by setting HISR(13).

Valid Return Codes

x00 Operation completed successfully
x01 Invalid command code
x04 Adapter closed, should be open

DIR.SET.FUNCT.ADDRESS x07

SUMMARY: Set the functional address for the adapter to receive messages. If this command is issued with the FUNCT_ADDRESS field containing all zeros, any previously set functional address is disabled. Bits 31, 1, and 0 will be ignored. The adapter will accept this command anytime after the adapter is opened and before a close adapter command is issued. See the DIR.CONFIG.BRIDGE.RAM command, which can also alter the functional address. The upper 2 bytes of the 6-byte functional address will be set to xC000.

Offset	Parameter Name	Byte Length	Description
0	COMMAND	1	x07, DIR.SET.FUNCT.ADDRESS
1		1	Reserved
2	RETCODE	1	Set by the Adapter Upon Return
3		3	Reserved
6	FUNCT_ADDRESS	4	New Functional Address to Set

When the adapter completes the operation, it sets the return code in the SRB and interrupts the Host by setting HISR(13).

Valid Return Codes

x00 Operation completed successfully
x01 Invalid command code
x04 Adapter closed, should be open

DIR.SET.GROUP.ADDRESS x06

SUMMARY: Set the group address for the adapter to receive messages.

The adapter will accept this command anytime after the adapter is opened and before a close adapter command is issued. The upper 2 bytes of the 6 byte group address will be set to xC000.

Offset	Parameter Name	Byte Length	Description
0	COMMAND	1	x06, DIR.SET.GROUP.ADDRESS
1		1	Reserved
2	RETCODE	1	Set by the Adapter Upon Return
3		3	Reserved
6	GROUP_ADDRESS	4	New Group Address to Set

When the adapter completes the operation, it sets the return code in the SRB and interrupts the Host by setting HISR(13).

Valid Return Codes

x00 Operation completed successfully
x01 Invalid command code
x04 Adapter closed, should be open

DLC (IEEE 802.2 SAP and Station Interfaces) SRB Commands

These commands affect SAPs (Service Access Points) and link stations, and make use of LLC protocols. They may be issued by the Host software to the adapter. The adapter must have been initialized and opened with direct interface commands before it will accept any of these commands. Some of these commands apply only to the SAP interface (DLC.OPEN.SAP and DLC.CLOSE.SAP), and some apply only to the station interface (DLC.OPEN.STATION, DLC.CONNECT.STATION, DLC.CLOSE.STATION, DLC.STATISTICS). The rest apply to both interfaces.

Command Name	Code (Hex)	Description
DLC.CLOSE.SAP	16	Closes (deactivates) an SAP and frees associated control block(s).
DLC.CLOSE.STATION	1A	Closes one link station; will not complete while Ring is "beaconing"
DLC.CONNECT.STATION	1B	Initiates a SABME_UA exchange to place the local and remote link stations in a data transfer state, or completes such an exchange that has been initiated by the remote station
DLC.FLOW.CONTROL	1D	Controls the flow of data across a specified link station on an SAP, or every link on an SAP
DLC.MODIFY	1C	Modifies selected working values on an open link station or the default values of an SAP
DLC.OPEN.SAP	15	Opens (activates) an SAP and allocates an individual SAP control block
DLC.OPEN.STATION	19	Allocates resources to support a logical link connection
DLC.REALLOCATE	17	Removes a given number of link station control blocks from an SAP and returns them to the adapter pool, or removes a given number of link station control blocks from the adapter pool and returns them to an SAP
DLC.RESET	14	Resets one SAP and all associated link stations, or all SAPs and all associated link stations
DLC.STATISTICS	1E	Reads statistics for a specific link station

DLC.CLOSE.SAP x16

SUMMARY: Close (deactivate) a service access point (SAP) and free the associated control blocks

This command is rejected if any links are open for the specified SAP, or the SAP was opened with the group option specified with any active members in the group. If the specified SAP is a group member, its membership should be canceled using a DLC.MODIFY command before issuing this command. If an adapter command to the Host is pending for the specified SAP when the DLC.CLOSE.SAP command is issued, the Host must complete that action before this command will be completed.

Any frames directed to the specified SAP that have been received by the adapter and for which the adapter has not posted a receive ARB will be discarded.

Note: If a x47 error code results when a DLC.CLOSE.SAP command closely follows a DLC.CLOSE.STATION command for the last open station for that SAP, reissue the DLC.CLOSE.SAP command.

Offset	Parameter Name	Byte Length	Description
0	COMMAND	1	x16, DLC.CLOSE.SAP
1		1	Reserved
2	RETCODE	1	Set by the Adapter Upon Return
3		1	Reserved
4	STATION_ID	2	ID of the SAP to be Closed

When the adapter completes the operation, it sets the return code in the SRB and interrupts the Host by setting HISR(13).

Valid Return Codes

x00 Operation completed successfully
x01 Invalid command code
x04 Adapter closed, should be open
x40 Invalid STATION_ID
x47 SAP cannot close unless all link stations are closed
x46 Group SAP cannot close until all member SAPs are closed
x4C Unable to close, commands pending

4

DLC.CLOSE.STATION x1A

SUMMARY: Close one link station. This command will not be completed while the ring is beaconing.

The link control block will be freed for use by another link station on the same SAP. This command will be rejected if there is a DLC.CLOSE.STATION or a DLC.CONNECT.STATION command pending for the specified link station. If the command is accepted, the adapter will either:

- Transmit a DISC command to the remote station and enter disconnecting mode while waiting for an acknowledgment
- Send a DM response if there is a SABME or DISC command pending, or if the link is in the disconnecting state, and close the link station when the response has been transmitted.

If there are pending Transmit I Frame requests when this command is accepted, they will not be returned by the adapter. If an adapter command to the Host is outstanding for the specified link station when DLC.CLOSE.STATION command is issued, the Host must complete that action before this command will be completed. Any frames directed to the specified link station that have been received by the adapter but not processed will be handled according to the state the adapter enters upon receipt of this command. Those link station states would be either disconnecting state or link closed state.

Offset	Parameter Name	Byte Length	Description
0	COMMAND	1	x1A, DLC.CLOSE.STATION
1	CMD_CORRELATE	1	Set by the Adapter Upon Return
2	RETCODE	1	Set by the Adapter Upon Return
3		1	Reserved
4	STATION_ID	2	ID of the Link Station to be Closed

If there is no immediate error, the adapter sets the RETCODE to xFF (command in process), sets the CMD_CORRELATE field in the SRB, and interrupts the Host by setting HISR(13) if an SRB Free Request interrupt is received by the adapter. When the command is completed later, the Host will be interrupted with a response in the SSB. If there is an immediate error, the adapter sets the RETCODE with the error code and sets HISR(13) to interrupt the Host.

Valid Return Codes

x00 Operation completed successfully
xFF Command in process
x01 Invalid command code
x02 Duplicate command, one already pending
x04 Adapter closed, should be open
x40 Invalid STATION_ID
x4C Unable to close, commands pending

Final RETCODE in SSB

x00 Operation completed successfully
x4B Station closed, no remote acknowledgment

DLC.CONNECT.STATION x1B

SUMMARY: To initiate a SABME_UA exchange to place both the local and remote link stations in data transfer state, or to complete such an exchange initiated by the remote station.

This command will not be accepted if the link station is in the disconnecting or link closed state, or if a DLC.CLOSE.STATION or DLC.CONNECT.STATION command is in process. Any pending transmit commands queued to the link station will be lost.

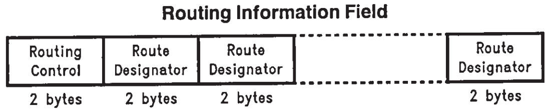
Offset	Parameter Name	Byte Length	Description
0	COMMAND	1	x1B, DLC.CONNECT.STATION
1	CMD_CORRELATE	1	Set by the Adapter Upon Return
2	RETCODE	1	Set by the Adapter Upon Return
3		1	Reserved
4	STATION_ID	2	ID of the Link Station to be Closed
6	ROUTING_INFO	18	See Following Description

ROUTING_INFO

If the remote partner for this station is on a different ring, routing information is needed for frames to be exchanged. If the link is being established because of a DLC.OPEN.STATION command, the routing information must be provided with the command. If the link is being established due to receipt of a SABME from the remote partner, the adapter obtains the routing information from the received frame and ignores any ROUTING_INFO provided with the DLC.CONNECT.STATION command. The DLC.CONNECT.STATION command may also be used to provide new routing information if there is a link failure. The information must be provided in the format in which it will be used in transmitted frames. If the routing information length field (discussed shortly) is zero and no SABME is outstanding, the remote partner will be assumed to be on the same ring. For more information on routing information and XID, see the *IBM Token-Ring Network Architecture Reference*. You may also want to refer to any documentation related to implementation by bridges in your network.

The Routing information field contains a 2 byte routing control field and up to eight 2 byte route designators, as shown below:

Routing Information Field



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The Routing Control and Routing Designator sub-fields are described next.

Routing Control Sub-Field

The Routing Control Sub-Field consist of two separate bytes of information, as shown below:

First Byte (Offset 6 in DLC.CONNECT.STATION Command)

7	6	5	4	3	2	1	0
B	B	B	L	L	L	L	L

B = Broadcast Indicators
L = Length Bits

Second Byte (Offset 7 in DLC.CONNECT.STATION Command)

7	6	5	4	3	2	1	0
D	F	F	F	r	r	r	r

D = Direction Bit
F = Largest Frame Bits
r = Reserved Bits

Route Designator Sub-Fields

Each 2-byte (word) Route Designator Sub-Field is divided into two portions:

- **Individual Bridge Portion—**This portion is k-bits long, where k is the same for all bridges in a given multiple-ring network. Bridges that are attached to the same ring can have the same Individual Bridge Portion value. However, parallel bridges (those that are attached to the same two rings) must have different values.
- **Ring Number Portion—**This portion is (16-k)-bits long. Bridges that are attached to different rings have different Ring Number Portion values; bridges that are attached to the same ring have the same value.

These portions are located in each Route Designator Sub-Field; a word (2 byte) read returns the Sub-Field as shown below:

Route Designator Field (As Returned by Word Read)

15	8	0
RN_0	IB	RN_1
8k (bits)	k bits	8 bits

IB = Individual Bridge Portion
RN = Ring Number Portion (split into elements 0 and 1)

This word value must be byte-swapped before interpreting. The result is shown below:

Route Designator Field (After Byte Swap)

15	0
RN	IB
16k (bits)	k bits

Return Codes

If there is no immediate error, the adapter sets the RETCODE field to xFF (command in process), sets the CMD_CORRELATE field in the SRB, and interrupts the Host by setting HISR(13) if an SRB Free Request interrupt is received by the adapter. When the command is completed later, the Host will be interrupted with a response in the SSB. A successful return code indicates that the local link station has entered the link opened state. An unsuccessful return code indicates that it has entered the disconnected state.

If there is an immediate error, the adapter sets the RETCODE with the error code and sets HISR(13) to interrupt the Host.

Valid Return Codes

xFF Command in process
x01 Invalid command code
x02 Duplicate command, one already pending
x04 Adapter closed, should be open
x40 Invalid STATION_ID
x41 Protocol error, link in invalid state for command
x44 Invalid routing information
x4A Sequence error, command in process

Final RETCODE in SSB

x00 Operation completed successfully
x4D Unsuccessful link station connection attempt

DLC.FLOW.CONTROL 1D

SUMMARY: To control the flow of data across a specified link station on an SAP, or every link station on an SAP.

Local busy state is set either because of a user request, or because a RECEIVED.DATA command from the adapter to the PC system has been rejected. In the latter case, the condition must be reset by the Host program when buffers become available, by using this command with option bit 6 set.

This command affects the secondary state of target link stations, causing the local busy states to be set or reset. The command will be completed successfully even if it makes no change to the existing state. That is, a request to reset local busy will be accepted even if the link is not in local busy state.

Offset	Parameter Name	Byte Length	Description
0	COMMAND	1	x1D, DLC.FLOW.CONTROL
1		1	Reserved
2	RETCODE	1	Set by the Adapter Upon Return
3		1	Reserved
4	STATION_ID	2	ID of the Link Station or SAP
6	FLOW_OPTIONS	1	Option Byte

STATION_ID

If the STATION_ID is an SAP (xnn00), the command will be applied to all link stations included in the SAP. If the STATION_ID is a link station (xnnss), the command will be applied only to the specified link station.

FLOW_OPTIONS

The flow option byte is described below:

Bit 7	**Set/Reset Local Busy State**	If this bit is zero, the related link stations will enter the local busy link secondary state. If the station is in the link opened primary state and not already in local busy state, a Receiver Not Ready supervisory frame is transmitted. Then I frames received for this station are discarded until this condition is reset by the Host software. If this bit is on, option bit 6 is checked to determine whether local busy (user set) or local busy (buffer set) should be reset. If both local busy states are reset after this command has been accepted and the primary link state is link opened, the link will enter either the checkpointing or clearing secondary state to ensure that the remote station is aware that the condition has been reset.
Bit 6	**User/Buffer Reset**	If bit 6 is 0 and option bit 7 is 1, local busy (user set) will be reset. If bit 6 is 1 and option bit 7 is 1, local busy (buffer set) will be reset. If option bit 7 is zero, this bit is ignored.
Bits 5–0	**Reserved**	

Return Codes

When the adapter completes the operation, it sets the return code in the SRB and interrupts the Host by setting HISR(13).

Valid Return Codes

x00 Operation completed successfully
x01 Invalid command code
x02 Duplicate command, one already pending
x04 Adapter closed, should be open
x40 Invalid STATION_ID

DLC.MODIFY x1C

SUMMARY: To modify certain working values of an open link station or the default values of an SAP.

The values to be updated are included in the SRB.

Offset	Parameter Name	Byte Length	Description
0	COMMAND	1	x1C, DLC.MODIFY
1		1	Reserved
2	RETCODE	1	Set by the Adapter Upon Return
3		1	Reserved
4	STATION_ID	2	SAP or Link Station ID
6	TIMER_T1	1	T1 Value, Response Timer
7	TIMER_T2	1	T2 Value, Acknowledgment Timer
8	TIMER_Ti	1	Ti Value, Inactivity Timer
9	MAXOUT	1	Max Transmits without a Receive Acknowledgment
10	MAXIN	1	Max Receives without a Transmit Acknowledgment
11	MAXOUT_INCR	1	Dynamic Window Increment Value
12	MAX_RETRY_COUNT	1	N2 Value
13	ACCESS_PRIORITY	1	New Access Priority for Transmission
14	SAP_GSAP_MEM	1	Number of Following Group SAPs
15	GSAPS	n	GSAP List, Maximum 13

STATION_ID

If this is an SAP STATION_ID, the command will affect the default values held in the SAP control block, but not the current values of open link stations. If it is a link station STATION_ID, the command will affect the current values of the designated (open) link station.

TIMER_T1, TIMER_T2, TIMER_Ti

These values must be less than 11 for T1 and Ti. If a value greater than 10 is provided for T2, the acknowledgment timer will not run. If the field is zero, the existing value remains unchanged. For an explanation of the values, see the DLC.OPEN.SAP command description.

MAXOUT

This parameter cannot exceed 127. If the field is zero, the existing value remains unchanged.

MAXIN

This parameter cannot exceed 127. If the field is zero, the existing value remains unchanged.

MAXOUT_INCR

This parameter cannot exceed 255. If the field is zero, the existing value remains unchanged.

MAX_RETRY_COUNT

This parameter cannot exceed 255. If the field is zero, the existing value remains unchanged.

ACCESS_PRIORITY

If the requested access priority exceeds the limit authorized for the adapter, it will be rejected. The access priority is contained in the 3 low-order bits of this byte.

SAP_GSAP_MEM

The number of SAP_VALUES in the GSAPS field.

This field is only checked and used if the SAP was opened as a group member. The maximum value is 13 (the greatest number of SAP_VALUES that the SRB length will accommodate).

GSAPS

This field is used for an individual SAP to request membership in additional group SAPs or to request that membership be canceled. If the low-order bit of an SAP_VALUE is zero, it indicates that membership in the associated group SAP is being requested. If the low-order bit of an SAP_VALUE is 1, it indicates that membership should be canceled. The group SAPs must be open when the assignment is requested, and all members of a group SAP must have the same XID handling option selected. If an error is found while processing the list of group SAPs, an error return code will be set and processing will stop. The SAP_GSAP_MEM field will be overwritten with the value of the failing group SAP. Other parameter changes will take place as requested.

SRB Response

When the adapter completes the modify command, the return code is placed in the RETCODE field. The adapter then interrupts the Host by setting HISR(13).

Valid Response Codes

x00 Operation completed successfully
x01 Invalid command code
x04 Adapter closed, should be open
x08 Unauthorized access priority
x40 Invalid STATION_ID
x42 Parameter exceeded maximum allowed
x45 Membership requested in non-existent group SAP
x49 Group SAP has reached maximum membership
x4E Member SAP not found in group SAP list

DLC.OPEN.SAP x15

SUMMARY: Open (activate) a service access point (SAP) and allocate an individual SAP control block.
A group SAP control block and one or more link station control blocks can also be allocated by this command.

Offset	Parameter Name	Byte Length	Description
0	COMMAND	1	x15, DLC.OPEN.SAP
1		1	Reserved
2	RETCODE	1	Set by the Adapter Upon Return
3		1	Reserved
4	STATION_ID	2	Set by the Adapter Upon Return
6	TIMER_T1	1	T1 Value, Response Timer
7	TIMER_T2	1	T2 Value, Acknowledgment Timer
8	TIMER_Ti	1	Ti Value, Inactivity Timer
9	MAXOUT	1	Max Transmits without a Receive Acknowledgment
10	MAXIN	1	Max Receives without a Transmit Acknowledgment
11	MAXOUT_INCR	1	Dynamic Window Increment Value
12	MAX_RETRY_COUNT	1	N2 Value
13	GSAP_MAX_MEM	1	Maximum Number of SAPs for a Group SAP
14	MAX_I_FIELD	2	Maximum Received Information Field Length
16	SAP_VALUE	1	SAP Value to be Assigned
17	SAP_OPTIONS	1	Option Byte, see Below
18	STATION_COUNT	1	Number of Link Stations to Reserve
19	SAP_GSAP_MEM	1	Number of Entries in GSAP List
20	GSAPS	n	GSAP List, Maximum = 8

STATION_ID

The adapter will set this to the station ID to be used in future commands referencing this SAP

TIMER_T1, TIMER_T2, TIMER_TI

The LLC protocol uses timers called T1, T2, and TI. The DLC.OPEN.SAP and DLC.OPEN.STATION commands specify the values to be used for these LLC timers in a rather unique way:

The DIR.OPEN.ADAPTER command specifies six timer values, two each for T1, T2, and TI. When the DLC commands specify the 3 timer values, they specify a number from 1 to 10 for each timer. If a number from 1 to 5 is specified for a T(1, 2, I) timer, this number multiplied by the DLC_T(1, 2, I)_Tick_1 time becomes the value for T(1,2, I). If a number from 6 to 10 is specified for a T(1, 2, I) timer, this number, minus 5, multiplied by the DLC_T(1, 2, I)_Tick_2 time becomes the value for T(1, 2, I).

The values must be less than 11 for T1 and Ti. If a value greater than 10 is provided for T2, the acknowledgment timer will not run. If the field is zero, the adapter will provide defaults. The default values are T1 = 5, T2 = 2, and TI = 3.

MAXOUT

This parameter is the maximum number of unacknowledged transmitted I-frames. It cannot exceed 127. If a zero is provided, the default of 2 is used.

MAXIN

This parameter is the maximum number I-frames received before an acknowledgment is sent. It cannot exceed 127. If a zero is provided, the default of 1 is used.

MAXOUT_INCR

This parameter specifies the dynamic windowing algorithm increment. It cannot exceed 255. If a zero is provided, the default of 1 is used.

MAX_RETRY_COUNT

This parameter is the maximum number of retransmissions of an I-frame. It cannot exceed 255. If a zero is provided, the default of 8 is used.

GSAP__MAX__MEM

The maximum number of individual SAPs that can be assigned membership in the group SAP if this SAP is designated to be a group SAP. Membership is assigned in the group SAP as the individual SAPs are opened. This parameter may not exceed the similar parameter provided with the DIR.OPEN.ADAPTER command and will default to that value if it is zero.

MAX__I__FIELD

This parameter defines the maximum length of a received I frame for a link station. If the STATION__COUNT parameter is zero, this field is ignored. If this field is zero, the default will be 600 bytes long. The maximum length is 4905 bytes on a 4 Mbps ring and 18000 bytes on a 16 Mbps ring.

SAP__VALUE

The value that will be used as the source SAP in transmitted frames and recognized as the destination SAP in received frames. The low-order bit of this field will be ignored. A DLC.OPEN.SAP command always allocates an individual SAP control block. A value of x00 is always rejected and a value of xFE will be rejected if the group SAP option is requested. If option bit 1 is a 1, the SAP__VALUE with the low-order bit set to 1 will be the group SAP value. In other words, the next higher (odd-numbered) SAP control block will be allocated to be a group SAP.

SAP__OPTIONS

Bits	Name	Description
7–5	Priority	The transmission priority for this SAP. If the requested priority exceeds the limit authorized for the adapter, the command will be rejected.
4	Reserved	Should be zero. Not checked.
3	XID Handling Option	If this is zero, XID commands are handled by the adapter. If this is 1, XID commands are passed to the Host software.
2	Individual Option	If this bit is 1, the SAP will handle frames as an individual SAP.
1	Group Option	If this bit is 1, the SAP will handle frames as a group SAP.
0	Group Member	If this bit is 1, the SAP may be a member of a group SAP.

Note: If bit 0 is a 1, bit 2 must also be a 1. At least one of bits 2 and 1 *must* be Set.

STATION__COUNT

This parameter specifies the maximum number of link stations that can be open for this SAP at the same time, and applies only if the SAP is an individual SAP. If the number of link stations requested for this SAP, together with those already requested for previously opened SAPs, exceeds the DLC__MAX__STATIONS parameter value from the DIR.OPEN.ADAPTER command, the DLC.OPEN.SAP command will be rejected.

SAP__GSAP__MEM

The number of SAP__VALUES in the GSAPS field. The maximum value is 8. This parameter is ignored if SAP__OPTIONS bit 0 (Group Member) is a zero.

GSAPS

Used for an individual SAP to request membership in group SAPs. SAP__GSAP__MEM indicates the number of valid values in this field. If additional membership is needed, the DLC.MODIFY command may be used for the requests. The group SAPs must be open when the assignment is requested, and all members of a group SAP must have the same XID handling option selected. If an error is found while processing the list of group SAPs, an error return code is set, processing stops, and the SAP__GSAP__MEM field is overwritten with the value of the failing group SAP. This will not affect the status of the SAP.

SRB Response

When the adapter completes the open command, the return code is placed in the RETCODE field. The adapter then interrupts the Host by setting HISR(13).

Valid Response Codes

x00 Operation completed successfully
x01 Invalid command code
x04 Adapter closed, should be open
x06 Options missing, invalid, or incompatible
x08 Unauthorized access priority
x42 Parameter exceeded maximum allowed
x43 Invalid SAP__VALUE or value already in use
x45 Membership requested in non-existent group SAP
x46 Requested resources not available
x49 Group SAP has reached maximum membership

DLC.OPEN.STATION x19

SUMMARY: Allocate resources to support a logical link connection.

These resources may also be allocated when an SABME is received against an open SAP and the appropriate station is not already open.

Offset	Parameter Name	Byte Length	Description
0	COMMAND	1	x19, DLC.OPEN.STATION
1		1	Reserved
2	RETCODE	1	Set by the Adapter Upon Return
3		1	Reserved
4	STATION_ID	2	SAP ID (xnn00)
6	TIMER_T1	1	TI Value, Response Timer
7	TIMER_T2	1	T2 Value, Acknowledgment Timer
8	TIMER_Ti	1	Ti Value, Inactivity Timer
9	MAXOUT	1	Max Transmits without a Receive Acknowledgment
10	MAXIN	1	Max Receives without a Transmit Acknowledgment
11	MAXOUT_INCR	1	Dynamic Window Increment Value
12	MAX_RETRY_COUNT	1	N2 Value
13	RSAP_VALUE	1	The Remote SAP Value
14	MAX_I_FIELD	2	Maximum Received Information Field Length
16	STATION_OPTIONS	1	Option Byte, see Following Explanation
17		1	Reserved
18	REMOTE_ADDRESS	6	Ring Address of the Remote Station

STATION_ID

The Host software must specify the SAP STATION_ID (xnn00) under which the new station is to be established, and the adapter will return the link ID (ss portion of xnnss) to be used in future commands referencing this station.

TIMER_T1 through MAX_RETRY_COUNT

See the same parameters for the DLC.OPEN.SAP command.

RSAP_VALUE

The value that will be used as the destination SAP in transmitted frames and recognized as the source SAP in received frames. The low-order bit of this field must be zero, indicating an individual SAP. A value of x00 (the null SAP) will be rejected.

MAX_I_FIELD

This parameter defines the maximum length of a received I frame. If this field is zero, the value from the SAP control block will be used.

STATION_OPTIONS

The STATION_OPTIONS bits are described in the following table:

Bits	Name	Description
7-5	Priority	The transmission priority for this link station. If the requested priority exceeds the limit authorized for the adapter, the command will be rejected. If a zero is provided, an access priority of zero is used.
4–0	Reserved	Should be zero. Not checked.

REMOTE_ADDRESS

The 6 byte NODE_ADDRESS of the remote station. The high-order bit of the high-order byte of this field must be zero, indicating a specific address.

SRB Response

When the adapter completes the open command, the return code is placed in the RETCODE field. The adapter then interrupts the Host by setting HISR(13). This command should be followed by a DLC.CONNECT.STATION command, which should include the routing information if the remote station is on a different ring.

Valid Response Codes

x01 Invalid command code
x04 Adapter closed, should be open
x05 Required parameters not provided
x08 Unauthorized access priority
x40 Invalid STATION_ID
x42 Parameter exceeded maximum allowed
x43 Invalid SAP_VALUE or value already in use
x46 Requested resources not available
x4F Invalid remote address

DLC.REALLOCATE x17

SUMMARY: This command removes a given number of link station control blocks from an SAP and returns them to the adapter pool, or removes a given number of link station control blocks from the adapter pool and adds them to an SAP.

Offset	Parameter Name	Byte Length	Description
0	COMMAND	1	x17, DLC.REALLOCATE
1		1	Reserved
2	RETCODE	1	Set by the Adapter Upon Return
3		1	Reserved
4	STATION_ID	2	Link Station ID Affected
6	OPTION_BYTE	1	Add/Subtract Option
7	STATION_COUNT	1	Number of Link Station Control Blocks to Move
8	ADAPTER_COUNT	1	Number of Link Station Control Blocks for the Adapter. Set by Adapter on Return.
9	SAP_COUNT	I	Number of Link Station Control Blocks for the SAP. Set by Adapter on Return.

OPTION_BYTE

The OPTION_BYTE bits are described as follows:

- If bit 0 is 0, then take link station control blocks from the adapter and add to the SAP.
- If bit 0 is 1, then take link station control blocks from the SAP and add to the adapter.
- Bits 1 through 7 are reserved.

STATION_COUNT

The number of link station control blocks to be moved as indicated by the option byte. If more link station control blocks are requested than are available on the adapter or SAP, all those available will be moved.

ADAPTER_COUNT

The number of link station control blocks available for the adapter (not allocated to an SAP), after the command has been completed. This field is only valid if the return code is x00 or x40.

SAP_COUNT

The number of link station control blocks available for the SAP specified in the station ID field (not in use for an open station) after the command has been completed. This field is only valid if the return code is x00.

SRB Response

When the adapter completes the command, it sets the return code and the Host is interrupted with HISR(13) set.

Valid Response Codes

x00 Operation completed successfully
x01 Invalid command code
x04 Adapter closed, should be open
x40 Invalid STATION_ID

DLC.RESET x14

SUMMARY: Reset either one SAP and all associated link stations, or all SAPs and all associated link stations.

After the command is completed the affected SAPs and link stations will be closed. No commands or communication directed to them will be accepted. The reset command will not be completed until all related resources can be freed. This means that transmissions already queued to the ring hardware and commands from the adapter to the Host must be complete before this command will be completed. Frames received for the affected SAPs and link stations but not passed to the Host will be discarded by the adapter. The same is true for frames received while the reset is in progress. Requests queued to SAPs and link stations that have not started completion will not be completed. A beaconing ring can cause this command to hang if transmits are queued to the hardware. The command will be completed when beaconing clears.

Offset	Parameter Name	Byte Length	Description
0	COMMAND	1	x14, DLC.RESET
1		1	Reserved
2	RETCODE	1	Set by the Adapter Upon Return
3		1	Reserved
4	STATION_ID	2	ID of the SAPs or stations to be reset **x0000** All SAPs and All Stations **xnn00** SAP nn and All its Stations

When the adapter completes the operation, it sets the return code in the SRB and interrupts the Host by setting HISR(13).

Valid Return Codes

x00 Operation completed successfully
x01 Invalid command code
x04 Adapter closed, should be open
x40 Invalid STATION_ID.

DLC.STATISTICS x1E

SUMMARY: Read statistics for a specific link station.

The error counters (first five station statistics) may be reset if requested. If a counter overflows (high-order bit of the field changes from zero to 1), a DLC status adapter request block (ARB) will be presented to the Host, indicating that this command should be issued.

Offset	Parameter Name	Byte Length	Description
0	COMMAND	1	x1E, DLC.STATISTICS
1		1	Reserved
2	RETCODE	1	Set by the Adapter Upon Return
3		1	Reserved
4	STATION_ID	2	The Link Station to Obtain Statistics from
6	COUNTERS_ADDR	2	Offset to the Address of the Statistics*
8	HEADER_ADDR	2	Offset to the Address of the LAN Header*
10	HEADER_LENGTH	1	Length of the LAN Header*
10	RESET_OPTION	1	Option Byte, see Following Explanation **Note:** Overwritten by TROPIC on response.

*Values set by TROPIC in response

COUNTERS_ADDR

An address within the SRB where a copy of the counter contents is located. The Host software should move this information into Host memory before reusing the SRB. The structure of the counter statistics area is shown on the next page.

Link Station Statistics (Pointed to by COUNTERS_ADDR)

Offset	Parameter Name	Byte Length	Description
0	I_FRAME_XMIT_COUNT	2	The Number of I Frames Transmitted
2	I_FRAME_RCV_COUNT	2	The Number of I Frames Received
4	I_FRAME_XMIT_ERR	1	The Number of I Frame Transmit Errors
5	I_FRAME_RCV_ERR	1	The Number of I Frame Receive Errors
6	T1_EXPIRED	2	The Number of Times T1 Expired
8	STATION_RCVD_CMD	1	The Last Command or Response Received
9	STATION_SENT_CMD	1	The Last Command or Response Sent
10	STATION_PRMY_STATE	1	The Link Primary State, see Below
11	STATION_SCDY_STATE	1	The Link Secondary State, see Below
12	STATION_VS	1	The Send State Variable
13	STATION_VR	1	The Receive State Variable
14	STATION_VA	1	The Last Received NR

Note: All values are set by TROPIC.

HEADER_ADDR

The offset within shared RAM of the LAN header consisting of the access control (AC) field, the frame control (FC) field, the destination address, the source address, and the routing information. If no routing information is present, the header length will be 14 bytes. The source address field will not be set until the first frame is transmitted for the link station, except that the high-order bit of the high-order byte is set on if routing information is present.

RESET_OPTION

The RESET_OPTION bits are described in the following table:

Bit(s)	Description
7	If this bit is zero, the adapter will not alter the contents of the error counters. If this bit is 1, the adapter will reset the contents of the error counters.
6–0	Reserved

STATION_PRMY_STATE

This field indicates the link station's primary state as maintained in the control block at the time the DLC.STATISTICS command is completed. It consists of eight mutually exclusive bit flags, as follows:

Bit 7 Link Closed
Bit 6 Disconnected
Bit 5 Disconnecting
Bit 4 Link Opening
Bit 3 Resetting
Bit 2 FRMR Sent
Bit 1 FRMR Received
Bit 0 Link Opened

STATION_SCDY_STATE

This field indicates the link station's secondary state as maintained in the control block at the time the DLC.STATISTICS command is completed. It consists of seven non-exclusive bit flags, as follows:

Bit 7 Checkpointing
Bit 6 Local Busy (user set)
Bit 5 Local Busy (buffer set)
Bit 4 Remote Busy
Bit 3 Rejection
Bit 2 Clearing
Bit 1 Dynamic Window Algorithm Running
Bit 0 Reserved (may appear as 0 or 1)

Response Codes

When the adapter completes the operation, it sets the return code in the SRB and interrupts the Host by setting HISR(13).

Valid Return Codes

x00 Operation completed successfully
x01 Invalid command code
x04 Adapter closed, should be open
x40 Invalid STATION_ID

SUMMARY OF TRANSMIT METHODS

Fast Path Overview

The Fast Path interface provides a pool of transmit buffers that Host software can fill asynchronously to the TROPIC MPU's processing. Host software moves Transmit commands and related data together to these buffers and then signals TROPIC that the pools have been updated. TROPIC then processes frames according to each data block's associated command.

SRB (Non-Fast Path) Transmit Commands

If Fast Path Transmit is not activated, then TROPIC operates in a less efficient transmission mode that requires the Host software to first issue a transmit command only, wait for a TROPIC response, and then move transmission data to the Transmit buffer. This mode exists primarily for compatibility with earlier drivers, and it should not be used in new software.

The processing sequence for an SRB (non-Fast Path) transmit command is:

1. The Host software issues a transmit command to the adapter.
2. The adapter sets a command correlator and in-process return code in the SRB.
3. The adapter issues a TRANSMIT.DATA.REQUEST command (x82) to the Host using the Adapter Request Block (ARB). This command supplies the command correlator, the STATION_ID and the DHB address in shared RAM where the Host should start to transfer the data.
4. The Host moves the data into the DHB.
5. The Host responds using the adapter status block (ASB) providing the original transmit command used in the SRB, the command correlator, the STATION_ID, and the transmit data length information.
6. The adapter transmits the frame.
7. The adapter sets completion information in the system status block (SSB) on completion of the transmission for the direct and SAP interfaces, or on receipt of acknowledgment, or determination that acknowledgment will not be received for the link station interface. The adapter then interrupts the Host.

USING THE FAST PATH INTERFACE

Fast Path Interface Selection

Fast Path transmit is an optional (but *strongly* recommended) interface to the adapter for transmitting frames. Because it is optional, it must be activated by the Host software. The Fast Path transmit interface is activated by issuing a DIR.CONFIG.FAST.PATH.RAM command to TROPIC *before* the adapter is opened. During the initialization, the adapter reserves a block of storage for this interface. When the command completes, the adapter returns a new SRB address where subsequent SRB commands can be issued to the adapter by the Host.

When the Fast Path interface is selected, it is the only interface that can be used to issue requests for the adapter to transmit frames. The Host software should not place Transmit commands in the SRB, but should instead place transmit commands into the Fast Path Buffer queue, described next. If transmit commands are placed in the SRB when Fast Path is selected, the adapter will not accept them.

Note: The adapter cannot be configured for both Fast Path Transmit and bridging functions. If an adapter will be used for bridging, then the Fast Path interface cannot be used.

Fast Path Buffer Allocation

During processing of the DIR.OPEN.ADAPTER command after a DIR.CONFIG.FAST.PATH.RAM command, the adapter allocates buffers for the Fast Path interface into a free transmit queue and initializes the Fast Path Transmit Control Area (described next). The buffers are chained together in a link list with FREE_QUEUE_HEAD pointing to the first buffer and FREE_QUEUE_TAIL pointing to the last buffer.

Fast Path Transmit Control Area

The Fast Path Transmit Control Area is located at the start of the storage allocated in the Shared RAM for the Fast Path interface. The offset to this allocated storage is returned to the Host in the DIR.CONFIG.FAST.PATH.RAM response SRB. This control area allows the adapter and Host software to jointly manage the buffers in the Fast Path buffer pool.

Offset	Parameter Name	Byte Length	Description
0	BUFFER_COUNT	2	Number of Buffers in the Buffer Pool
2	FREE_QUEUE_HEAD	2	Offset to First Free Buffer
4	FREE_QUEUE_TAIL	2	Offset to Last Free Buffer
6	ADAPTER_QUEUE_HEAD	2	Offset to Next Expected First Buffer of Frame; TROPIC Use Only
8	BUFFER_SIZE	2	Size in Bytes of Each Buffer including Buffer Head; READ-ONLY
10	COMPLETION_QUEUE_TAIL	2	Offset of Last Completed Buffer
12		4	Reserved

BUFFER_COUNT

This field is a count of the number of buffers that were configured in the transmit buffer pool during the open adapter. It is valid only after the open adapter completes, and is not subsequently updated by the adapter.

FREE_QUEUE_HEAD

This field contains the offset to the NEXT_BUFFER field in the first buffer in the free transmit buffer queue. The adapter sets the value in this field only during the open adapter. When the Host software moves a frame to the buffer pool it must update this value to the NEXT_BUFFER value in the last buffer containing the frame. The adapter examines this value to determine if a frame is present in the transmit buffer pool.

FREE_QUEUE_TAIL

This field contains the offset to the NEXT_BUFFER field in the last buffer in the free transmit buffer queue. The adapter sets the value in this field only during the open adapter. The Host software adds buffers to the free transmit buffer queue after processing a frame on the completion queue by placing the LAST_BUFFER value from the completed frame in the FREE_QUEUE_TAIL field. The buffer that is pointed to by this field may not be used for transmission until more frames are placed on the free transmit buffer queue and FREE_QUEUE_TAIL has been updated by the Host.

ADAPTER_QUEUE_HEAD

This field is used solely by the adapter to keep track of the next expected buffer to contain a transmit frame. The Host software should ignore this field.

BUFFER_SIZE

The adapter stores the value of the requested buffer size from the DIR.CONFIG.FAST.PATH.RAM in this field. This field is used by the adapter at open adapter time to configure the transmit buffer queue. This field is read-only to the Host, but the Host software should not need to access this field since its value should already be known.

COMPLETION_QUEUE_TAIL

This field is used by the adapter to report the completion of frame transmissions. The adapter initializes this field to the value in FREE_QUEUE_TAIL during the open adapter. The adapter reports completion of frame transmissions by changing the NEXT_BUFFER pointer in the buffer pointed to by COMPLETION_QUEUE_TAIL to reflect the NEXT_BUFFER value of the last completed frame. COMPLETION_QUEUE_TAIL is then updated with the LAST_BUFFER value of the first buffer of the completed frame.

The Host software must keep track of the next completed frame to process by keeping its own completion queue head pointer. This pointer must be initialized to the value in COMPLETION_QUEUE_TAIL at the completion of the open adapter command. The Host software can compare its completion queue head to COMPLETION_QUEUE_TAIL to determine if any buffers are on the completion queue. When the two values are equal, all of the frames on the completion queue have been processed. When the values are different, the Host software locates the first completed frame by using the NEXT_BUFFER value pointed to by the value in the Host's completion queue head.

To remove the buffers associated with the completed frame from the completion queue and place them on the free queue, the Host software takes the LAST_BUFFER value of the first buffer of the frame that has been completed and places it in FREE_QUEUE_TAIL and its own completion queue head. The Host software continues to process completed frames until its own completion queue head is equal to COMPLETION_QUEUE_TAIL.

Fast Path Frame Transmission—Request

Before transmitting any frames the Host software must open any STATION_IDs on which frames will be transmitted. The procedures for doing this are the same as the Host software would use if issuing SRB (non-Fast Path) transmit commands.

To set up a frame for transmission the Host fills in the required fields in the first free buffer in the free transmit buffer queue and uses as many additional buffers as needed to complete the whole frame for transmission. For subsequent buffers, the Host must fill in the buffer length and frame data. Before issuing the transmit request to the adapter, the entire frame must be in the buffers and all required buffer header fields must be filled in.

The buffer pointed to by FREE_QUEUE_TAIL cannot be used to issue a transmit frame. This buffer is used to maintain a link for the NEXT_BUFFER field in the free queue and completion queue. If the Host reaches this buffer, it must wait until more buffers are added to the transmitted queue before requesting the transmission of the frame.

To issue the transmit request to the adapter, the Host places the value in the NEXT_BUFFER pointer of the last buffer (of the frame) into the FREE_QUEUE_HEAD pointer in the Fast Path Transmit Control Area, and then sets TISR(14) to one. The Host does not have to wait for an adapter response to begin setting up transmission of another frame to the adapter. The adapter will preserve the new transmit request even if it has not processed the previous request.

Fast Path Frame Transmission—Completion

After a frame has finished transmission, the adapter reports the completion by moving the buffers associated with the frame to the completion queue. The NEXT_BUFFER field in the buffer pointed to by COMPLETION_QUEUE_TAIL is updated to point to the completed frame, and COMPLETION_QUEUE_TAIL is then set to point to the NEXT_BUFFER field of the last buffer of the frame. The adapter then sets HISR(9) to a one to interrupt the Host.

After processing the completed frame, the Host software moves the frame to the free queue by filling FREE_QUEUE_TAIL with the contents of LAST_BUFFER in the first buffer of the frame. Host software must maintain its own completion queue head to determine the location of the first buffer of the next completed frame. This is done by first setting the completion queue head to the contents of COMPLETION_QUEUE_TAIL when DIR.OPEN.ADAPTER completes. Subsequently, the completion queue head is set to the LAST_BUFFER value in the first buffer of the completed frame. Host software locates the completed frame by using the NEXT_BUFFER value in the buffer pointed to by its own completion queue head.

Fast Path Protocol Considerations

The completion of a frame for Direct and SAP station IDs implies that the frame has been transmitted. Therefore, no retransmission requests will occur for these station IDs.

For a link station, however, the completion on the completion queue *does not* necessarily imply that the frame has been transmitted. The adapter will return frames on the completion queue that cannot be transmitted because of a change in the link status. These frames are returned to the Host system with a return code of x29, "Link retransmission in process." Frames are returned on the link when transmission of a frame would cause the frame to be out of sequence due to a frame being lost in the network, or when the remote link enters a busy state. Transmit completions with remote acknowledgments will be reported in the SSB as is done for the TRANSMIT.I.FRAME SRB.

The adapter issues a RETRANSMIT.DATA request ARB to the Host when it is ready to restart the transmission on a link. This ARB contains the correlator number of the frame that is to be transmitted next. The Host software issues the retransmits starting at the frame with the correlator indicated in the ARB. These transmits are issued to the adapter in the same manner that they were when initially issued. The adapter determines that the Host has acknowledged its retransmit request by finding the frame with the correlator indicated in the adapter's RETRANSMIT.DATA request ARB.

Additional Fast Path Considerations

Some adapters may have an 8-bit interface. When reading or writing to the Fast Path Transmit Control Area of such an adapter, the 8-bit interface must be taken into account, as follows:

- COMPLETION_QUEUE_TAIL: The Host software should only use this value if two consecutive reads of the field return the same value. If the two reads return different values, then the Host software should repeat reads of the field until two consecutive reads return the same value.
- FREE_QUEUE_HEAD: When updating this field the Host software first sets the low order bit in the odd byte of this field to 1. The Host software then sets the field to the new value. This procedure should be done with interrupts disabled. The adapter will not use this value when the field's low order bit is 1. If the adapter reads 1 in the low order bit it will loop on reading the field contents until that bit changes to a 0.

Host software is responsible for scheduling frames in the transmit buffer pool, and therefore is responsible for maintaining "fairness" to all station IDs in the utilization of buffers. For link stations the Host software should not put more frames in the buffer pool than allowed by the MAXOUT parameter for that link station.

Adapter posting of completed frames to the Host is an asynchronous process. Host software may process a frame from the completion queue on a previous interrupt. The Host software may subsequently see an interrupt with no frames completed.

TRANSMIT COMMANDS

There are only two variants of the transmit command format, one for Fast Path transmits and one for non-Fast Path (SRB) transmits, with various subcommands indicating the data type to be transmitted. Fast Path transmit commands are placed in the first buffer in a chain of buffers that contain an entire frame. Non-Fast Path transmit commands are placed in the SRB.

All Fast Path transmit commands share a common format , with the only difference being the actual command code. Similarly, all non-Fast Path transmit commands share a common format, although this format is different from the Fast Path transmit format. The table below lists the various transmit commands, which have the same command name, code, and description for both Fast Path and non-Fast Path use.

Command Name	Code (Hex)	Description
TRANSMIT.DIR.FRAME	0A	Requests transmission of a Direct transmission; the application must assemble the entire message, leaving room for the source address, which TROPIC inserts; no LLC protocol assistance is provided in this mode
TRANSMIT.I.FRAME	0B	Requests transmission of I-format (Information transfer format) frame
TRANSMIT.UI.FRAME	0D	Requests transmission of UI-format (Unsequenced Information transfer format) frame
TRANSMIT.XID.CMD	0E	Requests transmission of XID-format (Exchange Identification format) Command frame
TRANSMIT.XID.RESP.FINAL	0F	Requests transmission of XID-format final Response frame (in response to a XID Command being received)
TRANSMIT.XID.RESP.NOT.FINAL	10	Requests transmission of XID-format non-final Response frame (in response to a XID Command being received)
TRANSMIT.TEST.CMD	11	Requests transmission of TEST-format Command frame

Transmit Summary

Transmit commands can be summarized in the following categories:

Direct Station Can use only the TRANSMIT.DIR.FRAME command. No retry is provided.

SAP Station Can use all commands except the TRANSMIT.DIR.FRAME and TRANSMIT.I.FRAME commands. No retry is provided. The TRANSMIT.XID.RESP commands should only be issued to an SAP that has the XID handling option selected to pass XID frames to the Host software.

Link Station Can use only the TRANSMIT.I.FRAME command. All transmission retries are handled by the adapter.

Fast Path Transmit Buffer Format

Fast Path transmit buffers are transmitted out of buffers reserved for the Fast Path Interface. These buffers are allocated at open adapter time based on parameters in a previous DIR.CONFIG.FAST.PATH.RAM command issued by the Host. The format of Fast Path Transmit buffers is shown below:

Offset	Parameter Name	Byte Length	Description
0	XMIT_COMMAND	1	TRANSMIT Command Code
1	XMIT_CORRELATOR	1	Transmit Correlator (0–127)
2	RETCODE	1	Set by the Adapter Upon Return
3		1	Reserved
4	STATION_ID	2	ID of the Station Sending the Data
6	FRAME_LENGTH	2	Total Amount of Data in All Buffers of the Frame
8	HEADER_LENGTH	1	Length of Frame Header
9	RSAP_VALUE	1	Destination SAP Value
10		2	Reserved
12	LAST_BUFFER	2	Offset in Shared RAM to NEXT_BUFFER field of the Last Buffer in the Frame
14	FRAME_POINTER	2	Reserved for the Adapter
16	NEXT_BUFFER	2	Offset to NEXT_BUFFER Field of the Next Buffer in the Free Transmit Buffer Queue
18	XMIT_STATUS	1	Reserved for the Adapter
19	STRIPPED_FS	1	Final Status Returned from the Frame Stripping Process
20	BUFFER_LENGTH	2	Length of Frame Data in this Buffer
22	FRAME_DATA	n	The Frame Data to be Transmitted

XMIT_COMMAND

This specifies the type of transmit command being requested for this frame. The command is placed in the first (or only) buffer for the frame. The available commands are shown in the command table on the previous page.

XMIT_CORRELATOR

This field specifies a sequence number for the frame being transmitted. It is placed in the first (or only) buffer for the frame, according to the following rules:

— each Station ID uses a unique set of correlators

— the correlator for the first frame transmitted on by a Station ID is 0

— the correlator for each subsequent frame for a Station ID is incremented by 1 and wraps to 0 after reaching 127

— the correlator is coded as a binary count in this one byte field

— a maximum of 127 correlators may be outstanding for any one Station ID

RETCODE

The Host initializes the return code to xFE in the first buffer of a frame.

STATION_ID

This field specifies the STATION_ID on which to transmit the frame. It is placed by the Host in the first (or only) buffer of a frame. Valid Station IDs are:

*x*0000 Direct Station
*xnn*00 SAP Station *nn*
xnnmm Link Station *mm* under SAP Station *nn*

FRAME_LENGTH

This value is the sum of all the buffer lengths in the frame. It is placed by the Host in the first (or only) buffer of a frame. The adapter does not modify this value when returning completed frames.

HEADER_LENGTH

This value is the length of the LAN header contained in FRAME_DATA. It is placed by the Host in the first (or only) buffer of a frame only for frames that are to be transmitted on an SAP (Station ID = *xnn*00).

RSAP_VALUE

This is the destination SAP (DSAP) value for a frame transmitted on an SAP. It is placed by the Host in the first (or only) buffer of a frame only for frames that are to be transmitted on an SAP (Station ID = x*nn*00).

LAST_BUFFER

This is the offset in Shared RAM to NEXT_BUFFER in the last frame buffer. It is placed in the first buffer by the Host.

NEXT_BUFFER

This is the pointer to NEXT_BUFFER in the next free buffer in the free transmit queue. It is maintained by the adapter and should not be changed by the Host.

XMIT_STATUS

This is reserved for use by the adapter.

STRIPPED_FS

This value is placed by the adapter into the last buffer of a frame after the frame has been transmitted, and is the FS of the transmitted frame. This value is only valid if the adapter return code is x22 (Adapter frame error).

BUFFER_LENGTH

This value is the length of FRAME_DATA in this buffer. It is placed in each buffer by the Host.

FRAME_DATA

This is the content of the frame to be transmitted by the adapter. Its content varies depending on the transmit command used:

TRANSMIT.I.frame	This is the data field of the frame to be transmitted. The adapter will provide the LAN and DLC headers.
TRANSMIT.DIR.frame	This is the entire message, including the LAN header and any additional headers with space reserved for the LAN source address, which will be inserted by the adapter. If the LAN header contains routing information, the Host software must set the high order bit of the LAN source address field to a 1; otherwise, that bit should be a 0.
All other transmit commands	This is the entire message, including the LAN header and any additional headers with space reserved for the LAN source address, which will be inserted by the adapter. The LAN header is followed by 3 bytes reserved for the adapter to insert the LLC header which is followed by the data. The adapter will determine if the routing information is present in the header by examining the HEADER_LENGTH field in the buffer. The LAN header and reserved space for the LLC header must be in the first buffer for the frame.

Valid Return Codes from Adapter (Fast Path Transmits)

x00 Operation completed successfully
x01 Invalid command code
x08 Unauthorized access authority
x22 Error on frame transmission, examine STRIPPED_FS
x23 Error on frame transmit or strip process
x24 Unauthorized MAC frame
x25 Maximum commands exceeded
x26 Invalid correlator
x27 Link not transmitting I frames, state changed from link opened
x28 Invalid transmit frame length command
x29 Link retransmission in process, buffers free
x40 Invalid STATION_ID
x41 Protocol error, link in invalid state for command

Non-Fast Path (SRB) Transmit Command Format

The table below shows the format for Transmit commands issued when the Fast Path interface *is not* activated. These commands are placed in the SRB.

Offset	Parameter Name	Byte Length	Description
0	COMMAND	1	xxx, TRANSMIT.xxx
1	CMD_CORRELATE	1	Set by the Adapter Upon Return
2	RETCODE	1	Set by the Adapter Upon Return
3		1	Reserved
4	STATION_ID	2	ID of the Station Sending the Data

If there is no immediate error, the adapter sets the RETCODE field to xFF and sets the command correlator field. The adapter will interrupt the Host by setting HISR(13) if an SRB Free Request interrupt is received by the adapter. If there is an immediate error, the adapter sets the RETCODE field with the appropriate code and interrupts the Host by setting HISR(13).

Valid Return Codes (Non-Fast Path Transmits)

xFF Command in process
x01 Invalid command code
x04 Adapter closed, should be open
x25 Maximum commands exceeded
x40 Invalid STATION_ID
x41 Protocol error, link in invalid state for command
x4A Sequence error, command in process

When the adapter completes the transmit command, it prepares the system status block (SSB) and interrupts the Host by setting HISR(10). If more than one TRANSMIT.I.FRAME command is being reported, the command correlate field will contain the correlator for the last command completed.

Offset	Parameter Name	Byte Length	Description
0	COMMAND	1	xxx, The Transmit Command from the SRB
1	CMD_CORRELATE	1	Host/Adapter Command Correlator
2	RETCODE	1	Completion Code
3		1	Reserved
4	STATION_ID	2	ID of the Station Providing Status
6	TRANSMIT_ERROR	1	If RETCODE = x22 the Returned FS Byte

Valid SSB Return Codes (Non-Fast Path Transmits)

x00 Operation completed successfully
x08 Unauthorized access priority
x22 Error on frame transmission, check TRANSMIT_FS data
x23 Error in frame transmit or strip process
x24 Unauthorized MAC frame
x27 Link not transmitting I frames, state changed from link opened
x28 Invalid transmit frame length command

ARB (TROPIC-TO-HOST) COMMAND SUMMARY

The commands in the table below can be issued to the Host by TROPIC. The commands have the following in common:

- TROPIC prepares the command in the ARB and interrupts the Host by setting HISR(11).
- The Host reads the command information and interrupts the adapter by setting TISR(9) to acknowledge receipt of the command and indicate that the adapter can reuse the ARB.
- If a response is required, the Host will put the response information in the ASB and interrupt the adapter by setting TISR(12).
- After reading the ASB response, the adapter does one of the following:
  - Sets the return code to xFF and interrupts the Host by setting HISR(12) if the ASB Free Request interrupt bit is set
  - Sets a return code indicating that an error has been detected and interrupt the Host by setting HISR(12) regardless of the state of the ASB Free Request interrupt bit.

Command Name	Code (Hex)	Description
DLC.STATUS	83	Indicates a change in DLC status to the Host
RECEIVED.DATA	81	Informs the Host that data for a particular STATION_ID has been received; the Host must move the data from the Shared RAM Receive buffers to buffers in Host memory
RETRANSMIT.DATA	86	FAST PATH ONLY: Lets adapter request a retransmission of frames by the Host due to changes in link station status; the Host responds by moving frames to the transmit buffer pool starting at the frame with the correlator in the ARB
RING.STATUS.CHANGE	84	Indicates a change in network status to the Host
TRANSMIT.DATA.REQUEST	82	NON-FAST PATH ONLY: When Fast Path is *not* used, informs the Host that TROPIC now needs data for a Transmit command previously issued by Host

DLC.STATUS x83

SUMMARY: The adapter is indicating a change in DLC status to the Host.

When the Host has read the command information from the ARB, it will interrupt the adapter by setting TISR(9) to acknowledge receipt of the command and indicate that the adapter may reuse the ARB. No response is required for this command. However, see Section 8.0 for DLC Status codes and suggested responses.

Offset	Parameter Name	Byte Length	Description
0	COMMAND	1	x83, DLC.STATUS
1		3	Reserved
4	STATION_ID	2	ID of the SAPs or Stations Presenting Status
6	STATUS	2	DLC Status Indicator; see Following Explanation
8	FRMR_DATA	5	Data Sent or Received with FRMR Response
13	ACCESS_PRIORITY	1	New Access Priority for SAP or Station
14	REMOTE_ADDRESS	6	The Physical Ring Address of the Remote Station
20	RSAP_VALUE	1	Remote Station's SAP_VALUE

STATUS

More than one bit can be set in the status word if the adapter had to wait for the ARB to become available. The bit meanings are listed below. For more details and a list of responses to these conditions, see Section 8.

Bit 15 Ti Timer has expired
Bit 14 DLC counter overflow
Bit 13 Access priority reduced
Bits 12–9 Reserved
Bit 8 Local station has entered "local busy" condition
Bit 7 Link lost
Bit 6 DM or DISC received, or DISC acknowledged
Bit 5 FRME received
Bit 4 FRME sent
Bit 3 SABME received for an open link station
Bit 2 SABME received, link station opened
Bit 1 Remote station has entered local busy state
Bit 0 Remote station has left local busy state

RECEIVED.DATA x81

SUMMARY: This command informs the Host that data for a particular STATION_ID has been received. The data must be moved from the receive buffers in shared RAM and placed into buffers in Host memory.

When the Host has finished processing the RECEIVED.DATA command, it will provide a return code in the ASB and interrupt the adapter by setting TISR(12). If the return code is x20, and the frame was an I frame destined for a link station, the adapter will set local busy state (buffer set) for the affected link station. It is the Host software's responsibility to reset the local busy state when buffers become available.

Offset	Parameter Name	Byte Length	Description
0	COMMAND	1	x81, RECEIVED.DATA
1		3	Reserved
4	STATION_ID	2	ID of the Receiving Station, see Following Explanation
6	RECEIVE_BUFFER	2	Offset to the First Receive Buffer in Shared RAM
8	LAN_HDR_LENGTH	1	The Length of the LAN Header Field
9	DLC_HDR_LENGTH	1	The Length of the LLC Header Field
10	FRAME_LENGTH	2	Length of the Entire Frame
12	NCB_TYPE	1	Category of the Message Received, see Following Explanation

STATION_ID

This field will indicate the link station, the SAP, or (if x0000) the direct station that the data is destined for.

DLC_HDR_LENGTH

This is the actual LLC header length if the message is a non-MAC frame, and the destination is either an SAP or a link station. It is equal to x00 if the message is either a MAC frame or a non-MAC frame and the destination is the direct station.

NCB_TYPE

Following are the different categories of messages received:

Hex Value	Type
02	MAC frame
04	I frame
06	UI frame
08	XID command poll
0A	XID command not-poll
0C	XID response final
0E	XID response not final
10	TEST response final
12	TEST response not final
14	Other or unidentified.

The ASB Response from the Host

Offset	Parameter Name	Byte Length	Description
0	COMMAND	1	x81, RECEIVED.DATA
1		1	Reserved
2	RETCODE	1	Return (Completion) Provided by the Host Program
3		1	Reserved
4	STATION_ID	2	ID of the Station Receiving Data
6	RECEIVE_BUFFER	2	Offset to the Address of the First Receive Buffer in Shared RAM

Return Code to TROPIC

x00 Operation completed successfully
x20 Lost data on receive, no buffers available. Local busy will be set if NCB_TYPE specified I-frame.

Return Code to the Host

xFF Response valid, ASB available
x01 Unrecognized command code
x26 Unrecognized command correlator, see following Note
x40 Invalid STATION_ID

Note: For x26 only, "Unrecognized command correlator" means that the receive buffer address is not that which is expected by the adapter.

Received Data

Received data is held in the adapter shared RAM in one or more receive buffers, depending on the length of the frame. The address of the first, or only, receive buffer will be provided to the Host in the ARB with the RECEIVE.DATA command. In the last, or only buffer containing the frame, bytes 2 and 3 will contain x0000; otherwise they will contain the address of the next buffer plus 2 bytes.

Receive Buffer Format

Offset	Parameter Name	Byte Length	Description
0		2	Reserved
2	BUFFER_POINTER	2	Offset to the Address of the Next Buffer Plus 2, or Zero if this is the Last Buffer
4		1	Reserved
5	RECEIVE_FS	1	FS/Address Match (Last Buffer Only)
6	BUFFER_LENGTH	2	Length of the Data in this Buffer
8	FRAME_DATA	n	Frame Data

RECEIVE_FS

RECEIVE_FS bits are described below:

Bit 7 Address recognized indicator
Bit 6 Frame copied indicator
Bit 5 Reserved
Bit 4 Reserved
Bit 3 Address recognized indicator
Bit 2 Frame copied indicator
Bits 1–0 Reserved

RETRANSMIT.DATA x86

The adapter will use this ARB to request the retransmission of Fast Path transmitted frames due to changes in the status of a link station. This ARB is only used on the link interface. The Host software responds by moving frames to the transmit buffer pool starting at the frame with the correlator given in the ARB. See the earlier discussion of Fast Path Transmits for moro information on retransmissions.

Offset	Parameter Name	Byte Length	Description
0	COMMAND	1	x86, RETRANSMIT.DATA
1	CORRELATOR	1	Correlator Number with which to Start Retransmission
2		2	Reserved
4	STATION_ID	2	Station ID of Link Requiring Retransmission

RING.STATUS.CHANGE x84

The adapter is indicating a change in the network status to the Host.

The status provided with this command is the current network status and may possibly equal the last status if the adapter has had to wait for the ARB to become available. When the Host has read the command information from the ARB, it will interrupt the adapter by setting TISR(9) to acknowledge receipt of the command and indicate that the adapter may reuse the ARB. No response is required for this command.

Offset	Parameter Name	Byte Length	Description
0	COMMAND	1	x84, RING.STATUS.CHANGE
1		5	Reserved
6	NETW_STATUS	2	Current Network Status, see Section 8.0

TRANSMIT.DATA.REQUEST x82

This informs the Host that data for a non-Fast Path (SRB) transmit command previously issued by the Host is needed.

When the Host has read the command information from the ARB, it will interrupt the adapter by setting TISR(9) to acknowledge receipt of the command and indicate that the adapter may reuse the ARB. When the Host has completed processing the TRANSMIT.DATA.REQUEST command, it will provide a return code in the ASB and interrupt the adapter by setting TISR(12). Only a successful return code is expected by the adapter in response to this request. The Host program should make sure that the transmit request is valid before issuing the original command to the adapter.

Offset	Parameter Name	Byte Length	Description
0	COMMAND	1	x82, TRANSMIT.DATA.REQUEST
1	CMD_CORRELATE	1	PC/Adapter Command Correlator
2		2	Reserved
4	STATION_ID	2	ID of the Sending Station
6	DHB_ADDRESS	2	The Address of the DHB to Put the Data in

A description of DHB contents after the data move follows:

TRANSMIT.I.frame This is the data field of the frame to be transmitted. The adapter provides the LAB and DLC headers.

TRANSMIT.DIR.frame This is the entire message, including the LAN header and any additional headers, with space reserved for the LAN source address to be inserted by the adapter. If the LAN header contains routing information, the Host must set the high-order bit of the high-order byte of the source address field on.

All other commands These include the LAN header with space reserved for the LAN source address to be inserted by the adapter, followed by 3 bytes reserved for the adapter to insert the LLC header, followed by the data. The adapter determines whether or not the LAN header includes routing information by checking the length field in the ASB accompanying the DHB.

ASB Response from Host

Offset	Parameter Name	Byte Length	Description
0	COMMAND	1	The Transmit Command as Provided in the Original SRB Command
1	CMD_CORRELATE	1	PC/Adapter Command Correlator
2	RETCODE	1	Return (Completion) Provided by the Host Program
3		1	Reserved
4	STATION_ID	2	ID of the Station Sending Data
6	FRAME_LENGTH	2	Length of the Entire Frame
8	HEADER_LENGTH	1	Length of the LAN Header, Required Only for an SAP
9	RSAP_VALUE	1	Remote SAP, the DSAP in the Transmitted Frame, Required Only for SAP Station IDs

Return Code to the Adapter

x00 Operation completed successfully

Return Codes to the Host

xFF Response valid, ASB available
x01 Unrecognized command code
x26 Unrecognized command correlator
x40 Invalid STATION_ID

6.0 BRIDGE OPERATION AND COMMANDS

By using two TROPIC-based adapters in the same workstation, each connected to a separate Ring, a bridge application program can forward frames between the two Rings. This capability is supported by some additional resources:

- two additional SRB commands
- one additional ARB command
- two additional Shared RAM areas—a Bridge Transmit Control area and Bridge Transmission buffers
- two additional interrupt register bits, one in the HISR and one in the TISR

A DIR.CONFIG.BRIDGE.RAM command must be issued before the DIR.OPEN.ADAPTER command. This ensures that the shared RAM will be prepared with the bridge transmit areas allocated when the open is performed.

After the adapter has been opened, a DIR.SET.BRIDGE.PARM command must be issued to enable frames to be received for forwarding.

An adapter that is opened for bridge functions interrogates all frames passing on the ring. Any received frame that does not have any other address match for the adapter and has a routing information (RI) field is to be forwarded. Refer to the *IBM Token-Ring Network Architecture Reference* for more about routing frames.

When the adapter receives a frame from the ring for forwarding, the adapter issues an ARB command (the RECEIVE.BRIDGE.DATA command) to the Host.

The Host software must move the frame data from the receive buffers of the receiving adapter in shared RAM to the transmit buffers in the shared RAM of the adapter connected to the other ring. Then the Host software must inform the receiving adapter that the frame has been accepted by responding to the ARB with an ASB.

The Host software must set TISR(14) to initiate transmitting the frame now in the bridge transmit buffer in shared RAM of the transmit adapter. When the adapter has completed transmitting the frame, it sets HISR(9) to inform the Host software.

The bridge transmit control area is used during the transmission to monitor buffer use and availability.

Shared RAM Layout for Bridge Use

TROPIC assigns locations in shared RAM when the adapter is opened for bridge use in a format like the following:

Start of Shared RAM (as seen from TROPIC)

Host Read-Only Address Space	
Adapter Private Variables and Work Areas	Length: 1496 bytes
System Status Block (SSB)	Length: 20 bytes
Adapter Request Block (ARB)	Length: 28 bytes
Receiver Buffers	Length: space remaining after all SAPs or stations are defined
SAP and Link Station Control Blocks	Length: as defined by mnaximum number of SAPs or stations
Host Read/Write Address Space	
Data Holding Buffer (DHB)	Length: as specified at open adapter time. There may be one or more DHBs.
System Request Block (SRB)	Length: 28 bytes
Adapter Status Block (ASB)	Length: 12 bytes
Bridge Transmit Control Area	Length: 16 bytes
Bridge Transmit Buffers	Length: defined by the DIR.CONFIG.BRIDGE.RAM command
Reserved Area on 64 kB Shared RAM Adapters	
Reserved	Length: 512 bytes

End of Shared RAM (As Seen from TROPIC)

Note: On 64 kB adapters, the 512 bytes at the end are reserved.

The bridge transmit control area and the bridge transmit buffers are the additional fields defined in shared RAM for bridge functions (if the bridge functions are activated by a DIR.CONFIG.BRIDGE.RAM command).

The Bridge Commands

The following commands are provided to allow the use of TROPIC's bridge functions.

Command Name	Code (Hex)	Description
DIR.CONFIG.BRIDGE.RAM	0C	Tells adapter how much shared RAM to allocate for bridge transmit control areas and buffers
DIR.SET.BRIDGE.PARMS	09	Lets Host set values and conditions for adapter to use when copying frames for forwarding
RECEIVED.BRIDGE.DATA	85	Informs Host that adapter has received frame that requires forwarding

DIR.CONFIG.BRIDGE.RAM x0C

SUMMARY: This command tells the adapter how much shared RAM to allocate for bridge transmit control area and buffers. The adapter must have been initialized and must not be open for this command to be accepted. When subsequent commands are issued, the conditions enabled by this command are incorporated.

In addition to the allocation of shared RAM, this command forces bit 8 of the functional address to be set on regardless of the parameter passed by a subsequent DIR.OPEN.ADAPTER or DIR.SET.FUNCTIONAL.ADDRESS command. Once set, this functional address can be reset only by either closing and reinitializing the adapter, or issuing a DIR.CONFIG.BRIDGE.RAM command with a shared RAM size of zero.

Offset	Parameter Name	Byte Length	Description
0	COMMAND	1	x0C, DIR.CONFIG.BRIDGE.RAM
1		1	Reserved
2	RETCODE	1	Set by the Adapter Upon Return
3		5	Reserved
8	XMIT_RAM_SIZE	2	The Amount of Shared RAM for Bridge Transmit Space

XMIT_RAM_SIZE

The number of 8 byte blocks of shared RAM to dedicate for bridge transmit buffers and the associated bridge transmit control area. The transmit buffers will be formatted identically to the receive buffers when the adapter is opened. The minimum value for this field is 3 (24 bytes).

SRB Response

When the adapter completes the command, it sets return values in SRB bytes 8 through 11 and the return code is placed in the RETCODE field. The adapter then interrupts the Host by setting HISR(13). The SRB content will then be as shown below.

Offset	Parameter Name	Byte Length	Description
0	COMMAND	1	x0C, DIR.CONFIG.BRIDGE.RAM
1		1	Reserved
2	RETCODE	1	Return Code, see Below
3		5	Reserved
8	BRIDGE_XMIT	2	Offset to the Address of Bridge Transmit Control Area
10	SRB_ADDRESS	2	Offset to the Address of the SRB

Valid Return Codes

x00 Operation completed successfully
x01 Invalid command code
x03 Adapter open, should be closed

DIR.SET.BRIDGE.PARMS x09

SUMMARY: This command provides values and conditions for the adapter to use when copying frames for forwarding.

A DIR.CONFIG.BRIDGE.RAM command must have previously been completed successfully and the adapter must be open for this command to be accepted. A return code of x05 (required parameters not provided) is returned if the DIR.CONFIG.BRIDGE.RAM command was not previously completed successfully. The adapter does not check for parameters missing from this command.

Offset	Parameter Name	Byte Length	Description
0	COMMAND	1	x09, DIR.SET.BRIDGE.PARMS
1		1	Reserved
2	RETCODE	1	Set by the Adapter Upon Return
3		3	Reserved
6	SOURCE_RING	2	Source Ring Number
8	TARGET_RING	2	Target Ring Number
10	BRIDGE_NUMBER	2	Individual Bridge Number
12	PARTITION_BITS	1	Number of Partition Bits
13	SROUTE_BROADCAST	1	Single-Route Broadcast Path Indicator
14	TOKEN_PRIORITY	1	Access Priority for Forwarding Frames

SOURCE_RING

The adapter compares the value in this field with the routing information source ring field in frames received from the ring when determining if the frame is to be forwarded. This value must be the number of the ring to which this adapter is connected. For instance, the valid range of values is xX001 to xXFFF if the PARTITION_BITS parameter value is 4. The SOURCE_RING value must he different from the TARGET_RING value.

Note: All bridges connected to a specific ring must refer to the ring with the same ring number value.

TARGET_RING

The adapter compares the value in this field with the routing information target ring field in frames received from the ring when determining if the frame is to be forwarded. This value must be the number of the ring to which the other adapter in this Host is connected. For instance, the valid range of values is xX001 to xXFFF if the PARTITION_BITS parameter value is 4. The TARGET_RING value must be different from the SOURCE_RING value. See the note above.

BRIDGE_NUMBER

The adapter compares the value in this field with the routing information bridge number field in frames received from the ring when determining if the frame is to be forwarded.

PARTITION_BITS

The value in this field is used to determine what portion of each 2-byte segment in the routing information field contains the bridge number. A value of 4 indicates that the low-order 4 bits of the segment contain the bridge number. The remaining 12 bits contain the ring number. There is no default value for this field. The Host software is responsible for maintaining a validity check on the value used. All bridges in the network must use the same value for this field or its equivalent. See "Routing Control Field" in the *IBM Token-Ring Network Architecture Reference*.

SROUTE_BROADCAST

The value in this field is used to determine the handling of single-route broadcast frames that are received. If the value is zero, single-route broadcast frames will not be copied by the adapter. If the value is not zero, single-route broadcast frames will be copied by the adapter.

TOKEN_PRIORITY

This value indicates the priority token that can be captured or requested for bridge forward frame use. The maximum value allowed is 4. A value greater than 4 will cause a return code of x08 (unauthorized access priority).

This parameter does not affect the priority of frames sent by the Host software using the standard transmit buffer path. Refer to the Transmit Commands discussion in Section 5.0.

SRB Response

When the adapter completes the DIR.SET.BRIDGE.PARMS operation, it sets the return code in the SRB and interrupts the Host by setting HISR(13).

Valid Return Codes

x00 Operation completed successfully
x01 Invalid command code
x04 Adapter closed, should be open
x05 Required parameters not provided
x08 Unauthorized access priority

RECEIVED.BRIDGE.DATA x85

SUMMARY: This command informs the Host that the adapter has received a frame that does not have any other address match for the adapter (such as specific, group, or functional address match) and has an RI field. This command is only valid after a DIR.SET.BRIDGE.PARMS command has been received by the adapter.

All frames received by the adapter as bridge frames are given to the Host through the direct interface (station x0000). Therefore, until the Host issues an ASB response to the RECEIVE.BRIDGE.DATA ARB command, no other ARB interrupts for data received on the direct interface can be issued to the Host. This includes both MAC and additional frames to be forwarded.

The Host software must set TISR(9) to indicate that the command has been read from the ARB. After the Host software has completed processing the command and written the ASB, TISR(12) must he set to indicate completion to the adapter. Frames that have a destination address match are passed to the Host through the normal RECEIVE.DATA ARB (x81).

Offset	Parameter Name	Byte Length	Description
0	COMMAND	1	x85, RECEIVE.BRIDGE.DATA
1		3	Reserved
4	STATION_ID	2	ID of the Receiving Station, Always x0000
6	RECEIVE_BUFFER	2	Offset to the Address of the First Receive Buffer in Shared RAM
8	LAN_HDR_LENGTH	1	The Length of the LAN Header Field
9		1	Reserved
10	FRAME_LENGTH	2	Length of the Entire Frame (Including CRC)
12	NCB_TYPE	1	Category of the Message Received, Always x14 (Other)

Note: The last 4 bytes of data in the receive buffer for a fraome received via a RECEIVE.BRIDGE.DATA (x85) ARB are the received cyclic redundancy check (CRC).

The ASB Response from the Host

The Host software should respond to the RECEIVE.BRIDGE.DATA (x85) ARB with a RECEIVED.DATA (x81) ASB as shown below.

Offset	Parameter Name	Byte Length	Description
0	COMMAND	1	x81, RECEIVED.DATA
1		1	Reserved
2	RETCODE	1	Return (Completion) Provided by the Host Program
3		1	Reserved
4	STATION_ID	2	ID of the Station Receiving Data, Always x0000 (Direct Interface)
6	RECEIVE_BUFFER	2	Offset to the Address of the First Receive Buffer in Shared RAM

Return Code to the Adapter

x00 Operation completed successfully

Return Code to the PC System

xFF Response valid, ASB available
x01 Unrecognized command code
x26 Unrecognized command correlator
x40 Invalid STATION_ID

Note: For this response only, "Unrecognized command correlator" means that the receive buffer address is not that which is expected by the adapter.

The Received Data

See the RECEIVED.DATA ARB command description for details about the receive buffers.

TRANSMITTING BRIDGE FORWARDED FRAMES

Transmitting frames forwarded by a Host bridge program using TROPIC is performed differently than normal transmitting. The frame data can be moved directly from the receive buffers in the shared RAM of the receiving adapter to the transmit buffers in the shared RAM of the transmit adapter.

The bridge transmit control area allows the adapter and the Host software to jointly manage the transmit buffer pool. The locations of the bridge transmit control area and the bridge transmit buffers in shared RAM are available at the completion of the DIR.CONFIG.BRIDGE.RAM SRB command.

Bridge Transmit Control Area

Offset	Parameter Name	Byte Length	Description
0		2	Reserved
2	INPUT_COUNT	1	Count of the Buffers in Use by the Host
3	OUTPUT_COUNT	1	Count of the Buffers Transmitted by the Adapter
4	RETURN_COUNT	1	Count of the Buffers Returned to the Host by the Adapter after Transmission
5		1	Reserved for Host Use
6	MAX_BUFFERS	2	The Total Number of Bridge Transmit Buffers
8	NEXT_BUFFER	2	The Address of the Next Available Buffer
10	OLD_BUFFER	2	The Address of the Buffer Containing the Next Data to Transmit
12		4	Reserved for Adapter Work Area

INPUT_COUNT

This field is incremented by the Host software to indicate the number of bridge transmit buffers filled. The adapter can only read this field.

OUTPUT_COUNT

This field is incremented by the adapter to indicate the number of buffers that have been transmitted (successfully or unsuccessfully). The Host can only read this field.

RETURN_COUNT

This field is set by the Host software to indicate the number of buffers that have been returned after transmission by the adapter. The adapter docs not use this field.

MAX_BUFFERS

This field contains the total number of bridge transmit buffers formatted when the adapter is opened with the bridge functions active. The Host can only read this field.

NEXT_BUFFER

When the adapter is opened, it sets this field with the address in shared RAM of the first bridge transmit buffer. Thereafter, the adapter will neither read nor write this field.

OLD_BUFFER

When the adapter is opened, it sets this field with the address in shared RAM of the first bridge transmit buffer (the same as the NEXT_BUFFER field). Thereafter, the adapter will neither read nor write this field.

Initiating Transmission

The Host software must follow these steps to transmit frames using the bridge transmit control area.

1. Determine the number of transmit buffers currently available by the following calculation using 8-bit unsigned arithmetic.
   Number of buffers available = MAX_BUFFERS − INPUT_COUNT + RETURN_COUNT
2. If buffers are available, Host software then fills the data area of the buffers, sets BUFFER_LENGTH to the length of data in the buffer, and sets XMIT_CONTROL in the buffer appropriately (see "Bridge Transmit Buffer Layout" below).
   If an insufficient number of buffers are available to hold the entire frame to be transmitted, the Host software may fill the available buffers and wait until additional buffers become available. The Host software must not update the INPUT_COUNT field until the entire frame is copied into the bridge transmit buffers and the "last-buffer-indicator" bit in the XMIT_CONTROL field has been set.
3. After the Host software has placed an entire frame into the bridge transmit buffers, it must update the bridge transmit control area as follows:
   — It must update the NEXT_BUFFER field to point to the next available buffer (that is, the value of BUFFER_POINTER in the last buffer used is stored in the NEXT_BUFFER field of the bridge transmit control area).
   — It must increment the INPUT_COUNT field by the number of bridge transmit buffers used by the frame.
   The Host software must ensure that the "last-buffer-indicator" bit in the XMIT_CONTROL field has been set in the last buffer before updating the INPUT_COUNT field.
   Note: Failure to do this can result in an adapter check with a reason code of x0001 (program-detected error).
4. The Host software should then set the frame forward request (TISR bit 14) to indicate to the adapter that a bridge frame is ready for forwarding.
   After the adapter has transmitted the frame (successfully or unsuccessfully), it updates the OUTPUT_COUNT field of the bridge transmit control area and sets the frame forward complete (HISR bit 9) bit to interrupt the Host.
5. The Host software must then update its fields in the bridge transmit control area so that joint buffer management may be maintained. For example, it would set the RETURN_COUNT field equal to the OUTPUT_COUNT field value.
   Note: The BUFFER_POINTER field of the last buffer of a frame always points to the first buffer of the next frame to be transmitted, because the bridge transmit buffers are linked in a circular queue.

The Bridge Transmit Buffer Layout

Bridge frames are transmitted out of special buffers dedicated to bridge traffic. These buffers are formatted when the adapter is opened with bridge functions selected and are the same length as the receive buffers in that adapter. If both adapters are opened with the same parameters, the logic required to copy frames from the receive buffers of one adapter to the transmit buffers of the other is minimal.

There are two formats for the bridge transmit buffers: one for buffers filled by the Host software with the frame to forward and another for the buffers that are returned to the Host after the adapter has transmitted the frame.

The bridge transmit buffers before transmission are described in the table below:

Bridge Transmit Buffers (before Transmission)

Offset	Parameter Name	Byte Length	Description
0	FRAME_LENGTH	2	The Length of the Entire Frame (Including CRC), in First Buffer Only
2	BUFFER_POINTER	2	Offset to the Address of the Next Buffer Plus 2
4	XMIT CONTROL	1	Control Bits
5		1	Reserved
6	BUFFER_LENGTH	2	Length of the Data in this Buffer
8	FRAME DATA	n	Frame Data

FRAME_LENGTH

This field must be set by the Host software to indicate the entire length of the frame to be transmitted. This field is valid in only the first buffer of the frame. The field is reserved in the rest of the buffers for the frame.

BUFFER_POINTER

This field points to the BUFFER_POINTER field of the next available bridge transmit buffer. This field must not be altered by the Host software. It can only be interrogated.

XMIT_CONTROL

This field is set by the Host software to control the CRC generation and to flag the last buffer of a frame. The bit meanings are:

Bits **Description**
7–5 Reserved
4 CRC generation (required in first buffer only)
0 = CRC is to be calculated by the adapter and inserted after the buffer data.
1 = The last 4 bytes of data in the last buffer for the frame are the CRC to be sent with the frame.
3–1 Reserved
0 Last buffer indicator.
0 = There are additional buffers for the frame.
1 = This is the last buffer for the frame.

BUFFER_LENGTH

This field contains the total number of bytes to be transmitted from this buffer.

The bridge transmit buffers after transmission are described in the table below.

Bridge Transmit Buffers (after Transmission)

Offset	Parameter Name	Byte Length	Description
0	LAST_BUFFER	2	The Address of the Last Buffer in the Frame, Plus 2, First Buffer Only
2	BUFFER_POINTER	2	Offset to the Address of the Next Buffer, Plus 2
4	XMIT_STATUS	1	Transmit Completion Status, Last Buffer Only
5	STRIP_FS	1	The FS Byte as Removed from the Frame, Last Buffer Only
6	FRAME_LENGTH	2	Length of the Entire Frame (Including CRC), Last Buffer Only
8	NUMBER_BUFFERS	1	The Number of Buffers in the Frame, Last Buffer Only
9		n	Data Area

LAST_BUFFER

This field contains the address of the BUFFER_POINTER field of the last buffer in the transmitted frame. This field is valid in only the first buffer of the frame. The field is reserved in the rest of the buffers for the frame.

BUFFER_POINTER

This field points to the BUFFER_POINTER field of the next available bridge transmit buffer.

XMIT_STATUS

This field is set by the adapter to indicate the transmit completion status of the frame. The bit meanings are:

Bit #	Name	Description
7	Purge Indicator	0 = The frame has not been purged. 1 = The frame was not transmitted but was purged from the transmit queue by the adapter. The adapter may purge frames from the transmit queue under three conditions: — The ring the adapter is connected to is beaconing. — The source routing indicator bit in the source address field is not set. **Note:** This bit is not checked by the adapter. — The frame is a MAC frame with a source class and destination class of "ring station." When this bit is set, bits 6 through 1 are not set.
6	Strip Frame Error Detect (SFED)	When this bit is set, the adapter detected a transmission error when removing the frame from the ring.
5	Strip Error Detect Indicator (SEDI)	This bit is a representation of the error-detected bit found in the ending delimiter (ED) byte of the frame after transmission.
4–1	Transmit Completion Code	These bits represent a transmit completion code which is placed into the last transmit buffer of a frame. The field definitions are: Bits 4–3—Parallel Completion 00 = Good completion 01 = DMA parity error 10 = DMA underrun 11 = Next buffer in chain unavailable Bits 2–1—Serial completion 00 = Good completion 01 = PTT timeout; this frame's ending delimiter never returned 10 = Corrupted token 11 = Either an implicit or explicit abort was stripped
0	Last Buffer Indicator	This bit is always set to indicate the last buffer of a transmitted frame.

STRIP_FS

This field contains the frame status (FS) byte of the frame after transmission. This field is valid for only the last buffer of a frame. It is valid only when the purge bit in the XMIT_STATUS field is zero.

FRAME_LENGTH

This field contains the value of FRAME_LENGTH before the frame was transmitted. This field is valid for only the last buffer of a frame.

NUMBER_BUFFERS

This contains the number of bridge transmit buffers used for the frame. This field is valid for only the last buffer of a frame.

Note: This field overwrites the first byte of data in the last buffer of the frame.

7.0 EARLY TOKEN RELEASE ISSUES

Early Token Release (ETR) is a method of reducing the delay or latency that can occur within a token ring due to the signal propagation time on a 16 Mbps Token-Ring Network as intermediate nodes repeat the signal. As the physical ring length (number of active stations) or the data rate increase, the number of bytes required to "fill" the ring increases. The maximum efficiency of the standard token protocol can be affected if a high percentage of the frames are shorter than the latency of the ring, resulting in an overall average frame size that is less than the ring latency. This is due to the idle characters that must be inserted by a transmitting station until it has recognized its source address in the header of the returning frame and subsequent releasing of a new token. An early token release protocol allows a transmitting station to release a new token as soon as it has completed frame transmission, whether or not the frame header has returned to that station.

ETR can optimize the use of the available ring bandwidth when the average frame size is less than the ring length by decreasing the delay that subsequent stations would see before receiving a token. Frames from two or more different stations can be on the ring simultaneously with this enhancement to the protocol.

The ETR mode of operation alters the behavior of the priority protocol in that the station may not have received the header of the transmitted frame prior to releasing the token. When this occurs, the priority of the next token is the same as the token that was captured by the station prior to transmitting its frame. Any priority reservations that may appear in the header of the returning frame are ignored. However, application programs that offer a mixture of both long and short frames will see little or no negative performance impact due to this mode of operation.

The maximum ring efficiency is defined as that portion of the bandwidth that is available for frame information transfer. The maximum ring efficiency that can be achieved on a ring is simply the ratio of the average number of bytes per frame to the total number of bytes expended on the network to transfer the frame. If the average frame contains 100 bytes of information, but requires 25 idle bytes per frame, then a maximum ring efficiency of 80% can be achieved. This is expressed as:

Max Ring Eff = (Number of Frame bytes) / (Frame bytes + Idle bytes)

Max Ring Eff = (100)/(100 + 25) = 0.80

The number of idle bytes varies depending upon the total frame length. The standard token protocol requires the sender to transmit idle characters onto the ring until it recognizes its own address in the returning header of the frame. The length of the idle field is thus a function of the frame size relative to the total latency of the ring.

The typical latency of a 4 Mbps ring is approximately 50 to 100 bytes. However, 16 Mbps rings are more likely to be used in large backbone rings where the ring latency could exceed 400 bytes. The benefits of the ETR protocol will be greater where a 16 Mbps ring spans a large area. With ETR, no idle characters are required to fill such a ring.

Hardware implementation may require a small inter-frame gap between the end of one frame and the beginning of the next frame.

Additional Factors to Consider

Small frames are normally used for frame acknowledgements and command/control data. High link utilization is more likely to be associated with simultaneous file transfers by several stations, thus having a higher percentage of "long" frames. Also, since the short frames could be back-to-back, a sequence of 40 frames at 50 bytes each causes about the same delay to a priority station as one continuous 2000 byte frame, assuming the priority station had to simply wait its turn for the token. Fairness of service ensures that all stations continue to receive their fair share of the ring bandwidth during periods of heavy load.

Priority access provides the most benefit to a user only when the link utilization is extremely high. Utilizations at these high levels should only occur during bursts of activity rather than for extended periods. During periods of low utilization, the priority reservation scheme should be invoked less frequently, thus offering negligible transfer time improvement.

ETR Conclusion

ETR can provide a substantial increase in available data bandwidth when the average frame size is shorter than the latency of the ring.

The priority reservation protocol may be affected by the early token release mode of operation due to the loss of some reservations. However, based on simulation results, there appears to be negligible delay at utilizations below 80%, and the delays above 80% utilization should be limited for most rings exhibiting a mixture of long and short frames. The elimination of ring latency as a limiting factor in maximum ring efficiency is a major benefit of the ETR protocol.