                   A Proposed Standard for the Transmission of
                        IP Datagrams over FDDI Networks

Status of this Memo

   This RFC specifies a method of encapsulating the Internet Protocol
   (IP) [1] datagrams and Address Resolution Protocol (ARP) [2] requests
   and replies on Fiber Distributed Data Interface (FDDI) Networks.
   This RFC specifies a proposed protocol standard for the Internet
   community. Comments are welcome. Distribution of this memo is
   unlimited.

Acknowledgment

   This memo draws heavily in both concept and text from RFC 1042 [3],
   written by Jon Postel and Joyce K. Reynolds of USC/Information
   Sciences Institute.

Conventions

   The following language conventions are used in the items of
   specification in this document:

      "Must" or "Mandatory"--the item is an absolute requirement of the
      specification.

      "Should" or "Recommended"--the item should generally be followed
      for all but exceptional circumstances.

      "May" or "Optional"--the item is truly optional and may be
      followed or ignored according to the needs of the implementor.
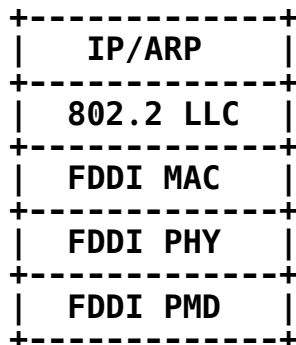
Introduction

   The goal of this specification is to allow compatible and
   interoperable implementations for transmitting IP datagrams and ARP
   requests and replies.

   The Fiber Distributed Data Interface (FDDI) specifications define a
   family of standards for Local Area Networks (LANs) that provides the
   Physical Layer and Media Access Control Sublayer of the Data Link
   Layer as defined by the ISO Open System Interconnection Reference
   Model (ISO/OSI). Documents are in various stages of progression

toward International Standardization for Media Access Control (MAC)
[4], Physical Layer Protocol (PHY) [5], Physical Layer Medium
Dependent (PMD) [6], and Station Management (SMT) [7]. The family of
FDDI standards corresponds to the IEEE 802 MAC layer standards [8, 9,
10].

The remainder of the Data Link Service is provided by the IEEE 802.2
Logical Link Control (LLC) service [11]. The resulting stack of
services appears as follows:

```
        +-------------+
        |   IP/ARP    |
        +-------------+
        |  802.2 LLC  |
        +-------------+
        |  FDDI MAC   |
        +-------------+
        |  FDDI PHY   |
        +-------------+
        |  FDDI PMD   |
        +-------------+
```
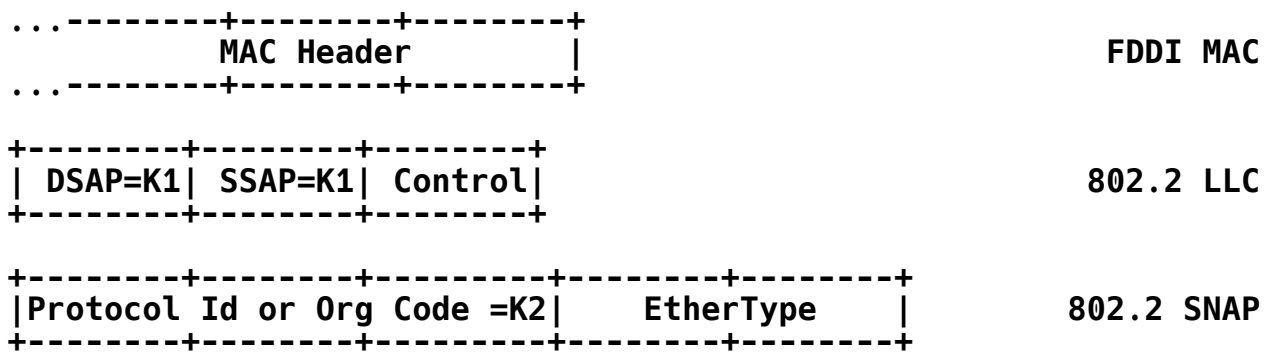
This memo describes the use of IP and ARP in this environment. At
this time, it is not necessary that the use of IP and ARP be
consistent between FDDI and IEEE 802 networks, but it is the intent
of this memo not to preclude Data Link Layer interoperability at such
time as the standards define it.

Packet Format

IP datagrams and ARP requests and replies sent on FDDI networks must
be encapsulated within the 802.2 LLC and Sub-Network Access Protocol
(SNAP) data link layers and the FDDI MAC and physical layers. The
SNAP must be used with an Organization Code indicating that the SNAP
header contains the EtherType code (as listed in Assigned Numbers
[12]).

802.2 LLC Type 1 communication (which must be implemented by all
conforming 802.2 stations) is used exclusively. All frames must be
transmitted in standard 802.2 LLC Type 1 Unnumbered Information
format, with the DSAP and the SSAP fields of the 802.2 header set to
the assigned global SAP value for SNAP [11]. The 24-bit Organization
Code in the SNAP must be zero, and the remaining 16 bits are the
EtherType from Assigned Numbers [12] (IP = 2048, ARP = 2054).

```
   ...--------+--------+--------+
              MAC Header        |                           FDDI MAC
   ...--------+--------+--------+


      +--------+--------+--------+
      | DSAP=K1| SSAP=K1| Control|                          802.2 LLC
      +--------+--------+--------+


      +--------+--------+---------+--------+--------+
      |Protocol Id or Org Code =K2|    EtherType    |        802.2 SNAP
      +--------+--------+---------+--------+--------+
```

   The total length of the LLC Header and the SNAP header is 8
   octets.

   The K1 value is 170 (decimal).

   The K2 value is 0 (zero).

   The control value is 3 (Unnumbered Information).

Address Resolution

   The mapping of 32-bit Internet addresses to 16-bit or 48-bit FDDI
   addresses must be done via the dynamic discovery procedure of the
   Address Resolution Protocol (ARP) [2].

   Internet addresses are assigned arbitrarily on Internet networks.
   Each host's implementation must know its own Internet address and
   respond to Address Resolution requests appropriately. It must also
   use ARP to translate Internet addresses to FDDI addresses when
   needed.

   The ARP protocol has several fields that parameterize its use in any
   specific context [2]. These fields are:

        hrd   16 - bits   The Hardware Type Code
        pro   16 - bits   The Protocol Type Code
        hln   8 - bits   Octets in each hardware address
        pln   8 - bits   Octets in each protocol address
        op   16 - bits   Operation Code

   The hardware type code assigned for IEEE 802 networks is 6 [12].
   FDDI networks, although not IEEE 802 networks per se, are
   semantically equivalent and use the same type code.

   The protocol type code for IP is 2048 [12].

The hardware address length is 2 for 16-bit FDDI addresses, or 6 for 48-bit FDDI addresses.

The protocol address length (for IP) is 4.

The operation code is 1 for request and 2 for reply.

Broadcast Address

The broadcast Internet address (the address on that network with a host part of all binary ones) must be mapped to the broadcast FDDI address (of all binary ones) (see [13]).

Trailer Formats

Some versions of Unix 4.x bsd use a different encapsulation method in order to get better network performance with the VAX virtual memory architecture. Consenting systems on the same FDDI network may use this format between themselves. Details of the trailer encapsulation method may be found in [14]. However, all hosts must be able to communicate using the standard (non-trailer) method.

Byte Order

As described in Appendix B of the Internet Protocol specification [1], the IP datagram is transmitted over FDDI networks as a series of 8-bit bytes. This byte transmission order has been called "big-endian" [15].

MAC Layer Details

Packet Size

The FDDI MAC specification [4] defines a maximum frame size of 9000 symbols (4500 octets) for all frame fields, including four symbols (two octets) of preamble. This gives the following MAC layer overhead:

Field	Size in Octets
Preamble	2
Start Delimiter	1
Frame Control	1
Destination Address	6 (2)
Source Address	6 (2)
FCS	4
End Delimiter/Frame Status	2
Total	22 (14)
Remaining for Data	4478 (4486)

Subtracting the 8 byte LLC/SNAP header, this gives a maximum
packet size (MTU) of 4470 (4478) octets. For compatibility
purposes, the maximum packet size used with IP datagrams or ARP
requests and replies must be consistent on a particular network.

The overhead calculations (above) assume a standard Frame Status
field consisting of three symbols. Additional Implementor Defined
frame status information, although permitted by the FDDI MAC
specification, must not be used with IP datagrams because it
affects the maximum packet size.

Gateway implementations must be prepared to accept full-length
packets and fragment them when necessary.

Host implementations should be prepared to accept full-length
packets; however, hosts must not send datagrams longer than 576
octets unless they have explicit knowledge that the destination is
prepared to accept them. A host may communicate its size
preference in TCP-based applications via the TCP Maximum Segment
Size option [16].

Datagrams on FDDI networks may be longer than the general Internet
default maximum packet size of 576 octets. Hosts connected to an
FDDI network should keep this in mind when sending datagrams to
hosts that are not on the same local network. It may be
appropriate to send smaller datagrams to avoid unnecessary
fragmentation at intermediate gateways. Please see [16] for
further information.

There is no minimum packet size restriction on FDDI networks.

Other MAC Layer Issues

The FDDI MAC specification does not require that 16-bit and 48-bit
address stations be able to interwork fully. It does, however,

require that 16-bit stations have full 48-bit functionality, and that
both types of stations be able to receive frames sent to either size
broadcast address. For use with IP and ARP, all communicating
stations on a LAN must use a consistent address size.
Implementations must discard any IP or ARP packets received with an
unimplemented or inactive address size. 16-bit and 48-bit
implementations may coexist on the same FDDI network; however, if
they wish to interwork they must be considered separate IP networks
and linked with an IP router capable of supporting 16-and 48-bit
addresses simultaneously.

Group (multicast) addresses are defined by the FDDI MAC specification
but are not necessarily supported by existing hardware. Therefore,
this feature must not be used by IP and ARP.

The FDDI MAC specification defines two classes of frames,
Asynchronous and Synchronous. Asynchronous frames are further
controlled by a priority mechanism and two classes of token,
Restricted and Unrestricted. Only the use of Unrestricted tokens and
Asynchronous frames are required by the standard for FDDI
interoperability. The priority mechanism is currently implemented
locally by the transmitting station and the Priority field in
Asynchronous frames is ignored by other stations. This field will
likely be interpreted by Transparent Bridges once they are defined.
There is no default value for priority called out in the MAC
standard.

Therefore, all IP and ARP frames must be transmitted as Asynchronous
frames using Unrestricted tokens, and the Priority value is a matter
of local convention. Implementations should make the priority a
tunable parameter for future use. It is recommended that
implementations provide for the reception of IP and ARP packets in
Synchronous frames.

After packet transmission, FDDI provides Frame Copied (C) and Address
Recognized (A) indicators. There are four possible combinations of
the indicators with the following semantics:

        (C)   (A)
        Reset   Reset   The frame was not received by any station.
        Reset   Set   The addressed station is congested.
        Set   Reset   Reserved.
        Set   Set   The addressed station received the frame.

Implementations may use these indicators to provide some amount of
error detection and correction:

    If the Frame Copied bit is reset but the Address Recognized bit is

set, receiver congestion has occurred. It is recommended, though
not mandatory, that hosts retransmit the offending packet a small
number of times (4) or until congestion no longer occurs.

If the both the Address Recognized indicator and the Frame Copied
indicator are reset, an implementation has three options: (1)
ignore the error and throw the packet away, (2) return an ICMP
destination unreachable message to the source, or (3) delete the
ARP entry which was used to send this packet and send a new ARP
request to the destination address. The latter option is the
preferred approach since it will allow graceful recovery from
first hop bridge and router failures and changed hardware
addresses.

As of this writing there is a proposal within ANSI to set the
Frame Copied indicator and reset the Address Recognized indicator
when a frame is forwarded by a Transparent Bridge. For future
compatibility, implementations should interpret this combination
of indicators as if the frame were successfully delivered to the
destination (i.e., do nothing).

IEEE 802.2 Details

While not necessary for supporting IP and ARP, all implementations
must support IEEE 802.2 standard Class I service in order to be
compliant with 802.2. This requires supporting Unnumbered
Information (UI) Commands, eXchange IDentification (XID) Commands and
Responses, and TEST link (TEST) Commands and Responses.

When an XID or TEST command is received, a response must be returned
with Destination and Source addresses, and DSAP and SSAP, swapped.

When responding to an XID or a TEST command, the value of the Final
bit in the response must be copied from the value of the Poll bit in
the command.

The XID command or response has an LLC control field value of 175
(decimal) if the Poll/Final bit is off or 191 (decimal) if the
Poll/Final bit is on.

The TEST command or response has an LLC control field value of 227
(decimal) if the Poll/Final bit is off or 243 (decimal) if the
Poll/Final bit is on.

Command frames are identified by having the high order bit of the
SSAP address reset to zero. Response frames have the high order bit
of the SSAP address set to one.

   XID response frames must include an 802.2 XID Information field of
   129.1.0 indicating Class I (connectionless) service.

   TEST response frames must echo the information field received in the
   corresponding TEST command frame.

Appendix on Numbers

   The IEEE specifies numbers in bit transmission order, or bit-wise
   little-endian order. The Internet protocols are documented in byte-
   wise big-endian order. This may cause some confusion about the
   proper values to use for numbers. Here are the conversions for some
   numbers of interest.

Number	IEEE HEX	IEEE Binary	Internet Binary	Internet Decimal
UI Op Code	C0	11000000	00000011	3
SAP for SNAP	55	01010101	10101010	170
XID	F5	11110101	10101111	175
XID	FD	11111101	10111111	191
TEST	C7	11000111	11100011	227
TEST	CF	11001111	11110011	243
Info	818000			129.1.0

References

   [1] Postel, J., "Internet Protocol", RFC-791, USC/Information
        Sciences Institute, September 1981.

   [2] Plummer, D., "An Ethernet Address Resolution Protocol - or -
        Converting Network Protocol Addresses to 48.bit Ethernet Address
        for Transmission on Ethernet Hardware", RFC-826, MIT, November
        1982.

   [3] Postel J., and J. Reynolds, "A Standard for the Transmission of
        IP Datagrams over IEEE 802 Networks", RFC1042, USC/Information
        Sciences Institute, February, 1988.

   [4] ISO, "Fiber Distributed Data Interface (FDDI) - Media Access
        Control", ISO 9314-2, 1988. See also ANSI X3.139-1987.

   [5] ISO, "Fiber Distributed Data Interface (FDDI) - Token Ring
        Physical Layer Protocol", ISO 9314-1, 1988. See also ANSI
        X3.148-1988.

   [6] ISO, "Fiber Distributed Data Interface (FDDI) - Physical Layer
        Medium Dependent", ISO DIS 9314-3, 1988. See also ANSI X3.166-

198x.

[7] ANSI, "FDDI Station Management", ANSI X3T9.5/84-49 Rev 4.0, 1988.

[8] IEEE, "IEEE Standards for Local Area Networks: Carrier Sense
     Multiple Access with Collision Detection (CSMA/CD) Access Method
     and Physical Layer Specifications", IEEE, New York, New York,
     1985.

[9] IEEE, "IEEE Standards for Local Area Networks: Token-Passing Bus
     Access Method and Physical Layer Specification", IEEE, New York,
     New York, 1985.

[10] IEEE, "IEEE Standards for Local Area Networks: Token Ring Access
     Method and Physical Layer Specifications", IEEE, New York, New
     York, 1985.

[11] IEEE, "IEEE Standards for Local Area Networks: Logical Link
     Control", IEEE, New York, New York, 1985.

[12] Reynolds, J.K., and J. Postel, "Assigned Numbers", RFC-1010,
     USC/Information Sciences Institute, May 1987.

[13] Braden, R., and J. Postel, "Requirements for Internet Gateways",
     RFC-1009, USC/Information Sciences Institute, June 1987.

[14] Leffler, S., and M. Karels, "Trailer Encapsulations", RFC-893,
     University of California at Berkeley, April 1984.

[15] Cohen, D., "On Holy Wars and a Plea for Peace", Computer, IEEE,
     October 1981.

[16] Postel, J., "The TCP Maximum Segment Size Option and Related
     Topics", RFC-879, USC/Information Sciences Institute, November
     1983.

Author's Address

   Dave Katz Merit/NSFNET 1075 Beal Ann Arbor, MI 48109-2112

   Phone: 1-800-66-MERIT

   Email: Dave_Katz@um.cc.umich.edu