ARCNET PACKET FRAGMENTATION STANDARD

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Version 1.4

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1.0 Introduction

1.1 Scope

This standard defines the method and the frame formats by which a block of data can be transferred utilizing ARCNET [1] independent of the number of octets in the block of data. This standard defines a protocol by which data can be fragmented into one or more ARCNET frames and re-assembled at the receiving station.

This standard builds upon the definition of ARCNET [1] therefore all definitions from that document are hereby incorporated into this document. The protocol definitions in this document are used to determine the contents of the ARCNET INFO field. All other fields of the ARCNET frame remain unaffected.

The use of this protocol is limited to the use of one octet system codes.

It is not required that all protocols operating on ARCNET use this fragmentation method. Rather, it is a decision made by the designer of the protocol used over ARCNET that this algorithm be used.

1.2 Terminology

1.2.1 Acronyms

ARCNET	Attached Resource Computer NETwork
ATA	ARCNET Trade Association
LLC	Logical Link Control
MAC	Medium Access Control
MTU	Maximum Transmission Unit

1.2.2 Definitions

Frame	A frame is a unit of data that can be transmitted over ARCNET without violating any of the requirements of ARCNET (MTU, etc.).
Data Packet	A data packet is the unit of data that is exchanged with the user of the Fragmentation Protocol service. A data packet is not constrained by the MTU of the underlying network.
Fragmentation	The activity of partitioning a Data Packet into one or more units such that each of the partitioned units does not exceed the MTU of the network.
Fragmentation Data	That portion of the data packet assigned to a given fragment is the Fragmentation Data for that fragment.
FSN	Frame Sequence Number. The number that uniquely identifies the fragments of a data packet.

A *data packet* is *fragmented* into *frames* for transmission on a network.

1.2.3 Numbers

In this document, numbers are to be interpreted as decimal numbers unless they are precede by "0x" in which case they are in hexadecimal, or by "0b" in which case the numbers are in binary.

1.3 References

[1] ARCNET Trade Association, "*ARCNET Local Area Network Standard, ATA/ANSI 878.1*", ARCNET Trade Association, 1992

[2] Provan, Don, "*Transmitting IP Traffic over ARCNET*", RFC1201, Novell, February 1991

[2] Novell, "*ARCNET Packet Header Definition Standard*", Novell Part Number 100-000721-001, Novell, November 1989

[3] Datapoint Corp., "*ARCNET Designers Handbook*", Document Number 61610, 2nd Edition, Datapoint Corp., 1988

[4] ANSI/X3.159, *Programming Language C Standard*

1.4 Acknowledgment

The protocol described in this document was originally developed under the sponsorship of the following companies and published as RFC 1201 [2].

Apple Computer, Inc.
Novell, Inc.
ACTINET Systems, Inc.
Standard Microsystems, Corp.
Pure Data Research, Ltd.

The protocol described in this document is an extension of that described in RFC 1201 but as documented by Novell and Pure Data and in use by a number of other companies.

2.0 General Description

This standard specifies a protocol to fragment data packets for subsequent transfer using ARCNET. The relationship of this protocol to the Open Systems Interconnection (OSI) Basic Reference Model of the International Organization for Standardization (ISO) is shown in figure 1.

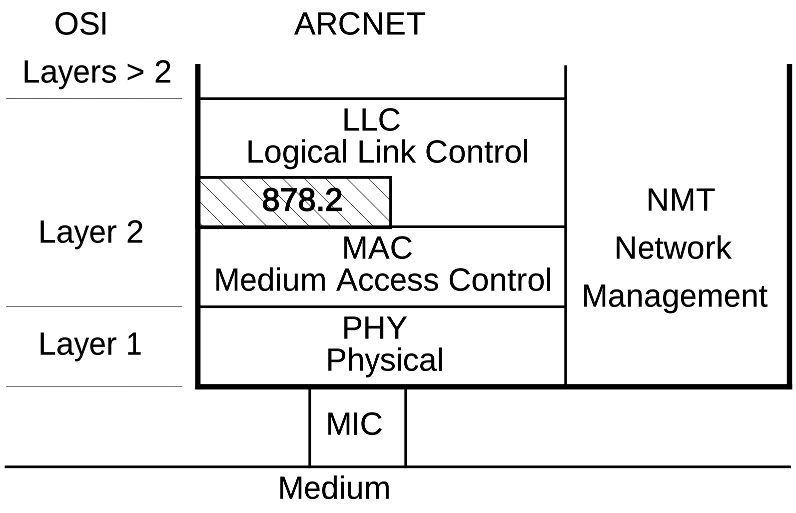

Figure 1 - OSI Reference

2.1 Overview

To use a network, the constraints of the network must be met. Often, however, these constraints are in direct conflict with the knowledge and capability of the user of the service. For example, to send a frame on ARCNET the frame must contain less than 507 octets in the INFO field. A standard IP stack, however, is unaware of this constraint on ARCNET and, therefore, generates packets whose size is in excess of the ARCNET MTU.

The protocol described in this document is designed to circumvent this problem. The protocol defines a method by which a data packet is fragmented into one or more fragments each of which can be sent as a ARCNET frame (reference figure 2).

Fragmentation of a data packet occurs at the source of the data packet (the sender). After all fragments of a data packet are received (at the receiver) they are re-assembled.

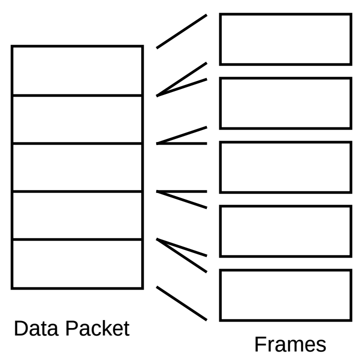

Figure 2

2.2 System Codes

Identification of protocols is implemented using ARCNET Trade Association assigned protocol ID type numbers. Use of this standard does not interfere with the standard method of protocol identification.

This standard only applies to the use of one octet system codes.

Refer to the ARCNET Standard [1] for the usage of system codes.

2.3 Reassembly

Reassembly of fragmented data packets is implemented using a single octet "Split Flag". This provides a consistent method for the fragmentation and reassembly of large data packets created by upper layer transport or service protocol.

2.4 Frame Sequence Numbers

All fragments include a Frame Sequence Number (FSN) which uniquely identify a data packet. If a station is going to retry a transmission, the FSN is changed before the retransmission. On the receiving side, FSNs are checked to verify that all fragments of a given data packet are received. All fragments of a data packet have the same FSN.

2.5 Frame Formats

ARCNET frames must be of lengths that fit into one of the two following categories. The length referred to here is the length of the INFO field. Note that this length is the sum of the lengths of the Fragmentation Protocol header and the Fragmentation Data.

$0 \le length \le 252$
$256 \le length \le 507$

Note that INFO fields of length 253 to 255 octets (inclusive) cannot be encoded for transmission over ARCNET.

Due to this constraint, three formats of frames are required based upon the amount of Fragment Data in a fragment.

Short Packet for Fragment Data lengths of 0 to 249 octets
Long Packet for Fragment Data lengths of 253 to 504 octets
Exception Packet for Fragment Data lengths of 250 to 252 octets

3.0 Protocol

This chapter defines the algorithm used to fragment and reassemble data packets. The actual frame formats and field definitions are in Chapter 4.

3.1 Transmit

A data packet submitted for transmission by the LLC using this protocol must first be partitioned into fragments.

A data packet containing *N* octets is fragmented in to *M* fragments as follows.

If...	then...
N *mod* 504 = 0	M = N *div* 504
N *mod* 504 ≠ 0	M = (N *div* 504) + 1

Notes:

1. The value *504* is the maximum number of octets from a data packet that can be placed into a frame. Of the remaining 8 octets in the ARCNET frame, 5 are used by the ARCNET MAC and 3 are used by the Fragmentation Protocol.
2. The *mod* operator returns the integer remainder resulting from the division of the operands. The *div* operator returns the integer result of the division of the operands.

The general outline of the procedure is as follows.

(Although the following procedure uses the concept of buffers, this is not intended to constrain a compliant design but rather to aid in the explanation. An implementation that causes ARCNET frames to be generated with the frame formats described in chapter 4 is considered compliant regardless of internal implementation.)

- Using the above rules, determine the number of fragments required to contain the data packet.
- Allocate buffers for each of the fragments. The size of the buffers is determined by the amount of data to be placed in the buffer *plus* 8 octets for the MAC and Fragmentation Protocol headers.
- Copy the data into the buffers.
- Set the Frame Sequence Number (FSN) in each fragment to the current sequence number. All fragments get the same FSN.
- Set the Split Flag according to the rules in section 4.1.3.
- Post the fragments for transmission.
- Update the Frame Sequence Number.

Refer to sections in the following chapter for the definition of these fields. Refer to Appendix A.3 for recommended practices.

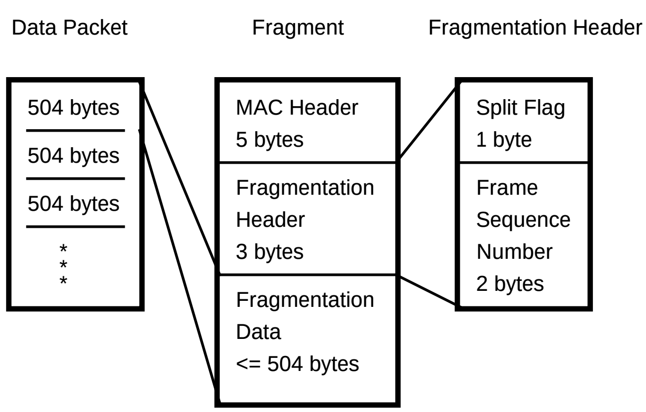

Figure 3 - Fragmentation

3.2 Receive

The process of reception is generally the reverse of transmission with the added complexity of handling the conditions of lost and duplicated frames.

The general outline of the procedure is as follows.

(Although the following procedure uses the concept of buffers, this is not intended to constrain a compliant design but rather to aid in the explanation. An implementation that accepts ARCNET frames conforming to the frame formats described in chapter 4 is considered compliant regardless of internal implementation.)

- Upon reception of the first fragment of a data packet (as indicated by the Split flag and Frame Sequence Number, FSN) allocate sufficient memory to hold all of the data for all expected fragments. In addition, start a timer.
- As each fragment is received and using the FSN, insert the fragment into the pre-allocated buffer as indicated by the Split flag.
- Upon reception of the final fragment (as indicated by the Split flag) stop the timer, verify that all fragments for a data packet were received, and forward the data packet to the user of the service.
- Upon expiration of the timer for a given data packet, discard the allocated memory (abandon the reception of the data packet).

4.0 Frame Formats

This chapter defines the format of a frame using this Fragmentation Protocol. The definition in the following sections uses the format defined for the ARCNET Standard [1].

4.1 Field Definitions

The ARCNET PAC frame is composed of three fields: the ARCNET MAC layer header, the information field, and the frame check sequence. The Fragmentation Protocol defined in this document is only concerned with the contents of the information (INFO) field since the header and frame check sequence are fixed by the ARCNET standard. However, for completeness and readability, all fields in the ARCNET frame are included in the diagrams below.

4.1.1 Basic ARCNET Frame Format

ARCNET provides for two frame formats depending on the amount of data in the information field. For lengths up to 252 octets, a short frame is used. For lengths of 256 up to 507 octets, a long frame is used. The difference between these two formats is the size of the Information Length (IL) field. For a short frame the IL is one octet and for long frames the IL is 2 octets in length. Note that ARCNET does not support information field lengths of 253 up to 255 octets. The diagram below shows the format of a basic ARCNET frame. Refer to the ARCNET Standard [1] for the meaning of the various fields.

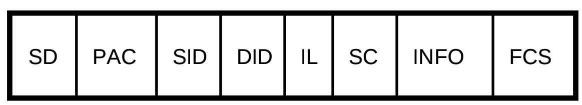

Figure 4 - Basic Frame Format

4.1.2 Information Field Format

The information field is partitioned as follows.

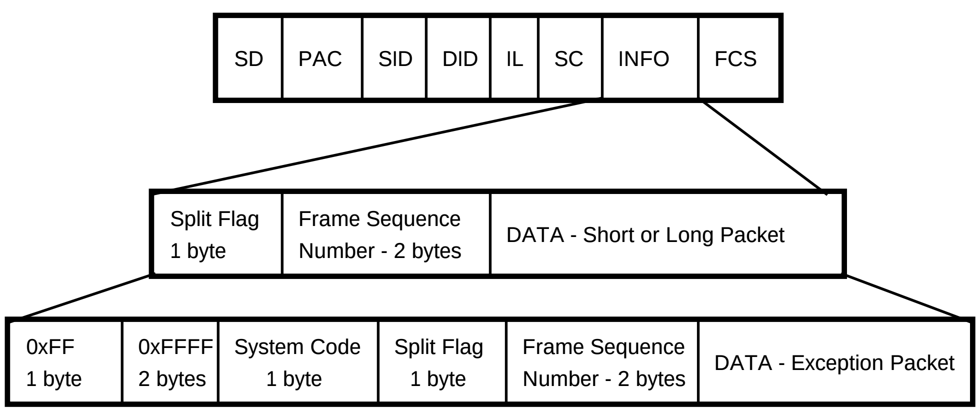

Figure 5 - Fragmentation Protocol Field Definition

4.1.3 Split Flag

The Split flag is used to indicate the fragment number of the frame.

Split Flag Usage	
Data Packet Length (octets)	Split Flag Value
$0 \le N \le 503$	0
$N \ge 504$	First Frame: ((M-2)*2)+1 Other Frames: (i-1)*2

Where:

N = Total number of octets in the data packet to be fragmented
M = Total number of fragments required (see section 3.1), $2 \le M \le 120$
i = Number of the fragment, $1 \le i \le M$

The Split flag is designed such that the value of the first fragment indicates the total number of fragments in this sequence. Therefore, the Split flag can be used to determine the upper bound on the amount of data to be received so that memory can be allocated in advance of further fragment reception.

The Split flag in the final frame is always one more than the Split flag in the first fragment and can therefore be used to detect the end of sequence condition.

To illustrate, consider the following examples.

Example 1: Send a 1535 octet data packet. Therefore, N = 1535, M = 4 (from section 3.1)

Fragment	i	Fragment Data Length	Split Flag	Frame Type
First	1	504	5	Long
Second	2	504	2	Long
Third	3	504	4	Long
Final	4	23	6	Short

Example 2: Send a 1259 octet data packet. Therefore, N = 1259, M = 3 (from section 3.1)

Fragment	i	Fragment Data Length	Split Flag	Frame Type
First	1	504	3	Long
Second	2	504	2	Long
Final	3	251	4	Exception

4.1.4 Frame Sequence Number

The Frame Sequence Number (FSN), a 16-bit unsigned integer, is set by the sender of the frame. All fragments of a data packet have the same FSN.

$0 \le$ Frame Sequence Number $\le$ 0xFFFF

4.2 Short Fragment

A fragment containing 249 octets or less of Fragment Data is sent using a short fragment. In a short fragment, the IL field is one octet in length.

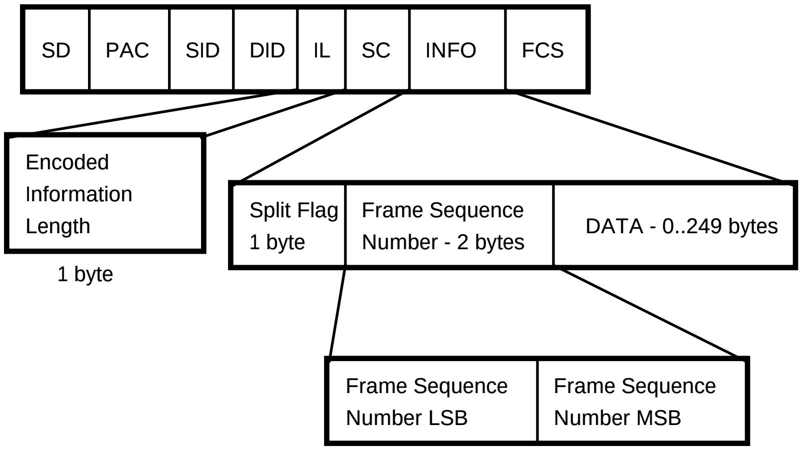

Figure 6 - Short Fragment

4.3 Long Fragment

A fragment containing more than 253 octets (but not more than 504 octets) of Fragment Data is sent using a long fragment. In a long fragment, the IL field is two octets in length.

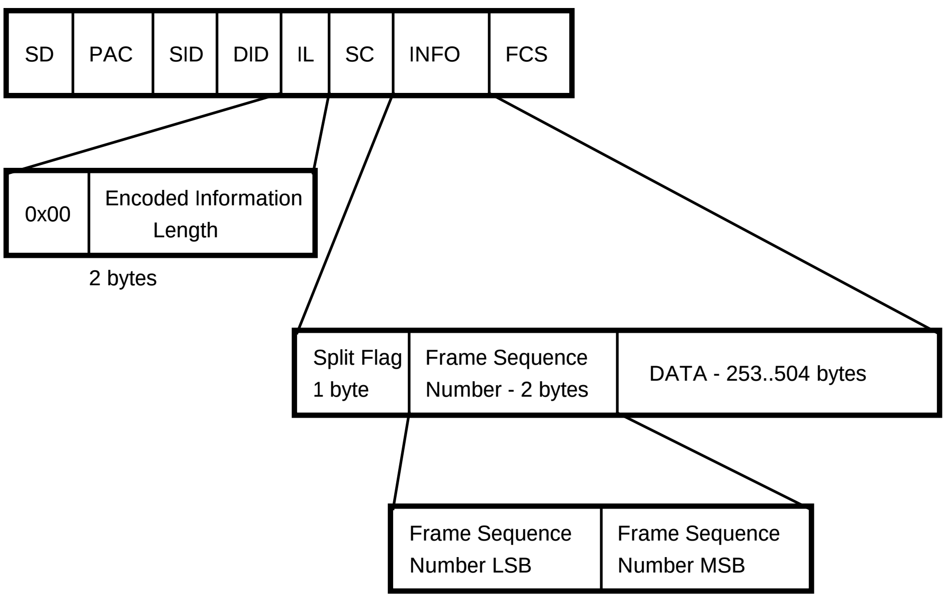

Figure 7 - Long Fragment

4.4 Exception Fragment

A fragment containing 250 octets up to 252 octets of Fragment Data is an Exception Fragment. In an exception fragment, the IL field is two octets in length. To conform to ARCNET, three octets of pad are added so that the total length can be encoded in an ARCNET frame. The value of each of the three pad octets is 0xFF.

Note that by the definition of the Split flag it is not possible for a Split flag to have the value 0xFF. Therefore, any fragment beginning with 0xFF can be assumed to be an Exception fragment such that the first three octet are the pad octets with the Fragmentation Header following the pad octets.

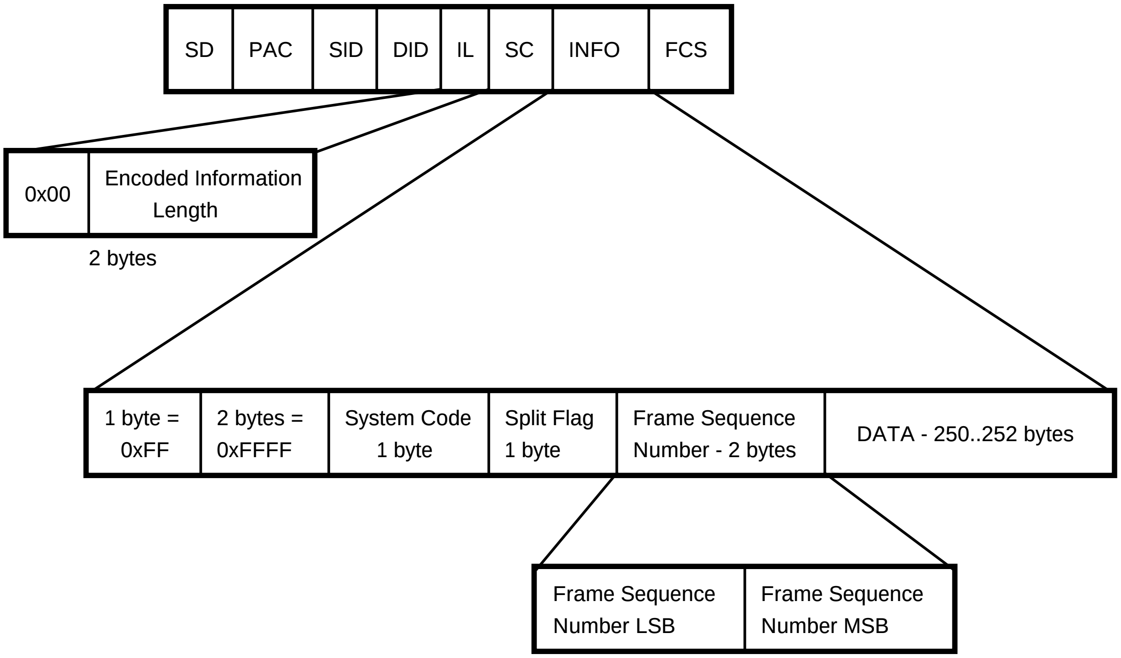

Figure 8 - Exception Fragment

Appendix A - Recommended Practice

(This section is not a part of the standard but included for informational purposes only.)

A.1 Retransmission Policy

Since the ARCNET hardware provides an indication that a frame was not received by the destination, the sender of a frame should retransmit a failed frame a fixed number of times (5 is usually sufficient). If after the allocated number of retries the frame has not been successfully received by the destination then the transmission of the data packet should be abandoned.

A.2 Duplicate Packets

As a result of the above retransmission policy, it is possible for a given frame to be received more than once at the receiving node. Therefore, a duplicate frame as indicated by the Split flag and Frame Sequence Number should be ignored.

A.3 General Transmission

The following are recommended practices for use in transmission.

- It is recommended that the fragments of a data packet be transmitted in order.
- The partitioning of data into the fragments should be done in such a way as to maximize the amount of data in each fragment.
- Upon completion of the generation of a set of fragments for a data packet, the sequence number should be incremented by one (modulo 65536).

A.4 Missing Packets

Since the frames in a sequence are transmitted in order, the out of order arrival of the frames is sufficient cause to abandon the receive activity for the given data packet.