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# Mapping of IP/MPLS ~~Packets~~ packets into IEEE 802.17 (Resilient ~~Packet~~packet ~~Ringring~~) ~~Networks~~networks

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## Abstract

This document specifies a basic standard method of encapsulating IPv4, IPv6, and MPLS datagrams into IEEE 802.17 Resilient ~~Packet~~packet ~~Ring~~ring (RPR) datagrams.

## Conventions used in this document

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in **RFC 2119 (Bradner, S., "Key words for use in RFCs to Indicate Requirements Levels," March 1997.)**[1].

The term "Higher Layer" refers to IPv4, IPv6, and MPLS when they act as clients of the IEEE 802.17 network.

"IP" refers to both IPv4 and IPv6. The terms "IPv4" and "IPv6" are used only when a specific version of IP is meant.

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## 1. IEEE 802.17

This section gives a brief introduction to the IEEE 802.17 protocol. The intent is to provide information

needed to understand the rest of this document. This section is SHALL NOT be used as a definitive description of IEEE 802.17 (~~Resilient Packet Ring-ring Access-access Method-method and Physical Layer Specifications - medium access control parameters, physical layer interface, and management parameters,~~ July 2004.)[2].

IEEE 802.17 SHALL be consulted for specific details on the functionality. Section 5 contains a ~30 page overview of the ~700 page specification. Details on the MAC service is contains in section 6.

### **1.1 Overview of IEEE 802.17**

IEEE 802.17 is a dual, counter-rotating, ring network technology with destination stripping. In the event of a fault (such as a fiber cut) the stations on each side of the fault can continue to function by wrapping the ring and/or by steering away from the fault and towards the operational path. When the fault clears, the ring reverts to normal operation.

The ring is composed of two ringlets, called ringlet0 and ringlet1.

A station may transmit a frame in either direction around the ring. IEEE 802.17 includes MAC-level protocols to determine the "best" path to each destination. The determination of "best" may be by any of several algorithms, including shortest path. Normally, the 802.17 MAC layer will automatically send frames via the "best" path. Alternatively, higher layers (such as IP) may explicitly specify the ringlet to use.

All stations on the ring have 48-bit IEEE 802 addresses.

IEEE 802.17 is a media-independent network protocol that is layered over several different physical media. SONET/SDH, Gigabit Ethernet and 10-Gigabit Ethernet are currently specified. The higher layers are shielded from any media dependencies.

There are fairness and bandwidth-management elements. There are three service classes: ~~Class-class~~A provides low delay and low delay variation, class-B has committed and excess bandwidth components, and class-C is best-effort.

There are several frame types, one of which is a data frame. The data frame contains a payload (such as an IPv4, IPv6, or MPLS packet). The type of the payload is indicated by a 2-byte type field. The type-field is identical to the type field in IEEE 802.3 Ethernet.

There is a TTL in the IEEE 802.17 frame headers. This TTL is used to prevent frames from infinitely looping.

## 1.2 IEEE 802.17 MAC ~~Service~~service

The IEEE 802.17 MAC ~~Service-service~~ Definition definition defines the MA\_DATA.request primitive which a station uses to transmit data (see section 6.4.1 of [2] (~~), "Resilient Packet-packet Ring-ring Access-access Method-method and Physical physical Layer-layer Specifications-specifications - medium access control parameters, physical layer interface, and management parameters," July 2004.~~)). This primitive takes several Parameters parameters (only three of which are mandatory):

destination\_address  
source\_address optional  
mac\_service\_data\_unit  
frame\_check\_sequence optional  
service\_class  
ringlet\_id optional  
mac\_protection optional  
mark\_fe optional  
strict\_order optional  
destination\_address\_extended optional  
source\_address\_extended optional  
flooding\_form optional

### 1.2.1 IEEE 802.17 ~~Addressing~~addressing

The ~~Destination~~-destination Address-address (DA) [destination\_address] is the 48-bit MAC address of the destination station. This may be a multicast or broadcast address. This address is an IEEE 802 address. This is a required parameter.

The ~~Source~~-source Address-address (SA) [source\_address] is the 48-bit MAC address of the source station. This address is an IEEE 802 address. This is an optional parameter. If it is omitted, the MAC uses the source address that is assigned to the station.

### **1.2.2 IEEE 802.17 ~~Payload~~payload**

The MAC SDU [mac\_service\_data\_unit] is the RPR payload. It includes the entire IP/MPLS packet prefaced with the Ethertype field. This is a required parameter. .

### **1.2.3 IEEE 802.17 ~~S~~service Classes~~classes~~**

One of the key features of RPR that can distinguish it from other network interconnects, is its ability to support multiple service qualities. Per service quality flow control protocols regulate traffic introduced by clients. The list of supported service classes are listed below:

#### ~~Class-a~~A:

Class-A services provides an allocated, guaranteed data rate, and low end-to-end delay and jitter bound. ~~Class-A~~ClassA traffic is allocated with a committed information rate (CIR). Traffic above the allocated rate is rejected. ~~Class-A~~ClassA traffic has precedence over class B and class-C traffic at the ingress to the ring. This class is well suited for real time applications.

#### ~~Class-b~~B:

Class-B services provides an allocated, guaranteed data rate, and bounded end-to-end delay and jitter for the traffic within the allocated rate. Class-B also provides access to additional best effort data transmission that is not allocated, guaranteed, or bounded. ~~Class-B~~ClassB traffic is allocated with a CIR component. Any class-B traffic amount beyond the

allocated CIR is referred to as excess information rate (EIR) class-B traffic. Class-B traffic (including class B EIR) has precedence over class C traffic at the ingress to the ring.

**Class-C:**

Class-C services provides a best-effort traffic service with non allocated or guaranteed data rate, and no bounds on end-to-end delay or jitter. Class-C traffic has the lowest precedence for ingress to the ring. Both class-B EIR and class-C traffic is governed by the RPR fairness algorithm which ensures proper partitioning of opportunistic traffic over the ring. This class is well suited for best effort applications. The RPR datagram carries the priority (i.e., service class) of the traffic being transported within a sc (service class) field found within the baseControl field of the RPR header.

The RPR sc is a 2-bit field. The values are shown in Table 1 below.

Value	Name
00	CLASS_C
01	CLASS_B
10	CLASS_A1
11	CLASS_A0

Table 1: sc values

**1.2.4 IEEE 802.17 Fairness**

The RPR fairness algorithm ensures proper partitioning of opportunistic traffic over the ring and governs class B EIR and class-C traffic. The RPR datagram conveys the application of the fairness algorithm on the datagram by the value of the fairness eligible (fe) field, found in the baseControl field of the RPR header.

The fe (fairness eligible) bit marks whether the frame is subject to the fairness algorithm. A value of 0 indicates that the frame is not fairness eligible, while a value of 1 indicates that the frame is fairness eligible.

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## 2. General Mapping Details

This section covers issues that are common to IPv4, IPv6, and MPLS.

### 2.1 IEEE 802.17 MAC ~~Service~~ ~~service~~ ~~Parameters~~ ~~parameters~~

When transmitting an IP or MPLS packet, a host or router indicates various parameters to the IEEE 802.17 MAC layer (see section 6.4 of [2] (~~“,Resilient Packet Ring Access Method and Physical Layer Specifications - medium access control parameters, physical layer interface, and management parameters,” July 2004.)~~)). This section specifies how those parameters are to be used:

#### 2.1.1 Destination\_address

Is the 48-bit MAC address of the 802.17 station to which the packet is being transmitted.

#### 2.1.2 Source\_address

The source\_address SHOULD be the address assigned to the station that is transmitting the packet. Per [2] (~~“,Resilient Packet Ring Access Method and Physical Layer Specifications - medium access control parameters, physical layer interface, and management parameters,” July 2004.)~~) if the client omits this parameter then the MAC inserts the correct address.

#### 2.1.3 mac\_service\_data\_unit

This is the payload, including the Ethernet type field. See "**Protocol Type Field**" (**Protocol Type Field**), for more information.

#### **2.1.4 frame\_check\_sequence**

The MAC will calculate the FCS

#### **2.1.5 serviceClass**

Specific service class mapping from DSCP and EXP within the client payload SHOULD be used to determine the RPR service class. These mappings are shown in **Section 3.2 (IP Differentiated Service (DSCP) Mapping to RPR)** and **Section 5.1 (MPLS EXP bit Mapping to RPR)**.

#### **2.1.6 Ringletringlet\_id**

The client SHOULD NOT specify the ringletID. The MAC will use its default algorithm to select a ringlet.

#### **2.1.7 mac\_protection**

This is set by the MAC to indicate if RPR protection is used for the frame.

#### **2.1.8 mark\_fe**

This parameter SHOULD NOT be specified unless the RPR service class is CLASS B as indicated from the mappings in **Section 3.2 (IP Differentiated Service (DSCP) Mapping to RPR)** and **Section 5.1 (MPLS EXP bit Mapping to RPR)**.

#### **2.1.9 strict\_order**

This parameter SHOULD NOT be specified. The IEEE 802.17 MAC will then use its default treatment.

#### **2.1.10 destination\_address\_extended**

This parameter SHOULD NOT be specified. The IEEE 802.17 MAC will populate if necessary.



### **2.1.11 source\_address\_extended**

This parameter SHOULD NOT be specified. The IEEE 802.17 MAC will populate if necessary.

### **2.1.12 flooding\_form**

This parameter SHOULD NOT be specified. The IEEE 802.17 MAC will populate if necessary.

## **2.2 Protocol Type Field**

The 16-bit protocol type field (or Ethertype) is set to a value to indicate the payloads protocol. The values for IPv4, IPv6, and MPLS are:

0x0800 If the payload contains an IPv4 packet.

0x0806 If the payload contains an ARP packet.

0x86DD If the payload contains an IPv6 packet.

0x8847 If the payload contains a MPLS Unicast packet.

0x8848 if the payload contains a MPLS Multicast packet.

0x8100 if the payload contains an Ethernet VLAN/Priority tagged packet.

## **2.3 Payload**

The payload contains the IPv4, IPv6, or MPLS packet. The first byte of the IPv4 header, IPv6 header, or top MPLS label begins immediately after the 802.17 headers.

Note that in 802.17 there is no minimum size for frames carried over Ethernet physical layers, thus there is no need to pad frames that are shorter than the minimum size. However, the robustness principle dictates that nodes be able to handle frames that are padded.

Like 802.3 Ethernet, 802.17 defines the maximum regular frame payload as 1500 bytes. Note that a maximum jumbo frame payload size that MAY be supported is defined at 9100 bytes.

## **2.4 Byte Order**

As described in "APPENDIX B: Data Transmission Order" of **RFC 791 (Postel, J., "Internet Protocol," September 1981.)**[3], IP and MPLS datagrams are transmitted over the IEEE 802.17 network as a series of 8-bit bytes in "big endian" order. This is the same byte order as used for Ethernet.

## **2.5 Trailer ~~Format~~format**

Trailer encapsulation is NOT specified for IEEE 802.17 networks.

## **2.6 Ringlet and ~~Direction~~direction ~~Selection~~selection**

IEEE 802.17 allows the ~~Higher~~higher ~~Layer~~layer to select the direction around the ring that traffic is to go. If the ~~Higher~~higher ~~Layer~~layer does not make the selection then the IEEE 802.17 MAC makes the decision. Ringlet and ~~Direction~~direction selection are left to the MAC. The advanced version of this specification may change this.

## **2.7 Higher ~~Layer~~layer TTL and Ring-~~ring~~ring ~~TTL~~ttl**

There is no correlation or interaction between the ~~Higher~~higher ~~Layer~~layer TTL and the IEEE 802.17 ~~TTL~~ttl.

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# **3. IPv4 ~~Specific~~specific ~~Mapping~~mapping ~~Details~~details**

## **3.1 Address ~~Resolution~~resolution**

ARP (Plummer, D., "An Ethernet Address Resolution Protocol," November 1982.)[4] is used to map IPv4 addresses to the appropriate MAC address. The "Hardware Address Space" parameter (ar\$hrd) used for IEEE 802.17 networks is TBD. ARP parameter assignments may be found at IANA.

### **3.1.1 Editor's ~~Notes~~notes**

The hardware type is to be allocated by IANA prior to publication.

We could overload the Ethernet (1) or IEEE 802 (6) hardware type value since 802.17 addresses are the same size and format as Ethernet addresses. However, it is not inconceivable that overloading this value may turn out to have unforeseen undesired consequences. As we are not in any danger of running out of ARP hardware codes, we'll get an 802.17-specific one.

### 3.2 IP Differentiated Service (DSCP) ~~Mapping~~ mapping to RPR

The ~~Differentiated~~ differentiated ~~Service~~ service (DS) field of the IPv4 and IPv6 frame can be used to convey service priority. The format of the IP DS field is shown in Figure 1 below.

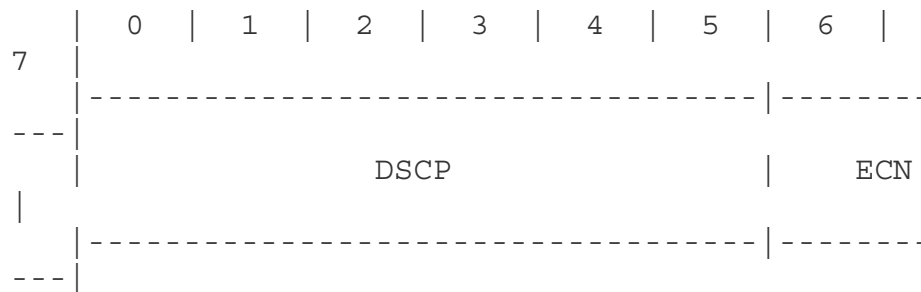


Figure 1: Differentiated ~~Services~~ services ~~Field~~ field

The DSCP field denotes the differentiated services codepoint. The DSCP is used to select the per hop behavior a packet experiences at each network node. As per [6] (Nichols, K., "Definition of the Differentiated Services Field (DS Field) in the IPv4 and IPv6 Headers.," December 1998.), [7] (Heinanen, J., "Assured Forwarding PHB Group.," June 1999.), [8] (Jacobson, V., "An Expedited Forwarding PHB Group.," June 1999.) and [9] (Babiarz, J., "Configuration Guidelines for Diffserv Service Classes," June 2005.), the DSCP field description is illustrated in Table 2.

IP Service Class	DSCP	Per Hop Behaviour
Standard	000000	Default Forwarding
Low Priority Data	001000	Class Selector 1
High Throughput Data	001010	AF11
	001100	AF12
	001100	AF13
OAM	010000	Class Selector 2
	010010	AF21
Low Latency Data	010100	AF22
	010110	AF23
Broadcast Video	011000	Class Selector 3
Multimedia	011010	AF31
Streaming	011100	AF32
	011110	AF33

Selector 4	Real-time Interactive	100000	Class
	Multimedia	100010	AF41
	Conferencing	100100	AF42
		100110	AF43
Selector 5	Signaling	101000	Class
	Telephony	101110	EF
Selector 6	Network Control	110000	Class
Selector 7	Reserved for future use	111000	Class

Table 2: DSCP ~~Field~~ field ~~Definition~~ definition

The best effort DSCP group denotes a best effort service.

The ~~Assured~~ assured ~~Forwarding~~ forwarding (AF) PHB groups are a means for a provider DS domain to offer different levels of forwarding assurances for IP packets received from a customer DS domain. In case of congestion, the drop precedence of a packet determines the relative importance of the packet within the AF class. A congested DS node tries to

protect packets with a lower drop precedence value from being lost by preferably discarding packets with a higher drop precedence value.

The ~~Expedited~~ ~~expedited~~ ~~Forwarding~~ ~~forwarding~~ (EF) PHB group is used to build a low loss, low latency, low jitter, assured bandwidth, end-to-end service through DS domains.

The Class Selector PHBs are to provide limited backwards capability for IP precedence.

The mapping between IP DSCP to RPR header service class relevant fields are shown in Table 3. Note that four treatment aggregates are used as suggested by [10] (Chan, K., "Aggregation of Diffserv Service Classes.," February 2005.).

	DSCP	RPR Service	service Class	class
	RPR sc	RPR fe		
	000000	Class C	00	
1	001000			
	001010			0-
Class B CIR				---
	001100			1-
Class B EIR				
	001110			
	010000			0-
Class B CIR				

	-----	Class B		---
	-----			
	010010			
	010100			1-
Class B EIR				
	010110			
	-----			---
	-----			
	011010			0-
Class B CIR				
				---
	-----			
	011100			1-
Class B EIR				
	011110			
	----- ----- ----- -----			---
	-----			
	011000			
	-----			
	100000	Class \-A0	11	
	-----			
	100010			
	100100	or	or	
0				
	100110			
	-----			
	101000	Class -A1	10	
	-----			
	101110			
	----- ----- ----- -----			---
	-----			
		Class -A0	11	

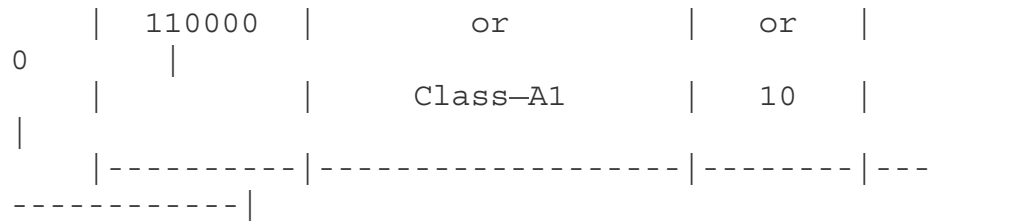


Table 3: IP DSCP to RPR Header header Mapping

Internal to the RPR MAC, ~~Class-A~~ traffic is partitioned into two sub classes: ~~Class-A0~~ and ~~Class-AclassA1~~. This partitioning is done in order to increase the ability of the ring to reclaim unused ~~Class-AclassA~~ traffic. The RPR MAC is configured for a total ~~Class-AclassA~~ amount, from which it determines how much is ~~Class-AclassA0~~ and ~~Class-A1classA1~~. The division of ~~Class-AclassA~~ is based on ring circumference and the size of internal transit queues. The reclaimable bandwidth allocated to ~~Class-AclassA1~~ can be reclaimed by traffic of ~~Class-classB~~-EIR and Class C when not being used by the station originating the ~~Class-classA~~ traffic being reclaimed.

Services marked with a DF and CS1 DSCP do not have a small amount of assured bandwidth component. That is, it only has an EIR component. Services marked with AF1x, AF2x, AF3x, AF4x and CS2 DSCPs have an aggregate CIR and EIR component. Services marked with CS3, CS4, CS5 and EF DSCPs only have a CIR component. Routing traffic marked with CS6 DSCP class also only has a CIR component. As CS7 is for future use, no mapping is provided.

As per [11] (Ramakrishnan, K., "The Addition of Explicit Congestion Notification (ECN) to IP," September 2001.), bits 6 and 7 of the DS field can be defined to be the ~~Explicit-explicit Congestion congestion Notification-notification~~ (ECN) field. The coding of the ECN does not influence the mappings to the RPR service class relevant fields (listed in Table 3).



## 4. IPv6 Specific Details

Transport of IPv6 packets over IEEE 802.17 networks is designed to be as similar to IPv6 over Ethernet as possible. The intent is to minimize time and risk in developing both the standard and the implementations.

### 4.1 Stateless Autoconfiguration ~~autoconfiguration~~

IPv6 stateless autoconfiguration follows the rules and procedures in section 4 of RFC 2464 (Crawford, ., "Transmission of IPv6 Packets over Ethernet Networks," December 1998.)[5].

### 4.2 Link Local ~~Local~~ Address ~~address~~

IPv6 link-local addresses follow the rules and procedures in section 5 of RFC 2464 (Crawford, ., "Transmission of IPv6 Packets over Ethernet Networks," December 1998.)[5].

### 4.3 Unicast Address ~~address~~ Mappings ~~mappings~~

IPv6 unicast address mappings follow the rules and procedures in section 6 of RFC 2464 (Crawford, ., "Transmission of IPv6 Packets over Ethernet Networks," December 1998.)[5].

### 4.4 Multicast Address ~~address~~ Mappings ~~mappings~~

IPv6 multicast address mappings follow the rules and procedures in section 7 of RFC 2464 (Crawford, ., "Transmission of IPv6 Packets over Ethernet Networks," December 1998.)[5].

### 4.5 Diffserv mapping

The mapping is as specified in Section 3.2 (IP Differentiated Service (DSCP) Mapping to RPR)

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## 5. MPLS Specific ~~specific~~ Details ~~details~~

Transport of MPLS packets over IEEE 802.17 follows **RFC 3032 (Rosen, E., "MPLS Label Stack Encoding," January 2001.)**[12]. As with IPv6, the intent is to allow the IEEE 802.17 network to be treated as a simple Ethernet LAN.

### 5.1 MPLS EXP bit ~~Mapping~~ mapping to RPR

MPLS support for DiffServ is defined in **RFC 3270 (Le Faucheur, F., "Multi-Protocol Label Switching (MPLS) Support of Differentiated Services," May 2002.)**[13]. The MPLS shim header is illustrated in Figure 2 below.

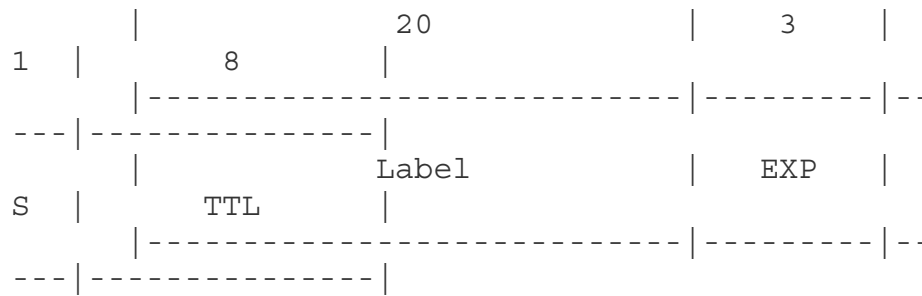
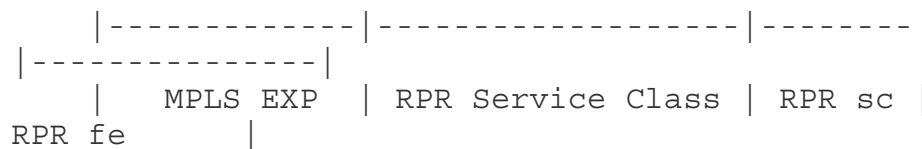


Figure 2: MPLS shim

The EXP bits define the PHB. However **[12] (Rosen, E., "MPLS Label Stack Encoding," January 2001.)** does not recommend specific EXP values for DiffServ PHB (e.g., EF, AF, DF).

#### 5.1.1 MPLS EXP PHB ~~Mapping~~ mapping to RPR

The mapping between MPLS EXP bits to RPR header service class relevant fields are shown in Table 4. Note that four treatment aggregates are used as suggested by **[10] (Chan, K., "Aggregation of Diffserv Service Classes.," February 2005.)**.



EXP		RPR Header	
000	Class C	00	
001			
-----			
010	Class B	01	
011			
1-Class B EIR			
-----			
100	Class A0	11	
	or	or	
101 (reserved)	Class A1		
-----			
110	Class A0		
	or	or	
111 (reserved)	Class A1		
-----			

Table 4: MPLS EXP to RPR Header Mapping

## 6. Ethernet Specific Details

Encapsulation of Ethernet packets over IEEE 802.17 is fairly simple since they are both 802 MACs and can be either transparently mapped or bridged.

Details of address translation, priority mappings and learning are fully described in IEEE 802.17 (“Resilient packet ring access method and physical layer specifications - “Resilient Packet Ring Access Method and Physical Layer Specifications” - medium access control parameters, physical layer interface, and management parameters,” July 2004.)[2], IEEE 802.17a (, “Media Access Control (MAC) Bridges - Amendment 1: Bridging of 802.17,” October 2004.)[14], and IEEE 802.17b (, “Resilient Packet Ring Access Method and Physical Layer Specifications - Amendment 1: Spatially Aware Sublayer,” .)[15]

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## **7. Security Considerations**considerations

This specification provides no security measures. In particular:

1. Masquerading and spoofing are possible. There is no strong authentication.
2. Traffic analysis and snooping is possible since no encryption is provided, either by this specification or by IEEE 802.17
3. Limited denial of Service attacks are possible by, eg, flooding the IEEE 802.17 network with ARP broadcasts. These attacks are limited to other class-C (best effort) traffic.
4. Attacks against the IEEE 802.17 ring management protocols are possible by stations that are directly connected to the ring. We note that all of these vulnerabilities exist today for transport of IP and MPLS over Ethernet networks.

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## **8. IANA Considerations**considerations

A new ARP codepoint is to be assigned by IANA per **Section 3.1 (Address Resolution)**

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## 9. Acknowledgements

The authors acknowledge and appreciate the work and comments of the IETF IPoRPR working group and the IEEE 802.17 working group.

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## 10. References

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- [2] "**Resilient Packet Ring Access Method and Physical Layer Specifications - medium access control parameters, physical layer interface, and management parameters**," IEEE 802.17-2004, July 2004.
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- [5] Crawford, ., "**Transmission of IPv6 Packets over Ethernet Networks**," RFC 2464, December 1998.
- [6] Nichols, K., "**Definition of the Differentiated Services Field (DS Field) in the IPv4 and IPv6 Headers**," RFC 2474, December 1998.
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- [9] Babiarz, J., "**Configuration Guidelines for Diffserv Service Classes**," draft-ietf-tsvwg-diffserv-service-classes-00 (work in progress), June 2005.
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