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Private Network-to-Network Interface (PNNI) Signaling in Asynchronous Transfer Mode (ATM) Networks
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Abstract

This document describes the Private Network-to-Network Interface (PNNI) signaling procedures used in Asynchronous Transfer Mode (ATM) networks. PNNI is a hierarchical link-state routing protocol that enables topology discovery, dynamic routing, and call establishment across ATM networks. This document outlines the signaling model, hierarchical routing structures, call setup procedures, and interoperability considerations for both modern and legacy ATM network implementations.

Status of This Memo

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1. Introduction

The Private Network-to-Network Interface (PNNI) is a hierarchical link-state routing protocol specifically designed for Asynchronous Transfer Mode (ATM) networks. PNNI provides automated topology discovery, dynamic routing, and Quality of Service (QoS) aware path selection capabilities that are essential for scalable ATM network operations.

Originally developed by the ATM Forum in the mid-1990s [ATM-FORUM-PNNI], PNNI addresses the unique requirements of ATM networks, including support for multiple service categories, traffic management, and connection-oriented communication. The protocol operates across hierarchical peer groups, enabling scalable routing in large ATM networks while maintaining detailed QoS information for optimal path selection.

This document revisits PNNI signaling principles in the context of modern networking requirements, identifies common interoperability issues encountered in multi-vendor environments, and proposes clarifications for current implementers and network operators [CHIDESTER-2024]. While ATM technology is considered legacy in many contexts, PNNI principles continue to inform modern network design, particularly in areas requiring strict QoS guarantees and hierarchical routing structures.

1.1. Requirements Language

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "NOT RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in BCP 14 [RFC2119] [RFC8174] when, and only when, they appear in all capitals, as shown here.

1.2. Scope and Applicability

This document focuses on the signaling aspects of PNNI and is intended for network operators managing existing ATM infrastructure, implementers developing or maintaining PNNI-capable systems, researchers studying hierarchical routing protocols, and engineers migrating from ATM to modern networking technologies.

2. PNNI Signaling Model

PNNI signaling operates through a distributed model where each ATM switch maintains local topology information and participates in network-wide topology distribution. The signaling model consists of several key components working in coordination to provide end-to-end connectivity establishment.

2.1. Peer Group Structure

PNNI organizes ATM networks into hierarchical peer groups. Within each peer group, nodes exchange detailed topology information using the PNNI topology distribution protocol. Each peer group elects a Peer Group Leader (PGL) responsible for representing the group at higher hierarchy levels and aggregating topology information.

The hierarchical structure enables scalable routing by reducing the amount of detailed topology information that must be maintained at each level. Lower-level groups provide summarized reachability information to higher levels, while detailed routing decisions are made locally within each peer group.

2.2. Topology Distribution

Topology information is distributed through PNNI Topology State Elements (PTSEs), which are flooded within peer groups using a reliable flooding mechanism. PTSEs contain information about node connectivity and available resources, link characteristics including bandwidth, delay, and cost metrics, QoS parameters for different service categories, and reachability information for external addresses.

The flooding mechanism ensures that all nodes within a peer group maintain consistent topology databases, enabling optimal path computation for connection establishment.

3. Call Setup and Signaling Procedures

PNNI call setup procedures extend standard ATM signaling protocols with routing capabilities. The signaling process involves route computation, resource reservation, and connection establishment across potentially multiple peer groups.

3.1. Call Setup Flow

The call setup process follows these major steps: route computation based on destination address and QoS requirements, resource reservation along the computed path, signaling message propagation using the computed route, and connection establishment and confirmation.

Each step involves coordination between multiple network elements and MUST maintain consistency with PNNI topology information and QoS constraints.

3.2. Crankback Procedures

When a connection setup fails due to resource unavailability or other constraints, PNNI provides crankback mechanisms to attempt alternate routes. Crankback information SHOULD include specific failure reasons to enable intelligent alternate route selection and avoid repeated failures.

4. Quality of Service Signaling

PNNI provides comprehensive QoS signaling capabilities that enable connection establishment with specific performance guarantees. The QoS model supports multiple ATM service categories and allows for detailed specification of traffic parameters and performance requirements.

4.1. Service Categories

PNNI supports signaling for all standard ATM service categories including Constant Bit Rate (CBR), Variable Bit Rate (VBR), Available Bit Rate (ABR), and Unspecified Bit Rate (UBR). Each service category has specific QoS parameters that MUST be considered during route computation and resource reservation.

4.2. Traffic Parameter Negotiation

During connection establishment, PNNI signaling allows for negotiation of traffic parameters to accommodate network capabilities and resource availability. Parameter negotiation SHOULD be performed in a way that maintains the essential QoS requirements while allowing for reasonable flexibility in implementation.

5. Interoperability Considerations

Multi-vendor PNNI implementations have historically faced several interoperability challenges. This section identifies common issues and provides guidance for ensuring successful deployment across heterogeneous environments.

5.1. Protocol Version Compatibility

Implementations SHOULD support graceful degradation when communicating with nodes running different PNNI versions. Version negotiation mechanisms MUST be implemented to ensure baseline functionality across mixed environments.

5.2. Vendor-Specific Extensions

Vendor-specific PNNI extensions SHOULD be designed to fail gracefully when interoperating with implementations that do not support these extensions. Critical functionality MUST NOT depend on vendor-specific features to ensure broad interoperability.

6. Security Considerations

PNNI signaling introduces several security considerations that network operators and implementers must address to ensure network integrity and prevent unauthorized access or service disruption.

6.1. Topology Spoofing

Malicious nodes may attempt to inject false topology information to redirect traffic or cause network instability. Implementations SHOULD implement authentication mechanisms for PNNI peer relationships and validate topology state information before accepting updates.

6.2. Resource Exhaustion Attacks

Attackers may attempt to exhaust network resources through excessive connection setup requests or by advertising false resource availability. Rate limiting and resource reservation validation mechanisms SHOULD be implemented to mitigate these attacks.

7. IANA Considerations

This document makes no requests to IANA. All protocol elements described in this document use existing ATM Forum assigned values or are implementation-specific parameters that do not require global coordination.

8. References

8.1. Normative References

[RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", BCP 14, RFC 2119, DOI 10.17487/RFC2119, March 1997,

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Acknowledgments

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