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A YANG Data Model for Automatic Multicast Tunneling (AMT)
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Abstract

This document defines a YANG data model for the management of Automatic Multicast Tunneling (AMT) protocol operations.

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1. Introduction

[RFC7450] introduces the protocol definition of the Automatic Multicast Tunneling (AMT) for delivering multicast traffic from sources in a multicast-enabled network to receivers that lack multicast connectivity to the source network. AMT uses UDP encapsulation and unicast replication to provide this functionality.

[RFC8777] updates [RFC7450] by modifying the relay discovery process. It defines DNS Reverse IP AMT Discovery (DRIAD) mechanism for AMT gateways to discover AMT relays that are capable of forwarding multicast traffic from a known source IP address.

This document defines a YANG data model for managing AMT protocol.

RFC Ed.: Please replace all occurrences of 'XXXX' with the actual RFC number (and remove this note). Also, please update the revision date to match the publication date.

2. Terminology & Notation Conventions

2.1. Conventions

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.

2.2. Terminology

The terminology for describing YANG data models is found in [RFC6020] and [RFC7950], including:

- * augment
- * data model
- * data node
- * identity
- * module

The following AMT terms are used in this document:

- * Gateway: A functional entity that acts as an endpoint for AMT tunnels on the receiver's domain. Its primary role is to discover AMT Relays, establish AMT tunnels to them, receive multicast traffic over these tunnels, and then forward that traffic natively within its local domain.
- * Relay: A functional entity located in the source's domain or a multicast-enabled part of the Internet. Its primary role is to listen for requests from AMT Gateways, replicate multicast traffic from native multicast routing domains, and encapsulate/ forward this traffic through established AMT tunnels to requesting Gateways.

- * Tunnel: A unidirectional, UDP-based encapsulation tunnel established between an AMT Gateway (the tunnel head) and an AMT Relay (the tunnel tail). It is used to transport multicast packets from the Relay to the Gateway over networks that do not support native IP multicast.
- * Pseudo-Interface: A logical interface within the AMT Gateway or Relay that represents the endpoint of an AMT tunnel. Multicast routing protocols interact with this interface as if it were a physical interface receiving native multicast traffic.
- * Gateway Service: The functional component in the AMT protocol architecture. It interacts downstream with local multicast receivers and upstream with AMT Relays. It implements the complete service functionality of the AMT protocol, including processing multicast subscription requests, establishing tunnels, decapsulating data, and forwarding multicast traffic.
- * Relay Service: The central component in the AMT protocol architecture. It establishes and manages tunnels between multicast sources and AMT gateways, enabling the conversion and forwarding of multicast traffic from multicast networks to unicast networks.
- * Secret Key Timeout: The maximum recommended validity period or rotation interval for the private secret (or key) used by a AMT Relay to compute Response Message Authentication Code (MAC) values, according to Section 5.3.6 of [RFC7450].

2.3. Tree Diagrams

Tree diagrams used in this document follow the notation defined in [RFC8340].

3. Data Model Overview

The AMT protocol mainly includes two components illustrated in Figure 1. The two components are Relay and Gateway entities, each with their internal modules (Discovery, Tunnel Management, and Multicast Forwarding).

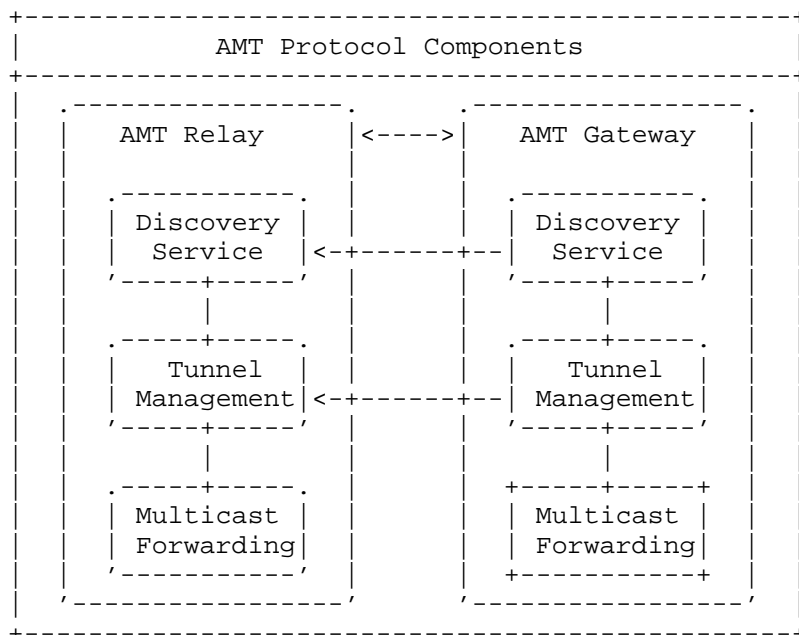


Figure 1: AMT Protocol Components

The AMT data model provides methods for managing AMT protocol, covering all its core functional components as illustrated in Figure 1. It includes:

- * Parameters of AMT relay service, such as Relay Discovery Address (Section 4.1.5 of [RFC7450]), Relay Address (Section 4.1.5 of [RFC7450]), the maximum number of tunnels, and secret key timeout.
- * Parameters of AMT gateway service, such as Relay Discovery Address (Section 4.1.5 of [RFC7450]), Relay Address (Section 4.1.5 of [RFC7450]), Discovery Timeout (Section 5.2.2.4 of [RFC7450]), Request Timeout (Section 5.2.2.4 of [RFC7450]), and Maximum Retransmission Count (Section 5.2.2.4 of [RFC7450]).
- * AMT tunnel information, such as endpoint IP address and UDP port number, local IP address and UDP port number.
- * DNS Resource Record (RR) used by an AMT relay service.

4. AMT YANG Module

4.1. Prefixes

Table 1 summarizes the prefixes used in this document.

Prefix	YANG module	Reference
inet	ietf-inet-types	[RFC9911]
rt-types	ietf-routing-types	[RFC8294]
rt	ietf-routing	[RFC8349]
yang	ietf-yang-types	[RFC9911]
if	ietf-interfaces	[RFC8343]

Table 1: Prefixes and Corresponding YANG Modules

4.2. Tree View

The full tree diagram of the "ietf-amt" YANG module is provided in Appendix A. The following subsections list the subtree structures.

4.2.1. Overall Structure

The overall tree structure of the AMT YANG module is shown in Figure 2.

The AMT YANG module augments the core routing YANG module "ietf-routing" specified in [RFC8349]. Specifically, the AMT YANG module augments "/rt:routing/rt:control-plane-protocols".

```

module: ietf-amt
  augment /rt:routing/rt:control-plane-protocols:
    +--rw amt!
      +--rw relay {amt-relay}?
      |   ...
      +--rw gateway {amt-gateway}?
      ...

```

Figure 2: Overall AMT Tree Structure

The 'amt' container encapsulates all AMT functionality and serves as the primary entry point for its configuration and state. The 'amt' container consists of two functional components: the relay and the gateway. Support of relay or gateway is indicated by dedicated YANG features.

The 'relay' container manages the AMT Relay function on the multicast source side. It provides the configuration and operational state for AMT Relay devices that receive multicast traffic, tunnel it to AMT Gateways over unicast, and act as tunnel termination points. This container is conditionally present only if the device implements the 'amt-relay' feature, typically on service provider edge routers or data center gateways.

The 'gateway' container manages the AMT Gateway function on the multicast receiver side. It provides the configuration and operational state for AMT Gateway devices that discover AMT Relays, establish tunnels to receive multicast traffic, and forward it to local receivers. This container is conditionally present only if the device implements the 'amt-gateway' feature, typically on enterprise edge routers or Customer Premises Equipment (CPE).

4.2.2. Relay

The overall structure of 'relay' is shown in Figure 3.

```

module: ietf-amt
augment /rt:routing/rt:control-plane-protocols:
  +--rw amt!
    +--rw relay {amt-relay}?
      +--rw addresses
      |   +--rw address* [family]
      |   |   +--rw family          identityref
      |   |   +--rw anycast-prefix  inet:ip-prefix
      |   |   +--rw local-address   inet:ip-address
      |   +--rw tunnel-limit?      uint32
      |   +--rw secret-key-timeout? uint32
      |   +--rw relay-dns-resource-records
      |   |   +--rw record* [source-address]
      |   |   |   +--rw source-address   inet:ip-address
      |   |   |   +--rw precedence?     uint32
      |   |   |   +--rw d-bit?          boolean
      |   |   |   +--rw relay-type?     enumeration
      |   |   |   +--rw discovery-address? inet:ip-address
      |   |   |   +--rw domain-name?    inet:domain-name
      |   +--ro tunnels
      |   |   ...
      |   +--ro relay-message-statistics
      |   |   ...
      +--rw gateway {amt-gateway}?
      |   ...

```

Figure 3: AMT Relay Subtree Structure

The 'relay' data nodes are described as follows:

'addresses': Indicates the core address configurations for AMT Relay.

This data node includes 'family', 'anycast-prefix', and 'local-address'. The 'family' indicates the address family (IPv4 or IPv6). The 'anycast-prefix' indicates the address prefix used by the Gateway to discover the Relay. The 'local-address' indicates the local interface address the Relay actually listens on and sends AMT messages on, or the actual communication address after the tunnel is established.

'tunnel-limit': Indicates the maximum number of endpoint Gateways that a Relay can serve simultaneously.

'secret-key-timeout': Indicates the maximum recommended validity

period or rotation interval for the private secret (or key) used by a AMT Relay to compute Response MAC values. In addition, the private secret (or key) is known only to the AMT relay, and the provisioning of the private secret (or key) is out of scope.

'relay-dns-resource-records': Indicates the DNS RR configuration for AMT relay discovery. Each DNS RR configuration ('record') includes the specific multicast source IP address to which this DNS RR applies ('source-address'), the priority value of this DNS RR ('precedence'), the discovery optional flag ('d-bit'), the type of AMT relay address ('relay-type'), the directly specified IP address of AMT relay discovery address ('discovery-address'), and the wire-encoded domain name of AMT relay ('domain-name').

'tunnels' (Figure 4): Indicates tunnel information from various AMT gateways connected to this AMT relay.

Each tunnel entry ('tunnel') includes the IP address and port number of the tunnel opposite end ('gateway') ('gateway-address' and 'gateway-port'), the local IP address and UDP port number used by the local ('relay') end for this tunnel ('local-address' and 'local-port'), the tunnel status ('state'), the multicast flow information ('multicast-flows') carried by the tunnel, the number of different multicast groups currently carried by this tunnel ('multicast-group-num'), the message counter carried by the tunnel ('request-message-count', 'membership-query-message-count', and 'membership-update-message-count'), and the time on the most recent occasion at which any one or more of the tunnel's counters suffered a discontinuity ('discontinuity-time').

Each multicast flow information ('flow') has multicast source address ('source-address') and multicast group address ('group-address').

Design note: The four data nodes ('gateway-address', 'gateway-port', 'local-address', and 'local-port') do not reuse the standard "udp-client" grouping defined in [I-D.ietf-netconf-udp-client-server] because AMT requires the gateway to be a specific IP address (inet:ip-address), while the "udp-client" grouping allows the use of domain names (inet:host). Reuse could lead to configuration errors or runtime risks, so a custom structure must be defined to enforce this constraint.

```

module: ietf-amt
augment /rt:routing/rt:control-plane-protocols:
  +--rw amt!
    +--rw relay {amt-relay}?
      |
      | ...
      | +--ro tunnels
      |   +--ro tunnel* [gateway-address gateway-port]
      |     +--ro gateway-address      inet:ip-address
      |     +--ro gateway-port         inet:port-number
      |     +--ro local-address        inet:ip-address
      |     +--ro local-port           inet:port-number
      |     +--ro state                 identityref
      |     +--ro multicast-flows
      |       +--ro flow* [source-address
      |         |          group-address]
      |         +--ro source-address
      |         |          ip-multicast-source-address
      |         +--ro group-address
      |         |          rt-types:ip-multicast-group-address
      |     +--ro multicast-group-num   yang:gauge32
      |     +--ro request-message-count
      |       |          yang:zero-based-counter64
      |     +--ro membership-query-message-count
      |       |          yang:zero-based-counter64
      |     +--ro membership-update-message-count
      |       |          yang:zero-based-counter64
      |     +--ro discontinuity-time     yang:date-and-time
      |   +--ro relay-message-statistics
      |     |
      |     | ...
      |   +--rw gateway {amt-gateway}?
      |     |
      |     | ...

```

Figure 4: AMT Relay Tunnel Subtree Structure

'relay-message-statistics': Indicates various messages and error statistics handled by AMT relay as shown in Figure 5.

```

augment /rt:routing/rt:control-plane-protocols:
  +--rw amt!
    +--rw relay {amt-relay}?
      ...
      +--ro tunnels
      | ...
      +--ro relay-message-statistics
        +--ro received
          +--ro relay-discovery      yang:zero-based-counter64
          +--ro request              yang:zero-based-counter64
          +--ro membership-update    yang:zero-based-counter64
          +--ro teardown             yang:zero-based-counter64
        +--ro sent
          +--ro relay-advertisement yang:zero-based-counter64
          +--ro membership-query     yang:zero-based-counter64
        +--ro error
          +--ro incomplete-packet    yang:zero-based-counter64
          +--ro invalid-mac          yang:zero-based-counter64
          +--ro unexpected-type      yang:zero-based-counter64
          +--ro invalid-relay-discovery-address
            | yang:zero-based-counter64
          +--ro invalid-membership-request-address
            | yang:zero-based-counter64
          +--ro invalid-membership-update-address
            | yang:zero-based-counter64
          +--ro incomplete-relay-discovery-messages
            | yang:zero-based-counter64
          +--ro incomplete-membership-request-messages
            | yang:zero-based-counter64
          +--ro incomplete-membership-update-messages
            | yang:zero-based-counter64
          +--ro no-active-gateway     yang:zero-based-counter64
          +--ro invalid-inner-header-checksum
            | yang:zero-based-counter64
          +--ro gateways-timed-out   yang:gauge64
        +--ro discontinuity-time     yang:date-and-time
      +--rw gateway {amt-gateway}?
        ...

```

Figure 5: AMT Relay Statistics Subtree Structure

4.2.3. Gateway

The structure of 'gateway' is shown in Figure 6.

```

module: ietf-amt
augment /rt:routing/rt:control-plane-protocols:
  +--rw amt!
    +--rw relay {amt-relay}?
    | ...
    +--rw gateway {amt-gateway}?
      +--rw pseudo-interfaces
        +--rw interface* [interface]
          +--rw name if:interface-ref
          +--rw discovery-method identityref
          +--rw relay-discovery-address? inet:ip-address
          +--rw relay-address? inet:ip-address
          +--rw relay-port? inet:port-number
          +--ro local-address? inet:ip-address
          +--ro local-port? inet:port-number
          +--rw upstream-interface? if:interface-ref
          +--rw discovery-timeout? uint32
          +--rw discovery-retrans-count? uint32
          +--rw request-timeout? uint32
          +--rw request-retrans-count? uint32
          +--rw dest-unreach-retry-count? uint32
          +--ro tunnel-state identityref
          +--ro relay-discovery-message-count
          | yang:zero-based-counter64
          +--ro relay-advertisement-message-count
          | yang:zero-based-counter64
          +--ro request-message-count
          | yang:zero-based-counter64
          +--ro membership-query-message-count
          | yang:zero-based-counter64
          +--ro membership-update-message-count
          | yang:zero-based-counter64
        +--ro gateway-message-statistics
          +--ro discontinuity-time yang:date-and-time
          +--ro received
          | +--ro relay-advertisement yang:zero-based-counter64
          | +--ro membership-query yang:zero-based-counter64
          +--ro sent
            +--ro relay-discovery yang:zero-based-counter64
            +--ro request yang:zero-based-counter64
            +--ro membership-update yang:zero-based-counter64
            +--ro teardown yang:zero-based-counter64

```

Figure 6: AMT Gateway Subtree Structure

The 'gateway' data nodes are described as follows:

'pseudo-interfaces': Indicates the configuration and operational

state of pseudo interfaces used to establish AMT tunnels between gateways and relays.

'gateway-message-statistics': Indicates the message statistics of the AMT gateway. It has the time on the most recent occasion at which any one or more of the AMT gateway message counters suffered a discontinuity ('discontinuity-time'), the received message statistics of AMT gateway ('received'), and the sent message statistics of AMT gateway ('sent').

'received' container includes the number of AMT relay advertisement messages received ('relay-advertisement') and the number of AMT membership query messages received ('membership-query').

'sent' container includes the number of AMT relay discovery messages sent ('relay-discovery'), the number of AMT membership request messages sent ('request'), the number of AMT membership update messages sent ('membership-update'), and the number of AMT teardown messages sent ('teardown').

4.3. YANG Module

This document imports modules defined in [RFC9911], [RFC8294], [RFC8343], and [RFC8349].

```
<CODE BEGINS> file "ietf-amt@2026-03-10.yang"
module ietf-amt {
  yang-version "1.1";
  namespace "urn:ietf:params:xml:ns:yang:ietf-amt";
  prefix amt;

  import ietf-inet-types {
    prefix inet;
    reference
      "RFC 9911: Common YANG Data Types, Section 4";
  }

  import ietf-yang-types {
    prefix yang;
    reference
      "RFC 9911: Common YANG Data Types, Section 3";
  }

  import ietf-routing-types {
    prefix rt-types;
    reference
      "RFC 8294: Common YANG Data Types for the Routing Area";
```

```
}

import ietf-interfaces {
  prefix if;
  reference
    "RFC 8343: A YANG Data Model for Interface Management";
}

import ietf-routing {
  prefix rt;
  reference
    "RFC 8349: A YANG Data Model for Routing Management
      (NMDA Version)";
}

organization
  "IETF Multicast Backbone Deployment (MBONED) Working Group";

contact
  "WG Web:    <https://datatracker.ietf.org/wg/mboned/>
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description
  "This module describes a YANG data model for managing the
  Automatic Multicast Tunneling (AMT) protocol.

  The key words 'MUST', 'MUST NOT', 'REQUIRED', 'SHALL', 'SHALL
  NOT', 'SHOULD', 'SHOULD NOT', 'RECOMMENDED', 'NOT RECOMMENDED',
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All revisions of IETF and IANA published modules can be found at the YANG Parameters registry group (<https://www.iana.org/assignments/yang-parameters>).

This version of this YANG module is part of RFC XXXX; see the RFC itself for full legal notices.";

```
revision 2026-03-10 {
  description
    "Initial Version";
  reference
    "RFC XXXX: A YANG Data Model for Automatic Multicast
      Tunneling (AMT)";
}

feature amt-gateway {
  description
    "Indicates support of AMT Gateway functionality.";
  reference
    "RFC 7450: Automatic Multicast Tunneling, Section 4.1.2";
}

feature amt-relay {
  description
    "Indicates support of AMT Relay functionality.";
  reference
    "RFC 7450: Automatic Multicast Tunneling, Section 4.1.3";
}

typedef ip-multicast-source-address {
  type union {
    type rt-types:ipv4-multicast-source-address;
    type rt-types:ipv6-multicast-source-address;
  }
  description
    "This type represents a version-neutral IP multicast source
      address. The format of the textual representation implies
      the IP address family.";
}

identity tunnel-state-base {
  description
    "Base identity for AMT tunnel states.";
```

```
}

identity up {
  base tunnel-state-base;
  description
    "The AMT tunnel has been successfully established.";
}

identity establishing {
  base tunnel-state-base;
  description
    "The AMT tunnel is being established.";
}

identity initial {
  base tunnel-state-base;
  description
    "Initial AMT tunnel state.";
}

identity discovering {
  base tunnel-state-base;
  description
    "The Relay Discovery message has been sent
    and is waiting for the Advertisement message.";
}

identity requesting {
  base tunnel-state-base;
  description
    "The Request message has been sent, waiting for the Query
    message.";
}

identity discovery-method-base {
  description
    "Base identity for all methods used to discover an
    AMT relay address.

    New discovery methods should be defined by creating
    new identities derived from this base identity.";
}

identity by-amt-solicit {
  base discovery-method-base;
  description
    "Find the relay address by sending an AMT Discovery message.
```



```
        This method involves sending an AMT Discovery message to
        discover available relays in the network.";
    reference
        "RFC 7450: Automatic Multicast Tunneling, Section 5.1.1";
}

identity by-dns-reverse-ip {
    base discovery-method-base;
    description
        "Find the relay address by DNS reverse IP AMT Discovery.

        This method uses DNS reverse IP lookup to discover AMT
        relays based on the client's IP address.";
    reference
        "RFC 8777: DNS Reverse IP Automatic Multicast Tunneling (AMT)
        Discovery";
}

augment "/rt:routing/rt:control-plane-protocols" {
    description
        "AMT augmentation to the routing instance model.";
    container amt {
        description
            "Management parameters for the AMT protocol.";
        container relay {
            if-feature "amt-relay";
            description
                "Parameters of the AMT relay service.";
            container addresses {
                description
                    "Parameters of AMT relay addresses.";
                list address {
                    key "family";
                    description
                        "Each entry contains parameters for an AMT relay
                        address identified by the 'family' key. Under
                        normal operation, these addresses SHOULD belong
                        to the same address family indicated by 'family'.
                        Any mismatch is an indication of abnormal
                        configuration and is therefore allowed to be
                        reported.

                        The 'anycast-prefix' serve as the discovery entry
                        for AMT relays, while unicast IP addresses
                        'local-address' are the actual communication entities
                        of AMT relays. The AMT gateway first locates the AMT
                        relay via the 'anycast-prefix' and then uses its
                        'local-address' to complete all subsequent AMT
```

```
        interactions.";
    leaf family {
        type identityref {
            base rt:address-family;
        }
        description
            "Indicates the address family for the entry.";
    }
    leaf anycast-prefix {
        type inet:ip-prefix;
        description
            "An anycast IP prefix of the AMT relay discovery
            address which is used when sending discovery
            messages to a relay.

            If 'family' is IPv4, it SHOULD be an IPv4 prefix;
            If 'family' is IPv6, it SHOULD be an IPv6 prefix.

            Any mismatch is an indication of abnormal
            configuration and is therefore allowed to be
            reported.";
    }
    leaf local-address {
        type inet:ip-address;
        description
            "A unicast IP address of the AMT relay address
            which is obtained as a result of the discovery
            process.

            If 'family' is IPv4, it SHOULD be an IPv4 address;
            If 'family' is IPv6, it SHOULD be an IPv6 address.

            Any mismatch is an indication of abnormal
            configuration and is therefore allowed to be
            reported.";
    }
}
}
leaf tunnel-limit {
    type uint32;
    description
        "The total number of endpoints.";
}
leaf secret-key-timeout {
    type uint32;
    description
        "The timeout interval of secret key.";
}
```

```
container relay-dns-resource-records {
  description
    "The DNS Resource Records (RRs) of the AMT relay.";
  list record {
    key "source-address";
    description
      "Specifies an RR entry.";
    leaf source-address {
      type inet:ip-address;
      description
        "The unicast IP address of multicast sender.";
    }
    leaf precedence {
      type uint32;
      description
        "The precedence value of this record, used
        for relay selection priority.

        Lower values indicate higher priority.
        Relays listed in AMT relay records with
        a lower value for precedence are to be
        attempted first.";
      reference
        "RFC 8777: DNS Reverse IP Automatic Multicast
        Tunneling (AMT) Discovery,
        Section 4.2.1";
    }
    leaf d-bit {
      type boolean;
      default false;
      description
        "If the D-bit is set to true, the gateway MAY
        send an AMT Request message directly to the
        discovered relay address without first
        sending an AMT Discovery message.

        If the D-bit is set to false, the gateway MUST
        receive an AMT relay advertisement message
        for an address before sending an AMT
        Request message to that address.";
      reference
        "RFC 8777: DNS Reverse IP Automatic Multicast
        Tunneling (AMT) Discovery,
        Section 4.2.2";
    }
    leaf relay-type {
      type enumeration {
        enum empty {
```

```
        value 0;
        description
            "The relay field is empty.";
    }
    enum ipv4-address {
        value 1;
        description
            "The relay field contains a 4-octet IPv4
            address.";
    }
    enum ipv6-address {
        value 2;
        description
            "The relay field contains a 16-octet IPv6
            address.";
    }
    enum domain-name {
        value 3;
        description
            "The relay field contains a wire-encoded
            domain name.";
    }
}
description
    "Indicates the type of relay in the AMT relay RR.

    Value 0 indicates that no AMT relay should be
    used for multicast traffic from this source.

    Values 1 and 2 indicate that the IP address is
    used to describe the AMT relay.

    Value 3 indicates that the domain name is
    used to describe the AMT relay.";
reference
    "RFC 8777: DNS Reverse IP Automatic Multicast
    Tunneling (AMT) Discovery,
    Section 4.2.3";
}
leaf discovery-address {
    type inet:ip-address;
    description
        "The IP address of AMT relay discovery address.

        When the 'relay-type' value is 1 or 2, this
        data node is used to indicate the AMT relay of
        the AMT relay RR.";
}
```

```
    leaf domain-name {
      type inet:domain-name;
      description
        "The wire-encoded domain name of the AMT relay.

        When the 'relay-type' value is 3, this data node
        is used to indicate the AMT relay of the AMT
        relay RR.";
    }
  }
}
container tunnels {
  config false;
  description
    "AMT tunnel session information, which contains
    session parameters, state, and statistics for
    all AMT tunnels established between gateways
    and this relay.";
  list tunnel {
    key "gateway-address gateway-port";
    description
      "Records a tunnel entry.";
    leaf gateway-address {
      type inet:ip-address;
      description
        "The IP address of an AMT gateway.";
    }
    leaf gateway-port {
      type inet:port-number;
      description
        "The UDP port number of an AMT gateway.";
    }
    leaf local-address {
      type inet:ip-address;
      description
        "The local IP address of the AMT relay.";
    }
    leaf local-port {
      type inet:port-number;
      description
        "The local UDP port number of the AMT relay.";
    }
    leaf state {
      type identityref {
        base tunnel-state-base;
      }
      description
        "The state of AMT tunnel.";
    }
  }
}
```

```
}
container multicast-flows {
  config false;
  description
    "The multicast flow information in the AMT tunnel.

    Contains operational data for all multicast
    flows being forwarded through AMT tunnels between
    this relay and connected gateways.";
  list flow {
    key "source-address group-address";
    description
      "Records the characteristics of a multicast flow.";
    leaf source-address {
      type ip-multicast-source-address;
      description
        "The source IP address of a multicast flow.

        It MUST belong to the same address family as
        group-address.";
    }
    leaf group-address {
      type rt-types:ip-multicast-group-address;
      description
        "The group IP address of a multicast flow.

        It MUST belong to the same address family as
        source-address.";
    }
  }
}
leaf multicast-group-num {
  type yang:gauge32;
  description
    "Number of multicast groups.";
}
leaf request-message-count {
  type yang:zero-based-counter64;
  description
    "Number of AMT Request messages received
    in the tunnel.";
}
leaf membership-query-message-count {
  type yang:zero-based-counter64;
  description
    "Number of AMT membership Query messages sent
    in the tunnel.";
}
```

```
leaf membership-update-message-count {
  type yang:zero-based-counter64;
  description
    "Number of AMT membership Update messages received
    in the tunnel.";
}
leaf discontinuity-time {
  type yang:date-and-time;
  description
    "The time on the most recent occasion at which any
    one or more of this AMT tunnel's counters suffered
    a discontinuity.

    If no such discontinuities have occurred since the
    last re-initialization of the AMT tunnel, then this
    node contains the time when the AMT tunnel was last
    initialized or the tunnel was established.";
}
}
}
container relay-message-statistics {
  config false;
  description
    "Message statistics of an AMT relay.";
  container received {
    description
      "Received message statistics of AMT relay.";
    leaf relay-discovery {
      type yang:zero-based-counter64;
      description
        "Number of AMT relay discovery messages
        received.";
    }
    leaf request {
      type yang:zero-based-counter64;
      description
        "Number of AMT membership Request messages
        received.";
    }
    leaf membership-update {
      type yang:zero-based-counter64;
      description
        "Number of AMT membership Update messages
        received.";
    }
    leaf teardown {
      type yang:zero-based-counter64;
      description
```

```
        "Number of AMT Teardown messages received.";
    }
}
container sent {
    description
        "Sent message statistics of AMT relay.";
    leaf relay-advertisement {
        type yang:zero-based-counter64;
        description
            "Number of AMT relay advertisement messages sent.";
    }
    leaf membership-query {
        type yang:zero-based-counter64;
        description
            "Number of AMT membership Query messages sent.";
    }
}
container error {
    description
        "Error message statistics of AMT relay.";
    leaf incomplete-packet {
        type yang:zero-based-counter64;
        description
            "Number of messages received with length errors
            so severe that further classification could not
            occur.";
    }
    leaf invalid-mac {
        type yang:zero-based-counter64;
        description
            "Number of messages received with an invalid
            Message Authentication Code (MAC).";
    }
    leaf unexpected-type {
        type yang:zero-based-counter64;
        description
            "Number of messages received with an unknown
            message type specified.";
    }
    leaf invalid-relay-discovery-address {
        type yang:zero-based-counter64;
        description
            "Number of AMT relay discovery messages
            received with an address other than the
            configured anycast address.";
    }
    leaf invalid-membership-request-address {
        type yang:zero-based-counter64;
```



```
    description
      "Number of AMT membership request messages
      received with an address other than the
      configured AMT local address.";
  }
  leaf invalid-membership-update-address {
    type yang:zero-based-counter64;
    description
      "Number of AMT membership update messages
      received with an address other than the
      configured AMT local address.";
  }
  leaf incomplete-relay-discovery-messages {
    type yang:zero-based-counter64;
    description
      "Number of AMT relay discovery messages
      received that are not fully formed.";
  }
  leaf incomplete-membership-request-messages {
    type yang:zero-based-counter64;
    description
      "Number of AMT membership request messages
      received that are not fully formed.";
  }
  leaf incomplete-membership-update-messages {
    type yang:zero-based-counter64;
    description
      "Number of AMT membership update messages
      received that are not fully formed.";
  }
  leaf no-active-gateway {
    type yang:zero-based-counter64;
    description
      "Number of AMT membership update messages
      received for a tunnel that does not exist
      for the gateway that sent the message.";
  }
  leaf invalid-inner-header-checksum {
    type yang:zero-based-counter64;
    description
      "Number of AMT membership update messages
      received with an invalid IP checksum.";
  }
  leaf gateways-timed-out {
    type yang:gauge64;
    description
      "Number of gateways that timed out because
      of inactivity.";
```

```
    }
  }
  leaf discontinuity-time {
    type yang:date-and-time;
    description
      "The time on the most recent occasion at which any
       one or more of this AMT tunnel's message counters
       suffered a discontinuity.

       If no such discontinuities have occurred since the
       last re-initialization of the AMT tunnel, then this
       node contains the time when the AMT tunnel was last
       initialized or the tunnel was established.";
  }
} // relay
container gateway {
  if-feature "amt-gateway";
  description
    "Parameters of AMT gateway service.";
  container pseudo-interfaces {
    description
      "Parameters of AMT pseudo-interface.";
    list interface {
      key "name";
      description
        "An entry of AMT pseudo-interface.";
      leaf name {
        type if:interface-ref;
        description
          "Indicates the name of a pseudo interface.";
      }
      leaf discovery-method {
        type identityref {
          base discovery-method-base;
        }
        description
          "The method used to discover the relay address.";
      }
      leaf relay-discovery-address {
        type inet:ip-address;
        description
          "Specifies the AMT relay discovery address.";
      }
      leaf relay-address {
        type inet:ip-address;
        description
          "Specifies the IP address of the AMT relay.";
```

```
}
leaf relay-port {
  type inet:port-number;
  description
    "The UDP port number of the AMT relay.";
}
leaf local-address {
  type inet:ip-address;
  config false;
  description
    "The local IP address of this AMT tunnel.";
}
leaf local-port {
  type inet:port-number;
  config false;
  description
    "The local UDP port number of this AMT tunnel.";
}
leaf upstream-interface {
  type if:interface-ref;
  description
    "Indicates the upstream interface to reach the AMT
    relay.";
}
leaf discovery-timeout {
  type uint32;
  description
    "Initial time to wait for a response to
    a Relay Discovery message.";
}
leaf discovery-retrans-count {
  type uint32;
  description
    "Maximum number of Relay Discovery retransmissions
    to allow before terminating relay discovery
    and reporting an error.";
}
leaf request-timeout {
  type uint32;
  description
    "Initial time to wait for a response
    to a Request message";
}
leaf request-retrans-count {
  type uint32;
  description
    "Maximum number of Request retransmissions
    to allow before abandoning a relay and restarting
```

```
        relay discovery or reporting an error.";
    }
    leaf dest-unreach-retry-count {
        type uint32;
        description
            "The maximum number of times a gateway should
            attempt to send the same Request or Membership
            Update message after receiving an ICMP Destination
            Unreachable message.";
    }
    leaf tunnel-state {
        type identityref {
            base tunnel-state-base;
        }
        config false;
        description
            "The tunnel's state.";
    }
    leaf relay-discovery-message-count {
        type yang:zero-based-counter64;
        config false;
        description
            "Number of AMT relay discovery messages sent
            on the interface.";
    }
    leaf relay-advertisement-message-count {
        type yang:zero-based-counter64;
        config false;
        description
            "Number of AMT relay advertisement messages received
            on the interface.";
    }
    leaf request-message-count {
        type yang:zero-based-counter64;
        config false;
        description
            "Number of AMT membership request messages sent
            on the interface.";
    }
    leaf membership-query-message-count {
        type yang:zero-based-counter64;
        config false;
        description
            "Number of AMT membership query messages received
            on the interface.";
    }
    leaf membership-update-message-count {
        type yang:zero-based-counter64;
```

```
        config false;
        description
            "Number of AMT membership update messages sent
            on the interface.";
    }
}
}
container gateway-message-statistics {
    config false;
    description
        "Message statistics of the AMT Gateway.";
    leaf discontinuity-time {
        type yang:date-and-time;
        description
            "The time on the most recent occasion at which the AMT
            gateway message counters suffered a discontinuity.

            If no such discontinuities have occurred since the
            last re-initialization of the gateway, then this
            data node contains the time when the gateway was last
            initialized.";
    }
}
container received {
    description
        "Received message statistics of the AMT Gateway.";
    leaf relay-advertisement {
        type yang:zero-based-counter64;
        description
            "Number of AMT relay advertisement messages
            received.";
    }
    leaf membership-query {
        type yang:zero-based-counter64;
        description
            "Number of AMT membership query messages
            received.";
    }
}
}
container sent {
    description
        "Sent message statistics of the AMT Gateway.";
    leaf relay-discovery {
        type yang:zero-based-counter64;
        description
            "Number of AMT relay discovery messages sent.";
    }
    leaf request {
        type yang:zero-based-counter64;
```

```
        description
            "Number of AMT membership request messages sent.";
    }
    leaf membership-update {
        type yang:zero-based-counter64;
        description
            "Number of AMT membership update messages sent.";
    }
    leaf teardown {
        type yang:zero-based-counter64;
        description
            "Number of AMT teardown messages sent.";
    }
    }
} // gateway
} // amt
} // augment
}
<CODE ENDS>
```

5. Operational Considerations

This document specifies a YANG data model for AMT that configures and monitors address parameters for both Relay and Gateway functions. Operators MUST monitor for address family mismatches between associated address parameters to ensure correct protocol operation, tunnel establishment, and forwarding behavior.

The following address pairs and combinations are critical and MUST be validated for address family consistency:

- * On the AMT Relay:

Within the 'relay/addresses/address' list entry indexed by a given address family ('family'):

- The 'anycast-prefix' (discovery anycast prefix)
- The 'local-address' (unicast IP address)

These IP addresses MUST belong to the same address family indicated by the 'family' leaf (either both IPv4 or both IPv6). A mismatch (e.g., IPv4 'anycast-prefix' paired with IPv6 'local-address' under the same IPv4 'family' entry) indicates a configuration anomaly that can prevent Relay discovery, Advertisement responses, and tunnel setup.

* On the AMT Gateway:

Within each 'gateway/pseudo-interfaces/interface' entry:

- The 'relay-discovery-address'
- The 'relay-address'
- The 'local-address' (operational state)

These IP addresses MUST all belong to the same address family. A mismatch can lead to failure in Relay discovery, tunnel establishment, or traffic decapsulation.

Network operators SHOULD implement configuration validation and operational monitoring to detect such address family mismatches. When detected, the device MUST log an appropriate error or alarm, and MAY prevent the inconsistent configuration from being applied. Corrective actions include reconfiguring the affected addresses to match the intended address family and verifying routing reachability for the configured addresses.

6. Security Considerations

This section is modeled after the template described in Section 3.7.1 of [I-D.ietf-netmod-rfc8407bis].

The "ietf-amt" YANG module defines a data model that is designed to be accessed via YANG-based management protocols, such as Network Configuration Protocol (NETCONF) [RFC6241] and RESTCONF [RFC8040]. These YANG-based management protocols (1) have to use a secure transport layer (e.g., Secure Shell (SSH) [RFC4252], TLS [RFC8446], and QUIC [RFC9000]) and (2) have to use mutual authentication.

The Network Configuration Access Control Model (NACM) [RFC8341] provides the means to restrict access for particular NETCONF or RESTCONF users to a preconfigured subset of all available NETCONF or RESTCONF protocol operations and content.

There are a number of data nodes defined in this YANG module that are writable/creatable/deletable (i.e., config true, which is the default). All writable data nodes are likely to be sensitive or vulnerable in some network environments. Write operations (e.g., edit-config) and delete operations to these data nodes without proper protection or authentication can have a negative effect on network operations. The following subtrees and data nodes have particular sensitivities/vulnerabilities:

Under `/rt:routing/rt:control-plane-protocols/rt:control-plane-protocol/`: Unauthorized access to any data nodes in these subtrees can adversely affect the AMT subsystem of both the local device and the network. This may lead to network malfunctions, delivery of packets to inappropriate destinations, and other problems.

`amt/relay/addresses/address`:

: This subtree specifies the IPv4 or IPv6 address information for an AMT relay. Modifying the configuration may cause the AMT tunnel to be torn down or established.

`amt/relay/relay-dns-resource-records/record`:

: This subtree specifies the DNS RR configuration used to discover AMT relays. Modifying this configuration may cause the AMT gateway to discover new AMT relay devices, or fail to discover AMT relay devices.

`amt/gateway/pseudo-interfaces/interface`:

: This subtree specifies the parameters of AMT pseudo-interface for an AMT gateway. Modifying this configuration may cause the AMT gateway to establish or tear down tunnels with multiple AMT relays.

Some of the readable data nodes in this YANG module may be considered sensitive or vulnerable in some network environments. It is thus important to control read access (e.g., via `get`, `get-config`, or `notification`) to these data nodes. Specifically, the following subtrees and data nodes have particular sensitivities/vulnerabilities:

Under `/rt:routing/rt:control-plane-protocols/rt:control-plane-protocol/`: `amt/relay` and `amt/gateway`. Unauthorized access to any data nodes in these subtrees can disclose operational state information about the AMT relay or AMT gateway on this device.

7. IANA Considerations

7.1. IETF XML Registry

IANA is requested to register the following URI in the "ns" registry within the "IETF XML Registry" group [RFC3688]:

URI: `urn:ietf:params:xml:ns:yang:ietf-amt`

Registrant Contact: The IESG.

XML: N/A; the requested URI is an XML namespace.

7.2. YANG Module Names Registry

IANA is requested to register the following YANG module in the "YANG Module Names" registry [RFC6020] within the "YANG Parameters" registry group:

```
Name: ietf-amt
Maintained by IANA? N
Namespace: urn:ietf:params:xml:ns:yang:ietf-amt
Prefix: amt
Reference: RFC XXXX
```

8. Acknowledgments

Thanks to Mohamed Boucadair for review and comments.

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Appendix A. Full Tree

```
module: ietf-amt
  augment /rt:routing/rt:control-plane-protocols:
    +--rw amt!
      +--rw relay {amt-relay}?
        |
        | +--rw addresses
        | |
        | | +--rw address* [family]
        | | |
        | | | +--rw family          identityref
        | | | +--rw anycast-prefix  inet:ip-prefix
        | | | +--rw local-address   inet:ip-address
        | | +--rw tunnel-limit?     uint32
        | | +--rw secret-key-timeout? uint32
        | +--rw relay-dns-resource-records
        | |
        | | +--rw record* [source-address]
```

```

|--rw source-address          inet:ip-address
|--rw precedence?            uint32
|--rw d-bit?                 boolean
|--rw relay-type?            enumeration
|--rw discovery-address?     inet:ip-address
|--rw domain-name?          inet:domain-name
+--ro tunnels
  +--ro tunnel* [gateway-address gateway-port]
    +--ro gateway-address     inet:ip-address
    +--ro gateway-port        inet:port-number
    +--ro local-address       inet:ip-address
    +--ro local-port          inet:port-number
    +--ro state                identityref
    +--ro multicast-flows
      +--ro flow* [source-address
        |         group-address]
        +--ro source-address  ip-multicast-source-address
        +--ro group-address   rt-types:ip-multicast-group-address
    +--ro multicast-group-num  yang:gauge32
    +--ro request-message-count
      | yang:zero-based-counter64
    +--ro membership-query-message-count
      | yang:zero-based-counter64
    +--ro membership-update-message-count
      | yang:zero-based-counter64
    +--ro discontinuity-time   yang:date-and-time
+--ro relay-message-statistics
  +--ro received
    +--ro relay-discovery     yang:zero-based-counter64
    +--ro request             yang:zero-based-counter64
    +--ro membership-update   yang:zero-based-counter64
    +--ro teardown            yang:zero-based-counter64
  +--ro sent
    +--ro relay-advertisement yang:zero-based-counter64
    +--ro membership-query    yang:zero-based-counter64
  +--ro error
    +--ro incomplete-packet   yang:zero-based-counter64
    +--ro invalid-mac         yang:zero-based-counter64
    +--ro unexpected-type     yang:zero-based-counter64
    +--ro invalid-relay-discovery-address
      | yang:zero-based-counter64
    +--ro invalid-membership-request-address
      | yang:zero-based-counter64
    +--ro invalid-membership-update-address
      | yang:zero-based-counter64
    +--ro incomplete-relay-discovery-messages

```

```

| | | | | yang:zero-based-counter64
| | | | | +--ro incomplete-membership-request-messages
| | | | | | | yang:zero-based-counter64
| | | | | +--ro incomplete-membership-update-messages
| | | | | | | yang:zero-based-counter64
| | | | | +--ro no-active-gateway yang:zero-based-counter64
| | | | | +--ro invalid-inner-header-checksum
| | | | | | | yang:zero-based-counter64
| | | | | +--ro gateways-timed-out yang:gauge64
| | | | | +--ro discontinuity-time yang:date-and-time
+--rw gateway {amt-gateway}?
+--rw pseudo-interfaces
| +--rw interface* [interface]
| | +--rw name if:interface-ref
| | +--rw discovery-method identityref
| | +--rw relay-discovery-address? inet:ip-address
| | +--rw relay-address? inet:ip-address
| | +--rw relay-port? inet:port-number
| | +--ro local-address? inet:ip-address
| | +--ro local-port? inet:port-number
| | +--rw upstream-interface? if:interface-ref
| | +--rw discovery-timeout? uint32
| | +--rw discovery-retrans-count? uint32
| | +--rw request-timeout? uint32
| | +--rw request-retrans-count? uint32
| | +--rw dest-unreach-retry-count? uint32
| | +--ro tunnel-state identityref
| | +--ro relay-discovery-message-count
| | | | | yang:zero-based-counter64
| | +--ro relay-advertisement-message-count
| | | | | yang:zero-based-counter64
| | +--ro request-message-count
| | | | | yang:zero-based-counter64
| | +--ro membership-query-message-count
| | | | | yang:zero-based-counter64
| | +--ro membership-update-message-count
| | | | | yang:zero-based-counter64
+--ro gateway-message-statistics
| +--ro discontinuity-time yang:date-and-time
| +--ro received
| | +--ro relay-advertisement yang:zero-based-counter64
| | +--ro membership-query yang:zero-based-counter64
+--ro sent
| +--ro relay-discovery yang:zero-based-counter64
| +--ro request yang:zero-based-counter64
| +--ro membership-update yang:zero-based-counter64
| +--ro teardown yang:zero-based-counter64

```

Appendix B. Data Model Example

This section presents a simple and illustrative example of how to configure AMT.

The example is represented in both XML [W3C.REC-xml-20081126] and JSON [RFC7951] formats.

Figure 7 shows a sample configuration for an AMT relay service in XML format. This example configures the protocol address family (IPv4 or IPv6), secret key timeout (120 minutes), and tunnel limit (10) for AMT relay function. In addition, the AMT anycast prefix is set to 192.0.2.1/32 for IPv4 and 2001:db8::1/128 for IPv6, and the AMT local address is configured to 198.51.100.42 for IPv4 and 2001:db8:abcd:12::42 for IPv6.

```
<?xml version="1.0" encoding="UTF-8"?>
<config xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <routing xmlns="urn:ietf:params:xml:ns:yang:ietf-routing">
    <control-plane-protocols>
      <amt xmlns="urn:ietf:params:xml:ns:yang:ietf-amt">
        <relay>
          <addresses>
            <address>
              <family>ipv4</family>
              <anycast-prefix>192.0.2.1/32</anycast-prefix>
              <local-address>198.51.100.42</local-address>
            </address>
            <address>
              <family>ipv6</family>
              <anycast-prefix>2001:db8::1/128</anycast-prefix>
              <local-address>2001:db8:abcd:12::42</local-address>
            </address>
          </addresses>
          <tunnel-limit>10</tunnel-limit>
          <secret-key-timeout>120</secret-key-timeout>
        </relay>
      </amt>
    </control-plane-protocols>
  </routing>
</config>
```

Figure 7: Data Model Example in XML

Figure 8 shows the same sample configuration for an AMT relay service in JSON format.

```
{
  "ietf-routing:routing": {
    "control-plane-protocols": {
      "ietf-amt:amt": {
        "relay": {
          "addresses": {
            "address": [
              {
                "family": "ipv4",
                "anycast-prefix": "192.0.2.1/32",
                "local-address": "198.51.100.42"
              },
              {
                "family": "ipv6",
                "anycast-prefix": "2001:db8::1/128",
                "local-address": "2001:db8:abcd:12::42"
              }
            ]
          },
          "tunnel-limit": 10,
          "secret-key-timeout": 120
        }
      }
    }
  }
}
```

Figure 8: Data Model Example in JSON

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